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**Article**

## Global trend of open innovation research: A bibliometric analysis

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## MANAGEMENT | RESEARCH ARTICLE

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## MANAGEMENT | RESEARCH ARTICLE

# Global trend of open innovation research: A bibliometric analysis

Ha Thi Thu Le<sup>1</sup>, Quyen Thi Mai Dao<sup>2\*</sup>, Van-Chien Pham<sup>34</sup> and Duong Thuy Tran<sup>2</sup>

**Abstract:** A bibliometric approach was conducted to evaluate the global scientific outputs of open innovation based on literature in Social Science Citation Index (SSCI) database from 2003 to 2017, with the ultimate goal of assisting researchers to fulfil the potentiality of open innovation research and to establish future directions. Overall, 1,046 articles in 318 journals were analysed by research performance of countries, continents and institutes, authorship, journals, most cited articles, first articles, author-keywords, keywords plus and paper titles to identify relevant trends in this period. This study demonstrates that Europe was the most productive continent featured by Italy's remarkable surge by 150% in total articles between 2016 and 2017. However, with respect to research performance by country, the USA came top with the highest total number of articles. The analysis of keywords groups in this study shows that while intangible assets were given decreasing attention, issues pertaining to business performance, firm openness and innovation capacity became foci in open innovation research. Articles were published by top journals which all featured the "management" field in their subject categories, indicating that open innovation spectrum was mainly explored in the field of management.



Ha Thi Thu Le

### ABOUT THE AUTHOR

Ha Thi Thu Le is Associate Professor of Innovation and Intellectual Property and Director of Innovation and Incubation Space (FIIS) at Foreign Trade University (Vietnam). Ms. Le has over 15 years of research, teaching and consulting experience in intellectual property, innovation and branding. She took a role as an independent consultant in some projects funded by NGOs, international organizations and the government of Vietnam regarding innovation and intellectual property. As the Director of FIIS, she has initiated and supervised key activities including research on strategy, policy, trends and impacts of innovation and intellectual property, support for students and start-up groups with creative and community-oriented sustainable solutions. This paper on the bibliometric analysis of global trend in Open Innovation research is among the outcomes of the project on "Developing university ecosystem", which is conducted by the research team "Innovation and Intellectual Property" of Foreign Trade University.

### PUBLIC INTEREST STATEMENT

The exploitation of an open approach in the creation and implementation of inventive ideas is gaining grounds in various organizations. This paper aims to identify and analyze the most significant current trends in open innovation research and to establish future directions for academic scholars, industry practitioners and policy makers in this field. Our findings demonstrate that Europe was the most productive continent while with respect to research performance by country, the USA came top regarding all indicators: total articles, first author, corresponding author, single country and international collaboration. Furthermore, this paper provides potential gaps that need to be addressed by the future research, including the interface between open innovation and business performance, firm openness and innovation capacity.

**Subjects: Science; Social Sciences; Law; Economics, Finance, Business & Industry; Innovation Management**

**Keywords: bibliometric research; open innovation; knowledge; research performance**

## 1. Introduction

Innovation has become a mounting concern for scholars from different disciplines (Fagerberg, 2004; Fagerberg & Verspagen, 2009; Martin, 2012). At the organizational level, innovation is the implementation of a new or significantly improved product (either good or service), process, a new marketing method or organizational approach in business practices, workplace organization or external relations (Oslo Manual, 2005). The innovation process thus covers invention and all the work necessary to bring an idea or concept to final form (Kahn, 2012). Innovations bring the key competitive edge that determines economic success and sustainability of an organization. Acknowledging the importance of innovation at business level (Chesbrough & Crowther, 2006) highlighted that “innovation is a core business necessity and companies that don’t innovate, die”.

Nowadays a specific innovation can no longer be considered as the result of a predefined and isolated contributions but rather as the outcome of a co-creation process with knowledge flows in and out the entire economic and social environment (Sivam, Dieguez, Ferreira, & Silva, 2019). That triggers an increasing need of organizations to open up the innovation process to all active players. Over 200 years since the very first theoretical framework of innovation was formulated in a research by Tarde (1890), another emerging body of research on “open innovation” has now garnered increasing popularity. The notion of “open innovation” was coined by Chesbrough (2003) and refers to a process in which firms seek to acquire ideas and resources from the external environment in conjunction with their internal resources. It is contrasted with the traditional “close” innovation model, which calls for firms’ self-reliance solely on their own internal research and development efforts (Chesbrough, 2003). “Open innovation” has been further described as “a distributed innovation process based on purposively managed knowledge flows across organizational boundaries” (Chesbrough & Bogers, 2014). Although open innovation is not a totally new phenomenon by nature (Christensen, Olesen, & Kjær, 2005; Gann, 2005), there is little doubt that it is gaining grounds among researchers. In the literature, the open innovation paradigm has been widely explored from large firms by means of case study and in-depth interviews (Chesbrough, 2003; Ciravegna, Romano, & Pilkington, 2013) to small and medium-sized enterprises (SMEs) either based on empirical study (Freel & Robson, 2017; Paik & Chang, 2015; Van de Vrande, De Jong, & Vanhaverbeke, 2009) or through a qualitative approach (Radziwon & Bogers, 2018; G Santoro, Ferraris, & Winteler, 2019). The adoption and practice of open innovation model could be found in a broad range of industries: high technology (Chesbrough, 2003, 2007; Delgado-Verde, Martín-de-Castro, & Navas, 2011), transport (Cassetta, Marra, Pozzi, & Antonelli, 2017), knowledge-intensive business services (Miozzo, Desyllas, Lee, & Miles, 2016), pharmaceuticals (Ku, 2015), food and beverage (Gabriele Santoro, Vrontis, & Pastore, 2017; Tardivo, Thrassou, Viassone, & Serravalle, 2017). The most frequently used definition of “open innovation” is “the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and to expand the markets for external use of innovation, respectively” (Chesbrough & Crowther, 2006). This definition clearly incorporates three processes: outside-in (inbound), inside-out (outbound) and coupled activities (Gassmann & Enkel, 2004), which have been thoroughly examined thus far: the empirical study in Chesbrough and Crowther (2006) and Enkel, Gassmann, and Chesbrough (2009) demonstrated a tendency of companies to perform more inbound than outbound activities. Interestingly, Enkel et al. (2009) found that only large multinationals developed an active out-licensing strategy. Also, the coupled process, which refers to co-creation with complementary partners via alliances, cooperation and joint ventures (Enkel et al., 2009) was extensively explored (Kendall, Kendall, & Germonprez, 2006; Perkmann & Walsh, 2017; Von Hippel & Von Krogh, 2006).

