Competitiveness and innovation of small and medium enterprises under Industry 4.0 and 5.0 challenges: A comprehensive bibliometric analysis

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Abstract

Research background: In the context of Industry 4.0 and 5.0, competitiveness is intricately linked to innovativeness and ongoing technological advancements, posing a formidable challenge for countries and organizations aspiring to thrive in this environment. Within this...
framework, the significance of innovativeness is escalating, emerging as a crucial factor for the competitiveness of enterprises and economies alike.

**Purpose of the article:** The article aims to present the structure and dynamics of research on the competitiveness of SMEs shaped on the basis of their innovativeness to further guide both research and management practice.

**Methods:** This comprehensive bibliometric analysis delves into the Scopus database to uncover the leading authors, journals, and countries driving empirical research on SME competitiveness and innovation. The study utilizes the VosViewer software to graphically represent the overarching themes explored by researchers in this field. Additionally, an analysis of the selected articles identifies trends shaping the discourse on SME competitiveness and innovation. This multifaceted approach provides a holistic understanding of the current state of research in this domain, paving the way for future directions and insights.

**Findings & value added:** In this study, the authors conduct a comprehensive analysis of the current research landscape on SME competitiveness and innovation in the digital transformation era. By identifying key challenges, opportunities, and strategies for SMEs, our findings offer valuable guidance for researchers, policymakers, and SMEs themselves in navigating the complexities of the digital transformation landscape.

**Introduction**

Small and medium-sized enterprises (SMEs) are drivers of economic growth and innovation, constituting a substantial portion of the global economy, with 99% of all businesses and contributing around 60% of business sector value-added (OECD, 2023). In the context of Industry 4.0 and the emerging dimensions of Industry 5.0, the business landscape for SMEs has experienced a profound metamorphosis. SMEs are now operating within a dynamic, digitally driven environment that presents both unprecedented opportunities and challenges. As highlighted by Skare et al. (2023), the competitiveness of SMEs in global markets is significantly contingent upon the pace and extent of their digitization efforts. This transformative era is also reshaping the conventional business models of SMEs and altering the customer value-creation process, owing to digital advancements (Matarazzo et al., 2021; Ključnikov et al., 2021; Salfore et al., 2023; León-Gómez et al., 2022).

The advent of Industry 4.0 marked a paradigm shift characterized by the integration of smart technologies, artificial intelligence, automation, and data-driven processes into traditional manufacturing and business operations (Alenizi et al., 2023). For SMEs, Industry 4.0 enhanced connectivity through the Internet of Things (IoT), advanced data analytics, artificial intelligence, and machine learning. This connectivity has empowered SMEs to optimize production processes, streamline supply chains, and improve
operational efficiency. Additionally, Industry 4.0 has facilitated a move towards mass customization, enabling SMEs to tailor products and services to meet the evolving demands of a rapidly changing market (Ghobakhloo et al., 2022).

As Industry 5.0 unfolds, the business context for SMEs is further shaped by a human-centric approach to industrialization. Industry 5.0 envisions a collaborative and symbiotic relationship between humans and machines, emphasizing the role of technology in augmenting human capabilities rather than replacing them (Hein-Pensel et al., 2023). This evolution encourages SMEs to prioritize innovation in areas such as human-machine collaboration, personalized customer experiences, and sustainable practices. The integration of technologies like augmented reality, advanced robotics, and the continued development of artificial intelligence further amplifies the potential for SMEs to excel in this new industrial landscape (Madhavan et al., 2023).

In this transformative business context, SMEs are compelled to embrace a culture of adaptability and agility. The ability to harness digital technologies for improved decision-making, customer engagement, and operational excellence becomes a cornerstone of competitiveness. Simultaneously, SMEs must grapple with cybersecurity concerns, talent acquisition for specialized skills, and the imperative to foster a culture of innovation to thrive amidst the evolving industrial landscape shaped by Industry 4.0 and the unfolding prospects of Industry 5.0. Consequently, to remain competitive and thrive in the digital age, SMEs must embrace innovation as a core competency. Innovation enables SMEs to develop new products, processes, and services that meet the evolving needs of customers and gain a competitive edge in the market (Kő et al., 2022). Moreover, innovation fosters resilience and adaptability, enabling SMEs to navigate the disruptions and uncertainties associated with technological advancements and changing market trends (Zighan & Ruel, 2023).

However, SMEs face unique challenges in the era of digital transformation, particularly in the context of Industry 4.0 and Industry 5.0, characterized by the rapid adoption of advanced technologies such as artificial intelligence, robotics, and the Internet of Things (IoT) (Espina-Romero et al., 2023). These technologies offer immense potential for enhancing efficiency, optimizing resource utilization, and fostering innovation, but they also pose significant challenges for SMEs in terms of adoption costs, integration complexities, and the need for specialized expertise (Shahadat et al., 2023).
Consequently, SMEs are engaged in unprecedented competition, expansion, and disruptive endeavors, driven by swift technological transformations (Alexa et al., 2022).

