Received 18 October 2019
Revised 10 February 2020
7 May 2020
Accepted 29 May 2020

The past, present and future of open innovation

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Abstract

Purpose – Through a comprehensive review of the literature on open innovation (OI), this study aimed to achieve two objectives: (1) to identify the main thematic areas discussed in the past and track their evolution over time; and (2) to provide recommendations for future research avenues.

Design/methodology/approach – To achieve the first objective, a method based on text mining was implemented, with the analysis focusing on 1,772 journal articles published between 2003 and 2018. For the second objective, a review based on recent and relevant papers was conducted for each thematic area.

Findings – The paper identified nine thematic areas explored in existing research: (1) context-dependency of OI, (2) collaborative frameworks, (3) organizational dimensions of OI, (4) performance and OI, (5) external search for OI, (6) OI in small and medium-sized enterprises, (7) OI in the pharmaceutical industry, (8) OI and intellectual property rights, and (9) technology. The analysis of the most recent papers belonging to the more investigated areas offers suitable suggestions for future research avenues.

Originality/value – To the best of the authors' knowledge, no review has yet been undertaken to reorganize the OI literature.

Keywords Open innovation, Review, Text mining, Future research avenues

Paper type Literature review

1. Introduction

Since the 2003 publication of Chesbrough's seminal work, *Open Innovation: The New Imperative for Creating and Profiting from Technology,* the concept of open innovation (OI) has garnered increasing attention from academics and practitioners alike. As a demonstration of its importance, Chesbrough's study has gained more than 19,000 citations in 16 years, according to Google Scholar (Google Scholar, July 2019), with this number growing on a daily basis. OI was developed based on the observation of large innovative companies and their deviations from traditional ways of innovating (Chesbrough, 2003, 2006). The original definition of OI stressed that "*valuable ideas can come from inside or outside the company and can go to market from inside or outside the 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*" (Chesbrough, 2003, p. 43). The antecedents of OI, however, have to be found prior to the publication of Chesbrough's book. Since the 1970s, scholars such as Freeman (1974, 1979), Rothwell *et al.* (1974) and Allen (1977) have understood that sources of innovative ideas often come from outside the firm. Later, innovation scholars stressed the "two faces of research and development" (R&D); in other words, that the internal

European Journal of Innovation Management
Vol. 24 No. 4, 2021
pp. 1130-1161
Emerald Publishing Limited
1460-1060
DOI 10.1108/EJIM-10-2019-0296

R&D investments of a company not only allow for the generation of new knowledge in general but an increased ability to assimilate external knowledge (Cohen and Levinthal, 1989, 1990). Based on this notion, studies then investigated the ways in which firms during the late 1990s/early 2000s leveraged the internet to develop new value chains and revenue models (e.g. Timmers, 1998; Magretta, 2002). Thus, OI can be seen as a call to a return to the late twentieth and early twenty-first century model of innovation (Mowery, 2009).

Since the term OI was initially coined, both innovation scholars and Chesbrough have modified its original definition, with the latter stressing the intentionality of knowledge inflows and outflows: "*Open innovation is the use of purposive inflows and outflows of knowledge to accelerate internal innovation and expand the markets for external use of innovation, respectively*" (Chesbrough, 2006, p. 1). More recently, in 2014, Chesbrough proposed the following definition of OI based on the concept of 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).

Regardless of the definition, OI is based on the idea that, within the modern competitive context in which firms have to operate, the linear model of innovation (von Hippel, 1988) is no longer able to adequately explain innovation activities. Today's organizations have to collaborate with external stakeholders through the iterative exchange of knowledge, technology, and resources across their boundaries (Galati, 2015; Galati and Bigliardi, 2017). In other words, to stay abreast of competition, a single organization cannot innovate in isolation; rather, it has to engage with different types of partners, ranging from suppliers to customers, as well as universities, research centers and competitors (Bigliardi and Galati, 2013), in order to acquire ideas and resources from the external environment (Laursen and Salter, 2006). Thus, according to this paradigm, the boundaries of an organization have to become permeable rather than closed, since innovation developed through intentional inflows and outflows of knowledge exists within a system of relationships, including external partners (Bogers and West, 2012; Enkel *et al.*, 2009; Gassmann and Enkel, 2004).

OI has become one of the most researched topics in innovation management, attracting attention from both academics and managers. Interest from academics is not only highlighted by the steady increase in conferences, special issues and books on the topic, but by the hundreds of published articles: a search on Google Scholar for the keyword "open innovation" results in more than 145,000 documents, and the same search on Scopus in the article title, abstract and keywords results in around 5,000 documents (data retrieved on June 2019). Moreover, and perhaps surprisingly, different disciplines have also shown interest in OI: these range from "business, management and accounting," to "engineering" and "decision science," as well as "medicine," "psychology," "chemistry," and even "physics and astronomy." In terms of managers' interest, one need only consider the growing number of papers describing the adoption of OI by companies, within both high-tech (e.g. Bianchi *et al.*, 2011; Bigliardi *et al.*, 2012; Galati and Bigliardi, 2016; Henkel, 2006; Remneland-Wikhamn *et al.*, 2011) and low-tech (e.g. Bigliardi and Galati, 2013) industries, and within both large companies (Dodgson *et al.*, 2006; Kirschbaum, 2005) and small and medium-sized enterprises (SMEs) (e.g. Galati and Bigliardi, 2016; Spithoven *et al.*, 2013; van de Vrande *et al.*, 2009). In addition, governments have recently started aligning their policy frameworks with OI (West *et al.*, 2014).

As a natural and negative consequence of the rapid growth of the literature, OI is evolving into a diverse and fragmented body of knowledge within the field of innovation literature (Huizingh, 2011; van de Vrande *et al.*, 2010). As such, scholars are beginning to recognize the need for a full understanding of the topic to bring about further clarity (Dahlander and Gann, 2010; Lichtenthaler, 2011), reviewing and synthesizing the literature into different aspects of OI research. In Table 1, some of the more recent reviews available in the literature since 2010 are provided as an example.

Author(s) (year)	Topics investigated
Dahlander and Gann (2010)	Definition of the openness construct in OI research
Huizingh (2011)	Context, content, and process of OI
Brunswicker *et al.* (2012)	Exploration in the open innovation front-end and the role of technologies
Remneland-Wikhamn and Wikhamn (2013)	Classification of OI literature into the firm perspective and ecosystem perspective
West and Bogers (2014)	Inbound (and coupled) processes of OI
Greco *et al.* (2015)	OI and innovation performance
Rossi (2015)	Role of venture capital in the OI system
Fraceto *et al.* (2016)	Development of OI in the agribusiness industry
Poutanen *et al.* (2016)	OI and complexity
Natalicchio *et al.* (2017a)	Knowledge assets for OI
Spender *et al.* (2017)	Startups and OI
Schuhmacher *et al.* (2018)	External sources for OI

Table 1.
Some examples of recent reviews on OI

Previous reviews have adopted different methods to analyze the literature. For example, while Huizingh (2011) adopted a qualitative approach, Remneland-Wikhamn and Wikhamn (2013) adopted an empirical one. Similarly, Fraceto *et al.* (2016) combined a bibliometric technique with content analysis, while Natalicchio *et al.* (2017a) systematically reviewed the extant literature.

However, in focusing on specific issues, existing reviews consider only a part of the OI literature. As such, the OI paradigm has evolved over time, encompassing different perspectives. Notwithstanding the huge amount of literature on OI, there is a lack of systematic reorganization of previous research, with no past review tracking the evolution of the OI literature in a comprehensive manner. This study posits that tracking the evolution of OI over the years could be crucial to identifying: the most debated areas; the maturity reached by each thematic area; whether some thematic areas were abandoned, and the potential opportunities to make further steps in the research. The objective of this paper is twofold: (1) to identify the main thematic areas discussed in the past and track their evolution over time, and (2) to identify avenues for future research on this topic. For achieving the first objective, a method based on text mining was implemented, with the analysis focusing on 1,772 journal articles published between 2003 and 2018. For achieving the second objective, a review based on recent and relevant papers was made for each thematic area. In so doing, it is hoped that this study could help to bring further clarity to the broad and scattered field of innovation literature.