Not only emerging as an important concept in academic research and industrial practice, open innovation has been observed and implemented in the public policy domain (Bogers, Chesbrough, & Moedas, 2018). In an initiative to foster new technologies and business models from research,

the Europe Commission has set three goals for the European Union research and innovation policy: Open Innovation, Open Science and Open to the World.<sup>1</sup> The first pillar “Open Innovation” means “to open up the innovation process to all active players so that knowledge can circulate more freely and be transformed into products and services that create new markets, fostering a stronger culture of entrepreneurship”. Back in 2010, a research by Hilgers and Ihl presented a structural overview of how citizen integration and participation can help improve the governmental process and public administration. Accordingly, exemplars of collaboration between citizens and public administration were featured in the breakthrough of the Peer-to-Patent program by the United States Patent and Trademark Office (USPTO) in 2007,<sup>2</sup> the Future Melbourne program in 2008<sup>3</sup> and the USAID Development 2.0 Challenge in 2009.<sup>4</sup> These prominent examples demonstrate that the “open government” approach, with the advent of digital technologies, has enabled and facilitated citizens to actively engage in democratic decision-making and public administration (Di Gennaro & Dutton, 2006; Hilgers & Ihl, 2010; Lathrop & Ruma, 2010).

This study was conceived to gather and evaluate the global scientific outputs of open innovation in the fifteen-year period from 2003–2017. To map the literature in this regard, we deployed the “bibliometric” approach, which has been broadly used in identifying research trends. By definition, bibliometric means “the application of mathematics and statistical methods to books and other communication media” (Chang & Ho, 2010). The bibliometric approach was previously employed in the area of physics (Perc, 2013), innovation (Cancino, Merigo, & Palacios-Marqués, 2015), financing innovation (Padilla-Ospina, Medina-Vásquez, & Rivera-Godoy, 2018), information systems related to innovation (Pereira, Verocai, Cordeiro, Gomes, & Costa, 2015) and social innovation (Gaitán-Angulo, Cubillos Díaz, Viloría, Lis-Gutiérrez, & Rodríguez-Garnica, 2018). Notably, in a bibliometric study on open innovation in 2017, Ale Ebrahim and Bong extracted a dataset of 3,567 publications at the initial stage and 2,406 at the intensive level of investigation from Scopus. Our current bibliometric analysis of open innovation is, however, based on the Web of Science (WoS) database, which is stricter than Scopus in terms of acceptance with its demanding standards. Given that, we believe that our dataset covered a lower number of journals but higher impact articles. Furthermore, unlike Scopus, whose coverage is mostly limited to recent articles, WoS offers a strong coverage, which goes back to 1990 (Chadegani et al., 2013). The database of our current research covers publications on open innovation from 2003–2017 which is more comprehensive than the five-year-period of study (2012–2017) as focused in the research by Ale Ebrahim and Bong. In addition, our research covered more indicators, namely distribution of document type, research performance by countries/continents, keywords plus and article titles. Another marked advancement of our current study compared with the research by Ale Ebrahim and Bong was an in-depth analysis of hot issues based on the grouping of top author-keywords. In light of that, our bibliometric analysis of open innovation shall provide a more detailed picture of scientific outputs devoted to open innovation. Our findings would thus better guide researchers to explore the breadth of open innovation research and to establish future research directions.

## 2. Data sources and methodology

Research data were retrieved from the Web of Science, the online version of the Social Sciences Citation Index (SSCI). The SSCI is a multidisciplinary bibliographic database originally developed by the Institute for Scientific Information (ISI; now Thompson Reuters, New York). According to Journal Citation Reports (JCRs), the ISI indexes 11,459 major journals with citation references across 236 disciplines in 2017. The online version of the SSCI database was searched by the keywords “open innovation” and “open innovations” as part of the title, abstract, and keywords (author keywords) to gather a bibliography of all manuscripts related to open innovation research. The term “open innovation” was initially coined by Chesbrough, H.W. in 2003 and there had been no equivalent of the term in documented research papers before then. Therefore, the search was conducted within the publication year with a limit of 2003 to 2017. The impact factor (IF), the subject category and rank in the category of the journals were obtained from the Journal Citation Reports 2017, Thomson Reuters (JCR2017, release based on 2016 data). The contributions of different countries/continents and institutes were determined by the participation of at least one

author of the publication, through the author addresses. The term “single country” was understood as all authors from the same country; the term “internationally collaborative” was used for articles that were co-authored by researchers from more than one country. Similarly, the term “single institute” was assigned when the addresses of all authors were for the same institute; the term “inter-institutionally collaborative” was used when the co-authors were from more than one institute. In the SSCI database, “corresponding author” is defined as the author to whom all correspondence should be addressed. In a single-author article where authorship was unspecified, “single author” was designated both first author and corresponding author. All of the articles in the fifteen-year period from 2003–2017 were assessed by the following criteria: Document type, publication performance by country, continent, institute, authorship, citation, distribution of journal and hot issue analysis.

### 3. Results and discussion

#### 3.1. Distribution of document type

The distribution is shown in Table 1. There was a recorded number of 1,046 journal articles, accounting for more than 88% of all the document types. This was followed by editorial material (6.5%) and review (5.5%). In general, there was an increasing trend in the publication of open innovation articles. Figure 1 illustrates a surge in the decade of 2007–2017 from eight articles (2007) to 211 articles (2017). The number of articles decreased slightly in 2012 and 2015, but rocketed in the subsequent years. Other document types remained stable around 10 productions per year. The total number of 1,046 articles, which were the most frequently used document type, were the subject of this analysis.