Despite the growing recognition of innovation's critical role in SMEs' competitiveness in the digital transformation era (Civelek et al., 2023), there exists a research gap in the comprehensive understanding of the specific factors and strategies that enable SMEs to effectively embrace innovation. Existing research often focuses on broad concepts and generic approaches, lacking in-depth analysis of the unique challenges and opportunities faced by SMEs in navigating the complexities of Industry 4.0 and 5.0. This research gap necessitates a systematic and comprehensive approach (Khan et al., 2023; Lewandowska, 2021; Chavez et al., 2021;). Thus, this research paper explores the role of innovation as a pillar of competitiveness for SMEs in the era of digital transformation (Industry 4.0 and 5.0) and aims to answer the following research questions:

RQ1. What is the structure of the research on SME competitiveness and innovation?

RQ2. What are the research dynamics and the most common issues being studied in the field of SME competitiveness and innovation?

RQ3. What are the research gaps and potential future research directions related to SME competitiveness and innovation in the context of Industry 4.0 and 5.0?

To address the identified gap and answer the aforementioned research questions, this paper employs bibliometric analysis of the Scopus database, a valuable method for handling large datasets. It helps identify patterns and trends that may not be apparent through traditional qualitative reviews. By systematically analyzing a substantial corpus of scholarly literature, bibliometric analysis offers a quantitative and objective assessment of research trends, emerging topics, and influential authors and institutions. The bibliometric analysis will be complemented with science mapping using the VosViewer Software. This analysis facilitates the identification of gaps in the literature, unexplored areas of research, and potential avenues for future investigation.

Overall, the paper contributes to the current state of the art by offering a comprehensive and insightful analysis of the current state of research on
SME competitiveness and innovation in the digital transformation era. It identifies key challenges, opportunities, and strategies for SMEs, providing valuable guidance for researchers, policymakers, and SMEs themselves in navigating the complexities of the digital transformation landscape.

The subsequent sections of this paper are organized as follows. The following section delineates the theoretical framework underpinning the study. The Research methods section provides an introduction to the data, sample, and methods employed. The ensuing Results section outlines the obtained results, while the Discussion section delves into the discourse surrounding these findings. The concluding section summarizes the paper, offering conclusions that include reflections on limitations, practical and theoretical implications, and avenues for future research.

Literature review

The changing landscape of competitiveness: embracing digital transformation

The notion of competitiveness has undergone a substantial metamorphosis in recent decades, primarily propelled by the advent of digital transformation. Historically, competitiveness centered around factors such as cost efficiency, economies of scale, and product differentiation (Kalinic & Brouthers, 2022). As outlined by Krynke (2021), companies sought a competitive advantage by optimizing production processes, cost reduction, and offering distinctive features or benefits to customers. This traditional approach heavily relied on physical assets, robust distribution networks, and established market positions.

The emergence of the information age prompted a paradigm shift in competitiveness, emphasizing knowledge-based factors. Popa et al. (2022) assert that companies began recognizing the significance of intangible assets, including intellectual capital, human resources, brand reputation, and innovative capabilities. According to Chang and Lin (2015), the effective acquisition, management, and leveraging of information became pivotal for gaining a competitive edge.

Digital transformation has further redefined the concept of competitiveness, necessitating companies to seamlessly integrate digital technologies into their core business operations to maintain a competitive stance. In their research, Chi (2021) underscore that digital transformation empowers
companies to augment their capabilities, provide personalized customer experiences, and harness data-driven insights for decision-making and innovation. Additionally, studies by Leung and Sharma (2021) and Rabadán et al. (2019) highlight a positive correlation between innovation and firm performance. These studies demonstrate that innovative firms tend to experience heightened sales growth, increased market share, and enhanced profitability. Moreover, they suggest that a firm’s competitive position plays a pivotal role in influencing its innovative behavior.

Digital transformation assumes a pivotal role in augmenting competitiveness across various dimensions. Primarily, through the integration of automation, data analytics, and process digitization, companies can attain heightened efficiency and productivity, as highlighted by Bonnard et al. (2021). This not only translates into cost savings, but also fosters improved responsiveness and streamlined operations. Secondly, digital technologies offer novel avenues for companies to engage with customers and provide personalized experiences, spanning online shopping, self-service portals, chatbots, and mobile apps (Wang et al., 2022b). By aligning with customer expectations, digital transformation contributes to enhanced satisfaction and the cultivation of brand loyalty.

Thirdly, digital transformation equips companies with tools and technologies to collect, analyze, and derive insights from extensive datasets (León-Gómez et al., 2022; Cuomo et al., 2021). These insights become invaluable for making informed decisions, identifying market trends, comprehending customer preferences, and optimizing overarching strategies. Fourthly, by facilitating rapid prototyping, iterative development, and swift responses to market changes, digital transformation fosters agility and innovation (Bouncken et al., 2021; Warner & Wäger, 2019). This agility enables companies to experiment with new business models, products, and services more efficiently, thereby accelerating innovation efforts and enhancing overall competitiveness.

