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Recent Research Trends in Open Innovation in SMEs: A Bibliometric Literature Review

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Abstract

Open innovation (OI) has captured the attention of both academics and practitioners since its inception. However, research on OI in small and medium-sized enterprises (SMEs) has experienced rapid growth in recent years. Our research aims to scrutinize the evolution of scientific production and emerging research themes of OI in SMEs. The study employs a bibliometric analysis using the Scopus database and the ARTIREV software. The findings indicate a considerable increase in the scientific production of research on OI in SMEs, with the last five years contributing the most. Additionally, the most relevant and involved constituents of research on OI in SMEs are illuminated alongside the most productive and influential publications and authors. The study also sheds light on several divergent research themes concerning firm and innovation performance, business model innovation, OI practices, OI challenges, OI in crisis times, entrepreneurship, economic growth, and sustainable innovation. Our study provides a detailed overview of the research contexts of OI in SMEs for future research investigations.

Keywords: open innovation; small and medium-sized enterprises; SMEs; bibliometric analysis; document bibliographic coupling analysis; performance analysis

1. INTRODUCTION

Twenty years ago, the term “Open Innovation” (OI) was coined (Chesbrough, 2003). The concept of OI refers to “*valuable ideas can come from inside or outside the company and can go to market from inside or outside the company as well*” (Chesbrough, 2003, p.43). The primary purposes of OI models are to accelerate internal innovation and accumulate

additional value through the market by using both outside-in and inside-out movements of knowledge and technologies between different actors (Chesbrough & Crowther, 2006). This open mode allows partners to benefit simultaneously from the open process using external sources and a closed model based on property protection and exploitation. Researchers have successfully synthesized different concepts and have attracted the attention of managers, academics, and policymakers to the open processes. After the advent of the concept, research on OI immediately began burgeoning in the innovation literature, yet primarily focused on large enterprises (e.g., Chesbrough & Crowther, 2006; Gassmann & Enkel, 2004; Henkel, 2006; Laursen & Salter, 2006; Lecocq & Demil, 2006; Lichtenthaler, 2008). Research has identified three modes of OI, including inbound (outside-in), outbound (inside-out), and coupled (Enkel et al., 2009; Gassmann & Enkel, 2004). This classification stresses the intentional nature of OI, comprising “*purposive inflows and outflows of knowledge to accelerate internal innovation*” (Chesbrough, 2006, p.01). The inbound mode of OI describes the acquisition of external discoveries and knowledge to drive internal innovation (Chesbrough & Crowther, 2006). In contrast, the outbound OI refers to strategies in which firms open up their organizational boundaries to externalize their knowledge and innovation to markets (Gassmann & Enkel, 2004). However, firms combine inbound and outbound by cooperating with external partners in strategic networks (Gassmann & Enkel, 2004) to jointly develop and commercialize innovation (Enkel et al., 2009). This co-creation process is the coupled mode of OI (Enkel et al., 2009).

Most studies on OI have investigated the three main processes in large companies (Chesbrough & Brunswicker, 2013). SMEs have received limited attention in OI research (Gassmann et al., 2010). However, the existing studies confirm the importance of SMEs in the open innovation landscape (Bianchi et al., 2011; Spithoven et al., 2011). It is widely recognized that smaller companies increasingly and extensively practice open innovation

activities to overcome their “*liability of smallness*” (Gassmann et al., 2010; van de Vrande et al., 2009). Indeed, their limited resources impede the building and maintenance of collaborative networks (Huizingh, 2011; Lee et al., 2010). Another obstacle to open innovation for SMEs is their limited capacity to absorb and exploit external knowledge and, therefore, to effectively share knowledge within open innovation projects. A new understanding of knowledge management posits that knowledge-sharing cannot be stimulated by imposing structures but by social interaction and immersion in practices (Hislop, 2005).

This research focuses on the evolution of research trends of OI in SMEs through a bibliometric analysis (BA). Our goals are to present the development of research on OI in SMEs and recent research themes in the field. Therefore, our research questions are:

- 1. What are the most relevant and involved constituents (authors, institutions, journals, countries, and funding parties) in the field of OI in SMEs?***
- 2. Which publications have received the most attention in research on OI in SMEs?***
- 3. What are the research themes on OI in SMEs that have emerged over the past five years?***

The study applies performance analysis (PA) and document bibliographic coupling analysis (DBCA). PA helps to present different research constituents of the studied topic. This analysis resembles the profile of participants found in empirical research but is more analytical (Donthu et al., 2021). In contrast, DBCA is more complex and was first introduced by Kessler (1963). It is a method for science mapping working under the assumption that two publications with common references share similarities in their content (Kessler, 1963; Weinberg, 1974). The method specifies publications into thematic clusters (Zupic & Čater, 2015), allowing recent and niche publications to gain visibility through bibliographic coupling (Donthu et al., 2021). The technique used in DBCA especially redirects “*the focus of analysis from past traditions to current trends*” (Vogel & Güttel, 2013, p. 426). The greater the number of common references among documents, the more likely they belong to the same research

theme (Daniel et al., 2022). However, the method is most effective when applied within a specific timeframe (Zupic & Čater, 2015) and is ideal when aiming to explore a range of research themes and their latest developments, providing a visualization of the research landscape (Donthu et al., 2021).

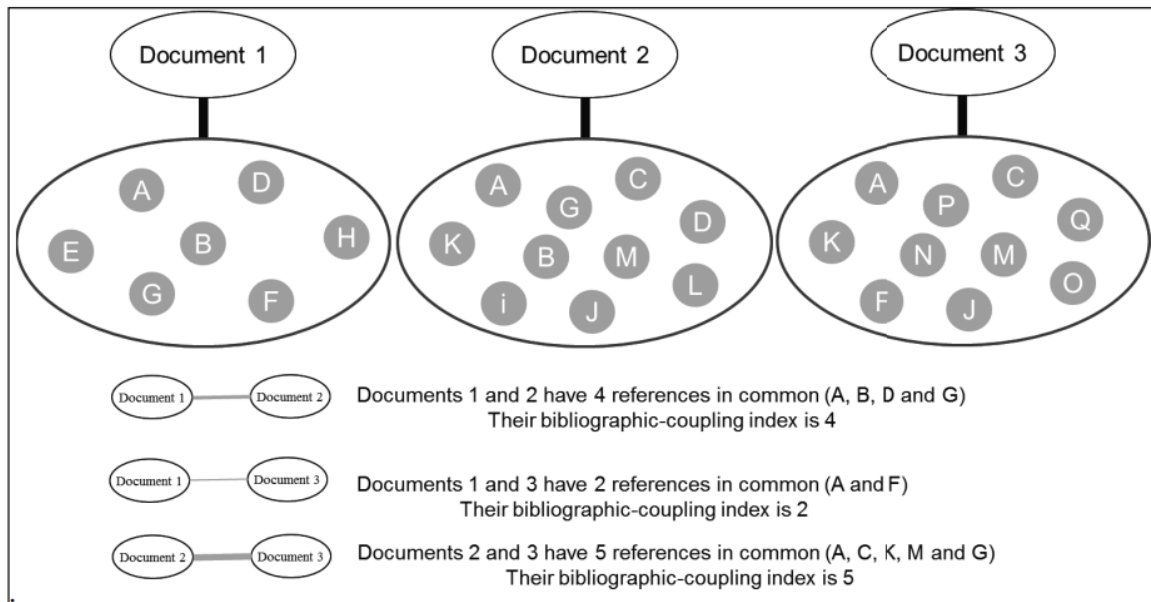


Figure 1. Bibliographic coupling of documents – Adopted from Walsh & Renaud (2017)

The following sections of the study comprise methodology – details on all methodological steps, findings – presentations of PA and DBCA, discussion – relationships and connections of the results, and conclusions – contributions and future research directions.