#### 3.2. Research performance by countries/continents

An analysis of the performance of countries may provide an insight into the mainstream participants and collaborators in research (Wambu, Fu, & Ho, 2017). Our research shows that authors from a total number of 60 countries published on open innovation research during the period from 2003–2017. Table 2 lists the 15 most productive countries, which were analysed and ranked by the total output of articles with four parameters, namely: first-author articles, corresponding author articles, single-country articles and internationally collaborative articles. Among the 1,030 articles with author addresses published from 2003–2017, international collaborations accounted for 34.7% (357) as compared to 65.3% (673) of the articles originating from single-country research. The USA (21%) was the most productive country followed by the UK (16%), Germany (13%), Italy (11%) and Spain (10%). The top 15 countries in open innovation research mainly comprised of countries in Europe (10).

The dominance of Europe as the leading region in open innovation research could be justified by a number of driving forces, among which a milestone could be traced in 2010 when the European Union (EU) launched the Innovation Union as one of seven flagship initiatives of the Europe 2020 Strategy.<sup>5</sup> Open innovation was also promoted as one of three key policy goals in 2015 within the framework of the EU research and innovation.<sup>6</sup> As a result, four out of the five most productive countries as shown in Figure 2 were in Europe (the UK, Germany, Italy and Spain). Italy had the first articles rather late in 2008. It made a stable progress until 2016, when the figure rocketed by 150% from 16 articles to 46 articles (2017), reaching its peak far above the USA and UK having been the predecessors in the field. This might be ascribed to an array of national incentives of the Italian government to create favourable conditions for the establishment and development of innovative start-ups such as the Italy’s Start-up Act (2012), Italia Start-up Visa (2012), Smart&Start Italia funding program (2013) and the ‘Industry 4.0’ strategic plan (2016).<sup>7</sup>

South Korea (6.6%) and China (4.7%) were the top two Asian countries in open innovation research. South Korea’s innovation system is featured by the strong government support in R&D to build up a science and technology capacity through developing industrial cities, technology and science parks since 1980s-1990s (Gupta, Healey, Stein, & Shipp, 2013). In pursuit of a “creative

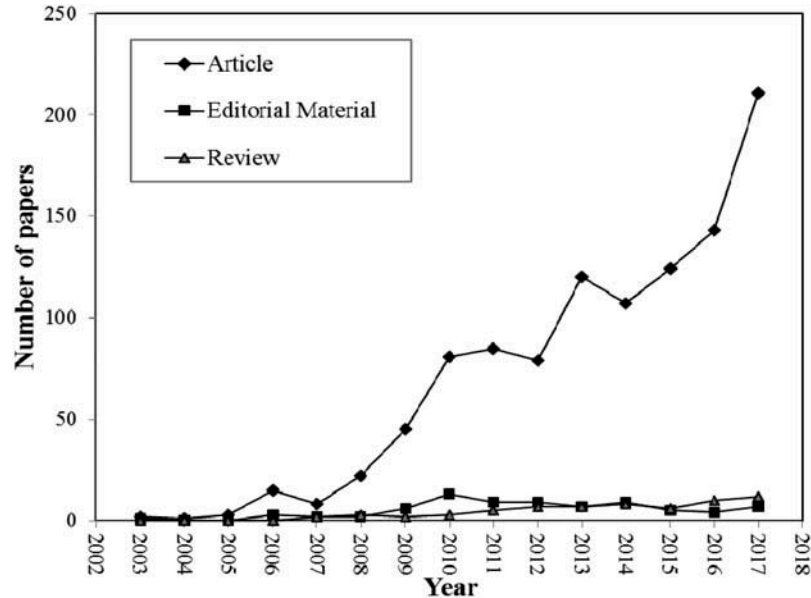
**Table 1. Distribution of document type**

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Article	2	1	3	15	8	22	45	81	85	79	120	107	124	143	211
Editorial Material	1	0	0	3	2	2	6	13	9	9	7	9	5	4	7
Review	0	0	0	0	2	3	2	3	5	7	7	8	6	10	12

In total, there was a recorded number of 1,046 journal articles on open innovation during 2003–2017, accounting for 88% of all document types. Publications in the form of review and editorial material, albeit following an upward general trend, constituted a relatively small part.

**Figure 1. Comparison of the growth trends of document types during 2003–2017.**

Articles accounted for the majority of publications in open innovation during the period 2003–2017.



economy” policy, which was adopted in 2013, South Korea has developed a number of open science initiatives for promoting a creative environment and openness of R&D information. The government and industry’s open approach towards innovation shown in high investment in collaborative research projects might justify South Korea’s position in the top 10 countries in open innovation research. The high ranking of China can be explained because of the great openness imbedded into its global aspirations to develop an innovative economy, which is featured in various strategies of Chinese firms to better their innovation performance such as technology license (Liu, Qian, & Jin, 2016), alliances (Duysters, Jacob, Lemmens, & Jintian, 2019) and outward FDI (Huan & Ghauri, 2008).

The USA, the UK and Germany, the three most productive countries with respect to the total number of articles (TP), also came out as the most frequent partners in open innovation research (CP) demonstrating that the country’s rank and percentage research output controlled its proportion of international collaboration. In addition, the top five countries by FP (first-author articles) also reached the top by RP (corresponding author articles). The discrepancy between single-country article (SP) and the country’s total publications (TP) suggests that the number of single-country research varied from country to country, which may be due to national research policies (Wambu et al., 2017). Notwithstanding the USA being ranked first, Germany superseded the USA in 2008 and 2010 but experienced a fall by 20% from 2016–2017.

### 3.3. Research performance by institutes

Table 3 lists the top 15 productive institutes from 2003 to 2017. Of the 1030 articles with author addresses, 381 (37.0%) were single-institute publications and 649 (63%) articles were inter-institute collaborative results.

