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Open Innovation research: trends and influences – a bibliometric analysis

António Bob Santos

ISCTE-IUL (University Institute of Lisbon)
abmsantos@netcabo.pt, m18020@iscte-iul.pt

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.

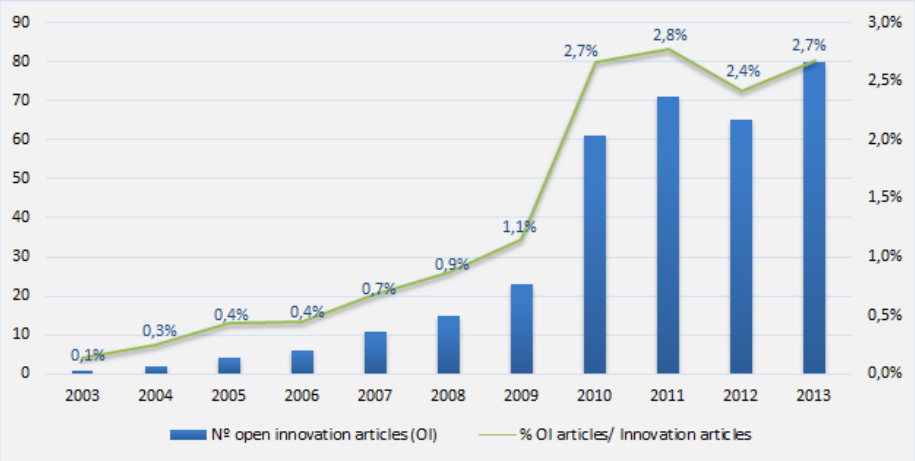


Fig. 1. Evolution of published articles on open innovation and percentage of open innovation related articles in the total of innovation articles (2003-2013)-Scopus Database.[10]

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.

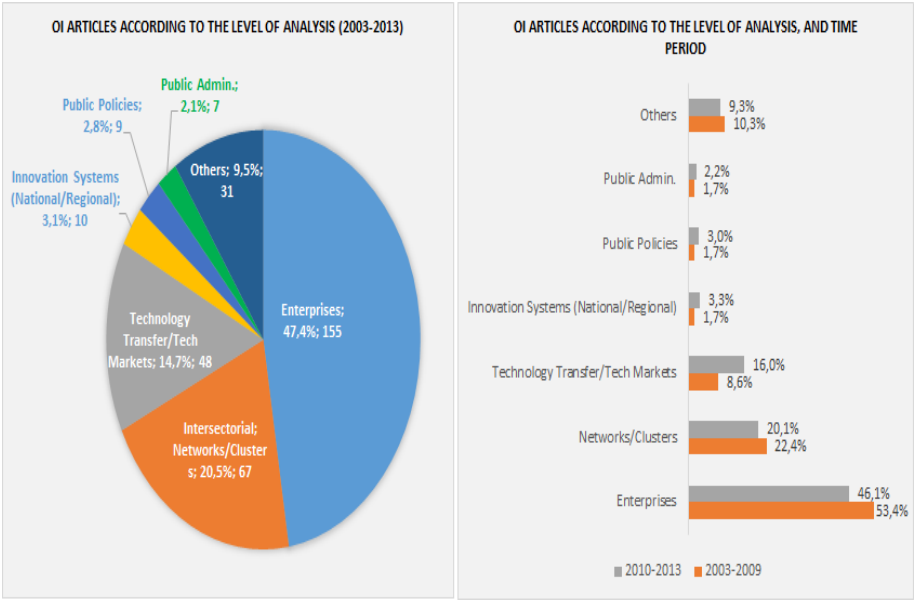


Fig. 2. Open innovation articles, according to the topic of analysis and time period.[11]

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).

