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Editorial

Facing the winds of change: The managerial power of Open Innovation

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Since Henry Chesbrough coined the term of Open Innovation in 2003, it has attracted increasing interest from academics, practitioners and policy-makers alike. More than a decade after, some noticeable and contrasted facts emerge. First, Open Innovation has deeply penetrated the research realms, across disciplines, yet mainly in business, economics and management. Interestingly, this research has primarily focused on the inbound side of Open Innovation, first depicting the phenomenon, then exploring the contingencies and processes, and finally, examining the relationship between Open Innovation adoption and performance. Qualitative, exploratory research has been progressively complemented by large-scale, empirical studies. Unfortunately, few studies exploit indicators going beyond the usual suspects, such as cooperation practices, information sourcing, strategic alliances, joint patenting, and the like to capture the complex and multifaceted nature of Open Innovation. The Outbound, and concomitantly, the coupled side of Open innovation is now gaining more popularity within the research community, with seminal contributions, usually depicting how firms can leverage on external channels to increase their profits and societal impact. An illustration of such research, authored by Chesbrough and Chen, is included in this thematic issue. This broadening of the scope of research on Open Innovation may signal a growing awareness of firms for alternative ways to monetize their novelties in times of uncertainty, complexity, volatility and ambiguity. It may also reflect a shift in the mindset of organizations, thanks to innumerable initiatives, networks, conferences, communities and events focusing on Open Innovation, with brilliant keynote speeches, excellent illustrations and showcases. The policy making arena is also increasingly involved and is actively shaping the R&D and innovation programs so that they require the involvement of several stakeholders, they advocate for an open and inclusive approach. Among this myriad of initiatives, we purposefully want to shed light on three of those, which also resonate with our aim of combining academia, practice and policy-making. First, the largest European-funded network, OI-Net, which aims at shaping new curricula centered on Open Innovation. The young generation is our future. Raising their awareness to Open Innovation and its foundational principles, is key as it may impact their propensity to implement Open Innovation practices, and to avoid the typical syndromes hampering its success, namely the "not-invented-here" (Katz & Allen, 1982) and the "not-sold-here" (Lichtenthaler et al., 2010) and to the best of our knowledge, the not-yet coined "not-

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funded-here" syndrome. Second, the MOOI (Managing and Organizing Open Innovation, mooiforum.com) forum, which is an online community of professionals active in the field of Open Innovation, and which teams up with academics to develop actionable content for innovation managers and leaders. Third, the Open Innovation 2.0 initiative, which describes itself as "a positive approach for innovation which helps solving key European challenges by embracing change, not resisting it!"(Digital Agenda, European Commission). Bringing together stakeholders from all backgrounds, fields, disciplines, businesses, and organizations, this forum and conference is a key platform for thought leadership in the field of Open Innovation. These initiatives, and many others, reflect the shift in individual mindsets, in organizational behavior, and in public policy development. They also pinpoint that Open Innovation is growing concurrently with the richness of approaches used to apprehend and comprehend it, the mingling of diverse scholars, disciplines and fields, and the increasing maturity and readiness of organizations to turn its principles into practice. As the say goes, Rome has not been built in a day, so this is the first thematic issue on Open Innovation and we are already looking forward to next year's edition, hoping that giant and robust leaps will have been performed in the understanding of Open Innovation, and in its implementation in practice with societal impact. We advocate an even diverse and richer research in the field, at all levels of analysis, and for positive evolution of organization ethos regarding Open Innovation.

The Academic Letter of this Issue, by Torkkeli and Mention, elaborates on the emergence of Open Innovation as an academic field. Since the term was originally coined by Chesbrough (2003), Open Innovation has attracted increasing interest from scholars, practitioners and policy-makers. This simultaneous enthusiasm from all communities has materialized into a growing number of academic publications, an expanding awareness and adoption of OI practices by firms, across all sectors, sizes and industries, and by the elaboration of public policies fostering the implementation of OI. These rationales have supported the development of the largest European-funded network in the field of OI (namely, OI-Net, www.oi-net.eu), which aims at developing academic curricula where OI is the cornerstone. Education is one of the most powerful tools to shape the future. Developing curricula, targeting all levels of education, from bachelor to executive masters and PhDs, revolving around OI and establishing it as a discipline is the intended contribution of this network.

The second Letter of this Issue reviews the evolution of OI, and elaborates on the new era of Open Innovation 2.0, which is defined as "a new paradigm based on principles of integrated multidisciplinary collaboration, co-created share value, cultivated innovation ecosystems, unleashed exponential technologies, and focus on innovation adoption", as stated by Curley in his Letter. One of the tenets of this new paradigm is the involvement of civil society, as well as the simultaneous prerequisites of having a common vision, aiming at delivering value and sharing values. Curley further discusses the role of intelligent solutions, and the role of ICT as a transformational tool for addressing societal challenges. After giving a couple of examples of OI2.0 initiatives in action, Curley elaborates on the need for measuring innovation, depicting the research yield index, which apparently avoids the traditional pitfalls of measurement systems, and adopts an impact-based approach.

The third Letter of this Issue by Erkinheimo et al. discusses about crowdsourcing and how this practice can affect the leanness and success of start-ups. The Authors provide illustrations on several mechanisms which can help start-ups grow and innovate, relying on the crowd either for the development of products and services or for achieving internal process innovations. They also elaborate on how crowdsourcing can influence the decision-making process in the early stage of innovation.

The opening article of this Issue is a contribution co-authored by the Father of Open Innovation, Henry Chesbrough. In their article, Chesbrough and Chen explore the

effectiveness of the outbound Open Innovation strategy to recover abandoned, yet developed at high costs, pharmaceutical compounds. In doing so, they enrich the stream of research on the outbound side of Open Innovation, which remains relatively scarcely covered to date, and they unveil how such a strategy can help address unmet societal needs while simultaneously widening the pool of revenue sources and business models for the pharmaceutical industry.

In their research on the relationship between OI practices and performance, which is captured through three manifest variables, Ahn et al. concentrate on a sample of 306 innovative Korean SMEs. Their empirical study, which responds to the call for more quantitatively-grounded research on the essential relationship between innovation and performance, unveils that broad and intensive OI adoption positively affects the performance of the firm. Their findings also indicate, in contrast to prior literature, that adopting many OI modes may not harm the performance of the firm, suggesting to some extent, that there is no such thing as "too much openness". Nevertheless, their findings also reveal that not all OI modes affect performance positively and further stress that technology and market-oriented OI modes, taking the forms of joint R&D, user involvement and open sourcing, which involve relatively low levels of change can positively enhance firm's performance. Finally, they confirm that innovative SMEs can benefit from cooperation with non-competing parties such as customers, consultancies, intermediaries and public research institutes.

In their empirical contribution, Alvarez and Iske concentrate on low and medium tech SMEs as they are a significant component of the European economy. Their research aims at testing the complementarity or substitutability between internal innovation capabilities and external knowledge sourcing, distinguishing between technology and market knowledge sources, and their effect on innovation performance, measured as the successful introduction of new products to the market. Their results confirm the widely acknowledged fact that product innovation in low and medium tech industries is not only about technology but is rather a market-driven process. Exploring further the interplay between internal capabilities and knowledge sourcing, their findings unveil that technological capability and external technology knowledge sourcing are substitute, thus leading to a negative relationship between them. Their exploratory study of 142 Dutch SMEs further uncover a negative interplay between marketing capability and external market knowledge sourcing. These last findings pave the way for further research in this specific type of firm, and a deeper understanding of the framework conditions, as well as the contingencies for Open Innovation to unleash its potential benefits in this peculiar setting.

Prud'homme van Reine elaborates a comprehensive framework comprising a set of nine connecting capabilities, which is intended as an analytical tool to assess the readiness of firms towards Open Innovation. The Scholar empirically validates the developed framework in two Dutch regions which display comparable features including specialized clusters. This exploratory study unveils that the technology industry is ahead, compared to the knowledge intensive business services sector, in terms of its ability to benefit from Open Innovation, which may be the consequence of prior and long experience in innovation networking. Prud'homme van Reine further advocates that the framework of connecting and networking capabilities is a promising tool to support companies in their journey of joint value creation and capture in open innovation networks. Policy implications, namely the framework conditions to set up an efficient and effective regional open innovation ecosystem, are also provided.

Virlée et al. concentrate on the largely ignored service industry and explore the contextual factors conducive to the adoption of OI practices, as well as the types of practices implemented. Based on an in-depth review of the literature on OI focusing on services, the Scholars elaborate a framework unveiling four practices, classified

according to their inbound versus outbound nature and the degree of control or freedom, embracing the monetary and non-monetary features. Their empirical study of eighteen service SMEs from high tech and knowledge intensive service firms uncovers that SMEs are more prone to adopt inbound OI practices, whereas the decision on which sub-practice should be adopted is largely determined by the type of actor, the firm's vulnerability, its internal managerial skills and the existence of complementarities.

In "Open Innovation research: trends and influences – a bibliometric analysis", Santos reviews the abundant literature on OI over the 2003-2013 period. His undertaking pursues a threefold objective: first, to characterize the Scopus-listed literature in the field; second, to explore the theoretical influence on OI research and third to analyze the influence of OI literature on other fields of research. His contribution unveils the prominent and most prolific scholars in the field, traces the roots of OI in several areas of economics and management, and also highlights the linkages and interrelationships, as well as the lack of those, with innovation systems, clusters and networks, public policy analysis and the need for further research on OI at individual level. Santos further advocates for an enlargement of the scope of OI research, through diversification strategies, in terms of e.g. units of analysis, methods and disciplines.

This call for an enlargement of the research scope of OI resonates with our views, and depicts the necessary evolution of OI, as a new paradigm for addressing the challenges and transformational needs of the 21st Century and hopefully achieving Ramaswami & Ozsan's 3Ws, "Wealth, Welfare and Wellbeing for our societies.

We would like to conclude this editorial by thanking Prof. Giovanni Perrone, Università degli Studi di Palermo, and Associate Editor of the Journal of Innovation Management for his valuable contribution in producing this Issue. We also would like to welcome onboard of our journey Dimitrios Salampasis, an Open Innovation Scholar and our first Editorial Assistant.

We wish you an enlightening journey in your reading of this issue of the Journal of Innovation Management.

Innovatively Yours,

Anne-Laure Mention, Marko Torkkeli, João José Pinto Ferreira
Editors

References

Chesbrough, H. (2003). Open innovation: The new imperative for creating and profiting from technology. Boston: Harvard Business School Press.

Katz, R., & Allen, T. J. (1982). Investigating the Not Invented Here (NIH) syndrome: A look at the performance, tenure, and communication patterns of 50 R&D Project Groups. R&D Management, 12(1), 7-20.

Lichtenthaler, U., Ernst, H. and Hoegl, M. (2010) 'Not-sold-here: how attitudes influence external knowledge exploitation', Organization Science, Vol. 21, No. 5, pp.1054–1071 (retracted – yet the concept of "not-sold-here "remains of high relevance).

Ramaswamy, V. & Ozcan, K. (2014) The Co-Creation Paradigm. Palo Alto, CA: Stanford University Press.

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Letter from Academia

Open Innovation & The emergence of a new field: Empowering Future Generations

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Abstract. Open Innovation has been attracting an increasing interest from academics and practitioners alike over the last decade. Companies are increasingly prone to engage in Open Innovation journeys, yet they face a myriad of challenges, including the fact that their workforce is not endowed with skills that are required to smoothly implement Open Innovation. Interestingly, despite the growing interest of all communities, education in the field is clearly lagging behind, as the analysis of existing innovation curricula reflects. While universities should empower young generations with tomorrow's required skillsets, they apparently disregard an essential component and neglect to adopt a foresight approach on their core business. In this Academic Letter, we argue that this may relate to the fact that Open Innovation is not yet recognized as a discipline per se and we discuss six forces that may help elevate it to this stage. Overall, we also aim to demonstrate that the journey to establish Open Innovation as a field of education is only beginning.

Keywords. Discipline, Emergence, Teaching, Research field, Professionalization, Open Innovation

1. Introduction

The European Union has placed innovation high on its agenda, since the Lisbon Strategy, aiming at making Europe the most innovative and competitive economy in the world, along with the subsequent EU2020 strategy, targeting a smart, inclusive and sustainable growth for its Member States. The implementation of those strategies has taken various forms and facets including the development of innovative funding instruments covering the whole spectrum from basic research to the diffusion of novelties. The Juncker plan is another recent mechanism to support the renewal, growth and competitiveness of European industries, as well as its transformation to address new societal challenges. As stated by the European Investment Bank, being the entity overseeing its implementation, the Investment Plan for Europe aims to revive investment in strategic projects around Europe so as to ensure that money reaches the real economy. This should unlock an additional investment of at least EUR 315bn over the next three years. (European Investment Bank website).

2. On the largest EU network for Open Innovation education

Among the variety of instruments and vehicles created by the European Union to

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support Europe face its current and future challenges, is the Erasmus Programme. Originally focused on fostering the mobility of students and researchers, it nowadays covers a wider range of activities, including the set-up of large academic networks. Foreseeing the opportunity to leverage on a large, European-wide network to federate actors and establish Open Innovation as a field of teaching, the OI-NET proposal was submitted by Torkkeli. The purpose of this project, now funded under the Erasmus scheme, is multifold. Firstly, it aims to define a joint framework for curricula on Open Innovation on a European level. Secondly, it aspires to explore how such curricula can complement or supplement existing schemes offered by universities and higher education institutions, including its recognition in terms of educational credits, i.e. the so-called ECTS. Thirdly, it targets the development of customized modules, based on the peculiarities of the different structures of European economies. Fourthly, it addresses the elaboration of an online library of cases embracing all aspects of Open Innovation for educational purposes. Fifthly, its purpose is to build a sustainable community, with a shared interest in the field of Open Innovation, and self-reinforcing the awareness raising both among high education institutions, companies, associations, policy makers and civil society. Ultimately, the purpose of the project is to establish Open Innovation as a self-standing discipline per se. In practical terms, it started with a survey on Open Innovation practices implementation across the main industries of every European country involved. It further explored what skills are specific to Open Innovation implementation, covering explorative, exploitative, transformational categories of skills to name just a few. In parallel, case studies encompassing strategic concerns, i.e. why do firms engage into Open Innovation strategies; organizational questions, i.e. what modes and practices of Open Innovation are selected, how are those implement, and what are the obstacles and catalysts for doing so; and performance-related issues, such as what is the impact of Open Innovation practices on firm's performance. Concomitantly, a review of existing curricula, and to what extent they include Open Innovation distinctively, has been performed. Another team of Open Innovation experts built the structure of the curricula, defined indicators and progress markers as well as the learning outcomes. Next steps include pilot testing of the developed modules, as well as further development, involving multidisciplinary teams, to enrich this first basis. Gathering more than 50 experts across Europe and through a coordinated effort, the underlying purpose is to elevate Open Innovation to the status of a field of teaching and to establish it as a discipline per se.

3. Establishing OI as a field of education

Such initiative can be analyzed through the lens of Aldrich's view on the emergence of an academic field. According to Aldrich (2012), six forces create the institutional infrastructure to establish a field: social networking, publication opportunities, training and mentoring, funding sources, recognitions and rewards, globalizing forces. We will review the OI-NET initiative from the perspective of these forces. Social networking is achieved through the gathering of a wide community of academics and practitioners, from one of the leading worldwide economy, the European Union, thus building a community in itself. The interaction of this community with the wider innovation management community and the natural embeddedness, both at individual and at collective level with innovation management professional associations, leading groups and conferences, demonstrate the synergies between Open Innovation and Innovation Management. Yet, dedicated conferences, such as the World Open Innovation Conference, the Open Innovation Forum, the Open Innovation 2.0 Conference, as well as dedicated tracks during leading innovation events, provide evidence of the need to hold self-alone events revolving around Open Innovation.

Second, the number of Special Issues in leading academic journals such as R&D Management, Technovation and Research Policy, dedicated to Open Innovation, has grown drastically over the last decade. This Journal is also supporting the emergence of Open Innovation as an academic field, through this first Issue entirely dedicated to a single theme, yet addressed through multiple facets and lenses in line with our multidisciplinary philosophy. The number of books on Open Innovation is also booming, irrespectively of whether these are academically grounded or addressing a managerial audience. Training programmes are the core focus of the OI-NET project, and it complements and supplements other initiatives, such as professional workshops and PhD seminars (e.g. ESADE's PhD seminars by Henry Chesbrough). Funding of Open Innovation research certainly deserves further attention, as it currently seems to be included in wider funding schemes. Similarly, regular data collection on Open Innovation practices, through surveys similar to the Global Entrepreneurship Monitor originally funded by the Kauffman Foundation (Aldrich, 2012). Currently, large-scale innovation surveys fail to capture the multifaceted nature of Open Innovation. More specifically, the Community Innovation Survey, which is the harmonized instrument to collect information about innovation inputs, practices, and outcomes, across Europe and most OECD countries, includes a few questions, which reflect inbound Open Innovation practices but disregards the outbound side at this stage. Awards for Open Innovation exist (see e.g. The American Leaders), yet in the eyes of these Authors, much remains to be done in order to nurture the recognition of the research and the achievements in the field. Globalizing forces take various forms for Open Innovation research: it has now significantly departed from its original scope (defining, characterizing and depicting the phenomenon), geographical and sectoral areas for empirical investigations. Nowadays, Open Innovation research covers all industries and adopts a worldwide approach, even if there is a predominance of US and European-based research. Yet, there is no doubt that this will be changing shortly.

4. Perspectives

This journey is only at its beginning. Current literature is still extensively debating about the relevance, usefulness and applicability of Open Innovation. Numerous scholars have expressed their concerns and criticisms about Open Innovation, have questioned whether it should be considered as a concept, paradigm or simply a (relatively) new managerial fad. By challenging Open Innovation, these criticisms induce new reflections, thoughts and actions, so as to constructively contribute to this vibrant debate on what Open Innovation entails and to what extent it is valuable to depict economic and managerial phenomena. To raise Open Innovation to the status of a discipline, to convince universities and decision-makers to invest into the development of dedicated curricula and trainings will still require lots of effort and dedication. Our conviction is that Open Innovation needs to be debated in different arenas from a multidisciplinary perspective, and most importantly, with insights from thought leaders, policy makers and the civil society. As we conclude in "Open Innovation: a multifaceted perspective" (Mention & Torkkeli, 2015), Open Innovation requires to astutely combine eight O's, "Openness is central, and embodies the overall philosophy of the innovation process as seen nowadays. Openness entails the ability to listen to different, even divergent, Opinions, so as to be receptive to other mindsets, cultures, environments and to transform these into Opportunities. Individuals, teams, firms, organizations, nations, societies should capture Opportunities in a meaningful, productive, efficient and effective manner so as to create value. Value creation requires the ability to achieve a perfect Orchestration of capabilities, both individual and collective abilities and capabilities. Such Orchestration may benefit from Observation, conducted by third parties,

providing impartial and fair advice, or from Observation of third parties, such as competitors, suppliers, customers and all stakeholders involved in the value constellation. Optimization is the Holy Grail and may, at least partially, rely on the technological progress, which is still booming nowadays. The use of technologies, as well as the reshaping of ecosystems, requires more and more Operability and interoperability between firms and systems. And only Optimism and willingness to engage into an Open Innovation journey can lead to fruitful and mutually rewarding relationships, ensuring that innovation delivers its intrinsic mission of building a better future while achieving societal impact."

5. References

Aldrich, H.E. (2012). The emergence of entrepreneurship as an academic field: A personal essay on institutional entrepreneurship. *Research Policy,* 41, 1240-1248.

European Investment Bank, http://www.eib.org/about/invest-eu/index.htm, accessed on March18th, 2015.

Mention, A.-L. & Torkkeli, M. (2015). Open Innovation: A multifaceted perspective. *World Scientific Publishing. Imperial College Press*. Forthcoming.

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The usual disclaimer applies.

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Letter from Industry

The Evolution of Open Innovation

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Abstract. This paper describes the evolution of open innovation and the emergence of a new paradigm Open Innovation 2.0 (OI2) which can help drive development of shared value solutions which can drive changes far beyond the scope of what any one organization could achieve on its own. OI2 is based on principles of integrated collaboration, co-created shared value, cultivated innovation ecosystems, unleashed exponential technologies, and focus on adoption. The paper reflects on the fact that the basis of competition is moving from competing organizations to competing ecosystems and the importance of shared vision which allows the collective intelligence of actors across the value chain to be leveraged. As the sharing economy emerges where information technology allows better distribution, sharing, use and re-use of products and services, OI2 will become more mainstream helping create better and greener cities, safer transportation and more efficient energy systems. Patterns are generally reusable solutions to commonly reoccurring problems and opportunities and the paper briefly introduces twenty patterns observed in this new non-linear paradigm, adoption of which can help with faster and better innovation progress.

Keywords: Open Innovation 2.0, Patterns, Adoption, Shared Value, Quadruple Helix Innovation.

1. Introduction

The discipline of Innovation is constantly evolving and we are now arguably at a strategic inflection point where a new paradigm of innovation is emerging. In the last century often it was a brilliant scientist at a Bell Lab or IBM lab which drove new inventions and subsequent innovations. Then along came Open Innovation which was neatly conceptualized by Henry Chesbrough (2003) and concerns a systematic process where ideas can pass to and from different organizations and travel on different exploitations vectors for value creation. Open Innovation was based on the idea that not all of the smart people in the world can work for your company or organization and that you also have to look outside the organization for ideas. At this point Open Innovation was still seen a linear process which had an emphasis on licensing of technologies. Procter and Gamble are frequently referenced as a role model for practicing open innovation and their 'Connect and Develop' open innovation strategy has resulted in almost fifty percent of their new products emanating from ideas and innovations which started outside of the company.

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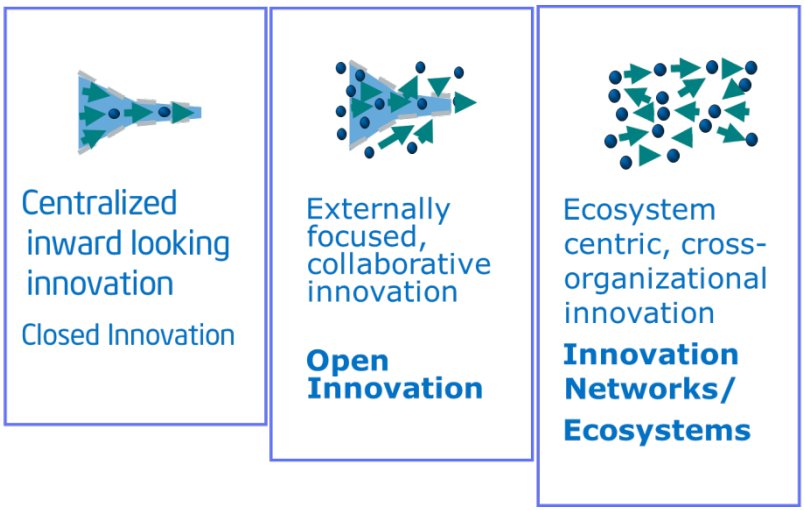

Fig. 1. The evolution of Innovation, Bror Salmelin, EU OISPG

Much of today's progress is driven by collaborative and open innovation. As we move forward new products and services are often new intelligent combinations of existing and emerging technologies and companies cannot afford to do it all on their own. Indeed the unit of competition is changing in that it is often no longer about how good an individual company or organization is but the strength of the ecosystem in which they participate in is often the differentiating factor for great success, mediocrity or even failure. A seminal paper in Harvard Business Review in 2004 called "Strategy as Ecology" (Iansiti and Levien, 2004) introduced the idea of the ecosystem being central to competitive advantage. As the importance of the ecosystem has grown, a new paradigm Open Innovation 2.0 (OI2) is emerging which spans boundaries across organizations, disciplines and stakeholders and is often non-linear and synergistic in nature. In parallel to the organic emergence of OI2, the development of the new paradigm is being stewarded by the EU Open Innovation Strategy and Policy Group (EU OISPG) a cross-functional working group which advises on Open Innovation.

2. Open Innovation 2.0

Open Innovation 2.0 is a new paradigm based on principles of integrated multidisciplinary collaboration, co-created shared value, cultivated innovation ecosystems, unleashed exponential technologies, and focus on innovation adoption. In parallel there is increasing recognition that innovation can be a discipline practiced by many, rather than an art mastered by few. Over the past five years at the EU Open innovation strategy and policy group (OISPG) we have published more than ten studies on the evolution of open innovation and we have observed twenty key patterns of this new phenomenon (See figure 1).

Fig. 1. Open Innovation 2.0 Key Patterns; source M. Curley and B. Salmelin, OISPG

At the core of OI2 is the idea of a compelling shared vision which different stakeholders commit to and collaborate to create a reality and shared value. When a quadruple helix innovation (see below) configuration is deployed the possibility exists to drive real structural change and add value.

Another central tenet of OI2 is idea of the user and indeed citizens participating in the Innovation process. Indeed the innovation process is being turned on its head and the OISPG report on the socio-economic impact of open service innovation (Meijer and Sarsygan, 2012) has conceptualized this as the reverse innovation pyramid. Rather than innovation being something that is done for or to a user, the user co-participates in the innovation process as well as profiting from its outcome. The Lego ideas platform where children help create new designs for Lego products is a good example of this. Experimentation and rapid prototyping are other key characteristics of OI2 where failing and learning fast accelerates the time to market for a new offering.

Another key pattern in OI2 is the use of an Innovation platform which forms the basis for integrated collaboration and co-creation. The Apple App store is arguably a good example of an innovation platform and the reverse innovation pyramid at work where the momentum of many independent application developers helps drive Apple's overall business forward. A key advantage of an innovation platform is that both experimentation and scale-out costs are often close to zero so that the return of investment on successful innovations can be very high.

Cultivating and orchestrating innovation ecosystems are important parts of OI2. It is increasingly clear that innovation ecosystems can be created and transformed by creating a shared vision and reinforcing the vision with active social network management and orchestration. Active orchestration of ecosystems result in efficient and effective platforms for emergence and then delivery of new innovations.

3. Shared Vision, Value and Values

OI2 is not just about the 'how' of Innovation but the 'what'. Innovation capacity is most powerful when it is mobilized in the context of a compelling shared vision. In a successful multi-stakeholder innovation initiative a shared vision which will yield shared value (Porter and Kramer, 2011) is crucial to success. In parallel where participants or ecosystem players share similar values then the probability of success is heightened further.

One candidate over-arching vision for OI2 is 'Sustainable Intelligent Living' (SIL) where innovation efforts are focused on delivering intelligent innovations. Using the ever increasing power of information technology a SIL vision results in new products and services that are people centric and are better than previous offerings, easier to use and very importantly are more resource efficient than previous generations of products. Systematic development and adoption of SIL innovations in different domains can lead to real sustainable living. We have all seen how IT has transformed the music and book industry led by companies such as Apple and Amazon for example. Imagine the possibilities if we could deliver similar transformations in our cities, healthcare, transportation and energy systems. While these transformations are much more complex the OI2 paradigm and methodology are targeted exactly at enabling these kinds of transformations.

The invention, development and of the Universal Serial Bus (USB) technology is a good example of the use of some of the core OI2 patterns. Prior to the creation of USB the connection of different peripherals to computers was difficult, customized and often created driver conflict. While the USB technology was invented by Ajay Bhatt and others at Intel, Intel created a shared vision and initial USB ecosystem with other companies such as Microsoft, Digital, Compaq and IBM to drive a standard way to connect peripherals. In parallel this created a new innovation platform which spurned multiple new products and innovations. USB enabled everything from smartphones, scientific instruments, and webcams to connect seamlessly to computers while also making software and hardware development easier for developers which enabled a whole new wave of innovation. The invention and adoption of USB created shared value and both significant economic and societal benefits with the shipment of more than 10 billion USB equipped devices a very tangible measure of its success.

4. Quadruple Helix Innovation

A core pattern of the OI2 paradigm is the use of the quadruple helix model where government, industry, academia and civil participants work together to co-create the future and drive structural changes far beyond the scope of what any one organization or person could do alone. When all participants commit to a significant change such as transforming a city, or an energy grid, by collaborating together everyone can move faster, share risk and pool resources.

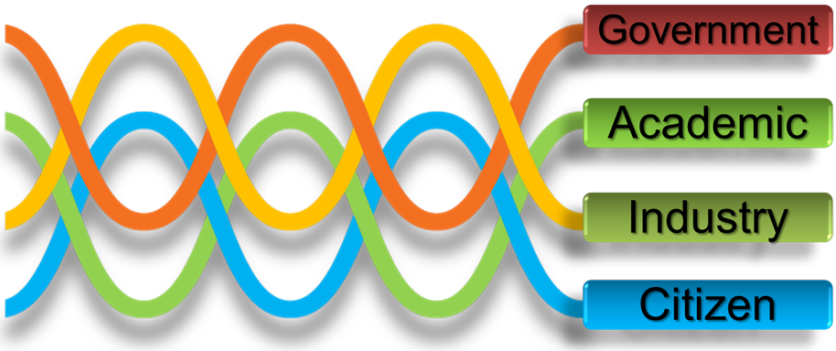

Fig. 2. Quadruple Helix Innovation

Together government, industry, academia and civil participants work together to co-create the future and drive structural changes far beyond the scope of what any one organization or person could do alone. For example in Ireland, Intel Labs Europe are working together with a leading electrical heating company Glen Dimplex, the National Grid, Utilities and home owners to co-innovate a new Electrical energy operating model which will optimally take advantage of renewable energies, new technologies and maximize efficiencies while lowering costs for all involved.

Europe's FP7 and now Horizon 2020 are arguably the world's largest open innovation and research funds and Horizon 2020 is increasingly adopting an OI2 posture. In Horizon 2020 we are increasingly seeing Quadruple Helix Innovation configurations arising where the use of users and citizens as co-innovators and participants in Living Labs is actively promoted and incentivized. For example Intel participates in OrganiCity which is a new Horizon 2020 project with € 7.2m in funding that puts people at the centre of the development of future cities with 3 leading smart cities London, Santander, and Aarhus as living labs. The project uses a number of key OI2 patterns including co-creation and innovation platforms, with a thriving ecosystem around it to support scalable Quadruple Helix innovation. As part of the project, €1.8m, one quarter of the entire budget, is reserved directly for collaborative citizen-driven city experiments.

5. Innovation Culture

Not everything in a company needs to be done in an open innovation fashion. A company's secret sauce may well continue to be developed internally but development of different applications of the use of the product or service may be done in an open innovation mode. It is important to consider the importance of culture within a company, particularly to consider a company's appetite for innovation. Where the culture is supportive of innovation there is more likely to be success with open innovation and also increased likelihood of a breakthrough innovation.

A key aspect to helping a company or indeed a society adopt open innovation 2.0 is culture. Peter Drucker often said that 'Culture eats strategy for breakfast every time' so it is important to make sure the culture is open to innovation. In the adoption of any innovation, explaining the benefit of adopting the innovation is very helpful and this also applies to the adoption of open innovation. When people see the benefits of co-creation they generally are stimulated to adopt it. However it would be a mistake to see open innovation as some kind of panacea and when adopting open innovation

one needs to carefully consider the intellectual property implications of open innovation.

6. Intel Labs Europe as an Exemplar of OI2 in action

Intel Labs Europe (ILE) is both a practitioner of and a thought leader in Open Innovation 2.0. Across Europe Intel has built a network of European labs and development centres with several thousand European R&D employees. But the real power of what we do is achieved by an ecosystem of hundreds of research and innovation partners who are aligned with us around shared visions. By working together we can amplify and accelerate the collected efforts of all concerned. A great example of the fast progress is our collaboration and living labs in the cities of Dublin and London where we partner with the cities, universities, state research organizations, other companies and citizens to envision and quickly prototype solutions which have the potential to transform quality of life and the environment while helping the cities run more efficiently and effectively. An example of this is the deployment of our air quality monitoring systems in the borough of Enfield and linking these to traffic management systems. Or our work in Brixton, where school children have helped design an app to encourage parents and students to walk to school, helping children stay healthier while ameliorating air pollution.

ILE has participated strongly in the EU FP7 program and are continuing to invest and participate in the follow on program Horizon 2020. The open labs in Ireland, Munich and Istanbul serve as portals to the broader network of European R&D labs. Additionally we have created co-labs with companies such as BT and SAP where using a shared agenda we were able to move much quicker together.

Together with ILE, Dublin City itself is an active driver and user of the OI2 methodology. Recently Intel and Dublin City Council announced a collaboration to create an infrastructure which will sense distributed city parameters such as air quality, local weather conditions and enable new innovations from other stakeholders. In London the task of creating a smart London vision was crowd sourced to ordinary Londoners and dozens of suggested visions were suggested by citizens which were synthesized to create a compelling smart vision for London. At the core of the Smart London plan is the idea of putting people and businesses at the heart of the plan so that Londoners can help propel the innovation that will make London an even greater city and change people's lives.

7. The Innovation Value Institute as an OI2 exemplar

In 2006 Intel and the National University of Ireland, Maynooth joined by Boston Consulting Group established the Innovation Value Institute (IVI). The shared vision of the IVI is to drive a structural change in the way organizations get value from Information Technology Innovation. Many organizations struggle to realize the full potential of information technology and IVI was formed to help codify and co-create the best IT management and IT innovation practices. The IVI has created a reference model and a body of knowledge called the IT Capability Maturity Framework (IT-CMF) (Curley and Kenneally, 2012) which has been adopted and used by hundreds of organizations worldwide. About one hundred organizations, big and small are members of IVI and hundreds of their employees have contributed to the research and co- development of the IT-CMF. Organizations use the IT-CMF to assess their overall IT capability or a specific capability such as Innovation Management or IT Governance and then can draw best practice recommendations to improve their

capability and the value they create. IVI uses the OI2 approach with six different types of organizations participating in the research ecosystem with many competitors collaborating together such as Boston Consulting Group, EY and Bearing Point. With over fourteen hundred research wiki contributors, over two hundred thousand man hours contributed by members of the ecosystem, more than 500 formal assessments of organizations completed and thousands of professional learners the OI2 approach has proved to be a very effective one for IVI.

8. OI2 and Innovation Measurement

Andy Grove once said "if you can't measure it, you can't manage it' and historically it has been difficult to measure Innovation performance at both national and firm levels. OI2 attempts to take a more holistic approach to innovation measurement than relatively crude innovation input measures such as percentage of national gross domestic product spent on research, development and innovation. A significant innovation in Europe has been the creation of the Innovation Union Scorecard (IUS) which evolved from the European Innovation Scorecard (EIS) and leveraged the output of the high level panel on Innovation Measurement (Mas-Colell et al, 2010) sponsored by Commissioner for Research Maire Geogeghan Quinn. The creation of this instrument gives an opportunity to measure the relative strength of the different components which make up each national research and innovation ecosystem and then apply interventions to strengthen each ecosystem. The EIS consists of three broad categories of indicator measurements, enablers, firm activities and most importantly outputs. Enablers track the basic building blocks which enable innovation to take place – finance, human resources, and support and research systems while Firm activities track innovation efforts in European firms such as investments, linkages, entrepreneurship level and intellectual assets. Finally outputs measure the collective impact of the innovation efforts for example increased employment, exports and sales.

At Intel Labs Europe we have created a research yield index (RYI) which helps provide a holistic relative measure of innovation performance which not only values research results such as successful proof of concepts or patent filed but also values strategic impact, revenue enabled, improved reputation or an expanded research ecosystem. The RYI index consists of weighted measures of the different measurement dimensions, whose weightings can be changed based on what type of impact is most important at a particular time in the cycle of the business.

9. Conclusion

Innovation itself is changing faster than a speeding bullet and a new Innovation paradigm is emerging arising from the collision of three mega trends, increasing digitization driven by the increasing power of IT, mass collaboration and sustainability. These three mega trends create the conditions and resources which enable a new kind of Innovation mentality and methodology where deep integrated collaboration and exponential technologies result in co-created innovations which are rapidly adopted and results in new products, solutions and services which deliver both financial and societal wealth.

The emergence of OI2 does not mean that other types of innovation such as incremental innovation, disruptive and indeed regular open innovation will cease, in fact it will create more opportunities to accelerate these kinds of efforts. OI2 will just create a different order of Innovation where new processes and environment can help

better create and manage disruptions which can drive significant structural changes across different types of integrated societal systems. If properly orchestrated these disruptive innovations can deliver very significant outcomes for both the innovation creators and adopters, creating both economic and societal wealth.

The kind of outcomes which are delivered can be characterized by Ramaswami's (2014) 3Ws, "Wealth, Welfare and Wellbeing'. Isn't this the kind of Innovation outcomes we should all aspire to? Ones which will deliver sustainable intelligent living. Imagine the possibilities if governments, universities, companies, students and citizens were to collaborate together in a quadruple helix innovation fashion aligned around a common vision. Shared visions could include creating cities with the best quality of life in the world, countries with the best healthcare, transportation systems which work efficiently always and where nobody gets injured or killed on roads. This is all possible we just need to decide to do it.

10. References

Chesbrough, H. (2003). *Open Innovation: The New Imperative for Creating and Profiting from Technology*. Boston: Harvard Business School Press.

Curley, M. (2012). Sustainable Intelligent Systems. *Intel Technology Journal, 16*(3), 1-209.

Curley, M., & Kenneally, J. (2012). *Executive Review: IT Capability Maturity Framework*. Retrieved from Website:

http://www.erp.org.il/download/Specializations/Green Book Executive Overview.pdf

Curley, M., & Salmelin, B. (2013). *Open Innovation 2.0: A new paradigm*. Intel and European Commission Joint Paper. Retrieved from the EU Commission Website: http://ec.europa.eu/newsroom/dae/document.cfm?doc_id=2182

Iansiti, M., & Levien, R. (2004). Strategy as Ecology. *Harvard Business Review*, *82*(3), 68-81.

Mas-Colell, A., Curley, M., Foray, D., Hall, B., Hollanders, H., Huč, B., Kagermann, H., Malerba, F., Ormala, E., Rendez, H., Salter, A., Serafin, M., & Vasconcelos, D. (2010). *Elements for the setting-up of headline indicators for innovation in support of the Europe 2020 strategy*. Final Report of the High Level Panel on the Measurement of Innovation established by Ms Máire Geoghegan-Quinn, European Commissioner for Research and Innovation. Retrieved from the EU Commission Website: http://ec.europa.eu/research/era/docs/en/hlp-report-en.pdf

Sargsyan, G., Meijer, G., Janssen, W., van Buuren, R., Husmann, E., Ali-Vehmas, T., Niitamo, V-P., McGuirk, St., & Donellan, B. (2011). S*ocio-economic impact of open service innovation*. Final report for DG INFSO Study SMART2009-0077. Retrieved from the EU Commission Website: http://files.openinnovation-platform.eu/policydocs/osi_study_final_report.pdf

Porter, M. E., & Kramer, M. R. (2011). Creating shared value. *Harvard Business Review*, *89*(1/2), 62-77.

Ramaswamy, V., & Ozcan, K. (2014). *The Co-Creation Paradigm*. Palo Alto, CA: Stanford University Press.

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Letter from Academia

Lean start-up companies by means of crowdsourcing

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Abstract. Lean start-up approach provides both small and larger companies a novel, important and useful way to organize their business development, while reducing related high risks. Traditional start-ups face a multitude of significant challenges and risks. A study by Ghosh showed that as many as 75% of all start-ups fail. Earlier research has preliminarily demonstrated that crowdsourcing has the potential to reduce the risks of failure of start-ups, as well as overcome some of the inherent challenges lean start-ups face. We argue that crowdsourcing can significantly improve the leanness and agility of start-ups' business functions.

Keywords. Lean start-up, crowdsourcing, innovation, open innovation

1. Introduction

Crowdsourcing (Howe, 2006; Howe, 2008) has been one of the driving forces of change in many fields of life, from the approaches to (self-)organise aid of volunteers during natural catastrophes to crowdsourcing the whole software design & development and marketing of a mobile phone. According to Howe (2008), "crowdsourcing isn't a single strategy. It's an umbrella term for a highly varied group of approaches that share one obvious attribute in common: they all depend on some contribution from the crowd". This contribution can consist of one or several of the following: ideas, concepts, information, knowledge, working time, financing, or other resources (Helander, Jussila, & Kärkkäinen, 2013).

One widely accepted useful definition that describes the concept of crowdsourcing is by Jeff Howe (2008). This definition describes crowdsourcing as an "act of taking a job traditionally performed by a designated agent (usually an employee) and outsourcing it to an undefined, generally large group of people in the form of an open call.".

The added value that can be derived from various crowd-based activities and the crowd contributions can be of quite various types, from cost- related issues such as cost-and time-savings to innovation related value, such as new information and knowledge, which the company probably would not have been able to come up with by the use of internal workforce only.

Some studies have referred to crowdfunding as a possibility for start-ups (e.g. Blank, 2013; Cornell, 2014), but they have not studied the possibilities of crowdsourcing in more depth.

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2. Lean start-ups and crowdsourcing

Traditional approaches to build new enterprises bear large risks and often are a "hit-and-miss" task: writing business plans, pitching them to investors, building teams and expertise, developing products, and selling the products as well and as hard as the enterprises can. Some studies claim that as many as 75% of all start-ups fail (Gage, 2012), due to involved risks.

Recently, novel approaches have risen, which employ a very different approach which could be called as "lean start-up" approach. Some key features of lean start-ups include quick experiments over elaborate (and time-consuming) planning, fast and in-depth customer feedback over intuition, and iterative design over traditional extensive up-front development (Blank, 2013) Some of their major objectives include fast learning, elimination of waste, minimizing risks by taking no unnecessary leaps of faith, as well as efficiency and agility (e.g. Ries, 2011; Blank, 2013). This methodology and its major concepts have changed and even revolutionized the way many successful start-ups operate.

On the one hand, start-up companies which are normally relatively small in size, are in a position that they are able to extensively and flexibly make use of crowds and crowdsourcing. Start-ups are often flexible and eager in adopting new ways of working and new knowledge for instance due to the leanness of their organization structure, as well as the yet non-standardised processes and ways of working. On the other hand, they face a multitude of challenges which can be solved efficiently by crowdsourcing. For instance the small size of start-ups, as well as their position as a novel company with commonly limited networks, markets and funding, lead to serious limitations in available resources to carry out the various tasks related to their business. Due to their limited resources, they may also be able to react fast to new outside stimuli that may enable them to focus better on the activities they centrally should carry out to facilitate their business, and may benefit significantly from such lean and agile approaches (see e.g. Blank, 2013). Start-ups may benefit significantly from novel approaches such as crowdsourcing that help them strategically to concentrate on the development of their own core competences while outsourcing even almost everything else.

There are various ways the leanness in start-ups can be achieved, and how the risks involved in start-ups can be even significantly reduced. A relatively recently popularized approach which has a large potential for leaning up start-up companies' processes and minimizing their risks is crowdsourcing. To our knowledge, no earlier studies have explored in more depth the possibilities of crowdsourcing, as a whole, to lean start-ups. Some studies have referred to crowdfunding as a possibility for start-ups (e.g. Blank, 2013; Cornell, 2014), but they have not studied the possibilities of crowdsourcing in more depth.

3. Mechanisms behind crowdsourcing added value

It has been found that in many cases, non-expert crowds and crowdsourcing can provide solutions that are as good as the solutions of internal company experts, or in some cases, even better than what would be achieved by company internal personnel and experts (e.g. Brabham, 2008). Here, we try to briefly explain why and in which situations the results of crowdsourcing can be this good, and why start-ups might thus significantly benefit from crowdsourcing efforts.

There are different ways of approaching why and how crowdsourcing can bring added value to companies and their basic processes. First of all, crowds can provide various

types of resources (e.g. information, work, funding) for carrying out a tasks that replace or add to the internal resources normally used to carry out a task. Second, the resources can complement the internal resources by for instance providing information or knowledge (e.g. about customer needs) that would be difficult or even impossible to access or obtain without crowds. Third, crowds can be a source for serendipity, i.e. they can increase the possibility of unplanned or accidental solutions and discoveries (such as penicillin or Viagra). Serendipity has been considered in the literature to form an integral part of the creative process in the arts and humanities, social sciences and the sciences (Foster & Ford, 2003).

In addition to merely providing resources that are similar to the ones that would be used in carrying out the tasks internally, crowdsourcing utilizes significantly the concepts of Wisdom of Crowds (Surowiecki, 2004) and Collective Intelligence (Malone, 2008; Bonabeau, 2009). These can be understood as approaches making use of crowds in such a way that a crowd of ordinary people can in certain conditions make better judgments and decisions than best expert can do (concept of Wisdom of Crowds by Surowiecki 2004), or approaches that people and computers jointly can make better decisions than people, groups or computers have individually been able to make (concept of Collective Intelligence by Malone 2008). Both rely on the concept of diversity (meaning diversity of information, knowledge, cognitive skills, cultural background etc.). Crowdsourcing can also diminish the negative impacts of groupthink (Esser, 1998).

4. Conclusions

Crowdsourcing can help to outsource even a major part of start-ups' business functions that a start-up normally performs internally, at the same time helping to create e.g. market experiments in the manner belonging to lean start-up methodology, and simultaneously, help to significantly reduce several business risks, which traditional types of outsourcing cannot similarly enable. This new mode of lean start-ups enabled by crowdsourcing requires, essentially, actually only an initial business idea from the entrepreneur(s), while nearly all the other traditional business functions, including funding and product development, can be outsourced by means of crowdsourcing.

This means a radically new way to reduce the extensive risks of start-ups, and make their operations as agile and lean as possible. Crowdsourcing can radically facilitate the way for start-ups to make use of the lean start-up methodology, and to become more lean. For instance, crowdfunding can enable start-up to make the decision to start developing a new product or a service not before a viable amount of customers have already pre-purchased the product. The start-up, however, does not even have to develop the product in-house, but by means of crowdsourcing platforms, it can make use of the best experts around the world to develop the product. Furthermore, crowdsourcing makes it possible to execute the experiments and hypotheses testing related to lean start-up methodology with greater speed and agility that would be possible using only internal resources or traditional outsourcing.

5. References

Blank, S. (2013). Why the lean start-up changes everything. *Harvard Business Review*, *91*(5), 63–72.

Bonabeau, E. (2009). Decisions 2.0: The power of collective intelligence. *MIT Sloan Management Review*, *50*(2), 45–52.

Brabham, D. C. (2008). Crowdsourcing as a model for problem solving an introduction and cases. *Convergence: The International Journal of Research into New Media Technologies*, *14*(1), 75–90.

Cornell, C.-J. (2014). CROWDFUNDING: MORE THAN MONEY JUMPSTARTING UNIVERSITY ENTREPRENEURSHIP. Retrieved from http://venturewell.org/open2014/wp-content/uploads/2013/10/CORNELL-2.pdf

Esser, J. K. (1998). Alive and well after 25 years: A review of groupthink research. *Organizational Behavior and Human Decision Processes*, *73*(2), 116–141.

Foster, A., & Ford, N. (2003). Serendipity and information seeking: an empirical study. *Journal of Documentation*, *59*(3), 321–340.

Gage, D. (2012). The venture capital secret: 3 out of 4 start-ups fail. *Wall Street Journal*, *20*.

Helander, N., Jussila, J., & Kärkkäinen, H. (2013). Value Creation in Business-to-Business Crowdsourcing. *International Journal of Knowledge Society Research (IJKSR)*, *4*(4), 52–63.

Howe, J. (2006). The rise of crowdsourcing. *Wired Magazine*, *14*(6), 1–4.

Howe, J. (2008). *Crowdsourcing: How the power of the crowd is driving the future of business*. New York: Crown Publishing Group.

Malone, T. W. (2008). What is collective intelligence and what will we do about it. *Collective Intelligence: Creating a Prosperous World at Peace, Earth Intelligence Network, Oakton, Virginia*, 1–4.

Ries, E. (2011). *The lean startup: How today's entrepreneurs use continuous innovation to create radically successful businesses*. Random House LLC.

Surowiecki, J. (2004). The wisdom of crowds: Why the many are smarter than the few and how collective wisdom shapes business. *Economies, Societies and Nations*.

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Using Inside-Out Open Innovation to Recover Abandoned Pharmaceutical Compounds

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Abstract. Pharmaceutical drug development costs have risen rapidly over the past twenty years. However, the number of new molecular entities being approved has not increased. As pharmaceutical companies scale back their R&D in light of this deteriorating productivity, significant unmet medical needs remain unaddressed. Much of these rising costs can be traced to work on compounds that are abandoned before getting to market. There is a growing need to recover these abandoned compounds. The inside-out branch of open innovation provides a way to increase the performance of pharmaceutical firms, both in addressing unmet societal needs, and potentially in identifying new revenue sources and business models for a more distributed model of commercializing new drugs. This aspect of open innovation is not much discussed in the literature to date. The medical research community, in conjunction with a number of industry and nonprofit organizations, has started several projects to recover more abandoned compounds. These new initiatives are still at an early stage, and have not received much critical evaluation to date. Examining four of these initiatives, we find that they do extend the cognitive frames in the research phase, while doing less to extend those frames in the commercialization phase.

Keywords. R&D, Project Evaluation, False Negatives, Open Innovation, Pharmaceuticals.

1. Introduction

Pharmaceutical industry observers and participants have long noted the incredible challenges of drug development. The development costs per approved drug, including the cost of failures, have increased from approximately $140M in the 1970s to $320M in the 1980s, $800M in the 1990s, and $1.2B in the 2000s (PhRMA, 2012). The latest analysis from the Tufts Center for the Study of Drug Development pegs the figure at $1.3B (Tufts CSDD, 2011). Meanwhile, average drug development timelines of new compounds have remained steady at around 14 years from initial screening to approval (Abrantes-Metz et al., 2006; Bogdan & Villiger, 2010; Tufts CSDD, 2011). Despite the great promises of biotechnology, the industry as a whole has failed to create significant value in excess of its costs over its lifetime (Pisano, 2006).

Existing analyses of the crisis in pharmaceutical drug development readily note the skyrocketing costs, the declining productivity of R&D, and the cliff of drugs coming off patent (Pammolli et al., 2011). Less often noted, however, is the unstated assumption of the prevalent business model for pharmaceutical drug development - that of the blockbuster drug. The blockbuster model discards innovations that have expected revenues below large thresholds, typically $1 billion annually. A more distributed business model that divides the innovation work among multiple parties

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might enable more compounds with smaller market sizes to reach the market.

The emerging shift from a blockbuster to a distributed business model is being driven by two key factors. First, scientific and technological advances have enabled a deeper understanding of the biological underpinnings of disease. Genetic sequencing technologies are becoming ever cheaper, rapidly approaching a cost point that would make sequencing available for mainstream use. At the same time, drug targeting approaches are becoming ever more sophisticated. Technologies such as antibody drug conjugates and nanospheres allow scientists to address specific disease targets in a manner that was not previously possible.

The second key factor has been the rise of value-based reimbursement practices around the world. The combination of increasing healthcare costs and weakened state economies has forced governments and insurance companies to re-evaluate their approaches to paying for drugs. We've seen a shift from volume-based to value-based reimbursement. For example, the UK government struck a deal with Johnson & Johnson (J&J) to cover its drug Velcade, but only for those patients in which clinical benefit is seen. For the patients who do not respond to therapy, J&J will pay for the cost of their product. (Europharma Today, 2009). A similar risk-sharing reimbursement contract was established in Germany for the reimbursement of Roche's cancer drug Avastin.

Combined, these scientific and economic factors along with the research productivity challenges are fundamentally transforming the pharmaceutical industry. As the nature of their products moves away from one-size-fits-all towards personalized medicine, pharmaceutical companies will also be forced to change their business model. This will require more use of open innovation.

Open innovation is defined as the "use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation, respectively" (Chesbrough et al., 2006). The former part of the open innovation model, "to accelerate internal innovation," is referred to as the "outside-in" approach. The latter part of the open innovation model, to "expand the markets for external use of innovation," is referred to as the "inside-out" approach.

Most academic discussion of open innovation has focused on the outside-in half of the model, and indeed, many papers treat that half as the totality of the model (e.g., Boudreau & Lakhani, 2009). Overlooking the inside-out half of the open innovation model is more than an important oversight. It inhibits creative approaches to addressing business model restrictions that hold back innovation. We focus in this paper on the cognitive barriers to increasing inside-out innovation in drug development. We then consider how "inside-out" open innovation approaches can be overcome these improve the societal and financial performance of pharmaceutical firms.

2. The case for redeveloping abandoned compounds

It is well known that it takes $1 billion or more in investment to get an approved compound into the market (DiMasi et al., 2010). Much less well known, however, is that the actual cost of development per approved product, without adding in the cost of failures, is closer to $100 million (Abrantes-Metz et al., 2006; DiMasi et al., 2010). In other words, roughly $900 million of the investment companies make per successful drug development program has gone to failed compounds. Yet this waste in the system is generally accepted as a cost of doing business in the pharmaceutical industry.

Declining clinical approval success rates means that more and more compounds are

being abandoned in intermediate stages of development. Such compounds have taken years of research and investment to reach the clinic. In many cases, they have also already been proven to be safe in humans. One review of the reasons for abandonment of compounds after this clinical stage found that only 20% were due to safety while 34% were due to economics, and another 38% were due to weak efficacy for the intended disease (Bogdan et al., 2010). While safety issues may rightly foreclose further exploration, the other 80% of abandonments have as much or more to do with the lack of an identified market or an attractive business model.

This large percentage of non-safety related abandonments creates opportunities for recovery of some of these compounds for alternative uses and/or smaller markets. If more people had access to the relevant pre-clinical and clinical data, more thorough consideration of alternative diseases, markets or business models could ensue. For example, a small patient population for a particular drug may not deter patient groups from advancing a compound in concert with a foundation's funding support. Weak efficacy signals, in turn, might be greatly enhanced with more advanced diagnostics, which could sort potential patients via one or more markers, such that a subset of patients might receive significant therapeutic benefit. Unmet medical needs thus could be addressed in more economical ways, by utilizing extant knowledge more thoroughly.

False Negative Evaluation Errors in Drug Development

Drug development is highly complex, and organizational decisions about whether to continue or abandon a particular program are subject to evaluation errors of the Type 1 (false positive) or Type 2 (false negative) variety. On the one hand, false positive (Type 1) evaluation errors are largely eliminated due to rigorous review by regulatory bodies such as the FDA. Drug candidates that companies think will succeed based on early animal or human studies may only yield insignificant or negative clinical trial results in larger studies, and then be abandoned.

On the other hand, false negative (Type 2) errors often are not mitigated through any formal regulatory or internal R&D process (Chesbrough, 2003, chapter 4; Chesbrough et al, 2006, chapter 1). These are compounds that could have been valuable, had the organization found an appropriate market and business model to commercialize them. GlaxoSmithKline, for example, recently decided to abandon its entire neuroscience program that had been built over decades, with hundreds of compounds effectively cut off from any further consideration for subsequent development (Ruddick, 2010). This may be an appropriate decision for the company, but the abandonment of all these compounds, and the associated research data collected on them, is a loss for society, especially for patients suffering from unmet neurologic disorders.

This false-negative aspect of innovation is a latent source of performance improvement for firms. Allowing unused projects to go outside the firm lets others examine these projects from the perspective of new and different business models. While many projects will doubtless languish outside the firm, a few may reveal unforeseen social and financial benefits.

Recovering False Negative Drug Compounds

There are examples of drugs that were once abandoned, and then successfully recovered. These examples provide evidence that Type II errors in drug development can and do occur. The prototypical example is thalidomide, which was originally developed to treat morning sickness during pregnancy. After being linked to tragic birth defects, the drug was pulled from markets around the world in the 1970s. It was

precisely this calamity that led to substantially enhanced FDA oversight of drug development. After being reclaimed by a small biotech firm, Celgene, it was eventually approved for use under proper guidelines in cancer patients suffering from myeloma, a form of bone cancer (Bartlett, et al, 2004). So this once discredited drug is now a common therapy, albeit in a very different use. Another well-known example of repurposing is, of course, Viagra. In human trials to reduce hypertension, the drug was failing in clinical trials for efficacy, relative to the placebo. However, the drug evoked unusual side effects, and the drug's eventual use for erectile dysfunction was thus initially discovered.