As the pioneering institute in open innovation research, the University of California accounted for the highest number of articles (27; 2.6%), followed by the Technology University of Munich and Polytechnic University of Milan (both with TP of 27, accounting for 1.8%). Being pro-active in creating open innovation initiatives, Europe hosted up to 11 (more than 75%) of the most productive institutes. Seoul National University was the only institute in Asia that reached the top 15 productive institutes with 13 articles, constituting 1.3%.



**Table 2. Top 15 countries in open innovation research during the period 2003–2017**

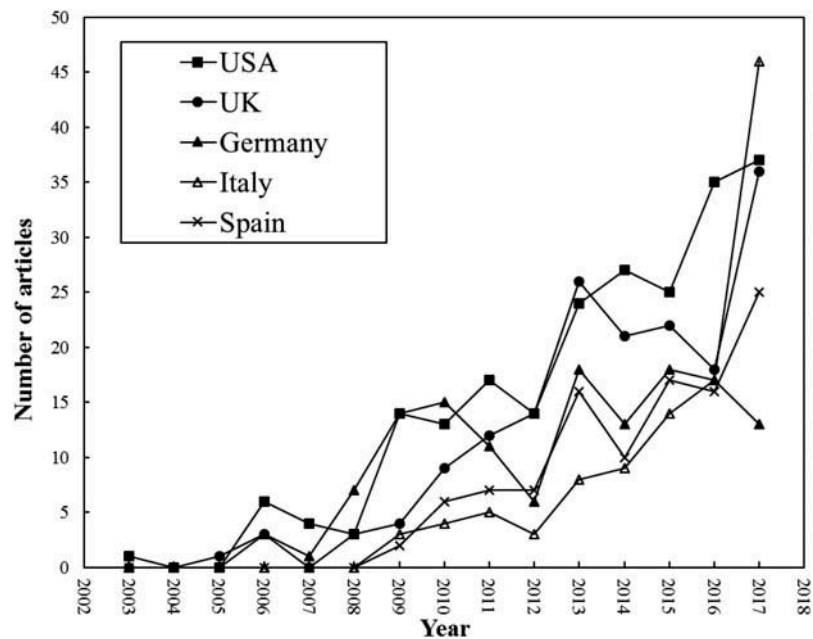
Country	TP	TPR (%)	FPR (%)	RPR (%)	SPR (%)	CPR (%)
USA	220	1 (21)	1 (13)	1 (13)	1 (14)	1 (36)
UK	169	2 (16)	3 (9.4)	3 (9.6)	4 (8.8)	2 (31)
Germany	136	3 (13)	2 (11)	2 (11)	2 (10)	3 (18)
Italy	109	4 (11)	4 (8.3)	4 (8.9)	3 (9.1)	5 (13)
Spain	106	5 (10)	5 (7)	5 (7.1)	5 (7.7)	4 (15)
Netherlands	81	6 (7.9)	7 (5.3)	7 (5.2)	7 (5.2)	6 (13)
South Korea	68	7 (6.6)	6 (5.6)	6 (6.1)	6 (7.3)	14 (5.3)
Sweden	57	8 (5.5)	8 (4.2)	9 (3.7)	9 (3.6)	8 (9.2)
Switzerland	55	9 (5.3)	12 (2.6)	12 (2.4)	12 (2.5)	7 (11)
China	48	10 (4.7)	9 (3.8)	8 (3.8)	9 (3.6)	12 (6.7)
Denmark	44	11 (4.3)	11 (2.9)	10 (2.9)	11 (2.8)	11 (7)
Belgium	43	12 (4.2)	13 (2.4)	12 (2.4)	14 (1.8)	9 (8.7)
France	39	13 (3.8)	15 (2)	15 (2)	13 (2.4)	13 (6.4)
Australia	37	14 (3.6)	14 (2.3)	14 (2.2)	15 (1.6)	10 (7.3)
Taiwan	36	15 (3.5)	10 (3.2)	10 (2.9)	8 (4)	20 (2.5)

(TP: total articles; TPR (%): rank and percentage of total articles; FPR (%): rank and percentage of first-author articles; RPR (%): rank and percentage of corresponding authored-articles; SPR (%): rank and percentage of single-country articles; CPR (%): rank and percentage of internationally collaborative articles.)

Two-thirds of top15 countries in open innovation research were countries in Europe. The USA, UK and Germany came top with the highest number of total publications.

**Figure 2. Comparison of the growth trends of total articles of the top five countries during 2003–2017.**

Among top five countries in open innovation research, Italy had the first recorded article rather late (in 2008) but experienced a surge by 150% in 2017, when it reached its peak far above the USA and UK.



The University of California in the USA was also ranked top in the number of independent articles (IPR = 1.8%) and inter-institute articles (CPR = 3.1%). It should be noted, however, that the Polytechnic University of Milan in Italy and the Chalmers University of Technology in Sweden were also leading institutes with respect to independent articles (IPR = 1.8%). Albeit being the second most productive institute, the Technology University of Munich in Germany came top by FP (first-author articles) and RP (corresponding author articles), accounting for 1.6% in both regards,