2. METHODOLOGY

Bibliometric analysis involves quantitatively examining bibliographic materials (Broadus, 1987). It has become a widely employed and rigorous way for researchers to handle substantial amounts of scientific data and generate significant research impact (Donthu et al., 2021). It employs mathematical and statistical techniques to increase researchers' objectivity when classifying publications in a given field (Borgman & Furner, 2002). BA, therefore, helps unravel the accumulated scientific knowledge of a specific field whilst illuminating current research themes (Donthu et al., 2021).

As shown in Figure 2, the research follows a total of 6 steps:

The first step is to select essential keywords to extract related publications within the field. The keywords were “open innovation” and “small and medium-sized enterprise*”. However, the keyword “small and medium-sized enterprise*” has various expressions. It is necessary to include all possible forms (e.g., “SME*” and other related expressions) to ensure the accurate extraction of papers. Note that the symbol “*” enables the inclusion of the plural form of the keyword.

The second step involves choosing the software. To ensure an effective and efficient bibliometric literature review, the research used ARTIREV software (**ART**ificial **I**ntelligence and Literature **RE**view)¹ – *an automated and integrated bibliometric-based artefact developed, designed, and tested/evaluated with direct input from end users* (Walsh et al., 2022). ARTIREV was selected for the following reasons: (1) direct extraction from SCOPUS through an application programming interface (API) (Walsh et al., 2022); (2) easy to use for both seasoned bibliometric experts and newcomers (Walsh et al., 2022); (3) advanced functionalities for automatically cleaning cited references to ensure reliable results and avoid time-consuming (Walsh et al., 2022); (4) automatic selection of citation thresholds and the number of documents based on the size of the database and various other parameters for effective science mapping (Walsh et al., 2022); (5) easily readable and interpretable graphical representations/maps of bibliometric outcomes (Walsh et al., 2022); and (6) software access availability.

¹ ARTIREV is a bibliometric tool developed by Scanlitt SAS, France (<https://www.scanlitt.com>) to accelerate the acquisition of scientific knowledge and the production of literature reviews. This tool enables users to identify relevant scientific articles in a field, cluster selected documents toward sense-making, and assist in prioritizing users’ readings.

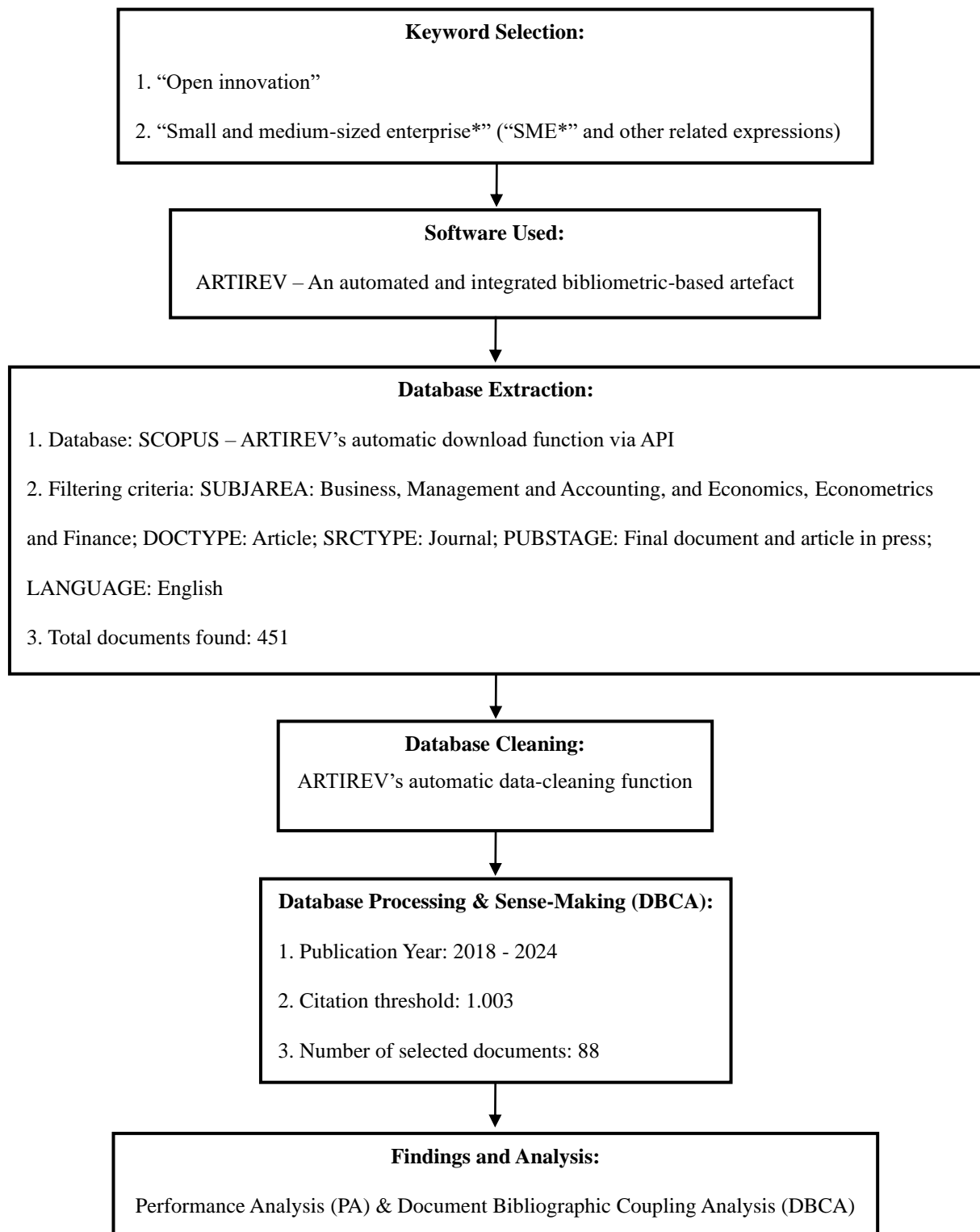


Figure 2. Research methodology structure

In **the third step**, database extraction occurred in ARTIREV in December 2023 using advanced search functions and Boolean operators. To ensure accuracy, various filtering criteria were applied. Firstly, subject areas were limited to *Business, Management, and*