Other, more general evidence for the presence of false negative evaluation errors comes from the very large number of drugs prescribed by clinicians to their patients for off-label use. This means that the drug was not approved by regulators for the treatment prescribed, but the physician nonetheless believes that the drug may provide therapeutic benefit to the patient (often based on limited clinical data and the physician's personal experience, without the benefit of a double-blind, controlled study). These off label uses can be quite beneficial to patients who are nonresponsive to approved medicines. Off-label prescriptions of drugs are quite common, and in some disease categories like central nervous system (CNS) disorders, the bulk of sales of certain drugs come from off-label usage. Off-label usage of a drug effectively is a repurposing of that compound, albeit in a limited and informal way for a small number of physicians and their patients.

The Improved Economics of Recovering Abandoned Compounds

None of the foregoing analysis is meant to imply that all abandoned drugs should be redeveloped; some may not be of sufficient medical or economic value to warrant continuation under any business model. Rather, our hypothesis is that at least some compounds that do not make economic sense under a blockbuster model may become medically useful and economically viable if pursued under a more distributed business model. Enabling this shift will require new, more inside-out open innovation practices with regard to unutilized compounds in R&D.

One of the strongest arguments in favor of redeveloping abandoned compounds is not just that untapped potential opportunities exist but that there is potentially an abbreviated development path to capturing those opportunities. Compounds that were abandoned after positive clinical trial results were achieved in Phase I have proven drug formulations and have been shown to be safe for human use within a certain dosage range. Past this stage, research can focus entirely on finding unmet medical needs that the compound could address. Building on the years of prior research experience with the compounds, further development could start at a much later point than for a new compound, with a potentially shorter path to market.

The other very strong argument for redeveloping abandoned compounds is their potential ability to address otherwise unmet patient needs. For example, there has been an alarming exodus of pharmaceutical companies from studying neurologic diseases in recent years due to poor return on investment in the therapeutic area (e.g., GlaxoSmithKline discussed above). Yet patients suffering from central nervous system disorders, such as epilepsy, suffer from a significant amount of unmet medical need. It is estimated that fully one-third of the epilepsy patient population is refractory (meaning that these patients do not obtain any meaningful therapeutic benefit) to all existing therapies on the market. Another one-third of the population obtains therapeutic benefit at the expense of incurring moderate to severe side-effects (including cognitive impairment) from the medicines taken (Devinsky, 2007). While there may not be another blockbuster drug available in the pipeline for treating epilepsy, there may be a range of drugs that provide significant benefit to different

sub-sets of these patients. If the development costs decline sufficiently and if the probability of success increases as well, some of these new drugs may well come from the pool of previously abandoned compounds.

However, if this is really the case, then why hasn't a market mechanism developed to take advantage of this scenario? Why are the recoveries of compounds like Viagra and Thalidomide the exception, and not the rule? We explore these questions in the next section.

3. Cognitive barriers to inside-out open innovation in drug development

To better understand the barriers to greater inside-out open innovation, we conducted interviews with pharmaceutical executives and managers. Our interview respondents were primarily in the R&D or business development organization in the company (different companies organized the management of unused compounds differently). Table 1 lists the titles, headquarters location and type of company we interviewed. Each respondent was promised anonymity, along with a copy of the paper upon its completion. We deliberately sampled companies of different sizes and locations, to get a range of industry perspectives.

Table 1. List of pharmaceutical industry interviews conducted.

Title	Company type	Company HQ location	Interview date
Sr Vice President, R&D	Pharma	Europe	04/28/2011
Sr Director, Business Development	Biotech	US West Coast	05/06/2011
Sr Manager, Business Development	Biotech	US West Coast	06/22/2011
Director, Business Development	Pharma	US Midwest	08/25/2011
Associate Director, Alliance Management	Biotech	US West Coast	09/02/2011
Associate Director, Strategy	Pharma	Europe	09/30/2011
Director, Business Development	Biotech	US West Coast	10/7/2011
Vice President, Medical	Pharma	US East Coast	10/19/2011
Head of Intellectual Property	Biotech	US West Coast	01/23/2012
Senior Director, Corporate Development	Biotech	US West Coast	01/18/2012
CEO	Biotech	US West Coast	01/26/2012
Director, Marketing	Pharma	US East Coast	03/07/2012
Vice President, Corporate Development	Biotech	US West Coast	04/17/2012
Corporate IP Counsel	Biotech	US West Coast	12/18/2012
Partner, Technology & IP Litigation	Law Firm	US West Coast	01/02/2013
Vice President, Business Development	Pharma	US East Coast	7/22/2013
Attorney	Academic Research Institute	US East Coast	7/26/2013

Each interview was conducted with a semi-structured instrument of questions regarding the respondent's experience with the management of unused compounds. Where geographically possible, these interviews were conducted in face-to-face discussions. Where geographic distance was large, we relied on phone interviews. Each interview ranged from 30 minutes to over an hour in length.

In multiple interviews, we heard about compounds abandoned due to insufficient market size or lack of definitive clinical signals. Both reasons explain why a firm would not pursue a compound internally, but do not explain why other parties would not be given the chance to consider licensing that compound for their own pursuit.

We also heard about lack of organizational resources severely limiting any potential outlicensing activity. For example, one leading pharmaceutical manufacturer in Europe has just two executives tasked with licensing out the company's compounds. This same company has 7,700 people in R&D positions. One of the two outlicensing executives reported that one outlicensing transaction had been completed in the past year, while the company was working on thousands of internal R&D compounds. We also heard from both R&D and business development executives that while they don't like to admit it, they were sometimes happy when a program would fail because they already had more work than they could handle.

But these are merely symptoms that beg a deeper analysis. Why do companies lack the motivation or resources to pursue recovery of abandoned compounds? We posit that the underlying reason is that the cognitive frames of pharmaceutical executives reflect interpretations arising from previously successful responses to the environment (Weick, 1995; Prahalad and Bettis, 1986) – in other words, they are dominated by the blockbuster business model. As a result, the organizational structures and managerial incentives of today's pharmaceutical companies have been developed to optimize that blockbuster model, which does not attribute significant value to recovery of abandoned compounds. .

Cognitive limits can be particularly relevant when the underlying business model that commercializes technological developments is itself in transition. Tripsas and Gavetti (2000) document the challenges that Polaroid faced in trying to adapt its "razor and razor blade" business model of instant photography to the challenges posed to that business model by digital technologies. Chesbrough and Rosenbloom (2002) detail the difficulties Xerox had in utilizing the technologies developed at its PARC laboratory in the nascent computer industry, given its copier and printer business model. Furr, Cavarretta and Garg (2012) report similar challenges for various firms in photovoltaic manufacturing.

We argue that a similar fundamental challenge faces the pharmaceutical industry as both scientific and economic pressures are forcing a change in its business model. In order to make a successful transition, managers will need to move beyond their existing cognitive frames. Here is precisely where inside-out open innovation can play a role. Open innovation can engage new and different actors in the innovation process, and explore alternative commercialization approaches beyond the blockbuster business model.

Based on these issues, we now turn to four different initiatives focused on recovery of abandoned compounds in public-private partnerships. We highlight the differences in each approach. None of the initiatives are designed to fully redevelop and commercialize abandoned compounds on their own. Rather, the goal of these initiatives appears to be an effort to enable a compound to advance one step further in

its clinical development. The greater impact, we would argue, is the potential for these initiatives to collectively show the value of unlocking abandoned compounds in a more distributed business model. Therefore, we try to understand how well each initiative might fare in successfully shifting cognitive biases and eventually drive organizational adaptation to a more open, distributed business model in pharmaceutical companies.

4. Evaluation of initiatives to recover abandoned compounds

A number of initiatives have recently emerged with the intention of addressing the problem of recovering abandoned compounds. We chose four initiatives to focus on based on their salience, as well as variation in the types of participants and the models used in recovering abandoned compounds. Specifically, the initiatives vary in the number of companies contributing their abandoned compounds and the number of potential research partner organizations (see Figure 1). Each of the initiatives is detailed in Table 2 and described briefly below.

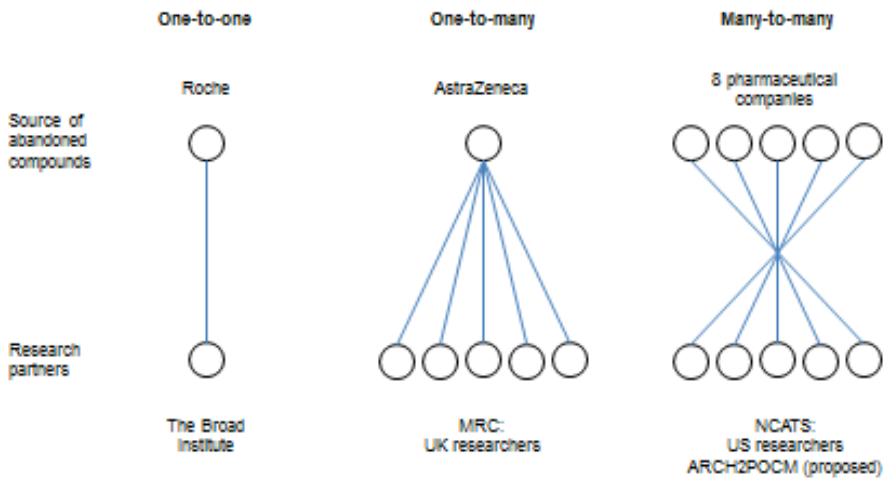

Fig. 1. Alternate structures of initiatives to recover abandoned compounds

Table 2. Description of recent initiatives to recover abandoned compounds.

	AZ-MRC	**NIH NCATS**	**Roche-Broad**	**ARCHZPOCM**
Model	One-to-many	Many-to-many	One-to-one	Open science
Governance	Public-private partnership with MRC as administrator	Public-private partnership with NCATS as administrator	Private partnership	Not-for-profit consortium
Country of origin	UK	US	US	US

Scale	22 compounds	58 compounds (8 companies)	300+ compoun ds	To be determined by participants
Types of compounds	Preclinical and clinical stage	Clinical stage that have completed Ph1 safety testing	Clinical stage that failed Ph2 or halted for strategic reasons	Preclinical and clinical stage
Operating model	Companies provide 1 page summary on each compound and in-kind contributions: drug supply, data, expertise; Researchers provide novel idea, define experiments, collect the data; Final MRC proposals written collaboratively by MRC and AZ	Roche providing compound library; Broad using novel screening technologies to find new applications	Pharma companie s have been reluctant to participat e to date	
IP rules	Contributors maintain original IP; Researchers own new IP; Researchers have right to publish with companies given 30 days to review	Undisclosed	Open Science approach	
Announceme nt date	Dec 2011	May 2012	Nov 2012	Planning stages
Funding	$15 million Funded 15 projects; 7 clinical, 8 preclinical	$20 million Funded 9 projects	Undisclos ed	To be determined by participants

The first initiative is a government supported public-private partnership between the UK's Medical Research Council (MRC) and AstraZeneca. Launched in December 2011, the "Mechanisms of Disease" program will provide up to $15 million of funding to UK academic researchers to study 22 of AstraZeneca's abandoned compounds. Both government and industry participants are hoping that crowdsourcing new ideas from a broad range of academics will lead to recovery of

the abandoned compounds (Mullard, 2012).

The second recently initiated pilot, led by the National Institutes of Health (NIH), has perhaps received the most attention. The "Discovering New Therapeutics for Existing Molecules" program, administered by the National Center for Advancing Translational Sciences (NCATS), was launched in May 2012 (Mullard, 2011). Eight large pharmaceutical companies have combined to make 58 abandoned compounds, which have already undergone safety testing in humans, available to the program. NCATS will then match novel scientific ideas proposed by academic researchers with the existing compounds, providing up to $20 million in funding for approximately nine research grants aiming to show new proof-of-concept data (Mullard, 2012). These academic researchers, in turn, will own the IP to whatever subsequent discoveries they make, while the contributors continue to hold their original IP on the compounds.

A third initiative, announced in late 2012, pairs the Broad Institute and over 300 compounds from the Roche Repurposing Compound Collection (RRCC) in search of new applications. Under this collaboration, the Broad Institute will screen all of the compounds in Roche's collection, leveraging its advanced biological assays and disease expertise. The RRCC includes drug candidates from the past 20 years that did not make it to market, which have been compiled into an annotated set (Roche press release November 28, 2012). The IP arrangements under this agreement have not been made public, but we assume Roche retains all IP rights needed to commercialize any hits.

The Archipelago to Proof of Concept in Medicine (ARCH2POCM), organized by the Structural Genetics Consortium and Sage Bionetworks, is the fourth initiative included in our analysis. Another public-private partnership, ARCH2POCM embraces an open source approach to early-stage R&D. The goal is to create a globally distributed pre-competitive collaboration to share data, reduce duplication of effort, and ultimately find more clinically validated targets (through Phase IIa). While the initiative hopes to advance many novel compounds to proof-of-concept, it will also include existing compounds not currently under active development.

Cognitive Implications of Each Initiative

One of the first observations to make regarding the four different initiatives is that each involves a private company collaborating with a nonprofit or public entity. This immediately broadens the cognitive frame at the research phase. The expectation is that academic medical researchers may have unique insights into possible ways to advance these compounds beyond those available within the large pharmaceutical firms. These researchers are not constrained by the managerial or psychological frames of the pharmaceutical firms. As NCATS director Christopher Austin recently stated, while the compounds being explored may not have made "the best business case…these [new] indications may be fantastic for patients and public health." (Nature News Blog, 18 June 2013)

This diversity of approaches is appropriate at such an early stage of exploration to increase variance in search (March, 1991) for recovering abandoned compounds. They invite more people from outside the originating organization to scrutinize the therapeutic potential of compounds. In addition, they employ different tools and processes beyond those used in the originating company. As one respondent told us, "…lots of companies are going after the [recovery] space, it only takes 2 or 3 successful compounds to make it worthwhile. Right now, I would posit that they probably don't have the right tools yet though, such as novel, high throughput screening profiling technologies."

The question then becomes, who will actually bring those products to market? The

Roche-Broad and MRC collaborations appear to keep all product commercialization rights with the participating pharmaceutical company. So any exploitation of new knowledge resulting from these initiatives will still encounter the extant managerial frame of that pharmaceutical company. The potential pitfall in this scenario is that even if some compounds are shown to be effective in new indications, the pharmaceutical company may still decide that the business case does not warrant additional investment, due to the cognitive limits imposed by its business model. The NIH/NCATS and ARCH2POCM initiatives, by contrast, offer the potential for another organization to exploit new knowledge gained from this research.

This new entrant, perhaps a start-up company or a patient advocacy group, may not be cognitively constrained by the blockbuster business model. That could lead to more novel targeted medicines reaching the market and encourage others, including large pharmaceutical companies, to reconsider the benefits of employing a more distributed business model.

5. Conclusions

In the past twenty years, pharmaceutical drug development has moved from a largely closed model of innovation to a far more open model. However, the implementation of a more open model of drug development within the pharmaceutical business model has been partial, and largely focused upon "outside in" innovation sources. At the same time, the vast majority of potential drug candidates fail during the development process. "Inside out" open innovation mechanisms could spur the recovery, and/or redeployment of these abandoned compounds to address unmet medical needs.

Rather than stockpiling potential products that are no longer being pursued, pharmaceutical companies and society as a whole would benefit from expanding their cognitive frames. The concept of false negative evaluation errors in drug development, the example of recovered compounds such as Thalidomide and Viagra, and the extensive use of off-label drugs to treat patients, all demonstrate the potential of these more creative approaches.

A number of early initiatives have recently emerged to address these issues. Though none in our judgment has fully resolved the cognitive issues we discuss, collectively we hope they will have a positive impact. Company collaborations with public and nonprofit entities to find new uses for their existing IP extend the efforts by pharmaceutical companies to pursue inside-out open innovation. The academic freedom of these research partners can help companies explore beyond not only their current scientific knowledge, but also beyond their extant cognitive biases and dominant business model.

6. References

Abrantes-Metz, R., Adams, C., & Metz, A. (2006). Pharmaceutical development phases: A duration analysis. *Journal of Pharmaceutical Finance, Economics, & Policy 14*, 19–41.

Bartlett, J. B., Dredgel, K. & Dalgleish, A. G. (2004). The evolution of thalidomide and its IMiD derivatives as anticancer agents. *Nature Reviews Cancer 4*, 314-322.

Bogdan, B., & Villiger, R. (2010). *Valuation in Life Sciences: A Practical Guide*. Springer, 3rd Edition. 370 p.

Boudreau, K. J., & Lakhani, K. R. (2009). How to manage outside innovation: Competitive markets or collaborative communities? *MIT Sloan Management Review 50*(4), 69-75.

Chesbrough, H. (2003). *Open Innovation: The New Imperative for Creating and Profiting from Technology*. Boston: Harvard Business School Press.

Chesbrough, H. (2006). *Open Business Models: How to Thrive in the New Innovation Landscape*. Boston: Harvard Business School Press.

Chesbrough, H., Vanhaverbeke, W., & West, J., (Eds.) (2006). *Open Innovation: Researching a New Paradigm*. Oxford: Oxford University Press

Chesbrough, H. & Rosenbloom, R. S. (2002). The role of the business model in capturing value from innovation: evidence from Xerox Corporation's technology spin-off companies. *Industrial and Corporate Change, (11)*3, 529-555

Chesbrough, H., & Chen, E. (2013). Recovering Abandoned Compounds Through Expanded External IP Licensing. *California Management Review,(55)*4, 1-19

Cook-Deegan, R. (2007). The science commons in health research: Structure, function, and value. *Journal of Technology Transfer 32*(3), 133-156.

DeMonaco, H., Ayfer, A., & von Hippel, E. (2006). The major role of clinicians in the discovery of off-label drug therapies. *Pharmacotherapy: The Journal of Human Pharmacology and Drug Therapy 26*(3), 323–332.

Devinsky, O. (2007). *Epilepsy: Patient and Family Guide*, Demos Health, 3rd Edition.

DiMasi, J. A., Hansen, R. W., & Grabowski, H. G. (2003). The price of innovation: New estimates of drug development costs. *Journal of Health Economics 22*, 151-185.

DiMasi, J. A., Feldman, L., Seckler, A., & Wilson, A. (2010). Trends in risks associated with new drug development: Success rates for investigational drugs. *Clinical Pharmacology & Therapeutics 87*, 272-277.

Europharma Today (2009). More Velcade-Style Risk-Sharing in the UK. www.europharmatoday.com/2009/01/more-velcadestyle-risksharing-in-the-uk.html Retrieved August 13, 2013.

Furr, N. R., Cavarretta, F. & Garg, S. (2012), Who Changes Course? The Role of Domain Knowledge and Novel Framing in Making Technology Changes. *Strategic Entrepreneurship Journal, (6)*3, 236–256.

Hunter, J. (2010). Is open innovation the way forward for big pharma? *Nature Reviews Drug Discovery, (9)*2, 87-88.

March, J. G. (1991). Exploration and exploitation in organizational learning. *Organization Science, (2)*1, 71–87.

Mullard, A. (2011). Could pharma open its drug freezers? *Nature Reviews Drug Discovery, (10)*6, 399-400.

Mullard, A. (2012). Drug repurposing programmes get lift off. *Nature Reviews Drug Discovery (11)*1, 1-2.

Nature blog 2013 (Nature News Blog, 18 Jun 2013)

Pammolli, F., Magazzini, L., & Riccaboni, M. (2011). The productivity crisis in pharmaceutical R&D. *Nature Reviews Drug Discovery, (10)*6, 428-438.

Pharmaceutical Research and Manufacturers of America (PhRMA) (2012). Key Industry and PhRMA Facts.

Pisano, G. (2006). Profiting from innovation and the intellectual property revolution. *Research Policy, (35)*8, 1122-1130.

Prahalad, C. K., & Bettis, R. A. (1986). The dominant logic: A new linkage between diversity and performance. *Strategic Management Journal, (7)*6, 485-501.

Ruddick, G. (2010). GSK seeks to abandon 'white pill and Western markets strategy', The Telegraph, February 5, 2010.

Sagebase (2012). Arch2POCM: A fundamental systems change for drug discovery. http://sagebase.org/info/NewsInfoDownloads/SendaiFriend2.pdf (Retrieved July 19, 2012)

Tripsas, M., & Gavetti, G. (2000). Capabilities, cognition, and inertia: Evidence from digital imaging. *Strategic Management Journal, 21*(10-11), 1147-1161.

Tufts Center for the Study of Drug Development Reports (2011).

Weick, K. E. (1995) *Sensemaking in Organizations*, Sage

Winslow, R. (2013). Gene Breakthroughs Spark A Revolution in Cancer Treatment, Wall Street Journal, August 13, US edition: p.1.

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Open innovation: a new classification and its impact on firm performance in innovative SMEs

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Abstract. This paper attempts to deepen understanding of the relationship between open innovation (OI) and firm performance in small and medium-sized enterprises (SMEs). Based on survey data from 306 Korean innovative SMEs, the results of this study show that: (1) broad and intensive engagement in OI and cooperation with external partners are positively associated with firm performance; (2) technology and market-oriented OI modes (Joint R&D, user involvement and open sourcing), involving relatively low level of changes, can positively contribute to performance enhancement; and (3) innovative SMEs benefit from working with non-competing partners, such as customers, consultancy/intermediaries and public research institutes. This work has broadened the evidence available on SMEs' OI adoption and has proposed a new way to study OI adoption and implementation.

Keywords. Open innovation, Innovation collaboration, Small and medium-sized enterprises, and Performance

1. Introduction

Open innovation (OI) is a distributed innovation process based on purposively managed knowledge flows across organisational boundaries (Chesbrough and Bogers, 2014), and it has become a widely known business strategy in many industries (Dahlander and Gann, 2010; Gassmann et al., 2010; Huizingh, 2011; Mortara and Minshall, 2011). The majority of studies have focused on studying OI in multinational corporations (MNCs), but our knowledge of OI in small and medium-sized enterprises (SMEs) is still fragmented (Lee et al., 2010; Schroll and Mild, 2012; Van de Vrande et al., 2009). Although recent studies have investigated SMEs in many contexts, due to the complexity and breadth of the concept of OI, encompassing various innovation activities, there have been substantial challenges in the measurement of OI (Podmetina et al., 2014; Schroll and Mild, 2012). This made it difficult for researchers to cover the full OI spectrum. Until now, research focus has been on OI proxies (rather than OI itself), such as information search breadth and depth (e.g., Laursen and Salter, 2006), technology sourcing and scouting (e.g., Parida et al., 2012) or inter-organisational networks (e.g., Lasagni, 2012; Zeng et al., 2010). These proxies are certainly important indicators of OI activities, but they represent a rather focused (and potentially limited) interpretation of OI adoption, hindering a complete understanding of OI approaches. In this regard, this paper attempted to investigate various OI modes in a single study, which is novel in the context of OI adoption in SMEs.

Theoretically, OI can be a good approach enhancing SMEs' performance. SMEs' organisational characteristics, such as flexibility (Rothwell and Dodgson, 1994) or a simple hierarchy (Teece, 1996), may represent their advantages in the implementation of OI. By opening their boundaries, SMEs can access the necessary complementary assets to deal with their inadequate research and development (R&D) capacity or

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involve end-users in their innovation process to develop marketing related capability (Lee et al., 2010; Teece et al., 1997). However, given their resource constraints, it might not be easy for SMEs to employ many OI modes at the same time. Further, owing to the heterogeneity of OI, decisions relating to its adoption might be difficult for SMEs. As each OI mode differs from others in terms of knowledge flow direction and types of change being brought in, this diverse nature of OI will raise issues of choice for SMEs who might end up with an incomplete OI approach. Yet, the literature has not fully shed light on how OI affects SMEs' performance. Along with other researchers in the OI domain, we would like to understand whether a broad or deep (intensive) OI adoption may enhance firm performance, but unsatisfied with the approaches taken to date relying on a limited number of proxies, we propose a concurrent method by interpreting OI adoption as a process involving changes and by expanding Laursen and Salter's (2006) breadth and depth concept to OI modes.

To address the research gap, survey data from 306 innovation-oriented Korean manufacturing SMEs were collected and analysed using an ordered-Probit model. Recognising the heterogeneity of SMEs, emphasis has been placed on innovation-oriented firms due to their strong internal R&D and clear focus on innovation. As, in general, SMEs are not formally engaged in R&D (Brunswicker and Vanhaverbeke, 2014), this focus on innovative SME may lead to a clear linkage between OI and firm performance.

The remainder of this paper comprises four sections. We first introduce the theoretical background and develop hypotheses about the relationship between OI and firm performance. Then, in section 3, we describe the data and method, and present the results in section 4. Section 5 covers discussion and the paper concludes with implications and possible research limitations.

2. Theoretical background and hypotheses

2.1. Open innovation

Figure 1 shows the traditional "closed" approach to innovation in firms focusing on core markets which use primarily internal resources to develop products (Mortara et al., 2011). Simplistically, a focal company has internal R&D units, each of which is pursuing innovation targeting an "existing" or "identified" key market area.

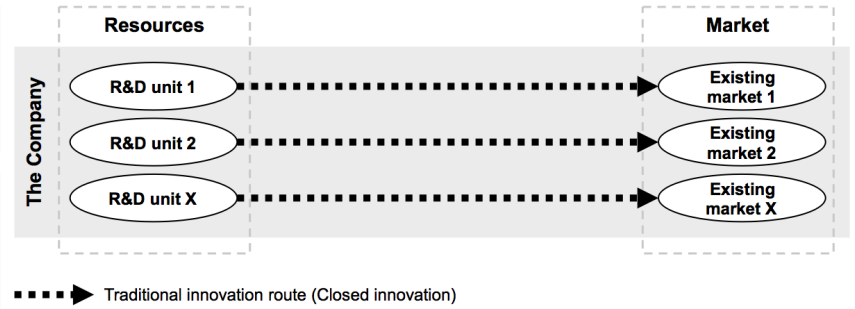

Fig. 1. Closed innovation (Mortara et al., 2011, p 294)

In contrast, OI is "the purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation, respectively" (Chesbrough et al., 2006, p.1). This means that with OI, all knowledge

(internal knowledge as well as external knowledge) can find its way to commercialisation for existing or new markets by crossing a firm's boundary.

In-bound OI refers to innovation activities focusing on acquiring external knowledge (Spithoven et al., 2011); 'in-sourcing' (or 'licensing-in'), 'joint R&D', 'Merger and Acquisition (M&A)/strategic alliance' and 'user involvement' fall into this category. As illustrated in Figure 2, the firm can achieve new resource combinations by using competences and resources of external partners, which will focus on existing or new markets (Mortara et al., 2011). For example, firms which face the challenge of maintaining a high pace of innovation can use external resources to fuel existing pipelines with innovative products (curved line A in Figure 2), or two organisations can contribute to the formation of a new market (curved line B in Figure 2) (Mortara et al., 2011)

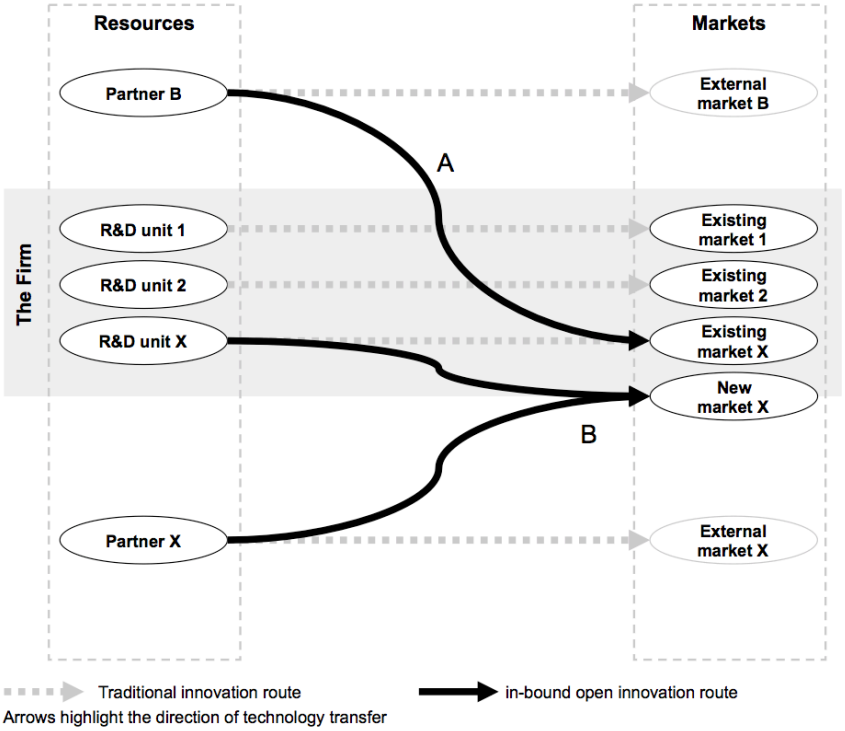

Fig. 2. In-bound open innovation (Mortara et al., 2011, p. 296)

Out-bound OI relates to the exploitation of knowledge in a variety of ways. By revealing internal knowledge via out-bound OI, innovation finds its way towards commercialisation. 'Licensing-out', 'spin-off' and 'open-sourcing' are examples. As illustrated in Figure 3, internal resources can lead to the targeting of a new market. For example, licensing-out (curved line D in Figure 3) enables an external partner to use the firm's internal knowledge and create a new market (Mortara et al., 2011).

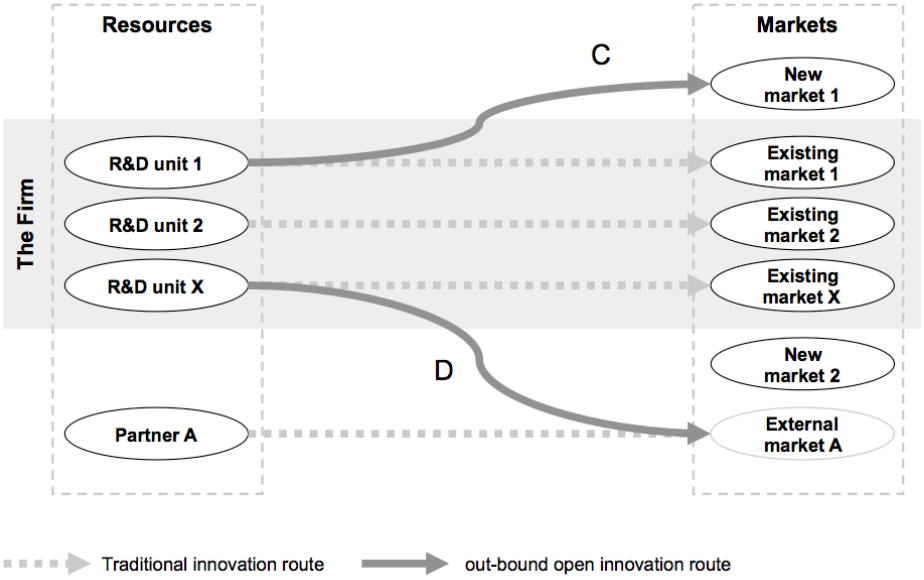

Fig. 3. Out-bound open innovation (Mortara et al., 2011, p. 295)

Although Enkel et al. (2009) suggested a 'coupled process' combining both in- and out-bound knowledge flows and Dahlander and Gann (2010) and Chesbrough and Bogers (2014) extended the coupled model definition, for the purpose of this analysis we concentrate on the main in- and out-bound knowledge flows (e.g., Chesbrough and Brunswicker, 2013), according to the flow dominance. In fact, from the viewpoint of a single partner (e.g. the focal firm), when knowledge is exchanged simultaneously in two directions (e.g., when a firm is doing a strategic alliance with another firm), it could be represented by two independent knowledge flows (i.e., two arrows) which happen concurrently. In this situation, however, for the focal firm, even though there is an out-bound flow of knowledge for the benefit of another firm, the main purpose would be the acquisition of the knowledge necessary to create new value for its own purposes. Thus, we assume that there is always a dominant direction in the knowledge flow from the perspective of the focal firm. For instance, in Figure 2, the curved line B can be an example of coupled OI process. From the firm's perspective it is in-bound OI, but it is out-bound OI when viewed from Partner X's perspective.

2.2. Open innovation in SMEs

Despite the relative scarcity of studies covering OI in SMEs (Ahn et al., 2013; Brunswicker and van de Vrande, 2014; Lee et al., 2010; Parida et al., 2012; Spithoven et al., 2013; Van de Vrande et al., 2009), a few notable ones have shown various motives for and barriers to OI adoption in SMEs. Amongst the motives, an insufficient marketing capacity has been identified as the main driver of OI adoption in SMEs (Narula, 2004). In general, most of the SMEs' weaknesses in innovation arise from their size (Freel, 2000; Narula, 2004; Teece, 1986). SMEs can adopt OI in order to react actively to market changes, to meet customer demand and/or develop new sale channels (Lee et al., 2010; Van de Vrande et al., 2009). A weak R&D capacity has also been found as an incentive for reliance on external knowledge (Kim and Park, 2010). To overcome the problem of insufficient R&D expertise, SMEs can attempt to explore a wide range of external information sources (Lee et al., 2010) or

to exploit other companies' expertise by forming alliances to access complementary assets (Ahern, 1993; Nooteboom, 1994; Teece et al., 1997; Van Dijk et al., 1997).

In terms of barriers, as it is not easy for SMEs to achieve economies of size and scope, they may not transfer their technologies across product lines to create new products (Teece, 1980, 1982). In fact, internal R&D often has a dual function, in the sense that it not only generates new technologies but also increases absorptive capacity (Cohen and Levinthal, 1990; Rosenberg, 1994). As this capacity development mainly depends on the level of accumulated prior knowledge (Cohen and Levinthal, 1990), SMEs with less intensive R&D capacity may not be able to exploit external knowledge efficiently (Rosenberg and Steinmueller, 1988). Also, difficulties in recruiting highly skilled workers, changing organisational cultures and problems in finding and interacting with external partners are also frequently cited as hindrances to OI (Lee et al., 2010; Van de Vrande et al., 2009). The high cost of patent management may be prohibitive for SMEs, resulting in infrequent adoption of out-bound OI modes, such as IP licensing (Spithoven et al., 2013). Further, the limited ability to barter technology assets may make it difficult for SMEs to establish symmetric relationships with large established firms (Minshall et al., 2010; Narula, 2004).

OI in SMEs seems to be different from that in large firms (Ahn et al., 2013; Lee et al., 2010). While there have been a few examples of out-bound OI modes, the in-bound mode has been actively adopted by most SMEs (Van de Vrande et al., 2009). Among various in-bound OI modes, joint R&D and user involvement have been the most frequently observed modes and this mode preference has also been observed in many subsequent studies (Laursen and Salter, 2006; Lee et al., 2010; Van de Vrande et al., 2009). Even though large firms are more widely involved in various OI activities, SMEs seem more intensely involved in a few OI activities (Spithoven et al., 2013). Since SMEs cannot invest large financial resources in internal R&D, they carefully build an innovation portfolio and use it to get maximum benefits (Alstrups, 2000). Because of this careful and intensive innovation engagement, OI can contribute more to new product development in SMEs than in large firms (Spithoven et al., 2013).

2.3. Re-defining open innovation modes according to the changes involved

Owing to the complexity and heterogeneity of OI, it has not been easy to investigate the effect of OI on firm performance. In this context, we propose to re-define the OI modes in order to include the challenges of implementation highlighted above and allow a more in-depth evaluation of OI, in particular in the SME context. The OI literature has mainly dealt with knowledge flow directions, but OI modes can also be classified according to the type of changes involved in the adoption and implementation process. In Figure 1-3 each shift represents a 'change' implying a certain level of 'corporate entrepreneurship' and some risks and hence some associated resistance to its adoption (Mortara et al. 2011). Every time an innovation is directed towards an existing market (i.e. horizontal shift), a certain degree of change (dominantly technological) is involved. However, when an OI mode which also involves a vertical shift is implemented, a firm has to face changes in both technology and market. In the OI paradigm, not only do firms have to utilize external technology, but they also have to have access to new markets to exploit their internal knowledge in different ways (e.g., IP licensing) or to make new organisations (e.g., M&A or spin-off) to absorb or examine a potentially innovative disruptive technology. Additionally, as OI can be perceived as innovating innovation (Chesbrough, 2003), if a firm is required to establish new organisational constructs to operate any of the modes, a further degree of change becomes involved. OI adoption will reform organisations, in the sense that it forces them to experiment and adopt new ways, such as new knowledge (technology), new markets and even new forms of organisations (Mortara et al. 2010).

In this context, we propose a new OI taxonomy (see Table 1) by classifying the OI modes according to the dominant changes involved. Accordingly, 'technology-oriented OI', such as 'in-sourcing' and 'joint R&D', refers to innovation activities aiming at technological innovation. As the aim of this OI is to expand the boundary of its innovation sources, the adoption of this OI brings in substantial increase in technology stock. 'In-sourcing' is the fastest way of acquiring technological knowledge, but it does not usually involve a great deal of market and organisational change. 'Joint R&D ' may occasionally involve some degree of organisational changes (e.g., Intel's Lablet, see Tennenhouse (2004)), but its focus is still on acquiring the necessary technology. 'Market-oriented OI', on the other hand, attempts to identify new market needs. Examples are 'user involvement', 'open-sourcing' and 'licensing-out'. 'User involvement' and 'open sourcing' aims to identify market needs. 'Licensing-out' may necessitate a certain level of organisational change (e.g., the creation of a new IP division), but the focus of this OI is on commercialising under-utilised knowledge by generating a new market for it (i.e., making a new commercialisation route, see a curved line D in Figure 3). Last, 'organisation-oriented OI' causes drastic changes in organisational structures and 'M&A/alliance' and 'spin-off' are examples of this OI mode. 'M&A/alliance' may aim to acquire external technology, but this kind of OI involves greater changes in a firm's organisational structure. Similarly, 'spin-off' involves substantial changes in organisational structure.

This classification is based on the type of dominant (i.e., the highest) core changes (from technological to organisational change) involved. Thus, for instance, we classified 'open-sourcing' as 'market-oriented', in the sense that it emphasizes interactions with customers/users and 'M&A' and 'spin-off' as 'organisation-oriented' because the adoption of these OI modes involves (mainly) new organisational forms and practices. Our classification relies upon dominant changes, so it suggests that a higher level of change can include a smaller one (i.e., it is an inclusive concept). For instance, market-oriented OI can include technology changes, whilst organisation-oriented OI can embrace both technological and market changes, in the sense that organisational changes are the most complicated ones involving many types of different sub-level changes.

Table 1. Open innovation classification (Note: '✓'denotes a low and'✓✓' denotes a high level change)

	Dominant knowledge flow direction	Changes involved in OI			Dominant core change
		Technology	Market	Organisational structure	
In-sourcing (Licensing-in)	In-bound	✓✓			Technology-oriented
Joint R&D		✓✓			Technology-oriented
User involvement		✓	✓✓		Market-oriented
M&A/alliance		✓	✓	✓✓	Organisation-oriented
Open sourcing	Out-bound	✓	✓✓		Market-oriented
Licensing-out		✓	✓✓	✓	Market-oriented
Spin-off		✓	✓✓	✓✓	Organisation-oriented

2.4. Open innovation and firm performance

Recent studies have investigated the influence of OI on performance using large-scale data sets (Podmetina et al., 2014), and their approaches can be grouped into the following three: 1) the degree of openness (OI proxies), 2) individual OI mode

influence and 3) collaboration influence.

Firstly, researchers have attempted to identify the effect of openness on firm performance. Rather than examining individual OI modes one by one, studies in this group have tried to discover the influence of the degree of openness in firms. Laursen and Salter's (2006) seminal paper employed search strategy as a proxy variable for a firm's openness by introducing the 'breadth of search' and 'depth of search' concept as two distinctive dimensions of openness. Their study showed that external search and linkages with external partners are positively associated with sales of new or improved products. The approach of Laursen and Salter (2006) has been developed further in many subsequent studies. For example, Chen et al. (2011) found that the breadth and depth of openness can improve both science-based and experience-based innovation, and Chiang and Hung (2010) found that breadth affects incremental innovation, whilst depth influences radical innovation.

Studies in the second group have focused on the individual effect of each OI mode. Brunswicker and Vanhaverbeke (2014) found that not all OI modes are always beneficial in enhancing innovation performance, and their findings are in line with the rest of the literature. Mazzola et al. (2012) examined the effect of twelve different OI modes on financial and innovation performance and found that the OI effect can be both positive and negative. In their study, acquisition, licensing-out, co-patenting and alliance were significantly associated with both innovation and financial performance, whilst university collaboration, public funding and R&D alliance were insignificantly associated with them. Also, they found that supplier collaboration, government collaboration and licensing-in were only significantly associated with innovation performance, while external technology commercialisation was only significant for financial performance. Hung and Chou (2013) investigated the influence of external technology acquisition (i.e., in-bound OI) and external technology exploitation (i.e., out-bound OI) but found that only external technology acquisition positively affects performance.

Lastly, some researchers have investigated the effect of collaboration. Almirall and Casadesus-Masanell (2010) simulated the effects of OI in two different settings: where partnerships were fixed or flexible. They showed that a high level of openness can bring better performance, particularly in a dynamic environment where firms can change their partners freely. Since one of the most important benefits of collaboration is accessing a partner's complementary assets (West and Gallagher, 2006), broad and intensive collaboration will enable firms to exploit external knowledge more efficiently. However, as the literature has shown, different types of external partners play crucial roles in different innovation modes. In Chen et al.'s (2011) study, collaboration with universities and research institutes affected science-based innovation, whilst this type of collaboration did not influence experience-based innovation. Rather, value chain partners and competitors influenced experience-based innovation performance

The above three strands of research show that the relationship between OI and firm performance is not simple. These complex (and sometimes inconsistent) results have inhibited our clear understanding of the effect of OI on performance. However, two points arise here. First, the complexity arises from diverse nature of OI (Dahlander and Gann, 2010), and second, this diversity brings about issues of choice. Firms have to make the most appropriate choice(s) from among various options, and this is more important in SMEs. Given the resource constraints it is not easy for SMEs to employ many innovation routes at the same time (Vanhaverbeke et al., 2012). Therefore, the relationships between OI and performance have to be further investigated and for this our OI classification (see Table 1) can be used in order to help SMEs to make better decisions with regard to choice of OI adoption.

2.5. Hypotheses

The literature has shown that SMEs are actively engaged in OI (Cosh and Zhang, 2011; Spithoven et al., 2013; Van de Vrande et al., 2009) and suggested many benefits they may obtain through OI (Brunswicker and van de Vrande, 2014; Lee et al., 2010). As the adoption of each OI mode represents a new managerial option, firms employing various OI modes may deal more flexibly with a fast-changing environment. By diversifying their innovation strategies, firms' knowledge will find its ways to commercialisation in existing and new markets. Hence:

H1) A broad OI adoption (i.e., adopting many modes) is positively associated with SMEs' firm performance.

However, since SMEs might not be able to focus on various managerial options simultaneously, adopting too many OI modes may bring in substantial risks. OI adoption, with its challenges, such as more managerial choices (Nelson and Winter, 1982) and difficulties in finding trustworthy partners (Dyer and Singh, 1998; Narula, 2004), will increase uncertainty levels. Thus, the intensive adoption of OI (rather than adopting too many OI approaches) may contribute to the enhancement of firm performance. Hence:

H2) A broad OI adoption will show a curvilinear relationship with firm performance.

H3) A deep (i.e., intensive) OI adoption is positively associated with SMEs' performance.

Because of the different types of innovation activities involved in OI (Dahlander and Gann, 2010; Spithoven et al., 2013), the influence of each OI mode on firm performance will be different. According to our OI classification in Table 1, we argue that the influence of OI on performance will vary according to the type of changes introduced by the adopted OI mode. Since SMEs typically lack the resources and management experience that are essential for dealing with changes and adapting themselves to a new innovation routine, they may not equally and effectively benefit from all kinds of OI. OI modes demanding substantial resources and involving high risks may not affect firm performance significantly. In this regards, we assume that OI modes involving relatively low level changes (such as technology or market-oriented OI) will affect firm performance more significantly than those involving more complex and higher changes (e.g., in organisation structure). Hence:

H4) The OI modes are differently associated with SMEs' performance according to the types of changes brought by the OI modes.

The literature has shown that different types of external partners play crucial roles in different innovation activities (Mention, 2011). Gronum et al. (2012) showed that collaboration with various partners can improve innovation in SMEs. However, the collaboration process is not simple. Absorptive capacity, which is an essential capacity in OI (Spithoven et al., 2011), depends upon good social relationship as well as strong internal R&D (Zahra and George, 2002). Therefore, in collaboration, not only do firms have to resolve differences embedded in external knowledge to integrate it with the internal (Salter et al., 2014), they also have to establish new protocols (Kitchell, 1997; Narula, 2004). Firms have to recognise that innovation clock speed varies in different organisations (Kitchell, 1997). Yet, this may not be easy for SMEs. Given their resource constraints, SMEs may not adequately deal with time consuming trust building process (Narula, 2004). Thus, even though collaborations contribute to the enhancement of firm performance, too many collaboration projects may not do so. Hence:

H5) A broad collaboration (many partners) is positively but curvilinearily related to firm performance in SMEs.

H6) An intensive collaboration is positively associated with SMEs' performance.

Despite the potential positive effects, collaborations with different partners may not contribute to performance improvement equally. For example, Lasagni (2012) suggested that innovation performance in SMEs can be higher when they strongly collaborated with users, customers and suppliers. His results also showed that SMEs can be better successful in product development when they closely work with research institutes. This suggests that there can be specific types of partners SMEs may prefer. As collaboration can bring in various risks, such as information leakage (Laursen and Salter, 2014; Oakey, 2013), SMEs may prefer to collaborate with partners which may not threaten them. Hence:

H7) The effect of collaboration on SMEs' performance is differently associated according to partners.

3. Data and method

3.1. Samples

Data were collected through a survey using the database of the Korean Small and Medium Business Administration (SMBA). The SMBA is a government agency giving a government certificate to innovation-oriented SMEs (so-called 'inno-biz' program which was inspired by the Small Business Innovation Research (SBIR) of the US and aims to select and stimulate innovative SMEs) to encourage innovation activities. These firms are assessed by the SMBA according to four major criteria (innovation capacity, commercialisation ability, innovation management and innovation performance (OECD, 1997)). By the second quarter of 2013, a total of 17,295 SMEs had obtained the "inno-biz" certification, indicating their high level of innovativeness.

For the main survey, 3,000 manufacturing SMEs were randomly selected from the inno-biz database, and a structured questionnaire was delivered to CEOs via e-mail, using an on-line survey system in January 2013. 68 firms were not reached due to errors in contact details, and in total 329 responses were eventually collected. This gives an 11.3% response rate (i.e., 329/(3000-68)). However, 23 responses were excluded from the final sample as key information was missing. So, 306 responses were finally used for the analysis.

To examine any non-response bias, the extrapolation method was used, i.e., comparing early and late responding mean values of variables, whereby late respondents are likely to have similar characteristics to non-respondents (Armstrong and Overton, 1977). In terms of the number of employees, sales and firm age, no significant difference between the two groups was found.

3.2. Variables

Performance. Each firm's performance (a latent variable) was measured by three manifest variables. When investigating large established firms, measuring business performance in the traditional way (e.g., total revenue or return on investment) can be a good approach increasing the validity of the responses; so objective dependent variables have been used in many studies. However, acknowledging the following two aspects, the current paper attempted to use multiple subjective variables rather than single objective one. First, it is not easy for a single objective variable to measure a firm's performance exactly. For example, financial performance, such as revenue, is a good objective measurement, but it only reflects a part of firm

performance (i.e., only financial aspect). Similarly, some studies (e.g., Community Innovation Survey) used a binary variable to measure innovation performance by asking whether firms were successful in product development, but this binary variable cannot reflect the extent of firm performance improvement. Second, not only are SMEs typically reluctant to reveal their financial status (Fiorito and LaForge, 1986), but neither is it easy to evaluate the accuracy of reported figures (Covin and Slevin, 1989). Further, neither do low net-income or operating-losses necessarily indicate poor management in growth-oriented SMEs (Cooper, 1979), nor can their financial figures be free from influences of their business environment (Miller and Toulouse, 1986). As such, this study adopted subjective indicators as it happened in other SME studies (e.g., Akgun et al., 2007; Miller and Toulouse, 1986; Rhee et al., 2010). Questions regarding how good the firm was in terms of sales, new product development (or related service), and market share were included in the survey. Respondents were asked to indicate relative performance on a seven-point Likert scale, when compared with average-level competitors in their industry. Before the main analysis, confirmatory factor analysis (CFA) was conducted to see whether these three manifest variables could construct one performance latent variable. As shown in Table 2, the result shows good reliability and validity. The reliability of measurement was assessed by Cronbach's alpha, and the constructed latent variables satisfied the recommended level (i.e., good if it is larger than 0.7 (Field, 2009)). All standardized factor loadings on latent variables were over 0.5 and significant at the 0.001 level (two-tailed), thus verifying a convergent validity. In order to include this latent variable in a regression (Hung and Chou, 2013), we averaged these three manifest variables.

Table 2. Confirmatory factor analysis result

Factor loadings	Std. estimate	Critical ratio	Cronbach's alpha
Relative sales <--- Performance	0.624	-	0.742
Relative new product development <--- Performance	0.642	8.542***	
Relative market share <--- Performance	0.849	7.992***	

Significance: *** $p < 0.001$

Open innovation. We adapted Laursen and Salter (2006)'s 'breadth' and 'depth' concepts to quantify the degree of OI adoption breadth and depth (meaning how many OI modes were employed and how intensely). First, we asked how many times firms had adopted seven different OI modes in the last three years. These OI adoption variables were transformed into binary variables (0:not used, 1:used) to indicate the adoption of each OI mode. Then the binary variables were added up to indicate how broadly firms use OI, i.e., 'breadth of OI'. The seven OI adoption variables were also transformed into other binary variables (0: not used or low intensity (1~2 times used), 1: high intensity (used than more than 3 times)) and added up in order to quantify the 'depth of OI'.

Collaboration partners. Laursen and Salter (2006)'s concept was applied to measure how firms broadly and intensively collaborate with external partners. We asked the frequency of collaboration with seven different partners in implementing OI for the last three years as seven levels (0: not collaborated with, 1~6: six levels according to collaboration frequency). These variables were transformed into binary variables (0: no collaboration, 1: collaborated with) and added up to indicate how broadly firms collaborate with external partners (i.e., breadth of collaboration). As in the case of 'depth of OI', these seven collaboration variables were also transformed into other seven binary variables (0: not or low collaboration (1~2 times), 1: high intensity

(collaborated more than 3 times)) and then added up to quantify how firms intensely collaborate with OI partners.

Control variables. The following five variables were controlled due to their significance in the literature. First, the firms' 'R&D intensity' was included due to its importance in generating and absorbing knowledge (Cohen and Levinthal, 1990; Spithoven et al., 2011; West and Bogers, 2013). It was measured as the ratio of the expenditure on internal R&D to total revenue. Second, 'firm size' was measured as a natural logarithm of the number of employees. An abundance of resources is recognised as a critical factor for innovation (Chaney et al., 1991; Cyert and March, 1963), and the literature has showed its significance in OI adoption and implementation (Spithoven et al., 2013; Van de Vrande et al., 2009). As the scale of this variable was larger than those of other variables, a natural logarithm was applied. Third, a measure of the 'firm age' was employed. Research has shown that the age of a firm can influence innovation both positively and negatively (Mazzola et al., 2012). Fourth, 'government support' was introduced, as government funding encourages SMEs' networking and interaction with other innovation actors (Kang and Park, 2012). Also, in general, many governments provide significant funding and apply weaker regulations to SMEs in order to encourage the increase of SME competence (Nooteboom, 1994; Rothwell and Dodgson, 1991). Lastly, since a competitive market environment is also a strong driver of change (Hung and Chou, 2013; Lee et al., 2010), an exogenous factor, 'market turbulence', was examined. 'Government support' and 'market turbulence' were measured using the 7-point Likert scale, to establish how often the firms received government support (all kinds of government support, such as subsidies, tax deductions, loans, and research grants) and to what extent they felt that the market environment was competitive and hostile.

4. Results

4.1. Descriptive statistics

Table 3 shows the descriptive statistics with minimum and maximum values, mean and standard deviations of the respondents. The sample's average number of employees per company was 28.81, and the average firm age was 11.42 years. As their average R&D intensity (11.60) indicates, the sample firms were highly involved in innovation. For comparison, the average R&D intensity across all Korean firms in 2007 was just 2.43 (KOITA, 2009). Before the regression, multicollinearity was examined. A variance inflation factor (VIF) greater than 10 can cause a serious multicollinearity problem (Myers, 1990), but for all the tested variables, VIF values were between 1.039 and 2.039, confirming that there was no serious collinearity issue in the sample.

Figure 4 illustrates the distribution of the OI adoption of the respondent firms. The results show that in-bound OI was more favoured than out-bound OI. Particularly three OI modes, in-sourcing, joint R&D and user involvement, were actively implemented by the sample firms. Interestingly, for M&A/alliance and spin-off, there were very few examples of these modes, and when reported they only occurred one or twice. For other OI modes, the frequency of adoption showed a gradual decline.

Table 3. Descriptive statistics

Variables	Min.	Max.	Mean	St. deviation
Performance	1.00	7.00	3.897	1.097
OI breadth	0.00	7.00	1.759	1.406
OI depth	0.00	6.00	0.452	0.779
Collaboration breadth	0.00	7.00	4.261	1.909
Collaboration depth	0.00	7.00	1.958	1.864
R&D intensity (%)	0.00	80.00	11.602	10.156
Firm age (year)	3	40	11.420	7.126
Firm size (the number of employee)	3	300	28.810	36.852
Government support	1.00	7.00	2.380	1.235
Market turbulence	1.00	7.00	5.390	1.184

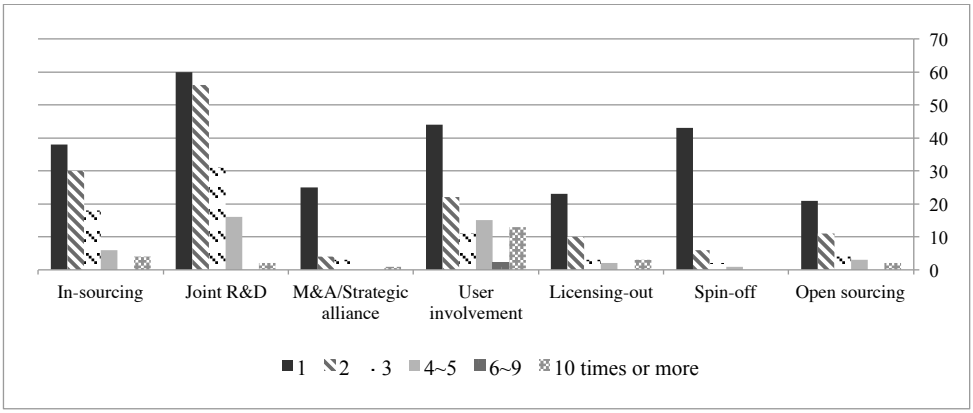

Fig. 4. Open innovation adoption (Unit of the vertical axis: the number of firms)

Figure 4 showed that in-bound OI, especially joint R&D and user involvement, were the most frequently adopted OI modes. This is in line with other studies that investigated Korean SMEs (Abulrub and Lee, 2012; Kim and Park, 2010), but this OI preference is also identified in the context of other countries. For example, Van de Vrande et al. (2009), who investigated Dutch SMEs, found that their sample firms preferred in-bound OI and meeting customer demands was the most important driver of OI. Cosh and Zhang (2011) who investigated British SMEs also found that their sample firms were actively collaborating with customers and suppliers and implementing joint R&D or joint marketing.

4.2. Open innovation modes

The latent variable (performance) is a mean value of three manifest variables and has an ordered value between 1 and 7 with interval 0.33. Considering this, an ordered-Probit regression model was employed and a normality assumption was verified by the Wilks W test. As shown in Table 4, three different models were examined in order to see the influence of the OI adoption on performance. First,

Model 1 includes only control variables (a baseline model), whilst the 'breadth of OI', its square term and 'depth of OI' were added in Model 2 to identify the relationship between the extent of OI adoption and firm performance. The robust method was used to estimate a marginal effects of square terms in a non-linear model (Norton et al., 2004). In Model 3 the effect of individual OI adoption was examined in order to see which OI mode could have contributed to firm performance.