**Table 3. Top 15 institutes in open innovation research during the period 2003–2017**

Institute	TP	TPR (%)	FPR (%)	RPR (%)	IPR (%)	CPR (%)
University of California, Berkeley, USA	27	1 (2.6)	2 (1.5)	2 (1.5)	1 (1.8)	1 (3.1)
Technology University of Munich, Germany	19	2 (1.8)	1 (1.6)	1 (1.6)	5 (1.3)	4 (2.2)
Polytechnic University of Milan, Italy	19	2 (1.8)	3 (0.97)	3 (1.2)	1 (1.8)	6 (1.8)
Hasselt University, Belgium	17	4 (1.7)	22 (0.49)	35 (0.39)	56 (0.26)	2 (2.5)
Harvard University, USA	17	4 (1.7)	13 (0.58)	13 (0.59)	18 (0.79)	4 (2.2)
Esade Business School, Spain	16	6 (1.6)	89 (0.19)	85 (0.2)	56 (0.26)	3 (2.3)
University of Cambridge, UK	14	7 (1.4)	6 (0.78)	6 (0.79)	12 (1)	9 (1.5)
Seoul National University, South Korea	13	8 (1.3)	8 (0.68)	6 (0.79)	5 (1.3)	21 (1.2)
Massachusetts Institute of Technology, USA	13	8 (1.3)	38 (0.39)	35 (0.39)	28 (0.52)	7 (1.7)
Copenhagen Business School, Denmark	13	8 (1.3)	38 (0.39)	23 (0.49)	28 (0.52)	7 (1.7)
University of Groningen, Netherlands	12	11 (1.2)	22 (0.49)	13 (0.59)	18 (0.79)	14 (1.4)
University of Southern Denmark, Denmark	12	11 (1.2)	13 (0.58)	9 (0.69)	18 (0.79)	14 (1.4)
University of London, Imperial College of Science, Technology and Medicine, UK	12	11 (1.2)	13 (0.58)	13 (0.59)	28 (0.52)	9 (1.5)
Chalmers University of Technology, Sweden	12	11 (1.2)	3 (0.97)	4 (0.98)	1 (1.8)	51 (0.77)
University of St Gallen, Switzerland	11	15 (1.1)	38 (0.39)	49 (0.29)	28 (0.52)	14 (1.4)

TP: total articles; TPR (%): rank and percentage of total articles; FPR (%): rank and percentage of first-author articles; RPR (%): rank and percentage of corresponding authored-articles; IPR (%): rank and percentage of single-institute articles; CPR (%): rank and percentage of internationally collaborative articles.

More than 75% (11 institutes) of the top 15 institutes in open innovation research were located in Europe. Seoul National University was the only institute in Asia that was ranked in the top 15 institutes.

followed by the University of California (FPR = RPR = 1.5%) and the Polytechnic University of Milan (FPR = 0.97%; CPR = 1.2%). This showed a positive correlation between FPR and RPR of the three leading institutes.

### 3.4. Authorship

The experts on open innovation could be found by examining the background of the authors. Table 4 showed the top seven authors who had at least nine publications during the period from 2003 to 2017. Chesbrough (University of California at Berkeley, USA) ranked first with 26 publications. Following shortly in this list was Lichtenthaler (International School of Management, Germany) with 25 articles. However, Lichtenthaler came top in terms of the first author, corresponding author and second author while Chesbrough was ranked second in these respects. Other noticeable names in this list were Yun (11 articles), Lazzarotti (10 articles) and Gassmann

**Table 4. Top 7 authors (total number of articles >8), first authors, corresponding authors and second authors during the period 2003–2017**

Author	Rank (TP)	Rank (FP)	Rank (RP)	Rank (SP)
Chesbrough, H	1 (26)	2 (17)	2 (15)	2 (10)
Lichtenthaler, U	2 (25)	1 (25)	1 (22)	1 (18)
Vanhaverbeke, W	3 (15)	#N/A	#N/A	#N/A
Frattini, F	4 (12)	#N/A	11 (2)	#N/A
Yun, JJ	5 (11)	3 (11)	3 (9)	3 (1)
Lazzarotti, V	6 (10)	6 (4)	8 (3)	#N/A
Gassmann, O	7 (9)	9 (2)	14 (1)	#N/A

TP: total articles; FP: first-author articles; RP: corresponding authored-articles; SP: second authored-articles; N/A: not applicable.

(9 articles). Nevertheless, bias could arise as the names of two or more researchers were the same or in some cases, authors adopt different names in their publications (for instance, due to a change of name after marriage) (Chang & Ho, 2010).

### 3.5. Analysis of journals

Characteristics of publications including their subject categories provide useful information for the examination of bibliographic trends of journal publications, citations and performances of most frequently cited journals and papers (Chuang, Wang, & Ho, 2011). Table 5 lists the top 10 journals (TP>20 articles) in open innovation from 2003–2017. *Research Policy* came top with 45 articles, followed by *Research Technology Management* and *International Journal of Technology Management* (both with 44 articles), *R&D Management* (42), *Technological Forecasting and Social Change* (37), *Technovation* (35), *Technology Analysis and Strategic Management* (33) and *Journal of Product Innovation Management* (26). Seven of the top 10 journals were listed in the WoS under the subject category of “Management of Technology and Innovation” and “Strategy Management”, followed by “Business, Management and Accounting” (6/10 journals). The common element of all the subject categories in those 10 top journals was “management”, which clearly reflected the close nexus between open innovation and the management field.

### 3.6. Most frequently cited articles and first articles

Citation analysis was conducted to select the most frequently cited articles out of the WoS, which shows the number of times a specific article is cited in all journals in the database. The total citation count (TC) does not necessarily reflect the quality of the article but rather, it may indicate the scholarly impact thereof. Table 6 lists the top 10 cited articles in open innovation research. The most cited article was “The Era of Open Innovation”, which was published by Chesbrough in 2003 in *MIT Sloan Management Review*. This is also the first article that officially and systematically touched upon the concept of open innovation. In this article, Chesbrough presented an observed shift in the manner companies generate and commercialize innovative ideas by collaborating with external partners. This article was cited 852 times during 2003–2017 with an average citation count of 57 times/year.

Table 7 lists the first six articles which were published in 2003 (2), 2004 (1) and 2005 (3). Except for the very first published article in the field ‘The Era of Open Innovation (Chesbrough, 2003), none of the other five articles were in the list of the top 10 frequently cited articles.