The paper is structured as follows: Section 2 presents the aim of the study and describes in detail the text mining methodology adopted. Section 3 outlines the results obtained in terms of patterns interpretation, evaluation, validation, and identification of future research avenues. Conclusions, policy implications and limitations of the study conclude the paper.

2. Objective and methodology

In order to achieve the research aim, this study adopts a three-step methodology, as depicted in Figure 1.

2.1 Preprocessing

Following the validation of clusters, the process began by following the methodology proposed by Delen and Crossland (2008) in order to achieve the first objective of the study (i.e. to identify the main thematic areas discussed in the past and track their evolution over time).

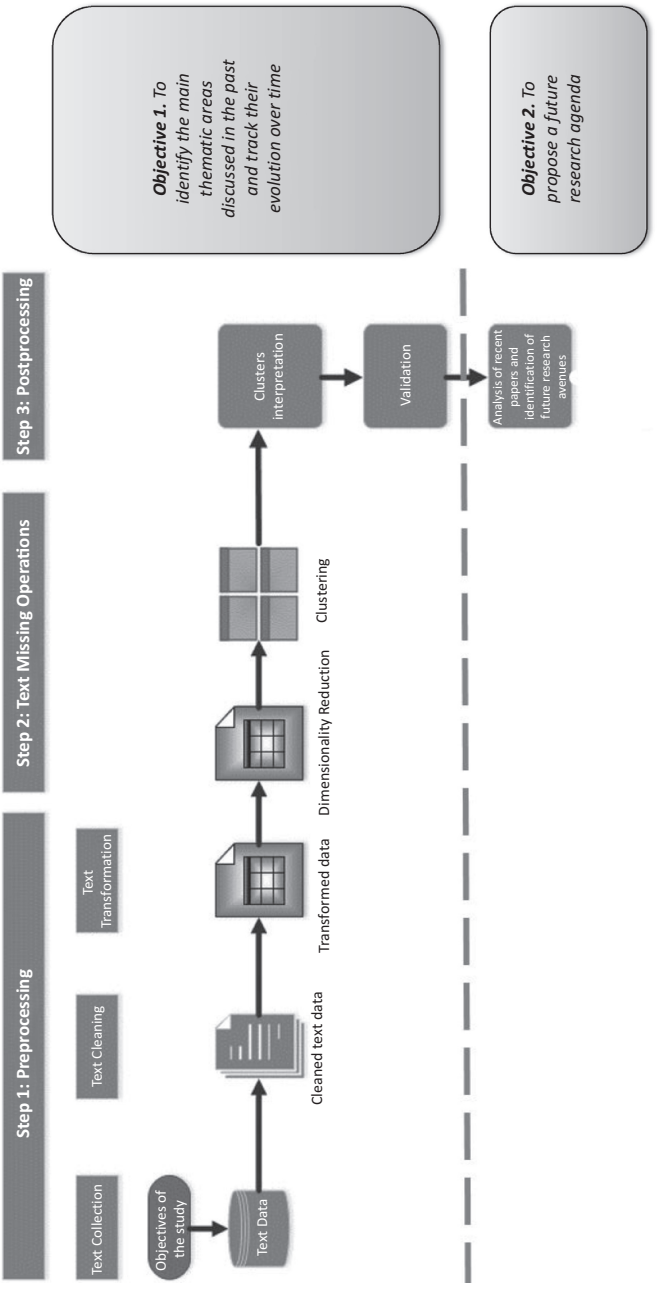


Figure 1.
The methodological process (in the upper-right side of the figure (objective 1), the methodology adopted refers to the one proposed by Delen and Crossland, 2008)

Since the text mining method adopted by these authors does not rely on predetermined notions regarding topics from texts, subjective bias is removed from the analysis. Such a method was adopted since it is able to extract the contextual-usage meaning of words and discover hidden, latent topics that facilitate modeling synonyms, as well as to detect multiple words that have a similar meaning

For doing this, the Scopus database was used as the source of peer-reviewed articles. All of the papers dealing with the topic were included, providing a robust empirical analysis of the existing research and key OI concepts. Numerous scholars consider the Scopus database a reliable source of information (e.g. Fahimnia *et al.*, 2015; Malviya and Kant, 2015) due to the fact it integrates all major publishers such as Emerald, Taylor and Francis, Springer, and Willey (Galati and Bigliardi, 2019a; Tseng *et al.*, 2019).

For the substep "text collection," we included all Scopus scientific journal publications containing the caption "open innovation" in the abstract, title or keywords. The decision to include only journal manuscripts and not others (such as conference proceedings, books, and so on) was due to the willingness to consider high-quality publications. More specifically, we chose to use only the abstract of an article as the source of the text mining analysis.

A total of 1,772 journal articles published between 2003 and March 2018 were considered. For each publication, we extracted the title, year of publication, journal, authors, and abstract. We then loaded these into a Microsoft Excel file.

Text cleaning was implemented based on the notion that not all terms are important in the characterization of documents: some of them (terms used in almost all of the documents in the corpus, articles, auxiliary verbs, etc.) have no differentiating power and, consequently, should be omitted in the indexing process.

For the substep "text transformation," the list of documents (abstracts) was converted into a term-by-document matrix. The columns were populated with the list of all the unique terms identified in the abstracts, and the rows contained all of the abstracts; the occurrence count (frequency) of each term for each abstract (cells) was included. However, the large number of documents (and thus abstracts) considered in our study resulted in a term-by-document matrix with a very large number of terms (columns). This implies that processing such a large matrix is time-consuming, and more importantly, can lead to inaccurate patterns.

2.2 Text mining operations

Once the input abstracts had been indexed and the term-by-document matrix computed, it was possible to calculate the inverse document frequencies to create the "term frequency-inverse document frequency (TF-IDF) matrix." This step was necessary to improve the accuracy of the analysis.

Then, in order to reduce the dimensionality of the TF-IDF matrix to a manageable size, we implemented singular value decomposition (SVD). This technique, like principal components analysis, reduces the overall dimensionality of the TF-IDF matrix to a lower dimensional space, in which each consecutive dimension represents the largest degree of variability possible.

After the implementation of the SVD on the TF-IDF matrix, an expectation-maximization algorithm was used to create clusters. Several experimental runs were conducted to identify the "optimal" number of clusters, which was determined following three main criteria: (1) clusters' sizes, (2) the plausibility of the clusters identified, and (3) the statistical properties in terms of the relationship between within-cluster and between-cluster variance (Calinski and Harabasz, 1974; Bigliardi and Galati, 2016).

Several cluster analyses were performed (2 clusters, then 3 clusters, 4 clusters, and so on) until a solution characterized by 15 clusters was reached. Then, each clustering solution was evaluated according to the above-mentioned criteria. As for criteria number 2, for each clustering solution obtained, an iterative process of word selection for each cluster was

performed, aimed at identifying the most descriptive terms. This technique was based on the relative frequency of each term in each cluster, measured considering the mean of the number of times each term appears in the cluster and the number of documents in the cluster, including that term. The process started by deleting the terms that frequently occurred in more than one cluster. Then, the process calculated a descending rank of terms for each cluster based on the relative frequency measure. To be considered as a descriptive term of a given cluster, a term needed to be in a high position in the rank and to appear only in one cluster, or to be in a high position only in one cluster and in a low position (third or fourth quartile) in the others. After obtaining the main descriptive terms for each cluster and in each clustering solution, their convergence toward a given topic or a meaningless association was evaluated, allowing us to judge whether a given clustering solution was plausible or not. This was done for each cluster analysis solution. At the end of this process, the best solution was identified.

2.3 Postprocessing

The last step (postprocessing) consists of the following substeps. Clusters' interpretation was performed to interpret the meaning of each cluster and to analyze the evolution of each thematic area over time, highlighting and thus allowing us to understand whether a topic was relevant or outdated. In more detail, based on the main descriptive terms that emerged, the contents of the clusters were presented, thus revealing the main issues discussed in the papers included in each cluster.