Accounting, and Economics, Econometrics, and Finance, focusing on the management field. Secondly, only *articles* were selected for their representativeness and high quality (Álvarez-García et al., 2018). Thirdly, the study collected publications exclusively from *journals* recognized for their prestige within the scientific community (Thyer, 2008). Fourthly, the database included *articles in press* and *final documents*. Finally, only *English* publications were chosen due to the authors' linguistic constraints and the language's primary role in scientific dissemination (Martín-Martín et al., 2018). The established search query for database extraction was:

```
TITLE-ABS-KEY ( ( ( "open innovation" ) AND ( "SME*" OR "small and medium-sized enterprise*" OR "small and medium enterprise*" OR "small or medium enterprise*" OR "small and medium-sized business*" OR "small and medium business*" OR "small or medium business*" OR "small and medium-sized firm*" OR "small and medium firm*" OR "small or medium firm*" OR "small-sized enterprise*" OR "medium-sized enterprise*" OR "small-sized business*" OR "medium-sized business*" OR "small-sized firm*" OR "medium-sized firm*" OR "small enterprise*" OR "medium enterprise" OR "small business*" OR "medium business" OR "small firm*" OR "medium firm*" ) ) ) AND SUBJAREA ( busi OR econ ) AND DOCTYPE ( ar ) AND SRCTYPE ( j ) AND PUBSTAGE ( aip OR final ) AND LANGUAGE ( english )
```

A total of 451 documents were obtained and downloaded in ARTIREV.

The fourth step, therefore, is database cleaning, which was carried out by the software, including cited reference cleaning, identification of duplicates, and matching references poorly labelled by citing authors or presented in different formats. This process was supported by the automatic data-cleaning function of ARTIREV, which requires no manual decision-making (Walsh et al., 2022).

After cleaning the database, **the fifth step** involves processing and sense-making using the ARTIREV software. The software offers reference co-citation analysis (RCCA) and document bibliographic coupling analysis (DBCA). While RCCA identifies co-cited references, highlighting theoretical pillars and schools of thought, DBCA reveals commonalities among citing documents, helping identify research themes (Walsh et al., 2022). The present study focuses on understanding recent emerging research themes in OI in SMEs. Consequently, only DBCA was considered, with default parameters retained for final science mapping. Eighty-eight documents from the last five years, cited at least 1.003 times the average, were deemed most significant. The goal of employing ARTIREV is to generate a science map of recent research trends accomplished during the sense-making stage using default parameters set during processing.

The final step features two distinct analyses: (1) performance analysis encompassing the number of publications/citations by year, authors, affiliations, journals, countries, and sponsoring parties, and (2) document bibliographic coupling analysis enabling visualization of clusters that represent recent research themes in the field (Walsh et al., 2022).

3. FINDINGS

3.1. Performance Analysis

Evolution of the number of publications/citations on OI in SMEs

Since the study aims to identify all publications that had covered the research topic, there were no time restrictions. This resulted in identifying 451 articles in the Scopus database focusing on OI in SMEs from 2007 to 2024. These articles received 17,395 citations, with the ones published in 2017 gaining the most. The earliest articles in 2007 addressed regional innovation systems (Torkkeli et al., 2007) and innovation policies in European Union (Vigier, 2007). Figure 3 illustrates a steady increase in publication trends, particularly with a notable

surge in the last five years (2019-2023), contributing 59.42% to the overall production. The most prolific year was 2023, with 68 articles, and the highest growth rate occurred in 2017, witnessing a remarkable 168.75% increase, followed by 2019 with a 115% rise.

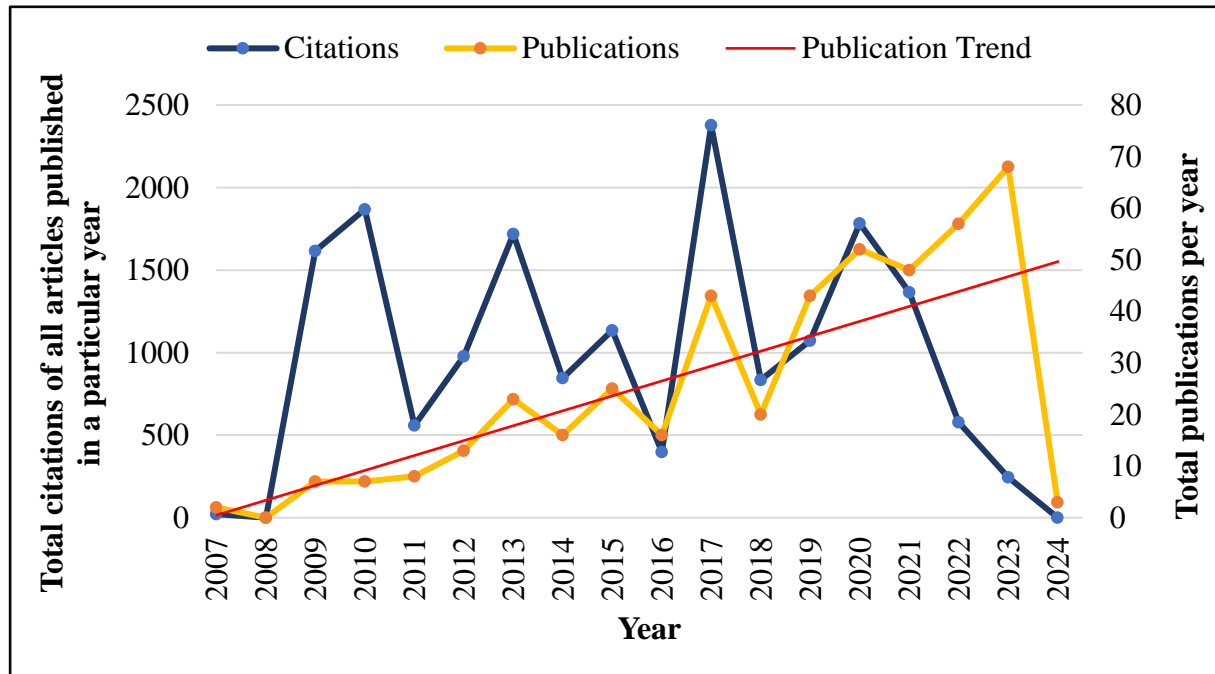


Figure 3. Evolution of scientific production of OI in SMEs
Most cited articles

Rank	Authors	Title	Year	Journal	Citations
1	van de Vrande et al.	Open innovation in SMEs: Trends, motives and management challenges	2009	Technovation	1509
2	Lee et al.	Open innovation in SMEs-An intermediated network model	2010	Research Policy	1010
3	Parida et al.	Inbound Open Innovation Activities in High-Tech SMEs: The Impact on Innovation Performance	2012	Journal of Small Business Management	582
4	Brunswicker & Vanhaverbeke	Open Innovation in Small and Medium-Sized Enterprises (SMEs): External Knowledge Sourcing Strategies and Internal Organizational Facilitators	2015	Journal of Small Business Management	498
5	Spithoven et al.	Open innovation practices in SMEs and large enterprises	2013	Small Business Economics	431
6	Spithoven et al.	Building absorptive capacity to organise inbound open innovation in traditional industries	2010	Technovation	333