### 3.7. Analysis of keywords

Author-provided keywords illustrate information about research trends that capture researchers’ ultimate concern (Wambu et al., 2017). We have thus identified a list of 34 keywords that have most constantly recurred in articles from 2003 to 2017. The most frequent searching term is “open

**Table 5. Top 10 journals in open innovation research during 2003–2017**

Journal	TP	Number of Articles Rank (%)	Impact factor (IF)	JCR Category	Quartile in Category
Research Policy	45	1 (4.3)	3.688	Management of Technology and Innovation Strategy and Management Management Science and Operations Research Engineering (miscellaneous)	Q1 Q1 Q1 Q1
Research Technology Management	44	2 (4.2)	0.722	Management of Technology and Innovation Strategy and Management Engineering (miscellaneous)	Q2 Q2 Q1
International Journal of Technology Management	44	2 (4.2)	0.411	Industrial Relations Strategy and Management Computer Science Applications Engineering (miscellaneous) Law	Q2 Q2 Q2 Q2 Q2
R & D Management	42	4 (4.0)	0.822	Business and International Management Business, Management and Accounting (miscellaneous) Management of Technology and Innovation Strategy and Management	Q1 Q1 Q2 Q1
Technological Forecasting and Social Change	37	5 (3.5)	1.38	Business and International Management Management of Technology and Innovation Applied Psychology	Q1 Q1 Q1
Technovation	35	6 (3.3)	2.01	Business, Management and Accounting Management of Technology and Innovation Engineering (miscellaneous)	Q1 Q1

(Continued)

**Table 5. (Continued)**

Journal	TP	Number of Articles Rank (%)	Impact factor (IF)	JCR Category	Quartile in Category
Technology Analysis & Strategic Management	33	7 (3.2)	0.61	Business, Management and Accounting Strategy and Management Decision Sciences Management Science and Operations Research	Q2 Q2
Journal of Product Innovation Management	26	8 (2.5)	3.04	Business, Management and Accounting Management of Technology and Innovation Strategy and Management Engineering (miscellaneous)	Q1 Q1 Q1
Management Decision	22	9 (2.1)	0.54	Business, Management and Accounting Business, Management and Accounting (miscellaneous) Decision Sciences Management Science and Operations Research	Q1 Q2
Creativity and Innovation Management	21	10 (2.0)	0.75	Business, Management and Accounting Management of Technology and Innovation Strategy and Management	Q2 Q2

Top 10 journals with the highest number of publications in open innovation. The JCR category demonstrated that all top journals featured “management” which indicated a close nexus between open innovation and management.

**Table 6. The 10 most frequently cited articles**

Author	Title	Journal	PY	TC	TC/Year
Chesbrough, HW	The Era of Open Innovation	Mit Sloan Management Review	2003	852	57
Dahlander, L & Gann, DM	How Open is Innovation?	Research Policy	2010	633	79
Chesbrough, HW & Crowther, AK	Beyond High Tech: Early Adopters of Open Innovation in Other Industries	R & D Management	2006	543	45
Vandevrande, V et al.	Open Innovation in SMEs: Trends, Motives and Management Challenges	Technovation	2009	498	55
Enkel, E et al.	Open R&D and Open Innovation: Exploring the Phenomenon	R & D Management	2009	467	52
Huizingh, EKRE	Open Innovation: State of The Art and Future Perspectives	Technovation	2011	437	62
Gassmann, O et al.	The Future of Open Innovation	R & D Management	2010	385	48
Cooper, RG	Perspective: The Stage Gate (R) Idea to Launch Process Update, What's new, and Nexgen Systems	Journal of Product Innovation Management	2008	335	34
Lee, S et al.	Open Innovation in SMEs: an Intermediated Network Model	Research Policy	2010	314	39
Chesbrough, HW & Appleyard, MM	Open Innovation and Strategy	California Management Review	2007	300	27

PY: Publication year; TC: total citation since its publication to 2017

The 10 most frequently cited articles on open innovation. "The era of open innovation" by Chesbrough (2003) ranked top and it is also the first article systematically discussing open innovation phenomenon among companies.

innovation" (569 times), followed by "innovation" (110), "absorptive capacity" (40), "crowdsourcing" (39), "collaboration" (27), "intellectual property" (25) and "knowledge management" (24).

Since open innovation has been discussed in a wide array of industries from various perspectives during 2003 and 2017, we would highlight the need to generate a topical taxonomy of the multiple strands of research which touch upon open innovation. In light of this, four themes of keywords were identified: (1) intangible assets; (2) business performance; (3) firm openness; (4) innovation capacity.

### 3.7.1. Intangible assets

The relationship between open innovation and intangible assets has garnered huge attention among researchers in the last three decades (Grimaldi, Corvello, Mauro, & Scarmozzino, 2017). Our finding showed that there were three keywords in this group, namely: (1) intellectual property, (2) open source software (3) R&D. These three keywords exhibited a downward trend throughout the period 2003–2017, which indicated a decreasing interest of researchers regarding intangible assets with reference to open innovation. For instance, "intellectual property" was ranked third

**Table 7. The first six articles in open innovation**

Author	Title	Journal	PY
Chesbrough, HW	The Era of Open Innovation	Mit Sloan Management Review	2003
Chesbrough, HW	The Logic of Open Innovation: Managing Intellectual Property	California Management Review	2003
Chesbrough, HW	Managing Open Innovation	Research Technology Management	2004
Kirschbaum, R	Open Innovation in Practice	Research Technology Management	2005
Cooke, P	Regionally Asymmetric Knowledge Capabilities and Open Innovation Exploring 'Globalisation 2': A New Model of Industry Organisation	Research Policy	2005
Christensen, JF	The Industrial Dynamics of Open Innovation Evidence from the Transformation of Consumer Electronics	Research Policy	2005

PY: Publication year

during both periods 2006–2008 and 2009–2011, then slightly falling to the fifth position in 2012–2014 before plunging to 34<sup>th</sup> ranking in 2015–2017.

The rationale behind this downward trend lies in the shift of business management of innovation from closed innovation to open innovation paradigm. Traditionally, intangible asset or intellectual property (IP) represents the outcome of business internal R&D initiative and is the centrepiece of a company's closed innovation management (Chesbrough, 2003). When companies shift their innovation management towards a more open approach, the control over their proprietary ideas and expertise is inevitably more challenging (Hossain, 2012). Collaboration with partners outside their organization in the form of joint ventures or strategic alliances requires joint R&D effort for creating or developing shared innovative ideas and expertise. The focus on IP as the business asset of one party in such collaborative relationships has been dissipated, which arguably justifies the decreasing frequency of keywords in this “intangible assets” group.