Finally, digital transformation opens up new market opportunities, allowing companies to diversify their offerings, expand into new geographies, and penetrate emerging market segments (Schauer et al., 2021). Leveraging digital channels, companies can reach broader audiences, engage in collaborative partnerships, and tap into the burgeoning digital economy. In summary, the multifaceted impacts of digital transformation on efficiency, customer engagement, data utilization, innovation, and mar-
ket expansion collectively contribute to elevating the competitiveness of businesses in the contemporary landscape.

To conclude, digital transformation stands as a transformative force that has fundamentally redefined the paradigm of competitiveness. Its impact extends beyond conventional considerations such as cost and differentiation, embracing intangible assets, knowledge-based capabilities, and a pronounced focus on customer-centricity. Through the strategic utilization of digital technologies, companies can elevate their efficiency levels, deliver engaging customer experiences, and unearth novel avenues for growth and innovation. This holistic approach serves as a driving force behind their competitiveness in the digital age, marking a departure from traditional metrics to a more comprehensive and dynamic understanding of what contributes to success in the contemporary business landscape.

Innovation in Industry 4.0 and 5.0

The intersection of innovation with the advent of Industry 4.0 and its subsequent evolution to Industry 5.0 has wielded a profound impact on industrial processes. Industry 4.0, characterized by the seamless integration of cyber-physical systems, the Internet of Things (IoT), and advanced data analytics, has been a catalyst for enhanced innovation capabilities (Dixit et al., 2022). This integration allows for real-time data-driven decision-making, predictive maintenance, and streamlined production processes, facilitating agile innovation. Companies can swiftly respond to customer needs and market trends, thereby enhancing their innovative capacities.

Simultaneously, Industry 4.0 fosters the creation of collaborative innovation ecosystems, bringing together diverse stakeholders and endorsing open innovation practices (Shvetsova & Lee, 2021). These ecosystems promote collaboration among companies, suppliers, customers, and even competitors, facilitating cross-sector partnerships and knowledge exchange. Organizations, by leveraging these collaborative networks, gain access to external expertise and resources, propelling innovation and the development of novel value propositions.

In the progression from Industry 4.0 to Industry 5.0, the latter builds upon the technological foundations of the former by prioritizing the reintegration of human skills and creativity into the production system (Aslam et al., 2020). Industry 5.0 emphasizes human-machine collaboration and the
augmentation of human capabilities through artificial intelligence (AI) and robotics. This approach enables organizations to foster human-centered innovations that harness unique human qualities such as creativity, empathy, and problem-solving skills. Industry 5.0, by combining human ingenuity with technological advancements, serves as a catalyst for innovation that is both technologically advanced and deeply rooted in human-centric attributes.

To conclude, Industry 4.0 paves the way for agile innovation, leveraging advanced technologies and collaborative ecosystems, while Industry 5.0 places emphasis on human-centered innovations. Nevertheless, organizations are confronted with challenges inherent in the realm of technological transformation.

Innovation challenges for SMEs in the digital age

In recent years, the emergence of Industry 4.0 and the wave of digital transformation have become pivotal drivers of competitiveness and innovation across various industries. This manufacturing and automation revolution is characterized by the seamless integration of technologies such as the Internet of Things (IoT), artificial intelligence (AI), big data analytics, and cloud computing. Despite the promises of numerous benefits, the adoption of Industry 4.0 technologies poses significant challenges for small and medium-sized enterprises (SMEs).

Numerous studies underscore that a primary challenge faced by SMEs in adopting Industry 4.0 technologies is the scarcity of resources (Hein-Pensel et al., 2023) and expertise (Azevedo & Almeida, 2021). Unlike large corporations, SMEs often operate within constrained financial capacities, limiting their ability to invest in expensive technological infrastructure and skilled labor. This financial limitation hampers their effective utilization of the potential of Industry 4.0 technologies, impeding their competitiveness and innovation. Roblek et al. (2021) highlight that digital transformation necessitates a shift in mindset and organizational culture for SMEs. To adapt to the rapid changes brought about by Industry 4.0, SMEs must embrace a more agile and flexible approach, requiring not only financial resources but also a transformation in the skill sets of employees and the management’s willingness to drive and embrace change.
Research by Amaral and Peças (2021) emphasizes the imperative of ensuring data security and privacy. The increased connectivity and data exchange in Industry 4.0 compels SMEs to invest in robust cybersecurity measures to safeguard sensitive information. However, this presents a significant challenge, given that SMEs often lack the necessary expertise and resources to implement effective cybersecurity measures, rendering them vulnerable to potential cyber threats. Additionally, a review by Dutta et al. (2020) identifies technology integration and interoperability as fundamental challenges in Industry 4.0. SMEs encounter difficulties in integrating these technologies with their existing infrastructure and legacy systems, resulting in compatibility issues and operational inefficiencies.