7	Scuotto et al.	Shifting intra- and inter-organizational innovation processes towards digital business: An empirical analysis of SMEs	2017	Creativity and Innovation Management	274
8	Spithoven et al.	Building absorptive capacity to organise inbound open innovation in traditional industries	2011	Technovation	274
9	Popa et al.	Antecedents, moderators, and outcomes of innovation climate and open innovation: An empirical study in SMEs	2017	Technological Forecasting and Social Change	259
10	Scuotto et al.	Knowledge-driven preferences in informal inbound open innovation modes. An explorative view on small to medium enterprises	2017	Journal of Knowledge Management	255

Table 1. Most cited articles

Table 1 lists the most-cited articles on OI in SMEs, representing 31.20% of total citations. All of them are published in high-ranked journals and have been cited over 250 times in Scopus. The leading article is the publication of van de Vrande et al. (2009), published in *Technovation* (1509 citations). This work investigates 605 SMEs in the Netherlands to understand OI application incidence and common trends. SMEs in the Netherlands, especially medium-sized firms, are increasingly involved in OI and tend to be more heavily engaged than their smaller counterparts. The purposes and motivations for Dutch SMEs to practice OI are associated with market-related motives to catch up with their competitors or address customer demands. SMEs that adopt OI practices face challenges concerning organizational and cultural aspects due to their external exposure (van de Vrande et al., 2009). The second article is from Lee et al. (2010), published in *Research Policy* (1010 citations). This publication addresses the concept of OI in Korean SMEs and emphasizes the importance of an intermediary input in driving innovation. The authors report Korean SMEs' success in adopting OI through an intermediated network, indicating that effective networking facilitates SMEs' innovation capabilities (Lee et al., 2010). The third article (500 citations) published in *Journal of Small Business Management* belongs to Parida et al. (2012). This article

investigates the impacts of four different inbound OI practices on SME innovation performance. The authors examine 252 high-tech SMEs in Sweden to demonstrate that divergent inbound OI practices contribute positively to distinct innovation outcomes in SMEs (Parida et al., 2012).

Two papers have obtained between 400 and 500 citations. The publication by Brunswicker & Vanhaverbeke (2015) in *Journal of Small Business Management* (498 citations), explores the engagement of SMEs in external knowledge sourcing (Brunswicker & Vanhaverbeke, 2015). The paper by Spithoven et al. (2013) in *Small Business Economics*, deeply analyses differences in innovative performance between SMEs and large firms in adopting OI practices (Spithoven et al., 2013).

The remaining articles include two papers by Spithoven et al. (2010, 2011) in *Technovation*, one from Scuotto et al. (2017) in *Creativity and Innovation Management*, Popa et al. (2017)'s publication in *Technological Forecasting and Social Change*, and another by Scuotto, Del Giudice, Bresciani, et al. (2017) in *Journal of Knowledge Management*. All five of these publications have received between 250 and 350 citations.

Most productive authors

In Figure 4, *Alberto Di Minin* and *Gabriele Santoro* lead with nine scientific publications each. However, *Santoro* has obtained more citations (708) than *Di Minin* (443). Although they have not collaborated on articles, their research converges on various topics. These include Big Data for OI (Del Vecchio et al., 2018; Scuotto, Santoro, et al., 2017), OI driving digital transformation (Crupi et al., 2020; Jabeen et al., 2022), external knowledge sourcing (Del Sarto et al., 2023; Santoro et al., 2018, 2021), OI propensity (Marullo et al., 2021; Santoro, Quaglia, et al., 2020), and OI practices (Costa et al., 2023; Marullo, Di Minin, et al., 2020; Marullo, Minin, et al., 2020; Santoro, 2017; Santoro et al., 2019). As mentioned earlier, *Wim Vanhaverbeke* has the most-cited article, and this author's studies (8) have also received the

highest number of citations (2635) on the research topic. His articles concentrate on strategic topics such as challenges and advantages of OI practices in SMEs (Livieratos et al., 2022; Spithoven et al., 2013; van de Vrande et al., 2009), entrepreneurship (Usman et al., 2023; Usman & Vanhaverbeke, 2017), stakeholder engagement (Grama-Vigouroux et al., 2020), external knowledge sources (Brunswicker & Vanhaverbeke, 2015), and business model innovation (Albats et al., 2021).

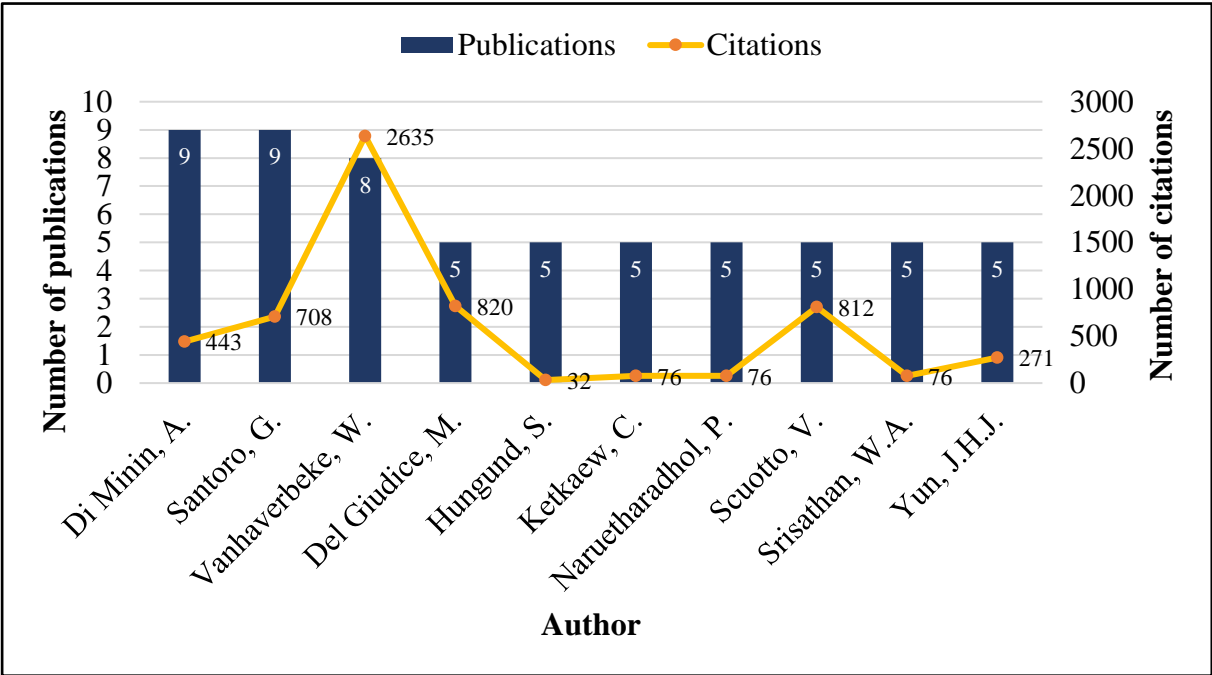


Figure 4. Most productive authors

The last seven authors in Figure 4 all have the same number of published articles (5) on OI in SMEs. Note that two prominent authors, *Giudice Manlio Del* and *Scuotto Veronica*, have obtained 820 and 812 citations, respectively, and share four common articles. Their research topics relate to digital innovation (Del Giudice et al., 2021; Scuotto, Santoro, et al., 2017), social media networks (Scuotto, Del Giudice, Peruta, et al., 2017), and knowledge-driven approaches and inbound OI practices (Scuotto, Del Giudice, Bresciani, et al., 2017).