Interestingly, it should be noted that the protection mechanism of IP tends to be signified in an open innovation environment. Put it another way, businesses appear to seek forms of protecting their intangible assets by means of either “legal mechanism” (IP rights such as patents, trade secret, copyright and non-disclosure agreements) or ‘natural barriers to imitation (challenge in reverse engineering and tacitness of relevant technology) (Piscano & Teece, 2007) or a combination of both mechanisms.

### 3.7.2. Business performance

An upward trend was observed in the “business performance”, which included “firm performance”, “innovation performance” and “new product development”. These terms did not emerge in open innovation articles until 2009–2011. “Innovation performance” and “firm performance” started in the 69<sup>th</sup> place (0.68%) but boosted to rank 6<sup>th</sup> and 13<sup>th</sup> respectively in 2015 and 2017. “New product development” began higher at rank 24<sup>th</sup> in 2009–2011 and jumped to the 8<sup>th</sup> position in the next 2-year-period, however, slightly decreased to rank 11<sup>th</sup>.

By featuring interactions with other firms and using external source of knowledge, an open innovation paradigm affects the innovating capability of firms (Chesbrough, 2003). This justified the increasing number of research papers on innovation performance in relation to open innovation. The keyword “new product development” also followed an increasing trend since it is a part of

innovation performance. In the literature, there are two types of innovation performance: efficiency—“reduced development risks, costs and time to market” and novelty “entailing new products, processes, or access to new markets” (Lazzarotti, Bengtsson, Manzini, Pellegrini, & Rippa, 2017; Stefan & Lars Bengtsson, 2017). “New product development” specifically highlights “novel” features, which would thus reflect innovation performance. The rise in articles featuring “firm performance” as a keyword was possibly attributable to its relationship with “innovation performance”. Accordingly, “firms with high R&D and market information management capabilities benefit from open innovation, and find it easier to find new ideas and technologies outside, and have better product portfolio innovativeness”, which improves firm financial performance (Rubera, Chandrasekaran, & Ordanini, 2016).

### 3.7.3. *Firm openness*

One of the most important principles of open innovation is the exploration and exploitation of expertise outside the organization (Chesbrough, 2003). The mindset of openness is arguably a prerequisite for an organization to pursue their open innovation goals. It would constantly necessitate firm’s engagement into certain forms of cooperation with partners either intra- or cross its organization. In this regard, three keywords which point to the concept of firm openness were identified: “crowdsourcing”, “collaboration” and “co-creation”. All three keywords showed a general upward tendency: “crowdsourcing” and “collaboration” were both ranked 24<sup>th</sup> (1.4%) in the period 2009–2011 before jumping to the 4<sup>th</sup> (5.5%) and 5<sup>th</sup> (3.8%) position, respectively, during the time 2015–2017; meanwhile, “co-creation” went through some fluctuations, being at the 24<sup>th</sup> position (2009–2011) and going down to 55<sup>th</sup> (2012–2014) before sharply stepping up to 9<sup>th</sup> (2015–2017).

The upward trend in the frequency of “crowdsourcing”, “co-creation” and “collaboration” as a keyword is attributable to the booming of communication and internet technologies. According to (Deng, Yang, Tong, Dong, & Peng, 2012; Geri, Gafni, & Bengov, 2017), the scaling-up of interconnectivity obtained through Internet-based technologies has transformed the manner to accomplish organizational tasks. Firms could now easily enhance their interactions with external players such as customers (mostly shown in co-creation scenarios), partners in joint-ventures or even a large-undefined crowd who could potentially provide innovative solutions to the company’s existing problems (as in the case of crowdsourcing).

### 3.7.4. *Innovation capacity*

An upward trend was also noted in the keyword group of “innovation capacity” comprising three keywords: “absorptive capacity”, “entrepreneurship” and “radical innovation”. “Absorptive capacity” and “entrepreneurship” witnessed an improvement in its ranking from 8<sup>th</sup> (7.4%) in 2006–2008 to 5<sup>th</sup> (3.4%) in 2009–2011. Nonetheless, in the period 2012–2014, both “absorptive capacity” and “entrepreneurship” fell to the 8<sup>th</sup> and 30<sup>th</sup> position respectively before climbing to the 3<sup>rd</sup> and 9<sup>th</sup> position in 2015–2017. Not until 2014–2016 did the term “radical innovation” emerge in the literature and it experienced a surge in ranking from 30<sup>th</sup> to 18<sup>th</sup> in 2015–2017.

As companies engaged in open innovation, they tend to create radical innovation and sell more new products (Inauen & Schenker-Wicki, 2012). However, radical innovation is also considered risky due to its connection with uncertain development, complex customer engagement and marketing process (Lassen & Laugen, 2017). This character matches with the basis of entrepreneurship that is “seeking for opportunities and risk taking” (Rangus & Slavec, 2017). Rangus and Slavec (2017) also found the flexibility in an entrepreneurial culture that looked for new opportunities of technology and market trends, and this created the necessary environment in terms of collaboration and information that foster radical innovation. Confronted with a vast range of information, firms would avail themselves of their “absorptive capacity”, which refers to the extent to which firms can learn from outside knowledge and apply it to internal technologies and processes (Presenza, Abbate, Meleddu, & Cesaroni, 2016). This capacity enables the exchange and combination of information from different sources and creates new information. “Absorptive



capacity” is thus one important driving force of radical innovation (Flor, Cooper, & Oltraa, 2018; Ritala & Hurmelinna-Laukkanen, 2012).