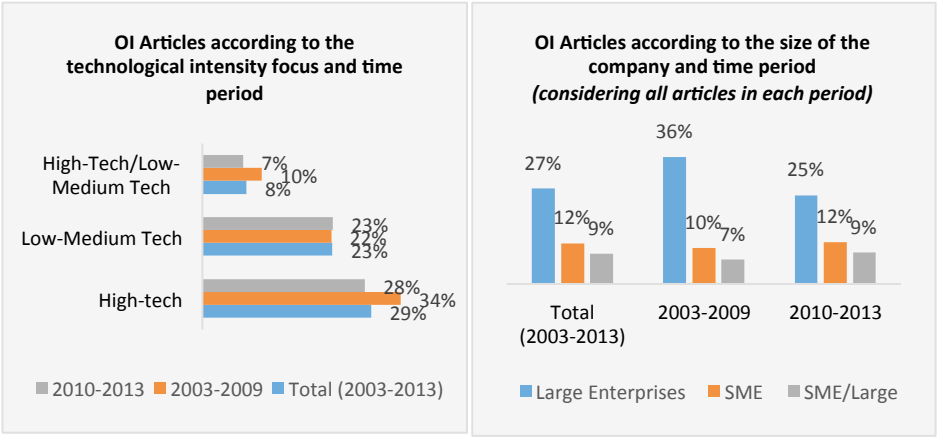


Fig. 3. Open innovation articles, according to the technological intensity focus and size, by time period.[12]

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).

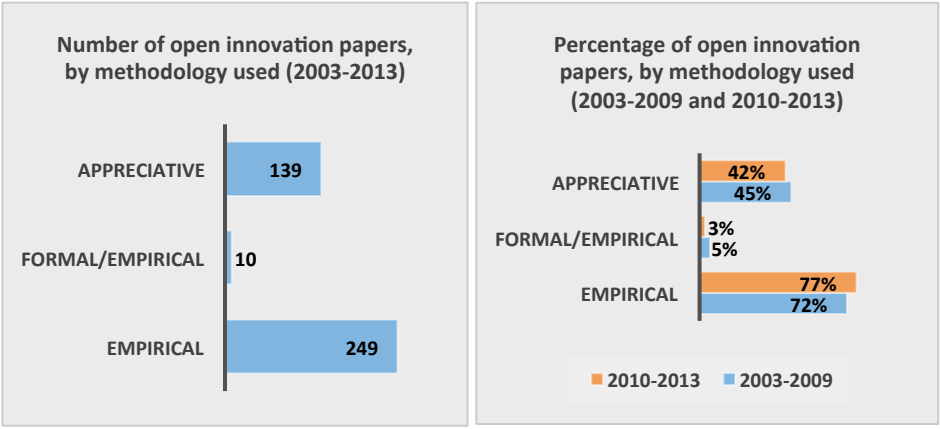


Fig. 4. Open Innovation related articles, by method of analysis (total and in percentage).[13]

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.