Table 4. OI adoption and firm performance

Variables	Model 1	Model 2	Model 3
(***Controls***)			
Firm size	0.034(0.074)	0.023(0.077)	0.041(0.078)
R&D intensity	-0.004(0.006)	-0.002(0.007)	0.001(0.007)
Firm age	0.004(0.009)	0.001(0.009)	0.005(0.009)
Market turbulence	-0.109(0.050)*	-0.133(0.052)*	-0.155(0.052)**
Government support	0.124(0.049)*	0.043(0.053)	0.040(0.060)
(***OI breadth and depth***)			
Breadth of OI		0.179(0.950)$^{+}$	-
(Breadth of OI)^2		-0.020(0.021)	-
Depth of OI		0.240(0.088)**	
(***OI adoption***)			
In-sourcing			-0.032(0.055)
Joint R&D			0.125(0.058)*
M&A/alliance			-0.080(0.117)
User involvement			0.133(0.041)***
Licencing-out			0.120(0.079)
Spin-off			-0.138(0.116)
Open sourcing			0.244(0.082)**
(Model fit)			
Cox and Snell R^2	0.044	0.102	0.157
Nagelkerke R^2	0.045	0.103	0.158
McFadden R^2	0.009	0.021	0.033
Δ (-2LogLikelihood)[a]	13.521***	29.869***	48.037***

Note: Estimates are beta coefficient and robust standard errors are in parentheses.
$^{***}p<0.001$, $^{**}p<0.01$, $^{*}p<0.05$, $^{+}p<0.1$ / [a] difference with intercept only model

The results suggest that OI adoption can be positively associated with firm performance. Model 2 confirms that both broad and intensive OI adoption can contribute to performance. The square term of 'OI breadth' showed a negative association but it was statistically insignificant. Thus, hypothesis 1 and 3 were supported, whilst hypothesis 2 was rejected.

The results of Model 3 showed that only OI modes introducing relatively low levels of change, such as joint R&D (technology-oriented), user involvement and open sourcing (market-oriented), are positively associated with performance. The other OI (i.e., organisation-oriented) introducing high levels of change had no impact on performance. This partially validates hypothesis 4. Also, it was found that the coefficient of market-oriented OI was larger than that of technology-oriented OI, conjecturing high importance of market-oriented OI in SMEs.

In terms of control variables, only the 'market turbulence' was significantly associated with performance. As expected, a competitive and hostile market environment negatively influenced firm performance. However, the other control variables did not show any significance in our sample.

4.3. Collaboration partners

To see the effects of collaboration on firm performance, three models were examined as shown in Table 5.

Table 5. OI partners and firm performance

Variables	Model 4	Model 5	Model 6
(***Controls***)			
Firm size	-0.037(0.085)	0.002(0.088)	-0.003(0.088)
R&D intensity	-0.008(0.007)	-0.005(0.007)	-0.008(0.007)
Firm age	-0.001(0.011)	0.001(0.011)	-0.006(0.011)
Market turbulence	-0.109(0.055)*	-0.124(0.056)*	-0.127(0.057)*
Government support	0.070(0.062)	0.065(0.066)	-0.016(0.065)
(***OI breadth and depth***)			
Breadth of OI			0.080(0.044)+
Depth of OI			0.322(0.102)**
(Collaboration breadth and depth)			
Breadth of collaboration	0.253(0.151)+	-	0.090(0.059)
(Breadth of collaboration)^2	-0.022(0.019)		-
Depth of collaboration	0.102(0.049)*	-	0.056(0.031)+
(***Collaboration partner***)			-
Other firms		-0.120(0.148)	-
Suppliers		0.188(0.199)	-
Customers/clients		0.519(0.190)**	-
Affiliated firms		-0.212(0.154)	-
Consultancy/intermediaries		0.358(0.161)*	-
Universities		-0.009(0.163)	-
Research Institutes		0.379(0.170)*	-
Cox and Snell R^2	0.130	0.166	0.190
Nagelkerke R^2	0.131	0.167	0.191
McFadden R^2	0.027	0.035	0.041
Δ (-2LogLikelihood)[a]	32.451***	42.369***	47.493***

Note: Estimates are beta coefficient and robust standard errors are in parentheses.
***p<0.001, **p<0.01, *p<0.05, +p<0.1 / [a] difference with intercept only model

Model 4 included two aggregated collaboration variables, breadth and depth of collaboration, whilst Model 5 showed the effect of individual OI partners. As in the case of OI adoption, the aggregated collaboration variables (i.e., breadth and depth) were positively associated with performance. The results of Model 4 showed that both broad and intensive collaboration can contribute to the enhancement of performance. However, the square term of collaboration breadth did not show its statistical significance, even though it showed a negative association with firm performance. In model 5, the effect of each individual OI partner on performance was examined. The results showed that external collaboration with customers, consulting firms/intermediaries and public research institutes can contribute positively to performance. We ran an additional model (Model 6) including all aggregated variables. The results showed that wide and intensive OI adoption with intensive collaboration can enhance firm performance, which is in line with the finding of

Spithoven et al. (2013) that SMEs benefit from intensive OI engagement.

5. Discussion

This paper has investigated the influence of OI on firm performance. Based on survey data on innovative manufacturing SMEs, we found that OI can be a good approach enhancing firm performance in SMEs. The following findings are drawn from the analysis.

First, we found that both broad and intensive OI adoption can positively contribute to the enhancement of firm performance. OI adoption can be perceived as a process of introducing a new innovation route that may not previously be provided by internal R&D. In this regard, broad OI adoption can diversify firms' managerial options that will be useful when firms deal with a fast-changing market environment. Also, intensive OI adoption, which indicates how deeply firms are engaged in specific OI modes, helps firms to examine and select efficient and most suitable innovation routes among diverse choices, which in turn could enhance performance. However, as noted by Laursen and Salter (2006), too much openness may make it difficult for firms to benefit from their innovation. So, an inverted U-shaped curvilinear relationship between OI breadth and firm performance was assumed, but the square term of OI breadth showed no significant association, which rejects our conjecture. This may be interpreted by recognising the nature of OI implementation and the changes involved. Since OI adoption is, in fact, the development of new innovation routes, its influence may be different from that of external information search that simply consumes organisational resources. As OI provides new opportunities for commercialisation by diversifying innovation routes (see Figure 2 and 3), adopting many OI modes may not harm firm performance. This finding is important for SMEs, in the sense that given the resource constraints they typically hesitate to change their innovation routes.

Second, our results also indicate that not all OI modes affect performance positively. As shown in Table 1, OI adoption involves different types of changes in technology, market and organisational structure. Our results suggest that the OI modes involving technology (joint R&D) and market level changes (user involvement and open sourcing) contribute to firm performance positively. This might be interpreted in two ways. First, this phenomenon may reflect the characteristics of SMEs that generally focus on technological development and implement market-oriented innovation (Brunswicker and Vanhaverbeke, 2014; Lee et al., 2010; Oakey, 2013). Technology is an essential source of innovation (Dosi, 1982) and innovative SMEs which do an application-oriented search perceive OI as a beneficial complement of internal R&D (Brunswicker and Vanhaverbeke, 2014). Also, most SMEs implement market-oriented, demand-driven OI (Brunswicker and van de Vrande, 2014; Lee et al., 2010; Van de Vrande et al., 2009) because they generally lack the capability to identify market trends and access new marketing channels (Narula, 2004). The fact that 'open sourcing' significantly affected performance despite its low adoption frequency (see Figure 4) may also support this explanation. As 'open sourcing' is market-oriented OI and at the same time it aims to exploit external technology (Henkel, 2006), it may satisfy SMEs' needs. The next interpretation is based on the types of changes introduced by each OI mode. Due to their insufficient resources and weak managerial capacity, they cannot deal with every kind of risk and change involved in OI (Ahn et al., 2014). They have to implement innovation discreetly according to circumstances (Alstrups, 2000). However, OI adoption results in an innovation routine modification that brings with it various changes, such as new technology, new market and new organisational structure (Mortara et al., 2011). Therefore, only when SMEs have the necessary managerial resources in dealing with

these changes can they have benefit from OI. Yet, as the advantage that most innovative SMEs have lies in technology rather than managerial resources (Narula, 2004; Oakey, 2013), they are not likely to cope with the higher level changes (e.g., building a new business model and setting up a new organisation) that require systematic resource reallocation. Thus, complex OI requiring substantial organisational changes (M&A and spin-off) or IP management (licensing-out) may be infrequently adopted compared to other OI modes and not significantly contribute to performance improvement.

Third, we investigated the relationship between collaboration partners in OI implementation and firm performance, and as in the case of OI adoption we found that broad and intensive engagement with partners can affect performance positively. We presumed an inverted U-shaped curvilinear relationship between collaboration breadth and firm performance, in the sense that collaboration is a time-consuming process requiring an establishment of new protocols (Kitchell, 1997; Narula, 2004). Yet, in our results no evidence was found with regard to such a relationship. This may suggest that collaboration partners can also be perceived as providing important paths leading to new innovation routes. Certainly, building a new relationship demands resources, but as this newly established relationship can contribute to the diversification of firms' innovation routes, collaborating with many partners may not harm performance improvement. Our results also showed that non-competing partners, such as customers, consultancy/intermediaries and public research institutes, can positively affect firm performance. This is in line with the literature (e.g., Cosh and Zhang, 2011; Lee et al., 2010; Van de Vrande et al., 2009). As SMEs choose to open their firm boundaries to survive fierce competition, they may prefer OI partners who do not threaten their business.

Last, with regards to control variables, many of them did not show direct influence on performance. Despite what previous literature found (e.g., Laursen and Salter, 2006; Spithoven et al., 2011), for our sample of SMEs, internal R&D did not directly affect performance. This discrepancy might spring from our sample characteristics. As we investigated innovative SMEs with high levels of internal R&D intensity, they may already be at a high technology level, thus difficult to improve upon only by virtue of internal R&D. Just as 'over search' can be detrimental to firm performance (Laursen and Salter, 2006), too much investment in internal R&D may result in failure to allocate the limited resources elsewhere, in turn resulting in insignificant contribution to performance improvement. Rather, as our results show, broadening managerial options by opening firm boundaries will be a winning approach for highly innovative SMEs. Further, although government support did not directly contribute to the improvement of firm performance, as our correlation matrix shows (see Appendix), it was significantly related with many OI modes and innovation partners, such as in-sourcing, joint R&D, M&A/alliance, other firms and suppliers. In this respect, it can be said that government support stimulates collaboration among innovation actors and encourages OI adoption. Its importance in the OI context must not be overlooked.

6. Implications and limitations

Our study has some theoretical and practical implications. First, a possible theoretical contribution of the paper lies in the suggested OI taxonomy that classifies OI according to the type of changes involved in it (see Table 1). We used this classification to interpret our analysis results, but it can also be applied in other contexts (e.g., large firms) to enrich our understanding of OI.

Second, for practical implications, senior managers and policy makers should be aware of the importance of OI in enhancing SME performance. The findings of the

study have provided further empirical evidence that SMEs can benefit from OI by broadly and intensively engaging in OI modes and collaborating with external partners. This can be a useful guideline for mangers and policy makers who are interested in the promotion of SME OI. Given their resource limitations, SMEs may hesitate to engage in many OI modes and collaborate with many partners. However, as our results indicate, it is recommended for them to do so, as broad OI adoption and collaboration does not harm performance improvement. Since newly adopted OI and established collaboration relationships can provide firms with new innovation routes which might not be achieved through closed innovation approach, an increase in openness will contribute to the enhancement of firm performance by diversifying innovation strategies. Thus, when facing OI mode choice issues, it is indeed necessary for SME managers to broaden their OI strategies.

However, despite the above potential contributions, this paper has some research limitations. First, the sample concerns only innovative manufacturing SMEs with high R&D intensity. Thus, our findings may be affected by the sample characteristics and might not be easily generalised to other sub-populations of SMEs, such as service firms or non-innovative small firms. Second, as innovation can be different in a different national innovation system (NIS), our results from a single country context might have been influenced by national context, such as economic fundamentals and culture. As noted by Edwards et al. (2005), a higher level of understanding is achieved when considering the complex linkage between an SME and its socio-cultural context. Thus, future studies may obtain better understanding by including variables reflecting socio-cultural contexts or conducting comparative studies of two or more countries. Last, since this study did not deal with longitudinal data, any discrepancies with the literature could not be not fully investigated. For example, even though the performance variable this study used was a three-year average value, a possible delay effect may exist. Thus, it was not possible to examine whether the insignificant effect of internal R&D was caused by a delay effect. Improved results might be obtained by future studies addressing these research limitations.

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8. References

Abulrub, A.-H. G., & Lee, J. (2012). Open innovation management: challenges and prospects. *Procedia-Social and Behavioral Sciences, 41*, 130-138.

Ahern, R. (1993). Implications of Strategic Alliances for Small R&D Intensive Firms. *Environment and Planning A, 25*(10), 1511-1526.

Ahn, J. M., Mortara, L., & Minshall, T. (2013). The effects of open innovation on firm performance: a capacity approach. *STI Policy Review, 4*(1), 74-93.

Ahn, J. M., Mortara, L., & Minshall, T. (2014). *Linkages between CEO characteristics and open innovation adoption in innovative manufacturing SMEs*. Paper presented at the The DRUID Academy, Aalborg, Denmark.

Akgun, A. E., Keskin, H., Byrne, J. C., & Aren, S. (2007). Emotional and learning capability and their impact on product innovativeness and firm performance.

Technovation, 27(9), 501-513.

Almirall, E., & Casadesus-Masanell, R. (2010). Open Versus Closed Innovation: A Model of Discovery and Divergence. *Academy of management Review, 35*(1), 27-47.

Alstrups, L. (2000). Coaching continuous improvement in small enterprises. *Integrated Manufacturing Systems, 11*(3), 165-170.

Armstrong, J. S., & Overton, T. S. (1977). Estimating Nonresponse Bias in Mail Surveys. *Journal of Marketing Research, 14*(3), 396-402.

Brunswicker, S., & van de Vrande, V. (2014). Exploring Open Innovation in Small and Medium-sized Enterprises. In H. Chesbrough, W. Vanhaverbeke & J. West (Eds.), *New Frontiers in Open Innovation*. Oxford: Oxford University Press.

Brunswicker, S., & Vanhaverbeke, W. (2014). Open Innovation in Small and Medium-Sized Enterprises (SMEs): External Knowledge Sourcing Strategies and Internal Organizational Facilitators. *Journal of Small Business Management*.

Chaney, P. K., Devinney, T. M., & Winer, R. S. (1991). The impact of new product introductions on the market value of firms. *The Journal of Business, 64*(4), 573-610.

Chen, J., Chen, Y., & Vanhaverbeke, W. (2011). The influence of scope, depth, and orientation of external technology sources on the innovative performance of Chinese firms. *Technovation, 31*(8), 362-373.

Chesbrough, H. (2003). *Open innovation : the new imperative for creating and profiting from technology*. Boston, Mass.: Harvard Business School Press.

Chesbrough, H., & Bogers, M. (2014). Explicating open innovation: clarifying an emerg- ing paradigm for understanding innovation. In H. Chesbrough, W. Vanhaverbeke & J. West (Eds.), *New Frontiers in Open Innovation*. Oxford, UK: Oxford University Press.

Chesbrough, H., & Brunswicker, S. (2013). Managing Open Innovation in Large Firms. Stuttgart: Fraunhofer Institute for Industrial Engineering.

Chesbrough, H., Vanhaverbeke, W., & West, J. (2006). *Open innovation : researching a new paradigm*. Oxford: Oxford University Press.

Chiang, Y. H., & Hung, K. P. (2010). Exploring open search strategies and perceived innovation performance from the perspective of inter-organizational knowledge flows. *R & D Management, 40*(3), 292-299.

Cohen, W. M., & Levinthal, D. A. (1990). Absorptive-Capacity - a New Perspective on Learning and Innovation. *Administrative Science Quarterly, 35*(1), 128-152.

Cooper, A. C. (1979). Strategic management: New ventures and small business. In D. E. Schendel & C. W. Hofer (Eds.), *Strategic Management: A New View of Business Policy and Planning* (pp. 316-327). Boston: Little, Brown and Company.

Cosh, A., & Zhang, J. J. (2011). Open Innovation Choices: What Is British Enterprise Doing? Cambridge, UK: Centre for Business Research.

Covin, J. G., & Slevin, D. P. (1989). Strategic Management of Small Firms in Hostile and Benign Environments. *Strategic Management Journal, 10*(1), 75-87.

Cyert, R. M., & March, J. (1963). *The behavioral Theory of the Firm*. Englewood Cliff, NJ: Prentice Hall.

Dahlander, L., & Gann, D. M. (2010). How open is innovation? *Research Policy, 39*(6), 699-709.

Dosi, G. (1982). Technological Paradigms and Technological Trajectories - a Suggested Interpretation of the Determinants and Directions of Technical

Change. *Research Policy, 11*(3), 147-162.

Dyer, J. H., & Singh, H. (1998). Strategic supplier segmentation: The next "best practice" in supply chain management. *California Management Review, 40*(4), 660-679.

Edwards, T., Delbridge, R., & Munday, M. (2005). Understanding innovation in small and medium-sized enterprises: a process manifest. *Technovation, 25*(10), 1119-1127.

Enkel, E., Gassmann, O., & Chesbrough, H. (2009). Open R&D and open innovation: exploring the phenomenon. *R & D Management, 39*(4), 311-316.

Field, A. (2009). *Discovering Statistics Using SPSS* (3rd ed.). London: Sage.

Fiorito, S. S., & LaForge, R. W. (1986). A marketing strategy analysis of small retailers. *American Journal of Small Business Management, 10*(4), 7-17.

Freel, M. S. (2000). Do small innovating firms outperform non-innovators? *Small Business Economics, 14*(3), 195-210.

Gassmann, O., Enkel, E., & Chesbrough, H. (2010). The future of open innovation. *R & D Management, 40*(3), 213-221.

Gronum, S., Verreynne, M.-L., & Kastelle, T. (2012). The role of Networks in small and medium-sized enterprise innovation and firm performance. *Journal of Small Business Management, 50*(2), 257-282.

Henkel, J. (2006). Selective revealing in open innovation processes: The case of embedded Linux. *Research Policy, 35*(7), 953-969.

Huizingh, E. K. R. E. (2011). Open innovation: State of the art and future perspectives. *Technovation, 31*(1), 2-9.

Hung, K. P., & Chou, C. (2013). The impact of open innovation on firm performance: The moderating effects of internal R&D and environmental turbulence. *Technovation, 33*, 368-380.

Kang, K. N., & Park, H. (2012). Influence of government R&D support and inter-firm collaborations on innovation in Korean biotechnology SMEs. *Technovation, 32*(1), 68-78.

Kim, H., & Park, Y. (2010). The effects of open innovation activity on performance of SMEs: the case of Korea. *International Journal of Technology Management, 52*(3-4), 236-256.

Kitchell, S. (1997). CEO characteristics and technological innovativeness: A Canadian perspective. *Canadian Journal of Administrative Sciences-Revue Canadienne Des Sciences De L Administration, 14*(2), 111-125.

KOITA. (2009). *Major Indicators of Industrial Technology*. Seoul: Korean Industrial Technology Association.

Lasagni, A. (2012). How can external relationships enhance innovation in SMEs? New evidence for Europe. *Journal of Small Business Management, 50*(2), 310-339.

Laursen, K., & Salter, A. (2006). Open for innovation: The role of openness in explaining innovation performance among UK manufacturing firms. *Strategic Management Journal, 27*(2), 131-150.

Laursen, K., & Salter, A. J. (2014). The paradox of openness: Appropriability, external search and collaboration. *Research Policy, 43*(5), 867-878.

Lee, S., Park, G., Yoon, B., & Park, J. (2010). Open innovation in SMEs-An intermediated network model. *Research Policy, 39*(2), 290-300.

Mazzola, E., Bruccoleri, M., & Perrone, G. (2012). The effect of inbound, outbound

and coupled innovation on performance. *International Journal of Innovation Management, 16*(06).

Mention, A.-L. (2011). Co-operation and co-opetition as open innovation practices in the service sector: Which influence on innovation novelty? *Technovation, 31*(1), 44-53.

Miller, D., & Toulouse, J. (1986). Strategy, Structure, CEO Personality and Performance in Small Firms. *American Journal of Small Business, Winter*.

Minshall, T., Mortara, L., Valli, R., & Probert, D. (2010). Making "Asymmetric" Partnerships Work. *Research-Technology Management, 53*(3), 53-63.

Mortara, L., & Minshall, T. (2011). How do large multinational companies implement open innovation? *Technovation, 31*(10-11), 586-597.

Mortara, L., Napp, J., Ford, S., & Minshall, T. (2011). Open innovation activities to foster corporate entrepreneurship. In L. Cassia, T. Minola & S. Paleari (Eds.), *Entrepreneurship and Technological Change*. Cheltenham, UK: Edward Elgar.

Myers, R. (1990). *Classical and modern regression with applications* (2nd ed.). Boston, MA: Duxbury.

Narula, R. (2004). R&D collaboration by SMEs: new opportunities and limitations in the face of globalisation. *Technovation, 24*(2), 153-161.

Nelson, R., & Winter, S. (1982). *An Evolutionary Theory of Economic Change*. Cambridge, MA: Belknap Harvard Press.

Nooteboom, B. (1994). Innovation and Diffusion in Small Firms - Theory and Evidence. *Small Business Economics, 6*(5), 327-347.

Norton, E. C., Wang, H., & Ai, C. (2004). Computing interaction effects and standard errors in logit and probit models. *Stata Journal, 4*, 154-167.

Oakey, R. P. (2013). Open innovation and its relevance to industrial research and development: The case of high-technology small firms. *International Small Business Journal, 31*(3), 319-336.

OECD. (1997). Proposed guidelines for collecting and interpreting technological innovation data: the Oslo Manual. Paris: OECD.

Parida, V., Westerberg, M., & Frishammar, J. (2012). Inbound Open Innovation Activities in High-Tech SMEs: The Impact on Innovation Performance. *Journal of Small Business Management, 50*(2), 283-309.

Podmetina, D., Fiegenbaum, I., Teplov, R., & Albats, E. (2014). *Towards open innovation measurement system - a literature review*. Paper presented at the The XXV ISPIM Conference on 8-11 June 2014, Dublin, Ireland.

Rhee, J., Park, T., & Lee, D. H. (2010). Drivers of innovativeness and performance for innovative SMEs in South Korea: Mediation of learning orientation. *Technovation, 30*(1), 65-75.

Rosenberg, N. (1994). *Exploring the Black Box: Technology, Economics, and History*. Cambridge: Cambridge University Press.

Rosenberg, N., & Steinmueller, W. E. (1988). Why Are Americans Such Poor Imitators. *American Economic Review, 78*(2), 229-234.

Rothwell, R., & Dodgson, M. (1991). External Linkages and Innovation in Small and Medium-Sized Enterprises. *R & D Management, 21*(2), 125-137.

Rothwell, R., & Dodgson, M. (1994). Innovation and size of firm. In M. Dodgson (Ed.), *Handbook of Industrial Innovation* (pp. 310-324). Aldershot: Edward Elgar.

Salter, A., Cricuolo, P., & Ter Wal, A. (2014). Coping with Open Innovation:

Responding to the Challenges of External Engagement in R&D. *California Management Review, 56*(2), 77-94.

Schroll, A., & Mild, A. (2012). A critical review of empirical research on open innovation adoption. *Journal fur Betriebswirtschaft, 62*, 85-118.

Spithoven, A., Clarysse, B., & Knockaert, M. (2011). Building absorptive capacity to organise inbound open innovation in traditional industries. *Technovation, 31*(1), 10-21.

Spithoven, A., Vanhaverbeke, W., & Roijakkers, N. (2013). Open Innovation Practices in SMEs and Large Enterprises. *Small Business Economics, 41*(3).

Teece, D. J. (1980). Economies of Scope and the Scope of the Enterprise. *Journal of Economic Behavior & Organization, 1*(3), 223-247.

Teece, D. J. (1982). Toward an economic theory of the multiproduct firm. *Journal of Economic Behaviour and Organisation, 3*(1), 39-63.

Teece, D. J. (1986). Profiting from Technological Innovation - Implications for Integration, Collaboration, Licensing and Public-Policy. *Research Policy, 15*(6), 285-305.

Teece, D. J. (1996). Firm organization, industrial structure, and technological innovation. *Journal of Economic Behavior & Organization, 31*(2), 193-224.

Teece, D. J., Pisano, G., & Shuen, A. (1997). Dynamic capabilities and strategic management. *Strategic Management Journal, 18*(7), 509-533.

Tennenhouse, D. (2004). Intel's open collaborative model of industry-university research. *Research-Technology Management, 47*(4), 19-26.

Van de Vrande, V., De Jong, J. P. J., Vanhaverbeke, W., & De Rochemont, M. (2009). Open innovation in SMEs: Trends, motives and management challenges. *Technovation, 29*(6), 423-437.

Van Dijk, B., den Hartog, R., Menkveld, B., & Thurk, R. (1997). Some new evidence on the determinants of large- and small-firm innovation. *Small Business Economics, 9*, 335-343.

Vanhaverbeke, W., Vermeersch, I., & De Zutter, S. (2012). Open innovation in SMEs: how can small companies and start-ups benefit from open innovation strategies? Leuven, Belgium: Flanders District of Creativity.

West, J., & Bogers, M. (2013). Leveraging external sources of innovation: a review of research on open innovation. *Journal of Product Innovation Management, Forthcoming*.

West, J., & Gallagher, S. (2006). Challenges of open innovation: the paradox of firm investment in open-source software. *R & D Management, 36*(3), 319-331.

Zahra, S. A., & George, G. (2002). Absorptive capacity: A review, reconceptualization, and extension. *Academy of management Review, 27*(2), 185-203.

Zeng, S. X., Xie, X. M., & Tam, C. M. (2010). Relationship between cooperation networks and innovation performance of SMEs. *Technovation, 30*(3), 181-194.

Appendix: Pearson correlation table

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1. In-sourcing	1																		
2. Joint R&D	.227**	1																	
3. M&A/Strategic alliance	.278**	.264**	1																
4. User involvement	.084	.076	.117	1															
5. Licensing-out	.199**	.044	.387**	.154*	1														
6. Spin-off	.099	.093	.220**	.179**	.192**	1													
7. Open-sourcing	.213**	.077	.311**	.277**	.320**	.246**	1												
8. Other firms	.080	.189**	.098	.154*	.077	.233**	.235**	1											
9. Suppliers	.116	.213**	.170**	.260**	.045	.108	.161*	.391**	1										
10. Customers/client	.124	.105	.111	.343**	.096	.170**	.201**	.363**	.514**	1									
11. Affiliated firms	.101	.215**	.193**	.045	.096	.291**	.157*	.299**	.245**	.267**	1								
12. Consultancy/intermediary	.127	.215**	.082	.113	.044	.069	.064	.389**	.425**	.327**	.334**	1							
13. Universities	.102	.523**	.166*	-.058	.148*	.056	.046	.368**	.237**	.185**	.212**	.379**	1						
14. Research institutes	.221**	.516**	.140*	.121	.046	.162*	.042	.361**	.311**	.330**	.221**	.434**	.562**	1					
15. Firm size	.105*	.069	.121	-.008	.053	.080*	.133*	.010	.021	.024	.123	.025	-.140*	-.023	1				
16. R&D intensity	.123*	.028	.134+	-.041*	.097*	.088	.036	.126	.094	.076	-.035	.111	.143*	.064	.318**	1			
17. Firm age	.047	-.105	.020	-.001	.071	.028	-.013	-.050	-.107	-.067	-.038	-.065	-.128	-.071	.382**	.223**	1		
18. Market turbulence	-.063	-.093	-.056	.015+	-.005	.049	.026	-.071	-.119	-.115	-.068	-.138*	-.126	-.167*	.013	-.068	.089	1	
19.Government support	.243**	.547**	.197**	.086	.013	.100	.164*	.278**	.186**	.151*	.188**	.220**	.403**	.430**	.024	.069	-.152*	-.122	1

** Correlation is significant at the 0.001 level (2-tailed) / * Correlation is significant at the 0.05 level (2-tailed) / + Correlation is significant at the 0.1 level (2-tailed) / Bootstrap results are based on 1,000 bootstrap samples.

Variables: (2~7) the adoption frequency of each open innovation mode / (8~14) the frequency of collaboration with each partner

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Internal Capabilities and External Knowledge Sourcing for Product Innovation in LMT SMEs

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Abstract: Low- and medium-tech small and medium-sized enterprises (LMT SMEs) constitute a large and important segment in European economies. Because of increasingly international competition, LMT SMEs must rely on innovation to strengthen their competitive position over time. In this study, we empirically analyze possible complementarity or substitutability between internal capabilities and external knowledge sourcing. Using a short panel of 142 Dutch LMT SMEs, we find empirical evidence that suggests a negative interplay between internal capabilities and external knowledge sourcing.

Keywords: Low-tech and Medium-tech Small Sectors, Medium-Sized Enterprises, Open Innovation, Innovation Strategy.

1. Introduction

One may distinguish two dominant approaches to achieving innovation: the first approach views a firm's internal capabilities as the primary drivers of innovation (Dosi, 1982), while the second approach views innovation as driven by a firm's external partnerships (von Hippel, 1998). The theory of open innovation (Chesbrough, 2003) considers that firms cannot longer afford to rely exclusively on internal innovative capabilities to cope with today's global market challenges, but rather need to engage in external knowledge sourcing to ensure survival in nowadays economy where technology shifts occur at an increasingly rapid pace. Open innovation then implicitly posits complementarity between a firm's internal capabilities and external knowledge sourcing (e.g., Cassiman and Valentini, 2011). A key pre-condition to open innovation is that firms dispose of absorptive capacity to internalize external knowledge (e.g., Vanhaverbeke et al., 2008). Absorptive capacity has been defined as a firm's "ability to recognize the value of new information, assimilate it, and apply it to commercial ends" (Cohen and Levinthal, 1990, p.128).

Since its introduction, the concept of open innovation has received considerable coverage in the business management literature (e.g., Cassiman and Valentini, 2011; Chesbrough et al., 2006; Hagedoorn and Ridder, 2012; Laursen and Salter, 2006; Mazzola et al., 2012; Mention, 2011; Mention and Asikainen, 2012). Empirical evidence to support the importance of open innovation has been mainly concentrated on so-called high technology industries, e.g., computers, information technology, and pharmaceuticals (Chesbrough et al., 2006). Additionally, open innovation has been studied mostly in multinational enterprises, of which most have large internal R&D departments (Vanhaverbeke et al., 2012). In this context, empirical evidence has indicated that internal capabilities and external knowledge sourcing are complements

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rather than substitutes (e.g., Chesbrough, 2003; Chesbrough et al., 2006; Denicolai et al., 2014; Laursen and Salter, 2006), suggesting that the greater the internal capabilities of the firm, the greater the effect of external knowledge sourcing on innovative performance.

Despite this considerable attention, research on open innovation in small medium-sized enterprises in low- and medium-technology industries (henceforth, LMT SMEs) has remained scarce and therefore it remains an open question whether the concepts of open innovation can be readily applied (Vanhaverbeke et al., 2012). It may be that open innovation practices do not hold in the context of LMT SMEs because of their specific innovation pattern.

LMT SMEs are not at the forefront of innovation when compared to their counterparts in high-tech sectors. LMT industries are depicted as being characterized by process, organizational and marketing innovations, by weak internal innovation capabilities and by strong dependence on external sources of knowledge (Heidenreich, 2009). Hirsch-Kreinsen (2008) allocates the degree of novelty of innovations in LMT sectors, as somewhere between incremental and architectural in nature. For these firms, innovations are usually the outcome of recognizing new market opportunities, with technology push innovations only playing a minor role (Vanhaverbeke et al., 2012).

The goal of this study is to contribute to the empirical literature by advancing and testing the implicit complementarity connected to open innovation in the context of LMT SMEs. We examine the nature of the relationship between a firm's internal capabilities i.e., technological and marketing-related and external knowledge sourcing. To test our hypotheses, we rely on four innovation surveys conducted by a not-for-profit innovation intermediary in the Netherlands that correspond to the years: 2000 to 2003. From these four waves we constructed an unbalanced panel of 142 Dutch LMT SMEs.

The study is structured as follows: in the next section, we review the literature on LMT SMEs and open innovation and present the theoretical arguments for our research hypotheses. We then go on to provide information on the database and methodological approach, followed by the empirical results obtained. Finally, we draw some conclusions and discuss the policy implications and limitations of our research.

2. Literature background and hypotheses

The OECD distinguishes four different categories of industries on the basis of the technology intensity (Hatzichronoglou, 1997). Industry sectors with an R&D intensity of more than 5% are classed as high technology and those with an R&D intensity between 3% and 5% as medium-high technology. Industry sectors with an R&D intensity of between 3% and 0.9% are classified as medium-low technology and those with an R&D intensity below 0.9% as low-technology. The latter two are generally referred to as low- and medium-technology (LMT).

LMT industry sectors play an important role in industrialized economies as they provide more than 90% of output[1] (as a result, their contribution to aggregate growth is likely to largely outweigh that of high technology sectors) and account for over 60% of employment in the manufacturing sector (e.g., Hirsch-Kreinsen, 2008; Robertson, Smith and von Tunzelmann, 2009). LMT firms in Europe are mostly

[1] European Union, the USA and Japan

small- and –medium sized enterprises and they constitute a large and significant segment in European economies (e.g., Hirsch-Kreinsen et al., 2003; Hirsch-Kreinsen, 2008; Potters, 2009).

LMT SMEs are a highly heterogeneous population in terms of their technology base, industry classification, internal capabilities and their position in the value added chain (e.g., Hirsch-Kreinsen, 2013). LMT SMEs by their very nature are characterized by a low R&D activity and predominantly include mature industries, such as the manufacture of household appliance, food processing, paper, printing and publishing, wood and furniture, metal and plastic products industries (e.g., Hirsch-Kreinsen et al., 2008).

Given the growing international competition, LMT SMEs must rely on innovation to strengthen their competitive position over time (e.g., Hirsch-Kreinsen, 2008; Morrison, 2011). Literature has distinguished two main types of innovation activity: process and product innovation. A process innovation is defined as the implementation of a new or significantly improved production or delivery method employed to produce a product or service, whereas a product innovation is the commercial introduction of a good or service new or significantly improved with respect to its technology (OECD, 2005). Process and product innovations are two valuable but distinct activities. On one hand, process innovation can lead to improved flexibility and increased capacity of production, reduced costs of labour, materials and energy (Heidenreich, 2009). On the other hand, product innovation enables firms to accomplish product differentiation, whereby an increased range of products and hence new markets can be attained (Wziatek-Kubiak, 2008). By adopting a product differentiation approach, firms seek to distinguish their products from competitors, where quality upgrading and novel characteristics and functionalities can be regarded as differentiating attributes (e.g., Morrison, 2011; von Tunzelmann and Acha, 2006).

A number of studies have stressed the considerable importance of process innovation for firms in LMT sectors (e.g., Heidenreich, 2009; Kierner et al., 2008). The main argument behind is that factors, such as cost competition and economies of scale, are much more prevalent in LMT industries. Then, a logical step for many LMT SMEs would be to focus, by large, on process innovation rather than on product innovation. By this means, firms are able to cut costs quickly and improve their efficiency. However, studies have revealed that LMT firms achieve a significant growth in income from new and technological changed products that have considerable aggregate impact (IMP3rove II study, 2011; Robertson et al., 2009). Increasingly, LMT firms are strategically expanding the share of complex and customized products as a specific strategy of competing with companies from low-cost countries (Hirsch-Kreinsen, 2008). Moreover, by increasing the degree of novelty of innovation in products, LMT firms can improve their competitive advantage and create opportunities to access new market segments ahead of competitors (e.g., Amara et al., 2008; Wziatek-Kubiak, 2008).

LMT firms are not at the forefront of innovation when compared to their counterparts in high-tech sectors. Hirsch-Kreinsen (2008) places the degree of novelty of innovations, in LMT environments, as somewhere between incremental and architectural in nature. For Hirsch-Kreinsen, incremental innovations are reflected in the step-by-step product development path, which is characterized by the constant further improvement of individual components concerning their material, their function and their quality, however the structure and the technological principles of the products remain unaffected. On the contrary, for Hirsch-Kreinsen, architectural innovations are direct and specific customer-oriented and their main feature is the continual reconfiguration of individual components for the development of new products that can meet special customer requirements and open up new market segments. In LMT industries, innovations that are new to a market segment (or

market niche) are often the result of changes in the overall design of a product or the way its components interact with each other (e.g., Hirsch-Kreinsen, 2008).

Given the shortening of product life cycles, the multidisciplinary nature of many technologies and the growing complexity of knowledge processes, firms are increasingly engaging in external knowledge sourcing to supplement their internal capabilities (e.g., Brunswicker and Vanhaverbeke, 2014; Chesbrough, 2003; Chesbrough et al., 2006). The role of external knowledge sourcing as a determinant of innovation has been underlined by the theory of open innovation (Chesbrough, 2003). At the core of the theory of open innovation is that, firms can gain valuable knowledge for innovation from a wide range of distributed external sources of knowledge. Firms may engage in open innovation in two ways: (1) Inbound open innovation, and (2) Outbound open innovation (Chesbrough and Crowther, 2006). Inbound open innovation refers to inward technology transfer, where firms monitor their environment to source technology and knowledge into their internal knowledge base. Outbound open innovation, in contrast, refers to outward technology transfer, where firms look for external organizations that are better suited to commercialize a given technology (Lichtenthaler, 2009).

In the context of low-tech or mature industries, inbound open innovation has been shown to be prevalent over outbound open innovation (e.g., Chesbrough and Crowther, 2006; Chiaroni et al., 2010; Tsai and Wang, 2009). For LMT firms, it has been customary to consider specialized suppliers as the most important cooperation partners and the main external sources of knowledge for innovation activities (Hirsch-Kreinsen, 2008). As a consequence, we would expect external actors, such as, customers, competitors, universities and knowledge institutions to have a limited role in LMT SMEs' inbound open innovation activities. This challenges the assumption from an open innovation perspective that LMT SMEs' innovate performance relies on different external knowledge sourcing modes (Vanhaverbeke, 2006). Moreover, depending heavily on suppliers for critical knowledge may pose substantial risks (Fine and Whitney, 1996).

Although their relative importance may vary from enterprise to enterprise and from sector to sector, innovation depends, to one degree or another, on externally generated technological and market knowledge (e.g., Amara and Landry, 2005; Bender, 2008; Grimpe and Sofka, 2009; Hervas-Oliver et al., 2012; Laursen and Salter, 2006; Robertson and Smith, 2008). Technological and market knowledge can increase a firm's ability to discover and exploit opportunities e.g., to recognize wants and needs in the marketplace and to determine a product's optimal design and market value of new scientific discoveries (Wiklund and Shepherd, 2003). Technological knowledge is largely associated with university research and specialized suppliers (Laursen and Salter, 2006), while market knowledge is linked to customers and competitors (Grimpe & Sofka, 2009; Li and Calantone, 1998). Applying the concepts of open innovation, we anticipate that LMT SMEs that tap on external knowledge-be it technological or market-will be more likely to develop product innovations with a higher degree of novelty. Taken together, these arguments suggest the following hypotheses:

> *Hypothesis 1: External sources of market knowledge (customers and competitors) will have a positive impact on a LMT SME's innovative performance.*
>
> *Hypothesis 2: External sources of technology knowledge (universities and suppliers) will have a positive impact on a LMT SME's innovative performance.*

Having access to external knowledge stocks is recognized as a necessary but not sufficient condition for value delivery (Dierickx and Cool, 1989). It is only when

knowledge is properly deployed via the firm's capabilities that superior organizational performance can be developed (Day, 1994). Previous research suggests that there are firm-specific capabilities that affect the value that a firm derives from external knowledge sourcing (Su et al., 2009; Vega-Jurado et al., 2009). More specifically, a firm's technological and marketing capabilities affect its ability to identify and explore external knowledge sourcing opportunities (e.g., Su et al., 2009).

Technological capability refers to as a stock of technological knowledge that a firm accumulates over time (e.g., Srivastava and Gnyawali, 2011; Wu, 2014). One of the key components of a firm's technological capability is absorptive capacity, which refers to its ability to identify, assimilate and utilize external technological knowledge (e.g., Cohen and Levinthal, 1990; Jo and Lee, 2014). Building technological capability requires firms to invest substantial resources in R&D (Zhou and Wu, 2010). As a result, the accumulation of technological knowledge increases the firm's ability to engage in product innovations beyond the current technological boundaries. In the context of LMT SMEs, internal R&D activities and consequent technological capabilities are expected to be conducive to the introduction of architectural innovations, which Hirsch-Kreinsen (2008) characterizes as the recombination of existing components in order to obtain a new product design.

In the debate on LMT industry innovations, it is often assumed that external sources of knowledge are considerable important and that these compensate for lower levels of internal R&D activities. At lower levels of technological capability, specialized suppliers and universities may constitute the main sources of technological knowledge generation. Universities or research institutes may represent a viable alternative to gain technological knowledge, as LMT SMEs may have access to the expertise of the academic staff and technical facilities they need for new product development (George et al., 2002). A similar alternative to gain technological knowledge may be through highly specialized suppliers, as LMT SMEs may have access to their in-depth technical knowledge of individual components (e.g., Cui and Loch, 2011; Lee and Veloso, 2008). Therefore, we anticipate that LMT SMEs may opt to substitute their relatively little R&D and technological capabilities for external sources of technological knowledge. We therefore hypothesize:

> *Hypothesis 3: At lower levels of technological capability, universities and suppliers (external sources of technological knowledge) become a substitute for the in-house R&D performed.*

Marketing capability is related to a firm's ability to integrate knowledge pertaining to customers' current and potential needs for new products and knowledge about competitors' products and strategies to take advantage of market opportunities (e.g., Su et al., 2009). A review of the literature shows the debate whether market knowledge fosters or hinders innovation. Empirical evidence on this topic has varied; some indicating that having a strong customer and competitor orientation may lead to imitations and incremental innovation in products (e.g., Atuahene-Gima, 1995; Christensen & Bower 1996; Lukas & Ferrell, 2000). This might hold true particularly for technology-driven industries, where it is assumed that a strong focus on R&D is required for truly innovative products. But, in certain sectors, where innovation is not solely about technology but is rather a market-driven process, market knowledge might directly contribute to the increase of the share of sales of new products, regardless the level of R&D expenditure (e.g., Kirner et al., 2009). More specifically, in the context of LMT industries, the exploration and understanding of markets and the use of market information to shape the creation of new products, taking advantage of market niches, are central to innovation (e.g., Grimpe and Sofka, 2009; Hirsch-Kreinsen, 2008; Robertson and Smith, 2008).

Marketing capability may enable LMT SMEs to leverage customer-related market

knowledge as their needs can be identified, elaborated and translated into new product specifications (e.g., Hauser and Clausing, 1988; Li and Calantone, 1998; Song et al., 2005; von Hippel et al., 1999; Yassine and Wissmann, 2007). Additionally, marketing capability may enable LMT SMEs to leverage competitor-related market knowledge to enhance its understanding about market conditions that can be used to create products or marketing programs that are differentiated from those of competitors (e.g., Im and Workman, 2004; Wu, 2014). We anticipate a synergy effect between marketing capability and external market knowledge. Thus, the following hypothesis is proposed:

> *Hypothesis 4: Marketing capability and customers and competitors (external sources of market knowledge) are complements, thus having a positive impact on a LMT SME's innovative performance.*

3. Data, Methods and Sample Description

For our empirical analysis, we rely on four innovation surveys conducted by Syntens a not-for-profit innovation intermediary in the Netherlands that correspond to the years: 2000-2001-2002-2003. From these four waves we construct an unbalanced panel of Dutch SMEs since not all firms responded throughout the four years. A firm is included within the 4-year panel if, and only if, it consecutively answered the survey for at least two years.

Our final dataset consists of an unbalanced panel of 250 observations on 142 LMT SMEs. The percentage distribution of LMT SMEs across the different industries is as follows: Manufacture of Food and Beverages (9%); Manufacture of Wood and Products of Woods (4%); Publishing and Printing (5%); Manufacture of Rubber and Plastic Products (5%); Manufacture of Non-Metallic Mineral Products (5%); Manufacture of Basic Metal (3%); Manufacture of Fabricated Metal Products, except machinery and equipment (29%); Manufacture of Machinery and Equipment (12%); Manufacture of Furniture (6%); and Construction (21%).

3.1. Measures

Our dependent variable is *innovative performance*, reflected in product innovations that were successfully introduced by a firm into the market. New product development is a quite common measure of firm's innovation performance in open innovation literature (Mazzola et al., 2015). It provides an indication of a firm's innovative performance, as it shows how well a firm succeeded in introducing a new technological product into the market (e.g., Brouwer and Kleinknecht, 1999). Variable *innovative performance* is estimated as the percentage of turnover resulted from new to market product innovations.

3.2. Hypothesis testing variables

A first group of focal variables captures a LMT SME's internal capabilities. Prior studies (Wu and Wu, 2013; Wu, 2014) have used R&D intensity as a measure of a firm's technological capability, suggesting that firms that invest more in R&D, are considered to have greater technological capabilities. We follow that lead by using the ratio of internal R&D spending to total sales as a measure of the variable *technological capability*. Following previous studies (Wang et al., 2011), the variable *marketing capability* is measured as a LMT SME's marketing intensity (the share of annual expenditure incurred in marketing in sales). A second group of focal variables captures a LMT SME's inbound open innovation activities. The variable *external business knowledge* measures the variety of external sources of business knowledge:

customers and competitors. The variable *external technological knowledge* reflects the variety of external sources of technological knowledge: universities and suppliers. These variables can take integral values between 0 and 2 respectively, because a firm can use up to two different external sources, including clients and/or competitors for business knowledge and universities and/or suppliers for technological knowledge.

3.3. Control variables

We include a number of firm-level variables to control for the effect of own R&D efforts as well as the impact of incoming knowledge spillovers that are not due to external knowledge sourcing. The first control variable is *firm size* (the logarithm of the number of employees). In addition, we include the variable *human capital* (share of employees with a university degree) and the variable *purchased R&D-related intensity* (as share of annual expenditure incurred in the acquisition of other external knowledge in sales e.g., machinery, equipment, software). We include the lagged dependent variable *innovative performance* as a control variable, as we expect a firm's innovative performance to be largely determined by its past performance. In addition, the LMT SME's past innovative performance controls for unobserved heterogeneity. An additional control variable includes *training* (share of annual expenditure incurred in employee training in sales). Further control variables include a set of 2-digit industry dummies (we distinguish 10 LMT manufacturing sectors) and 4 time dummies with 2000 as the base year. Table 1 shows descriptive statistics and pairwise correlations for the variables used.

3.4. Statistical method

Our statistical method is determined by the nature of our dependent variable, *innovative performance* and by the fact that we use an unbalanced panel dataset. The underlying dependent variable can take values from 0 to 1, as the share of new to the market products in sales is nonnegative. Given the left and right censoring in the dependent variable, the Tobit model, also called a censored regression model, is applicable. Since the panel data is highly unbalanced (as only 25% of the LMT SMEs are observed for two years or more), a fixed-effects model is not preferable. In these circumstances we apply a Tobit analysis, which is also assumed to allow for unobserved firm heterogeneity.

4. Results

Table 1 indicates that the average annual internal R&D intensity is 0.60%. Additionally, 7.2% of the SMEs' sales refer to products that were introduced to new markets. The average firm in our sample consists of 26 employees and on average 14% of its workforce possesses university degrees. Following the standard definition used by the European Commission, all firms of the sample can be considered SMEs as they have less than 250 employees, their turnovers do not exceed EUR 50 million and their assets are valued at under EUR 43 million. Additionally, in accordance to previous studies (e.g., Nieto and Santamaria, 2007), no distinction was made between innovating and non-innovating firms, since such a distinction could give rise to a biased result.

Table 1. Descriptive statistics and pairwise correlations

	Mean	S.D.	1	2	3	4	5	6	7	8	9
1 Innovative performance *	0.072	0.160	1								
2 Innovative performance	0.085	0.216	0.575								
3 Technological capability	0.006	0.013	0.273	0.183							
4 Marketing capability	0.009	0.019	0.248	0.147	0.083						
5 External market knowledge	0.858	0.349	0.127	0.079	0.077	0.052					
6 External technological knowledge	1.439	0.845	0.169	0.085	0.157	0.207	0.400				
7 Human capital	0.143	0.227	0.197	0.274	0.243	0.375	0.050	0.232			
8 Training	0.002	0.005	0.126	0.051	0.069	0.170	0.125	0.145	0.189		
9 Firm size	2.693	1.112	0.004	-0.100	-0.044	-0.210	0.147	0.138	-0.357	-0.053	
10 Purchased R&D-related intensity	0.023	0.071	-0.004	-0.022	0.011	-0.063	0.050	0.046	-0.048	0.018	0.008

Notes: The descriptive statistics are sample means for the years 2000-2003. The number of observations is 250. All time-variant explanatory variables are in t-1. Absolute values of the correlation coefficient of 0.138 or higher are significant at the 5% significance level.

Table 2. Tobit regression results for external market, and external technological knowledge and LMT SME's innovation performance

	Model I	**Model II**	**Model III**
Intercept	-0.217***	-0.312***	-0.450***
	(0.067)	(0.073)	(0.094)
Innovative performance lagged	0.497***	0.5000***	0.437***
	(0.077)	(0.650)	(0.063)
Human capital	0.089	-0.035	-0.087
	(0.097)	(0.0853)	(0.086)
Training	3.581	3.145	2.889
	(2.926)	(2.753)	(2.683)
Firm size	0.310*	0.028*	0.025*
	(0.018)	(0.015)	(0.014)
Purchased R&D-related intensity	0.208	0.098	0.026
	(0.210)	(0.196)	(0.190)
Technological capability		3.528***	8.725***
		(1.070)	(2.807)
Marketing capability		2.103**	13.533***
		(0.836)	(3.998)
External market knowledge		0.101*	0.236**
		(0.056)	(0.086)
External technological knowledge		0.007	0.028
		(0.019)	(0.213)
Interactions terms			
Market knowledge x marketing capability			-2.846**
			(1.489)
Technological knowledge x technological capability			-11.758***
			(3.996)
Log Likelihood	-29.696	-18.758	-7.837
LR test (II vs. I; III vs. II)		21.88***	21.84***
Sigma	0.190(0.02)	0.176(0.02)	0.147(0.02)
Left-censored obs.	158	158	158
Right-censored obs.	3	3	3

Notes: Standard errors in parenthesis, *p < 0.1, **p < 0.05, ***p < 0.01. All samples are estimated on a sample of 250 observations for 142 LMT SMEs. All models include 3 time dummies and 9 industry dummies.

Model (I) contains regression results incorporating the control variables,

manufacturing sector and year dummies only. Results show that *innovative performance* ($p < 0.01$) and firm *size* ($p < 0.10$) have a significant and positive effect on innovative performance. Regarding the industries dummies, the industry effects together are jointly significant ($p < 0.10$). Additionally results show a negative significance for Publishing and Printing ($p < 0.05$), Wood and Products of Woods ($p < 0.10$) compared to the reference sector Food and Beverages. Firms from these sectors seem to innovate less. Whereas, for Rubber and Plastic Products, Machinery and Equipment and Fabricated Metal Products ($p < 0.05$), show a positive significance compared to the reference sector.

Model (II) shows regressions results including technological and marketing capabilities, as well as external sources of business and technological knowledge. Control variables at firm level, manufacturing sector and year dummies were included. Results show significant and positive effects on the innovative performance for *technological capability* ($p < 0.01$), *marketing capability* ($p < 0.05$) and *external business knowledge* ($p < 0.10$). The coefficient for *external technological knowledge* and *purchased R&D-related intensity* are statistically not significant. These results support the proposed hypothesis 1) confirming the overall positive contribution of external market knowledge sourcing to firm's innovative performance. These results, contrary to expectations, do not support the proposed hypothesis 2) with regard to the impact of external technology sourcing on LMT SME's innovative performance.

In *Model (III)*, the coefficient for the interaction term *external technical knowledge x technological capability* is negative and statistically significant ($p < 0.01$) whereas for *external business knowledge x marketing capability* is negative and statistically significant ($p < 0.05$). The coefficients for the variables *technological capability*, *marketing capability*, *purchased R&D-related intensity* and *external market knowledge* retain their signs and significance, when the interaction terms are added. These results support the proposed hypothesis 3) confirming that for LMT SMEs external (technological) knowledge sourcing substitutes or compensates for the low in-house R&D and technological capability. These results, however, do not support the proposed hypothesis 4) with regard to the complementarity between marketing capability and external sources of market knowledge.

Table 3 is used for robustness check whether the two types customers and competitors, and the two types universities and suppliers can be aggregated into market and technological knowledge source groups. Table 3 shows significant and positive effects on innovative performance for technological and marketing internal capabilities. We observe that customers and competitors (both sources of market knowledge) have different effects on LMT SME's innovative performance. While the statistical significance of market knowledge inputs from customers is apparent, market knowledge inputs from competitors is statistically not significant. These results suggest that market knowledge for innovation is primarily customer-driven. The knowledge inputs from universities and suppliers (both sources of technological knowledge) appear not to have a statistical significant effect. The coefficient for the interaction term *customers x marketing capability* is statistically not significant, whereas for *competitors x marketing capability* is negative and statistically significant. The coefficients for both interaction terms *universities x technological capability* and *suppliers x technological capability* are statistically not significant. Likelihood ratio tests for Model II is 2.86, and for Model III is 1.28, respectively. This suggests that the aggregation as done in Table 3 is warranted.

Table 3. Tobit regression results for customers, competitors, universities, and suppliers and LMT SME's innovation performance

	Model I	**Model II**	**Model III**
Intercept	-0.217***	-0.278***	-0.379***
	(0.067)	(0.075)	(0.091)
Innovative performance lagged	0.497***	0.489***	0.428***
	(0.077)	(0.640)	(0.061)
Human capital	0.089	-0.039	-0.082
	(0.097)	(0.089)	(0.083)
Training	3.581	3.251	2.721
	(2.926)	(2.618)	(2.539)
Firm size	0.310*	0.029*	0.023*
	(0.018)	(0.016)	(0.015)
Purchased R&D-related intensity	0.208	0.089	0.024
	(0.210)	(0.189)	(0.193)
Technological capability		4.748***	7.525***
		(1.241)	(2.683)
Marketing capability		1.773*	11.523***
		(0.933)	(2.998)
Customers		0.132**	0.089*
		(0.064)	(0.065)
Competitors		-0.066	-0.079
		(0.088)	(0.221)
Universities		-0.046	-0.031
		(0.113)	(0.221)
Suppliers		0.198*	0.252
		(0.184)	(0.388)
Interactions terms			
Customers x marketing capability			-3.460
			(5.094)
Competitors x marketing capability			-13.436***
			(3.962)
Universities x technological capability			-1.058
			(2.086)
Suppliers x technological capability			17.045
			(11.90)
Log Likelihood	-29.696	-17.327	-7.196
LR test (II vs. I; III vs. II)		25.57***	20.26***
Sigma	0.190(0.02)	0.168(0.08)	0.143(0.01)
Left-censored obs.	158	158	158
Right-censored obs.	3	3	3

Notes: Standard errors in parenthesis, *p < 0.1, **p < 0.05, ***p < 0.01. All samples are estimated on a sample of 250 observations for 142 LMT SMEs. All models include 3 time dummies and 9 industry dummies.

5. Conclusions and further research

This study sheds light on the possible complementarity between internal capabilities and external knowledge sourcing defined by the theory of open innovation. To test our hypotheses, we mainly focused on a short panel of 142 Dutch LMT SMEs in the period 2000-2003. In the Netherlands, LMT industries continue to play a key role in the economic development in terms of both employment and value added (OECD, 2013). This underscores the major importance of this sector and makes the Netherlands a very suitable research setting to be able to pick up on the kind of trends we wish to capture.