Most influential journals

Rank	Journal	Articles	Citations	SJR 2022
1	Journal of Open Innovation Technology Market and Complexity	44	922	0.736
2	Technological Forecasting and Social Change	19	1249	2.644
3	International Journal of Innovation Management	17	163	0.488
4	European Journal of Innovation Management	16	319	1.142
5	Technovation	16	2599	2.410
6	Technology Analysis and Strategic Management	13	475	0.774
7	Journal of Business Research	12	632	2.895
8	IEEE Transactions on Engineering Management	10	133	1.002
9	Journal of Knowledge Management	10	876	2.220
10	International Journal of Entrepreneurship and Innovation Management	9	153	0.298

Table 2. Most influential journals
Note: SJR = SCImago Journal Rank

Journal of Open Innovation Technology Market and Complexity leads Table 2 with 44 published articles on OI in SMEs. Despite its relative longevity compared to other journals, it has fostered a welcoming environment for scholarly discussions. Following closely, four different journals, namely *Technological Forecasting and Social Change* (19), *International Journal of Innovation Management* (17), *European Journal of Innovation Management* (16), and *Technovation* (16), exhibit similar publication numbers. Notably, *Technovation* stands out with the highest impact, having 2599 citations, aligning with the findings in Table 1, where it published several highly cited articles. The remaining journals, *Journal of Business Research* and *Journal of Knowledge Management* have received 632 and 876 citations, respectively. Although not leading in citations and article count, the former journal holds the highest SJR score.

Most involved countries

Figure 5 shows the most involved countries leading research on OI in SMEs. Remarkably, the top three nations are all in Europe, with the *United Kingdom* leading with 72 publications, *Italy* and *Spain* with 70 and 41 articles, respectively. Surprisingly, the *United States* has the

same number of articles (31) as *China*, despite the origin of the OI concept derived from the U.S. However, European countries dominate the ranking, with *France*, *Germany*, and *Belgium* also making significant contributions. The combined contribution of these six European nations accounts for 257 articles, comprising 56.98% of the overall scientific production. Additionally, *Indonesia* and *South Korea*, two Asian nations, are noteworthy in the ranking, with *Indonesia* surpassing *South Korea* in the number of articles despite entering the field later in 2017. *Journal of Open Innovation Technology Market and Complexity* has published most Indonesian articles (16).

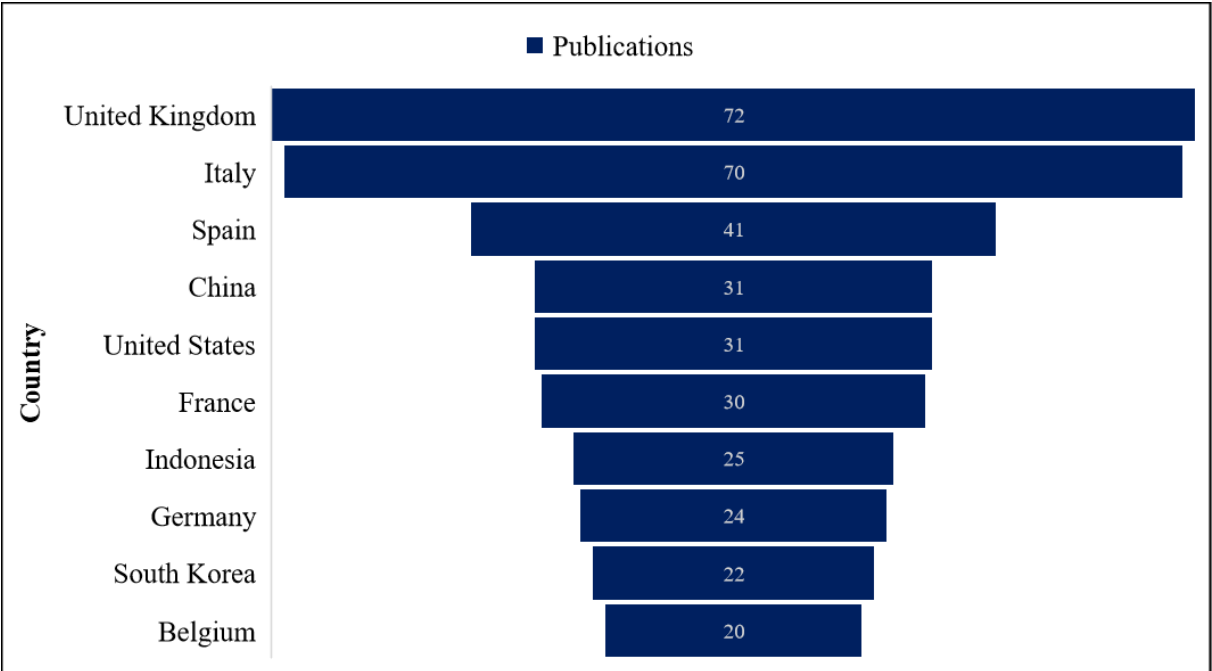


Figure 5. Most involved countries

Most relevant affiliations

Table 3 aligns with the statistics in Figure 5, with 9 out of the 10 institutions situated in Europe. Despite the United Kingdom leading in the number of publications, only *University of Cambridge* is among the most relevant affiliations. Italian institutions dominate the ranking, with four institutions (*University of Turin*, *Sant’Anna School of Advanced Studies*, *University of Padova*, and *University of Siena*) contributing 35 articles to the overall scientific production. Notably, *University of Turin* receives 1571 citations for all its affiliated articles.

Federal University of Rio Grande Do Sul stands as the sole institution from South America in Table 3, despite Brazil not appearing in the most involved countries. Additionally, while *Hasselt University* from Belgium contributes only five articles, it has the highest number of citations (2578) among the top 10, attributed to its affiliation with the most cited article.

Rank	Affiliation	Country	Publications	Citations
1	University of Turin	Italy	15	1571
2	Sant'Anna School of Advanced Studies	Italy	10	643
3	Luleå University of Technology	Sweden	7	770
4	University of Cambridge	United Kingdom	7	531
5	University of Padova	Italy	5	271
6	University of Beira Interior	Portugal	5	62
7	University of Siena	Italy	5	48
8	Federal University of Rio Grande Do Sul	Brazil	5	94
9	Hasselt University	Belgium	5	2578
10	Polytechnic University of Valencia	Spain	5	232

Table 3. Most relevant affiliations

Most sponsoring parties

Figure 6 details the top sponsors from 2007 to 2024. *European Commission* prominently funds research in this area, with other European contributors including *Horizon 2020 Framework Programme*, *Economic and Social Research Council*, *Engineering and Physical Sciences Research Council*, *Seventh Framework Programme*, and *Agence Nationale De La Recherche*. This elucidates the prevalence of research on OI in SMEs within European affiliations.