In conclusion, while Industry 4.0 and digital transformation hold substantial potential for competitiveness and innovation, SMEs confront numerous challenges in adopting and leveraging these technologies. Limited resources, a lack of expertise, data security concerns, organizational culture, and compatibility issues constitute key hurdles that SMEs must overcome to fully exploit the benefits of Industry 4.0 and propel their competitiveness and innovation.

Research methods

This paper aims to explore the structure and dynamics of research on the competitiveness of SMEs shaped based on their innovativeness to further guide both research and management practice. To achieve this aim, the authors employed a bibliometric performance analysis together with science mapping — well-established and reliable methods of providing a snapshot of research trends in literature. Bibliometrics is one of the most critical research domains that quantitatively analyzes patterns in scientific literature to understand global trends and the intellectual structure of the field analyzed (Cobo et al., 2011; Mishra et al., 2020). While analyzing secondary data from digital scientific databases, it facilitates a methodical, transparent, and replicable review process, consequently bolstering the reliability and overall quality of the review (Velasco-Muñoz et al., 2022; Wang et al., 2022a).

In this research, we established a systematic process to identify search terms, choose a suitable database, define selection criteria for the search,
opt for software for analysis, and conduct a comprehensive analysis of the results (Figure 1). As the research domain being studied is the competitiveness of SMEs shaped based on their innovativeness, this study defined the following keywords to be searched for in the title, abstract, and author keywords of the research papers. The “AND” and “OR” Boolean operators were used: “SME” OR “small and medium” AND “innovat*” AND “competit*”. The next step was to choose the database from a number of possible options such as Scopus, Web of Science, or Dimensions. Scopus was chosen for this study based on the recommendation of numerous research articles, which have indicated that this database is particularly well-suited for bibliometric analysis (Quintero-Quintero et al., 2021; Saleem et al., 2021) as, compared to the WOS database, Scopus is more accessible regarding the export of data (Cobo et al., 2011), and encompasses a broader spectrum of papers within the domain of business and management (Quintero-Quintero et al., 2021; Saleem et al., 2021).

The original results showed 2,936 documents published in the time span of 1983 to 2022. This paper aims to analyze the overall structure of the research and, therefore, we did not limit the time range. In the next stage, we narrowed the database using two criteria: language (English) and document type (article and review). The final size of the database was 1,834 document results.

In the fourth step, we needed to decide about the software we wanted to use to analyze the dataset as it would determine the format of the files to which databases are downloaded. We decided to use Microsoft Excel to conduct the initial descriptive analysis and VOSviewer, version 1.6.18, to further analyze and visualize the results.

Ultimately, two bibliometric analysis approaches were chosen: performance analysis and science mapping. Performance analysis primarily assesses productivity and influence by considering the number of publications and citations, aiming to gauge the impact of citations from authors, universities, and countries on scientific production in the relevant field. On the other hand, scientific mapping is employed to visually represent information in literature, offering a clear depiction of the dynamic and structural characteristics of scientific works and their evolution (Baier-Fuentes et al., 2019). This research used citation analysis (of authors and documents), keyword co-occurrence analysis, and coupling analysis (of countries).
Consistent with similar studies utilizing VOSviewer, we employed fractional counting to normalize the impact of documents with multiple authors. In this method, each paper is assigned only one unit, which is then fractionated based on the number of co-authors (Gaviria-Marin et al., 2018; Martínez-López et al., 2020). The utilization of fractional counting ensures that the strength of a co-authorship link between two authors is influenced not only by the number of documents co-authored but also by the number of authors associated with each co-authored document.

Results

The number of publications over time is one of the most relevant factors as to the extent to which a scientist is interested in a specific topic and as an expansion indicator of the field of research (Ahmed & Huang, 2019; Udomsap & Hallinger, 2020). Figure 2 shows the number of published documents on competitiveness and innovation of small and medium enterprises (1,834 in total) that were published in the last 40 years. It is worth noting that there is an increasing trend in the number of scientists researching the subject of the competitiveness of SMEs shaped on the basis of their innovativeness. This increase is particularly noticeable in the last fifteen years, aligning with the Industry 4.0 era.

The studies analyzed derive from 1,834 sources such as journals. Indeed, above 95% of these publications are articles (1,748): the other types are related to reviews (68), and 18 documents are undefined in the Scopus database. Figure 3 presents the top 10 funding sponsors’ research on the competitiveness of SMEs shaped based on their innovativeness (and 130 published documents). Among the top 10 funding sponsors, as many as 5 represent a source of funding from the European Union (77 papers from 130 in this sample, 59%). In total, 159 funding sponsors were indicated in 391 papers.