Then, to further validate the results obtained in the previous steps and to reach the second objective of the present study (i.e. to propose a future research agenda), a review of recent and relevant studies was performed. It soon became apparent that effective validation of the analysis could be achieved only by reading each of the selected studies and evaluating whether each paper was included in the correct cluster. However, the implementation of such a manual and time-consuming process would render useless the text mining methodology itself. As such, based on the work of Kobayashi *et al.* (2018) and Galati and Bigliardi (2019a), we combined qualitative experts' evaluations of the plausibility of the resulting clusters and extracted (for clusters referring to relevant issues) ten of the most recent papers published in specific journals. It is worth noting how this method should not be deemed a way with which to achieve strong validation, but a first empirical attempt to judge the consistency of the clustering results.

In the third substep of postprocessing, papers considered in the previous phase were analyzed to derive future research avenues. The decision to develop future research avenues from the most recent papers included in the relevant thematic areas were derived from the need to identify recent research conducted on the topic (Galati and Bigliardi, 2019a). Therefore, other approaches (e.g. selecting the most cited papers) could have favored older manuscripts, meaning any suggestions for future research could have already been addressed in subsequent studies.

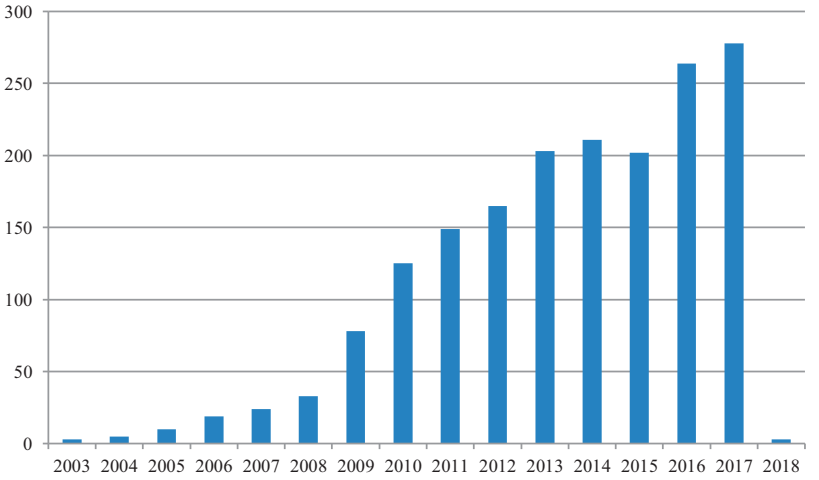
In the following section, the results of the adopted methodology are presented in detail.

3. Results

3.1 Patterns interpretation and evaluation

As a solid starting point, the analysis allows us to portray the broad trends of research on OI. Specifically, Figure 2 shows the number of publications per year, from 2003 (when the first study by Chesbrough was published) to 2018 [1]: as shown, the number of investigated papers dealing with the topic has grown exponentially. Table 2 lists the top ten journals by the number of papers on OI published.

In order to identify the natural groupings of the articles (by putting them into separate clusters) and then list the most descriptive terms that characterize those clusters, we



Source(s): Own database constructed from Scopus data

Figure 2.
Number of papers published on OI over time

Number of articles	Journal name
56	International journal of innovation management
50	Research technology management
44	Research policy
43	International journal of technology management
40	R&D management
40	Technological forecasting and social change
37	Technovation
37	Technology analysis and strategic management
35	European journal of innovation management
28	Journal of product innovation management

Table 2.
Most common outlet journals

conducted a cluster analysis, representing the most commonly used analysis technique in text mining studies. We conducted several experimental runs to identify the "optimal" number of clusters, which was identified as 9, each of them representing a thematic area. To identify the descriptive terms for each cluster, we implemented an iterative process. We deleted the terms that frequently occur in more than one cluster (e.g. "Open," "Innovation," "Collaborat," etc., where terms like "Collaborat" is the root of a group of words such as "Collaboration" or "Collaborative.". Then, we calculated a descending rank of terms for each cluster based on the relative frequency measure. The descriptive terms associated with each cluster gave us an idea about the possible interpretation of the corresponding topics. The results of the clustering experiment are illustrated in Table 3: in the first two columns represent the cluster number and label, respectively, while the third column lists the most descriptive terms for each cluster.

Figure 3 shows the size of each cluster (in terms of the number of papers). The most numerous clusters are, in order, clusters 5, 1, 9, and 2.

Figure 4 presents the evolution over time of the corresponding thematic areas for each cluster. The figure reveals how some investigated thematic areas have arisen since the emergence of the OI paradigm (i.e. the thematic areas of clusters 4 and 5), other thematic areas

started after a few years of delay (i.e. clusters 1, 2, 8, and 9), while for the remaining clusters 3, 6, and 7, the first papers appeared after 2009. In addition, the same figure also shows how the number of papers has grown within each cluster. Almost all the thematic areas have grown, as shown by the growing number of publications.

In the following section, we briefly describe the contents of each thematic cluster identified through the analysis.

A number of papers focused on the "context dependency of OI" (cluster 1), whereby the most evident external context characteristic is that of industry. The adoption of OI was at first investigated within pioneering high-tech industries such as software, electronics, telecommunication (e.g. Chesbrough, 2003; Bigliardi *et al.*, 2012), and only after within other low-tech industries (e.g. Bigliardi and Galati, 2013). Numerous studies refer to specific industries: automotive (e.g. Ili *et al.*, 2010), biotechnology (e.g. Fetterhoff and Voelkel, 2006), consumer electronics (e.g. Chesbrough, 2003), food (e.g. Sarkar and Costa, 2008), and so on. Other studies have investigated differences in OI adoption between industries (e.g. Keupp and Gassmann, 2009; Lichtenthaler, 2008). However, a number of studies claim that the adoption of OI is more related to business strategy than to industry trends (e.g. Keupp and Gassmann, 2009), thus suggesting that internal factors are more important than external ones in explaining the adoption of OI. Some scholars went beyond industry and suggested that the adoption of OI is influenced by other factors such as globalization, competitive intensity, technological aggressiveness, technology intensity and knowledge leveraging (e.g.

Cluster number	Label	Descriptive terms
1	Context-dependency of OI	Industry, market, context, environment
2	Collaborative frameworks	Model, academic, framework, intermediary
3	Organizational dimension of OI	HR, implement, improve, social capital
4	Performance and OI	Success, business, result, performance
5	External search for OI	Explore, relation, network, source
6	OI in SMEs	SME, small, medium, enterprise
7	OI in the pharmaceutical industry	Living Lab, drug, discovery, pharma
8	OI and Intellectual Property Rights	Intellectual property, patent, exploit, protect
9	Technology	Tech, support, crowd, system