In the earlier analysis, China emerges as the leading Asian contributor, with 31 scientific publications on OI in SMEs. This can be explained by two Chinese research foundations, *National Natural Science Foundation of China* and *China Postdoctoral Science Foundation*, supporting 13 published articles. Additionally, Brazil, through *Coordenação de Aperfeiçoamento de Pessoal de Nível Superior* and *Conselho Nacional de Desenvolvimento*

Científico e Tecnológico, plays a role in funding research on the topic. This explains Brazil's absence among the most productive countries, while a Brazilian university contributes to the most relevant institutions in scientific production.

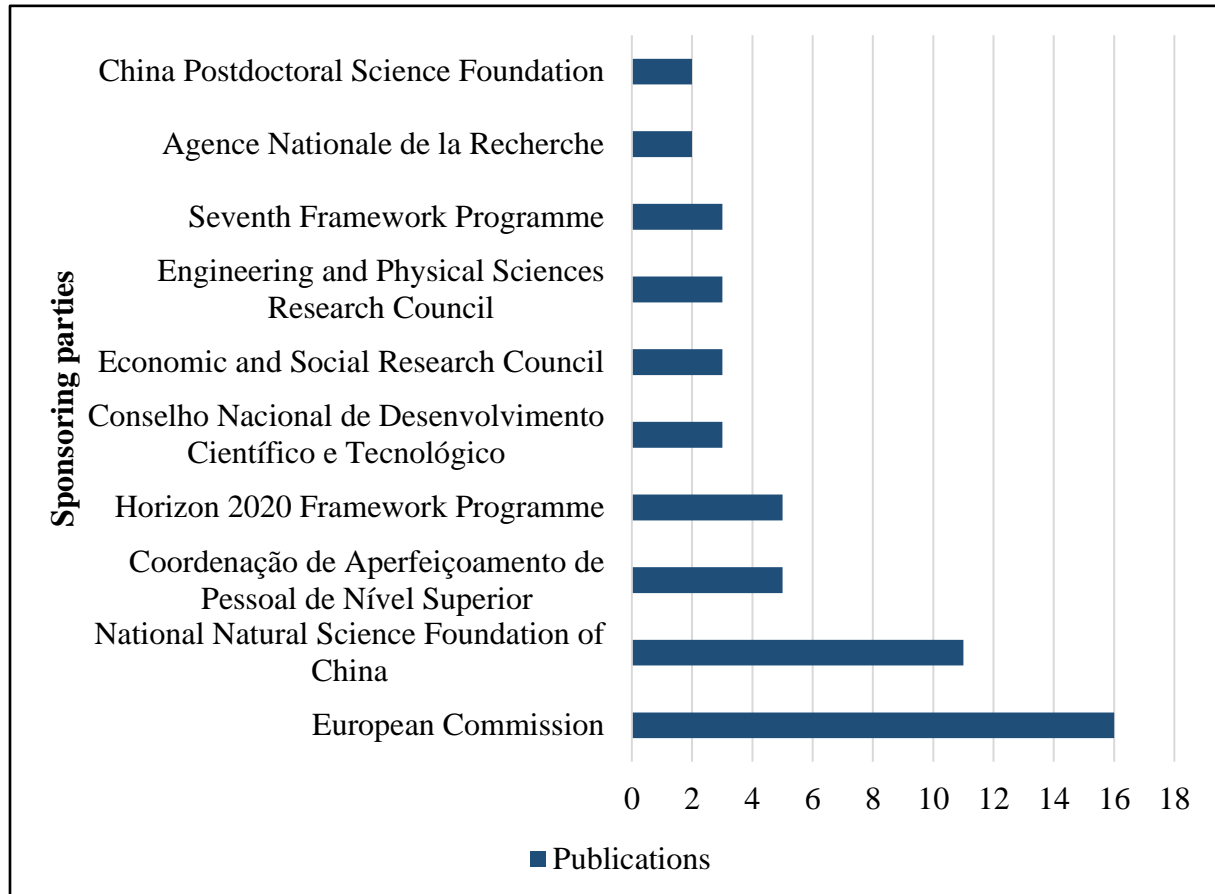


Figure 6. Most sponsoring parties

3.2.Document Bibliographic Coupling Analysis (DBCA)

The ARTIREV software enabled the selection of the most significant 88 articles out of 451 publications in the database for DBCA. Figure 7 illustrates the bibliographic coupling analysis of documents from the last five years, with 6 clusters.

The first cluster (red) in Figure 7 includes 29 articles exploring the influence of *OI adoption on innovation performance, firm performance, and business model innovation*. Singh et al. (2021) highlight OI as a pivotal driver for firm performance, indicating that top management knowledge value and knowledge creation practices influence OI based on data collected from 404 SMEs. Ngo (2023) finds that OI indirectly influences Vietnamese restaurant SMEs'

performance through cost leadership and differentiation strategies. Freixanet et al. (2021) note the mediating role of OI in the relationship between international entrepreneurial orientation and innovation performance. Tian et al. (2020) show that organizational learning ambidexterity significantly influences SMEs' innovation performance, further amplifying when openness increases. Several articles stress absorptive capacity's positive impact on OI in SMEs (Arias-Pérez et al., 2022; Cuevas-Vargas et al., 2022; Gad David et al., 2023; Jasimuddin & Naqshbandi, 2019; Woods et al., 2022). OI is a foundation for developing business model innovation in SMEs, indicating that OI plays a role as preconditions (Ibarra et al., 2020) and formation mechanisms (Liao et al., 2019).