Besides providing a quantitative overview of the authors and key studies, it is beneficial to enhance the analysis by examining the primary journals that publish such studies. Table 1 shows that the most popular journals in the field of SME competitiveness and innovation are Sustainability (MDPI, IF: 3.889, h-index 109) with 74 published papers, Competitiveness Review (Emerald, h-index 31) with 19 published documents, and Techno-
logical Forecasting and Social Change (Elsevier, IF: 10.884, h-index 134) with 18 papers.

The basic subject of the studies is focused on publications by country, including their social networks (Veloutsou & Mafe, 2020; Peng et al., 2020). The most productive researchers in this area are from the United Kingdom, with 186 articles comprising 10% of all articles on competitiveness and innovation of SMEs.

Furthermore, noteworthy research in this domain has been conducted in the United States, China, and Italy, constituting approximately 7% and 6% of review papers, respectively. Figure 4 depicts a geographical map illustrating 108 countries based on the volume of published articles. 52 countries are undefined in the Scopus database.

One of the most popular and useful approaches in assessing the structure of a selected research area comprises the analysis of citation relations. These can be categorized into direct citation relations, bibliographic coupling relations, and co-citation relations (Boyack & Klavans, 2010). The authors decided to employ the direct citation analysis technique as bibliographic coupling and co-citation relations analysis are based on indirect relations, and thus provide less accurate information on the relatedness of publications and authors than direct citation relations (Waltman & Van Eck, 2012). The authors decided to analyze direct citations of documents and authors.

The document citation analysis employed covered 1,834 documents. In the analysis, we decided to include only the documents with a minimum of 40 citations. 208 documents met the threshold, but only 47 were connected with each other, as visualized in Figure 5. The documents included in the analysis formed 4 clusters.

The first cluster (blue) focuses on SME innovativeness and the impact of market orientation, business strategy, marketing innovation (Naidoo, 2010), or innovation support (Kaufmann & Todtling, 2002) on innovation performance (Xie et al., 2013).

The red cluster encapsulates papers focused on the sources (Gupta & Barua, 2017), barriers (Madrid-Guijarro et al., 2009), and critical factors (Kumar et al., 2015) in SME innovations.

The green cluster is dedicated to current technological innovations (Akpan et al., 2022) with a special focus on cloud computing (Alshamaila & Papagiannidis, 2013), social CRM (Ahani et al., 2017), and e-business solutions (Ifinedo, 2011).
The last cluster (yellow) is focused on the open innovation concept (van de Vrande et al., 2009) and its ecosystem (Popa et al., 2017), as well as the opportunities and limitations of SME innovation (Narula, 2004).

The citation analysis presented in Figure 6 presents the research field structure from the perspective of the most frequently cited authors in the papers included in the data set covered by this analysis. Out of the 4,544 authors, only those with a minimum of 3 citations were selected. Based on that limitation, only 77 authors met the threshold and formed 6 clusters as follows.

The first cluster (blue) shows the 9 authors represented by Raymond L. (7 documents with 204 citations), Kumar R. (5 papers with 176 citations), and Gunasekaran A. (6 documents with 211 citations). The yellow cluster covers 7 authors including Madrid-Guijarro A. (4 papers and 388 citations), Valdez-Juárez L.E. (5 papers with 128 citations), and Castillo-Vergara m. (6 papers and 55 citations). The violet cluster is formed of 6 authors represented by de Jong J.P.J. (3 papers with 1408 citations), Ferreira J.J.M. (4 papers and 66 citations), and Andrei A.G. (3 papers and 38 citations). The red cluster has 9 authors such as Kraus S. (7 papers with 712 citations), Ferraris A. (3 papers and 148 citations), and Vrontis D. (5 papers and 121 citations). The green cluster represents 9 authors such as Ramayah T. (9 papers with 180 citations), Ahmad N.H. (6 papers and 87 citations), and Singh S. (3 papers and 249 citations). The last cluster (azure) with 6 authors includes McAdam R. (6 papers with 186 citations), Ferreira J. (4 papers with 118 citations), and Zhang Y. (4 papers with 66 citations).

The examination of author keywords holds significant importance as they correspond to the context of the publication, thereby delineating the primary topics and research trends (Crispim et al., 2022; Al-Hanakta et al., 2021). Table 2 presents a comparison of two periods 2013–2017 and 2018–2022 in terms of the number of occurrences for each author keyword mentioned. The most frequent author keywords are innovation, SMEs or SME, and competitiveness or competitive advantage. The results indicate that these studies have established various approaches to analyzing occurrences, such as innovation capability(ies), dynamic capabilities, absorptive capacity, and resource-based view. Some research was also involved with aspects related to strategic management, such as knowledge management, innovation management, open innovation, and performance (performance, firm performance, or innovation performance). These keywords also refer to contextual factors.
such as the size of companies (SMEs or small and medium or small businesses) and location (Malaysia, China or European Union).