Table 3.
Clustering results

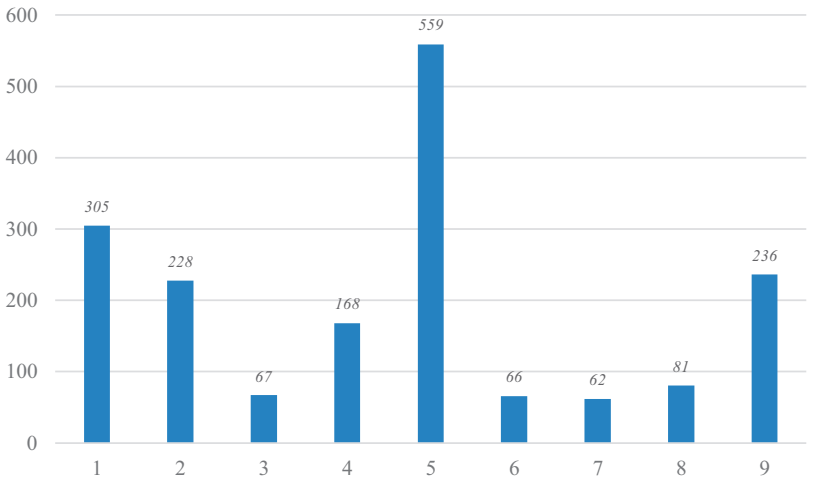


Figure 3.
Number of papers in each cluster

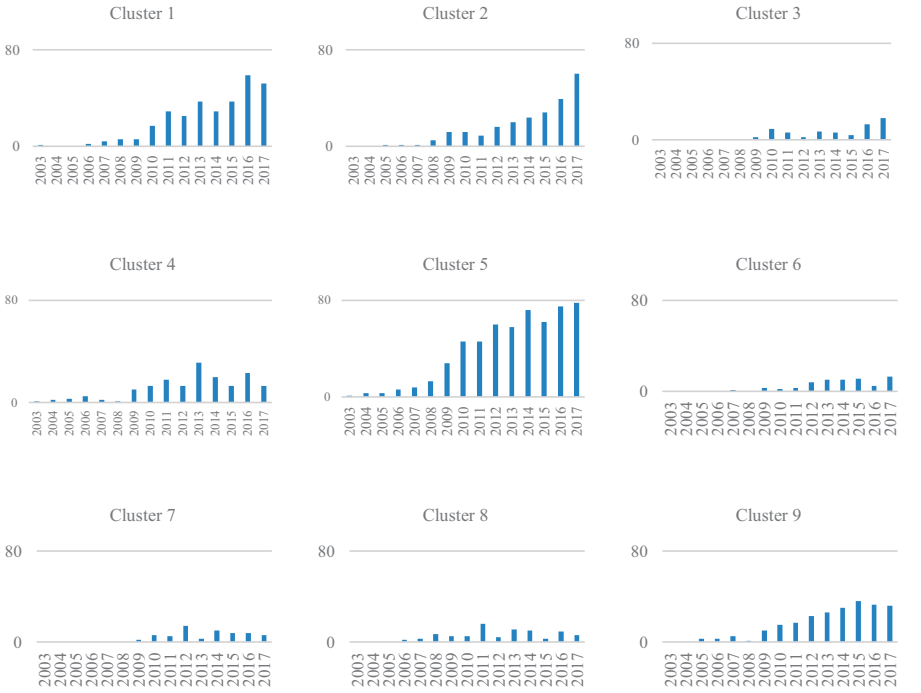


Figure 4.
The temporal evolution of thematic areas

Lichtenthaler, 2008; Poot *et al.*, 2009; Reed *et al.*, 2012), technology fusion, and new business models. Specifically, this paradigm is more appropriate in contexts characterized by the above-mentioned factors. For instance, in contexts with a high degree of globalization, companies are more likely to adopt OI. Other relevant characteristics include the importance of patenting and other forms of intellectual property protection, market and technology turbulence, and market competitive intensity (e.g. Arbussã and Llach, 2017).

A second highly investigated topic within the literature is the "collaborative frameworks" that companies may adopt when opening up their innovation process (cluster 2). Over time, this topic has garnered increasing attention, indicating that OI research has moved from the firm to network level (e.g. Rampersad *et al.*, 2010) by focusing on how collaboration can be managed (e.g. Crespin-Mazet *et al.*, 2013; Huggins, 2010; Michelfelder and Kratzer, 2013). Collaboration has been studied in relation to two main aspects: the actors of collaboration, and the stages of collaboration. As for the latter, different models have been proposed (e.g. Lee *et al.*, 2010; Wallin and Von Krogh, 2010), while, for the former, numerous papers have investigated the outside players with whom a company can collaborate when innovating (e.g. Bigliardi and Galati, 2018). These players range from suppliers, customers, and competitors to universities, research institutions, and organizations (e.g. Sieg *et al.*, 2010; Spithoven *et al.*, 2010). Specifically, different studies have stressed that it is important to maintain a diverse partner base over time (e.g. Dahlander and Gann, 2010), with researchers paying particular attention to collaboration with value chain stakeholders (namely, suppliers, customers, and partners) (e.g. Clausen, 2013; Obal and Lancioni, 2013). Moreover, the roles of institutional networks, the public sector, and government policymaking are also emerging as topics (e.g. Freitas *et al.*, 2013; Lee *et al.*, 2012).

The third stream of research investigated the "organizational dimension of OI" (cluster 3). OI is, by nature, a business model (e.g. Badawy, 2011) and a form of organizational innovation in itself (e.g. Christensen, 2006). By exploring the antecedents leading to a company opening up its business model, some studies have proposed different organizational dimensions (e.g. interorganizational networks, organizational structures, evaluation processes and knowledge management systems) or stages (unfreezing, moving and institutionalizing) as a way to move from a closed to open innovation model (e.g. Chiaroni *et al.*, 2010). Other publications have used the enabling role of top management and the promotional role of a champion as an example of organizational change (e.g. Bianchi *et al.*, 2011; Mortara *et al.*, 2009). However, few studies have dealt with the "human side" of OI (e.g. Chatenier *et al.*, 2010). Some of these scant available studies have investigated the OI challenges faced by R&D professionals and their coping strategies (e.g. West *et al.*, 2014), the link between individuals' openness to external knowledge sources and the innovation performance (e.g. Dahlander *et al.*, 2016; Salter *et al.*, 2015), or the ways in which specific CEOs' characteristics can facilitate the adoption of OI (e.g. Ahn *et al.*, 2016).

Another highly investigated topic is that of the link between "performance and OI" (cluster 4), in particular, how OI impacts performance and the aspects of OI that make it effective (e.g. Dahlander and Piezunka, 2014). OI performance has been measured in different ways: in addition to the obvious financial benefits (such as lower costs), performances driven by OI may also be nonfinancial. For example, a shorter time to market and more sales, innovativeness, number of innovations, gaining access to new markets, and enhancing a firm's technological position (e.g. Lichtenthaler, 2007; Nagaoka and Kwon, 2006; Rigby and Zook, 2002) have been proposed as measures of OI success. Contrasting results have been provided on this matter: on the one hand, some studies have found that OI has a positive impact on innovative performance (e.g. Tomlinson, 2010); on the other hand, too much OI has been found to hurt firm performance (e.g. Laursen and Salter, 2006). In addition, research has focused on the cost of openness, referring to the management of the networks of experts involved when adopting the OI paradigm, which increases with the number of interdependencies and relationships (e.g. Kim and Park, 2010).

Receiving the most attention, "external search for OI" (cluster 5) (e.g. Christensen *et al.*, 2005; Fey and Birkinshaw, 2005) relates to different types of openness; specifically, the three knowledge processes of knowledge exploration, retention, and exploitation, which can be performed either inside or outside a firm's boundaries (e.g. Lichtenthaler and Lichtenthaler, 2009). With the term "inbound OI," scholars refer to the internal use of external knowledge; conversely, "outbound OI" refers to the external exploitation of internal knowledge. In general, empirical studies have highlighted that companies perform more inbound than outbound activities (e.g. Lichtenthaler, 2010). A number of studies have investigated the possible reasons for external exploitation of internal knowledge (e.g. Rivette and Kline, 2000; Kline, 2003), highlighting (among others) historical reasons, the possibility of using existing relationships, and the fear of diffusing relevant knowledge. Some studies (e.g. Chesbrough *et al.*, 2006) claim that companies scan the external environment and/or marketplace, and if ideas and technologies they need are available, they use (source) or acquire them. Even if scholars agree on recognizing the importance of openness in terms of external sources, it is not apparent whether all companies rely on them (e.g. Christensen *et al.*, 2005). Moreover, different studies (e.g. von Zedtwitz and Gassmann, 2002; Huang *et al.*, 2015; Tortoriello, 2015) stress that, regardless of the benefits derived from adopting external sources, companies need the expertise to search for and evaluate them.

Since size allows one to characterize the evolution of research on OI (cluster 6), it is unsurprising that "OI in SMEs" is one of the most studied company characteristics. While early works mostly investigated the adoption of OI in large multinational companies (e.g. Chesbrough, 2006; Lichtenthaler and Ernst, 2009; van de Vrande *et al.*, 2009), recent years

have seen SMEs begin to open up their innovation processes (e.g. Gassmann *et al.*, 2010; van de Vrande *et al.*, 2009). Numerous studies (e.g. Bigliardi and Galati, 2016; Henttonen and Lehtimäki, 2017; Oakey, 2013; Spithoven *et al.*, 2013; Wynarczyk *et al.*, 2013) claim that SMEs are hindered by both internal and external structural impediments, such as smallness, managerial capacity, skills, awareness of and access to external knowledge and finance, and fewer technological assets. However, in spite of the fact that adoption of OI is highly critical, SMEs adopt OI far less than multinationals do due to resource constraints and scale limitations (e.g. Brouthers and Nakos, 2004; Lee *et al.*, 2010). Interestingly, although this lack of resources can force SMEs to engage in OI practices, and thus, overcome these liabilities, by opening up their innovation processes (e.g. Barney and Clark, 2007; Gassmann and Keupp, 2007), they have fewer resources to build and maintain collaborative networks and to create and enforce intellectual property rights. This side effect has been found to affect both inbound and outbound activities (e.g. Lichtenthaler and Ernst, 2009).