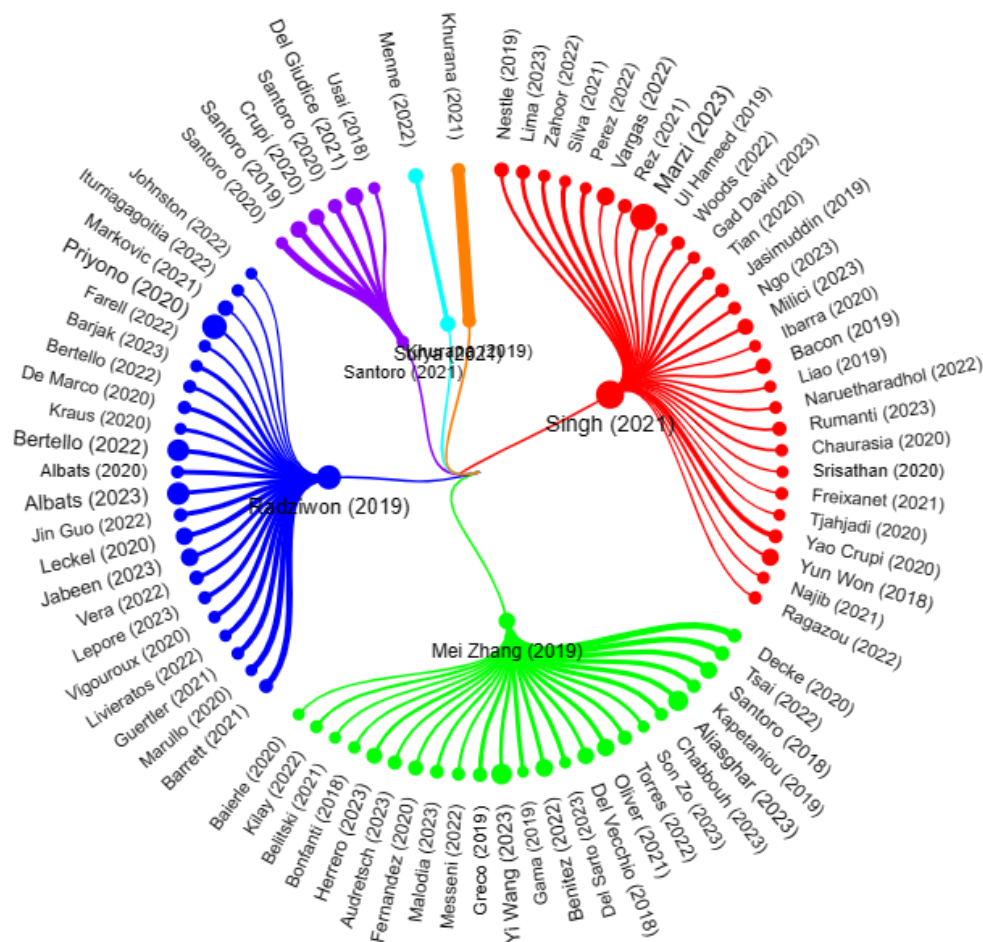


Figure 7. Recent research themes

The second cluster (green), comprising 25 articles, addresses *OI practices*. Greco et al. (2019) constructed a theoretical framework with twelve propositions highlighting benefits and

costs of inbound and outbound OI. Results show that while most firms recognize these, not all suffer from the outlined costs. Gentile-Lüdecke et al. (2020) explore how organizational elements influence OI practices. Specialization and centralization are pivotal for promoting both inbound and outbound OI, whereas formalization has a negative impact on outbound practices but is positively linked to inbound OI. However, most articles in this cluster mainly focus on inbound OI (Aliasghar et al., 2023; Benitez et al., 2021; Chabbouh & Boujelbene, 2023; Del Sarto et al., 2023; Gama et al., 2019; Gimenez-Fernandez et al., 2020; Hervas-Oliver et al., 2021; Oliveira et al., 2022; Santoro et al., 2018). Gimenez-Fernandez et al. (2020) investigate how R&D investments, external knowledge sourcing, and R&D policy subsidies affect innovation effectiveness in new and established small firms. The study emphasizes the potential benefits of firms being open to external sources. Del Sarto et al. (2023) show the benefits of various external knowledge sources for start-ups' innovation performance, highlighting coopetitors, educators, and investors as distinct and beneficial types. Additionally, customers are crucial external knowledge sources for SMEs (Santoro et al., 2018). Focusing on the depth dimension of external knowledge sourcing, Oliveira et al. (2022) highlight the intensity of external relationships that mitigates innovation constraints, facilitates knowledge flow, and bolsters innovation performance in emerging market firms. Other studies explore divergent aspects of inbound OI regarding relationships of inbound OI practices in the context of Industry 4.0 (Benitez et al., 2021), dynamic organizational capabilities (Chabbouh & Boujelbene, 2023), and in process innovation/simultaneous product and process innovation (Hervas-Oliver et al., 2021).

In Figure 7, **the third cluster** (dark blue) includes 23 articles focusing on *managing OI challenges and OI during crisis times*. Research on OI in SMEs during the Covid-19 pandemic focuses on changes in business models. Peñarroya-Farell & Miralles (2022) propose that OI helps understand how firms adapt their business models in hostile

environments like the Covid-19 crisis. Firms with limited digital literacy but high social capital seek partners with excellent digital capabilities for business model transformation during crises (Priyono et al., 2020). Markovic et al. (2021) highlight SMEs embracing new collaborative relationships during crises. Jabeen et al. (2022) show that external factors, like Covid-19, drive business model innovation in SMEs with OI playing a key role. Furthermore, SMEs face challenges in stable periods due to misalignments with their ecosystem's business models, as Radziwon & Bogers (2019) emphasize the importance of how SMEs perceive, organize, and manage open innovation through robust collaborative ties with members of the ecosystem. Marullo, Di Minin, et al. (2020) suggest that boundary conditions influence the effectiveness of OI search paths, learning processes, and appropriability mechanisms. Knowledge involved in OI projects exhibits diverse natures and dynamics, challenging the OI adoption of firms. Livieratos et al. (2022) introduce the "*OI move*" concept, indicating a paradox where resource-constrained SMEs engage in OI but hesitate due to attention capital demands, despite significant potential returns.

The fourth cluster (purple) in Figure 7 comprises seven articles in which the theme of *entrepreneurship* is investigated. For instance, Usai et al. (2018) scrutinize entrepreneurs' knowledge imperfections regarding open innovation. These imperfections do not limit innovation but foster resilience, promoting consistent business growth and new product development. Santoro, Santoro, Bertoldi, et al. (2020) explore the positive association between perceived resilience and entrepreneurial success, stressing the role of robust collaborative ties. In another study within this cluster, Santoro, Quaglia, et al. (2020) identify factors influencing entrepreneurs' openness propensity, emphasizing the interplay between entrepreneur-level and employee-level factors, leading to increased openness.

Clusters 5 (bright blue) and 6 (orange) each have only two articles. **The fifth cluster** explores *economic growth*, while **the sixth** focuses on *sustainable innovation*. However, their

research scope is not explicitly related to the concept of OI. For instance, Surya et al. (2021), in cluster 5, investigate various aspects, including business productivity, technological innovation, business capital support, government policies, human resource capacity, and sustainability of SMEs in Indonesia. The second paper in cluster 5 addresses a similar topic but heavily focuses on financial performance (Menne et al., 2022). In cluster 6, the first paper is a literature review on the importance of innovation for sustainability within Indian manufacturing SMEs, identifying determinants for theoretical models of sustainable oriented innovation (Khurana et al., 2019). The other article in cluster 6 is a continuation of the earlier literature review, quantitatively measuring critical factors facilitating the implementation of sustainable oriented innovation practices in micro, small, and medium enterprises (Khurana et al., 2021). Although these articles do not strictly address the OI concept, they are included in the clusters due to the appearance of the keyword "open innovation" in their title or keyword section. Additionally, papers in cluster 5 discuss technology licensing strategy, and those in cluster 6 mention OI and external collaborative strategy.

4. DISCUSSION

Research on OI in SMEs started in 2007 with only two articles. After that, it witnessed a steady increase in scientific production from 2007 to 2017, with several critical articles that mark its evolution. The study by Van de Vrande et al. (2009) addresses the motivations and purposes of SMEs in implementing open innovation practices. Other articles investigate the role of networks (Lee et al., 2010) and emphasize the importance of OI practices (Brunswick & Vanhaverbeke, 2015; Parida et al., 2012; Spithoven et al., 2011, 2013). Andre Spithoven and Wim Vanhaverbeke are the two key authors who contributed most during this period. After 2017, scientific production dramatically decreased in 2018 but stably increased until 2020. Alberto Di Minin and Gabriele Santoro are two prominent authors. Their research

concentrates on external knowledge sourcing (Santoro et al., 2018), OI practices (Marullo, Minin, et al., 2020; Santoro et al., 2019), OI propensity and entrepreneurship (Santoro, Bertoldi, et al., 2020; Santoro, Quaglia, et al., 2020). Additionally, other research considers aspects of digitalization and Big Data in OI (Crupi et al., 2020; Del Vecchio et al., 2018). After 2021, scientific production has increased significantly, with 2023 alone witnessing the publication of 68 articles. This period's three most productive authors include Chavis Ketkaew, Phaninee Naruetharadhol, and Wutthiya Srisathan. These authors collaborated during this timeframe to research open eco-innovation (Naruetharadhol et al., 2021; Srisathan, Ketkaew, Phonthanukitithaworn, et al., 2023), OI and ambidextrous innovation (Srisathan, Ketkaew, & Naruetharadhol, 2023), and OI for Industry 4.0 (Naruetharadhol et al., 2022).