Figure 7 presents a chronological analysis of publication topics, using the author keywords. It is possible to identify the current themes related to sustainability, firm performance, industry 4.0, business model innovation, digital transformation, government support, and innovation culture (circles 1 and 2), while innovation linked to SMEs, competitiveness, competitive advantage, open innovation, knowledge management, competitive strategy, and globalization (circles 3 and 4) is represented by a greater focus on articles from the past decade.

Figure 8 shows the author keywords divided into three clusters. The red cluster (circle 1) concerns the author keywords related to innovation, SMEs, competitiveness, industry 4.0, collaboration, technology, and innovation performance. The blue cluster (circle 2) focuses on the author keywords linked to competitive advantage, entrepreneurial orientation, innovativeness, product innovation, business performance, market orientation, and competitive strategy. Then, the green cluster (circle 3) displays the author keywords connected to SME, sustainability, knowledge management, internationalization, globalization, clusters, business model, and circular economy.

**Discussion**

Answering RQ1, the number of studies focusing on SME competitiveness and innovation has experienced a notable increase over the past two decades, particularly in the last ten years. Prior to 2008, the annual publication count in this domain was approximately 20, witnessing a substantial surge to 100 documents per year during the period 2013–2018, and a remarkable ascent to 240 in 2022. The escalation observed from 2019 to 2021 may be attributed, in part, to the COVID-19 pandemic, where the recognition of the significance of innovation and information technologies played a pivotal role, alongside the implementation of the New European Innovation Agenda (Communication from the Commission, 2022). Innovation holds a key role in the green and digital transitions and in securing the EU’s autonomy. The New European Innovation Agenda particularly emphasizes the significance of cutting-edge solutions through advanced technologies, especially deep tech innovation (e.g., Romme et al., 2023). The substantial
growth of over 400% in the last decade underscores the importance of the topic and underscores the necessity for further analysis in this field.

Answering RQ2, according to the bibliographic coupling analysis of countries the leading countries are the United Kingdom, the United States, China, Italy, Malaysia, Spain, and Indonesia. In some countries, especially in Africa, SME competitiveness and innovation are scarcely analyzed. Likewise, most studies in Europe continue to analyze Northern, Western, and Central Europe, while rather little focus is given to countries in the South (except for Italy) or Eastern Europe. Additional studies in developing countries, for example in the Western Balkans, are lacking in the attempt to understand the competitiveness of SMEs shaped on the basis of their innovativeness.

Some researchers, as noted in a study on the innovation of small and medium enterprises, have proposed broader and more intensive collaboration to facilitate the sharing of resulting benefits and costs (Al-Hanakta et al., 2021). Consequently, the study has not only revealed significant collaboration among different clusters, but also highlighted specific collaborations, such as between the United Kingdom, Italy, and Germany in one cluster, cooperation involving the United States, China, Australia, South Korea, and Canada in the second cluster, collaboration among Malaysia, Indonesia, India, and Saudi Arabia in the third cluster, and cooperation between Spain, Poland, and the Czech Republic in the fourth cluster. Overall, collaboration is predominantly occurring among developed countries, while cooperation in developing countries remains limited.

Examination of the most cited documents indicates that the SME competitiveness and innovation bibliography has been defined by various related research subjects (such as business, management, social sciences, economics, engineering, computer science, decision sciences, and environmental science). The most frequently cited documents concern the concept of open innovation (van de Vrande et al., 2009), the opportunities and limitations of SME innovation (Narula, 2004), current technological innovations (Akpan et al., 2022) with special focus on cloud computing (Alshamaila & Papagiannidis, 2013), SME innovativeness and the impact of market orientation, business strategy, marketing innovation (Naidoo, 2010) or innovation support (Kaufmann & Todtling, 2002), as well as the sources (Gupta & Barua, 2017), and barriers (Madrid-Guijarro et al., 2009). Furthermore, the most cited authors in this area are from Italy (Sasha Kraus — Free University of Bozen-Bolzano), the USA (Angappa Gunasekaran — Charlton College
of Business, University of Massachusetts), and Canada (Institut de recherche sur les PME, Université du Québec à Trois-Rivières, Trois-Rivières, Quebec). The geographical context of the research is highly significant as SME competitiveness and innovation are profoundly influenced by the macro environment and the business ecosystem, which encompasses financial support.