Although the adoption of "OI in the pharmaceutical industry" has attracted limited research focus when compared to other areas of research, it does emerge as the main investigated industry with regard to the topic (cluster 7). Such interest is due to the high levels of R&D investments that initially characterized the industry, as well as the importance of the discovery process for innovation purposes, two aspects that are particularly appealing to innovation management scholars. More specifically, interest in this industry started almost six years after the introduction of the OI concept, when the pharmaceutical industry underwent a shift from a product-based economy to a service economy. Consequently, many companies—hoping to discover new drug candidates while remaining innovative and maintaining their market position—started to collaborate with academic partners (e.g. Kaitin, 2010; Paul *et al.*, 2010; Galati and Bigliardi, 2016). In other words, recognizing the potential, the pharmaceutical industry responded to the increasing difficulties and expenses of discovering new medicines by embracing OI to access external ideas (e.g. Hunter and Stephens, 2010; Schuhmacher *et al.*, 2013). All in all, pharmaceutical companies adopt different forms of OI, from licensing and acquisition of drug candidates to acquisition of entire companies, outsourcing, and so on (e.g. Schuhmacher *et al.*, 2013). The openness of the drug discovery process was enabled by the advent of the internet, which allowed ideas to be obtained from a wider scientific crowd (e.g. Glen *et al.*, 2017). For example, Living Labs have grown rapidly to support companies based on five basic principles, namely, value, openness, realism, influence, and sustainability. These labs represent a neutral arena where stakeholders meet to codevelop innovations in real-world contexts (e.g. Almirall *et al.*, 2012). These and similar models of OI adoption have become a standard in the pharmaceutical industry and an example for other industries (e.g. Gassman *et al.*, 2010).

Cluster 8 groups together 81 papers investigating two (seemingly) contrasting topics: "OI and intellectual property rights" (IPRs). Indeed, OI refers to an innovation system where ideas and knowledge flow across the permeable firm boundaries. In contrast, IPRs are generally used to exclude others from using a firm's ideas and inventions (e.g. West, 2006). Specifically, IPRs refer to "*unique, value-adding creations of the human intellect that results from human ingenuity, creativity, and inventiveness*" (Kalanje, 2006, p. 1). IPRs are mainly used to prevent unintended knowledge drain and to allow companies to profit from OI collaborations (e.g. Bogers *et al.*, 2012). The adoption of IPRs has been investigated both within large companies and SMEs (e.g. Andries and Faems, 2013; Brem *et al.*, 2017). In order to protect innovation and to capture value from it, companies may adopt both formal methods (i.e. patent, trademark, or copyright protection) and informal methods (i.e. lead times, first-mover advantages, and lock-ins) (e.g. Luoma *et al.*, 2010). Patents are the most commonly used IPR (e.g. Thomä and Bizer, 2013), and a number of studies claim that IPR protection through patents is positively related to performance in terms of commercial success (e.g. Andries and Faems, 2013). However, other studies have shown that high sales performances are not automatically assured by

having many patents (e.g. Agostini *et al.*, 2015). In addition to patents, industrial designs and trademarks (e.g. Kalanje, 2006), as well as copyrights (e.g. Depoorter, 2004), are considered important tools for bringing new products to the market and for preserving creative and innovative work.

Finally, the literature highlighted the central role of "technology" when adopting OI (cluster 9). Many authors have highlighted the role of technology in supporting those companies looking to find new sources for ideas and solutions (e.g. Chesbrough and Crowther, 2006; Dodgson *et al.*, 2006; Gassmann, 2006) and increasing their ability to work across different geographic and organizational boundaries (e.g. Pavitt, 2003). In other words, technology has enabled the shift toward OI (e.g. Dodgson *et al.*, 2006). Overall, the focus of research has moved away from the role of classic information and communications technology (ICT) (i.e. computers and the internet) toward new technologies, such as simulation, virtual reality, data mining, and rapid prototyping (e.g. Dodgson *et al.*, 2006). Recently, scholars have shown that companies are increasingly adopting crowd-based platforms to develop new products and outcome-based services (e.g. Frey *et al.*, 2011). Crowdsourcing is defined as an OI approach where companies broadcast innovation challenges in the form of open calls to usually unknown and undefined groups of external contributors (e.g. Howe, 2008). Specifically, it refers to outsourcing the function of idea generation to these large groups of external contributors (e.g. Howe, 2008; Kozinets *et al.*, 2008; Surowiecki, 2005). Companies use the crowd as a source of innovation; for instance, by disclosing through the online OI platforms the problems they face when adopting OI (e.g. Jeppesen and Lakhani, 2010; Sawhney *et al.*, 2003).

As highlighted in Figure 5, four out of the nine clusters identified by our analysis have grown more than the others; namely, clusters 1, 2, 5 and 9. These represent hot thematic areas. For the further steps of the methodology (validation and identification of future research directions), we decided to consider only these clusters and to select the ten most recent studies, published in the first ten journals listed in Table 2, for each of these clusters. This was done to select more reliable studies, given that they were issued in journals that often publish papers dealing with the topic. Table 4 lists such papers.

3.2 Validation

As for the initial validation of the results (i.e. the second subphase of Step 3 of the methodological process), nine experts (academic scholars conducting research on OI from different perspectives) were included, having been judged as "plausible" in terms of both the

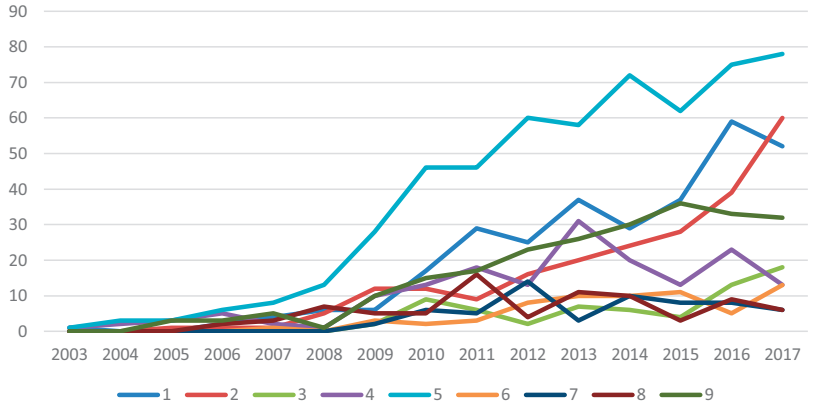


Figure 5.
The evolution of thematic areas over time

Cluster	Manuscript
1	Arbussã and Llach (2018)
1	Tsinopoulos *et al.* (2018)
1	Hecker (2017)
1	Ho *et al.* (2016)
1	Jones *et al.* (2016)
1	Kratzer *et al.* (2017)
1	Kwon and Motohashi (2017)
1	Manning, (2017)
1	Necoechea-Mondragon *et al.* (2017)
1	Radziwon *et al.* (2017)
2	Lin *et al.* (2020)
2	Greco *et al.* (2017)
2	Guerrero and Urbano (2017)
2	Kokshagina *et al.* (2017)
2	Martinez *et al.* (2017)
2	Meissner and Shmatko (2017)
2	Ollila and Yström (2017)
2	Rodriguez *et al.* (2017)
2	Saemundsson and Candi (2017)
2	Ter Wal *et al.* (2017)
5	Pateli and Lioukas (2019)*
5	Alberti and Pizzurno (2017)
5	Amponsah and Adams (2017)
5	Dong and Netten (2017)
5	Enkel *et al.* (2017)
5	Foege *et al.* (2017)
5	Hochleitner *et al.* (2017)
5	Homfeldt *et al.* (2017)
5	Weng and Huang (2017)
5	Zobel (2017)
9	Ogink and Dong (2019)*
9	Hofstetter *et al.* (2018a)
9	Hofstetter *et al.* (2018b)
9	Santoro *et al.* (2018)
9	Scheiner *et al.* (2018)
9	Valdez *et al.* (2018)
9	Natalicchio *et al.* (2017b)
9	Scuotto *et al.* (2017)
9	Stanko and Henard (2017)
9	Roberts *et al.* (2016)

Table 4.
The ten most recent studies for each hot cluster

Note(s): *When the "text collection" phase was performed, these studies were in press, while during the subsequent phases they were published and assigned to a volume of the year 2019

resulting descriptive terms and the clusters' size. All experts involved were academicians who had written at least three papers on the OI topic throughout their career.