Our results reveal the importance of technological and marketing capabilities for product innovation and may confirm the view that product innovation in LMT industries is not solely about technology, but is rather a market-driven process. As noted by prior studies (e.g., Hirsch-Kreinsen, 2008) LMT firms may engage in product innovations that are architectural in nature. Architectural innovation is based on the rearrangement of the product's components, aimed not only to meet special customer requirements but also to open up new market segments. Then, this specific type of innovation would involve marketing capabilities for the identification of customer needs and technological capabilities for the functional and technical upgrading of the product's architecture In the case of LMT SMEs, their small-scale R&D may indicate that the nature of internal R&D is largely adaptive and often carried out on an occasional basis. LMT SMEs may initiate occasional R&D when there is a direct demand, primarily aimed at adjusting product specifications to suit niche markets. Product components, for instance, are often improved incrementally with regard to materials, function and quality to accommodate changing customer demands. In the context of LMT SMEs, we suggest that product innovations largely depend upon adaptive technological capability.

With regard to external knowledge sourcing, our findings suggest that externally generated (market) knowledge plays an important role for the development of highly custom-designed products. LMT SMEs provide up-to-date customized product innovations, which are usually developed in close partnership with customers. As the research findings show, externally generated technological knowledge plays a marginal role, which underscores the strong market orientation of product innovation. We find that technological capability and external technology knowledge sourcing are substitutes, leading to a negative relationship between the two. One potential interpretation is that, R&D-related technological capability and external technology knowledge sourcing provides a LMT SME with similar type of knowledge. More specifically, our interpretation is that a LMT SME's efforts on R&D and external technology knowledge sourcing both put emphasis on component-type knowledge. LMT product innovations can be triggered by a change in an individual component (such as size or function) that creates new interactions or new linkages with other components within the product (e.g., Henderson and Clark, 1990; Hirsch-Kreinsen, 2008). Thus, for LMT SMEs component-type knowledge may be generated either by internal R&D or by external technology sourcing.

We find a negative interplay between marketing capability and external market knowledge sourcing. We interpret these results as evidence of liability of smallness and attention-allocation problems. While the possession of market knowledge makes the conditions for superior performance possible, marketing capabilities enable firms to deploy that knowledge (Vorhies et al., 2011). Compared to larger firms, LMT SMEs generally face constraints associated with the shortage of financial, management, and marketing resources. As a consequence, LMT SMEs may fail to integrate new externally generated market knowledge into their existing (market) knowledge base to develop new products. With regard to control variables, most

results are intuitive and in alignment with previous studies, for example, firm size has a positive association with innovative intensity (e.g., Archibugi et al., 1995).

Our results have some relevance for innovation policy. Our findings suggest that, in the case of LMT SMEs, technological and marketing capabilities are particularly effective to increased innovative performance. Policy initiatives should thus attempt to support R&D activities within LMT SMEs. Alternatively, initiatives can include the establishment of specific types of technology intermediaries that help SMEs in traditional sectors to scan the market for emergent technologies, as well as to perform complementary R&D activities if needed. Policies initiatives should also attempt to extend collaboration (open innovation) between LMT SMEs and customers, as well as, advisory and assistance services that help SMEs to capture, analyze, interpret and integrate external market knowledge effectively.

Given the exploratory nature of this study and the relative small sample size, results should be regarded with some caution. The preliminary nature of this empirical study points the way towards further research. Future studies may focus on the integration of external market knowledge in product innovation, in the case of LMT SMEs. Additionally, when LMT SMEs carry out their innovative activities, they often do so without formalized procedures. Future research thus may include these often informal and small-scale innovative activities.

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7. References

Amara, N., & Landry, R. (2005). Sources of information as determinants of novelty of innovation in manufacturing firms: evidence from the 1999 statistics Canada innovation survey. *Technovation*, 25(3), 245-259.

Amara, N., Landry, R., Becheikh, N., & Ouimet, M. (2008). Learning and novelty of innovation in established manufacturing SMEs. *Technovation*, 28(7), 450-463.

Archibugi, D., Evangelista, R., & Simonetti, R. (1995). Concentration, firm size and innovation: evidence from innovation costs. *Technovation*, 15(3), 153-163.

Atuahene-Gima, K. (1995). An exploratory analysis of the impact of market orientation on new product performance. *Journal of Product Innovation Management*, 12(4), 275-293.

Bender, G. (2008). How to grasp innovativeness of organizations: outline of a conceptual tool. In Hirsch-Kreinsen, H. & Jacobson, D. (Eds.) *Innovation in low-tech firms and industries* (pp.25-43), Cheltenham, UK • Northampton, MA, USA: Edward Elgar.

Brouwer, E., & Kleinknecht, A. (1999). Innovative output, and a firm's propensity to patent: An exploration of CIS micro data. *Research Policy,* 28(6), 615-624.

Brunswicker, S., & Vanhaverbeke, W. (2014). Open innovation in small and medium-sized enterprises (SMEs): External knowledge sourcing strategies and internal organizational facilitators. *Journal of Small Business Management*. doi: 10.1111/jsbm.12120.

Cassiman, B., & Valentini, G. (2011). What is open innovation, really? *Unpublished*

Manuscript. Available at:

http://mackinstitute.wharton.upenn.edu/wp-content/uploads/2013/04/Cassiman-Bruno-Valentini-Giovanni_What-Is-Open-Innovation-Really_v2.pdf

Chesbrough, H. (2003). *Open innovation: the new imperative for creating and profiting from technology*. Cambridge, MA: Harvard University Press.

Chesbrough, H. & Crowther, A. K. (2006). Beyond high tech: early adopters of open innovation in other industries. *R&D Management*, 36(3), 229-236.

Chesbrough, H., Vanhaverbeke, W., & West, J. (Eds.) (2006). *Open innovation: Researching a new paradigm*. Oxford: Oxford Univ. Press.

Chiaroni, D., Chiesa, V., & Frattini, F. (2010). Unravelling the process from Closed to Open Innovation: evidence from mature, asset-intensive industries. *R&D Management*, 40(3), 222-245.

Christensen, C. M., & Bower, J. L. (1996). Customer power, strategic investment and the failure of leading firms. *Strategic Management Journal*, 17(3), 197-218.

Cohen, W. M., & Levinthal, D. A. (1990). Absorptive capacity: a new perspective on learning and innovation. *Administrative Science Quarterly*, 35(1), 128-152.

Cui, Z., & Loch, C. (2011). A strategic decision framework for innovation outsourcing. *International Journal of Innovation Management*, 15(5), 899-930.

Day, G. S. (1994). The capabilities of market-driven organizations. *Journal of Marketing,* 58(4), 37-52.

Denicolai, S., Ramirez, M., & Tidd, J. (2014). Creating and capturing value from external knowledge: the moderating role of knowledge intensity. *R&D Management,* 44(3), 248-264.

Dierickx, I., & Cool, K. (1989). Asset stock accumulation and sustainability of competitive advantage. *Management Science,* 35(12), 1504-1511.

Dosi, G. (1982). Technological paradigms and technological trajectories: A suggested interpretation of the determinants and directions of technical change. *Research Policy,* 11(3), 147-162.

IMP3rove II study, (2011). Gaining competitiveness with innovations beyond technology and product: insights from IMP3rove. Europe Innova Innovation Management.

Available at

https://www.improve-innovation.eu/sme/valuable-links/publications/

Fine, C., & Whitney, D. (1996). Is the make-buy decision process a core competence? MIT Center for Technology, Policy, and Industrial Development.

Available at https://esd.mit.edu/esd_books/whitney/pdfs/make_buy.pdf

George, G., Zahra S. A., & Wood, D. R., (2002). The effects of business-university alliances on innovative output and financial performance: a study of publicly traded biotechnology companies. *Journal of Business Venturing,* 17(6), 577-609.

Grimpe, C., & Sofka, W. (2009). Search patterns and absorptive capacity: Low-and high-technology sectors in European countries. *Research Policy*, 38(3), 495-506.

Hagedoorn, J., & Ridder, A.-K. (2012). Open innovation, contracts, and intellectual property rights: an exploratory empirical study. Research Policy Special Issue Conference "Open Innovation: New Insights and Evidence", London, UK (2012).

Hatzichronoglou, T. (1997). Revision of the high-technology sector and product classification. (Working Paper 1997/02). OECD Science (Vol.2), Technology and Industry.

Available at
http://old.econ.ucdavis.edu/faculty/woo/0.BIES-2009-9-24/HongChang/1997%20OECD%20-%20Hatzichronoglou%20-%20classification%20Hi%20tech%20-1.pdf

Hauser, J. R., & Clausing, D. (1988). The House of Quality. *Harvard Business Review*, 66(3), 63-73.

Heidenreich, M., (2009). Innovation patterns and location of European low-and medium-technology industries. *Research Policy*, 38(3), 483-494.

Henderson, R., & Clark, K. (1990). Architectural innovation: the reconfiguration of existing product technologies and the failure of established firms. *Administrative Science Quarterly, Special Issue: Technology, Organizations, and Innovation*, 35(1), 9-30.

Hervas-Olivera, J. L., Albors-Garrigos, J., & Baixauli, J. J. (2012). Beyond R&D activities: the determinants of firms' absorptive capacity explaining the access to scientific institutes in low–medium-tech contexts. *Economics of Innovation and New Technology*, 21(1), 55-81.

Hirsch-Kreinsen, H. (2008). "Low-tech" Innovations. *Industry and Innovation*, 15(1), 19-43.

Hirsch-Kreinsen, H. (2013). "Low-Tech" Research-Revisited. Paper presented at the 35th DRUID Conference, Barcelona, Spain.

Hirsch-Kreinsen, H., Hahn, K., & Jacobson, D. (2008). The Low-Tech Issue. In H. Hirsch-Kreinsen, H. & D. Jacobson, (Eds.) "*Innovation in low-tech firms and industries"* (pp.3-22), Cheltenham, UK • Northampton, MA, USA: Edward Elgar.

Hirsch-Kreinsen, H., Jacobson, D., Laestadius, S., & Smith, K. (2003). "*Low tech industries and the knowledge economy: state of the art and research challenges"*. Paper written within the context of the research project PILOT: Policy and Innovation in Low-Tech.

Available at
http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.110.1684&rep=rep1&type=pdf

Im, S., & Workman Jr,, J. P. (2004). Market orientation, creativity, and new product performance in high-technology firms. *Journal of Marketing*, 68(2), 114-132.

Jo, Y., & Lee, C-Y. (2014). Technological Capability, Agglomeration Economies and Firm Location Choice. *Regional Studies*, 48(8), 1337-1352.

Kirner, E., Kinkel, S., & Jaeger, A. (2009). Innovation paths and the innovation performance of medium-low-technology firms-An empirical analysis of German industry. *Research Policy*, 38(3), 447-458.

Laursen, K., & Salter, A. (2006). Open for innovation: The role of openness in explaining innovation performance among UK manufacturing firms. *Strategic Management Journal*, 27(2), 131-150.

Lee, J., & Veloso, F. M. (2008). Interfirm innovation under uncertainty: Empirical evidence for strategic knowledge partitioning. *Journal of Product Innovation Management*, 25(5), 418-435.

Li, T., & Calantone, R. J. (1998). The Impact of Market Knowledge Competence on New Product Advantage: Conceptualization and Empirical Examination. *Journal of Marketing*, 62(4), 13-29.

Lichtenthaler, U. (2009). Outbound open innovation and its effect on firm performance: examining environmental influences. *R&D Management,* 39(4),

317-330.

Lukas, B., & Ferrell, O. (2000). The effect of market orientation on product innovation. *Journal of the Academy of Marketing Science*, 28(2), 239-247.

Mazzola, E., Bruccoleri, M., & Perrone, G. (2012). The effect of inbound, outbound and coupled innovation on performance. *International Journal of Innovation Management,* 16 (6), 1-27.

Mazzola, E., Perrone, G., & Kamuriwo, D. S. (2015). Network embeddedness and new product development in the biopharmaceutical industry: The moderating role of open innovation flow. *International Journal of Production Economics*. 160(2), 106-119.

Mention, A.-L. (2011). Co-operation and co-opetition as open innovation practices in the service sector: Which influence on innovation novelty? *Technovation,* 31(1), 44-53.

Mention, A.-L., & Asikainen, A.-L. (2012). Innovation & productivity: investigating effects of openness in services. *International Journal of Innovation Management, 16*(3), 1-27.

Morrison, A., (2011). Innovation and external knowledge sources in industrial districts: evidence from an Italian furniture cluster. In: P. Robertson, & D. Jacobson (Eds.), *Knowledge transfer and technology diffusion* (pp. 162-186). Dublin, Ireland: Edward Elgar Publishing Limited.

Nieto, M. J., & Santamaria, L. (2007). The importance of diverse collaborative networks for the novelty of product innovation. *Technovation*, 27(6), 367-377.

OECD, (2005). *"The measurement of scientific and technological activities Oslo Manual: Guidelines for collecting and interpreting innovation data. France"*, OECD Publication.

Available at

http://www.oecd-ilibrary.org/science-and-technology/the-measurement-of-scientific-and-technological-activities_19900414

OECD, (2013). OECD Science, Technology and Industry Scoreboard 2013: Innovation for Growth. OECD Publishing.

Available at http://www.oecd.org/sti/scoreboard-2013.pdf

Potters, L. (2009). R&D in low-tech sectors. JRC Technical Notes: IPTS Working Papers on Corporate R&D and Innovation, (08).

Available at

http://www.researchgate.net/publication/46464586_RD_in_low-tech_sectors/file/d912f508a4f02c8c9d.pdf

Robertson, P., & Smith, K. (2008). Distributed knowledge bases in low-and medium-technology Industries. In H. Hirsch-Kreinsen, & D. Jacobson, (Eds.) *"Innovation in low-tech firms and industries"* (pp.93-117), Cheltenham, UK, Northampton, MA, USA: Edward Elgar.

Robertson, P. L., Smith, K., & von Tunzelmann, N. (2009). Innovation in low- and medium technology industries. *Research Policy*, 38(3), 441-446.

Song, M., Droge, C., Hanvanich, S., & Calantone, R. (2005) Marketing and technology resource complementarity: an analysis of their interaction effect in two environmental contexts. *Strategic Management Journal*, 26(3), 259-276.

Srivastava, M. K., & Gnyawali, D. R. (2011). When do relational resources matter? Leveraging portfolio technological resources for breakthrough innovation. *Academy of Management Journal*, 54(4), 797-810.

Su, Y.-S., Tsang, E. W. K., & Peng, M. W. (2009). How do internal capabilities and external partnerships affect innovativeness*? Asia Pacific Journal of Management,* 26(2), 309-331.

Tsai, K. H., & Wang, J. C. (2009). External technology sourcing and innovation performance in LMT sectors: An analysis based on the Taiwanese Technological Innovation Survey. *Research Policy*, 38(3), 518-526.

Vanhaverbeke, W. (2006). The interorganizational context of open innovation. In H. Chesbrough, W. Vanhaverbeke, & J. West, (Eds.) *Open innovation: Researching a new paradigm* (pp. 205-219). Oxford: Oxford University Press.

Vanhaverbeke, W., Cloodt, M., & Van de Vrande, V. (2008). Connecting Absorptive Capacity and Open Innovation. SSRN Working Paper No. 1091265.

Available at http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1091265

Vanhaverbeke, W., Vermeersch, I., & De Zutter, S. (2012). *"Open innovation in SMEs: How can small companies and start-ups benefit from open innovation strategies?"* Vlerick Leuven Gent Management School.

Available at https://doclib.uhasselt.be/dspace/handle/1942/13758

Vega-Jurado, J., Gutierrez-Gracia, A., & Fernandez-de-Lucio, I. (2009). Does external knowledge sourcing matter for innovation? Evidence from the Spanish manufacturing industry. *Industrial and Corporate Change,* 18(4), 637-670.

von Hippel, E., Thromke, S., & Sonnack, M. (1999). Creating breakthroughs at 3M. *Harvard Business Review*, 77(5), 47-57.

von Hippel, E. (1994). Sticky Information and the Locus of Problem-Solving-Implications for Innovation. *Management Science*, 40(4), 429-439.

von Tunzelmann, N., & Acha, V. (2006). Innovation in "Low Tech" Industries. In J. Fagerberg, D. Mowery, & R. Nelson (Eds.) *The Oxford Handbook of Innovation*, (pp. 407-432), Oxford: Oxford University Press.

Vorhies, W. D., Orr, M. L., & Bush, D. V. (2011). Improving customer-focused marketing capabilities and firm financial performance via marketing exploration and exploitation. *Journal of the Academy of Marketing Science*. 39(5), 736-756.

Wang, C-F., Chen, L-Y, & Chang, S-C. (2011). International diversification and the market value of new product introduction. *Journal of International Management*, 17(4), 333-347.

Wiklund, J., & Shepherd, D. (2003). Knowledge-based resources, entrepreneurial orientation, and the performance of small and medium-sized businesses. *Strategic Management Journal*, 24(13), 1307-1314.

Wu, J. (2014). Cooperation with competitors and product innovation: Moderating effects of technological capability and alliances with universities. *Industrial Marketing Management,* 43(2), 199-209.

Wu, J., & Wu, Z. F. (2013). Firm capabilities and the performance in regional polarization. *Management Decision*, 51(8), 1613-1627.

Wziatek-Kubiak, A. (2008). Innovation Activities versus Competitiveness in Low- and Medium-Technology-based Economies: The Case of Poland. In H. Hirsch-Kreinsen, & D. Jacobson, D. (Eds.) *"Innovation In Low-Tech Firms And Industries"* (pp.197-220), Cheltenham, UK Northampton, MA, USA: Edward Elgar.

Yassine, A. A., & Wissmann, L. A. (2007). The implications of product architecture on the firm. *Systems Engineering*, 10(2), 118-137.

Zhou, K. Z., & Wu, F. (2010). Technological capability, strategic flexibility, and product innovation. *Strategic Management Journal*, 31(5), 547-561.

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A networking culture to benefit from open innovation - a comparison between technology and business services industries in The Netherlands

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Abstract. This paper aims to improve our understanding of why some companies are more successful in implementing open innovation strategies than others, by building a framework of capabilities required to benefit from open innovation. It argues that companies can benefit from open innovation when they have the capabilities to connect closed and open approaches to innovation. This requires building a culture conducive to developing networking capabilities. In the article, a comprehensive set of networking capabilities is developed intended as an analytical tool to evaluate to what extent companies are equipped to benefit from open innovation. As a first step to further validating the framework, empirical research has been carried out in The Netherlands to compare networking capabilities of companies in the technology industry and in the knowledge intensive business services sector. The results indicate that according to the framework, technology companies are in the lead in benefiting from open innovation, which may be explained by their previous experience in innovation networking. The results suggest that the networking capabilities framework is a promising tool for analysis that can help companies to become better equipped to jointly create value and capture value in innovation networks. The research has policy implications for regions as well, because it indicates that regional open innovation strategies need to address the development of networking capabilities of companies and other actors in the regional innovation system.

Keywords. Innovation, organizational culture, regional culture, service industry, technology industry, networking capabilities, regions in The Netherlands

1. Introduction: benefiting from open innovation-capabilities and culture

The concept of Open innovation, launched by Chesbrough (2003), has quickly gained acceptance among researchers (Christensen et al., 2005; Gann, 2005) and practitioners (Kirschbaum, 2005), and its introduction has resulted in a growing body of literature and ongoing research (Chesbrough et al., 2006; Chesbrough and Birkinshaw, 2006; Chesbrough and Schwartz, 2007; Cooke, 2005a, 2005b, 2007; Dahlander and Gann, 2010; Gassmann et al., 2010; Fleming and Waguespack, 2007; Lee et al., 2010; West and Bogers, 2014).

Open innovation can be defined as "The use of purposive inflows and outflows of knowledge to accelerate internal innovation and expand the markets for external use of innovation" (Chesbrough et al, 2006, p. 1). Chesbrough (2007, p. 22) argues that "to get the most out of this new system of innovation, companies must open their business models by actively searching for and exploiting outside ideas and by allowing unused internal technologies to flow to the outside". While early literature on open innovation focused on open innovation strategies, recent publications pay

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more attention to requirements for how to successfully implement an open innovation strategy (Cheng and Chen, 2013; Chesbrough, 2012; du Chatenier et al., 2011; Gassmann et al., 2010; Lichtenthaler, 2011; Mortara and Minshall, 2011). However, the challenges of organizing for open innovation are still a relatively underexplored area of research (West et al., 2014). This paper aims to improve our understanding of why some companies are more successful in implementing open innovation strategies than others, by building a framework of capabilities required to benefit from open innovation.

Chesbrough (2012) contrasts "open innovation" with the "old" model of "closed innovation". In "closed innovation", innovation processes are controlled by the company by investing in internal R&D and innovations coming out of these investments are protected by controlling intellectual property rights. However, recent studies suggest that successful innovation strategies *connect* internal and external sources of innovation by developing a dynamic balance between closed and open approaches to innovation (Marques, 2014; Prud'homme van Reine and Dankbaar, 2011; Tödtling et al., 2011). This can be understood with the help of the 'absorptive capacity' concept, defined as the ability to identify, assimilate and exploit knowledge from the environment (Cohen and Levinthal, 1989, 1990). By definition, absorptive capacity is a capacity necessary to 'absorb' open innovation. It has been called 'a precondition to open innovation' (Spithoven et al., 2010). However, as already demonstrated by Cohen and Levinthal and reiterated by Vanhaverbeke et al. (2008), companies use internal R&D capabilities to recognize and monitor external technologies and effectively exploit them. Without investing in own R&D and innovation activities, in other words in closed innovation, absorptive capacity cannot develop and external knowledge cannot be effectively exploited. Therefore, capabilities to create and share knowledge and ideas in networks, and to facilitate dynamic interaction of internal and external knowledge, are essential to make open innovation strategies work. Open innovation has strong links to the dynamic capabilities perspective (Teece, 2007; West et al., 2014). Networking capabilities are dynamic innovation capabilities, defined by Zollo and Winter (2002) as 'hard to transfer and hard to imitate innovation capabilities that firms use to develop, integrate, and reconfigure existing and new resources and operational capabilities'. Networking capabilities do not emerge spontaneously when a company implements Open Innovation strategies. It can be argued that opening up the innovation process starts with a mindset (Gassmann et al., 2010, p. 214)-it requires building a culture which is conducive to developing networking capabilities. Organizational culture is closely linked to network embeddedness (Noorderhaven et al., 2002) and plays an important role in the willingness and ability of an organization to identify, assimilate and exploit external sources of innovation in such a way that it contributes to performance. Dynamic innovation capabilities can be embedded in an organizational culture over time by building experience in open innovation networks, but this is a slow process. Therefore, part of the explanation why some companies are more successful in open innovation, may be that their previous experience in collaborative innovation has resulted in the development of networking capabilities (Frankenberger et al., 2014), further opening up their business model and building a culture conducive to open innovation.

Although the cultural perspective has been identified previously as one of the perspectives needed to develop an open innovation theory more fully (Gassmann et al., 2010), there is still a gap in the literature when it comes to the impact of competencies and culture on open innovation (Bogers and West, 2014). Studies of the role of organizational culture in connecting internal and external knowledge are relatively rare and often do not go much further than identifying obstacles for implementation of open innovation such as the classic 'Not Invented Here' (NIH)-

syndrome (Katz and Allen, 1982). E.g. Van de Vrande et al. (2009), in a study of the implementation of open innovation in SMEs, identified organizational and cultural issues as key barriers to implement open innovation, but did not investigate these issues in detail. Henkel et al. (2014) report that existing cultures and corresponding organizational processes can slow down the change toward openness, and point at the need to go through a learning curve, but do not make a systematic analysis of the effects of culture. Mortara and Minshall (2011) find that internal cultural heritage may actually facilitate the adoption of open innovation. They conclude that a firm's cultural background can overrule other implementation drivers, and recommend further qualitative studies to reveal the dynamics of open innovation adoption. The research of Herzog and Leker (2010) on characteristics of closed and open innovation cultures is probably the most detailed study linking culture and open innovation to date, but it does not address the cultural implications of the interaction between closed and open innovation needed to integrate external ideas. Moreover, the open innovation literature lacks a connection to established theories of corporate culture researchers who derived cultural characteristics of innovative companies in a systematic way based on culture models (Prud'homme van Reine and Dankbaar, 2009, 2011; Schein, 2003; Trompenaars, 2007).

This paper will make an attempt to fill this literature gap by developing a framework that connects the role of culture and network capabilities in the adoption and implementation of open innovation. The impact of culture on open innovation will then be further explored by using the framework to investigate differences in open innovation adoption between companies in different industries. It is well known that different industrial sectors may have distinctively different innovation patterns (Malherba, 2005; Pavitt, 1984). For instance, sources of innovations and how companies interact with these sources, which are closely related to open innovation, may differ significantly between industries. The industries that we selected for this comparative research are the technology industry and the services industry. In his original taxonomy, Pavitt classified the technology industry as 'science based' and the services industry as 'supplier-driven', however, in a later publication (Pavitt, 1994) he put software services into the "specialized supplier" group and added a category of "information intensive" firms. Malherba (2005) built further on this by proposing an integrated and comparative way to look at sectors based on a sectoral systems framework that allows for detailed analyses of innovation in sectors in terms of, among others, knowledge and learning processes and network relationships. Malherba (2005) explicitly mentions networks as a rather underexplored key variable and comparative work as particularly relevant for further research. This paper reports a comparative research between two sectors with different innovation patterns, focused on the specific issue of innovation networking.

The technology industry was selected for our research because the evidence of open innovation was first discovered in technology oriented companies (Chesbrough, 2003; Chesbrough and Kardon, 2006; Schroll and Mild, 2011). We argue that technology companies might be in the lead in benefiting from open innovation because of previous experience in developing network capabilities and building a culture conducive to open innovation. For many technology companies, several elements of open innovation such as external networking, co-development partnerships and outsourcing of R&D to public research institutes are by no means new. Hargadon (2003) has shown that already at the end of the 19th century, technology-brokers developed competences for breakthrough innovations by bridging the gaps in existing networks that separated industries and firms and by building new networks to guide the market acceptance of these breakthroughs. The European Industrial Research Management Association (EIRMA-in itself a collaborative organization of major European companies to provide a pool of knowledge in R&D working methods)

published reports on "Research bought outside the firm" (EIRMA, 1969), "Improving industry-university relations" (EIRMA, 1988) , "Cooperative R&D in industry" (EIRMA, 1989), "Effective collaboration R&D" (EIRMA, 1995), "Outsourcing R&D" (EIRMA, 1997) and "Innovation through spinning in and spinning out" (EIRMA, 2003) before the term Open Innovation was popularized. The author of this article represented the innovation sector of a Dutch technology company in one of EIRMAs workgroups in the early 1990s and personally witnessed how European technology companies already in that period changed their attitude from the "NIH-syndrome" to a more open attitude. Important triggers for this more open attitude were the influential 5th generation model of R&D management (Rothwell, 1992), which highlighted the need for increased external focus and Tidd's publication on an open and connected innovation model through intraorganizational and interorganizational networks (Tidd, 1993). Government support for European cooperative projects between technology companies and knowledge institutes was instrumental in the process of opening up innovation in the technology industry as well. Other data confirm that during the 1990s the importance of innovation networks as a source of knowledge, increased rapidly, triggering the interest for what were later called "Open Innovation" strategies. While in 1969 only 3% of research was bought outside the firm (EIRMA, 1969), in 2000 outsourced and collaborative R&D had risen to over 10% of total research. This percentage was estimated at 15% in 2008 (OECD, 2008) and still increases rapidly (Schroll and Mild, 2011). Some firms have outsourced their entire R&D to other firms or universities. These developments are due to the ever more rapid cycles of innovation, rapidly increasing investments necessary for R&D, the increased mobility of knowledge workers and the rising importance of venture capital, which made the closed model difficult to sustain and made companies look for new sources of innovation beyond a specific industry, discipline, or type of collaborative partner.

So, the insight that creation of useful knowledge and ideas takes place in a variety of settings, not just in the own R&D labs of a company, but also at universities, entrepreneurial firms, spin-offs of established firms, companies supplying essential components, sub-assemblies or complementary products and competitors, is for technology companies by no means new. Many technology companies were also already familiar with another aspect of open innovation, involving customers and lead-users in the innovation process, way before the open innovation concept was launched. The term "open innovation" was first used in 1999 in the title of a seminar on the benefits of networking for innovation with lead users in the open source software development movement (Horwitch et al., 2000). However, the experiences of technology companies in collaborative innovation with lead users were already described in the work by Von Hippel (1986). The introduction of the open innovation concept has definitely stimulated involving "customer-innovators" (Thomke and Von Hippel, 2002) and "lead users" (Von Hippel, 2005) in the innovation process, but many technology companies had experience in innovation networks with customers and lead users already. This overview of antecedents of open innovation in the technology industry suggests that technology companies with a strong history in R&D and experience in developing networking capabilities are in a good position to benefit from open innovation, because they are able to develop a dynamic balance between closed and open innovation by combining their absorptive capacity and networking capabilities and to develop a "culture of innovation" which connects strengths in closed innovation and external networking capabilities. The need for such a dynamic balance is related to Clippinger's reflections on the need for enterprises to balance between order and chaos because traditional top-down management methods no longer work in an age of fast technological change and world competition-Clippinger (1999) describes the balance as "that 'sweet spot' where creativity and resilience are at their maximum".

The services industry was selected for the comparative research, because although the focus of open innovation research has been on technology-oriented companies, there has recently been more attention for open innovation in the services industry (Chesbrough, 2011, 2012). Moreover, the services sector has an increasingly important role in building knowledge-based economies while over a long period of time it has suffered from a lack of attention to innovation:

- "Many services are poorly linked into wider innovation systems, and the formal institutions that support them" (Miles, 2005, p. 449)
- "Policies in support of services innovation have remained relatively underdeveloped in many regions" (EC Commission Staff, 2009, p. 53).

Den Hertog et al. (2010) argue for more attention to service innovation in open innovation studies: "New services are increasingly realised through combinations of service functions provided by a coalition of providers, both parties in the value chain, and actors in the wider value network-it is remarkable in this context that open innovation literature has started at the R&D and manufacturing side, whereas the relevance for service innovation might be even greater" (Den Hertog et al. 2010, p. 494). Several publications of the European Commission emphasize that it is of vital importance to understand how especially the Knowledge Intensive Business Services sector (KIBS) can benefit from open innovation:

- "The economic importance of services means that improvements in European living standards are likely to depend more and more on productivity improvements in business services than in manufacturing" (European Commission, 2007, p. 13)
- "KIBS are likely to be one of the main engines for future growth within the European Union." (European Commission, 2007, p. 7)

KIBS are private companies or organisations, relying heavily on professional knowledge i.e. knowledge or expertise related to a specific (technical) discipline or (technical) functional domain; and supplying intermediate products and services that are knowledge-based (Miles et al., 1995). KIBS are recognized as innovators in their own right and as contributing to innovation systems (Di Bernardo et al., 2012) but attention for how KIBS interact with other actors and their contribution to innovation dynamics is relatively recent (Doloreux et al., 2010).

In this paper we intend to address the literature gap in understanding the impact of culture and network capabilities on adopting and implementing open innovation by answering the following research questions:

- Is it possible to develop a comprehensive framework of networking capabilities, rooted in theories of how organizational cultures impact innovation that can be used to evaluate to what extent companies are equipped to benefit from open innovation?
- If this is the case, can the framework be tested by using it to compare to what extent companies in different industries which are likely to have different innovation patterns and cultures (the technology sector and the knowledge intensive business service sector) are equipped to benefit from open innovation, as a first step to further validating?

2. Theoretical background: networking capabilities and open innovation cultures

In order to understand how companies can build a culture conducive to developing

network capabilities, the extensive literature on knowledge transfer in networks (Dyer and Singh, 1998; Levin and Cross, 2004; March, 1991; Powell et al., 1996) and the concept of dynamic capabilities (Teece et al., 1996, 1997, 2007) are relevant. "Dynamic capabilities" refer to the ability to integrate, build, and reconfigure internal and external competencies to address rapidly changing environments (Teece et al., 1997) and are therefore directly connected to open innovation.

Networks enable partners to create knowledge and share knowledge. The extensive literature on the relationship between different types of networks and knowledge transfer provides insight in how companies interact with their environment to benefit from open innovation. E.g. Powell et al. (1996), in a discussion of interorganizational networks as locus of innovation, argue that sources of innovation are usually found in the gaps between firms, universities, research laboratories, suppliers and customers so that the degree to which firms learn about new opportunities depends on their participation in networks.

March (1991) makes the useful distinction between explorative and exploitative network ties, based on a discussion of different ways of organizational learning. Explorative ties are about experimentation with new alternatives, with uncertain returns. Exploitative ties relate to the refinement and extension of existing competencies, technologies and paradigms, and generate predictable returns. March argues that adaptation requires both exploitation and exploration to achieve persistent success. Gupta et al. (2006) argue that there are two different possible balancing mechanisms: ambidexterity, which refers to the synchronous pursuit of both exploration and exploitation via loosely coupled and differentiated subunits or individuals, each of which specializes in either exploration or exploitation, and punctuated equilibrium, which refers to alternating cycles of exploration and exploitation. Gupta et al. (2006) conclude that either ambidexterity or punctuated equilibrium may serve as the more appropriate balancing mechanism between exploration and exploitation, depending on the context. Both approaches are viable in open innovation networks. Vanhaverbeke (2006) and Simard and West (2006), in their discussion on open innovation and networks, build further on this when they distinguish "deep ties" that enable a firm to capitalize on existing knowledge and resources and "wide ties" that enable a company to find new technologies and markets. Deep network ties are associated with geographical proximity. These are usually networks based on trust because of long relationships. They are important for innovation potential but usually limited to incremental innovation. Wide network ties give access to a wider variety of knowledge, making it possible to access new opportunities and resources and to stimulate creativity and innovation leading to more radical innovation. Open innovation benefits from building ties that are wide and deep and from finding the right balance between these ties (Simard and West, 2006).

Powell et al. (1996) make another useful distinction in types of networks, between formal and informal network ties. Formal ties refer to knowledge exchange between organizations based on contracts or other formal agreements and are associated with sharing explicit knowledge. Informal ties are often based on personal relationships at different levels in organizations and are associated with sharing implicit knowledge. Formal ties, such as alliances, research consortia and licensing agreements and informal ties often go hand in hand: formal relationships may emerge from informal arrangements, and "beneath most formal ties, lies a sea of informal relations" (Powell et al., 1996, p. 120). Open innovation strategies benefit from both formal and informal ties for effective transfer of knowledge in collaboration (Simard and West, 2006). Formal ties can be part of an explicit, planned open innovation strategy. Informal ties give opportunities for unplanned, spontaneous knowledge sharing but require special attention for abilities to capture external innovation by tacit knowledge sharing.

Strategies to stimulate open innovation often include facilitating networks e.g. by

organizing events and supporting network organizations. However, in order to benefit from such networks in a structural way, firms need to strengthen their network capabilities. Building further on Penrose (1959), who identified knowledge and learning processes as a factor in determining the growth of the firm, Teece et al. (1997) introduces "dynamic capabilities", also defined as "the firm's capacity to sense and seize opportunities to reconfigure its knowledge assets and competencies" (Teece, 1998, p. 64), as a source of sustained competitive advantage. Eisenhardt and Martin (2000), building on the work of Teece, argue that dynamic capabilities reflect an organization's ability to innovate e.g. via knowledge brokering and alliancing and that dynamic capabilities are closely tied and build upon "absorptive capacity" (Cohen and Levinthal, 1990), the concept which we introduced already as the ability to identify, assimilate and exploit knowledge from the environment. Individuals in the network, so-called "gatekeepers" or "boundary spanners", play an important role in building and maintaining these dynamic capabilities (Fleming and Waguespack, 2007). Dynamic capabilities partly reside in knowledge networks resulting in what has been called "dynamic knowledge capabilities" (Dawson, 2000) of firms and their networks, which are a prerequisite for open innovation strategies. The capabilities based literature (Dosi et al., 2000; Helfat et al., 2007; Teece, 2000; Teece et al., 1996, 1997; Zander and Kogut, 1995;) focuses mostly on strategies to transform companies to become knowledge-based companies, but as observed by Chatzkel (2004), "efforts to develop knowledge-based companies and knowledge regions need to be co-joint and co-equal if a region is to become a true knowledge region over time" (Chatzkel 2004, p. 61). In order to become knowledge-based companies, companies need to tap into geographically based knowledge networks and contribute to them. Local and global networks need to be connected as well (Malecki, 2011; OECD, 2008).

Empirical evidence confirms that firms implementing open innovation need a number of networking capabilities. E.g., Huston and Sakkab (2006) describe the different types of networks at the heart of a Procter & Gamble's model of open innovation. Perkmann and Walsh (2007) describe innovation networks with universities and research Institutions, EmdenGrand et al. (2006) describe innovation networks with suppliers and Von Hippel (2005) and Simard and West (2006) describe innovation networks with users and customers. As predicted, not just formal networks at firm-level but also informal interpersonal networks allow firms to access important external innovation sources, e.g. the social networks of R&D managers with scientists. Fichter (2009) reports on the role of networks of promotors in the interaction in 'innovation communities'. He distinguishes different promotor roles, each focusing on different barriers in the innovation process: expert promotor (contributing through expert knowledge), power promotor (contributing through hierarchical power), relationship promotor (encouraging innovation by means of innovation-related business relationships inside the organization and with external partners) and process promotor (arbitrating between the technical and the economic world through organizational knowledge) and also points at interlinking organizations that enable other actors to innovate. Each of these promotor roles requires distinct networking capabilities. Lee et al. (2010) point at the evidence that firms involved in multiple types of ties are more innovative than those which only utilise one type of tie. They show the need for innovation networking capabilities in open innovation in SMEs and emphasize the role of intermediaries in supporting SMEs' ability to make collaboration networks and the importance of networking between big companies and SMEs, to make use of the capacity of big companies to manage the whole innovation process and the flexibility of small companies in accelerating innovation.

So, theoretical research and empirical evidence confirms that benefiting from open innovation requires internal and external networking and that the network capabilities required, reflect the need to balance open and closed innovation. However, a systematic approach to develop a complete framework of networking capabilities is

still lacking. An early attempt to develop such a framework is the three core processes archetype model developed by Gassmann and Enkel (2004), consisting of three capabilities needed for the different core processes in order to successfully approach open innovation: absorptive capacity, multiplicative capacity and relational capacity. Gassmann and Enkel refer to their model as 'first steps towards a framework for open innovation' and acknowledge the need for further research to develop a more complete framework. Lichtenthaler and Lichtenthaler (2009) and Lichtenthaler (2011), building further on the work of Gassmann and Enkel and also drawing on the work of Helfat et al. (2007), developed a capability-based framework for open innovation based on six knowledge capacities, that actually represent three fundamental tensions: inventive capacity (internal) vs absorptive capacity (external); transformative capacity (internal) vs. connective capacity (external); innovative capacity (internal) vs. desorptive capacity (external). Lichtenthaler's framework does consider the dynamic interaction of internal and external knowledge in open innovation processes. However, it mainly deals with the acquisition and assimilation of knowledge and does not specify what capabilities are required for a company to benefit from open innovation in term of outcomes such as effects on products and processes. Robertson et al. (2012) take Lichtenthaler's work one step further by explicitly discussing the capacities needed in knowledge application. They develop a framework of 'Innovative Capacities' consisting of 'accessive capacity' (similar to absorptive capacity), 'adaptive capacity' (related to putting new knowledge to use) and 'integrative' capacity, which is directed by 'innovative management capacity'. However, Robertson et al. acknowledge the limitations of their framework and point at the need for further research to unpack their categories into more fine-grained sets of underlying capabilities and to come to a better understanding of how the capabilities interact. Den Hertog et al. (2010) developed, based on a theoretical discussion, a framework of six dynamic innovation capabilities specifically for the service industry. However, they link only two of these dynamic capabilities to open innovation: 'conceptualizing capability' (capability to think out of the box by multidisciplinary teams within the firm) and 'co-producing and orchestrating capability' (capability to manage service innovation across the boundaries of the individual firm). Later in this section, it will be shown how these capabilities fit into a comprehensive framework of open innovation networking capabilities. Cheng and Chen (2013) also made an effort to link dynamic innovation capabilities to open innovation activities. However, networking capabilities are not included in the items they use to measure dynamic innovation capabilities, which underline the lack of an innovation capabilities framework rooted in theory.

So, despite the extensive research on networking capabilities and open innovation, the insight in networking capabilities required for open innovation is still not complete and there is the need for a framework rooted in theory. Mortara and Minshall (2011), in their research of implementation of open innovation, point at the importance of the development of appropriate culture and skills to enable the operation of an Open Innovation strategy. We argue that in order to develop such a framework findings on networking capabilities and open innovation have to be connected to theories on innovation that start from a cultural perspective (Prud'homme van Reine and Dankbaar, 2009, 2011; Schein, 2003; Trompenaars and Prud'homme, 2004; Trompenaars, 2007). In the following section we will make this connection between open innovation networking capabilities and the fundamental innovation dilemmas, which have been identified as a comprehensive set to characterize innovation cultures by Trompenaars (2007) and Prud'homme van Reine and Dankbaar (2009, 2011).

In the dilemma approach, cultures are not assessed as a fixed set of value orientations, but by how they pursue paradoxical criteria simultaneously. This approach builds further on the work of corporate culture researchers Schein (1985), who pointed at the paradox of culture as a way of making things predictable versus culture as by its very

nature learning oriented and innovative and Cameron and Quinn (1999), who see organisational culture as a continuous process of finding a balance between competing values. In the dilemma approach of organizational culture (Hampden-Turner and Trompenaars, 2000; Trompenaars and Prud'homme, 2004), the patterns of meaning of corporate culture are described by the pattern of connections between different value orientations-such as global standardisation versus local adaptation, people orientation versus achievement orientation, quick decision-making versus consensus seeking, focus on co-operation versus focus on competition. Companies can work to improve their ability to reconcile such values, for instance by learning to co-operate in innovation networks in order to become a more competitive innovative company. Several authors have translated traditional dilemmas facing organizations to innovation dilemmas that need to be resolved for innovation to be achieved (Heidenreich et al., 2010; Prud'homme van Reine & Dankbaar, 2011; Prud'homme van Reine and Dankbaar, 2009; Trompenaars and Hampden-Turner, 2010). In this article, we will use the comprehensive set of 9 innovation culture dilemmas identified by Prud'homme van Reine and Dankbaar (2009), by translating the 9 fundamental organisation culture dilemmas (Hampden-Turner and Trompenaars, 2000; Trompenaars and Prud'homme, 2004) to dilemmas in creating cultures of innovation (Dougherty, 1996; Flynn et al., 2003; Takeuchi et al., 2008). The nine innovation culture dilemmas are:

1. Strong identification with the own culture versus openness for cultural diversity
2. Big (with ample resources to invest in innovation) versus small and agile
3. Applied innovation versus fundamental research
4. Process orientation versus room for creativity and entrepreneurship
5. Incremental innovation versus radical innovation
6. Technology push versus market pull
7. Egalitarian versus hierarchical approaches in leadership of innovation
8. Stimulating individual performance versus cooperation and knowledge sharing in teams
9. Short term focus versus long term view in innovation

Developing a culture of innovation is according to this model a matter of connecting both sides of each innovation dilemma by finding a dynamic balance. The connection with networking capabilities for open innovation as discussed in the above is that these can be seen as fundamental tensions which can also be described as dilemmas: balancing formal and informal networks (Powell et al., 1996), balancing deep and wide networks (Simard and West, 2006), balancing explorative and exploitative network ties (Gupta, 2006), balancing internal and external networks (Lichtenthaler and Lichtenthaler, 2009; Lichtenthaler, 2011), balancing global and local networks (Malecki, 2011), balancing networking between big and small companies (Lee et al., 2010), balancing internal technology/product/service oriented innovation networks and user/customer innovation networks (Simard and West, 2006; von Hippel, 2005) etc. The required networking capabilities for open innovation can be categorized as follows by framing them in line with the 9 innovation dilemmas mentioned above:

Capability to connect global and local networks

One of the main challenges of open innovation is how companies can benefit from connecting to and participating in global innovation networks. The willingness to consider foreign operations as significant sources of innovation has increased. The foreign share of R&D sites increased from 45% in 1975 to 66% in 2004 (Doz et al., 2006). Companies do more of their R&D away from headquarters and in their location decisions for R&D activities, obtaining rapid access to local centres of knowledge across the world by open innovation plays a major role, e.g. benefiting from spill-overs from other R&D units, access to trained personnel, links with

universities or government institutions and the existence of an appropriate infrastructure for specific kinds of research (OECD, 2008; Malecki, 2011). The capability to connect global and local networks is therefore crucial in order to benefit from open innovation.

Capability to network between big and small companies

Historically, big companies have been dominant in research and innovation. However, innovation is increasingly being done in small and midsize entrepreneurial companies. Between 1981-2001, the share of small/midsize firms in total R&D increased from 4.4% to 24.7%, while the share of large firms (>25000 employees) decreased from 70% to 39.4% in the same period (Chesbrough, 2003). As shown by Christensen et al. (2005), the interplay between technology entrepreneurs and incumbents can be quite complex and may make that open innovation has to be conducted under conditions of high transaction costs. Co-producing and orchestrating managing service innovation across the boundaries of the individual firm and managing and engaging in networks is a key dynamic capability for being able to put a new service concept or configuration on the market. Therefore, in line with findings of Lee et al. (2010), one of the capabilities required to benefit from open innovation is networking between big and small companies.

Capability to connect innovation networks to networks in fundamental research.

The term 'knowledge paradox' refers to regions where high investment in good quality fundamental research results in insufficient innovative products/services and economic returns. It is closely related to the need to balance explorative and exploitative network ties (Gupta, 2006). The knowledge paradox exists e.g. in The Netherlands (Boekema et al., 2000). Despite attempts to enable knowledge transfer from universities and research institutes to companies by shaping 'entrepreneurial researchers' (Kooij, 2014) and attention for the role of 'gatekeepers' (Gemünden et al., 2007), the knowledge paradox still exists. This can be seen as a weak connection between 'inventive capacity' and 'absorptive capacity' (Lichtenthaler and Lichtenthaler, 2009). One of the capabilities required to benefit from open innovation is connecting innovation networks to networks in fundamental research.

Capability to connect formal and informal networks

The need to balance formal and informal networks in collaborative innovation, shown by Powell et al. (1996), holds for open innovation as well. Open innovation strategies often entail formal alliances, license contracts and formal consortium agreements to address competitive issues. The informal component is often forgotten: how professionals involved in open innovation can generate new knowledge, build trust, broker solutions and deal with low reciprocal commitment in open innovation cooperation (du Chatenier et al., 2010). In service innovation, informal networks suit the launch of an innovative service in an experimental setting, but creating a consistent set of service experiences or service solutions ('Scaling and stretching'- Den Hertog et al., 2010) requires a more formal approach. The capability to connect formal and informal networks is therefore another requirement to benefit from open innovation.

Capability to connect deep and wide network ties.

Radical innovation often requires open innovation with partners in adjacent industries so that cross-fertilization can take place. Lee et al. (2010) suggest a network model for open innovation in which intermediaries are used that help companies establish cross-functional collaborative networks. These intermediates can take the role of 'boundary spanners' who have the capability to connect deep and wide network ties. Similarly, Den Hertog et al. (2010) discern in service innovation 'recombinative innovation', which requires what they call 'bundling capability'. The capability to connect deep and wide network ties is another requirement to benefit from open

innovation.

Capability to connect to customer and lead-user innovator networks.

Von Hippel (2005) and Von Hippel and Thomke (2002) have pointed at networks with lead-users and customer innovators as a way to create value in open innovation e.g. by using knowledge brokers who are able to signal user needs and connect these to technological options. The capability to connect to customer innovators and lead-user innovation networks is another capability required to benefit from open innovation. It is related to 'innovative capacity' in the capabilities model of Lichtenthaler and Lichtenthaler (2009), which is associated with matching inventions with the context of their final market.

Capability to connect to regional innovation networks.

Connecting to regional open innovation networks, e.g. by participating in the governance of the regional innovation system in a triple helix between knowledge institutes, business and regional government (Etzkowitz and Leydesdorff, 2000), results in companies and regions capturing value of external transfer in open innovation. It requires striking a balance between top-down ways of managing innovation and a more co-operative culture, interactive learning and consensus approach at the regional level. This requires the capability to connect to regional open innovation networks.

Capability to connect inter-functional company networks.

Paradoxically, open innovation requires internal networking capabilities as well. If a company has opened up the flow of knowledge and ideas to and from other companies, internal boundaries may still limit the benefit of open innovation. This apparent contradiction was observed in companies such as Philips and DSM (Hacievliyagil, 2007). This capability is related to the need to connect internal transformative capacity and external connective capacity in the capabilities model of Lichtenthaler and Lichtenthaler (2009), reflecting the need for knowledge retention in internal and external networks and using the knowledge for innovation activities. Open innovation requires that ideas of every individual need to be used, not just ideas from the R&D department: "a good idea does not care who has it" (Flynn et al., 2003, p. 425). This capability is similar to what den Hertog et al. (2010), in relation to innovation in the services industry, call 'conceptualizing capability': capability to think out of the box by multidisciplinary teams within the firm. Employees who are traditionally not involved in the innovation process may not be motivated to participate in organizational innovation communities (Wendelken et al., 2014). Benefiting from open innovation therefore requires networking capabilities to connect creative, entrepreneurial, technology, R&D, business and managerial staff, surpassing hierarchical and functional boundaries.

Capability to connect to societal networks

One of the challenges of open innovation is to connect innovation aimed at short term profit to innovation aimed at long term solutions for societal problems such as transportation, energy, climate and health. This requires the capability to connect to societal networks involved in these issues.

The framework of 9 innovation network capabilities developed in the above is rooted in the dilemma approach to understand organizational cultures and incorporates the main findings of prior research on networking capabilities for (open) innovation. Based on the theoretical discussion in this section, we expect that the framework can be used to evaluate to what extent a company has developed a set of innovation networking capabilities or an 'innovation networking culture' conducive to benefiting from open innovation.

As argued in the previous section, technology companies with a strong history in

R&D and in external networking are likely to be in an advantageous position to benefit from open innovation because they developed networking capabilities and a 'networking culture' because of their previous experience in innovation networks. In the following sections of the paper, we report exploratory research to get insights into the applicability of the framework: a comparative study of the extent that companies in the technology industry and companies in the knowledge intensive business services sector are equipped to benefit from open innovation.

3. Research method

The aim of the empirical research was to get insight into the applicability of the networking capabilities framework by comparing two regions dominated by different industries: the technology sector and the knowledge intensive business service sector. These regions are likely to have different innovation patterns (Pavitt, 1984, 1994) and networking cultures. The framework developed in section 2 was used to evaluate to what extent companies are equipped to benefit from open innovation, as a first step to further validating the framework. Empirical research was conducted in the following regions:

- One region in which the economy is dominated by technology oriented companies: Southeast Netherlands (the region around the city of Eindhoven, also dubbed the 'Brainport region')
- One region in which the economy is dominated by knowledge intensive business services (KIBS) companies: the Utrecht region (the region around the city of Utrecht, also in The Netherlands).

It was decided to study companies in two regions with specialized clusters because this allows for studying the interaction between companies and other actors in the regional innovation systems such as innovation support intermediaries, regional government agencies and knowledge institutes. Studying open innovation in a setting that allows for studying interaction between different actors has many advantages for studying dynamic open innovation processes, as shown e.g. by Ollila and Elmquist (2011), who studied open innovation in an 'open innovation arena', Belussi et al. (2010), who studied open innovation processes within one region, and Tödtling et al. (2011), who studied the interaction between companies and regional actors in open innovation processes in different European regions.

The Brainport region and the Utrecht region were selected for this research because these regions have on the one hand a very different sectoral specialization (technology industry in Brainport versus KIBS in Utrecht), while on the other hand they are very similar in other aspects:

- They are both regions around a medium-sized main city: Eindhoven, the main city in the Brainport region is the 5th biggest city in The Netherlands; the city of Utrecht, centrally located in the Utrecht province, is the 4th biggest city in The Netherlands.
- They are both home to major universities which play an important role in the regional innovation system.
- They are both known as innovative regions.
- They are regions in the same country (The Netherlands), so that national cultural differences and differences in national innovation policies do not play a role in the comparison.

The region of Southeast Netherlands positions itself as "Brainport". The regional economy is dominated by technology oriented companies such as Philips, DSM,

ASML and FEI. The region has two major universities: the University of Technology in Eindhoven and the University of Maastricht. The region has embraced the concept of open innovation and is described by the regional development agency as "an open innovation ecosystem". The region has a dynamic mix of innovative global companies, SME businesses, techno start-ups and research institutes, which collaborate in an open environment, e.g. on the two open innovation campuses in the region, the High Tech Campus in Eindhoven (focus on High Tech Systems) and the Chemelot campus near Maastricht (focus on Life Sciences and High performance materials). Key companies in the region are Philips and DSM, which are both often mentioned as pioneers in open innovation: Philips (van der Meer, 2007), which transformed itself from an electronics company to a high-tech systems company over the past decades and DSM (Kirschbaum, 2005), which has been transformed into a life sciences and materials technology company. Both companies have a long tradition in investing on own R&D and patents, which is proudly described in books sponsored by Philips (de Vries, 2005) and DSM (van Rooy, 2007) itself. In fact, Philips took the initiative for the development of the High Tech Campus in Eindhoven by transforming its gated Research Lab into an Open Innovation Campus in 1999. This was an important step in a culture change to a more collaborative innovation culture. Similarly, DSM has made its R&D labs the centre of an open innovation campus on the integrated industrial site Chemelot. This was an important step in changing its innovation culture from strongly relying on in-house technological strengths to a more open innovation attitude as well.

The Utrecht region has a central location in The Netherlands, a highly educated workforce and was among the top ten innovative regions according to the EU Regional Competitiveness Index 2013. It positions itself as a 'Knowledge region': "a region of knowledge, culture and sustainable development". The regional economy is dominated by the knowledge intensive business service sector such as advisory services, ICT-services, financial services, legal services and engineering services. The biggest company in the region is the regionally rooted banking and financial services company Rabobank, which is organized as a cooperative. The biggest university of The Netherlands (University of Utrecht) and several other leading knowledge institutes are based in the region as well. The Utrecht Science Park, home to knowledge-intensive companies and institutions, is located on the University campus in the centre of the region. The Utrecht Science Park was established in 2011. Its primary aim is to attract companies and university spinoffs that provide a powerful impulse for innovation. The region comprises of several networking organisations to stimulate innovation such as the Utrecht Development Board, the Economic Board Utrecht, the Task Force Innovation (TFI) and the Utrecht Entrepreneurship Academy.

The research in the Brainport and the Utrecht regions can be considered as exploratory research, since it is aimed at getting more insight into the applicability of the innovation networking capabilities framework by comparing two regional cases of open innovation. It concerns investigation of interaction in networks and cultural phenomena. Exploratory research, social interaction, cultural phenomena and a case study approach are all associated with qualitative research approaches (Bryman and Bell, 2007; Punnett and Shenkar, 2004). Following Mortara and Minshall (2011), who argue, based on their own research of open innovation implementation, that studies with qualitative approaches are most likely to reveal the dynamics of Open Innovation adoption, we have chosen for a qualitative approach, drawing data from a combination of written sources/ documents, interviews, and observations.