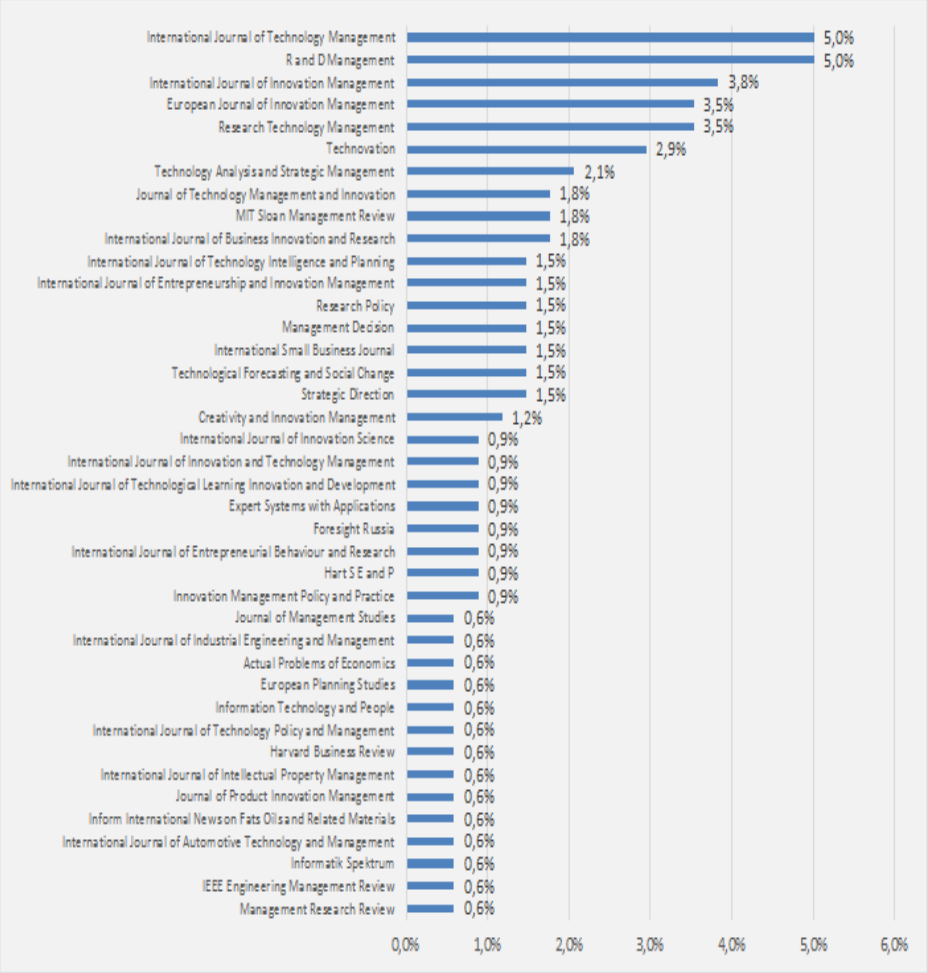


Fig. 5. Open Innovation Articles, by Journal (top 40), in percentage (2003-2013).[15]

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.

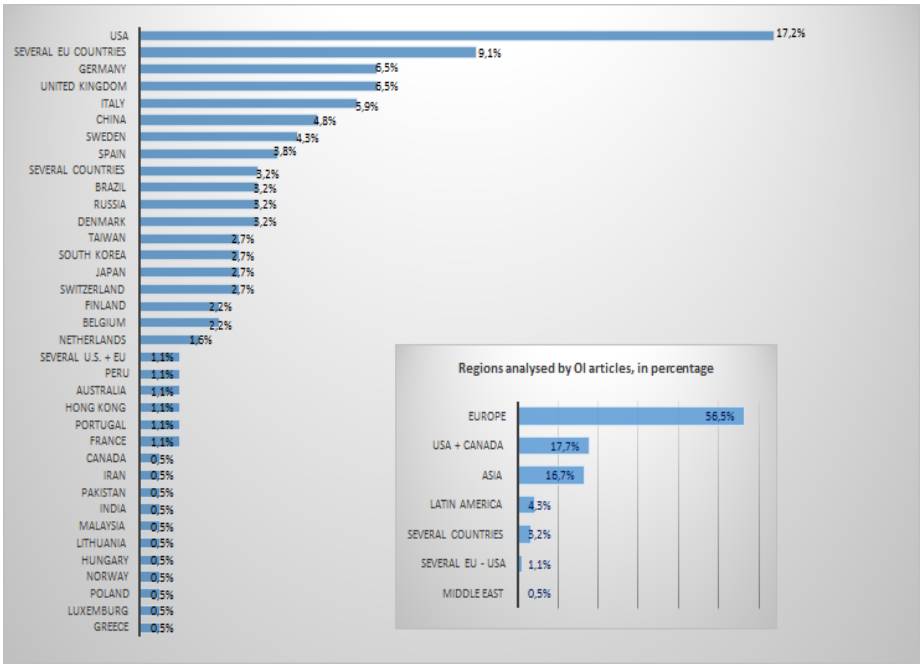


Fig. 6. Countries and Regions analyzed by open innovation related articles (2003-2013), in percentage.[16]

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).

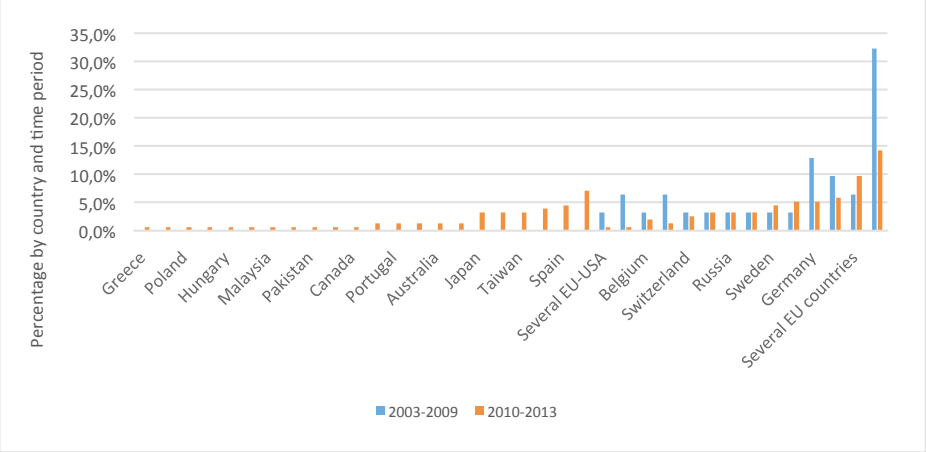


Fig. 7. Countries analyzed by open innovation articles, by country and time period (2003-2009 and 2010-2013), in percentage.[17]

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).