In addition to this "preliminary" validation step, a further validation test related to the resulting clusters was conducted, representing a first empirical attempt to validate the proposed method. This was performed by reading the abstract of the latest ten papers belonging to clusters representing relevant issues (papers presented in Table 4) and by evaluating whether they correctly fit the cluster in which they were classified. This analysis led us to affirm that only five papers (representing the 12.5% of the subsample) did not perfectly fit the cluster in which they were classified. In spite of the limited evidence, according to Galati and Bigliardi (2019a), this percentage of error can be considered a good

result in terms of methodological effectiveness, given the complexity of the methodology adopted.

3.3 Identification of future research avenues

In order to reach the second research objective (to identify future research avenues for each relevant issue), papers belonging to each cluster and selected in the previous validation stage were analyzed separately. The results of this phase are detailed in the following section.

3.3.1 Context dependency of OI (cluster 1). Against the backdrop of globalization, the traditional centralized system of the R&D process has begun to progressively transform (Kwon and Motohashi, 2017; Necoechea-Mondragon *et al.*, 2017), with companies belonging to a variety of industries trying to disaggregate their centralized R&D function and allocate their innovation processes across a global network of external partners and sites (Tidd and Bessant, 2013). In this way, multinational enterprises can distribute innovation activities according to the strengths of specific countries and external research centers, thereby keeping these firms at the forefront and allowing them to launch new products or services in markets ahead of competitors (Buckley, 2014). The creation of Global Innovation Networks is an organizational answer to such OI needs (Papadopoulos *et al.*, 2013; Guimón and Salazar-Elena, 2015). These are globally organized networks of interconnected and integrated functions and operations by firms and nonfirm organizations engaged in the development or diffusion of innovations. Such a development saw the emergence of an additional organizational form known as the Project Network Organization: a result of organizational specialization that combines the coordination capacity of project-based firms with the resource richness of networks (Manning, 2017). In spite of this recognized R&D trend, there is scant literature examining the main factors involved in the participation practices of global innovation networks or investigating how to balance and combine formal and informal, intra and interorganizational, local and global mechanisms of project-based learning and capability development in international project network organizations, given their dual nature. From these studies, the following questions emerge:

(1) What critical factors help organizations participate in Global Innovation Networks?

(2) How can formal and informal, intra and interorganizational, local and global mechanisms of project-based learning and capability development in international project network organizations be balanced and combined?

The internationalization of R&D activities has encouraged OI scholars to investigate the context-dependency of OI (Radziwon *et al.*, 2017). In the literature, the most widely studied external context effect is that of industry (Keupp and Gassmann, 2009; Lichtenthaler and Ernst, 2009). Conversely, Gassmann *et al.* (2010) highlight the need for additional research on the degree of internationalization of OI, labeled as the spatial perspective (Ho *et al.*, 2016). These authors argue that the irregular distribution of knowledge across regions may have delayed the shift from closed to open innovation in less technologically developed economies. By following this argument, Arbussã and Llach (2018) investigated whether firms in more technologically developed countries are able to benefit more from being open than their counterparts in less developed ones. They argued that the crux of the problem is related to the diffusion of knowledge. In a similar vein, Hecker (2017) tried to understand the influence of national culture on the effectiveness of inbound OI strategies, building on the works of Laursen and Salter (2006) and Hofstede (2001). His results highlight the need to develop a contingency perspective on OI strategies that is not confined to the firm- and industry-level characteristics but also include country-level attributes. Thus, the following question emerges:

(1) What country-level or region-specific attributes represent central contingencies for the OI paradigm?

An additional and interesting topic, related to shifting population demographics, is the influence that the diverse global workforce will exert on the OI paradigm. As OI becomes more ubiquitous, firms will need to increasingly rely on external organizations to provide support and connect them to the needed human resources. Millennials, for example, have grown up surrounded by technology and connectedness; as such, their perception of career, work location, and job satisfaction seems to differ from the generations preceding them (Brack and Kelly, 2012). In addition, they may be characterized as having advantageous attributes for innovation roles, as collaboration is innate to them: they are part of extensive networks of contacts across industries and geographies, and mobility is often a desire, as is as working in different geographic settings. According to Jones *et al.* (2016), millennials are now the largest part of the US labor force, and as emerging economies rise, talent pools of skilled labor will progressively come from emerging markets. This evolution will push firms to reconsider their human capital and recruitment models as they seek ways to satisfy the needs and preferences of these two groups (Oxford Economics, 2012). For multinational companies, the possibility of accessing sophisticated talents in emerging and developing economies will allow firms to build out indigenous workforces that can respond to the needs of local customers and reinforce their position in the market (Morrison *et al.*, 2013). Thus, the following question emerges:

(1) What influence will a global, mobile, more diverse workforce exert on the OI paradigm?

3.3.2 Collaborative frameworks (cluster 2). The success of OI in enhancing innovation development has resulted in public authorities incentivizing firms to adopt the paradigm through public subsidies for research and development activities (Guerrero and Urbano, 2017; Greco *et al.*, 2017). According to previous studies, these incentives have been largely successful in promoting OI (e.g. Segarra-Blasco and Arauzo-Carod, 2008; Gallego *et al.*, 2013). However, it has been argued (i.e. Laursen and Salter, 2006; Duysters and Lokshin, 2011; Galati and Bigliardi, 2019b; Galati *et al.*, 2019) that when the number of partners increases, the positive effect of collaboration on innovation performance is likely to decrease (for oversearching and overcollaboration issues). Thus, public authorities should not be satisfied by a mere increase in firms' propensity to collaborate and must carefully monitor how public subsidies can improve the efficiency of such collaborations (Greco *et al.*, 2016). Recently, Greco *et al.* (2017) introduced the concept of OI efficiency: a firm is more efficient in its OI processes than another if it obtains better innovation outputs starting from similar OI inputs. Their results show that local and national subsidies are associated both with collaboration in beneficiaries and with OI efficiency. However, such a concept is new, resulting in a need for additional research:

(1) How do public subsidies influence OI efficiency in different countries or industries?

The internal effort required to recognize, assimilate and exploit external knowledge represents a firm's absorptive capacity; largely considered a function of the firm's level of prior related knowledge (Cohen and Levinthal, 1990; Spithoven *et al.*, 2010; Patterson and Ambrosini, 2015; Saemundsson and Candi, 2017). When the absorptive capacity is absent internally, companies usually rely on an OI intermediary that is capable of developing its potential absorptive capacity (Kokshagina *et al.*, 2017; Lin *et al.*, 2020). This allows firms to access distant knowledge in a faster and more organized way (Howells, 2006), source knowledge from external actors outside their traditional links (Billington and Davidson, 2013), and organize search activities (Agogué *et al.*, 2017). OI intermediaries spread a problem

to a wide pool of potential solvers to identify original solutions and can realize the potential absorptive capacity for the company, thus potentially facilitating further diffusion of knowledge (Meissner and Shmatko, 2017; Ollila and Yström, 2017; Ter Wal *et al.*, 2017). To date, however, the role of intermediaries has been investigated considering only one dimension of the absorptive capacity construct—namely, value recognition—while the transfer and appropriation of ideas have yet to be clearly addressed (Kokshagina *et al.*, 2017). Therefore, the following future research arises:

(1) What is the role of OI intermediaries in terms of the transfer and appropriation of ideas?