While scientific production on OI in SMEs receives significant global attention, most articles are from developed European nations. This trend is due to financial support from various European foundations, especially European Commission. Among the top involved countries, China significantly contributes to OI in SME research, starting in 2011 with support from National Natural Science Foundation of China and China Postdoctoral Science Foundation. Surprisingly, despite China's substantial contribution, none of its universities feature among the relevant affiliations. In contrast, Federal University of Rio Grande Do Sul in Brazil positions itself notably among the top 10 institutions, despite Brazil not being among the top 10 nations involved. This result may be justified as an outcome of two Brazilian funding foundations appearing on the list of the most sponsoring parties.

A science map was produced in this research to help shed light on six research themes on OI in SMEs in recent years. **Cluster 1** explores the influence of OI adoption on innovation performance, firm performance, and business model innovation. In the direction of innovation performance, research investigates various perspectives that affect the adoption of OI concerning trust and dependency (Hameed & Naveed, 2019), social media usage (Freixanet et

al., 2021), social network analysis (Woods et al., 2022), organizational learning ambidexterity (Tian et al., 2020). Other research focuses on firm performance affected by knowledge-sharing practices and top management knowledge values in OI (Singh et al., 2021), cost-leadership and differentiation strategies (Ngo, 2023), eco-innovation and technological capabilities (Valdez-Juárez & Castillo-Vergara, 2021), absorptive capacity (Cuevas-Vargas et al., 2022). Additionally, some researchers have shifted from the performance focus to understanding the impact of the OI paradigm on business model innovation (Ibarra et al., 2020; Liao et al., 2019). **The second cluster** addresses the research theme of OI practices, which deal with research on inbound and outbound OI modes. External knowledge sourcing is the specific subject that several researchers pay attention to (Del Sarto et al., 2023; Gimenez-Fernandez et al., 2020; Oliveira et al., 2022; Santoro et al., 2018), as this strategy belongs to the most applied mode in OI – the inbound process (Chesbrough & Brunswicker, 2014). There is some research covering both inbound and outbound modes (Gentile-Lüdecke et al., 2020; Greco et al., 2019); the rest preferably examine only inbound OI (Benitez et al., 2021; Chabbouh & Boujelbene, 2023; Hervás-Oliver et al., 2021). **The third cluster** deals with managing OI challenges and OI in crisis times. Implementing OI can be challenging for SMEs, even those that are located in an innovation ecosystem (Radziwon & Bogers, 2019), as the nature and dynamics of knowledge involved in OI are complex (Marullo, Di Minin, et al., 2020), and OI poses both benefits and risks at the same time for firms (Livieratos et al., 2022). During crisis times, such as Covid-19, firms even face more struggles to look for partnerships (Markovic et al., 2021; Priyono et al., 2020), become quick adaptors (Peñarroya-Farell & Miralles, 2022), and innovate their business models (Jabeen et al., 2022). **The fourth cluster** delves into the research topic of entrepreneurship in OI. These studies aim to understand the knowledge and resilient mindset of entrepreneurs when adopting OI (Santoro, Bertoldi, et al., 2020; Usai et al., 2018) and the characteristics that influence their propensity

toward openness (Santoro, Quaglia, et al., 2020). Finally, **the last two clusters**, 5 and 6, point to the topics of economic growth and sustainable innovation. However, the articles within these two clusters are not explicitly related to the scope of the OI concept. They only highlight certain aspects of OI research in their content, such as licensing or external collaborative strategies.

5. CONCLUSIONS

Over the last two decades, research on OI has become well-established; however, the role of the OI paradigm in SMEs has received more attention in recent years. This research aimed to illuminate the evolution of research on OI in SMEs and the emergence of research themes in the field. The research used ARTIREV software and the Scopus database to facilitate the application of a bibliometric analysis, which helped discover the whole structure of scientific production and identify several research trends in OI in SMEs.

Initially, only two articles delved into OI in SMEs. However, by 2023, this research field witnessed a substantial increase with 68 articles. The seminal work by van de Vrande et al. (2009) is the most influential, accumulating 1509 citations. Wim Vanhaverbeke, Alberto Di Minin, and Gabriele Santoro rank among the most productive authors. The first leading journal is *Journal of Open Innovation Technology Market and Complexity*, which has a superior number of articles. Remarkably, most research originates from Europe, particularly the United Kingdom. Italian universities, such as University of Turin and Sant'Anna School of Advanced Studies, excel in institutional involvement. The dominance of Europe in this research field is due to substantial financial support from various funding foundations, particularly European Commission and programs sponsored by European Union.

The study helped shed light on divergent research trends in OI in SMEs. The most noticeable trend is how OI adoption affects firm and innovation performance and their business model

innovation. The relationship between OI and performance has been extensively explored since OI's spawning. However, OI's influences on business model innovation could be an exciting research path as OI adoption may require firm business model transformation (Chesbrough & Bogers, 2014). Note that adopting OI does not inherently mean that firms possess an open business model (Vanhaverbeke & Chesbrough, 2014). Understanding how firms with OI adoption innovate their business models from a closed to an open one and vice versa, can be intriguing. The second theme is OI practices in SMEs, in which most research focuses on the inbound OI mode, as it is the most widely applied strategy in companies (Chesbrough & Brunswicker, 2014). However, the outbound and coupled processes also play an essential role in OI (Gassmann & Enkel, 2004), and current research seems to neglect the importance of these strategies. It, therefore, is a promising direction for researchers to understand the role of these two modes in various aspects of SMEs. Other research themes were discovered in the bibliographic coupling analysis, including OI challenges, OI in crisis times, entrepreneurship, economic growth, and sustainable innovation. OI adoption can be a big challenge for SMEs since these companies face different difficulties in resources, capabilities, and liabilities of smallness and newness (van de Vrande et al., 2009; Vanhaverbeke, 2017). However, a high level of openness can help entrepreneurs and their firms identify opportunities for collaboration, innovation, and entrepreneurship (Nambisan et al., 2018). Research, therefore, on how various managerial and cognitive aspects of entrepreneurs facilitate the adoption of OI and manage OI-related risks can be a fruitful research path.

This study contributes to the literature on OI in SMEs in three ways. Firstly, it uncovers the evolutionary structure of the field by detailing constituents related to its development. Secondly, it sheds light on current research themes in the OI literature on SMEs over the last five years, helping future researchers explore specific aspects of OI in SMEs. Lastly, it provides guidance for novice researchers and doctoral students seeking to learn in the field.

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