### **3.8. Article titles and keywords plus**

The title of an article contains information that the author values most to deliver to readers. We found a recurrence of at least 36 items, among which the most frequent ones were “innovation” (752 times), “open” (549), “knowledge” (114), “performance” (90), “technology” (85), “industry” (75), “role” (66) and “firms” (61), indicating that mainstream issues were knowledge creation through open innovation, the role of different elements constituting open innovation paradigm and the role of open innovation in firm performance in a wide range of industries (including but not limited to technological field). This notion is consistent with the prominence of “business performance” and “firm openness” in open innovation that is demonstrated in the previous section on author-keywords analysis. While the most frequent search terms “innovation” and “open” remained unchanged over different periods of research, the terms “performance”, “role” and “firms” featured more prominently in recent years. For example, “performance” was at 4<sup>th</sup>, 8<sup>th</sup>, 4<sup>th</sup>, 3<sup>rd</sup> position in the period of 2006–2008, 2009–2011, 2012–2014 and 2015–2017, respectively.

Keywords Plus provides additional search terms and is extracted from the manuscript titles of papers which are cited by authors in their bibliographies and footnotes in the ISI database (Garfield, 1990). The Keywords Plus analysis may reveal further details about the contents of the articles. At least 47 searching terms were found with a minimum frequency of 25 times within research articles in open innovation during the period 2003–2017. In general, the most repetitive terms in the Keywords Plus category were “research and development” (276 times), “performance” (268), “absorptive capacity” (185), “knowledge” (167), “product development” and “firms” (both 153 times), “technology” (142), “industry” (130) and “management” (115), which all indicated hotspots in open innovation research. Our result showed that increasing attention was clearly given to the first three above-listed terms along with “perspective”, “firm performance” and “impact”, whose ranks steadily rose throughout the period under study. On the other hand, a number of search terms appeared to lose ground, such as “knowledge”, “product development”, “firm”, “firms”, “innovation”, “strategy”, “open source software”, “capabilities” and “biotechnology”.

### **4. Conclusion**

This bibliometric investigation of articles on open innovation research has disclosed some significant findings regarding the research performance worldwide from 2003 to 2017. Europe was the most productive continent with a highlight of Italy’s remarkable surge of 150% in articles between 2016 and 2017. The analysis of the research performance by country, however, showed that among 60 countries involved in open innovation research, the USA remained the leading country with respect to all metrics: total articles, first author, corresponding author, single country and international collaboration. This might attribute to the fact that the USA hosts the world’s most productive institute: the University of California, where Prof. Henry William Chesbrough as the pioneer in open innovation study published most articles. Further, it was discovered that open innovation papers were published by top journals which shared one common area of “management” regarding their subject categories. This indicates that open innovation was particularly significant for managers. An analysis of author-keywords demonstrated that while the keywords group of “intangible assets” was on a downward trend, the other three groups of “business performance”, “firm openness” and “innovation capacity” tended to come under the spotlight. This suggests that future work should continue to examine the multiple interfaces between open innovation and firm’s tendency towards collaborations within and beyond its organizational boundaries. Moreover, research focus can be directed towards firm practices of open innovation policy to optimize its performance and the follow-up effect of the adoption and practices of open innovation in enhancing a firm’s innovation capability. Our findings also highlighted the significant role of open innovation as a driving force of knowledge creation in a broad range of industries. This paper thus contributes to the insight of research trends in open innovation, providing important guidelines for academics in the field. It also has significant managerial implications as it further

highlights the role of open innovation in the area of management and draws out important rationale for the adoption of open innovation model.

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#### Notes

1. These three goals were initially set by the European Commissioner Carlos Moedas in a speech in June 2015 showing how research and innovation contribute across the political priorities of the European Commission. The Three Opens policy did not address a new policy initiative or funding program as such but came to reinforce existing programs, for instance Horizon 2020, and reinvigorate existing policies such as the European Research Area. More information is available: [http://europa.eu/rapid/press-release\\_SPEECH-15-5243\\_en.htm](http://europa.eu/rapid/press-release_SPEECH-15-5243_en.htm) (Accessed 8 May 2019).
2. This landmark initiative by the USPTO opened the patent examination process to public participation. Peer-to-Patent provided an online platform for the community to use its own expertise to review and render feedback on the claims of pending patent applications. The patent examiner would subsequently make final decisions based on certain legal requirements. More information is available: < <https://www.peertopatent.org/> (Accessed 7 May 2019).
3. The program which was based on a Wiki-and-blog-based approach invited citizens to openly edit and share their opinions on the plans for the city future

development. After two months, 2,000 people engaged in the phase of idea sharing via 30 face-to-face events and 2,000 people joined in online conversations ending up with a total number of 970 ideas for the future plan of the city. More information is available: <https://participate.melbourne.vic.gov.au/future> (Accessed 7 May 2019).

4. The United States Agency for International Development (USAID), the US governmental agency that aims to provide economic and humanitarian assistance worldwide, released an open call for mobile technology applications for developing countries. The Development 2.0 Challenge was the first open source challenge hosted by USAID. The challenge was also based on a Website platform where anyone could log in to comment and then vote for the best idea.
5. Accordingly, the Innovation Union was developed in parallel with the flagship initiative on an Industrial Policy for the Globalization Era. It is hailed as key to achieving the goals of the Europe 2020 Strategy for a smart, sustainable and inclusive economy. It aims to engage all actors and regions in the innovation cycle. See more: [https://ec.europa.eu/research/innovation-union/pdf/innovation-union-communication\\_en.pdf](https://ec.europa.eu/research/innovation-union/pdf/innovation-union-communication_en.pdf) (Accessed 24 December 2018).
6. In 2015, Commissioner Carlos Moedas set three main policy goals for the EU research and innovation including open innovation, open science and open to the world. See more: [https://ec.europa.eu/info/research-and-innovation/strategy/goals-research-and-innovation-policy/innovation-union\\_en](https://ec.europa.eu/info/research-and-innovation/strategy/goals-research-and-innovation-policy/innovation-union_en) (Accessed 24 December 2018).
7. More information is available: <https://www.sviluppoeconomico.gov.it/index.php/it/industria40> (Accessed 4 January 2019).

#### Cover image

Source: Author.

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