Our empirical investigation of open innovation in two regions is a qualitative multiple case study, based on Yin's approach (Yin, 2003). Bansal and Corley (2011) emphasize that qualitative research can accommodate different paradigms and different styles of research and research reporting, but that this should not go at the

expense of theoretical contribution and methodological rigor. In order to ensure methodological rigor, we conducted the case study according to the definition of qualitative field research by Polgar and Thomas (1995, p. 109): as a disciplined inquiry examining the meaning that actors attach to experiences and actions in the context of their social environment and cultural situation, in which 'disciplined' refers to methodological principles for theory formulation, problem definition, data collection and analysis guiding the inquiry. The data collection followed the concept of triangulation (Bryman and Bell 2007, p. 291; Punnett and Shenkar, 2004, p. 50). Multiple sources of evidence were used and the research issue was analysed from different perspectives to acquire more reliable results. The methods used were participant observation, document analysis and semi-structured interviewing. Using participant observation, semi-structured key informant interviews and other qualitative methods has strong roots in the study of cultural phenomena in organisations (Bryman and Bell, 2007, p. 13; Sackmann, 1997). It enables the collection of rich and varied material. For the semi-structured interviews, highly knowledgeable key informants were selected (Eisenhardt and Graebner, 2007), who had a good overview of the innovation processes and networking activities in the regions and were able to view these processes from diverse perspectives.

The data collection process in both regions consisted of three steps:

- The first step was to collect information and data from publicly available sources such as company websites, newspaper articles, company reports, etc.
- The second step was participant observation at events such as conferences and seminars on innovation policies and practices in the regions. In total 9 such events were attended. Data were systematically collected in the form of field notes. The researcher participated e.g. by acting as one of the presenters during a 1-day seminar, as a member of a working group at a work conference, by active participation in discussions and by participating in social gatherings at these events.
- The third step was carried out in parallel to step 2: interviews with key informants at companies, regional government departments, innovation support agencies and knowledge institutes involved in the innovation systems. These informants were identified in the document analysis phase and during participation in events as key players in innovation activities in their company or organization and in the region. Interviewees at companies were typically board members or managers with responsibility for innovation, business development and/or regional activities. Interviewees at (semi-) government agencies and knowledge institutes were typically department heads and project leaders involved in developing innovation policies or in innovation (support) projects. Data were collected using a semi-structured interview guide with open-ended questions. The focus in these interviews on was how people engage in open innovation, how they collaborate in practice, how they deal with openness and how they perceive the collaboration with innovation partners. Each of the 9 network capabilities was addressed in the interviews, either because the issue came up in answers on the open-ended questions, or by asking explicit questions per network capability towards the end of the interview. A total of 50 interviews have been conducted.

Summarizing, the data collection consisted in both regions of:

- Extensive documentation study of companies and other actors in the regional innovation systems of both regions: company documents, regional economic development and innovation policy documents, open sources (newspapers, business publications, academic articles and books, websites). The

documentation study was used to describe the regional economic context, to identify suitable companies and regional organizations for the research, and to identify key players for the interviews in phase 3.

- Participant observation at 9 conferences and seminars on innovation policies and practices in total:
  - ❖ In the Brainport region, the researcher participated in the following 5 events:
    - Interregional Innovation Workshop in Eindhoven
    - Colloquium 'Top economy, smart society' at the Chemelot Open Innovation Campus
    - Brainport 2020 'Top economy, smart society' programme meeting in Eindhoven
    - Conference on Open Innovation held at the Chemelot Open Innovation Campus
    - Open Friday afternoon innovation lecture at the High Tech Campus Eindhoven
  - ❖ In the Utrecht region, the researcher participated in the following 4 events:
    - 'Get connected' meeting 'The learning economy', organized by the Utrecht Economic Board
    - SURE (Sustainable Innovation in the Utrecht Region) event
    - Working conference 'City agenda Knowledge and Culture'
    - Utrecht Development Board conference
- Semi-structured interviews with key informants at companies, knowledge institutes and (semi-) government agencies supporting the innovation system.
  - ❖ In the Brainport region, 28 interviews were conducted:
    - Technology companies (in total 14 interviews at technology companies out of which 4 SMEs): High Tech Systems (8), Life Sciences (6).
    - Knowledge institutes (in total 7 interviews): Universities and College of Higher Education (3), Technological Research Institutes (4)
    - Regional government and regional organization/agencies supporting the innovation system (in total 7 interviews): Eindhoven City economic policy department and regional development agencies (3); Regional entrepreneurship support agencies (2); Open Innovation Campus management (2)
  - ❖ In the Utrecht region, 22 interviews were conducted:
    - KIBS Companies (in total 11 interviews at KIBS companies, out of which 3 SMEs): Financial services (3); Management Consultancy services (4); ICT services (2); Engineering & design services (2).
    - Knowledge institutes (in total 5 interviews): University and College of higher education (3), Research Institutes/Science Park (2)

- Regional government and regional organization/agencies supporting the innovation system: (in total 6 interviews): Utrecht City and Utrecht Province economic/innovation policy departments (2); Regional entrepreneurship support agencies (2); Regional economic/ innovation support agencies (2)

The framework of innovation network capabilities developed in section 2 was used as a conceptual framework for the analysis of the interviews, which allowed for axial coding of the transcripts (Strauss and Corbin, 1998), using the 9 network capabilities as an organising device. The data collected during the document analysis and participant observation were also categorized according to the framework of networking capabilities. This resulted in a case study database of research outcomes (excerpts from interviews, observation data, information from document analysis) for each innovation networking capability. The database was then analysed per company and per networking capability for evidence to assess each networking capability. Based on this analysis, the different network capabilities were rated as 'high', 'intermediate' or 'low'. After completing the analysis, the average per region/sector was determined. In the presentation of the results in the next section, citations from interviews, results of document analysis and observations are used to illustrate the interpretation of the empirical material.

4. Results

In the following section, the results are presented for each of the 9 networking capabilities discussed in section 2, both for the Brainport region (Southeast Netherlands) and the Utrecht region.

Capability to connect global and local networks

Brainport region:

From the document analysis it was derived that the capability to connect culturally diverse networks and a regional culture conducive to open innovation, started already when "immigrants" came to this (at the time) peripheral region in The Netherlands because of the founding of Philips in Eindhoven (end 19th century) and its rapid growth in the early 20th century. This "opening-up" of the region resulted in openness for diversity. Lead companies in the region Philips and DSM have a history of creation and sharing of knowledge and ideas in networks. Philips, for instance, started an alliance with its competitor Sony in 1979 to further develop the innovations that resulted in the CD. Moreover, Philips participated already in international research consortia, sharing ideas and knowledge with universities, competitors such as GE and suppliers such as Corning in the mid-1980s. Philips also cooperated with European competitors by participating in European technology projects such as Eureka, launched in 1985 (Eureka, 2006).

In a later stage, Philips and its high tech spin-offs and spin-outs such as ASML (semiconductor manufacturing equipment) attracted knowledge workers, entrepreneurs and managers from all parts of the world to the region. This has resulted in a mix of a traditional local culture characterized by informality, community feeling, inclination to networking and cooperation and a "modern" international, business and engineering oriented culture. We observed that most innovation networking meetings were conducted in English, while informal conversations were mostly in Dutch and the atmosphere at the events radiated the regional "gemoedelijkheid" (sociability and informality). Large companies in the technology sector such as Philips, ASML, FEI

and DSM, are part of a global open innovation system, but at the same time strongly rooted in the local environment. An interviewee of an SME in the region: "as a supplier of one of the globalized companies based in the region, we got involved in the regional innovation network. They helped us with their existing contacts to get access to global innovation networks as well. We would not have had the resources to do that on our own". The capability to connect global and local networks in innovation is evaluated as high.

Utrecht region

Although several of the major business service companies in the region are subsidiaries of international companies, the international orientation in innovation turns out to be surprisingly low. An interviewee: "Utrecht is the biggest village in The Netherlands. We do not have any companies that were founded in the region and grew into international companies". Innovation tends to be "local-for-local", with relatively few connections to global networks. An interviewee from a financial services company: "even in the rural areas in the east of The Netherlands, companies are more internationally oriented than here in Utrecht, at least they are close to the German border and find customers and partners across the border". Moreover, although the regional university and knowledge institutes have strong global networks, companies in the business services sector hardly capitalize on these networks. One interviewee from a consultancy company: "we should embrace entrepreneurial talent from abroad, the PhD's from China and India". Technology-based KIBS companies are the exception here. An interviewee about an engineering services company: "Because of their international client base, they play a role as knowledge intermediaries between international and local". However, on average the capability to connect global and local networks in innovation in the Utrecht region is low.

Capability to network between big and small companies

Brainport region

The open innovation campuses in the region play a major role in networking between big and small companies. Research and business facilities on these campuses are shared between large companies, SMEs and start-ups, including spin-offs from lead companies Philips and DSM. One SME owner/manager based on the high tech campus Eindhoven: "it is very easy to get in touch with high level managers of large companies when you are based here. One phone call or email is sufficient to arrange a meeting and they are happy to share ideas and contacts".

Large companies in the region actively contribute to the existence of a network of big and small innovative companies in the region. E.g. Philips has used spin-in acquisitions to get access to new technologies in health care and LED-lighting and actively spins out technology that is no longer part of the core business such as semiconductors (NXP), semiconductor manufacturing equipment (ASML) and electron microscopes (FEI). These companies subsequently become part of the open innovation ecosystem in a natural way, because of the existing personal contacts and because these spinoffs 'inherit' the open innovation culture. An interviewee at one of these spinoffs: 'we have a different shareholder now, but the culture is still the same'. Part of the open innovation strategy of Philips is to look for different paths of technology and to create new companies from non-core activities via the Philips Incubator, which supports start-ups with advice, business contacts and financing. Similarly, DSM has established a ventures business, through, which it invests in commercial products from small biotechnology and food ingredient companies, regularly spins out innovative companies, licenses technology out and invests in business accelerators. DSM supports, through its incubator initiative in cooperation with the regional development agency, spin-offs on the Chemelot open innovation

campus such as Isobionics, positioned as "a biotechnology company powered by DSM", and spin-offs from nearby University of Maastricht. Philips and DSM both have venture investment business, which contribute to innovation networks between big and small companies as well.

The risk of too much dominance of these large companies in the innovation networks in the region has been recognized and addressed. An interviewee at one of the SMEs: "The regional development company facilitates the formation of consortia and platforms of SMEs in the technology sector and knowledge institutes in the region to co-develop new products with large OEM's, so that we benefit from the advantages of being relatively small while also benefiting from being part of a larger network. The knowledge institutes are usually in the lead in these consortia so that there is more of a balance".

The capability to network in innovation between big and small companies in the Brainport region is evaluated as high.

Utrecht region

Large business services companies use small companies in the region mainly for outsourcing activities and to maintain a flexible capacity, not for collaborative innovation. However, there are some initiatives that contribute to the capability to network in innovation between big and small companies. E.g. the leading regional Rabobank has a Ventures department, which supports small entrepreneurial firms that innovate in order to make the global food supply chain more sustainable. Other large companies in financial services (pension funds, insurance companies and banks) invest via regionally based growth capital firms in small entrepreneurial companies to support innovative models in health care. Another initiative that facilitates innovation networking between big and small companies is the Utrecht Entrepreneurship Academy, a network organisation in which experienced managers from large companies act as coaches for starting entrepreneurs. Still, these initiatives are not sufficient to compensate for the lack of collaborative innovation between big and small companies. An interviewee at a regional agency for stimulating innovation/entrepreneurship: "what lacks in this region, is a large company that is known as very innovative. Currently, the leading companies in the region such as Rabobank are not seen that way. Innovation and entrepreneurship doesn't have a 'face' in this region, there is no company or person representing a large company who is seen as symbol for innovation".

The capability to network between big and small companies in the Utrecht region is evaluated as intermediate.

Capability to connect innovation networks to fundamental research.

Brainport region

There are many cohesive research programs in knowledge institutes in the region, which are structured as public-private partnerships and are designed in line with the ideas of open innovation. This involves collaborative R&D between companies and academia, aligning with industry needs. One example is the Holst Research Centre at the open innovation campus in Eindhoven, an open innovation initiative by the research organizations Imec (Belgium) and TNO (The Netherlands) in the field of technologies for flexible electronics, where research institutes and industrial partners, including global companies and SMEs, collaborate in pre-competitive research projects. Another example of a program on the campus where a range of different companies and knowledge institutes share knowledge and cooperate in innovation projects is the Centre for Translational Molecular Medicine. One more example of open innovation with knowledge institutes is the Incubator3+ organization in which

Philips partners with the University of Technology Eindhoven. It encourages a regional culture of entrepreneurship by stimulating initiatives by providing pre-seed and seed capital, supply of know-how, coaching and exchange of experience for prospective entrepreneurs in the region. DSM is actively involved in open innovation programs with knowledge institutes as well e.g. the Biomedical Materials research program, the Chemical Open Innovation Centre and Dutch Polymer Institute, all structured as public-private partnerships. The knowledge institutes in the region are aware that they should not just target R&D staff of big companies but also technical people involved in daily innovation activities and SMEs. An interviewee at one of the institutes for higher education in the region: "We try to contribute to boosting innovation by 'educating the innovators' e.g. the design of a program to educate the actual builders of high tech systems and an educational program for systems integrators" and: "We are establishing a High Tech Systems Centre at the university next to more fundamental research groups, this will lead to a better match between academic capabilities and industrial needs, thereby strengthening their innovation capabilities". The capability to connect innovation networks to fundamental research in the Brainport region is evaluated as high.

Utrecht region

The interaction between business services companies and knowledge institutes in the region is limited. Universities do little fundamental research to support innovation in business services. One explanation for this limited interaction seems to be that there is simply a lack of knowledge about business services at the academic side. One interviewee from a consultancy company: "we are problem solvers. The focus of the university in organizational science is still very much on fundamental research". An interviewee from another consultancy company emphasizes that proximity to the university and other knowledge institutes is not significant for the company: "we are independent of the local environment; we could decide to shift our offices to Amsterdam at any moment". Moreover, the role of gate-keepers as intermediates between companies and knowledge institutes does not seem to be appreciated as much as in the technology sector. An interviewee from a consultancy company: "if we need specific knowledge, we hire a specialist with the required background". There is one promising recent initiative to involve the business services sector in open innovation activities with knowledge institutes: the Utrecht Sustainable Finance Lab. This is an initiative of banks based in the region (Rabobank, Triodos Bank) and Utrecht University to develop innovative ways of financing sustainable development and creating a sustainable finance sector. However, there is also criticism on this initiative: "to some extent, it is about image building, not about innovation". Therefore, the capability to connect innovation networks to fundamental research in the Utrecht region is evaluated as low.

Capability to connect formal and informal networks

Brainport region

The Brainport region is very much a region where people know each other; are members of all kind of associations and networks, have frequent informal meetings, and are willing to give and take and to do business based on trust. It was observed that 'The Strip' (a 400 m long building with restaurants, bars, shops, services such as a fitness centre and a conference centre), at The High Tech Campus Eindhoven, serves as an informal meeting place for people involved in innovation from different companies and support organizations. It was also observed that innovation events in the region always finish with an informal 'borrel' (drinks) or even an 'after-party' and that people from big and small companies, regional government, innovation support agencies and knowledge institutes stay for this informal part of the event. Many people involved in the innovation system know each other already for years and see

each other not just as colleagues, but as personal friends. Most technology companies were founded in the region and are still embedded in the region, even in the cases where they have been acquired by companies from outside the region. This culture of cooperation facilitates open innovation e.g. in the network of suppliers and business partners. However, dealing with intellectual property rights (IP) in the open innovation environment is getting more difficult, because the "trust based" regional culture sometimes conflicts with a "contract based" business culture. An interviewee from an SME: "Sometimes you think that you have an informal agreement, and then the lawyers come in with extensive contracts, please sign here". Top managers of larger companies argue that formal agreements and detailed contracts are necessary, even in open innovation, to remain in control of IP. Negotiations between companies and universities about patent licenses also get more complicated because of increased attention for knowledge valorisation at the university side. Still, the capability to connect formal and informal networks in the Brainport region is evaluated as high.

Utrecht region

Business service companies in the Utrecht region are somewhat hesitant to practice open innovation. An interviewee from a consultancy company: "Our services are difficult to patent and the sector is characterized by a certain lack of trust". The 'product' of business services companies is less tangible than in technology companies, and often easy to copy. Although there are many informal networks the tendency is to work 'contract based' because of the lack of trust. Although there is often an informal part after innovation events in the Utrecht region as well, most people from the company side leave after the formal meeting, while people from support agencies, regional government and knowledge institutes tend to stay longer. An interviewee from a financial services company: "Business leaders do not see each other very frequently in this region". In general, people are less closely connected to the region in comparison with the Brainport region. An interviewee: "The main reason to be based in the Utrecht region is not to be part of a cluster, but to be in a central location with good road and rail connections". Indeed most offices of KIBS companies in the region are located at the edge of the city of Utrecht, near the highway. An exception is Rabobank which has its head office right in the centre of the city near the train station. Quality of life in the city is seen as high, so that it is relatively easy to attract talented people. However, companies are too dispersed and there are no informal meeting places where innovation networking takes place. It is the ambition of the Science Park, located on the grounds of the University on the outskirts of the city of Utrecht, to fulfil the role of "match between innovative knowledge and business", "in an inspiring environment", but it is not (yet) seen that way. One promising development in the region is that knowledge institutes have started to stimulate business services companies to cooperate in open innovation projects. Still, the capability to connect formal and informal networks in the Utrecht region is evaluated as low.

Capability to connect deep and wide network ties

Brainport region

Technology companies in the region are involved in the development of several innovation platforms, all based on cross-fertilization with partners in adjacent industries:

Smart mobility platform: Interface of High Tech Systems, Automotive, ICT and Design clusters

Medical Technology platform: Interface of High Tech Systems, Life Sciences, Performance Materials and Design clusters

Food for Life platform: Interface of Food Technology and Life Sciences clusters

Smart grids platform: Interface of High Tech Systems, Energy and ICT clusters

The interaction in these platforms has a self-perpetuating effect because participants develop into 'boundary spanners' who feel comfortable in connecting deep networks in their own sector with wide cross-sectoral networks. The capability to connect deep and wide network ties in the Brainport region is evaluated as high.

Utrecht region

Cross-sector collaboration in the business services sector in the region is very limited. Although there is willingness to explore new business service propositions together with partners, perceived difficulties in co-exploiting new services, lack of capabilities to coordinate co-development and lack of willingness to invest in learning from each other lead to a lack of a real open business services innovation system. The exception is cross-sector innovation with ICT companies, because ICT is seen more as an enabling technology in services. An interviewee: "Business services in all fields are represented on this office park: strategic consulting, HR-services, ICT, legal, you name it. And it is very strategically located near the University Science Park. But it seems that the only reason that we are based close to each other is that the location is so convenient. We could do much more together". An interviewee from a finance company: "There is a lot of hidden innovation power in the region". An interviewee from a consultancy company: 'We act as a source of state-of-the art knowledge but most of what we do is transferring best practices, we do not really act as a source of innovation. We facilitate innovation, but the customer implements the innovation". KIBS companies act to some extent also as a carrier of innovation from one company in the region to the other but "we are more knowledge brokers than bridgers". The capability to connect deep and wide networks in the Utrecht region is evaluated as low.

Capability to connect to customer-innovator and lead-user innovator networks.

Brainport region

Companies in the region are traditionally very technology-oriented but the need to connect to a more customer-focused culture is strongly felt. One of the initiatives to connect to customer and lead-user innovator networks is the Creative Conversion Factory on the open innovation campus in Eindhoven. It acts as a knowledge broker, encouraging attention for design and cooperation with the creative industry. One of the criteria in the evaluation of patentable creative and technological innovations as a potential project is the extent to, which, it enables participating organizations to achieve synergies and improve their capabilities. Another initiative is called "ExperienceLab": "we let people experience a new innovative concept in a very early stage of development to discover the practical, social and psychological implications of differentiating technologies-it means more innovation with the final customer". The growing importance of design has influence as well: "The growing attention for design leads to a different approach to innovation. It results in more cooperation with the creative industry and more attention for what customers want".

For some companies in the region, innovation networking is already inherent in their business model. The supply chain of semiconductor manufacturing equipment, an important business in the region, is an open innovation ecosystem in which suppliers, intermediate customers (equipment builder ASML) and final customers (buyers of the equipment-based outside the region) closely cooperate.

Still, not all companies have completed the transformation from technology to more customer and user orientation. The capability to connect to customer and lead-user innovator networks in the Brainport region is evaluated as intermediate.

Utrecht region

The emphasis put on the business service industry is on customized, client specific solutions. Although this is done in cooperation with the customer, the way of working doesn't match the definition of open innovation because the inflows and outflows of knowledge result in one-off solutions, not into building permanent innovation networks. An interviewee: "A lot of our work is relatively routine; based on professional, financial and business expertise and repeated business with clients-we keep on re-inventing the wheel". This has been recognized in the region and business services companies together with regional economic and innovation boards have launched initiatives to establish more permanent innovation networks between companies and customers. One of these is the Colab Services Innovation, a regional platform for digital services innovation. Colab matches launching customers to business services companies. It is a network of public and private partners and a 'pilot plant' to co-develop new digitals services and share knowledge in continuously changing combinations of business service companies, institutions and end users. The objective of the Colab initiative is to work as a marketplace matching supply and demand and as a learning organization connecting different domains. However, one interviewee from the regional government remarks: "we could do more to direct innovation towards targeting customers and sectors with a strong position in the region, such as health care, education, life sciences, creative industry, sustainable development, and other business services.

The ability to connect to customer and user innovator networks in the Utrecht region is evaluated as intermediate.

Capability to connect to regional innovation networks.

Brainport region

The Brainport region established the 'triple helix' model of intensive cooperation between regional (semi) government agencies, business and knowledge institutes already during the 1990s. Brainport is also the name of the regional development organization, a close cooperation between companies, knowledge institutes and regional authorities, with a board that represents these three parties. Brainport has embraced the open innovation approach and its development program addresses stimulating innovation (via knowledge creation, exchange, and transfer), developing human capital via education and stimulating entrepreneurship, creating and strengthening networks in business and international cooperation and improving the 'soft' and 'hard' infrastructure for open innovation. The Open Innovation Campus campuses in the region were driven by companies such as Philips and DSM and regional leaders in the Triple Helix of university-industry-government collaboration. The main open innovation campuses in the region, the High Tech Campus Eindhoven and the Chemelot campus have become new symbols for the region, because of their visibility from the highway and the good fit with the Brainport "brand". Interviewees frequently mention the names of 'visionary leaders' of leading companies, regional government and knowledge institutes who are credited for making the triple helix work and making the open innovation campuses reality. The capability to connect to regional innovation networks in the Brainport region is evaluated as high.

Utrecht region

Paradoxically, the economic success of the region over a long period of time has caused the region to fall behind other regions in terms of involvement of companies in the governance of innovation. Innovation policy initiatives in the region often remained top-down or isolated initiatives. Moreover, the regional knowledge institutes have been too dominant in the existing innovation networks. A KIBS company interviewee: "Knowledge does not equal innovation". However, other interviewees believe that companies should take more initiative: "Companies in this

region do not want to take leadership in innovation, they want to stay under the radar"; "Maybe our business leaders are too modest". Interviewees from the regional government side also point at the different leadership style in business services compared to the Brainport region: "the leadership style here is more transactional, almost detached". Recently, the region has established an economic board in an effort to come to more joint efforts by government, knowledge institutes, industrial companies and the services sector, e.g. by organizing "get connected" meetings with collaborative innovation as the main theme. The economic board works closely together with the Task Force Innovation (TFI), a network organization promoting regional innovation. Unfortunately, the participation of business services companies in these networks seems to be motivated to some extent by opportunities to acquire business from (semi-) government institutes: "conversations at networking events between regional government, support agencies and business services companies often end up in sales pitches". Moreover, the role of TFI is seen as limited: "Part of TFI's role is to initiate and encourage partnerships in innovation, however, it is a temporary organization that will be discontinued after 4 years-the local government doesn't realize that changing the mindset takes more time". An exception is the creative industry, where the networking organization Immovator plays a regional role towards promoting open innovation, e.g. in the Cross Media Innovation centre. The Dutch Game Garden, based in Utrecht, is another example of promoting regional innovation networks in the creative industry. It brings small companies in the gaming industry, many of them active in 'serious games', together in one building as a kind of 'small-scale open innovation campus'. The capability to connect to regional innovation networks in the Utrecht region is evaluated as intermediate.

Capability to connect inter-functional company networks.

Brainport region

The open innovation campuses in the region play an important role into building innovation communities and encourage interaction between 'creative minds', craftsmen, engineers, scientists and entrepreneurs to turn ideas into profitable business. Especially the high tech campus Eindhoven is a very open and attractive environment. The meeting places within the campus encourage external networking, but also inter-functional company networks. However, there are also some regional factors that currently hamper open innovation. For instance, finding entrepreneurs who combine technology insight, business insight, drive and willingness to take risk turns out to be difficult, despite efforts of regional agencies and open innovation campus management to seek and develop entrepreneurial talent. An interviewee at a regional development company: "there are more ideas for innovative businesses than entrepreneurial talent to pursue these ideas". The capability to connect inter-functional company networks in the Brainport region is evaluated as intermediate.

Utrecht region

Business services companies are often based close to each other in the region, e.g. on the Rijnsweerd and Papendorp business parks, but these locations do not radiate the same openness as the open innovation campuses in the Brainport region. Even during lunch hours on working days, the streets in the business park are empty. An 'Open Innovation Services Campus' does not yet exist. There are plans to extend the Science Park Utrecht, based on the University campus, to the nearby Rijnsweerd business park; however, without a change in mindset to a more collaborative attitude, it is doubtful whether this will result in a significant increase in networking for innovation. An interviewee from an ICT-company: "The distance between this business park and the science park is about 1 kilometre, but it's like two worlds apart". The culture of sharing knowledge and ideas is different from the Brainport region. An interviewee from a consultancy company: "We have very creative individuals, but that doesn't

automatically lead to innovation for the firm. Our people have a nomadic mentality. When they leave for another job or start their own business, they take their ideas and knowledge with them". The capability to connect inter-functional company networks in the Utrecht region is evaluated as low.

Capability to connect to societal networks

Brainport region

The Brainport region supports and stimulates sustainability initiatives and has embraced the 'Cradle to Cradle' concept of sustainable design and innovation (McDonough and Braungart, 2002). The pioneer of Cradle to Cradle in the region is DSM, which runs a 'Climate-Induced Innovation' initiative in collaboration with societal partners and has realized innovations in renewable energy, biofuels, innovative composites that enable energy-saving in transport and environmental friendly solvents. However, some companies in the region are sceptical about 'Cradle to Cradle', because the economic value is not always clear. Several companies have long-term mission statements related to sustainability (e.g. "improving the quality of life through the introduction of meaningful innovations"), but investors demand short-term profitability. Companies try to connect short-term and long-term by introducing new products that contribute to creating sustainable societies e.g. products to improve health and well-being, products to conduct research in the fields of energy and environment, or environmental friendly solutions. We participated in a seminar on one of the open innovation campuses with the aim to bring people together to stimulate innovative thinking in the use of renewable energy and "green" raw materials. The seminar was successful in bringing together researchers, product developers, regional government and politicians, but was not successful regarding the start of a dialogue with society at large. Transforming the need for sustainable solutions into innovative products, systems and services is still a challenge. The capability to connect to societal networks in the Brainport region is evaluated as intermediate.

Utrecht region

Business services companies in the region are rather reluctant to invest in longer term knowledge development which is necessary to get involved in sustainable innovation initiatives with societal partners and knowledge institutes, unless it creates business value in the short-term as well. An interviewee from a consultancy company: "We get involved in sustainability projects because our clients face new demands due to new legislation and regulation-however these are solution oriented projects to comply with legislation and regulation, not long term investments". Exceptions are companies like Ecofys, an advisory services company specialized in sustainability and Royal Haskoning DHV, an engineering services company, which puts a strong focus on innovation for sustainable development. Financial services company Rabobank is innovative in its contribution to social responsibility and sustainable development related to its strong position in the agricultural sector. Recently more business services companies started to participate in initiatives in order to turn sustainability challenges into innovative solutions with the objective of creating value for business and society. One of these is the University Utrecht Sustainability Institute, which targets innovations for sustainable urban development in cooperation with advisory, ICT, engineering, design, legal and financial services companies based in the region, thereby linking science, technology, financial-economic and socio-cultural issues in an open innovation environment. An interviewee from an engineering consultancy company: "We cooperate with other engineering companies, building companies and the regional knowledge institutes in the Centre of Expertise for smart sustainable cities, directed at innovation in services to realize smart sustainable cities". However,

these initiatives are seen as too limited: "The region could do more to raise its profile as a sustainable region. That would encourage open innovation with regional KIBS companies with a sustainable development strategy". The capability to connect to societal networks in the Utrecht region is evaluated as intermediate.

5. Discussion

Figure 1 summarizes the findings in the Technology sector (Brainport region) and the Knowledge Intensive Business Services sector (Utrecht region) on networking capabilities for each networking type.

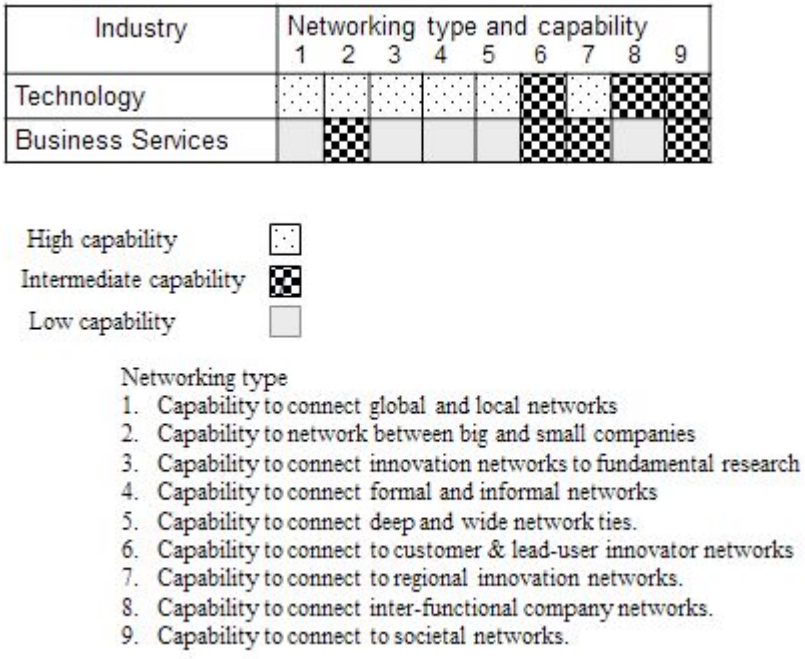

Fig.1. Summary of findings in Technology sector (Brainport region) and Knowledge Intensive Business Services sector (Utrecht region) on networking capabilities for each networking type.

The results show that, according to the framework, technology companies in the Brainport region have on average higher networking capability than KIBS companies in the Utrecht region and are in the lead of benefiting from open innovation. In the technology sector, there is room for improvement in connecting to customer and lead-user innovator networks, in connecting inter-functional company networks and in connecting to societal networks. These weaknesses can be explained by the still dominant technology orientation in the sector, which goes at the expense of customer orientation, inter-functional cooperation and anticipating societal needs. It means that on the Technology Push-Market Pull innovation dilemma, the emphasis is still at the technology push side, that on the 'Stimulating individual performance versus cooperation and knowledge sharing' innovation dilemma the emphasis is on the individualistic side and that on the short-term focus versus long-term focus in innovation dilemma, the emphasis is on the short-term side. On the other innovation

dilemmas, a dynamic balance is maintained. The business services sector main weaknesses are, according to the framework, in connecting global/local networks, connecting innovation networks to fundamental research, connecting formal/informal networks, connecting deep/wide networks and connecting inter-functional networks. This can be explained by the predominant orientation towards local-for-local and one-off customer specific solutions, the short-term orientation and the lack of openness and trust in the business services sector. It means that there is no dynamic balance on most innovation dilemmas.

The preliminary research confirmed that all networking capabilities in the framework, and the tensions implied by them, are relevant for benefiting from open innovation The results suggest that the framework of networking capabilities is comprehensive, and a promising tool for analysis that can serve as a checklist for companies how they can become better equipped to benefit from open innovation, providing an agenda for culture change.

This article builds on the results from a comparison of two regional cases, which means that the scope for generalizations is limited. However, it is a step towards a better understanding of the requirements for companies to benefit from open innovation. More research is needed so as to provide a more thorough understanding; but the exploratory research provides evidence for the proposition that technology companies are in an advantageous position to benefit from open innovation because of their previous experiences in innovation networking. Companies in the Brainport region, such as Philips, DSM, ASML and FEI, combine a long history in closed innovation with external networking resulting in a "culture of innovation" including innovation networking capabilities. This can be partly explained by the embeddedness of these companies in this region where they were founded. The region is known for its networking culture and the research shows that corporate innovation cultures and regional innovation cultures can reinforce each other. This supports the conclusions of Tödtling et al. (2011) who show that corporate innovation cultures and regional innovation cultures can influence each other into creating an environment conducive to open innovation. It also supports the conclusions of Belussi et al. (2010) who studied the life sciences sector in a specific region and found that relational and coordination capabilities of firms and research labs allow the establishment of a positive spiral of learning conducive to the development of an 'ORIS' ('Open Regional Innovation System'). The Brainport region seems to be on its way to become such an ORIS as well. The difference between a traditional RIS and an open ORIS is in the high score on the capability to connect global and local networks, which means that companies in the region can combine exploiting the advantages of local knowledge spill-overs and getting access to non-local sources of knowledge and information.

The research also provides evidence that the presence of a KIBS cluster in a region, combined with a regional open innovation strategy stimulating networking and cooperation, is not sufficient for creating an open innovation culture. KIBS companies in the region score low or intermediate on the networking capabilities. The literature on collaborative innovation involving KIBS firms to date shows mixed results (Doloreux et al., 2010). Qualifications of KIBS in terms of innovation range from "remarkable innovators in her own right", "knowledge intermediaries" and "central to the innovation processes of other firms" to "routine service providers". E.g. Aslesen and Isaksen (2010), in a study of KIBS in different Norwegian regions, find that KIBS do engage in collaborative learning processes and act as intermediaries between knowledge infrastructure and firms. Kautonen and Hyypiä (2010), in a study of management-KIBS in Finland, find that only a small number of KIBS companies play a role as intermediaries between local clients and the international business environment. Freel (2010, p. 93) concludes that technology-based KIBS

disproportionate engage in collaborative innovation with other KIBS but that there is relatively limited collaborative contribution of KIBS to other sectors. Miles (2005) finds that some technology-based KIBS are well linked to innovation systems, while IT services and more professional services tended to have low levels of contact, relying more on professional associations to refresh their knowledge. Our results for the Utrecht region are in line with Miles (2005), Freel (2010) and Kautonen and Hyypiä (2010). Overall, applying the framework to KIBS companies in the Utrecht region results in relatively low scores on innovation networking capabilities and low involvement in open innovation, with technology-based KIBS as the exception, and we find a limited role of KIBS companies in connecting local and global innovation networks. However, we have to be careful to draw conclusions on differences between technology industry and KIBS sector based on the comparison between two regions with a different sectoral specialization. E.g. Aslesen and Isaksen (2010) and Kautonen and Hyypiä (2010) report differences between the role of KIBS in innovation systems in different regions within one country. Differences between regions, such as high level of specialization versus more generic services, level of globalization, proximity of different KIBS-partners and differences in knowledge sources, may influence the role of KIBS in innovation systems.

The research indicates that the networking capabilities framework is a promising tool for analysis that can be used to compare to what extent companies from two different sectors are equipped to benefit from open innovation. The comprehensive framework of network capabilities for open innovation has been developed by connecting fundamental innovation culture dilemmas to networking capabilities and seems to offer a more complete framework than existing models on open innovation and capabilities (Cheng and Chen, 2013; Den Hertog et al., 2010; Fichter, 2009; Gassmann and Enkel, 2004; Lee et al., 2010; Lichtenthaler, 2011; Lichtenthaler and Lichtenthaler, 2009; Robertson et al., 2012; Simard and West, 2006; Vanhaverbeke, 2006;), also because differences in capabilities can be related to the way companies handle the innovation dilemmas. However, further research to validate the framework is necessary.

Next to the already mentioned managerial implications for companies, the research has important policy implications for regions as well. E.g., in the Utrecht region, several KIBS companies are not convinced that they can benefit from being involved in regional innovation networking. The innovation networking capabilities framework can help regional innovation policy makers to convince companies that they can benefit from open innovation by developing these capabilities.

6. Conclusion

Companies can benefit from open innovation when they have the capabilities to connect closed and open approaches to innovation. Benefiting from open innovation is not just a matter of implementing an open innovation strategy consisting of cooperative agreements, external technology acquisition, investing in start-ups, spinning-off activities etc. Benefiting from open innovation requires a culture change in the direction of a culture conducive to developing networking capabilities. The first research question has been answered by developing a comprehensive framework of nine networking capabilities, rooted in theories of how organizational cultures impact innovation and showing how the framework can be used to evaluate to what extent companies are equipped to benefit from open innovation. The research results suggest that the framework can serve as an analytical tool to evaluate to what extent companies are equipped to benefit from open innovation, and can help regions to develop policies to encourage and assist companies to improve their networking

capabilities and embark on culture change processes. The second research question has been answered by preliminary empirical research to test the framework by a comparative study of a region dominated by the technology industry and a region dominated by the business services industry in The Netherlands. The results indicate that technology companies are in the lead of benefiting from open innovation. A possible explanation for this advantageous position in being able to benefit from open innovation is that many technology companies have a long experience in improving their innovative performance by combining internal R&D capabilities and innovation activities with developing networking capabilities to recognize, monitor and use external knowledge resources and innovations developed elsewhere. Companies with previous experience in making internal skills and resources work together in innovation and a culture conducive to external networking benefit from networking in innovation with customers, competitors, suppliers, partners, knowledge institutes and other external stakeholders. However, definitive conclusions cannot be drawn because the comparative case study between two regions served as a first step to further validating the framework of network capabilities. Further research is necessary to investigate the influence of other differences between regions such as high level of specialization versus more generic services, level of globalization and differences in knowledge sources.

The framework of networking capabilities is a promising tool to serve as a checklist for companies how they can become better equipped to jointly create value and capture value in open innovation networks. The research has important policy implications as well, because it indicates that regional open innovation strategies need to address the development of networking capabilities of companies and other actors in the regional innovation system to create an open innovation environment. The framework of networking capabilities can potentially serve as an analytical tool to assess under which conditions companies can benefit from open innovation in a regional cluster.

Limitations of the study are the case study approach limited to two different industries in two different regions and the qualitative approach due to a lack of quantitative data on the benefits of open innovation. Further research should be aimed at assessing the generalizability of the approach by comparative research of other sectors and regions, detailed research of benefits of open innovation in specific companies and more quantitative research. Another possible area of research is in the new category of 'tech-service' companies-the growing group of technology firms with a large service component. It would be interesting to use the innovation network capabilities framework to assess to what extent these firms are able to transfer elements of an open innovation culture from the technology side of their business to the service side and possibly the other way around.

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8. References

Aslesen, H., & Isaksen, A. (2010). Knowledge-intensive business services as knowledge mediators in different regional contexts: the case of Norway. In: D. Doloreux., M. Freel. & R. Shearmur (Eds). *Knowledge-Intensive Business Services. Geography and Innovation* (pp. 99- 121). Aldershot: Ashgate.

Bansal, P., & Corley, K. (2011). The coming of age for qualitative research: embracing the diversity of qualitative methods. *Academy of Management*

Journal, 54(2), 233-237.

Belussi, F., Sammarra, A., & Sedita, R. S. (2010). Learning at the boundaries in an "Open Regional Innovation System": A focus on firms' innovation strategies in the Emilia Romagna life science industry. *Research Policy,* 39(6), 710-721.

Boekema, F., Borgers, K., Bakker, S., & Rutten, R. (2000). *Knowledge, Innovation and Economic Growth: The Theory and Practice of Learning Regions*. Cheltenham: Edward Elgar.

Bryman, A., & Bell, E. (2007). *Business Research Methods*. Oxford: Oxford University Press.

Cameron, S., & Quinn, R. (1999). *Diagnosing and changing organizational culture*. Reading: Addisson-Wesley.

du Chatenier, E., Verstegen, J., Biemans, H., Mulder, M., & Omta, O. (2010). Identification of competencies for professionals in open innovation teams *R&D Management*, 40(3), 271-280.

Chatzkel, J. (2004). Greater Phoenix as a knowledge capital. *Journal of Knowledge Management*, 8(4), 61-72.

Cheng, C., & Chen, J. (2013). Breakthrough innovation: the roles of dynamic innovation capabilities and open innovation activities. *Journal of Business & Industrial Marketing,* 28(5), 444-454.

Chesbrough, H. (2003). *Open Innovation: The New Imperative for Creating and Profiting from Technology*. Boston: Harvard Business School Press.

Chesbrough, H. (2006). *Open Business Models: How to Thrive in the New Innovation Landscape*. Boston: Harvard Business School Press.

Chesbrough, H., & Birkinshaw, J. (2006). Introduction to the Research Policy 20th anniversary special issue of the publication of Profiting from Innovation by David J. Teece. *Research Policy,* 35(8), 1091-1099.

Chesbrough, H., & Crowther, K. A. (2006). Beyond high tech: early adopters of open innovation in other industries. *R&D Management,* 36(3), 229-236.

Chesbrough, H., Vanhaverbeke, W., & West, J. (2006), *Open Innovation: Researching a new paradigm,* Oxford: Oxford University Press.

Chesbrough, H., & Schwartz, K. (2007). Innovating business models with co-development partnerships. *Research Technology Management,* 50(1), 55-59.

Chesbrough, H. (2011). *Open Services Innovation: Rethinking Your Business to Grow and Compete in a New Era*. New York, NY: Jossey Bass.

Chesbrough, H. (2012). Open Innovation Where We've Been and Where We're Going. *Research Technology Management,* 55(4), 20-27.

Christensen J., Olesen, M., & Kjær, J. (2005). The industrial dynamics of Open Innovation-Evidence from the transformation of consumer electronics. *Research Policy,* 34(10), 1533-1549.

Clippinger, J. (2009). *The Biology of Business: Decoding the Natural Laws of Enterprise*. San Francisco: Jossey Bass.

Cohen, W., & Levinthal, D. (1989). Innovation and Learning: The two faces of R&D. *The Economic Journal*, 99(397), 569-596.

Cohen, W., & Levinthal, D. (1990). Absorptive capacity: A new perspective on learning and innovation. *Administrative Science Quarterly,* 35(1) 128-152.

Cooke, P. (2005a). Regional knowledge capabilities and open innovation: regional innovation systems and clusters in the asymmetric knowledge economy. In S. Breschi & F. Malerba (Eds.), *Clusters, Networks & Innovation* (pp. 80-112).

Oxford: Oxford University Press.

Cooke, P. (2005b). Regionally asymmetric knowledge capabilities and open innovation: exploring 'Globalisation 2'-a new model of industry organisation. *Research Policy,* 34(8), 1128-1149.

Cooke, P. (2007). Theorizing regional knowledge capabilities. Economic geography under open innovation. In: J. Suriñach, R. Moreno & E. Vayá (Eds), *Knowledge Externalities, Innovation Clusters and Regional Development* (pp. 19-41). Massachusetts**:** Edward Elgar Publishing

Dahlander, L., & Gann, D. (2010). How open is innovation? *Research Policy,* 39(6), 699-709.

Dawson, R. (2000). Knowledge capabilities as the focus of organizational development and strategy. *Journal of Knowledge Management*, 4 (4), 320-327.

Di Bernardo, B., Di Maria, E., & Grandinetti, R. (2012). *Exploring Knowledge-Intensive Business Services*. New York: Palgrave Macmillan.

Doloreux, D., Freel, M., & Shearmur, R. (eds.) (2010). *Knowledge-Intensive Business Services. Geography and Innovation*. Aldershot: Ashgate.

Dosi, G., Nelson, R., & Winter, S. (Eds.) (2000). *The Nature and Dynamics of Organizational Capabilities*. Oxford: Oxford University Press.

Dougherty, D. (1996). Organizing for Innovation. In: S. Clegg, C. Hardy and W. Nord (Eds.), *Handbook of Organization Studies* (pp. 424-439). London: Sage.

Doz, Y., Wilson, K., Veldhoen, S., Goldbrunner, T., & Altman, G. (2006). *Innovation: Is Global the Way Forward? Survey Results*. Fontainebleau: INSEAD and Booz Allen Hamilton.

Available at:

http://www.boozallen.com/media/file/Innovation_Is_Global_The_Way_Forward_v2.pdf

Dyer, J., & Singh, H. (1998). The Relational View: Cooperative Strategy and Sources of Interorganizational Competitive Advantage. *Academy of Management Review,* 23(4), 660-679.

EIRMA, (1969). *Research bought outside the firm*. Paris: EIRMA.

EIRMA, (1988). *Improving industry-university relations*. Paris: EIRMA.

EIRMA, (1989). *Cooperative R&D in industry*. Paris: EIRMA.

EIRMA, (1995). *Effective collaboration R&D*. Paris: EIRMA.

EIRMA, (1997). *Outsourcing R&D*. Paris: EIRMA.

EIRMA, (2003). *Innovation through Spinning In and Out, Working Group Report WG60*. Paris: EIRMA.

EmdenGrand, Z., Calantone, R., & Droge, C. (2006). Collaborating for new product development: selecting the partner with the maximum potential to create value. *Journal of Product Innovation Management,* 23(4), 330-341.

Eisenhardt, K., & Graebner, M. (2007). Theory building from cases: Opportunities and challenges. *Academy of Management Journal,* 50(1), 25-32.

Eisenhardt, K., & Martin, L. (2000). Dynamic capabilities: what are they? *Strategic Management Journal*, 21(10-11), 1105-1121.

Etzkowitz, H., & Leydesdorff, L. (2000). The Dynamics of Innovation: From National Systems and 'Mode 2' to a Triple Helix of University-Industry-Government Relations. *Research Policy,* 29(2), 109-123.

EUREKA, (2006). *A cornerstone of the European research and innovation area*. Brussels.

Available at:

http://www.eurosfaire.prd.fr/7pc/doc/1143649200_eureka_cornerstone_era_03_2006.pdf

European Commission, (2007). *Challenges for EU support to innovation in services*. Commissions Staff Working Document.

Available at:

http://ec.europa.eu/enterprise/policies/innovation/files/swd_services_en.pdf

European Commission, (2009). *Challenges for EU support to innovation in services*. Pro Inno Europe paper no. 12.

Available at

http://ec.europa.eu/enterprise/policies/innovation/files/swd_services_en.pdf

Fichter, K. (2009). Innovation communities: the role of networks of promotors in Open Innovation. *R&D Management*, 39(4), 357-371.

Fleming, L., & Waguespack, D. (2007). Brokerage, Boundary Spanning, and Leadership in Open Innovation Communities. *Organization Science*, 18(2), 165-184.

Flynn, M., Dooley, L., O'Sullivan, D., & Cormican, K. (2003). Idea Management for Organisational Innovation. *International Journal of Innovation Management*, 7(4), 417-442.

Frankenberger, K., Weiblen, T., & Gassmann, O. (2014). The antecedents of open business models: an exploratory study of incumbent firms. *R&D Management,* 44(2), 173-188.

Freel, M. (2010). Knowledge intensive business services users and Uses: Exploring the propensity to innovation-related cooperation with Knowledge-Intensive Business Services. In D. Doloreux, M. Freel and R. Shearmur (Eds.). *KIBS: Geography and Innovation* (pp. 75-98). Aldershot: Ashgate.

Gann, D. (2005). Open innovation: The new imperative for creating and profiting from technology. *Research Policy*, 34(1), 122-123.

Gassmann, O., & Enkel, E. (2004). *Towards a Theory of Open Innovation: Three Core Process Archetypes*. Proceedings of The R&D Management Conference, Lisbon, Portugal, July 6–9.

Gassmann, O., Enkel, E., & Chesbrough, H. (2010). The future of open innovation. *R&D Management,* 40(3), 213-221.

Gemünden, H., Salomo, S., & Hölzle, K. (2007). Role models for radical innovations in time of open innovation. *Creativity and Innovation Management*, 16(4), 408-421.

Gupta, A., Smith, K., & Shalley, C. (2006). The Interplay between Exploration and Exploitation. *Academy of Management Journal*, 49(4) 693-706.

Hacievliyagil, N. (2007*). The Impact of Open Innovation on Technology Transfers at Philips and DSM*. Delft University of Technology, MSc Thesis Faculty of Technology, Policy & Management.

Hampden-Turner, C., & Trompenaars, F. (2000). *Building cross-cultural competence*. Chichester: John Wiley.

Hargadon, A. (2003). *How Breakthroughs Happen*. Boston (MA): Harvard Business School Press.

Heidenreich, M. , Barmeyer,C., Koschatzky, K., Mattes, J. , Krüth, K., Baier, E., & Helfat, C. (2012). *Multinational Enterprises and Innovation: Regional Learning*

in Networks. New York: Routledge.

Finkelstein, C. S., Mitchell, W., Peteraf, M., Singh, H., Teece, D., & Winter, S. (2007). *Dynamic Capabilities: Understanding Strategic Change in Organizations*. Oxford: Blackwell Publishing.

Henkel, J., Schöberl, S., & Alexy, O. (2014). The emergence of openness: How and why firms adopt selective revealing in open innovation. *Research Policy*, 43(5), 879-890.

den Hertog, P., van der Aa, W., & de Jong, W. (2010). Capabilities for managing service innovation: towards a conceptual framework. *Journal of Service Management*, 21(4), 490-514.

Herzog, P., & Leker, J. (2010). Open and closed innovation: Different innovation cultures for different strategies. *International Journal of Technology Management* 52 (3-4): 322-343.

Horwitch, M., Parikh, M., & Ziv, N. (2000). *Open Innovation: Transferring the Lessons from Software to Modern Value Creation*. Paper presented at CISEP Workshop on Innovation and Diffusion in the Economy, Lisbon, Portugal.

Huston, L., & Sakkab, N. (2006). Connect and develop, inside Procter & Gamble's new model for innovation. *Harvard Business Review,* 86(3), 58-66.

Kautonen, M., & Hyypiä, M. (2010) Knowledge intermediaries or routine service producers? Exploring Finnish M-KIBS using the innovation system approach. In: D. Doloreux., M. Freel. & R. Shearmur (eds). *Knowledge-Intensive Business Services. Geography and Innovation* (pp. 123-143). Aldershot: Ashgate.

Katz, R., & Allen, T. J. (1982). Investigating the not invented here (NIH) syndrome: a look at the performance, tenure, and communication patterns of 50 R&D project groups. *R&D Management*, 12(1), 7-19.

Kirschbaum, R. (2005). Open innovation in practice: New businesses get built from a culture of change at the Dutch specialty materials company DSM. *R&D Management,* 48(4), 24-28.

Kooij, H. (2014). Object formation and subject formation: The innovation campus in the Netherlands. *Planning Theory*, 1-21.

Lee, S., Park, G., Yoon B., & Park, J. (2010). Open innovation in SMEs-An intermediated network model. *Research Policy*, 39(2), 290-300.

Levin, D., & Cross, R. (2004). The Strength of Weak Ties You Can Trust: The Mediating Role of Trust in Effective Knowledge Transfer. *Management Science,* 50(11), 1477-1490.

Lichtenthaler, U., & Lichtenthaler, E. (2009). A capability-based framework for open innovation: complementing absorptive capacity. *Journal of Management Studies,* 46(8), 1315-1338.

Lichtenthaler, U. (2011). Open Innovation: Past Research, Current Debates, and Future Directions. *Academy of Management Perspectives*, 25(1), 75-93.

Malecki, E. (2011). Connecting local entrepreneurial ecosystems to global innovation networks: open innovation, double networks and knowledge integration. *International Journal of Entrepreneurship and Innovation Management*, 14(1), 36-59.

Malherba, F. (2005). Sectoral Systems: How and Why Innovation Differs across Sectors. In: R. Nelson, D. Mowery & J. Fagerberg (eds.), *The Oxford Handbook of Innovation* (pp. 380-406). Oxford: Oxford University Press.

March, J. (1991). Exploration and Exploitation in Organizational Learning. *Organization Science*, 2(1), 71-87.

Marques, J. (2014). Closed versus Open Innovation: Evolution or Combination? *International Journal of Business and Management*. 9(3), 196-203.

McDonough, W., & Braungart, M. (2002). *Cradle to Cradle: Remaking the Way We Make Things*. New York: North Point Press.

van der Meer, H. (2007). Open Innovation-The Dutch Treat: Challenges in Thinking in Business Models. *Creativity and Innovation Management*, 16(2), 192-202.

Miles I., Kastrinos N., Bilderbeek R., Hertog B., Huntink W. & Bouman M. (1995). *Knowledge-intensive business services-Users, carriers and sources of innovation*. Luxemburg: EIMS publication no. 15.

Available at:

http://www.academia.edu/4122950/Knowledge-Intensive_Business_Services_Users_Carriers_and_Sources_of_Innovation

Miles, I. (2005). Innovation in services. In: R. Nelson, D. Mowery & J. Fagerberg (Eds.), *The Oxford Handbook of Innovation* (pp. 434-458). Oxford: Oxford University Press.

Mortara, L., & Minshall, T. (2011). How do large multinational companies implement open innovation? *Technovation*, 31(10-11), 586–597.

Noorderhaven, N., Koen, C., & Beugelsdijk, S. (2002). *Organizational culture and network embeddedness*. Tilburg University discussion paper.

Available at:

http://www.researchgate.net/publication/4760301_Organizational_Culture_and_Network_Embeddedness/links/0912f50c83cf360d5e000000.pdf

OECD, (2008). *Open innovation in global networks*. Paris: OECD Publications.

Available at http://www.oecd.org/sti/openinnovationinglobalnetworks.htm

Ollila, S., & Elmquist, M. (2011). Managing Open Innovation: Exploring Challenges at the Interfaces of an Open Innovation Arena. *Creativity and Innovation Management,* 20(4), 273-283.

Pavitt, K. (1984). Sectoral patterns of technical change: towards a taxonomy and a theory. *Research Policy*, 13(6), 343-373.

Pavitt, K. (1994). Key Characteristics of Large Innovation Firms, in: M. Dodgson & R. Rothwell (eds.), *The Handbook of Industrial Innovation*. Aldershot: Edward Elgar.

Penrose, E. (1959). *The Theory of the Growth of the Firm*. Oxford: Oxford University Press.

Perkmann, M., & Walsh, K. (2007). University-industry relationships and open innovation: towards a research agenda. *International Journal of Management Reviews*, 9(4), 259-280.

Polgar, S., & Thomas, S. (1995). *Introduction to Research in Health Sciences* 3rd ed. Edinburgh: Churchill Livingston.

Powell, W., Koput, K., & Smith-Doerr, L. (1996). Interorganizational Collaboration and the Locus of Innovation: Networks of Learning in Biotechnology. *Administrative Science Quarterly*, 41(1), 116-145.

Prud'homme van Reine, P., & Dankbaar, B. (2009). Mythe en realiteit van het creëren van innovatieculturen. In: R. van Es & J. Boonstra, *Cultuurverandering: mythe en realiteit* (pp. 77-94). Deventer: Kluwer.

Prud'homme van Reine, P., & Dankbaar, B. (2011). The dynamic interaction between corporate and regional cultures. *Journal of Economic and Social Geography*, 102(5), 532-547.

Punnett, B., & Shenkar, O. (eds.) (2004). *Handbook for international management research 2nd edition*. Ann Arbor: University of Michigan Press.

Robertson, P., Casali, G., & Jacobson, D. (2012). Managing open incremental process innovation: Absorptive Capacity and distributed learning. *Research Policy*, 41(5), 822-832.

van Rooij, A. (2007). *The company that changed itself: R&D and the transformations of DSM*. Amsterdam: Amsterdam University Press.

Rothwell, R. (1992). Successful industrial innovation: Critical factors for the 1990's. *R&D Management*, 22(3), 64-84.

Sackmann, S. (1997). *Cultural complexity in organisations*. London: Sage.

Schein, E. (1985). *Organizational culture and leadership*. San Francisco: Jossey-Bass.

Schein, E. (2003). *DEC is dead, long live DEC. The lasting legacy of Digital Equipment Corporation*. San Francisco: Berrett-Koehler.

Schroll, A., & Mild, A. (2011). Open innovation modes and the role of internal R&D An empirical study on open innovation adoption in Europe. *European Journal of Innovation Management*, 14(4), 475-495.