The analysis of the co-occurrence of the author keywords identified three clusters. The first concerns industry 4.0 and external sources of innovation, such as an open and collaborative approach to the innovation process (cluster 1), the second relates to SME innovation efficiency, innovation activity, and strategy (cluster 2), and the last concerns human capital, clusters in the sustainable economy (cluster 3). These outcomes also demonstrate resemblances to the findings in the literature review regarding the concepts of innovation, business model innovation, competitiveness, and digital transformation. For instance, Dixit et al. (2022) observed that digital transformation has emerged as a catalyst for innovation, enabling organizations to adopt new technologies and processes that enhance their ability to innovate. Bouncken et al. (2021) also emphasized the importance of digital transformation that often requires organizations to re-evaluate and reinvent their business models, leading to innovative approaches. Shvetsova and Lee (2021) highlight that industry 4.0 encourages the development of collaborative innovation ecosystems, bringing together various stakeholders and enabling open innovation practices. The trends in the use of the author keywords indicate that many current keywords are sustainability, firm performance, industry 4.0, business model innovation, digital transformation, government support, and innovation culture, in the area of the innovation ecosystem and sustainable technology innovation. Therefore, further research is needed to assess whether this trend will continue in the future.

Addressing Research Question 3 sheds light on a noteworthy gap in the existing research landscape concerning SME competitiveness driven by innovation within the domains of Industry 4.0 and 5.0. The investigation underscores that the core elements of SME competitiveness and innovation within these technological revolutions are insufficiently emphasized in current research clusters. The co-cited keywords identified by the authors predominantly center around concepts such as competitive advantage, open innovation, and knowledge management. However, it is intriguing to observe a notable omission of topics related to innovations in competitive
strategies specifically tailored for SMEs operating in the digital era. This represents a significant gap in scholarly discourse. As a result, the subsequent section outlines future research proposals aimed at filling this critical void in understanding and exploring the intricacies of how SMEs can effectively navigate the digital landscape, innovate in their competitive strategies, and thrive in the evolving paradigms of Industry 4.0 and 5.0.

Conclusions

The article presents a comprehensive bibliometric analysis of the research on the competitiveness of SMEs based on their innovativeness from the perspective of leading journals, countries, and the most frequently cited documents and authors in the years 1983–2022. The analysis covered 1,834 documents retrieved from the Scopus database. Performance analysis of these records was complemented by scientific mapping using the VOSviewer program. The outcomes of the review, as presented in the article, furnish researchers with insights into the structure and dynamics of the selected research field, highlighting gaps and indicating potential directions for future research.

The results confirmed a significant increase in research in the analyzed area over the last twenty years, from 14 articles in 2002 to 244 articles in 2022. The results of the analyses showed that innovation in the context of the competitiveness of SMEs, and in particular their external environment (ecosystem) is an important problem and research topic, especially in developed countries and to a lesser extent in developing countries. Interestingly, among the top 10 funding sponsors, as many as 5 represent a source of funding from the European Union. The most productive researchers in this area are from the United Kingdom, the United States, China, and Italy. The author co-cited keywords focused mainly on competitive advantage, open innovation, and knowledge management.

Practical implications

The insights gleaned from the conclusions presented above unveil a roadmap of actionable recommendations for researchers, policymakers, and Small and Medium Enterprises (SMEs) navigating the complexities of
SME competitiveness and innovation in the face of Industry 4.0 and 5.0 challenges.

For researchers: As the vanguards of knowledge seeking to unravel the intricacies of SME competitiveness and innovation, researchers are urged to delve into emerging trends, particularly Industry 4.0, external sources of innovation, and sustainable technology innovation. These uncharted territories present fertile ground for in-depth exploration and the potential to revolutionize SME growth. However, this journey requires collaboration, transcending geographical boundaries and fostering robust partnerships to enrich the global tapestry of knowledge.

For policymakers: Policymakers, the architects of strategies shaping the future, are called upon to address the stark disparities in SME competitiveness and innovation across regions, particularly in Africa and specific corners of Europe. By inscribing these regions with targeted support and fostering research and innovation, policymakers can level the playing field and unleash the transformative potential of SMEs. Moreover, policymakers are urged to synchronize their initiatives with global endeavors, aligning their policies with the pivotal role of innovation, as exemplified by the COVID-19 pandemic and the New European Innovation Agenda.

For SMEs: As the protagonists of this tale, SMEs are the driving force behind economic growth and resilience. Embracing technology, particularly Industry 4.0 and its technological counterparts, is a non-negotiable step towards competitiveness in the dynamic digital landscape. SMEs must proactively harness these innovations to shape their destinies. Additionally, fostering collaboration within their ecosystems presents a powerful tool for growth. By leveraging shared benefits and costs, SMEs can cultivate a culture of innovation, propelling them into a realm of unparalleled competitiveness.

For all stakeholders: In this collaborative narrative, a gap emerges, beckoning a joint endeavor to uncover the essential features of competitiveness and innovation. Researchers, policymakers, and SMEs must co-author this change, focusing on competitive strategies and innovative approaches, even if they may be less conventional. These themes hold the key to unlocking growth and resilience in the face of Industry 4.0 and 5.0 challenges.
Limitations and future research

The limitation of the research lies in its narrow focus on the Scopus database and its quantitative nature. Thus, an in-depth analysis of SME competitiveness shaped on the basis of their innovativeness is necessary in order to better understand innovation as a pillar of SME competitiveness and to explain the role and significance of these dependencies. Such research should be based on qualitative methods using expert panels or focus groups with the participation of representatives of various entities forming the SME sector ecosystem.