The absorptive capacity of R&D human capital—defined as the knowledge, skills, and abilities residing and used by individuals (Subramaniam and Youndt, 2005)—plays a pivotal role in firm's knowledge gains from external sources (Petroni *et al.*, 2012; Teirlinck and Spithoven, 2013; Huang *et al.*, 2015; Galati and Bigliardi, 2019b). While the literature recognizes the importance of external linkages to augment the value of in-house R&D efforts, little is known about the value of alliance portfolio diversity and the importance of R&D human capital (Martinez *et al.*, 2017). Alliance portfolio diversity has received substantial interest from firms and policymakers (OECD, 2010), with several scholars providing empirical evidence for a positive, curvilinear (inverted U-shape) association between alliance portfolio diversity and firm innovation performance (e.g. de Leeuw *et al.*, 2014; Martinez *et al.*, 2017; Rodriguez *et al.*, 2017), thus implying that not only too little, but too much, alliance portfolio diversity may be disadvantageous to firm innovation performance. They also found that R&D human capital partially mediates the relationship between alliance partner diversity and firm innovation performance, thus indicating that it plays a significant role in innovation novelty. As such, investing in in-house R&D could potentially lead to increasing benefits derived from external ideas and technology. Building on this topic further, several aspects should still be investigated: firms that operate across a number of countries, the need to operationalize alliance diversity portfolio as a multidimensional concept, and the number of interorganizational ties that firms have with each partner. However, according to Martinez *et al.* (2017), the most promising research avenues focus on the role of strategic human resource management practices, such as knowledge management, training programs and developmental plans in enhancing R&D human capital. As such, the following question emerges:

(1) How effective are strategic human resource management practices in enhancing a firm's R&D human capital?

3.3.3 External search for OI (cluster 5). In the OI environment, external search has been studied from a number of differing viewpoints, including breadth and depth (Laursen and Salter, 2006), where the former refers to how widely firms rely on external knowledge sources and the latter refers to how intensely firms use external knowledge sources (Dong and Netten, 2017). For scholars, it is clear that external search breadth and depth are associated with innovation performance (e.g. Foss *et al.*, 2013; Laursen and Salter, 2014). Conversely, the antecedents of external search breadth and depth represent a critical gap in the literature (Dong and Netten, 2017). If they are important for innovation, what firms can do to enhance them should be understood. Throughout OI "history," ICT has been considered a key resource input to firms' innovation activity (e.g. Huston and Sakkab, 2006), as firms' ICT investment is related to their absorptive capacity. ICT allows firms to improve their absorptive capacity to acquire external knowledge (Dong and Yang, 2015; Amponsah and Adams, 2017; Homfeldt *et al.*, 2017), through improvements to communication and integration, the establishment of relationships, and the facilitation of knowledge transfer

to lower information deficiencies (Malhotra *et al.*, 2005; Li *et al.*, 2006; Saraf *et al.*, 2007; Rai *et al.*, 2012; Hochleitner *et al.*, 2017). However, while it has been stressed that ICT assets are fundamental for innovation performance, how ICT influences external search is unclear (Dong and Netten, 2017). Future research avenues could be driven by the following question:

(1) How does new ICT influence external search breadth and depth?

As previously affirmed, there is a gap in understanding in terms of the ways in which firms can translate their openness into innovation outcomes by tapping into external sources (Dong and Netten, 2017), a gap related to the well-known absorptive capacity concept (Cohen and Levinthal, 1990). Even if we assisted in conceptual developments of the concept (i.e. provided a process-based perspective of absorptive capacity) (e.g. Zahra and George, 2002; Todorova and Durisin, 2007), measures of absorptive capacity would still be underdeveloped. Commonly, absorptive capacity is operationalized in terms of internal R&D expenditure, and measurements outside of R&D are sporadic. Only a few studies have fractionated absorptive capacity into its multiple components (Volberda *et al.*, 2010). Zobel (2017) explored the relationships between such components and other relevant constructs, such as a competitive advantage in product innovation. In line with an extended resource-based view perspective (Zander and Zander, 2005), she found that a firm's technology-oriented capabilities play a pivotal role in mediating the effect on product innovation. In doing so, she explained why increasing openness in innovation may be effective, and provided a theoretical foundation for the link with OI-innovation performance. What is still missing, however, is an understanding of how absorptive capacity modifies firms' additional (different from R&D) resources and capabilities, such as those related to marketing. By taking everything into account, it is important to understand the implications of any given level of a firm's absorptive capacity. Based on these arguments, the following question is proposed:

(1) How does the absorptive capacity modify firms' resources and capabilities?

Based on the notion that firms typically consider individuals as crucial in order to learn from external sources, it is beneficial to understand the extent to which the dimensions of individual-level absorptive capacity are related to firms' innovation strategies (Enkel *et al.*, 2017). Individual-level absorptive capacity encompasses individuals' ability to: identify valuable external knowledge, assimilate the external knowledge to an existing organizational identity, and advocate for the utilization of the external knowledge within an organization (Cohen and Levinthal, 1990; Colombo *et al.*, 2011; Criscuolo *et al.*, 2013; Tortoriello, 2015; Weng and Huang, 2017). In spite of its importance, little attention has been paid to the behaviors of individuals involved in the effective absorption of external knowledge and to the extent to which these individual actions contribute to a firm's innovation strategy. As such, individuals' competencies in identifying external knowledge as a trigger have yet to be evaluated in terms of either exploratory and exploitative innovation. Results obtained by Enkel *et al.* (2017) stress that efforts of individuals to assimilate knowledge from external sources contribute to exploratory innovation, but that individual efforts in assimilating external knowledge are not significantly related to exploitative innovation, thus partially disproving the general finding that assimilation efforts are powerful for innovation, regardless of their specification. We believe that future research is needed in this direction, given that previous studies have focused on only one or a limited number of industries and have neglected to consider crucial concepts (e.g. individuals' cognitive distance to each source or needed organizational capabilities). Two consequent questions follow:

(1) What is the relationship between individual efforts in assimilating external knowledge and firms' innovation?

(2) What organizational capabilities are necessary for sustaining the assimilation of external knowledge at the individual level?

3.3.4 Technology (cluster 9). Representing a vehicle that helps innovative entrepreneurs get products developed, crowdfunding has become popular in recent years and is one of the most used ways that innovative, often small, organizations have been able to access capital (Mollick, 2014). It can also be viewed as one form of open search (Stanko and Henard, 2017). Crowdfunding backers are early adopters who offer advice, ideas and even criticism (including about design issues) throughout the product development process. They are considered important not only for their financial contribution but also for their cooperation and support during knowledge creation and for their help in creating and spreading word-of-mouth awareness for the crowdfunded idea. Results obtained by Stanko and Henard (2017) suggest that the number of backers attracted to a campaign has a significant impact on the later market performance of the crowdfunded product, while the amount of funding raised during a campaign does not. This does not imply that raising capital is not important/necessary, but that attracting backers could be seen as a key driver of the market performance of the crowdfunded product. Therefore, reward-based crowdfunding should not be viewed as a mechanism to raise funds, but a way to engage with interested early adopters, and involve them in the development effort. Some crowdfunding entrepreneurs have begun to recognize the potential value of backers, but more academic and practitioner-oriented research is needed on the topic, motivating the following question.

(1) What are the implications deriving from the involvement of crowdfunding backers in crowdfunding campaigns?

In a similar vein, crowdsourcing and idea competitions—which draw on a high volume of input from extended and often heterogeneous populations—have gained momentum in recent years (e.g. Natalicchio *et al.*, 2017b; Hofstetter *et al.*, 2018a, b), increasingly becoming used as resources with which to support the front end and downstream acceleration of innovation (Scheiner *et al.*, 2018). This enables organizations to create and refine product and service solutions (Valdez *et al.*, 2018). However, very few works (Kosonen *et al.*, 2014; Scheiner *et al.*, 2018) have investigated the operating contingencies under which they can prove to be effective or the ways in which their organization might be improved. If participation motives were addressed in past research (e.g. Boudreau and Lakhani, 2009; Boudreau *et al.*, 2011), unwanted behavioral patterns have been largely neglected, thus it is still not clear why participants behave in such ways. Scheiner *et al.* (2018) stress that unethical behavior is related to a situation of moral disengagement, in which people disengage from the self-regulatory process that generally impedes individuals from acting in a way inconsistent with their own moral standards. The unethical behavior of participants in such competitions can be negative for the motivation of the community and also for the organizer. This would represent an interesting area of research on OI concerning participants' ethics, as participants of idea competitions are commonly tempted to influence the outcome of an idea contest in their favor. Based on a current lack of multidisciplinary studies and given that the organizer of an idea competition cannot entirely prevent participants from gaming a system, the open questions are as follows:

(1) What are the reasons that drive people to act unethically in idea competitions?