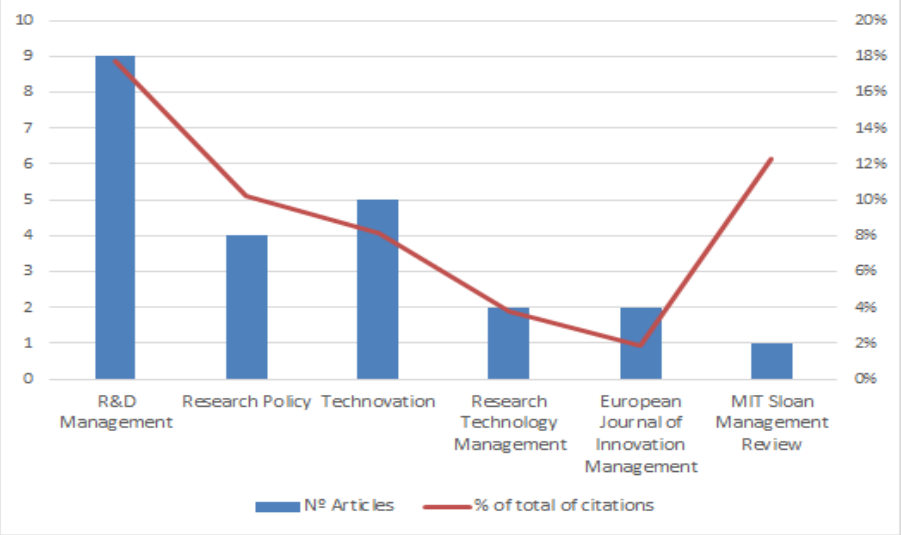


Fig. 8. Number of articles and citations by Journal, based on the 32 seminal articles.[26]

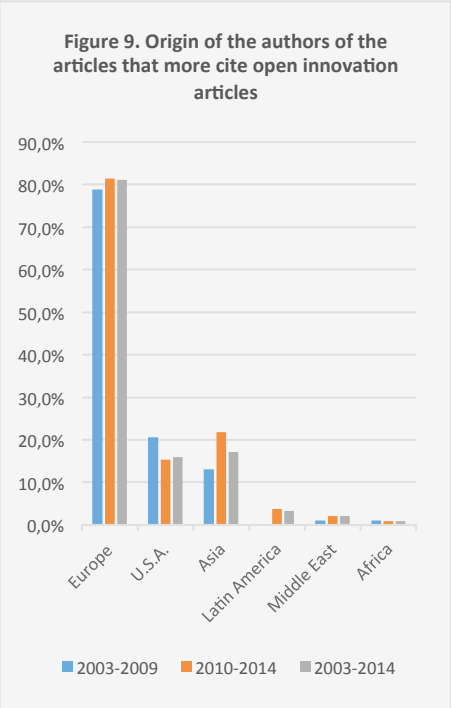
After reviewing the most cited articles and authors, to analyze the influence of open innovation literature, it is also necessary to characterize those who cited open innovation articles. The 339 open innovation related articles were cited by 2807 articles (which produced 4805 citations, as seen above), 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".



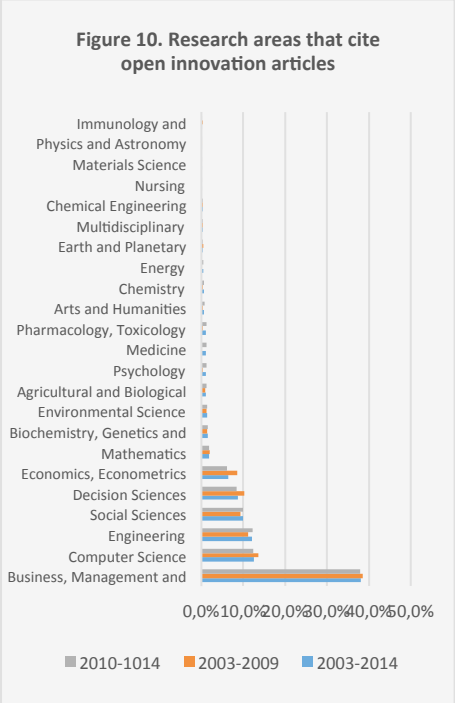


Fig. 9. and Fig. 10. Characterization of the articles that cite open innovation articles.[28]

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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Software programmes:

- 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*