Simard, C., & West, J. (2006). Knowledge networks and the Geographic Locus of Innovation, In: H. Chesbrough, W. Vanhaverbeke & J. West (eds), *Open Innovation: Researching a new paradigm* (pp. 220-240). Oxford: Oxford University Press.

Spithoven, A., Clarysse, B., & Knockaert, M. (2010). Building absorptive capacity to organise inbound open innovation in traditional industries. *Technovation,* 30(2), 130-141.

Strauss, A., & Corbin, J. (1998). *Basics of Qualitative Research: Grounded Theory Procedures and Techniques, 2nd edition*. Thousand Oaks, Ca: Sage.

Takeuchi, H., Osono, E., & Shimizu, N. (2008). The Contradictions That Drive Toyota's Success. In: *Harvard Business Review*, 86(6), 96-104.

Teece, D., & Pisano, G. (1996). The dynamic capabilities of firms: an introduction. *Industrial and Corporate Change*, 3(3), 537-56.

Teece, D., Pisano, G., & Shuen, A. (1997). Dynamic capabilities and strategic management. *Strategic Management Journal*, 18(7), 509-533.

Teece, D. (1998). Capturing value from knowledge assets: the new economy, markets for know-how, and intangible assets. *California Management Review*, 40(3), 55-79.

Teece, D. (2000). Strategies for Managing Knowledge Assets: the Role of Firm Structure and Industrial Context. *Long Range Planning*, 33(1), 35-54.

Teece, D. (2007). Explicating dynamic capabilities: the nature and microfoundations of (sustainable) enterprise performance. *Strategic Management Journal*, 28(13), 1319-1350.

Tidd, J. (1993). Development of Novel Products through intraorganizational and interorganizational networks. *Journal of Product Innovation Management*, 12(4), 307-322.

Thomke, S., & von Hippel, E. (2002). Customers As Innovators: A New Way to Create Value. *Harvard Business Review*, 80(4), 74-81.

Tödtling, F., Prud'homme van Reine, P., & Dörhöfer, S. (2011). Open Innovation and Regional Culture-Findings from Different Industrial and Regional Settings. *European Planning Studies*, 19(11), 1885-1907.

Trompenaars, F., & Prud'homme, P. (2004). *Managing change across cultures*. Chichester: Capstone-Wiley.

Trompenaars, F. (2007). *Riding the whirlwind: Connecting People and Organisations in a Culture of Innovation.* Oxford: The infinite ideas company Ltd.

Trompenaars, F., & Hampden-Turner, C. (2010). *Riding the waves of innovation.* New York: McGrawHill.

Van de Vrande, V., de Jong, J., Vanhaverbeke, W., & de Rochemont, M. (2009). Open innovation in SMEs: Trends, motives and management challenges. *Technovation* 29(6-7), 423-437.

Vanhaverbeke, W. (2006). The interorganizational context of open innovation. In: H. Chesbrough, W. Vanhaverbeke & J. West (eds), *Open Innovation: Researching a new paradigm* (pp. 205-219), Oxford: Oxford University Press.

Vanhaverbeke, W., Van de Vrande, V., & Cloodt, M. (2008). Connecting absorptive capacity and open innovation. *Research Paper Series*

Available at SSRN: http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1091265

Von Hippel, E. (1986). Lead Users: A Source of Novel Product Concepts. *Management Science*, 32(7), 791-805.

Von Hippel, E. (2005). *Democratizing innovation*. Cambridge, Mass: MIT Press.

de Vries, M. (2005). *80 years of research at the Philips Natuurkundig Laboratorium*. Amsterdam: Pallas Publications.

Wendelken, A., Danzinger, F., Rau, C., & Moeslein, K. (2014). Innovation without me: why employees do (not) participate in organizational innovation communities. *R&D Management,* 44(2), 217-236.

West, J., & Bogers, M. (2014). Leveraging External Sources of Innovation: A Review of Research on Open Innovation. *Journal of Product Innovation Management,* 31(4), 814-831.

West, J., Salter, A., Vanhaverbeke, W., & Chesbrough, H. (2014). Open innovation: The next decade. *Research Policy*, 43(5), 805-811

Yin, R. (2003). *Case study research, design and methods, 3rd ed*. Newbury Park: Sage Publications.

Zander, U., & Kogut, B. (1995). Knowledge and the speed of transfer and imitation or organizational capabilities: an empirical test. *Organizational Science* 6(1), 76-92.

Zollo, M., & Winter, S. (2002). Deliberate Learning and the Evolution of Dynamic Capabilities**.** *Organization Science,* 13(3), 339-351.

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Open Innovation Implementation in the Service Industry: Exploring Practices, Sub-practices and Contextual Factors

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Abstract. This paper addresses a major gap in reported research on open innovation (OI) literature: How do service firms adopt open innovation? This research focuses on data from eighteen service SMEs in Belgium from high-tech and knowledge-intensive service industries. Based on analysis, we find new insights regarding open innovation practices (i.e., inbound and outbound) and sub-practices (i.e., acquiring, sourcing, selling and revealing) for service firms. More specifically, the study showed that service SMEs are more inclined to use inbound practices due to reasons associated with firm size, industry, and knowledge intensity in the market, whereas the decision about which sub-practice to adopt seems to be strongly influenced by the type of actor, the firm's vulnerability and internal managerial skills, and the existence of complementarities. Thus, we contribute to OI literature as well as capability literature through providing initial insights regarding the adoption of OI by service firms.

Keywords. Open Innovation Adoption, Service Industry, SMEs, Inbound, Sourcing, Acquiring.

1. Introduction

Service innovation management in current hypercompetitive markets are considered to be important challenge for many service firms. This challenge is due to need to simultaneously consider multiple interrelated changes, such as organizational innovation, the involvement of multiple actors in the process of innovation, and the codification of knowledge for innovation. Although prior literature provides limited inputs, it acknowledges the importance of understanding the interaction between the various actors in the process of service innovation. Some service companies (mostly technology-based businesses) have been trying to break their boundaries through implementing a more open innovation processes. The emerging literature on open innovation (OI) captures such developed and is defined as *"the use of purposive inflows and outflows of knowledge to accelerate internal innovation and expand the markets for [the] external use of innovation, respectively*" (Chesbrough 2006; Chesbrough 2006). Two reasons motives companies to adopt OI approach. First, it can reduce the time to market and R&D-related costs. Second, firms can utilize an external path to market for internal developments that enables them to capture the benefits of their R&D investments (Huizingh 2011). The openness of the innovation process has been identified as one of the key success factors of service firms (de Jong et al., 2003; Du et al., 2014). Using OI, service firms can overcome barriers to

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innovation by acquiring and utilizing external resources to drive innovation output (de Jong et al., 2003).

Notwithstanding a recent increase in the number of OI publications, OI in the service industry has remained under-investigated (Evangelista and Savona 2010; Trigo and Vence, 2012)In this study, we argue that OI within service firms is widely recognized as different from OI in manufacturing firms (van de Vrande et al. 2006; Tether and Tajar 2008; Mention 2011). For example, service firms' heterogeneity, intangibility and customer-centric nature are expected to influence how innovation emerges and can be managed (Wilson et al., 2008). Thus, many recent studies have called for the investigation of OI in the service industry through developing the knowledge pertaining to open service innovation (van de Vrande et al., 2006; Gassmann et al., 2010; Vanhaverbeke et al., 2014).

We are still in early stages of understanding OI in services firms and several questions remain unanswered regarding how service firms adopt OI. Previous studies have shown that OI adoption is not dominated by any one type of firm, and it was found to depend on various factors, such as innovation needs, the organizational culture, the country, the industry, the timing of the implementation, etc. Few qualitative studies (e.g., Christensen et al., 2005; Neyer et al., 2009) and quantitative studies (van de Vrande et al., 2009a) have been devoted to that issue. Most studies on the adoption of OI have focused on large manufacturing firms, such as those presented by Chesbrough (2003)-i.e., Lucent, IBM, Intel and Millennium Pharmaceutical-DSM (Kirschbaum, 2005), P&G (Dodgson et al., 2006; Huston and Sakkab, 2006), and ItalCementi (Chiaroni et al., 2011). Several quantitative studies have been conducted in German-speaking countries, including Switzerland (Keupp and Gassmann, 2009), and in the Netherlands (Poot et al., 2009). However, despite the potential advantages of qualitative cross-company analysis (Eisenhardt, 1989), few studies have focused on OI practices in service firms (Mortara and Minshall, 2011). Furthermore, understanding under which circumstances formal or informal open innovation practices and sub-practices are adopted has been emphasized as a top research priority, but empirical studies that focus on that topic are still lacking (Enkel et al., 2009; Wikhamn, 2013; Henkel et al., 2014; West et al., 2014). This paper will thus focus on the process of OI, by analyzing the OI- practices and sub-practices implemented by services SMEs (Huizingh, 2011) and the context, by analyzing when these practices and sub-practices are implemented by services SMEs (Huizingh, 2011). This study attempts mainly to understand how and when OI should be implemented by services SMEs (Enkel et al., 2009; Huizingh, 2011). Indeed, firms need to learn routines to effectively implement OI practices and sub-practices (Vanhaverbeke et al., 2008). Taking such perspective enables us to contribute beyond OI literature towards capability development literature, which suggests that firms can secure competitive advantage through developing unique and inimitable routines and processes. (Helfat and Peteraf, 2003).

This paper addresses a gap in the OI literature with regard to service industry (Gassmann, 2006; Chiaroni et al., 2010, 2011). Consequently, in this study, we take an integrative perspective on OI adoption by developing a framework to analyze the practices and related sub-practices adopted by service firms in general and particularly of eighteen service SMEs in Belgium. Multiple case studies have been designed to involve firms from high-tech and knowledge-intensive service industries, in which OI practices are prevalent (Parida et al., 2012). This sample warrants an in-depth cross-company analysis. Furthermore, we argue that SMEs are particularly relevant for this study because they represent 99.8% of the firms in Belgium (3) and because previous OI studies have primarily focused on large firms (van de Vrande et al., 2006; Lasagni 2012; Parida et al., 2012). Moreover, service SMEs account for 57.7% of all firms in Belgium and contribute significantly to the national economy.

OI is beneficial and valuable for SMEs because it can assist such firms in overcoming size-related liabilities and ensuring competitiveness (van de Vrande et al., 2006; Bianchi et al., 2010). However, numerous factors can complicate the adoption and implementation of OI within SMEs, which is not as much of an issue in larger firms. For instance, many size-related factors (e.g., time or resources) are expected to reduce the adoption and output of OI for SMEs (van de Vrande et al., 2006). Moreover, SMEs increasingly practice OI through the integration of external resources; therefore, a more detailed understanding of these practices would be appropriate and relevant (Gassmann et al., 2010). Consequently, services SMEs represent a suitable target sample for the current study.

This article is structured as follows. First, the literature on OI practices and on OI in the service industry is reviewed. In the next section, we propose a framework to analyze the practices and sub-practices adopted by service firms. Then, we explain the research methodology. This is followed by the presentation of our empirical results and discussion. Finally, conclusions, limitations, and suggestions for further research are presented.

2. Literature review

2.1. OI Practices

Understanding the richness of the OI paradigm requires a study of the factors that drive firms to implement different OI practices (Dahlander and Gann 2010; Huizingh 2011). OI is divided into two categories of practices: outbound OI and inbound OI (Gassmann and Enkel 2004; Chesbrough 2006; Huizingh 2011; Drechsler and Natter 2012). Outbound OI refers to the process of using an external path to market for internal developments (Chesbrough 2006; Chesbrough 2006; Dahlander and Gann 2010; Parida et al., 2012). It includes activities such as out-licensing or selling IP, forming alliances, and creating spin-offs (Gassmann and Enkel 2004, Lichtenthaler and Ernst 2007). Outbound OI can be risky because it involves the divulging of expertise by a firm, which entails the risk of strengthening the market positions of competitors of the firm in question (Rivette and Kline, 2000). The benefits of outbound OI can be both monetary and strategic (Bidault 2004; Lichtenthaler and Ernst 2007). Inbound OI is, however, linked to the exploration and integration of external resources for internal development (Chesbrough 2006; Chesbrough 2006, Dahlander and Gann 2010; Parida et al., 2012). It includes activities such as networking, inter-firm collaboration, customer involvement, and the purchase of licenses from other organizations (Parida et al., 2012). Through inbound OI, firms can obtain access to new, complementary, and unique resources (Gassmann and Enkel 2004). This practice can be expensive because it requires time, money and the ability to effectively use external resources and knowledge (Madhok 2002; Bapuji et al., 2011).

Both practices can be beneficial, but firms more frequently practice inbound OI than outbound OI (ven der Meer 2007; Huizingh 2011). However, a few firms have reported engaging in both practices simultaneously. This behavior may reflect the complementary nature of the two types of OI (van de Vrande et al., 2006; Enkel et al., 2009). However, there is a lack of understanding of outbound practice, although it can produce high revenue (van de Vrande et al., 2006; Parida et al., 2012). Therefore, the determinants of the choice to implement particular OI practices are important because the context can influence a firm's decision (van de Vrande et al., 2006; Gardet and Fraiha, 2012).

2.2. Open innovation in the service industry

In addition to manufacturing firms, OI also holds value for service firms (van de Vrande et al., 2006; Mention, 2011). The openness of the innovation process has been identified as one of the key success factors of service firms (de Jong et al., 2003). Using OI, service firms can overcome barriers to innovation by acquiring and utilizing external resources to drive innovation output (de Jong et al., 2003). Despite the relevance of OI to service firms, there remains a lack of theoretical knowledge pertaining to open service innovation (Gassmann et al., 2010; Chae, 2011).

Prior studies have indicated that OI adoption in services can differ greatly from adoption in manufacturing firms for many reasons. First, the intangibility of services renders communication more difficult (Chesbrough and Davies, 2010) and requires close ties with the stakeholders involved (Hsueh et al., 2010). Because of their offerings' intangibility, service firms are resorting to copyright and confidentiality agreements as methods of protection rather than using patents, which are usually used in the manufacturing sector (Rubalcaba et al., 2010). Consequently, it is interesting to investigate how service firms will address intangibility to coordinate the parties involved in OI projects and to protect their outputs.

The simultaneity of production and consumption are also expected to affect OI implementation in the service industry (Chesbrough and Davies, 2010). This dimension is crucial given the highly interactive nature of OI practice. The study of OI practices and sub-practices in service firms is closely linked to the need to consider innovation management in services more systematically (Toivonen, 2010).

Many OI researchers have acknowledged the importance of understanding OI in the service industry (van de Vrande et al., 2006; Tether and Tajar, 2008; Chesbrough and Davies, 2010; Gassmann et al., 2010; Huizingh 2011; Love et al., 2011; Mention 2011; Salavisa et al., 2012; Trigo and Vence, 2012). Consequently, a thorough review of OI literature from 2002-2012 was conducted. A topic search option was used in EBSCO and Science Direct to search for scientific publications that contained the combination terms "open", "innovation" and "service" in the title, keywords or abstract fields. The research included only publications of the document type "article" in the categories of social sciences, business and management.

The initial research efforts resulted in a set of 53 publications. However, the topic search option captured not only publications that contained the combined terms "service open innovation" but also those that simply contained the three words separately. Only empirical papers have been retained; theoretical papers, literature reviews and books have been excluded. An ex-ante normative judgment with regard to whether the publications address the studied concept was performed. This stage yielded eight relevant studies, which are presented in table 1. Finally, eight articles have been included in this literature review. Those articles were published in three journals: "Research Policy" (3 articles), "Technovation" (4 articles) and "International Journal of Innovation Management" (1 article). These articles have been classified based on the practices studied. It can be observed that previous research focused mainly on inbound practices in service industries. Outbound OI was discussed in only two articles.

Prior literature on inbound OI studied many types of activities: (1) cooperation (Tether 2002; Mention 2011; Mention and Asikainen 2012; Trigo and Vence, 2012), (2) knowledge sourcing (Love et al., 2011; Mention 2011; Mention and Asikainen; 2012), (3) networking (van de Vrande et al., 2006; Salavisa et al., 2012) and (4) customer involvement, outsourcing R&D and licensing IP from other firms (van de Vrande et al., 2006) as types of inbound OI practices. Venturing, licensing to other firms and participating with other firms have been studied as types of outbound OI practices (van de Vrande et al., 2006). Love et al (2011) also considered both

outbound and inbound OI practices, but they did not indicate how these practices were adopted; they focused instead on the types of partners involved rather than on the way these companies involved the stakeholders.

Cooperation as inbound OI practice is defined as "*active participation in joint R&D and other technological innovation projects with other organizations*" (Tether 2002; Mention 2011). Tether (2002) investigated the factors that influence UK firms' adopted cooperation mode of innovation. It appears that the firm's size, its sector of activity, its level of R&D, its innovation behavior, its experience with innovation and the type of innovation introduced affect the firm's propensity to adopt the cooperation practice of OI (Tether 2002). The firm's motive to decrease the risk associated with innovation leads these firms to cooperate with customers and competitors. Mention (2011) studied the cooperation partners of service firms and their effect on the degree of novelty. The author showed that cooperation with science-based partners influences the degree of novelty of the innovation. Cooperation with the other types of partners (competitors, market-based partners and companies within the group) do not significantly influence the degree of novelty of the innovation project. Mention and Asikainen (2012) studied the effect of cooperation and information sourcing on innovation intensity and sales. They showed that cooperation with market players is positively related to innovation intensity in the firms and with sales. Finally, Trigo and Vence (2012) have shown that the cooperation mode adopted by service firms depends on the innovation type and the sector of activity and will influence the partners integrated in the innovation project.

Sourcing is a less formal type of inbound OI practice. Love et al (2011) emphasized that knowledge sourcing from customers will affect the number of ideas available in the first stage of the innovation process. Knowledge sourcing from other partners does not have a significant effect on the early stage of the innovation process. Information from market-based partners, from firms within the group and from competitors positively influences the degree of novelty of the innovation (Mention 2011) in service firms. In another study, it was found that information from market players influences the firm's innovation intensity, whereas information from competitors influences the firm's sales (Mention and Asikainen, 2012)

Networking is another type of inbound OI practice. Salavisa et al (2012) studied formal and informal networks in service firms (biotechnology and software). Formal networks are adopted more frequently than informal network. Indeed, an informal network requires strong ties. Informal networks are mainly adopted by biotechnology firms in connection with universities and by software companies in connection with firms from the same sector. Regarding the other types of inbound OI practices, customer involvement and network usage in the innovation process appears to be the most adopted practice by SMEs. Licensing IP from other firms is more frequently practiced by manufacturing firms than by service firms (van de Vrande et al., 2006).

Regarding outbound OI practices, van de Vrande et al., (2006) find that whereas outbound practices are increasingly adopted by SMEs, the adoption rate of outbound practices is stable. There is a significant difference between service firms and manufacturing firms to adopt outbound OI practices. Love et al (2011) emphasized that service firms generally use outbound practices during the second stage of the innovation process to transform resources into marketable innovation.

The literature on OI practices in service firms shows contradicting results regarding (1) the factors that influence the adoption of different types of inbound OI practices and (2) these factors' effect on a firm's performance indicators (Mention and Asikainen, 2012; Trigo and Vence, 2012). It is largely recognized that such discrepancies may be due to a lack of understanding/conceptualization of OI (Dahlander and Gann, 2010; Wikhamn, 2013). Indeed, inbound and outbound practices are broad concepts, and some managers may be confused regarding the

types of practices it includes (Dahlander and Gann, 2010). Services' characteristics may also lead companies from the sector to implement some forms of inbound and/or outbound OI practices. Indeed, because services are intangible, they are more difficult to protect than products. Consequently, these firms may rely more heavily on formal types of practices. Moreover, it appears that service firms may practice outbound OI (van de Vrande et al., 2006; Love et al., 2011), but few studies have considered this type of openness. Consequently, there is a need to study OI in services within a clearly defined framework. This study attempts to extend the understanding of how service firms implement OI by focusing on OI practices and their associated processes that are crucial to understanding the service context. Furthermore, this study attempts to understand why some practices and sub-practices are adopted by services SMEs and others are not adopted. To meet this objective, we will define a framework to identify OI practices and sub-practices in the next section.

Table 1. OI practices and activities in the service industry-Literature review

OI practices	Open innovation activities	Articles
Inbound	Cooperation	Tether, 2002; Mention, 2011; Mention and Asikainen, 2012; Trigo and Vence, 2012
	Customer involvement	van de Vrande et al., 2006
	Networking	van de Vrande et al., 2006; Salavisa et al., 2012
	Outsourcing R&D	van de Vrande et al., 2006
	License IP to other firms	van de Vrande et al., 2006
	Broadly defined	Love et al., 2011
	Coopetition	Mention, 2011
	Information sourcing	Mention and Asikainen, 2012
	Inter-firm relationships	Hsieh and Tidd, 2012
Outbound	Venturing	van de Vrande et al., 2006
	License IP to other firms	van de Vrande et al., 2006
	Participation in other firms	van de Vrande et al., 2006
	Broadly defined	Love et al., 2011

2. Development of the OI framework

Two main dimensions have been used in theory to classify OI practices: (1) inbound vs. outbound OI and (2) the controlled vs. the 'libre' perspective (Bass and Avolio, 1997; Wikhamn 2013). The proposed framework has been adapted from Dahlander and Gann (2010) to better represent the specificities of the service sector. Indeed, whereas the authors of the original article made the difference between exchanges that involve money and exchanges that do not involve money, we used the distinction between 'libre' and 'controlled'. This dimension has been proposed by Wikhamn (2013), who defines 'libre' openness as the "*availability of ongoing, socially*

constructed knowledge, permitting any users to access, add and modify it without legal or technical barriers". The idea behind 'libre' openness is that resources are freely available to everyone (Wikhamn, 2013). The second perspective, 'controlled openness assumes that resources can be shared under the control that is established through setting the price (Wikhamn, 2013). It has to be noted that 'libre' is not the opposite of controlled. Indeed, 'libre' does not mean uncontrolled or without protection. It is more related to the idea that knowledge is diffused in the society "*with the aim of transparency, accessibility and freedom of use*" (Wikhamn, 2013). In the 'libre' perspective, mechanisms such as intellectual property rights (IPRs) may be used by companies to protect openness (Wikhamn, 2013). The concept of open as 'libre' is related to the concept of free software, free culture, open science and open access. The 'controlled' openness is related to IP strategies to concept such as open IP platforms (Wikhamn, 2013) We suggest that these two perspectives are related to but are different from the perspective suggested by Dahlander and Gann (2010). Indeed, 'libre' openness does not mean that services are without the exchange of money but that they are freely available in an idea of transparency (Wikhamn, 2013). Given the intangible nature of services, firms may want to keep the control(Dahlander and Gann 2010). However, control is not necessarily associated with an exchange of money, as stated by Wikhamn (2013), because companies may use other mechanisms to protect their resources. Salavisa et al., (2012) also made the distinction between formal and informal networking for open innovation. However, they suggested that formal networks were established between organizations and informal networks between individuals. In this study, we argue that both may be adopted by services SMEs, with any type of stakeholder. We also argue that informal networking is not the same as uncontrolled networking. Indeed, firms may depend on each other to develop an innovation. In that case, both firms may keep the control without establishing a formal cooperation. This new way to classify the sub-practices of inbound and outbound OI may explain the divergences find in the literature on OI in the service sector.

Four related innovation sub-practices (or forms of inbound and outbound OI practices) have been highlighted. Acquiring and sourcing are related to inbound practices, whereas outbound practice is operationalized through revealing and selling. The various sub-practices are clearly defined in the following table.

Table 2: The OI practices and sub-practices (adapted from Dahlander & Gann, 2010)

	Inbound innovation	**Outbound innovation**
Controlled perspective	**Acquiring** How do firms access or in-license in external resources/knowledge?	**Selling** How is innovation developed internally sold/out-licensed?
'Libre' perspective	**Sourcing** How do firms use external resources for internal development?	**Revealing** How do firms reveal internal resources/knowledge to the external environment without immediate reward?

Through acquiring, companies obtain input(s) for innovation through the marketplace. This sub-practice is implemented when a firm wants to retain control over a set of elements in its OI-related interactions (Garavelli et al., 2013). Acquiring includes activities such as in-licensing, co-operating, formal networking, and outsourcing R&D. On one hand, acquiring external knowledge allows the company to reduce their time to market and uncertainty (Dahlander and Gann, 2010; Wang and Li-Ying, 2014). On the other hand, it requires firms to be able to manage the search for and evaluation of external ideas that can be integrated into the innovation process and to

control the distance between themselves and their external inputs (Sapienza et al., 2004; Dahlander and Gann, 2010). An excessively large gulf between a firm and its external inputs will create difficulties in aligning these inputs with current firm practices, whereas external inputs that are overly similar to a firm's current knowledge will reduce the possibility of combining available inputs in a manner that generates new and innovative outputs.

Sourcing is related to the use of ideas and technologies sourced from outside of a firm through, for example, participation in external innovation projects (Chesbrough, 2006). Sourcing includes activities such as informal networking and customer involvement. Through this sub-practice, firms can benefit from complementarities to which they would otherwise not have access (Dahlander and Gann, 2010). Firms can also benefit from creative ideas from external actors and obtain opportunities to develop and market new products or services (Garavelli et al., 2013). However, the knowledge that a firm can acquire through sourcing is limited. Indeed, the relationship between searching activities and innovative performance is curvilinear (Laursen and Salter, 2006).

Through revealing, a firm reveals its own resources without reaping immediate rewards and without having real control over the use of this information (Henkel, 2006; Wikhamn, 2013). Revealing has been extensively discussed in the context of open sources software (Henkel, 2006). Indeed, it may be required for successful OI and/or when legal protection is ineffective (Henkel et al., 2014). Revealing can be beneficial because it can generate incremental innovation within a particular industry (Murray and O'Mahony, 2007; Dahlander and Gann, 2010). It can also lead to cumulative advantages. Indeed, by focusing less on innovation protection, a firm can increase the use of its products/services, including external knowledge that can be integrated into its pool of knowledge. On the other hand, there is the risk that knowledge will be leaked to competitors. Moreover, the benefits are difficult to reap, and firms have to determine which resources will be revealed (Laursen and Salter, 2006; Dahlander and Gann, 2010).

The last form of openness, known as "selling", includes activities such as venturing and licensing intellectual property to other firms. Through these sub-practices, firms share or license internal resources to become commercialized them. Selling is increasingly adopted by managers (Mazzola et al., 2012). However, there are risks involved in providing critical information to potential customers. Firms must be able to appropriately utilize the potential value that is associated with sharing a particular resource (Arrow, 1971; Dahlander and Gann, 2010).

The above typology has been used to explore and analyze the adoption of OI within service firms. Beyond these practices, the related sub-practices have also been deeply studied. This framework is considered a foundation to a better understanding of the contextual drivers of the strategic selection of OI practices and sub-practices.

3. Methodology

A qualitative research method was adopted because it permits the understanding of complex social phenomena that are associated with real-life events (Yin, 2009). To identify and understand how service firms engage in OI practices and sub-practices and how these choices are influenced by certain contextual factors, we conducted multiple case studies (Baxter and Jack 2008; Yin 2009). This methodology decreases the likelihood of randomness and facilitates investigators to identify and study patterns across multiple cases.

In a total of eighteen SMEs (small and medium-sized enterprises) from high-tech (15 firms) and knowledge-intensive service (3 firms) industries from Belgium were

selected for this study. Two criteria were set in the choice of the case firms: (1) The firm had to have integrated external actors within its innovation process for at least one innovation project (Bass and Avolio, 1997), and (2) the firm must have commercialized/implemented this innovation. The cases were chosen through the use of replication logic, which emphasizes the similarities and differences within and between groups (Eisenhardt, 1989; Yin 2009). The case firms are members of Belgian organizations that promote collaboration (cluster and "pole de compétitivité) between companies.

The case SMEs were classified according to the innovation types that were achieved during each project (process or service innovation) and according to the degree of novelty (radical or incremental) because these criteria have been suggested as influencing the OI (Huizingh, 2011). Following the typologies of Gradey et al (1995) and Avontalis et al (2001), service modification, service line extensions, and service repositioning are grouped into the service innovation category, whereas architecture innovation, platform innovation, and (new or improved) delivery processes are referred to as process innovation. Moreover, based on the categorization adopted by Parida et al (2013) and Laursen and Salter (2006b), we view radical innovation to be related to a *"new-to-the-world"* innovation and incremental innovation to be related to a *"new-to-the-firm or significantly improved"* innovation. This framework allows for capturing a different degree of innovation or novelty through case firms. Having access to cases that are spread across innovation types and degree of novelty adds variation to our sample. Thus, six innovations were classified as radical process innovations, five as radical service innovations, one as an incremental process innovation, and six as incremental service innovations.

To obtain rich empirical data, we used multiple data sources (Baxter and Jack, 2008; Yin, 2009). Most data were collected through semi-structured interviews (duration on average: 90 minutes). The interviewees were either top managers or project managers who were supposed to be the most knowledgeable about the innovation strategy, the OI strategy and the past and ongoing OI projects in their firms. Information on the respondents is presented in the table in Appendix (Appendix A). A deductive research approach was adopted, and semi-structured interviews were conducted through developing an interview guide based on the theoretical framework and previous research findings. The interview started with a clear focus on the innovation strategy in the introduction. Then, respondents were asked to focus their attention on OI projects. An important part of the interview was dedicated to the project descriptions, where interviewees were asked to explain the OI practices and sub-practices they utilized and defend their choices. In addition, the secondary data concerning OI projects was made available by firms. These in-depth interviews were crucial to identifying and better understanding the contextual factors that influenced the choices OI practices. Thus, the selected innovation project was defined as the unit of analysis (Miles and Huberman, 2003). In addition, various types of documentation related to the OI projects (e.g., letters, progress reports, other personal or administrative documents) and archival records (e.g., reports on sales, survey data, customer feedback) were included in the empirical data.

In this study, the data was analyzed from a triangulation perspective to improve the construct validity; multiple sources of evidence provide multiple measurements of the same phenomenon (Yin, 2009) and can indicate that independent measures of this phenomenon are consistent and not contradictory (Miles and Huberman, 2003). The first step of the data analysis involved conducting a structural content analysis (Rothkopf, 2009).

To systematize the data analysis, a coding scheme was developed. This way to analyze data is often considered as a criterion of reliability and validity. We applied a

deductive procedure to develop the categories. The categories have been defined before the data collection based on the theoretical framework of the research. However, the procedure was iterative, some codes have been modified or sub-categories were added based on the collected data. A multi-stage categorization and coding process was used in this study at different level as suggested and applied by Rothkopf (2009). Firstly all the text passages from the set of documents having a link with the themes have been highlighted. Next, the text passages, words or sentences fitting the indicators and dimensions from the coding scheme (Rothkopf, 2009) were coded. After a first coding, the codes have been reviewed a first time. Next, a computerized method of qualitative data analysis has been used. Among the softwares available on the market, Atlas.ti (V4.2). Once a stable coding scheme was obtained, the codes have been categorized to reduce the amount of codes and facilitate the analysis.

A within-case analysis and a cross-case analysis were performed to reveal the similarities and differences between the cases and to derive patterns (Eisenhardt, 1989; Rothkopf 2009). A display of the data was constructed to allow users to draw valid conclusions from these data (Voss et al., 2002). Two matrices were built to describe the cases that were examined in this study. The first matrix presents each firm's "identity card". The second matrix describes the innovation project of interest, the actors that were integrated into this project, and the OI practice that was implemented with each actor, including the underlying reasons. Finally, a standardized table was created for each case.

Several measures were taken to ensure greater validity and reliability within this study. Construct validity has been improved by using multiple sources of data and by obtaining a review from each corresponding study respondent (Yin, 2009). Internal validity was improved by focusing on data creditability. We actively involved the respondents in reviewing our results and thus reduced the likelihood of misunderstanding (Yin, 2009). Addressing external validity (generalizability) is challenging with a case study approach. However, the primary aim was to obtain analytical generalizability (i.e., generalizability from empirical observations to theory rather than extension to a population). Therefore, we did not attempt to generalize the results beyond the sample under investigation. Finally, to further increase reliability and thus enhance transparency and the likelihood of replication, we constructed a case study protocol and a case study database. This database included case study notes, documents, and analysis (Yin, 2009).

4. Results

4.1. OI practices

Our results reveal that the services SMEs in our sample primarily integrate external resources for internal development. More specifically, we identified four prevalent modes of inbound OI in our case companies.

Public organization and university collaboration: According to a respondent from case company 2, "Two universities are close to us. They performed R&D for us (…) we simply used a contract with them for R&D outputs". They said that because universities can be specialized knowledge holders with no interest in competing with SMEs, it was typically easy to establish and maintain relationships with them. Case company 1 utilized another mode of collaborating with experts in a university. They explained, "It was simply a funded project at the University; the PhD received a grant". In certain cases, it was also possible to utilize public organizations as facilitators for establishing collaboration with a university. A respondent from case

company 7 shares, “They accompany us permanently (…) They get us in touch with the University (…) During the entire project they followed us (…) Even when we didn't need them (…) They help us to build the demand for the DGO6 and to meet them...".A respondent from case company 1 also explains, “Our project has been accepted for funding by the state, but they followed us during the entire process.”

In-licensing technologies: To drive innovation outputs, SMEs also explored a well-known mode of technology and knowledge integration, which relates to in-licensing resources. The basic idea for most case companies was to gain access to knowledge/knowhow, which is not possible to develop internally due to lack of time, resources or competence. A respondent from case company 5 explains, “The supplier had the patent for an element we needed, and thus, their knowhow was in-licensed”. In certain cases, SMEs’ networks were used to scout for technology that was necessary for innovation. A respondent from case company 8 explains, “The first supplier told us that we would need this type of supplier, and they proposed that we use this supplier that is one of their partners.” Formal procedures for in-licensing technologies were identified within the case companies. For example, a respondent from case company 16 stated, “The supplier has been selected based on a call for tender (…) he was selected and supplied the equipment to operationalize the technology.”

Co-development with customers: Customer involvement was found to be widely prioritized in in-bound OI practice. Several market intelligence approaches were employed to capture customer needs early in the innovation process. Case company 3 explains, “We ask them (particular customers); we call them and we ask them their opinions; we ask them to send us their comments, the problems they faced (…)". Similarly, a respondent from case company 8 shares, “The aim was to discuss with them to know what they want, what interested them (…). (After the meeting) we knew what they wanted, what we should integrate in our offer”. Respondent from case company 13 explains, “The customer that proposed to us this idea, he was integrated during the entire project to give us feedback (…)”. In addition to capturing the needs and expectations of customers, our case companies also conducted activities that elicited regular feedback during different stages of development. They argued that early and regular testing and validation were practices for reducing the risk of developing a misfit service or process. A respondent from case company 15 explains, “Customers simply tested the service for free and gave us feedback. We made some changes, and then, they tested the service again (…).

Informal and formal networking: Utilizing network relationships was a central practice for our case companies. It enabled them to expand the scope of technologies and knowledge, which can be integrated in the early innovation process. Two forms of networking were found during our analysis. Certain SMEs preferred to work in a more informal network structure. A case company 17 respondent explains, “Our external network partners (especially other SMEs) needs us, and we need them (…) It was an open collaboration, similar to the case with the University”. In other cases, more formalized structures were used. A case company 16 respondent states, “We (the company and 3 competitors) made a joint development project, and each partner brings its own expertise, as mentioned in the contract”. Similarly, a respondent from case company 9 states, "They deliver the software (…) we also signed a collaboration contract where we co-developed something".

In contrast to inbound OI, none of the eighteen OI projects in this study considered the implementation of outbound practices. The respondents explained that they implemented OI practices “(…) *because we do not have enough resources internally to achieve interesting innovation projects* (…)”. In the current context, the firms were unable to generate competitive ideas and/or technologies because “(…) *there are more ideas in a region than in our company, so we can profit from ideas that exist*

outside our company". However, the service SMEs in our sample did not perceive that they would be likely to benefit from outbound practices. Generally, outbound practices were considered risky and complex: "(…) *if I share our ideas or technologies with the world, what will be the benefit for my company*?" and "(…) *how can I manage this type of relationship? I have to maintain control of information sharing* (…)".

The data revealed that certain factors influenced the firms' decisions to engage primarily in in-bound OI rather than outbound OI. These factors are associated with firm size, industrial setting, and knowledge intensity.

Firm size: A common reason for the decisions of all our case companies was related to their size, which limited their scope to invest in outbound-oriented practices. A respondent from case company 5 explains, "We know it is a possibility, but, well, it is maybe more complex than what we currently do… You know, we are a very small structure, and we do not have any time or money to engage in the learning process and this … well, in this form of collaboration, it requires a lot". Respondents from 4 case firms also validated the limitations due to firm size: "Well, OI is interesting, but is it still beneficial for us if it requires investment; and when I say 'investment', that is financial but it also means time, resources (…) That is my opinion, and it could explain why we mainly use external technology: It is easier". "We spend a lot of money (regarding the number of people working for us) on innovation, so I will not reveal the information or the resources outside the company (…) I think that large companies can do that because they have structures, they can engage lawyers, but in our case, it is impossible". Certain respondents also expressed concerns about losing control over their technologies through outbound OI practices. For example, "We fear losing control over what we develop, and I don't see how we could see the benefit of such a practice (…) you know, we are not … I mean, we don't have a legal department as do large companies, and we do not have any procedure to, for example, capture the benefit that could be generated by this type of practice (...)." In other cases, size inhibits case firms from experimenting with outbound practices because they did not fit will with their strategic orientation. One respondent from case company 5 explains, "We sell our development (…) our small company cannot develop something and let it sleep (…) when we develop something, we need to commercialize it to our market quickly". Moreover, managing and evaluating the value of technology or know-how is a challenge for case companies. "It's too complicated for us (…) we cannot manage such activities in a very small company."

Industrial setting: Respondents highlighted that the industrial conditions inherent to services compared to products create challenges for SMEs to enforce knowledge protection. According to a respondent from case company 8, "It is very simple. In our sector, we have limited protection, or it is very difficult. So, if we implement outbound practices, will there be additional risks for us?" Several respondents also questioned the possibility of taking advantage of their internal knowhow through outbound practices. "The activity you mentioned (outbound) is also more relevant for companies that produce goods (…) these companies can better protect their innovations than we can". Another respondent added, "If there is a way to protect a service as goods are protected, I may try, but for now, it is not possible (…) well, that's my opinion". Other respondents questioned the possibility of capturing value through selling their knowhow without hampering their competitiveness in existing markets. One respondent explains, "Well, thinking about outbound, I foresee that when we have an idea, we want to develop it ourselves, or at least in cooperation to get the benefit from it (…) and if we invest in development and then we sell to other companies or organizations, it is too risky because it is very difficult to capture value of these developments ... but I think it is very specific to our sector of activity and to the fact that I manage a small company".

Knowledge intensity: With rapid changes in technology and the high demand for companies to operate in a high-tech industry, most case companies preferred to explore inbound OI rather than outbound. One respondent explains, "We prefer collaboration with external partners. The main objective is to get access to their resources, knowledge, information—and what you are speaking about does not allow us to reach this objective. In our sector (IT consulting), we need a lot of knowledge and information to achieve an innovation project (...)". Due to increased knowledge intensity, the respondents' view was that outbound OI practices were limited for them. "We are interested in external knowledge, but we don't want to share ours with others." Another respondent adds, "Simply because we want to get access to others' resources and not really to share ours (…) It is too risky (…) and people will not share more information or knowledge that could be interesting for my company because I share my ideas or development."

4.2. OI sub-practices

The ways in which service SMEs practice inbound OI were then observed. These firms appear to practice the two processes linked to inbound practices: acquiring ("*In this case, we collaborated by using a well-defined contract involving agreements concerning the terms of trade,"*) and sourcing (" (…) *by discussing with a potential partner (at this time), we discover that it was possible to work together in a less formal way as each one borrows something crucial for the innovation project*"). We found that the process of acquiring was practiced in the majority of cases (17 of 18 projects), whereas sourcing was practiced in only half of the projects.

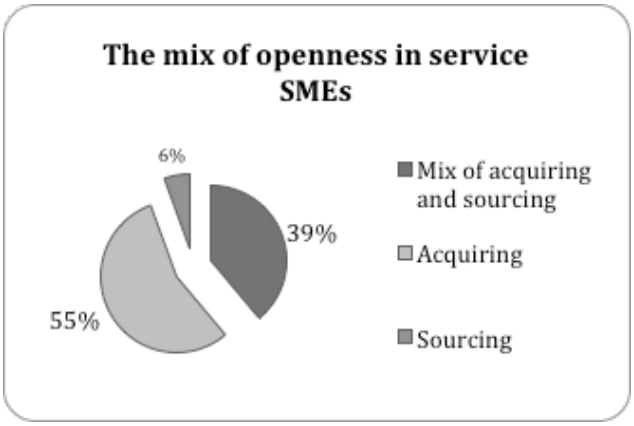

Fig. 1. The mix of openness in service SMEs

To classify a firm's OI activities between sourcing and acquiring, we focused on the degree of formality of the collaboration (using a contract, setting a price) and the extent to which the firm had the freedom to access, add and modify the external resources, as suggested by Wikhamn (2013). For example, case company 6 collaborated with a company from another sector, and the manager said, "*We share our knowledge and our resources without limitation because we need each other to achieve the project (…) Our collaboration was totally transparent; both partners had the possibility to freely use the resources provided by the other*". The manager of case company 17 mentioned, "We collaborate with this association, and because we needed each other, we were able to collaborate without limitations or a contract to control each other (…) they provided us information and feedback on the service (…) they always have access to the information regarding the project (…) finally, they

have the opportunity to use it without any restriction". These collaborations were classified as sourcing practices. On the contrary, the manager in the first case company said, "With the university, it was formal (…) we present our need and they develop the interface (…) we never get access to the source code and access to their knowledge was limited to the use of the interface". Case company 7 has also adopted acquiring strategies with a supplier: "We need access to their patent (…) we only get the right to use the technology. If modifications were required, these modifications had to be performed by their care (…) our use of their technology was limited and contractual".

More specifically, we identified three reasons why case companies were inclined to engage in acquisition instead of sourcing sub-practices.

Types of external relationship: We found that across different types of external partnerships, SMEs preferred to work in a formal rather than an informal arrangement. A respondent explains the relational conditions when they acquire knowledge from supplier: "It is a standard (…) we never think to work differently. It is easier and less risky when everything is anticipated in a contract. It prevents managerial problems, and when there is a problem, we know how to solve it". Other respondents' sourcing conditions were similar: "We always work like that with our suppliers. We also prefer this situation because it prevents a situation in which they want to be too involved in the project (...) they could get information that we wanted to keep for ourselves and use it on another project. Well, in an unfair way." We also found a similar perception of engaging in inbound OI practices with other partners, such as competitors and external consultants. For example, a respondent from case company 8 explained, "We use formal practices simply because there still exists a risk… they are our competitors, so even if we work together-and we work hardly together on an entire project-we cannot take any risks (...)". With regard to consultants, a respondent stated, "They propose a service. They are generally specialized in a preview, and to get access to this service, we have to pay and sign a contract. I don't see other explanations. It is not a question of risk management, like some cases, because consultants are, I think, very reliable". Thus, the above examples depict the concern shared by case companies. Regardless of the types of external relationships, respondents preferred acquisition practice.

Firm vulnerability: SME respondents did not rule out the likelihood of sourcing but explained that acquisition provided them with a lower possibility to be vulnerable to opportunistic behavior. For example, statements like "Why would we use a contract? Simply to avoid a situation in which our partner chose to use information on another project or take information to leave the project." Another respondent shared a more resource-driven reasoning: "We are a small company with limited resources. Contracting is the only way to avoid traitors." Similarly, "by anticipating potential problems and how to solve them in the contract, it partly protects us (…) Our small company cannot invest in a project and take the risk of never getting the financial benefits because the partner is an opportunist (…) I know that there is still a risk, but by knowing the potential sanctions, he could think twice before acting as an opportunist." Thus, generally, the case companies (i.e., SMEs) had a reserved internal view on their ability to manage informal relationships due to limited resources.

Lack of relational skills and competences: We found that to be able to manage formal and informal relationships required the development of relational skills and competencies. This presents a challenge for case companies; one respondent explains, "Maybe large companies that have a lot of departments with managers with lots of skills can practice OI in another way than we are doing it, but in our case, I cannot really imagine…" Therefore, reliance on contracts and formal structures was viewed as compensating for a lack of relationship management ability. One respondent states, "The contract is just there to keep control of the relationship, to avoid having a

partner become too important (…) we have to stay focused on the innovation project and our objective." Another respondent suggested that if contracts were not used to manage relationships, a high level of trust needed to be established. "I think that to collaborate without a contract, there is a need for high trust, and it costs a lot of time and resources and thus a financial investment to build a strong relationship with our partner."

Perceived complementarities: We found that when case companies collaborated in projects where both parties complemented each other's knowhow, it was easier to perform a task in a sourcing mode. A respondent explains, "With such partners, it was possible to work without a contract because we were sure that they needed us to realize the project. There are perhaps one or two companies that could help them, but they could never reach the level of quality that we reached…It is also a protection." Complementarity between partners provided a safety net to both actors because they needed each other to complete the project and reach the common goal. "They had the technology, but they didn't have the knowledge. We had the knowledge, but we didn't have the technology. It was impossible to work alone to achieve the innovation." Similarly, another respondent suggested, "We can use an informal way to collaborate, but we have to be sure that our partners need us at least as much as we need them to achieve the new services…" However, such specialized relationship conditions for inbound OI practice were not largely common for our case companies.

5. Discussion

OI is widely recognized as the next-generation innovation model for firms and a viable approach to secure a future competitive advantage. However, the examination of OI practices and sub-practices in the service industry is a largely understudied research area. Most prior studies have predominantly focused on manufacturing firms (Evangelista and Savona, 2010; Trigo and Vence, 2012; Parida et al., 2014). We argue that service firms are different with regard to OI adoption because of their service-related characteristics and underlining organizational structures, such as intangibility and close customer involvement. Therefore, to further advance our understanding of service firms' adoption of an open perspective of innovation, we address two key questions. First, how do service firms adopt OI practices and sub-practices? Second, what are the factors that influence the selection and adoption of OI practices and sub-practices? Figure 2 provides an illustrative explanation of relationship between OI practices, sub-practices and respective contextual factors.

Our results revealed that service SMEs primarily adopt inbound practices rather than outbound practices. This would imply that like manufacturing firms (ven der Meer, 2007), service firms are also inclined to use inbound OI practices. However, the underlining reasons for such selection may be different for service firms. We argue that underlying characteristics associated with offering services may partially explain such preferences. For example, due to intangibility, services are difficult to formally protect, whereas outbound practice is generally associated with the use of patents (Harhoff et al., 2003). Similarly, heterogeneity also makes it more difficult to deliver exactly the same service value, which makes it challenging to go outbound through creating spin-offs or selling to other firms (Wilson et al., 2008; Dahlander and Gann, 2010). The need is also higher to be customer-centric for service innovation (Johnsens et al., 2006), which makes it challenging for service firms to engage in outbound OI practices. Service offering and service innovation are much more complex because they require interaction with customers and, sometimes, multiple network actors (Chae, 2011). Consequently, firms that operate in such an environment seem to prefer a 'formal' (or controlled) process to an informal (or 'libre') process. Finally, service

firms are less likely to invest in R&D (Alic 2001), whereas outbound OI is generally adopted by companies to take advantage of un- or underexploited internal development(Chesbrough 2006).

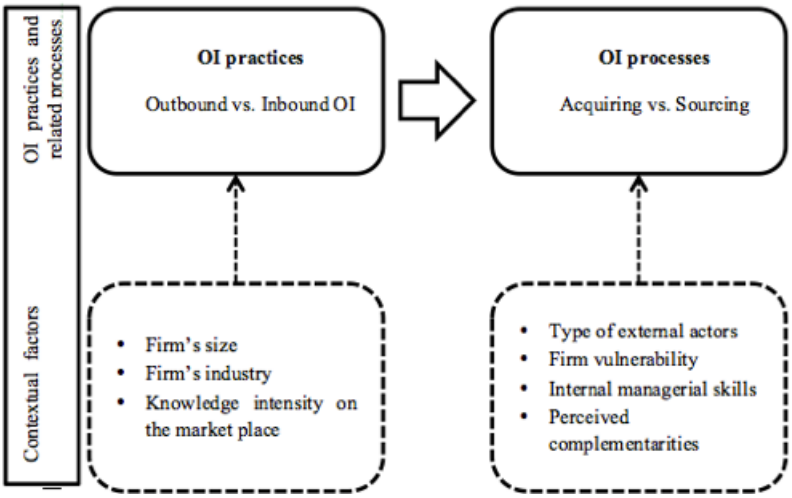

Fig. 2. Factors influencing the practices and sub-practices implemented by services SMEs

With regard to inbound OI practices, we find evidence for both sourcing and acquiring sub-practices. We found examples related to university search grants, contracted R&D, in-licensing, formal joint development and financed projects to be prevalent acquiring activities for service firms. Similarly, our case firms were also engaged in informal networking, customer co-creation and co-development, and public organizational funding as sourcing activities. On a more detailed level, we find that only a low number of our case firms found sourcing to be relevant for driving innovation, whereas the majority opted for acquiring processes. However, a reasonable number of case firms preferred a mixed approach for OI processes. These results highlight the importance of acquiring and sourcing external inputs for service SMEs. Thus, our results build on limited prior studies that have attempted to better understand the OI practices and sub-practices of SMEs (Laursen and Salter, 2006; van de Vrande et al., 2009; Parida et al., 2012).

In addition, we identified three contextual influences on our case firms' decisions to engage in inbound OI practices. These factors are related to firm size, firm industry and knowledge intensity on the market. Firm size, to a large extent, represents the availability of resources, which is generally limited in case of small service firms. This would imply that small service firms could engage in selective OI practices and may find it more beneficial to access external resources through inbound practices (e.g., networking) than more complex and resources-intensive outbound practices. For example, outbound OI requires financial resources for the implementation of a structured procedure for the identification of alternative technology applications. These activities involve complex coordination and high levels of managerial resources (Narula, 2004; van de Vrande et al., 2006; Bianchi et al., 2010). Thus, firm size partially explains why outbound practices are more frequently employed by larger firms than by smaller firms (Narula, 2004). Second, we agree with prior studies that suggest that a firm industry influences OI practice adoption (Chesbrough and Crowther, 2006). For example, manufacturing firms are more likely to practice R&D outsourcing and IP out-licensing relative to firms from another industry (van de Vrande et al., 2006). Outbound practices are often compared to the use of patents

(Harhoff et al., 2003). We find that service SMEs are less likely to be interested in such OI practices. Moreover, some outbound practices are associated with a risk of deviant behavior, and the difficulty in protecting their innovations often explains why service firms consider outbound OI to be a risky undertaking (Rubalcaba et al., 2010). Transaction costs can be another obstacle to the practice of outbound processes, according to (Dahlander and Gann, 2010). These costs may be higher because of the intangible and heterogeneous nature of services. In other studies, (Tether, 2002) and (Salavisa et al., 2012) have suggested that there are differences between service firms in different sub-industries. However, in the present study, no differences between high-tech and knowledge-intensive service industries were identified. Finally, consistent with previous research, the present study found that knowledge intensity is another factor that may explain a company's choice to use inbound OI (Gassmann and Enkel, 2004). This factor could also partially explain the contradictory results that have been revealed regarding the influence of technology intensity. It has been observed that technology intensity may affect the implementation of OI in firms (Miotti and Sachwald, 2003). In particular, firms in high-tech industries have been found to engage more frequently in integrating external resources through OI. In contrast, the results of Gassmann and Enkel (2004) suggested that firms that practice inbound OI are typically firms from low-tech industries that seek to acquire technologies complementary to their current capabilities. All of the firms that participated in the current study are active in an industry that requires a high level of knowledge (which may be combined with technology). Therefore, these firms may resort to inbound OI because their internal knowledge may not always be sufficient to meet their innovation needs (Gassmann and Enkel, 2004). Thus, the above three contextual factors largely explain the inclination towards inbound OI practices.

Further analysis reveals additional contextual factors that influence the decision to select and implement OI sub-practices associated with acquiring and sourcing. First, the type of external actor involved, such as suppliers, competitors, consultants, and public business promotion programs, may influence the company's choice between OI sub-practices. We find that acquiring may be practiced to limit the involvement of external actors or to provide protection against potential opportunistic behavior because risk and trust are two components of decision-making (Josang and Lo Presti, 2004). Alternatively, acquiring may simply be linked to a collaborator's market position. Sourcing is generally practiced among organizations that are linked to public services because the inherently low risk associated with this type of actor generally promotes collaboration between different organizations (Parida et al., 2014). There appears to be no consistent pattern with respect to the chosen OI processes that involve customers, other firms, and universities. The second factor that we identified was the vulnerability of firms. Compared with larger firms, SMEs are more vulnerable to opportunistic behavior[1](Nooteboom 1993; Dickson et al., 2006). The risk of opportunistic behavior motivates firms to allocate funds and resources to control and monitoring activities, even when such resources could have been allocated more efficiently (Wathne and Heide, 2000). This phenomenon thus explains SMEs' frequent use of the more formal OI sub-practice of acquiring. However, it has

[1] Opportunistic behavior is generally defined as "self-interest seeking with guile" (Williamson, 1985). Two types of opportunistic behavior have been identified by Bass and Avolio (1997): the voluntary hiding of various information during the initialization of a relationship and different types of violations that may occur during the relationship (Wathne and Heide, 2000). The vulnerability of SMEs to opportunistic behavior is based on the assumption that larger firms have more transaction actors and are thus less sensitive to opportunistic behavior from any of these actors (Nooteboom, 1993)

been suggested that an "excessive" use of contracts can have a negative effect on a firm's innovative performance because such heavy contract use leads to lower levels of flexibility (Wang et al., 2011). Third, the managerial skill deficiencies are also important factors for service SMEs: These deficiencies lead service SMEs to use acquiring processes to address the risk of opportunistic behavior. Indeed, Wathne and Heide (2000) presented solutions[2] for the risk of opportunistic behavior. However, because SMEs lack managerial skills, these firms may have trouble implementing these practices. Thus, the use of formal agreements may appear to be the only solution for facilitating innovative collaboration. Finally, the extant complementarities between an SME and external actors have been identified as influencing acquiring or sourcing decisions. Resource complementarity has been emphasized as a factor that exerts a positive influence on reciprocal commitment (Sarkar et al., 2001). Although perceived complementarity may not have a direct effect on trust (Sarkar et al., 2001), this perception may indirectly affect trust by making the actors in a collaboration aware of their mutual interests. Indeed, perceived complementarity has been identified as a factor that affects the choice between formal and informal modes of cooperation (Hakansson and Johanson, 2002). In the absence of perceived complementarities, such companies will choose to practice acquiring. If actors perceive their resources as complementary in nature, then sourcing (which is a less formal OI practice compared with acquiring) can be adopted because this OI practice increases reciprocal commitment and because SMEs will not regard the use of a contract as a necessity.

Taken together, understanding of OI practices, sub-practices and contextual factors provides insights towards routines (Enkel et al., 2010) and capability-based view (Helfat and Peteraf, 2003; Enkel, Gassmann et al., 2009)). Adoption of OI by service SMEs follows a specific approach where certain routines more preferred and feasible to secure future innovative competitiveness. Moreover, selection of inbound OI and diverse sub-practices largely depends upon several identified contextual factors. These factors influence the extent to which service firms can benefit from adaptation of OI. Though taking a holistic perspective towards OI adaption for service firms, we can better explain which practices or routines firms should strive to develop in order to open their innovation process. If successful, OI practices and sub-practices can act as microfoundations for development of dynamic capability (Teece et al., 1997), which would provide necessary flexibility to cope with changing market environment. Thus, we argue that our study holds theoretical implications towards capability literature, which have not been widely understood in relation to open service innovation.