(2) What self-governing practices emerge through relational participant interactions in idea competition communities?

As affirmed in previous paragraphs, the external search in innovation activities goes beyond company boundaries and can involve millions of users (Billington and Davidson, 2013; Mount

and Martinez, 2014; Du *et al.*, 2016; Santoro *et al.*, 2018; Scuotto *et al.*, 2017). Firms have increasingly adopted the use of social media (Roberts *et al.*, 2016; Ogink and Dong, 2019), as demonstrated by various case studies involving companies such as Starbucks (Gallaugher and Ransbotham, 2010), Dell Computers (Di Gangi *et al.*, 2010), and Barilla (Martini *et al.*, 2014), among others. Such uptake is based on the notion that involvement of consumers in the innovation process fosters and facilitates the acquisition of knowledge, playing an essential role in R&D activities (Dwyer and Mellor, 1991; Rothwell, 1994; Thomke and Von Hippel, 2002; Baldwin and Von Hippel, 2011). In short, firms seek new knowledge by interacting with users through social networking sites, which are then ideally combined with their internal ones. In spite of this process seemingly being improved through the use of social networking sites, there is still a degree of complexity when creating a new product or service, meaning the expected return on investment (ROI) is always uncertain (Scuotto *et al.*, 2017). Managers, as well as R&D employees involved in the process of innovation search, are becoming increasingly interested in achieving ROI in the short term (Kaske *et al.*, 2012; Billington and Davidson, 2013). However, the influence exerted by social networking sites on the process of knowledge search in innovation activities to facilitate the achievement of ROI has been rarely investigated, and few scholars have analyzed this aspect by taking a qualitative approach, given the difficulty of identifying and quantifying ROI (Scuotto *et al.*, 2017). As such, a question within this field is proposed:

(1) How can one define an ROI that measures the impact of social networking sites on the process of knowledge search in innovation activities?

4. Conclusions

4.1 Discussion

The OI paradigm is shaping the world we live in, and scholars belonging to a wide variety of academic disciplines are investigating the opportunities deriving from such a revolution. Through a comprehensive review of the literature on OI, the objective of this study is twofold: (1) to identify the main thematic areas discussed in the past and track their evolution over time; and (2) to provide recommendations for future research avenues.

In terms of the first objective, by applying the text mining technique developed by Delen and Crossland (2008), we identified nine clusters that, based on the respective descriptive terms from the clustering analysis, were labeled as "context dependency of OI," "collaborative frameworks," "organizational dimension of OI," "performance and OI," "external search for OI," "OI in SMEs," "OI in the pharmaceutical industry," "OI and intellectual property rights" and "technology." Considering the clusters' size and preliminary validation steps performed, we believe that each of them can be seen as a relevant thematic area in which scholars interested in the topic of OI could classify their research. The paper also made it possible to track the evolution of the thematic areas over time, highlighting the years in which they emerged, as well as their growth and/or decline. We observed that while thematic areas referring to clusters 4 and 5 — namely, "performance and OI" and "external search for OI," respectively — had been investigated since the emergence of the OI paradigm, others started to be investigated later, thus highlighting how the topic has evolved and grown over time. The debate surrounding the OI paradigm started when scholars began discussing inward possibilities and the potential performance improvements deriving from its implementation. Then, other issues emerged, such as the role of technology, the role of context, the adoption of IPRs, and the development of collaboration frameworks. These topics have improved the level of the debate by exploring further issues that, over time, have been considered central in the discourse. Last, the research has deepened the investigation of the implications deriving from the adoption of the OI paradigm in more detailed settings, through which organizational consequences, considerations concerning SMEs, and specific industries (the most debated

being pharmaceutical) have been explored. We believe that these findings could help bring further clarity to the broad and scattered field of innovation literature.

As for the second objective of the study, on the basis of the analysis of the most recent papers, we suggested several future research avenues that could be useful in guiding forthcoming investigations into the topic; in particular, for the four relevant issues of "context dependency of OI," "collaborative frameworks," "external search for OI" and "technology." It is possible to claim that recent themes are intertwined with other research streams, a process that shapes the OI debate. First, globalization issues are shaping the centralized and local system of the R&D process, and firms are starting to allocate their innovation processes through a network of external partners and sites across the world. Second, the evolution and the mobility of the workforce poses challenges and needs in terms of strategic human resource management practices, which have implications for the enhancement of firms' human capital. Finally, the digital revolution calls for reflections on the impact of such technologies on the OI paradigm, considering not only the possibility to improve the inward flows of ideas but also the implications for people's behavior. As such, this paper suggests that the OI debate is evolving by combining its idiosyncrasies with other academic and political discussions, a development that calls for a huge research effort.

To the best of our knowledge, the present study represents one of the few attempts to implement text mining methodologies to conduct a comprehensive literature review on a given issue. We are confident about the usefulness of this tool for a wide variety of academic purposes, and we hope that our study can inspire not only scholars interested in the OI phenomenon but also those who understand the potential of text-based methodologies.

4.2 Policy implications

The analysis of the most recent papers investigating the four aforementioned relevant issues made it possible to identify different policy implications. First, to foster the development of novel innovations, policymakers should work on policies aimed at forming cooperation networks that involve research institutions and universities. Particular emphasis should be put on those companies that have never been involved in collaboration activities, as current policy measures tend to support companies that have already experienced cooperation. Second, policy measures should consider OI efficiency, particularly for SMEs, with a particular focus on the diminishing returns of OI in relation to innovation performance (Greco *et al.*, 2017; Ardito *et al.*, 2019). Such a process may challenge the usefulness of establishing several and merely formal collaborations aimed at matching the constraints requested by public authorities, which can be ineffective in terms of innovation performance in that funds are dispersed. For example, in response to a recent European call, firms and universities chose to involve unnecessary partners with narrow contributions but with a strong international reputation and/or strategic geographic base. This reflects the inadequacy with which European subsidies are designed and the subsequent limited power of such subsidies in enhancing collaboration intensity; in short, there is not a proportional increase in turnover share from radical innovations. Thus, policymakers need to recognize the proper way to allocate their limited financial resources to improve firms' innovation performance. Third, policymakers and authorities should find a better way to integrate subsidies with consultancy services that can provide the necessary support to firms in terms of searching for and coordinating with partners. In addition, such consultancy services can help companies to identify partners in possession of complementary R&D competencies and technologies. Finally, given the recognized value of culture as a source of competitive advantage at the country level (considered a nontradable resource), policymakers should consider adopting an innovation strategy that includes cultural contingencies. This would involve a reconsideration of countries' idiosyncrasies, which can be turned into a competitive advantage by specializing in their innovation efforts as a function

of their cultural endowment. This cultural alignment could be relevant for several kinds of innovation strategies incorporating different degrees of openness.

4.3 Limitations

We are conscious of the limitations of our methodological approach. Findings are influenced by the scope and nature of the underlying research design and methods. The main limitation relates to the fact that it was impossible to perfectly cluster together studies dealing with a wide variety of detailed topics. This implies the presence of studies that do not perfectly fit the overall meaning of the specific cluster. However, one of the aims of the research was to highlight the main thematic areas related to OI. In our opinion, the fact that a limited number of papers do not fit the right cluster is barely significant for the objectives of the study. In addition, for the development of future research avenues, only studies in journals that have published several papers on the topic were considered, a choice motivated by the will to include relevant and reliable research. However, this approach could be contested by those who believe that it is also possible to consider citations as a proxy of relevancy. Finally, the preliminary nature of the validation steps should be considered. As previously stated, they were aimed at ensuring the plausibility of the results emerging from the analysis; as such, they cannot be considered complete.

Note

1. The current study included, also graphically, articles published in 2018, even if their number is low due to the fact text collection was performed at the beginning of the year (see Figure 1).

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