6. Practical implication, limitation and suggestions for future studies

These results also have implications for CEOs and innovation managers in service SMEs. We argue that managers need to better understand the complexities associated with selecting and adopting OI practices and processes. The results of this study indicate that different OI processes are chosen within different contexts. This knowledge could help managers to determine whether they should practice outbound OI, inbound OI, or a mixture of both types of OI. Moreover, based on our analytical

[2] These solutions include monitoring, the use of incentives, the appropriate selection of actors, and socialization.

results, a manager could consider whether to engage in acquiring or sourcing based on the full understanding of the firm's specific needs. We would suggest that depending upon contextual factors such as the type of external actors, the level of vulnerability, the managerial skills and the possibilities for complementarity, they should choose acquiring or sourcing processes.

This study offers a significant contribution to OI research. However, as with all studies, the results must be interpreted with consideration of certain limitations. First, this research investigated eighteen service SMEs from knowledge-intensive and high-tech service industries. Thus, we make no claims regarding the generalizability of our findings; rather, we have focused on advancing a deeper understanding of OI adoption in service firms. Moreover, we may observe variations in the results in the context of less knowledge-intensive service industries, such as financial services. Therefore, future research may emphasize the potential similarities and differences between various service industries with respect to OI adoption.

Second, the framework that was used in our study to classify OI practices and sub-practices was based on the recent study by (Dahlander and Gann 2010), who recognized two OI practices and four associated sub-practices based on an extensive literature study. This framework can be further expanded through the addition of new dimensions for deepening our understanding of OI adoption.

Given that firms evolve and can become more engaged in OI practices (van de Vrande, de Jong et al. 2006), the OI paradigm may become the rule rather than the exception. Thus, it could be interesting to investigate how the choice of OI practices and sub-practices evolves among the service firms. In fact, as OI practices become better known, documented, and common, SMEs could choose outbound OI in more extensive ways. Thus, longitudinal studies are required to further advance our understanding of the under-researched topic of open service innovation.

This study emphasized that service SMEs do not choose the processes of revealing and selling (which are both outbound OI practices). Further investigations should identify the situations in which service SMEs could select these two OI processes, which have been shown to result in revenue generation.

Finally, a large-scale quantitative examination of service SMEs should be performed to confirm the qualitative findings of the current study. This type of research could confirm the results and provide insights for explaining some contradictory results, such as the "non-influence" of the project type and project novelty on the choice of innovation processes and practices.

7. Conclusion

In conclusion, we contribute to emerging OI literature and capability literature by providing insights into the way service firms can implement practices and sub-practices to use external resources for innovation. Our results show that service firms are inclined to prefer to use external resources for internal development rather than sharing internal resources externally. Based on in-depth analysis, we also found indications for several contextual factors that largely explain the tendency to engage in certain 'controlled' and/or 'libre' sub-practices. Thus, we encourage innovation management researchers that are interested to advancing OI literature to further pursue the topic of open service innovation.

8. References

Alic, J. A. (2001). Postindustrial technology policy. *Research Policy 30*(6), 873-889.

Arrow, K. (1971). *Essays in the theory of risk-bearing*. Chicago: Markham Pub. Co.

Bapuji, H., Loree, D., & Crossan, M. (2011). Connecting external knowledge usage and firm performance: An empirical analysis. *Journal of Engineering and Technology Management, 28*(4), 215-231.

Bass, B. M., & Avolio, B. J. (1997). *Full range leadership development: manual for the Multifactor Leadership Questionnaire*. Palo Alto, CA: Mindgarden.

Baxter, P., & Jack, S. (2008). Qualitative case study methodology: Study design and implementation for novice researchers. *The Qualitative Report, 13*(4), 544-559.

Bianchi, M., Campodall'Orto, S., Frattini, F., & Verseci, P. (2010). Enabling open innovation in small-and medium-sized enterprises: How to find alternative applications for your technologies. *R&D Management, 40*(4), 414-431.

Bidault, F. (2004). Global licensing strategies and technology pricing. *International Journal of Technology Management*, *27*(2/3), 295-305.

Chae, B. K. (2011). An evolutionary framework for service Innovation: Insights of complexity theory for service science. *International Journal of Production Economics, 135*(2), 813-822.

Chesbrough, H. (2006). Open innovation: A new paradigm for understanding industrial innovation. In H. Chesbrough, W. Vanhaverbeke, & J. West (Eds.), *Open Innovation: Researching a New Paradigm* (pp. 1-12). Oxford: Oxford University Press.

Chesbrough, H. (2006). *Open innovation: The new imperative for creating and profiting from technology*. Boston: Harvard Business School Press.

Chesbrough, H., & Crowther, A. K. (2006). Beyond high-tech: Early adopters of open innovation in other industries. *R&D Management 36*(3), 229-236.

Chesbrough, H., & Davies, A. (2010). Advancing Services Innovation. In P. P. Maglio, C. A. Kieliszewski, & J. C. Spohrer (Eds.), *Handbook of Service Science* (pp. 579-601). Springer US.

Chiaroni, D., Chiesa, V., & Frattini, F. (2011). The Open Innovation Journey: How firms dynamically implement the emerging innovation management paradigm. *Technovation, 31*(1), 34-43.

Dahlander, L., & Gann, D. (2010). How open is innovation. *Research Policy, 39*(6), 699-709.

de Jong, J. P., Bruins, A., Dolfsma, W., & Meijaard, J. (2003). I*nnovation in service firms explored: what, how and why*. EIM Business Policy Research, Strategic Study B200205, 18.

Dickson, P. H., Weaver, M. K., & Hoy, F. (2006). Opportunism in the R&D alliances of SMEs: The roles of the institutional environment and SME Size. *Journal of Business Venturing, 21*(4), 487-513.

Dodgson, M., Gann, D., & Salter, A. (2006). The role of technology in the shift towards open innovation: the case of Procter & Gamble. *R&D Management, 36*(3), 333-346.

Drechsler, W., Natter, M. (2012). Understanding a firm's openness decisions in innovation. *Journal of Business Research, 65*(3), 438-445.

Du, J., Leten, B., & Vanhaverbeke, W. (2014). Managing open innovation projects with science-based and market-based partners. *Research Policy, 43*(5), 828-840.

Eisenhardt, K. (1989). Building theories from case study research. *The Academy of Management Review, 14*(4), 532-550.

Enkel, E., Gassmann, O., & Chesbrough, H. (2009). Open R&D and open innovation: Exploring the phenomenon. *R&D Management, 39*(4), 311-316.

Evangelista, R., & Savona, M. (2010). *Innovation and employment in services. The handbook of innovation and services: A multi-disciplinary perspective*. New-York: Edward Elgar Publishing.

Garavelli, C. A., Petruzzelli, M. A., Natalicchio, A., & Vanhaverbeke, W. (2013). Benefiting from markets for ideas-An investigation across different typologies. *International Journal of Innovation Management, 17*(6).

Gardet, E., & Fraiha, S. (2012). Coordination modes etablished by the hub firm of an innovation network: The case of an SME Bearer. *Journal of Small Business Management, 50*(2), 216-238.

Gassmann, O., & Enkel, E. (2004). *Towards a theory of open innovation: Three core process archetypes*. In R&D Management Conference (6).

Gassmann, O., Enkel, E., & Chesbrough, H. (2010). The future of open innovation. *R&D Management, 40*(3), 213-221.

Hakansson, H. and J. Johanson (1987). Formal and informal cooperation strategies in international industrial networks Cooperative strategies in international business: Joint ventures and technology partnership between firms. San Francisco, New Lexington Press.

Harhoff, D., Henkel. J., & von Hippel, E. (2003). Profiting from voluntary information spillovers: How users benefit by freely revealing their innovations. *Research Policy, 32*(10), 1753-1769.

Helfat, C. E., & Peteraf, M. A. (2003). The dynamic resource-based view: capability lifecycles. *Strategic Management Journal, 24*(10), 997-1010.

Henkel, J. (2006). Selective revealing in open innovation processes: The case of embedded Linus. *Research Policy, 35*(7), 953-969.

Henkel, J., Schöberl, S., & Alexy, O. (2014). The emergence of openness: How and why firms adopt selective revealing in open innovation. *Research Policy, 43*(5), 879-890.

Hsieh, K.-N., & Tidd, J. (2012). Open versus closed new service development: The influences of project novelty. *Technovation, 32*(11), 600-608.

Hsueh, J.-T., Lin, N-P., & Li, H-C. (2010). The effects of network embeddedness on services innovation performance. *The Service Industries Journal, 30*(10), 1723-1736.

Huizingh, E. (2011). Open innovation: State of the art and future perspective. *Technovation, 31*(1), 2-9.

Huston, L., & Sakkab, N. (2006). Connect and develop-Inside Procter & Gamble's new model for innovation. *Harvard Business Review, 84*(3), 58-66.

Johnsens, T., Phillips, W., Caldwell, N., & Lewis, M. (2006). Centrality of customer and supplier interaction in innovation. *Journal of Business Research, 59*(6), 671-678.

Jøsang, A., & Lo Presti, S. L. (2004). *Analysing the relationship between risk and trust*. In Trust Management (pp. 135-145). Springer Berlin Heidelberg.

Keupp, M. M., & Gassmann, O. (2009). Determinants and archetype users of open innovation. *R&D Management, 39*(4), 331-341.

Kirschbaum, R. (2005). Open innovation in practice. *Research and Technology Management, 48*(4), 24-28.

Lasagni, A. (2012). How can external relationships enhance innovation in SMEs? New evidence for Europe. *Journal of Small Business Management, 50*(2), 310-339.

Laursen, K., & Salter, A. J. (2006). "*My precious technology: The role of legal appropriability strategy in shaping innovation performance*". Working Paper - Tanaka Business School, Imperial College London.

Laursen, K., & Salter, A. J. (2006). Open for innovation: The role of openness in explaining innovation performance among UK manufacturing firms. *Strategic Management Journal, 27*(2), 131-150.

Lichtenthaler, U., & Ernst, H. (2007). External technology commercialization in large firms: Results of a quantitative benchmarking study. *R&D Management, 37*(5), 383-397.

Love, J., Roper. S., & Bryson, J. (2011). Openness, knowledge, innovation and growth in UK business services. *Research Policy, 40*(10), 1438-1452.

Madhok, A. (2002). Reassessing the fundamentals and beyond: Ronald Coase, the transaction cost and resources-based theories of the firm and the institutional structure of production. *Strategic Management Journal, 23*(6), 535-550.

Mazzola, E., Bruccoleri, M., & Perrone, G. (2012). The effect of inbound, outbound, and coupled innovation on performance. *International Journal of Innovation Management, 16*(6), 1-27.

Mention, A.-L. (2011). Co-operation and co-opetition as open innovation practices in the service sector: Which influence on innovation novelty? *Technovation, 31*(1), 44-53.

Mention, A.-L., & Asikainen, A.-L. (2012). Innovation and Productivity: investigating effects of openness in services. *International Journal of Innovation Management, 16*(3)

Miles, M. and M. Huberman (2003). Analyse des données qualitatives Belgium, Sage Publications.

Mortara, L., & Minshall, T. (2011). How do large multinational companies implement open innovation? *Technovation, 31*(10-11), 586-597.

Murray, F., & O'Mahony, S. (2007). Exploring the foundations of cumulative innovation: Implications for organization science. *Organization Science, 18*(6), 1006-1021.

Narula, M. (2004). R&D collaboration by SMEs: New opportunities and limitations in the face of globalisation. *Technovation, 24*(2), 153-161.

Nooteboom, B. (1993). Firm size effect on transaction costs. *Small Business Economics, 5*(4), 283-295.

Parida, V., Oghazi, P., & Ericson, Å. (2014). Realization of Open Innovation: A Case Study in the Manufacturing Industry. *Journal of Promotion Management, 20*(3), 372-389.

Parida, V., Wasterberg, M., & Frishammar, J. (2012). Inbound open innovation activities in high-tech SMEs: The impact on innovation performance. *Journal of Small Business Management, 50*(2), 283-309.

Poot, T., Faems, D., & Vanhaverbeke, W. (2009). Towards a dynamic perspective on open innovation: A longitufinal assessment of the adoption of internal and external innovation strategies in the Netherlands. *International Journal of Innovation Management, 13*(02), 177-200.

Rivette, K., & Kline, D. (2000). *Rembrandts in the attic: Unlocking the hidden value of patents*. Boston: Harvard Business School Press.

Rothkopf, M. (2009). Innovation in Commoditized Service Industries: An Empirical Case Study Analysis in the Passenger Airline Industry (2). Münster: LIT Verlag.

Rubalcaba, L., Gago, D., & Gallego, J. (2010). On the difference between goods and services innovation. *Journal of Innovation Economics, 1*(5), 17-40.

Salavisa, I., Sousa, C., & Fontes, M. (2012). Topologies of innovation networks in knowledge-intensive sectors: Sectoral differences in access to knowledge and complementary assets through formal and informal ties. *Technovation, 32*(6), 380-399.

Sapienza, H., Parhankangas, A., & Autio, E. (2004). Knowledge relatedness and post-spin-off growth. *Journal of Business Venturing, 19*(6), 809-829.

Sarkar, S., Echambadi, R., Cavusgil, T., & Aulakh, P. (2001). The influence of complementarity, compatibility, and relationship capital on alliance performance. *Journal of the Academy of Marketing Science, 29*(4), 358-373.

Teece, D. J., Pisano, G., & Shuen, A. (1997). Dynamic capabilities and management. *Strategic Management Journal, 18*(7), 509-553.

Tether, B. (2002). Who co-operates for innovation and why-an empirical analysis. *Research Policy, 31*(6), 647-967.

Tether, B., & Tajar, A. (2008). The organisational-cooperation mode of innovation and its prominence amongst European service firms. *Research Policy, 37*(4), 720-739.

Toivonen, M. (2010). Different types of innovation processes in services and their organisational implications. The handbook of innovation and services: A multi-disciplinary perspective. Cheltenham. UK, Edward Elgar Publishing.

Trigo, A., & Vence, X. (2012). Scope and patterns of innovation cooperation in Spanish service enterprises. *Research Policy, 41*(3), 602-613.

van de Vrande, V., de Jong, J., Vanhaverbeke, W., & de Rochemont, M. (2006). Open innovation in SME's: Trends, motives and management challenges. *Technovation, 29*(6-7), 423-437.

Vanhaverbeke, W., Van de Vrande, V., & Chesbrough, H. (2008). Understanding the Advantages of Open Innovation Practices in Corporate Venturing in Terms of Real Options. *Creativity and Innovation Management, 17*(4), 251-258.

Vanhaverbeke, W., West, J., & Chesbrough, H. (2014). Surfing the new wave of open innovation research. In H. Chesbrough, W. Vanhaverbeke & J. West (Eds.), New Frontiers in Open Innovation (chapter 15), Oxford: Oxford University Press.

van der Meer, H. (2007). Open innovation-The Dutch treat: Challenges in thinking in business models. *Creativity and Innovation Management, 16*(2), 192-202.

Voss, C., Tsikriktsis, N., & Frohlich, M. (2002). Case research in operations management. *International Journal of Operations and Production Management, 22*(2), 195-219.

Wang, L., Yeung, J. H., & Zhang, M. (2011). The impact of trust and contract on innovatoin performance: The moderating role of environmental uncertainty. *International Journal of Production Economics, 134*(1), 114-122.

Wang, Y., & Li-Ying, J. (2014). When does inward technology licensing facilitate firms' NPD performance? A contingency perspective. *Technovation, 34*(1), 44-53.

Wathne, K., & Heide, J. (2000). Opportunism in interfirm relationships: Forms, outcomes, and solutions. *Journal of Marketing, 64*(4): 36-51.

West, J., Salter, A., Vanhaverbeke, W., Chesbrough, H. (2014). Open innovation: The

next decade. *Research Policy, 43*(5), 805-811.

Wikhamn, B. R. (2013). Two Different Perspectives on Open Innovation-Libre versus Control. *Creativity and Innovation Management, 22*(4), 375-389.

Wilson, A., Zeithaml, V., Bitner, M. J., & Gremler, D. (2008). *Services marketing - Integrating customer focus accross the firm*. Berkshire: McGraw-Hill Education.

Yin, R. (2009). *Case study research-design and methods*. USA: Sage.

Appendix

Appendix A: Sample description

Case No	Service sector	Firm size	Interviewee position	Degree of novelty	Innovation type
1	High-tech, knowledge-intensive services	Small	Founder	Incremental innovation	Service innovation
2	High-tech, knowledge-intensive services	Small	Founder	Radical innovation	Process innovation
3	High-tech, knowledge-intensive services	Small	Managing director	Radical innovation	Service innovation
4	High-tech, knowledge-intensive services	Small	Technical director	Radical innovation	Process Innovation
5	Knowledge-intensive market services (excluding high-tech and financial services)	Small	Manager	Radical innovation	Process Innovation
6	High-tech, knowledge-intensive services	Micro	Manager	Radical innovation	Service innovation
7	High-tech, knowledge-intensive services	Small	CEO	Radical innovation	Service innovation
8	High-tech, knowledge-intensive services	Medium	CEO	Radical innovation	Process Innovation
9	Knowledge-intensive market services (excluding high-tech and financial services)	Small	Director	Incremental innovation	Service Innovation
10	High-tech, knowledge-intensive services	Small	Manager	Incremental innovation	Process Innovation
11	High-tech, knowledge-intensive services	Micro	Founder	Incremental innovation	Service innovation
12	Knowledge-intensive market services (excluding high-tech and financial services)	Small	Manager	Incremental innovation	Service innovation
13	High-tech, knowledge-intensive services	Small	Business Manager	Radical innovation	Service innovation
14	High-tech,knowledge-intensive services	Micro	Founder	Radical innovation	Service innovation
15	High-tech,knowledge-intensive services	Small	IT manager	Incremental innovation	Service Innovation
16	High-tech, knowledge-intensive services	Small	Manager	Radical innovation	Process Innovation
17	High-tech, knowledge-intensive services	Medium	Innovation Manager	Radical innovation	Process innovation
18	High-tech, knowledge-intensive services	Small	Founder	Incremental innovation	Service innovation

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Open Innovation research: trends and influences – a bibliometric analysis

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Abstract. In this paper, a bibliometric analysis about open innovation research is developed, covering the period of 2003-2013 (using the Scopus database) and carried out in three steps: 1) characterization of the research on the main trends of open innovation; 2) analysis of the theoretical influence on the open innovation research; 3) analysis of the influence of open innovation literature on other research areas and disciplines. The main conclusions are: open innovation research is mostly focused on the analysis of the U.S.A. and European countries reality; analysis by time periods shows an increase on the number of target countries and regions of open innovation research; the origins of open innovation were influenced by several areas of economics and management, developed over the last decades; there is a lack of research regarding open innovation outside the firm environment, such as in clusters/networks, innovation systems, public policies or at individual level; open innovation research is influencing a growing number of areas outside business, management and engineering; new research methodologies should be used by open innovation scholars in order to deepen the existing knowledge.

Keywords. Innovation, Open Innovation, Research Trends, Research Areas, Open Innovation Impact, Bibliometric Analysis, Theoretical Review, Theoretical Influence, Influential Authors, Time Periods, Longitudinal Analysis.

1. Introduction

The topic of open innovation has been one of the most discussed ones within the innovation management literature, receiving increasing attention in areas such as economics, psychology, sociology and culture (Huizingh, 2011). Existing literature on innovation has shown that changes in global economies in the recent decades (e.g. global competition, costs and risks associated to innovation activities, more qualified human resources, greater mobility of knowledge, etc.) have changed the way organizations manage and develop their innovation process (Chesbrough, 2003, 2006). In the last decades, scholars have acknowledged the growing importance of the collaboration of firms with external partners, the access to external networks, the incorporation of ideas and knowledge from various sources (internal and external), as well as the development of business models better suited for a more open reality in the innovation process (Chesbrough, 2006; Teece, 2007). Furthermore, the exploitation of technologies and ideas in the market and a more open and flexible approach of intellectual property are trends that companies and other organizations should look at, with more attention, in order to create value, taking advantage of the opportunities offered by the global markets of research and innovation (Helfat and Quinn, 2006). In 2003, based on the analysis of the economies' main trends, on a global level and also in innovation practices and processes of some firms, Chesbrough advanced with the concept of open innovation:

> *"Open innovation means that valuable ideas can come from inside or outside the company and can go to market from inside or outside the*

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> *company as well. This approach places external ideas and external paths to market on the same level of importance as that reserved for internal ideas and paths to market during the Closed Innovation Era." (Chesbrough, 2003, p.43).*

Later developments were made to this initial definition, particularly by Chesbrough (2006) and Chesbrough and Bogers (2014), which introduce the issue of pecuniary and non-pecuniary mechanisms associated with knowledge flows (following the work by Dahlander and Gann, 2010), stressing the importance of taking into consideration the existing business models:

> *"…we define open innovation as a distributed innovation process based on purposively managed knowledge flows across organizational boundaries, using pecuniary and non-pecuniary mechanisms in line with the organization's business model." (Chesbrough and Bogers, 2014, p.17).*

This definition reinforces the importance of managing knowledge flows (to and from the organization, or both) and considers that spillovers of research and development (R&D) and of innovation activities can be managed intentionally by organizations, through various research processes and appropriation of external knowledge and its incorporation into internal innovation activities, as well as through the outflow, to the external environment, of the knowledge unused by the organization (Chesbrough and Bogers, 2014). Thus, after the initial concept introduced by Chesbrough, research articles, in academic literature, have enlarged the original concept of open innovation. However, different definitions have been employed, leading to a conceptual and empirical ambiguity that has hindered the creation of a coherent body of knowledge about open innovation (Remneland-Wikhamn and Wikhamn, 2013). This paper aims at contributing to the better understanding of the open innovation paradigm by obtaining a global and comprehensive "state-of-the-art" view of the research conducted during the last ten years in the field of open innovation (2003-2013), using bibliometric analysis as a tool. For de Bellis (2009), bibliometrics:

> *"…stresses the material aspect of the undertaking: counting books, articles, publications, citations, in general any statistically significant manifestation of recorded information, regardless of disciplinary bounds … applied to scientific and technical literature." (de Bellis, 2009, p.3).*

In recent years, there has been an increasing use of bibliometrics to analyze research trends, whether in social sciences or in other sciences in general[1], helping to explore, organize and analyze large amounts of information and assist researchers to identify patterns in the literature produced (Silva and Teixeira, 2009). Thus, bibliometric analysis can be used to clarify the main aspects and trends of open innovation research. Although there are some (few) bibliometrics studies on open innovation, this paper goes even further than other analyses on open innovation research (e.g., Chesbrough and Bogers, 2014; Remneland-Wikhamn and Wikhamn, 2013; Salvador, Montagna and Marcolin, 2013), as it provides an integrated and comprehensive approach of what is being researched, the main theoretical influences, including the areas where open innovation is having a higher influence. Most of these bibliometric studies focus only on one of these areas, not providing a global perspective on the open innovation research. For example, Remneland-Wikhamn and Wikhamn (2013) use bibliometric analysis to relate several concepts of open innovation under the firm and ecosystem perspective. Salvador, Montagna and Marcolin (2013) apply cluster analysis on open innovation articles, proposing a classification of the key features

[1] For further analysis on this issue, see the works of De Bellis (2009) and Barman, Hanna, and LaForge (2001).

associated with SMEs. The analysis of Chesbrough and Bogers (2014) offers a general characterization of open innovation research and points to future development areas, not integrating the different research perspectives.

Thus, as an original contribution, this bibliometric analysis provides an integrated approach, identifying: 1) the main trends in open innovation research over time, on a global perspective (researched themes; methodologies used; geographical areas; focus of the analysis); 2) the main theoretical influences on open innovation literature, analyzing the main references and the open innovation literature most cited authors; 3) the influence of open innovation literature on other research areas, i.e., the characterization of articles that cite open innovation related articles the most and the analysis of the most influential authors and open innovation articles.

Another distinguishing feature of this paper is related to the mixed methodological method used: a longitudinal analysis, allowing the comparison of open innovation research characteristics by time period; a text analysis (using software programs) applied to the most cited articles by open innovation literature (references), identifying theoretical trends over time that influence open innovation research; a content analysis of open innovation related articles and of the articles citing those articles, allowing the characterization of current research and their influence on other research areas. Thus, this paper intends to fill the gap related to the abovementioned issues, contributing to a better understanding of the open innovation field.

This paper is organized as follows: description of the methodology used (section 2); in section 3, analysis of the main open innovation research trends by time period (2003-2009; 2010-2013; 2003-2013); in section 4, analysis of the theoretical influences on open innovation literature, by time period; in section 5, analysis of the influence of open innovation research on other areas, by time period; in section 6, discussion of the main results of this study and conclusions.

2. Methodology

For this bibliometric study, data was extracted on January 29th 2014 from the Scopus database-the main worldwide database with regards to the number of scientific publications[2] - and the analysis held on the 30th and 31st January 2014[3]. The rationale behind the choice of Scopus as a means of data extraction is twofold: 1) Scopus is the largest academic database, integrating nearly 21,000 titles from more than 5,000 publishers, of which 20,000 are peer-reviewed journals (with 2600 open access journals), 390 trade publications and 370 collections (altogether about 5.5 million articles available)[4] - in addition, Scopus distinguishes itself from its main competitor (Web of Science) by gathering "Articles-in-Press" (i.e. not yet published articles), available from over 3850 journals and publishers (e.g. Cambridge University Press, Elsevier, Springer, Wiley-Blackwell, Nature Publishing Group and IEEE)[5]; 2) concerning open innovation published articles, Scopus has a bigger database than Web of Science (339 articles with the term "open innovation" in their title, against 205 of Web of Science), covering 81% of the articles appearing in Web of Science, i.e., 166 out of the 205 articles of Web of Science about open innovation also appear in Scopus[6]. Thus, Scopus offers a larger database of articles on open innovation,

[2] http://libguides.hsl.washington.edu/content.php?pid=439591&sid=3614877.
[3] Data were updated in August 2014.
[4] Data for January 2014.
[5] www.elsevier.com/__data/assets/pdf_file/0007/148714/scopus_facts_and_figures.pdf.
[6] This analysis was done by combining the 339 articles listed in Scopus and the 205 listed in the Web of Science. For this analysis, it was used the Excel program.

covering almost all the articles appearing in the Web of Science database. The articles chosen for download (from Scopus) were those, which had the term “open innovation” in their title, thus avoiding analysis dispersion with articles that may not have open innovation as their main focus, in spite of analyzing related areas.

Bibliometric analysis of open innovation was carried out in three steps, following the methodology used in other bibliometric analysis (e.g. Teixeira, 2014):

- Step 1) characterization of the main trends of open innovation research, from the analysis of the aforementioned 339 articles published in Scopus (of which 327 were validated), that included the term "open innovation" in their title (articles published up to December 31, 2013);
- Step 2) identification of theoretical influences on open innovation research, based on the analysis of the references contained in those 339 articles (9,357 references found), through a) the identification of the most frequent words, which appear in the references’ abstracts and b) title analysis of the articles from authors with more references (articles) cited by the 339 articles;
- Step 3) analysis of the influence of open innovation literature, taking into account a) the characterization of the articles that cite those 339 articles (2807 documents found) and b) the analysis of the most “influential articles” (“seminal" articles, i.e., open innovation related articles most cited by other articles).

Regarding the main trends’ analysis and characterization of the research on open innovation (step 1), research was carried out in Scopus articles that contained the term "open innovation" in their title (339 articles found), of which: 321 were published in Journals; 10, in specialized publications (trade publications); five, in periodical collections (Book Series); and two, presented in conferences (conference proceedings). The target of this research is the analysis of academic papers that clearly focus on the theme "open innovation", avoiding papers that could focus on parallel areas of open innovation (this means that papers that have “open innovation” as keywords, are not included unless they also have “open innovation” in their title. For the same reason, books were not included in this analysis-only academic papers). Of the 339 articles, 327 were validated for the current analysis (of the step 1), since it was not possible to have access to the full text or abstracts of 12 articles. Of the 327 valid articles, a full download of 202 articles (60 % of total) was performed, then proceeding to the analysis of the remaining 125 articles’ abstracts (since it was not possible to carry out the full download of these articles).

Following a similar methodology, as the one used in other bibliometric studies (e.g. Cruz, 2007; Silva, 2008; Silva and Teixeira, 2009; Teixeira, 2014), 327 articles were analyzed and classified according to the topic of the research analysis, the technological intensity of the object studied and the size of the organizations analyzed (Table 1). The purpose of this classification is to verify changing patterns of open innovation research over time, namely if the research has been conducted in a certain direction or if there are distinct or emerging research directions. In particular, this classification provides information regarding: if the topic of analysis focuses on firm level or if there are other relevant or emerging areas of analysis outside the firm environment (e.g. clusters, innovation systems or public policies); if there has been a greater or lesser research orientation according to the technological-intensity of the object studied; if the size of organizations (including companies) is a relevant factor in the analysis that has been performed and if there are changes in the main thematic areas analyzed.

The 327 articles were also classified according to the type of methodology used in their analysis (Table 1). The classification proposed in this paper is similar to the one used by Silva (2008) and Silva and Teixeira (2009), that follows the work of Nelson

and Winter (1982), who proposed "formal theorizing" (development of a logic and structured theoretical argument or the usage of mathematical models) and "appreciative theorizing" (based more on explanations and concepts and not mathematically-based) as research methodologies in economics. Thus, following Nelson and Winter (1982) and based on the classification used by Silva (2008) and Silva and Teixeira (2009), the articles are going to be classified as "appreciative/survey" (critical reviews, theoretical or conceptual analysis, literature review), "empirical" (construction of an empirical evidence, through the usage of qualitative analysis-including case studies-and quantitative analysis-including the existence of statistical tests or econometric analysis) and "formal/empirical" (usage of mathematical models/simulations, with empirical construction through data analysis/econometric tests).

Table 1. Classification of open innovation related articles

Topic of the analysis	• Enterprise: company or business sector • Inter-sector; Networks / Clusters: analysis of companies in various industries; knowledge networks; clusters • Innovation Systems: focus on national or regional innovation systems • Technology Transfer: University-Enterprise relation; technology markets, technological intermediaries • Public Administration (PA): analysis of the upgrading and improvement of processes/procedures in PA • Public Policy: analysis of the definition of public policies to stimulate open innovation
Technology intensity	• High-tech: focus on business/technology-intensive sectors • Non high-tech: focus on companies / sectors of medium or low technological intensity • High-Tech and Non High-Tech: the analysis is not differentiated by technological intensity of the company/industry
Size of the enterprises	• SME: analysis focused on small and medium enterprises • Large Company: analysis focused on large and/or multinational enterprises • SME and Large Enterprise: the analysis is not differentiated by size of firm
Methodology used in the article`s analysis	• Empirical: empirical construction, with qualitative analysis (including case studies) and quantitative analysis (including the existence of statistical tests or econometric analysis) • Formal/empirical: usage of mathematical models/simulations, with empirical construction through data analysis/econometric tests • Appreciative / survey: theoretic arguments, conceptual analysis development or thorough literature review

The abovementioned classification was applied to the 327 articles, allowing the characterization of the open innovation research over the last 10 years and its evolution over time, taking into account the volume of published articles, by time period (2003-2009 as a period in which less articles were published and 2010-2013 as a period in which more articles were published; see section 3 for further details) as well as the analysis of the main research trends and emerging themes.

The analysis of the theoretical influences on open innovation (step 2), was carried out through the analysis of references produced by the 339 articles, using the text analysis methodology (Chen, 2006), identifying the most frequent words used in the references' abstracts and titles, allowing the identification of the main thematic areas of influence on open innovation literature. First, a global analysis was made to the 9,357 references produced by the 339 articles, enabling the analysis by author, journal, date and country (results provided by Scopus). Then, an analysis was performed to the most frequent words appearing in the abstracts of the 9,357

references. To that respect, the references were first exported from Scopus in RIS format (Research Information Systems) and then software programs provided by Leydesdorff[7] (the "Scopus.exe" and "Scop2WOS.exe" programs) were used to extract the abstracts from the 9,357 references. The extracted abstracts were analyzed based on their most frequent words, using the CiteSpace software[8], one of the most used in bibliometric analysis (Chen, 2006). In order to have a more detailed analysis, the titles of these references were also analyzed, concerning their main researched thematic areas. In this case and due to the complexity of the analysis and the large amount of data (9,357 references), it was necessary to limit the analysis to a reasonable number of data (Remneland-Wikhamn and Wikhamn, 2013). Thus, the analysis focused on the titles of references of those authors with more references (articles) cited by the 339 open innovation related articles-authors with 17 or more articles cited were chosen (35 authors found), producing a database of 957 articles (titles from the 957 articles copied from Scopus to the Excel program by the "copy-paste" procedure).

Concerning the analysis of the open innovation research influence (step 3), it was carried out in two phases. First, taking into account the identification of the "most influential articles" (open innovation related articles with more citations)[9], by analyzing research areas, authors, affiliation, date and geographic areas. For this analysis 32 articles with at least 32 citations were identified, i.e., with an h index of 32 (Hirsch, 2005), which represent 72% of the total citations made to the 339 open innovation articles. Second, and to obtain a deeper understanding on the influence of open innovation articles, articles citing the 339 open innovation related articles (2087 articles found) were also analyzed, concerning their authors, affiliation, journal, research areas and geographic areas (results from Scopus).

3. Open innovation research: overview and main trends

The evolution of the publication of articles on open innovation has had a growing trend since the early work by Chesbrough (2003), with most publications being published after 2009. In fact, of the 339 articles listed in Scopus, 277 (82 %) were published in the period of 2010-2013 (145 published in the period 2012-2013, 43 % of the total), and only 62 articles were published in the period of 2003-2009 (18 %). This reflects the novelty of open innovation as an area of research, given the relatively small number of published articles, but also shows the academic community's growing interest in the theme within the last decade, especially after 2009 (Huizingh, 2011; Silva, 2008; Wang et al., 2012). We reached the same conclusion as we analyzed the evolution of the annual weight of open innovation related articles in relation to the total number of articles about innovation, published between 2003-2013 (Figure 1): the percentage of articles that include the term "open innovation" in their title, in relation to the total number of articles that have the term "innovation" in their title, has more than tripled between 2004 and 2009 (an increase from 0.3 % to 1.1 %) and has increased 2,5 times between 2009 and 2013 (increasing from 1.1 % to 2.7 %). So, we can say that there is a more productive period where open innovation published articles is concerned (2010-2013) and a less productive period (2003-2009).

[7] Leydesdorff software: http://www.leydesdorff.net/scopus/index.htm.
[8] http://cluster.ischool.drexel.edu/~cchen/citespace/download.html.
[9] About most influential articles", see http://libraryresearch.weebly.com/seminal-works.html.

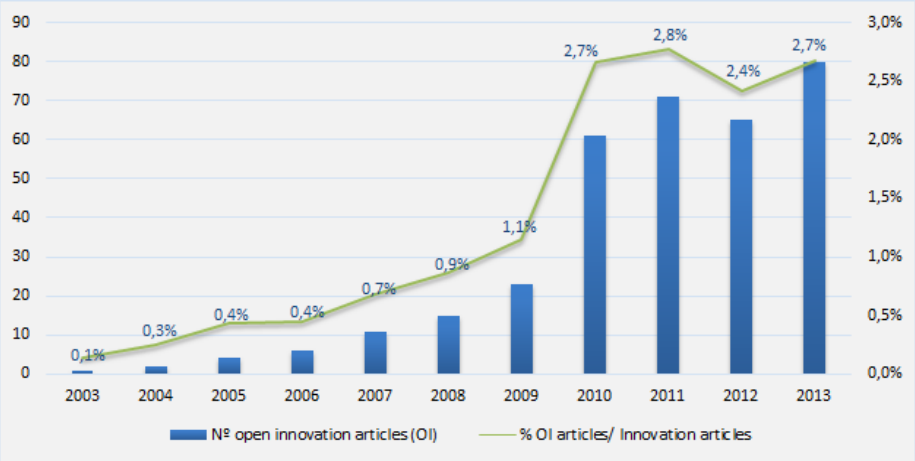

Fig. 1. Evolution of published articles on open innovation and percentage of open innovation related articles in the total of innovation articles (2003-2013)-Scopus Database.[10]

If we consider the articles by topic of analysis, we realize that in the period 2003-2013, the focus of open innovation related articles was largely related to the firm level or to a particular sector of activity (155 articles; 47.4 % of the 327 articles analyzed), followed by articles focusing on networks or on companies in various sectors (67; 20.5%) and technological markets or technology transfer issues (48; 14.7%). We can see that, out of the "business environment", there are a few articles that analyze open innovation (Figure 2): only 10 articles focus on national/regional innovation systems; there are also nine articles analyzing the role of public policies to stimulate open innovation and seven articles that analyze open innovation applied to administrative simplification and modernization of public administration. The focus of the analysis on enterprises has been observed over the years by several authors, like Chesbrough and Schwartz (2007), Helfat and Quinn (2006), Remneland-Wikhamn and Wikhamn (2013) and West et al. (2014).

If we consider the two main publication periods of open innovation related articles (2010-2013, with 82 %, and 2003-2009, with 18 %), we can see some trend changes concerning the topics of the analysis. Although, in both periods, articles about open innovation tend to focus more on enterprise or sector levels and on networks or companies from various sectors, there was a decrease in the relative weight of these two areas in the period 2010-2013 (Figure 2). Areas where there was a relative increase of articles on open innovation are: innovation systems (national/regional), technology transfer (university-industry relationship; intermediaries and technology markets), public administration and analysis of open innovation in the context of public policies. This trend is evidenced, for example, in articles that examine the importance of regional open innovation systems (Savitskaya and Torkkeli, 2011), open innovation platforms (Frey, Lüthje and Haag, 2011); public policies and open innovation (de Jong, Kalvet and Vanhaverbeke, 2010) or the role of universities in promoting open innovation in companies (Janeiro, Proença and Gonçalves, 2013). However, and despite this, the total number of articles in these areas is still very low, as we can see in Figure 2.

[10] Own elaboration, based on data from Scopus (www.scopus.com). 339 articles were found with the term "open innovation" in the title, and 19,672 with the term "innovation", in the period 2003-2013.

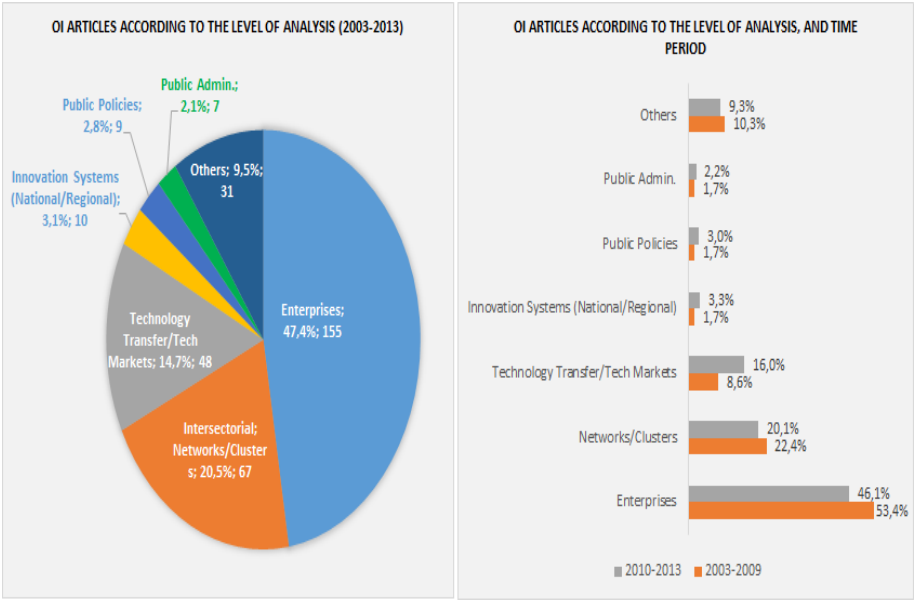

Fig. 2. Open innovation articles, according to the topic of analysis and time period.[11]

About 29% of all the articles analyze high-technology sectors/areas (Figure 3), despite the decrease of their relative weight between 2003-2009 (represented 34 % of all articles) and 2010-2013 (28 %). At the same time, there was an increase of the focus on low-technology or mature sectors between these two periods (22 % to 23%). In fact, we can find recent articles on open innovation emerging areas, such as smart cities (Schaffers et al., 2011) or on technologically mature sectors (lower technological intensity), as in education (Bogers and Sproedt, 2012), healthcare system (Guinan, Boudreau and Lakhani, 2013), shipbuilding in China (Zhao, 2012), service sector (Mention, 2011; Mention and Asikainen, 2012) or the wine sector in Hungary (Driesm et al., 2013).

Articles analyzing enterprises are mostly centered on large and/or multinational ones (89 articles; 27 % of the total), with this number relatively higher in the period of 2003-2009 (36 %). This trend leads to a small number of articles, which analyze open innovation in the context of small and medium enterprises-SMEs (38 articles; 12 % of the total)-although there are 28 additional articles (9 %) focusing on the relationship between SME and large enterprises with regards to open innovation practices (Figure 2).SMEs and SMEs/large enterprises' analysis increased in the period 2010-2013, compared to the previous period. For example, we can find recent articles analyzing open innovation in terms of integration of external knowledge and absorption of knowledge by firms, particularly in SMEs (Cheng and Chen, 2013; Malecki, 2011;), or analyzing organizational changes and business incentives for open innovation, in SMEs/Large companies (Rodriguez and Lorenzo, 2011).

[11] Own elaboration, based in the analysis of 327 articles that have the term "open innovation" in the title. Articles published in the periods: 2003-2013, 2003-2009 and 2010-2013. Data from Scopus (www.scopus.com).

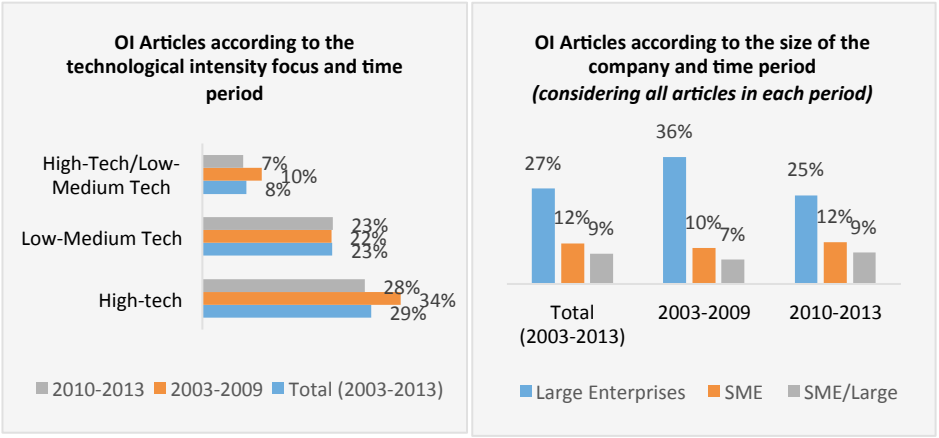

Fig. 3. Open innovation articles, according to the technological intensity focus and size, by time period.[12]

In terms of research methodology employed by the 327 articles (Figure 4), mostly they were empirical in nature (249 articles; 76 % of total), through the use of case studies at the firm level, sector of activity or entities from the scientific and academic system, and also using questionnaires/surveys (mainly in the recent years), with data treatment using statistical and/or econometric analysis. Formalization through mathematical models is still scarce, present only in 10 articles (3 %). It should also be noted that the component of literature review and/or theoretic/conceptual analysis is deeply present in most articles (139, or 43 %), as shown in Figure 4. The methodology used depicted no significant changes when we analyzed the periods 2003-2009 and 2010-2013, although it is necessary to highlight an increase in the percentage of articles that are of empirical nature (72% to 77%), reinforcing the importance of case studies in the open innovation analysis.

[12] Own elaboration, based in the analysis of 327 articles that have the term "open innovation" in the title. Articles published in the periods: 2003-2013, 2003-2009 and 2010-2013. Data from Scopus (www.scopus.com).

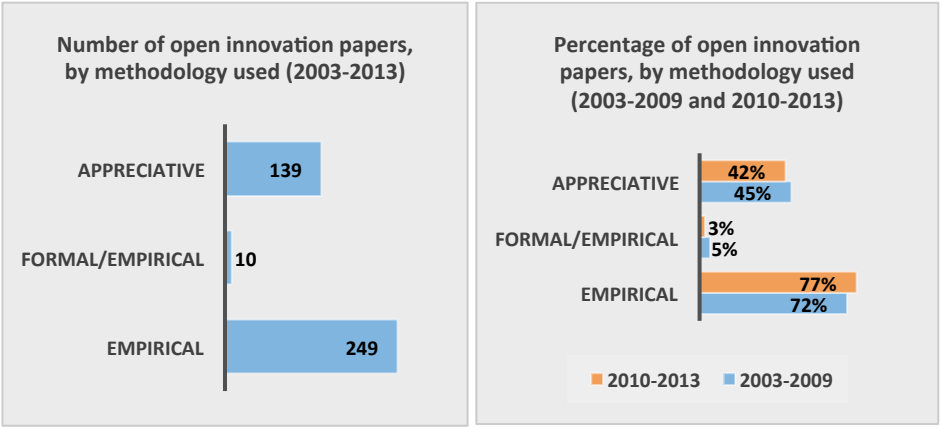

Fig. 4. Open Innovation related articles, by method of analysis (total and in percentage).[13]

Publication of articles on open innovation has occurred in 174 journals, with more than half the articles belonging to the Scopus database (58%) published by 40 journals (Figure 5)-this dispersion is justified by the fact that there are several journals that have, at most, two published articles. Meanwhile, there has been a concentration of published articles on a limited number of journals, with 24% (81 articles) published in only 6 journals: "International Journal of Technology Management" (17 articles, i.e., 5 % of total), "R&D Management" (5 %), "International Journal of Innovation Management" (3,8 %), "European Journal of Innovation Management" (3.5 %), "Research Technology Management" (3.5%) and "Technovation" (2,9 %). If we extend the range to over 15 journals, we find that they are responsible for 39 % of all published articles. Despite the fact that the major scientific journals in the field of economics (see Ritzberger, 2008) do not appear among those that publish more articles about open innovation, one can find a significant and strong presence of journals in the area of innovation management and technology (such as "Technovation", "R&D Management" or "International Journal of Technology Management")[14]-areas where research on open innovation has been mostly developed-or in the area of evolutionary economics theory, as in "Research Policy" (Silva and Teixeira, 2009). The larger number of published articles in the period 2010-2013 (of 339 articles, 277 were published in this period, as mentioned above) led to an increase in the number of journals that publish articles on open innovation: between 2003-2009 there were only 36 journals that published articles on open innovation, while the number increased to 157 journals in the period of 2010-2013.

[13] Own elaboration, based in the analysis of 327 articles that have the term "open innovation" in the title. Articles published in the periods: 2003-2013, 2003-2009 and 2010-2013. Data from Scopus (www.scopus.com).
[14] See the ranking of innovation and technology management journals in: http://www.scimagojr.com/journalrank.php?category=1405.

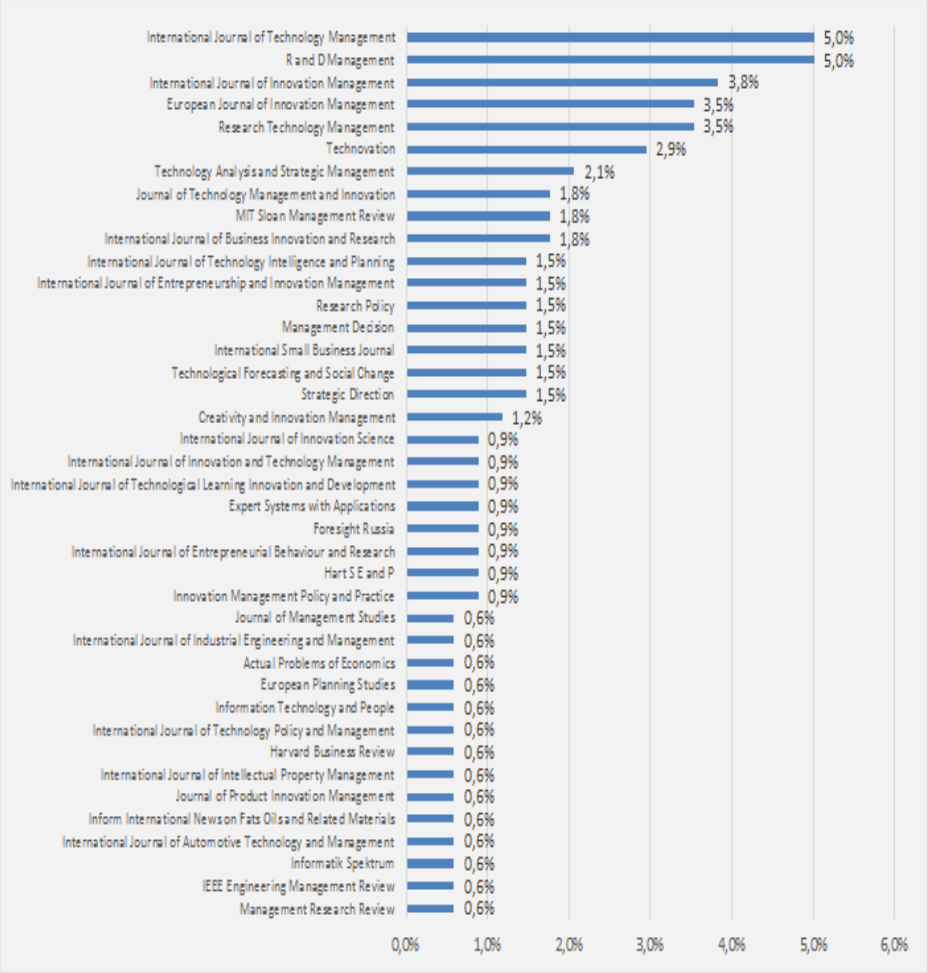

Fig. 5. Open Innovation Articles, by Journal (top 40), in percentage (2003-2013).[15]

Open Innovation research has mainly focused on the reality of the United States of America (U.S.A.)-which was the target country of 17.2 % of all articles published between 2003-2013 (Figure 6)-followed by articles that analyze open innovation between two or more European countries or between entities located in these countries (9.1 %), articles with the focus on Germany and United Kingdom (6.5 % each), Italy (5.9 %), China (4.8 %) and Sweden (4.3 %). This means that 45.2 % of all articles about open innovation published in the period of 2003-2013 have the focus of analysis on only 5 countries, 4 of them European. If we take into account only the European reality, we can see that Northern countries are the focus of about 19 % of all open innovation articles. Outside Europe, countries targeted more often by research on open innovation were China, Brazil (3.2 % each) and Russia (3.2 %), highlighting the interest of open innovation research on different and distinct countries.

[15] Own elaboration, based in the 40 journals with more published articles that have the term "open innovation" in the title. Articles published in the period 2003-2013. Data from Scopus (www.scopus.com).

If we carry out an analysis by geographical areas, we would find that most of the research has been focused on Europe (56.5 %), with articles covering most part of European countries, especially the ones from Northern Europe-research on open innovation is less centered in the Southern European countries, analyzed by 11.3 % of the articles (half of them centered in Italy). Following is North America, with 17.7 % (U.S.A. with 17.2 % and Canada with 0.5 % of the articles), Asia with 16.7 % (China, Taiwan, South Korea and Japan are the most analyzed countries) and Latin America, with 4.3% (including Brazil and Peru). There is little research focused on Middle East (only one article found, analyzing open innovation in the biotechnology industry in Iran) and the absence of any research focusing on Africa.

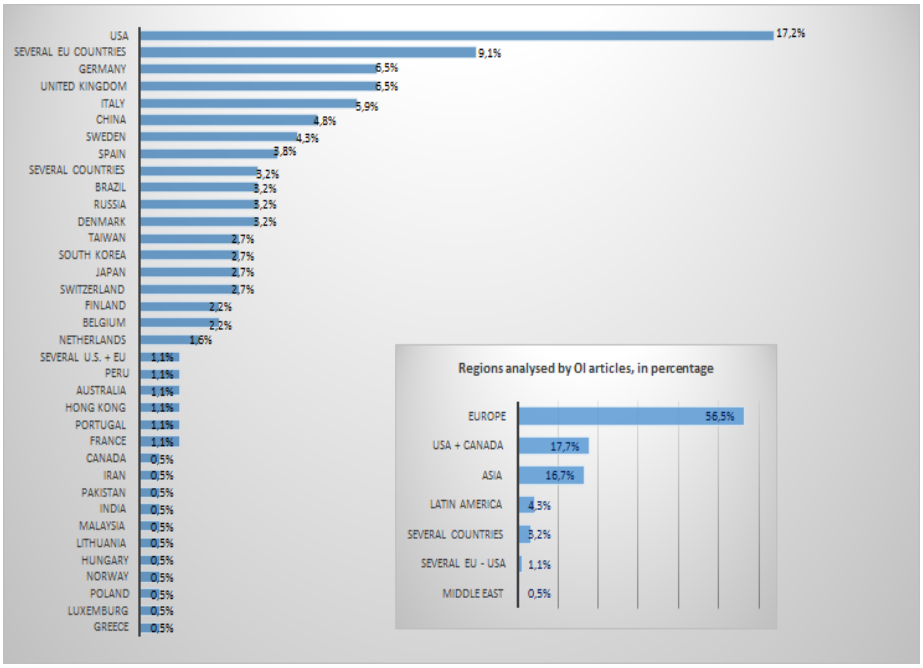

Fig. 6. Countries and Regions analyzed by open innovation related articles (2003-2013), in percentage.[16]

Analysis by time periods shows an increase on the number of target countries in the research on open innovation between 2003-2009 and 2010-2013, with emphasis on Asian countries (Malaysia, India, Pakistan, Taiwan, South Korea, Japan and Hong-Kong), some European countries (France, Poland, Hungary, Luxembourg, Lithuania, Portugal, Greece, Spain, Italy and Norway), Latin America (Peru and Brazil), Middle East (Iran) and Canada (Figure 7). This trend clearly shows the dispersion and relative attractiveness increase of countries outside the U.S.A-Europe axis, as a focus of open innovation analysis. Meanwhile, U.S.A. observed its relative importance as a target country of research being reduced between these two periods (32.3 % in 2003-2009, representing only 14.2 % in 2010-2013, but remains the country where open innovation is most analyzed). Research, comparing more than one European country, as well as research in China and Sweden, has also increased.

[16] Own elaboration, based in the analysis of 327 articles that have the term "open innovation" in the title. Articles published in the period 2003-2013. Data from Scopus (www.scopus.com).

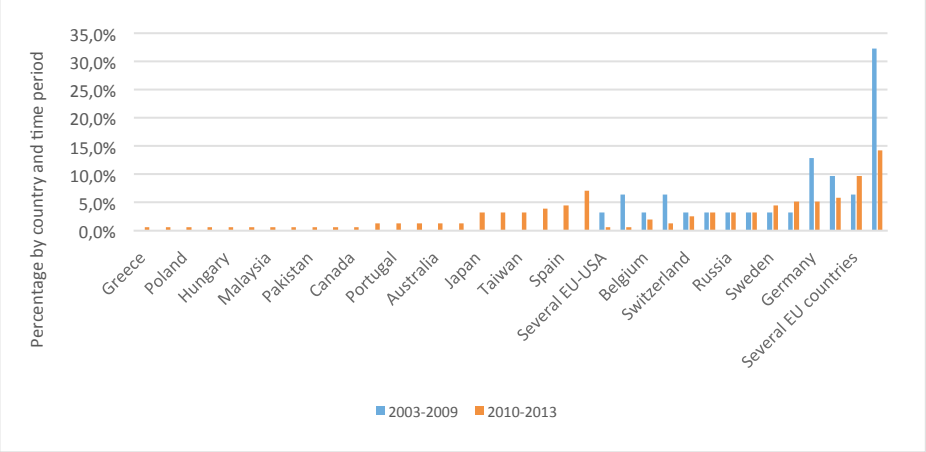

Fig. 7. Countries analyzed by open innovation articles, by country and time period (2003-2009 and 2010-2013), in percentage.[17]

There was also an increase on the number of authors' countries between the two periods, from different geographical areas, although there is a concentration of articles from authors proceeding from a small number of countries, in general. In the period 2003-2009, articles published originated from authors from 15 countries (U.S.A., Germany and UK in the top three, representing about 58%), of which three (20%) outside Europe. In the period 2010-2013, authors came from 41 countries (U.S.A, UK and Spain in the top three, but representing only 30.1 % of the authors), with 16 of them (39%) outside Europe, mainly from Asian countries. In total, for the period 2003-2013, we can see that only three countries are responsible for the 34 % of articles, with U.S.A. being the origin of a greater number of articles (54 articles; 13.2 % of the total), followed by Germany (10.3 %) and UK (10.3 %). Asia accounts for 11.5 % of the total number of articles produced, while Northern Europe countries represent 29.4 %.

There was also an increase in the number of areas covered, as well as on emerging areas of open innovation literature research. In the period 2003-2009 open innovation related articles covered 11 areas, while in 2010-2013 they covered 21 areas, with "Business, Management and Accounting", "Engineering" and "Social Sciences" being the main areas of open innovation research in the period 2003-2013 (67% of all articles published). Open innovation research is expanding to new areas, representing around 6.7 % of the articles published in 2010-2013, such as "Pharmacology, Toxicology and Pharmaceutics", "Mathematics", "Psychology", "Chemistry", "Medicine", "Arts and Humanities", "Energy", "Materials Science", "Physics and Astronomy", "Earth and Planetary Sciences".

Although relatively recent, the analysis above shows that open innovation is being recognized as an important research area, with more and more authors and academic institutions, originating from different geographic areas and countries, involved in its development. Open innovation has also expanded to new research areas beyond

[17] Own elaboration, based in the analysis of 327 articles that have the term "open innovation" in the title. Articles published in the periods 2003-2009 and 2010-2013. Data from Scopus (www.scopus.com).

business, management and economics, showing a growing acceptance in the academic field. However, it is clear that there are themes, which have still received scarce attention by the open innovation literature and a lack of knowledge regarding open innovation practices in some countries and regions (for a detailed discussion: section 6). For a better understanding of the open innovation paradigm, the main theoretical influences on open innovation literature are going to be analyzed in the next section.

4. Influence on open innovation research

The identification of the main theoretical influences on open innovation literature is important for a better perception on how open innovation research is being conducted and also to better understand the different subjects related to the open innovation concept. This analysis was carried out through: 1) the text analysis methodology-using Leydesdorff and CiteSpace software (further details in "Methodology", section 2)-analyzing references cited by the 339 open innovation articles; identifying the most frequent words found in their abstracts, and 2) the analysis of the references' titles, identifying their thematic areas of research (see section 2). This text analysis allows us to identify theoretic trends, over time, in references cited by open innovation articles, and, therefore, the main influences on the open innovation research.

In the period 2003-2013, the 339 articles from Scopus, containing the term "open innovation" in their title have cited more than 9,000 references (more precisely, 9,386), of which 48% belong to publications presented in Scopus and 52% are reference lists associated to Scopus (data generated by Scopus). About 30% of the references (2,815) have been published in only 35 journals (which have published 33 or more references). Journals with the most published references are: "Research Policy" (399 articles), the "Strategic Management Journal" (215), "Technovation" (164) and "Organization Science" (138), which jointly represent about 10% of all cited references. As we saw in section 3, although they are not mainstream journals in economics, they are very important for the areas of innovation, namely in innovation management, corporate innovation, innovation research and evolutionary economics.

Through the analysis of the references' abstracts, the most frequent words used can be identified (Table 2). In the 9,386 references published between the years of 1767 and 2013, some of the most common words are "innovation", "knowledge", "research", "firms", "technology/technological", "product", "development", "performance", "processes", "management", "business", "model", "industry", "market" or "organizational" (Table 2, 5th column, highlighted in green). Most part of those words can also be interconnected, highlighting some influential themes on open innovation: "research and development", "product innovation", "organizational innovation", "technological innovation", "product management", "product development", "knowledge management", "business model", "innovation management" or "technology management". These are major themes in the open innovation literature: e.g. "knowledge management" is directly linked to knowledge flows, external sources and the inbound and outbound open innovation processes (Dahlander and Gann, 2010; West and Bogers, 2013); "business model", "innovation management" and "organizational innovation" requiring a proper organizational structure to develop and adopt open innovation activities (Chesbrough and Schwartz, 2007; Rodríguez and Lorenzo, 2011); "research and development" with the R&D externalization or the firms' acquisition strategies (Chesbrough, 2006).

Considering the references' publication time periods (using decades as time periods), it`s possible to analyze some trends over time: there is a common base of the most frequent words in all periods (in bold, Table 2), there are words, which only appear in some periods (highlighted in blue, Table 2) and there are words that appear more

frequently from a certain period (highlighted in green, Table 2). In all the reference periods, the most cited references are the ones dealing with innovation, research, firms, product, technology, process, market or development (most frequent words appearing in all the reference periods). The word "firm" is the 1st or 2nd most frequent in all the referred periods, except in the 2000`s (ranking in 4th, with "innovation" as 1st). The word "knowledge" gained more attention over the last two decades, being the 4th most cited in the 1990`s and the 2nd after 2000 (although it has also appeared in references published before the 1980`s, but less frequently). The same happens with the words "performance" and "management", which were more frequent in the 1990`s and after 2000. After 2000, "open" and "business" appear in the list of the most frequent words in the references' abstracts (11th and 12th place, respectively), being also the period in which the concept of open innovation appeared. As we can see in Table 2, most of the cited references were published after 2000, (68% of the total), followed by the decade of 1990. This means that part of the influence on open innovation research derives from very recent literature and, probably, from authors who also write about open innovation.

To that respect, and based on the most frequent terms on the references` abstracts, one can say that major theoretical influences on open innovation seem to derive from the literature on innovation, management and the firm, regardless of the references' publication period. There is a clear focus on the firm`s reality-"firms" is always in the top 4 of the most frequent words, together with other words such as "product" or "business". However, there has been a growing importance of references focusing on knowledge, management and business in the last two decades-"knowledge management" and "business models" are core areas within the open innovation research (Chesbrough, 2003; Chesbrough and Bogers, 2014).

Table 2. Most frequent words of the abstracts of the references cited by open innovation articles, by time period (1767-2013)[18]

1767-1980	**1981-1990**	**1991-2000**	**2001-2013**	**Total (1767-2013)**
N=312	*N=506*	*N=2101*	*N=6400*	*N=9386*
product	**firms**	**research**	**innovation**	innovation
firms	**innovation**	**firms**	knowledge	knowledge
innovation	**research**	**product**	**research**	research
technology	**product**	knowledge	**firms**	firms
research	**model**	**innovation**	**paper**	paper
development	**process**	**technology**	**technology**	technology
process	**technological**	**paper**	**development**	product
paper	**technology**	**development**	performance	development
technological	**paper**	**process**	**product**	performance
model	data	organizational	**process**	processes
knowledge	industrial	performance	management	management
performance	economic	**technological**	open	organizational
market	market	**firm**	business	model
organizational	**development**	different	different	firm
firm	analysis	**market**	**model**	different
management	technical	management	**firm**	technological
industry	corporate	**model**	organizational	business
different	problem	learning	analysis	market
theory	strategy	industry	**market**	analysis
information		strategic	data	data / industry

We can have a deeper understanding of the influence on open innovation research, if we take into account the most cited authors in the open innovation literature (Table 3).

[18] Own elaboration, based in the analysis of the abstracts of 9,386 references cited by the 339 open innovation articles, using CiteSpace and Scopus.exe software. Data from Scopus (www.scopus.com). N=*number of references*.

Henry Chesbrough appears as the author (or co-author) with the most cited references (by the 339 articles), authoring (or co-authoring) 109 articles (Chesbrough is the "father" of the open innovation concept), almost the same number as the second and the third author with the most cited articles altogether-Gassmann (62) and Von Hippel (48), respectively. For a more detailed analysis and due to the volume of data available, authors with the most cited references (by the 339 open innovation related articles) were considered, in this analysis (authors with 17 or more cited references were chosen, i.e., 35 authors in total), with the references' titles being analyzed, in order to identify the main research themes (in total, the 35 authors are responsible for 975 references, about 10% of the total). Amongst the 35 most cited authors (i.e., the most influential authors on open innovation research), there are authors from the areas of open innovation (Chesbrough, Gassmann, Vanhaverbeke, Enkel or West), user innovation and open source (Eric von Hippel), as well as authors who have carried out their research in the areas of economics and management fields (Table 3). From the area of economics, it is necessary to highlight the presence of authors from the evolutionary approach[19]; from the innovation systems and economic geography literature (Nelson, on national innovation systems; Cooke, on regional innovation systems / open innovation and localization), technological skills and business R&D (Pavit); the successes and failures of technological innovation and industrial innovation (Rothewell) or knowledge networks (Nelson, Rothewell). From the management literature standpoint, the most cited authors originate mainly from networks and from the dynamic capabilities approach[20] - complementary assets (Teece), clusters and competitive advantages (Porter, Cooke), absorption capacity and knowledge management (Salter, Cohen, Nonaka), organizational change and business models (Christensen, Tushman) or organizational learning (Nonaka). If we analyze it by time period, i.e., considering the most cited authors by open innovation related articles published in 2003-2009 and 2010-2013, we could see that authors originating from the open innovation field are more cited in the 2010-2013 period, in relation to some authors from economics and management, who have lost their relative importance (like Nelson, Teece, Cohen or Arora). On the one hand, this situation can be explained by the development of the open innovation research: articles published in this period have a larger base of publications and authors to cite, rather than articles published in the period 2003-2009. One the other hand, worth noted is the recent character of open innovation research, which justifies the need for a period of consolidation and assertion of its theoretical basis, with resource-based literature of the economics and management fields.

If we analyze the relative importance of the most cited authors (i.e. the most cited authors by open innovation related articles published in 2003-2009 and in 2010-2013), we can see that there is a growing importance of some themes, like innovation networks and external networks (Carayannis, Laursen, Rothwell, Hagedoorn or Tushman), creativity and knowledge creation (Amabile, Von Krogh or Campbel), IP rights and technology commercialization (Wight, Zahra or Salter), knowledge and organizational management (Salter, Birkinshaw, Bessant or Nonaka), R&D management (Gassmann or Chiesa) and appropriability strategies (Rothwell or Laursen). In Table 3, we can see the authors and themes that achieved a higher importance between 2003-2009 and 2010-2013 (grey areas, in the 5th column).

[19] For a detailed analysis about the evolutionary approach, see: Chaminade and Edquist (2006); Dosi and Nelson (2010); Edquist (2001); Foray (eds) (2009); Marsh (2010); Metcalfe (1994); Nelson and Winter (1982); Saviotti and Metcalfe (1991, 2000).
[20] See Teece (2007).

Table 3. Most influential authors on open innovation research (most cited authors by the open innovation literature)[21]

Author *(position in 2003-2013)*	Nº articles cited (references)	Affiliation	Main themes of the cited articles	*Position of authors 2003-2009*	*Position of authors 2010-2013*
1.Chesbrough, H.	109	University of California, Berkeley, Haas School of Business, Center for Open Innovation, U.S.A.	Open innovation; Business models; Technology management.	1º	1º
2.Gassmann, O.	61	Institute of Technology Management, St. Gallen, Switzerland.	Open innovation; R&D management.	6º	2ª
3.Von Hippel, E.	48	MIT Sloan School of Management, Cambridge, U.S.A.	User innovation; Open source; External knowledge networks.	2º	7ª
4.Vanhaverbeke, W.	44	ESADE Business School, Barcelona, Spain.	Open innovation; external sources of technology; alliances and inter-organizational partnerships.	17º	3º
5.Enkel, E.	40	Zeppelin University, Friedrichshafen, Germany.	Open innovation; conceptualization.	13º	4ª
6.Lichtenthaler, U.	40	University of Mannheim, Germany.	Open innovation; Absorption capacity; Commercializatio n of technology; Intermediaries and innovation markets.	3º	5ª
7.Cooke, P.	37	Cardiff University, Centre for Advanced Studies, Cardiff, United Kingdom.	Clusters; Regional innovation system; Knowledge economy; Open innovation and localization.	7º	6ª
8.Hagedoorn, J.	29	MERIT, Faculty of Economics and Business Administration, Maastricht University,	Inter-organizational networks; R&D partnerships.	12ºª	11ª

[21] Own elaboration, based in the analysis of 975 references cited by the 339 articles that have the term "open innovation" in the title. Articles published in the periods: 2003-2013, 2003-2009 and 2010-2013. Data from Scopus (www.scopus.com).

		Netherlands.			
9.Chiesa, V.	29	Politecnico di Milano, Dipartimento di Ingegneria Gestionale, Milan, Italy.	Outsourcing of R&D; Open Innovation.	31ª	8ª
10.Teece, D.	28	University of California Berkeley Haas School of Business, Berkeley, U.S.A.	Appropriability; IP; Marketing and exploitation of knowledge; complementary assets.	5º	9ª
11.Nelson, R.R.	28	Columbia University, New York, U.S.A.	Innovation systems; Evolutionism; Intellectual property ; Spillovers of R&D networks of external knowledge.	4º	13ª
12.Cooper, R.G.	27	Michael G. DeGroote School of Business, McMaster University in Ontario, Canada.	Development and product innovation and process.	41ª	10ª
13.Duysters, G.	25	Tilburg University, Department of Organization and Strategy, Tilburg, Netherlands.	Knowledge networks; Inter-organizational networks; Business alliances.	10ª	18ª
14.Von Krogh, G.	24	Eidgenossische Technische Hochschule Zurich, Zurich, Switzerland.	Knowledge creation; organization and integration of knowledge; Open source	21ª	12ª
15.Carayannis, E.G.	23	George Washington University, Washington, U.S.A.	Triple and quadruple helix; Innovation Networks; Creativity and knowledge.		14ª
16.Pavitt, K.	22	University of Sussex, SPRU - Science and Technology Policy Research, Sussex, UK.	Technological change; Technological skills; Management and business R&D.	28ª	17ª
17.West, J.	22	KGI-Keck Graduate Institute of Claremont, California, U.S.A.	Open innovation; Open source; Appropriability; IP; Knowledge networks;	9º	15ª

			Knowledge communities; Marketing; Knowledge exploitation.		
18.Salter, A.	22	Imperial College London, School of Business, London, United Kingdom.	Intellectual property; Knowledge management; Absorptive capacity.	30ª	21ª
19.Ernst, H.	22	ETH in Zürich, Swiss Center for Automotive Research, U.S.A.	Patents; Virtual communities; Intermediates and innovation markets; Development of new products.	8ª	24ª
20.Frattini, F.	21	Polytechnic Institute of Milan, Department of Management, Milan, Italy.	Open innovation; Management innovation.		16ª
21.Rothwell, R.	21	University of Sussex, Science Policy Research Unit, Sussex, UK.	Project SAPPHO; business and technological innovation; External networks; appropriability strategies.	127ª	19ª
22.Amabile, T.M.	20	Harvard Business School, Boston, U.S.A.	Creativity; Motivation.		20ª
23.Porter, M.E.	20	Harvard Business School, Boston, U.S.A.	Clusters; Competitive strategy; Corporate organization.	54ª	22ª
24.Mowery, D.C.	19	University of California Berkeley Haas School of Business, Berkeley, U.S.A.	Strategic alliances; Knowledge transfer between companies; Patents; Contractual arrangements; Public-private collaboration for R&D.	34ª	26ª
25.Campbell, D.J.	19	Department of Political Science, University of Vienna, Austria.	Triple and quadruple helix; Knowledge production; Creativity		23ª
26.Cohen, W.M.	19	Duke University, The Fuqua School of Business, U.S.A.	Absorption capacity; public R&D; Business R&D; Spillovers;	18º	46ª

			Intellectual Property; Appropriability; Innovation policy.		
27.Tushman, M.L.	18	Stanford University, Stanford Graduate School of Business, Palo Alto, U.S.A.	Management and organizational change; Technological networks and innovation.	46ª	27ª
28.Wright, M.	18	Imperial College, London.	Entrepreneurship; Spin-outs; Technology transfer; Technology commercialization ; Business angels.		29ª
29.Zahra, S.A.	17	University of Minnesota Twin Cities, Gary S. Holmes Entrepreneurship Center, Minneapolis, U.S.A.	Absorptive capacity; Corporate entrepreneurship; University-Enterprise alliances; Technology integration; Technology commercialization .	63ª	35ª
30.Nonaka, I.	17	Hitotsubashi University, Kunitachi, Japan.	Knowledge creation; Organizational learning; Tacit knowledge.	53ª	25ª
31.Christensen, C.	17	Harvard Business School, Boston, U.S.A.	Business models; Innovation and disruptive technologies.	24º	32ª
32.Bessant, J.	17	Cranfield University, UK.	Innovation management; Technology transfer; Organizational change.	40ª	36ª
33.Arora, A.	17	Duke University, U.S.A.	Technology markets; Intellectual property rights.	11ª	54ª
34.Laursen, K.	17	Copenhagen Business School, DK.	Lead users; User-producer; External knowledge; Appropriability strategies.	104ª	31ª
35.Birkinshaw, J.	17	London Business School, UK.	Innovation management; Corporate entrepreneurship; Organizational management.	62ª	30ª

Most part of the references cited by the 339 articles were published in the last two decades, notably in the 2000s and in the 1990s, which clearly portrays this research's burgeoning character on some of these issues-such as user innovation, innovation systems, open source or the debate around intellectual property and knowledge commercialization. As expected, most part of these references (90 %) were cited by open innovation related articles published in the period 2010-2013, due to the higher volume of articles published in this period. Amongst the 35 most cited authors, there is a clear prevalence of affiliations to institutions located in Europe (18 institutions) and in the U.S.A. (15), with only one author affiliated to an entity in Canada (McMaster University, Ontario) and other in Japan (Hitotsubashi University, Kunitachi). In the U.S., Haas School of Business (University of California, Berkeley) is the most represented entity (entity of authors like Chesbrough, Mowery and Teece), followed by the Harvard Business School (authors like Christensen, Amabile and Porter). In Europe, the most represented entities are the Politecnico di Milano (of Chiesa and Frattini) and SPRU-University of Sussex (of Pavitt and Rothwell).

In short, the analysis of the most frequent words, occurring on the references' abstracts and research themes of the most cited authors, carried out by the 339 open innovation related articles shows that influences on open innovation are rooted in several areas of the economics and management fields, developed over several decades (Christensen et al, 2005; Dahlander and Gann, 2010; Huizingh, 2011; West et al., 2014), especially during the 1990s and 2000s. This refutes, in part, the criticism of authors like Trott and Hartmann (2009), who affirm that open innovation research takes an insufficient number of previous theories into account in its conceptual development. In fact, and based on the analysis of this section, one can say that some of the main literature of economics and management areas of influence are: organizational change, networks, the University-Industry-Government relation, the intellectual property management, knowledge and R&D management, technology transfer and the creation, management and absorption of knowledge. But there is, clearly, a focus on references related to the firm's theory, which is still the main focus of the open innovation analysis. Knowing the areas that most influenced open innovation research, it is also important to have a clear picture of which areas are being influenced by open innovation literature and, which authors and articles are the most recognized (more cited) by other research areas. A detail analysis is provided in section 5.

5. The influence of open innovation research

The 339 articles about open innovation published on Scopus were cited 4805 times by other studies (data up to December 31, 2013). However, 36.2 % (123 articles) never had any quote, while 63.8 % had at least one quote. It should be noted that relatively few articles have been cited many times, with only 4 % cited at least 100 times and 6 % at least 50 times. The 10 most cited articles account for 43.7 % of the total 4805 citations. If we consider only those "seminal" or "most influential" articles[22], i.e., the 32 articles cited at least 32 times by other articles, represent 72 % (3479) of the total citations (Table 4). Of these 32 articles, 21 analyzed companies or entities in a given sector/cluster or comparison between sectors, half the articles analyze

[22] About "seminal" or "most influential" articles: "In fact, authors may refer to a specific work as "seminal" or "influential" or "core" or "classic" or describe the work in some way that indicates its central importance to a body of research. Another tool for locating or identifying seminal works is citation analysis which is a tool that can help identify papers cited many times in the literature.", in http://libraryresearch.weebly.com/seminal-works.html.

large/multinational companies, and 41 % analyze technology-intensive companies/sectors. The analysis of SME (13 %) and mature or less intensive technology sectors (25 %) receives the attention from a smaller number of articles, following the trend of the research done by the majority of articles on open innovation, as seen in section 3.

From amongst the 32 seminal papers (Table 4), the highest number was published in the period 2003-2009 (72 %), even though the period 2010-2013 was the most productive in terms of number of published articles on open innovation. About 90 % of the most cited (seminal) articles have the focus of the analysis on the U.S. (40 %) and Europe (50 %)-the Netherlands (10 %, i.e., two articles) and Italy (10%) are the most represented European countries in these 32 most cited articles. Other regions or countries outside Europe or U.S.A. are not represented in these 32 seminal articles (Latin America and Africa are not the subject of research of any article), with the exception of Asia, with only one article, focusing on South Korea.

Moreover, there are articles analyzing open innovation in institutions/companies from more than one European country (10 %) and articles comparing the reality of countries from different continents (5 %; 1 article). The issues of technology transfer and technology intermediaries/markets are analyzed in 4 articles (13 %), while topics such as public policy or analysis of open innovation within public administration are not analyzed in any of these 32 seminal articles.

Table 4. Most cited open innovation related articles ("seminal articles")[23]

Article	Author(s)	Publication Year	Nº citations	Journal
1. The era of open innovation	Chesbrough, H.	2003	589	MIT Sloan Management Review
2. Beyond high tech: Early adopters of open innovation in other industries	Chesbrough H., Crowther, A.K.	2006	258	R&D Management
3. University-industry relationships and open innovation: Towards a research agenda	Perkmann, M., Wals,h K.	2007	184	International Journal of Management Reviews
4. Challenges of open innovation: The paradox of firm investment in open-source software	West J., Gallagher, S.	2006	179	R&D Management
5. The role of technology in the shift towards open innovation: The case of Procter & Gamble	Dodgson, M., Gann, D., Salter, A.	2006	171	R&D Management
6. Open innovation in SMEs: Trends, motives and management challenges	van de Vrande, V., de Jong, J.P.J., Vanhaverbeke, W., de Rochemont, M.	2009	169	Technovation
7. Selective revealing in open innovation processes: The case of embedded Linux	Henkel, J.	2006	153	Research Policy
8. The industrial dynamics of Open Innovation - Evidence from the transformation of consumer electronics	Christensen, J.F., Olesen, M.H., Kjaer, J.S.	2005	143	Research Policy
9. Open innovation in practice: An analysis of strategic approaches to technology transactions	Lichtenthaler, U.	2008	139	IEEE Transactions on Engineering Management
10. Brokerage, boundary spanning, and leadership in open innovation communities	Fleming L., Waguespack, D.M.	2007	117	Organization Science
11. A capability-based framework for open innovation: Complementing absorptive capacity	Lichtenthale,r U., Lichtenthaler, E.	2009	114	Journal of Management Studies
12. Regionally asymmetric knowledge capabilities and open innovation: Exploring 'Globalization 2' - A new model of industry organization	Cooke, P.	2005	113	Research Policy
13. Networking as a means to strategy change: The case of open innovation in mobile telephony	Dittrich, K., Duysters, G.	2007	111	Journal of Product Innovation Management
14. Managing open innovation	Chesbrough, H.	2004	109	Research Technology Management
15. Open innovation: State of the art and future perspectives	Huizingh, E.K.R.E.	2011	96	Technovation
16. Innovation contests, open innovation, and multiagent problem solving	Terwiesch, C., Xu, Y.	2008	88	Management Science

[23] Own elaboration, based on the analysis of 339 articles that have the term "open innovation" in the title. Were selected the 32 articles that have 32 or more citations from other articles, up to 31.12.2013. Articles published in the period 2003-2013. Data from Scopus (www.scopus.com).

17.	Open innovation in SMEs-An intermediated network model	Lee, S., Park, G., Yoon, B., Park, J.	2010	82	Research Policy
18.	Open innovation in practice	Kirschbaum, R.	2005	74	Research Technology Management
19.	Building absorptive capacity to organize inbound open innovation in traditional industries	Spithoven, A., Clarysse, B., Knockaert, M.	2010	61	Technovation
20.	Outbound open innovation and its effect on firm performance: Examining environmental influences	Lichtenthaler, U.	2009	60	R&D Management
21.	Open innovation: Past research, current debates, and future directions	Lichtenthaler, U.	2011	58	Academy of Management Perspectives
22.	Exploring the field of open innovation	Elmquist, M., Fredberg, T., Ollila, S.	2009	52	European Journal of Innovation Management
23.	Determinants and archetype users of open innovation	Keupp, M.M., Gassmann, O.	2009	47	R&D Management
24.	New ventures based on open innovation - An empirical analysis of start-up firms in embedded Linux	Gruber, M., Henkel, J.	2006	40	International Journal of Technology Management
25.	Unraveling the process from Closed to Open Innovation: Evidence from mature, asset-intensive industries	Chiaroni, D., Chiesa, V., Frattini, F.	2010	37	R&D Management
26.	Motivating and supporting collaboration in open innovation	Antikainen, M., Makipaa, M., Ahonen, M.	2010	36	European Journal of Innovation Management
27.	Organizational modes for Open Innovation in the bio-pharmaceutical industry: An exploratory analysis	Bianchi, M., Cavaliere, A., Chiaroni, D., Frattini, F., Chiesa, V.	2011	34	Technovation
28.	Innovation communities: The role of networks of promotors in open innovation	Fichter, K.	2009	34	R&D Management
29.	How open innovation: Can help you cope in lean times	Chesbrough, H.W., Garman, A.R.	2009	34	Harvard Business Review
30.	Opening up for competitive advantage - How Deutsche telekom creates an open innovation ecosystem	Rohrbeck, R., Holzle, K., Gemunden, H.G.	2009	33	R&D Management
31.	Managerial challenges in open innovation: A study of innovation intermediation in the chemical industry	Sieg, J.H., Wallin, M.W., von Krogh, G.	2010	32	R&D Management
32.	The Open Innovation Journey: How firms dynamically implement the emerging innovation management paradigm	Chiaroni, D., Chiesa, V., Frattini, F.	2011	32	Technovation

Based on Table 4, we can construct a table of the most influential authors (Table 5), i.e. the ones with the highest number of articles cited among the 32 seminal articles. The most influential author is Henry Chesbrough, with 4 articles (2 of them in co-authorship), with the articles "The Era of Open Innovation" (Chesbrough is the only author) and "Beyond high tech: Early adopters of open innovation in other industries" (Chesbrough and Crowther) being the most cited articles by other articles (Table 5).

Ulrich Lichtenthaler[24] also has 4 articles among the most cited, but with fewer citations than Chesbrough's. Chiaroni, Chiesa and Frattini (3 articles) and Henkel (2 articles) are the following. Research organizations with the most cited authors affiliated are located in the U.S. and Europe (Germany and Italy), namely the Haas School of Business at the University of Berkley (which welcomes authors such as Henry Chesbrough and Andrew Garman) and Politecnico di Milano, affiliating of authors like Chiaroni, Chiesa and Frattini (Table 5).

Table 5. Affiliation of Authors with the Most Published Articles, Amongst the 32 Seminal Articles[25]

Author	**Nº articles**	***Of which, in co-authorship***	**Affiliation**
Chesbrough, H.	4	2	University of California Berkeley, Haas School of Business
Lichtenthaler, U.	4	1	University of Mannheim, Germany
Chiaroni, D.	3	3	Politecnico di Milano, Dipartimento di Ingegneria Gestionale
Chiesa, V.	3	3	Politecnico di Milano, Dipartimento di Ingegneria Gestionale
Frattini, F.	3	3	Politecnico di Milano, Department of Management
Henkel, J.	2	1	Technische Universität München

R&D Management stands as the Journal with more published articles over the 32 seminal articles on open innovation (9 articles), followed by Technovation (5 articles) and Research Policy (4 articles), both journals from the field of innovation management and innovation policy (Figure 8). If we consider the number of citations, we find that R&D Management (851 citations, i.e., 18 % of the 4805 citations made to the 339 open innovation articles) and MIT Sloan (12 % of citations) are the journals that published the most cited articles, followed by Research Policy (10 %). To be noted that MIT Sloan has only one of the 32 seminal articles-"The Era of Open Innovation", from Chesbrough-in this case, the article more often cited by other articles (589 citations), being the most influential paper in the literature on open innovation.

[24] Ulrich Lichtenthaler has had some papers retracted by some journals. Please see: http://tinyurl.com/l4d3rq8.
[25] Own elaboration, based in the analysis of the 32 most cited articles that have the term "open innovation" in the title. Articles published in the period 2003-2013. Data from Scopus (www.scopus.com).

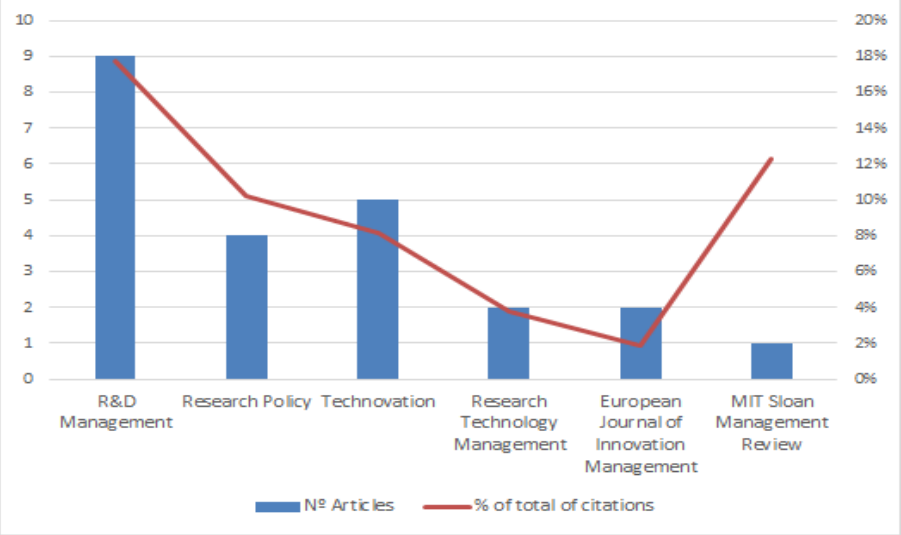

Fig. 8. Number of articles and citations by Journal, based on the 32 seminal articles.[26]

After reviewing the most cited articles and authors, to analyze the influence of open innovation literature, it is also necessary to characterize those who cited open innovation articles. The 339 open innovation related articles were cited by 2807 articles (which produced 4805 citations, as seen above), with 86 % published after 2010. Although most articles have authors from Europe, U.S. and Asia, it is possible to observe some trends, namely an expansion in the number of countries and geographical areas from where these citations originate (Figure 9). In fact, in the period 2003-2009, citations originate from authors of 34 countries (no countries from Latin America and only one country from Africa-South Africa), while in the period 2010-2014[27] the number of countries more than doubled (78). The most represented countries (U.S.A., UK and Germany) were the source of 51% of all authors in 2003-2009, decreasing this percentage to 40 % in 2010-2013. In 2010-2014, there was a significant growth in the number of authors from Asian countries, Latin America (Brazil, Mexico, Colombia, Peru, Argentina, Costa Rica, Cuba, Ecuador and Uruguay) and Africa (South Africa, Tunisia, Egypt, Morocco, Tanzania, Benin and Ghana). China (6th place), Australia (12th), Taiwan (14th) and Canada (15th) are the countries outside Europe and the U.S. with more authors, concerning articles that most cite open innovation related articles.

In the period 2003-2009, about 160 entities were responsible for the affiliation of the authors responsible for 2807 articles that cite the 339 open innovation related articles, while in the period 2010-2014 the top 160 entities represented merely 73% of all the affiliations, located in a more dispersed geographic area than in the previous period. Still, there is a clear prevalence of the authors' affiliation entities that cite open innovation related articles located in Europe the most, which represent 13 of the "top 15" entities (the other two are from Asia, namely China-Zhejiang University-and

[26] Own elaboration, based in the analysis of the 32 most cited articles that have the term "open innovation" in the title. Articles published in the period 2003-2013. Data from Scopus (www.scopus.com).
[27] For the characterization of the articles citing open innovation articles published in the period 2003-2013, the year of 2014 was also included, in order to have a greater coverage of the citations made to articles published in 2013. Thus, in this analysis were also included the articles available at Scopus up to August 2014, which cite open innovation articles published up to December 31, 2013.

Singapore-National University of Singapore).

In regards to the subject areas researched, open innovation related articles were cited by 23 different areas in the period 2003-2014, with most part of the citations deriving from the area of "Business, Management and Accounting", "Computer Sciences" and "Engineering" (62.7 % of the total, in 2003-2014), followed by "Social Sciences", "Decision Sciences" and "Economics, Econometrics and Finance" (Figure 10). However, there is a growing attention of other areas within the open innovation literature: between 2003-2009 and 2010-2014 there are new areas citing open innovation literature ("Nursing" and "Materials Science"), but also a higher weight of areas such as "Engineering", "Social Sciences", "Biochemistry, Genetics and Molecular Biology", "Environmental Science", "Agricultural and Biological Sciences", "Psychology", "Medicine", "Pharmacology, Toxicology and Pharmaceutics", "Arts and Humanities", "Chemistry", "Energy".

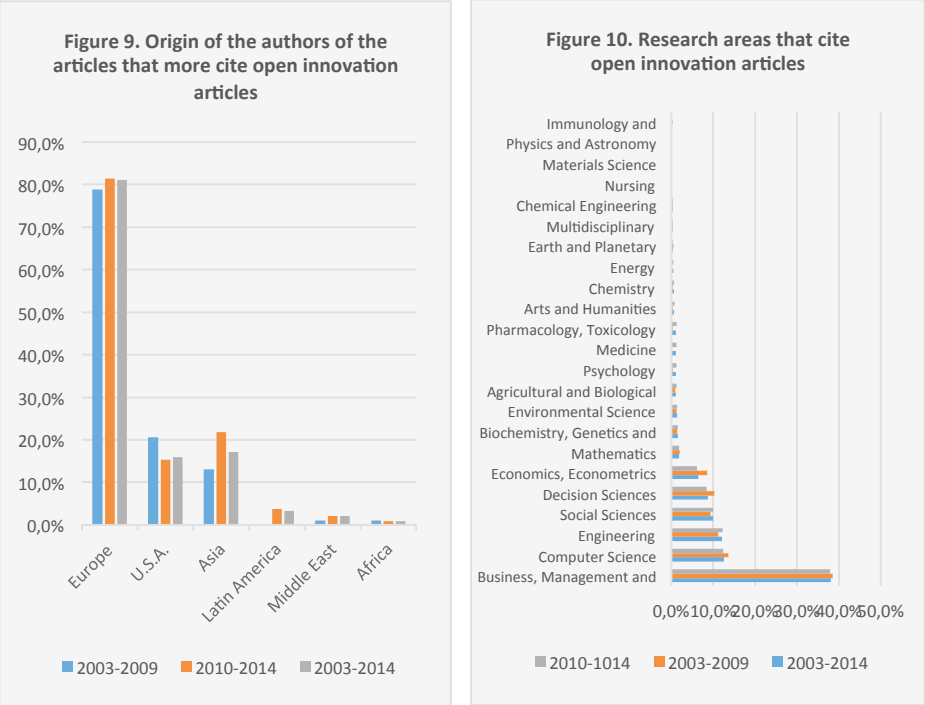

Fig. 9. and Fig. 10. Characterization of the articles that cite open innovation articles.[28]

In short, the analysis of section 5 highlights that the most influential authors and academic institutions are from the U.S. and from Europe, where open innovation research has mainly developed during the last decade (as seen in section 3). Meanwhile, the literature on open innovation seems to have a growing influence on a geographic and thematic level over time: there are more and more authors citing open innovation literature around the world, from different geographical areas and from higher number of countries; there is also a growing weight of countries outside Europe and the U.S. (especially from Latin America, Middle East and Africa) and a

[28] Own elaboration, based in the analysis of the 2807 articles that cite the 339 open innovation articles. Articles published in the periods: 2003-2013, 2003-2009 and 2010-2014. Data from Scopus (www.scopus.com).

higher number of entities per author`s affiliation. This is interesting, because in section 3 we saw that there were no articles analyzing the reality of some regions (e.g. Africa) and just a few articles about other regions (e.g. Latin America). So, it could mean that many of those authors are publishing articles (as authors or co-authors) without any particular region or country as focus, being a question that should be better perceived in further analysis. Open innovation literature is also extending its influence over other research areas. Although the main research areas citing open innovation are related to "Business, Management and Engineering", there are many others, including new areas (such as "Nursing") and emerging areas (such as "Phycology" or "Energy"). The question is whether this is a trend to continue in the coming years or if this is due to the novelty and curiosity about the field of open innovation. To be discussed, in the next section.

6. Conclusion and Discussion

Open innovation is a new research field within economics and management. Having started by observing cases of multinational companies located in the U.S. (work initially conducted by Chesbrough), mainly in high-tech sectors, open innovation research has received a growing attention over the years, extending its geographical and research scope of analysis. Being a new research area, the open innovation field is still under development and consolidation, requiring a broader and deeper analysis in order to gain influence in the academic field and a higher acceptance at a managerial and business level (Remneland-Wikhamn and Wikhamn, 2013). Through bibliometric analysis, this paper aims at contributing to that end.

6.1. Exploring other levels of analysis

The bibliometric analysis developed in this paper shows that the "firm" is still open innovation's main level of analysis, which is understandable, since it was the starting point of open innovation research (in 2003) and innovation (the new or improved product, service, organizational process or marketing) is mainly conducted by companies. Looking to the first 10 years of open innovation research (as seen in section 3), we can see that a large percentage of studies had their focus on firms (on large and/or multinational companies) and on technology-intensive areas and/or sectors. However, from the economics of innovation literature standpoint, we know that: innovation is a systemic and complex phenomenon; firms cannot innovate alone; innovation can occur outside the business sector and in all type of firms; innovation can occur in high-technology as well as in mature or low-technology areas (Caraça et al., 2009; Lundvall, 1988; Nelson and Rosenberg, 1993). So, it is expected that, for the consolidation and better understanding of the importance of open innovation as a research field, other levels of analysis can be studied with further intensity and depth. For example:

- How can the clusters' approach be linked with open innovation activities? Breschi and Malerba (2005) have a detailed analysis on the impact of clusters in the innovation process, analyzing cooperation networks, geographical location, agglomeration economies and network externalities, regional innovation networks and social networks. Based on Simard and West (2006), the benefits of open innovation can be enhanced in clusters (regional clusters), since the effect of innovation networks can be expanded by geographical proximity, with a positive impact on economic growth. But further analysis is necessary in order to perceive all the potentialities of clusters in promoting open innovation activities, and vice-versa.

- How does open innovation fit into the literature of innovation systems? What are the complementarities or divergences between both approaches? Since 2003 only 10 articles have been published (3% of the total) relating this two areas. For example, Wang et al. (2012) analyzed the impact of open innovation on national innovation systems (NIS), emphasizing the interactions since many of the practices of open innovation are dependent on the characteristics and performance of a particular NIS. But what do we know about regional innovation systems and open innovation? Or about open innovation adoption according to the specificities of different national innovation systems?
- What is the role of public policies in the creation of a better environment to promote open innovation activities? And how can open innovation be an approach used to design better public policies? Wang et al. (2012) and de Jong et al. (2010) identify public policies' action lines that can have impact in the adoption of open innovation by firms and organizations. There are also few advances in bringing open innovation to the local/municipality reality (e.g., Bakici, Almirall and Wareham, 2013) or in analyzing collaborative partnerships for open innovation between public and private entities (Salmi and Torkkeli, 2009). But research in the public sector or involving public policies is very scarce and limited, thus the necessity for further research towards a better understanding of the synergies between open innovation and these areas, is highly required.
- How about open innovation at the individual level? How can organizations benefit from individual orientation to new ideas and external sources of knowledge? How can this contribute to a more inclusive and innovative society? So far, it has been an area with little attention from open innovation literature. One of the pioneer studies in this area was developed by Salter et al. (2014), where they analyzed individual-level openness related to organizations and networks. This is an emerging and multidisciplinary area, involving economics, psychology and management, and a promising research field for future research.

Even at the firm level, there are under-researched areas, such as the skills needed in an open innovation context, the incentives and motivations to promote open innovation or the transaction costs issue (West et al., 2014). Or, for example, the analyses of open innovation practices within services and business services, as carried out in Mention (2011), Mention and Asikainen (2012) or in Mina, Bascavusoglu-Moreau and Hughes (2014). Or the work of Henkel, Schöberl and Alexy (2014), that analyzes how and why firms adopt selective revealing in open innovation. So, exploring other levels of analysis is a challenge that can bring new insights to the field of open innovation.

6.2. The extension to new realities

Gaps in the open innovation literature could be filled by taking into account the diverse realities and contexts of the economies all around the world, i.e. by extending the geographic areas of open innovation research. From the results of this paper (section 3), it is clear that open innovation research is still mostly focused on the analysis of the U.S. and European reality, despite the increase in the relative weight of research focused on other regions of the world after 2010, as in Asia or Latin America. In Europe, most studies are still focused on the North and Centre countries, with relatively little analysis centered in Southern countries (except for Italy) or Eastern Europe. Notwithstanding, analysis by time periods shows an increase in the number of open innovation research's target countries between 2003-2009 and 2010-2013, with emphasis on Asian countries (e.g. Malaysia, India, Pakistan or Hong

Kong), some European countries (France, Poland, Hungary, Luxembourg, Lithuania, Portugal, Greece and Norway), Latin America (Peru and Brazil), Middle East (Iran) or Canada. However, there is a lack of open innovation analysis at a regional level within those countries, as well as a lack of inter-regional or inter-countries comparisons. One of the examples comes from Padilla-Meléndez, Del Aguila-Obra and Lockett (2012), through the analysis of the social capital role in knowledge transfer and exchange in Andalucía, Southern Spain. A more recent example is given by Savitskaya, Salmi and Torkkeli (2014), who analyze outbound open innovation in China and Russia, in an innovation system approach. But further data and information at a regional or inter-regional (or countries) level is needed to better perceive open innovation dynamics, barriers and specificities.

Meanwhile, there are geographic areas and countries where the open innovation reality is barely known, as in the case of African countries-although there are researchers from these regions and countries that cite open innovation articles-they are not analyzing the reality of these countries (as seen in section 5). It is important to understand the reasons behind that in future studies (is it because the lack of valid data and information?). And how can the open innovation approach contribute to the growth and competitiveness in transitioning or developing economies? What tools and conditions are needed for the adoption of open innovation in those economies? Undoubtedly, these are pertinent questions requiring clarifications and open innovation researchers can contribute towards this direction.

6.3. New themes, new influences

The analysis of the most cited references shows that literature on open innovation has been influenced by various fields of research, namely from the evolutionary economics literature and from the dynamic capabilities approach (management and organizational change, marketing and promotion of knowledge and R&D, the creation, management and absorption of knowledge, etc.). Although the main influences on open innovation research are rooted in several areas of economics and management, developed over several decades, especially in the 1990s and 2000s (retracting criticisms of Trott and Hartman, 2009), the bibliometric analysis of this research has highlighted an overlap between authors who have more influence on open innovation research (references) and the most influential authors of the open innovation literature.

In fact, about 34% of the most cited authors by the open innovation literature (section 4) are also authors of the open innovation related articles more cited by other articles (section 5). Such is the case of authors like Chesbrough, Gassmann, Cooke, West, Vanhaverbeke, Salter or Christensen. This may be related to the fact that open innovation is a new area of research, with an increasing number of authors and articles, but with a concentration of articles in a small number of authors, namely concerning the most cited articles (as seen in section 5). Also important is the fact that most part of the references to open innovation research were published after 2000 (section 4), meaning that many authors are still publishing and many of them are also open innovation authors. Another reason may have to do with the focus of the analysis of open innovation research-mainly at the firm level-contributing to the similarity of authors and themes between references and the open innovation most cited articles. Analysis of open innovation at other levels (e.g. clusters, innovation systems, individual level) and themes (e.g. public policies, financial sector, skills, motivations, competition, communities) can contribute to enlarge the scope of influence on the open innovation research, consolidating the open innovation paradigm.

6.4. Other methodologies

We have seen in section 3 that most part of the methodology used by open innovation studies is empirical in nature, using mainly case studies and questionnaires. Being open innovation an "open" reality in a global and turbulent world, involving several actors and different types of relations between them to explore new ways to create innovation, open innovation literature could be enriched through the use of additional research methods. For example: new ways to collect information, using focus groups, online platforms or the Delphi method; new ways of predict trends and construct strategies, using prospective or forecasting methods. Experimental economics can also provide some insights to open innovation research, mainly with regards to the analysis of openness at the individual level.

6.5 Limitations of this research

As a limitation of the research, it can be pointed out the non-inclusion of articles that had "open innovation" in keywords or in abstracts, having only been considered the articles with the term "open innovation" in the title. This choice avoided the dispersion of the analysis with articles that may not have open innovation as the main focus, although they might analyze related areas (as referred in section 2) and can be important in terms of marking some research trends or other emerging research areas. A more detailed understanding of the trend and impact of open innovation research could be reached through the inclusion of these articles. In the text analysis, other kind of software can be employed, in order to highlight other possible details. It would also be interesting to compare the results with bibliometric papers that use co-citations as a methodological tool. Nevertheless, it is expected that this research can be considered as a step further into the knowledge on the open innovation field.

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8. References

Barman, S., Hanna, M. D., & LaForge, R. L. (2001). Discipline note-Perceived relevance and quality of POM journals: a decade later. *Journal of Operations Management, 19*(3), 367-385.

Bakici, T., Almirall, E., & Wareham, J. (2013). The role of public open innovation intermediaries in local government and the public sector. *Technology Analysis & Strategic Management*, *25*(3), 311-327.

Bogers, M., & Sproedt, H. (2012). Playful Collaboration (or Not): Using a Game to Grasp the Social Dynamics of Open Innovation in Innovation and Business Education. *Journal of Teaching in International Business*, *23*(2), 75-97.

Breschi, S., & Malerba, F. (2005). *Clusters, Networks and Innovation*. Oxford University Press.

Caraça. J., Lundvall, B.-Å. & Mendonça, S. (2009). The changing role of science in the innovation process: From Queen to Cinderella? *Technological Forecasting and Social Change*, *76*(6), 861-867.

Chen, C. (2006). CiteSpace II: Detecting and visualizing emerging trends and transient patterns in scientific literature. *Journal of the American Society for Information Science and Technology*, *57*(3), 359–377.

Cheng, C. C. J., & Chen, J.-S. (2013). Breakthrough innovation: the roles of dynamic innovation capabilities and open innovation activities. *Journal of Business & Industrial Marketing*, *28*(5), 444-454.

Chesbrough, H., & Bogers, M. (2014). Explicating Open Innovation: Clarifying an Emerging Paradigm for Understanding Innovation. In H. Chesbrough, W. Vanhaverbeke, & J. West (Eds.), *New Frontiers in Open Innovation* (pp.3-28). Oxford: Oxford University Press.

Chesbrough, H., & Schwartz, K. (2007). Innovating business models with co-development partnerships. *Industrial Research Institute, 50*(1), 55-59.

Chesbrough, H. (2006). Open innovation: a new paradigm for understanding industrial innovation, In H. Chesbrough, W. Vanhaverbeke, & J. West (Eds.), *Open Innovation: Researching a New Paradigm* (pp.1-12). Oxford: Oxford University Press.

Chesbrough, H. (2003). *Open Innovation: The New Imperative for Creating and Profiting from Technology*. Boston: Harvard Business School Press.

Cruz, S. C. S. (2007). *Surveying Clusters: A comprehensive bibliometric account*. PhD Dissertação de Mestrado da Faculdade de Economia. Retrieved from the Universidade do Porto Website: http://repositorio-aberto.up.pt/bitstream/10216/7563/2/07.pdf

Dahlander, L., & Gann, D. (2010). How open is innovation. *Research Policy*, *39*(6), 699-709.

De Bellis, N. (2009). *Bibliometrics and Citation Analysis, From the Science Citation Index to Cybermetrics*. The Scarecrow Press, Inc.

De Jong, J. P. J., Kalvet, T., & Vanhaverbeke, W. (2010). Exploring a theoretic framework to structure the public policy implications of open innovation. *Technology Analysis and Strategic Management*, *22*(8), 887-896.

Dries, L., Pascucci, S., Török, A., & Tóth, J. (2013). Open Innovation: A Case-study of the Hungarian Wine Sector. *EuroChoices, The Agricultural Economics Society and the European Association of Agricultural Economists*, *12*(1), 53–59.

Frey, K., Lüthje, C., & Haag, S. (2011). Whom Should Firms Attract to Open Innovation Platforms? The Role of Knowledge Diversity and Motivation. *Long Range Planning*, *44*(5–6), 397-420.

Guinan, E., Boudreau, K. J., & Lakhani, K. R. (2013). Experiments in Open Innovation at Harvard Medical School. *MIT Sloan Management Review*, *54*(3), 45-52.

Helfat, C., & Quinn, J. (2006). Open Innovation: the new imperative for creating and profiting from technology. *Academy of Management Perspectives, 20*(2), 86-88.

Henkel, J., Schöberl, S., & Alexy, O. (2014). The emergence of openness: How and why firms adopt selective revealing in open innovation. *Research Policy, 43*(5), 879-890.

Hirsch, J. E. (2005). An index to quantify an individual's scientific research output.

Proceedings of the National Academy of Science of the United States of America, *102*(46), 16569–16572.

Huizingh, E. (2011). Open innovation: state of the art and future perspectives. *Technovation*, *31*(1), 2-9.

Janeiro, P. M., Proença, I., & Gonçalves, V. (2013). Open innovation: Factors explaining universities as service firms innovation sources. *Journal of Business Research, 66*(10), 2017-2023.

Jarvenpaa, S. L., & Wernick, A. (2011). Paradoxical tensions in open innovation networks. *European Journal of Innovation Management*, *14*(4), 521-548.

Lundvall, B.-A. (1988). Innovation as an interactive process: from user-producer interaction to the national system of innovation. In G. Dosi, C. Freeman, R. Nelson, G. Silverberg, & L. Soete (Eds.), *Technical Change and Economic Theory* (pp.349-369). London: Pinter.

Malecki, E. (2011). Connecting local entrepreneurial ecosystems to global innovation networks: Open innovation, double networks and knowledge integration. *International Journal of Entrepreneurship and Innovation Management*, *14*(1), 36-59.

Mention, A.-L. (2011). Co-operation and co-opetition as open innovation practices in the service sector: Which influence on innovation novelty? *Technovation*, *31*(1), 44-53.

Mention, A.-L., & Asikainen, A. L. (2012). Innovation & Productivity: Investigating Effects of Openness in Services. *International Journal of Innovation Management, 16*(3), DOI: 10.1142/S136391961240004X.

Mina, A., Bascavusoglu-Moreau, E., & Hughes, A. (2014). Open service innovation and the firm's search for external knowledge. *Research Policy, 43*(5), 853-866.

Nelson, R., & Rosenberg, N. (1993). Technical innovation and national systems. In R.R. Nelson, (Ed.), *National Innovation Systems: A comparative analysis* (pp.1-18). New York: Oxford University Press.

Nelson, R., & Winter, S. (1982). *An Evolutionary Theory of Economic Change*. Cambridge, MA: Harvard University Press.

Padilla-Meléndez, A., Del Aguila-Obra, A. R., & Lockett, N. (2012). Shifting sands: Regional perspectives on the role of social capital in supporting open innovation through knowledge transfer and exchange with small and medium-sized enterprises. *International Small Business Journal*, *31*(3), 296-318.

Remneland-Wikhamn, B., & Wikhamn, W. (2013). Structuring of the Open Innovation Field. *Journal of technology management & innovation*, *8*(3), 173-185.

Ritzberger, K. (2008). A Ranking of Journals in Economics and Related Fields. *German Economic Review, 9*(4), 402-430.

Rodríguez, J. L. & Lorenzo, A. G. (2011). Open innovation: Organizational challenges of a new paradigm of innovation management. *European Research Studies Journal*, *14*(1), 77-84.

Salmi P., & Torkkeli, M. (2009). Success factors of interorganisational knowledge transfer: a case of a collaborative public–private R&D project. *International Journal of Business Innovation and Research*, *3*(2), 109-125.

Salter, A., Ter Wal, A. L. J., Criscuolo, P., & Alexy, O. (2014). Open for Ideation: Individual-Level Openness and Idea Generation in R&D. *Journal of Product Innovation Management* doi: 10.1111/jpim.12214

Salvador, E., Montagna, F., & Marcolin, F. (2013). Clustering recent trends in the

open innovation literature for SME strategy improvements. *International Journal of Technology, Policy and Management, 13*(4), 354-376.

Savitskaya, I., Salmi P., & Torkkeli, M. (2014). Outbound open innovation in China and Russia: innovation system approach. *International Journal of Business Innovation and Research*, *8*(2), 190-209.

Savitskaya, I., & Torkkeli, M. (2011). A framework for comparing regional open innovation systems in Russia. *International Journal of Business Innovation and Research*, *5*(3), 332-346.

Schaffers, H., Komninos, N., Pallot, M., Trousse, B., Nilsson, M., & Oliveira, A. (2011). Smart Cities and the Future Internet: Towards Cooperation Frameworks for Open Innovation. *The Future Internet, Lecture Notes in Computer Science, Book Part, 8,* 6656, 431-446. Springer Berlin Heidelberg.

Silva, J. M. (2008). *O Estado-da-arte da Literatura em Economia e Gestão da Inovação e Tecnologia. Um Estudo Bibliométrico*, Faculdade de Engenharia, Universidade do Porto, Tese de Mestrado em Inovação e Empreendedorismo Tecnológico, Retrieved from Universidade do Porto Website http://repositorio-aberto.up.pt/bitstream/10216/12115/2/Texto%20integral.pdf

Silva, S. T., & Teixeira, A. A. C. (2009). On the divergence of evolutionary research paths in the past fifty years: a comprehensive bibliometric account. *Journal of Evolutionary Economics*, *19*(5), 605-642.

Simard, C., & West, J. (2006). Knowledge networks and the geographic locus of innovation. In H. Chesbrough, W. Vanhaverbeke, & J. West (Eds.), *Open Innovation: Researching a New Paradigm* (pp.220-240). Oxford: Oxford University Press.

Teece, D. J. (2007). Explicating Dynamic Capabilities: The Nature and Microfoundations of (Sustainable) Enterprise Performance. *Strategic Management Journal, 28*(13), 1319-1350.

Teixeira, A. (2014). Evolution, roots and influence of the literature on National Systems of Innovation: a bibliometric account. *Cambridge Journal of Economics*, *38*(1), 181-214.

Trott, P., & Hartmann, D. (2009). Why "open innovation" is old wine in new bottles. *International Journal of Innovation Management*, *13*(4), 715-736.

Wang, Y., Vanhaverbeke, W., & Roijakkers, N. (2012). Exploring the impact of open innovation on national systems of innovation-a theoretic analysis. *Technological Forecasting and Social Change*, *79*(3), 419-28.

West, J., Salter, A., Vanhaverbeke, W., & Chesbrough, H. (2014). Open innovation: The next decade. *Research Policy, 43*(5), 805-811.

West, J., & Bogers, M. (2013). Leveraging External Sources of Innovation: A Review of Research on Open Innovation. *Journal of Product Innovation Management*, Bob Santos_final_formatted_05.05.2015.rtf *31*(4), 814-831.

Zhao, J. (2012). The role of CAD application in open innovation model: innovation technology in the Chinese shipbuilding industry. *International Journal of Business Innovation and Research*, *6*(6), 698-719.

Zou, G., & Yilmaz, L. (2011). Dynamics of knowledge creation in global participatory science communities: open innovation communities from a network perspective. *Computational and Mathematical Organization Theory*, **17**(1), 35-58.

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- Leydesdorff software (Scopus.exe and Scop2WOS.exe programme): *http://www.leydesdorff.net/scopus/index.htm*
- CiteSpace software: *http://cluster.ischool.drexel.edu/~cchen/citespace/download.html*