The exploration of future research avenues within the realm of SME competitiveness and innovation, amidst the backdrop of Industry 4.0 and 5.0, unveils additional distinct research gaps warranting attention. These include (1) the intricacies associated with data security challenges within organizational frameworks, and (2) the dynamics of cultural shifts essential for fostering innovation. (3) In the pursuit of enhancing competitiveness and capitalizing on the transformative opportunities presented by Industry 4.0/5.0, a critical imperative emerges — the formulation and examination of strategies that effectively nurture innovation within the context of these industrial revolutions. Delving into these uncharted territories will undoubtedly contribute to a more comprehensive understanding of the intricate interplay between SMEs, technological advancements, and innovation paradigms in the evolving landscape of Industry 4.0 and 5.0.

References


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Annex

Table 1. Top 10 journals in accordance with the number of published documents

<table>
<thead>
<tr>
<th>SOURCE</th>
<th>NUMBER OF PUBLICATIONS</th>
<th>% OF 1834</th>
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</thead>
<tbody>
<tr>
<td>Sustainability Switzerland</td>
<td>74</td>
<td>4.0349</td>
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<tr>
<td>Competitiveness Review</td>
<td>19</td>
<td>1.0360</td>
</tr>
<tr>
<td>Technological Forecasting And Social Change</td>
<td>18</td>
<td>0.9815</td>
</tr>
<tr>
<td>Journal Of Cleaner Production</td>
<td>16</td>
<td>0.8724</td>
</tr>
<tr>
<td>Journal Of Small Business And Enterprise Development</td>
<td>16</td>
<td>0.8724</td>
</tr>
<tr>
<td>Technovation</td>
<td>16</td>
<td>0.8724</td>
</tr>
<tr>
<td>International Journal Of Innovation Management</td>
<td>15</td>
<td>0.8179</td>
</tr>
<tr>
<td>Journal Of Open Innovation Technology Market And Complexity</td>
<td>15</td>
<td>0.8179</td>
</tr>
<tr>
<td>Management Decision</td>
<td>15</td>
<td>0.8179</td>
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<tr>
<td>Problems And Perspectives In Management</td>
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<td>0.8179</td>
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Table 2. Top 15 author keyword occurrences in 2013–2017 and 2018–2022

<table>
<thead>
<tr>
<th>AUTHOR KEYWORDS</th>
<th>OCCURRENCES 2013-2017</th>
<th>AUTHOR KEYWORDS</th>
<th>OCCURRENCES 2018-2022</th>
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<tr>
<td>innovation</td>
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<td>sme</td>
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<td>sme</td>
<td>68</td>
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<td>30</td>
<td>competitive advantage</td>
<td>67</td>
</tr>
<tr>
<td>competitiveness</td>
<td>28</td>
<td>competitiveness</td>
<td>55</td>
</tr>
<tr>
<td>small and medium-sized enterprises</td>
<td>24</td>
<td>small and medium enterprises</td>
<td>54</td>
</tr>
<tr>
<td>open innovation</td>
<td>20</td>
<td>sustainability</td>
<td>44</td>
</tr>
<tr>
<td>entrepreneurship</td>
<td>19</td>
<td>entrepreneurial orientation</td>
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<tr>
<td>competitive advantage</td>
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<td>14</td>
<td>open innovation</td>
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</tr>
<tr>
<td>business performance</td>
<td>13</td>
<td>small and medium-sized enterprises</td>
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<tr>
<td>innovativeness</td>
<td>12</td>
<td>performance</td>
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<tr>
<td>performance</td>
<td>12</td>
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<td>industry 4.0</td>
<td>27</td>
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<td>market orientation</td>
<td>10</td>
<td>product innovation</td>
<td>26</td>
</tr>
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</table>
**Figure 1.** Research process

- **Step 1**
  - **Determining the search terms**
    - "SME" OR "small and medium"
    - AND "innovat*"
    - AND "competit*"

- **Step 2**
  - **Selection of database**
    - Scopus

- **Step 3**
  - **Selection of search criteria**
    - Language: English
    - Document type: article and review

- **Step 4**
  - **Selection of software**
    - Microsoft
    - VOSviewer

- **Step 5**
  - **Analysis and results**
    - Performance analysis: number of articles per year, funding sponsors, top journals
    - Science mapping: citation of documents and authors, co-occurrence of keywords

**Figure 2.** Number of published papers (1983–2022)
Figure 3. Top 10 funding sponsor in accordance with the number of published documents

European Commission; 33; 25%
European Regional Development Fund; 16; 12%
National Natural Science Foundation of China; 15; 12%
Fundação para a Ciência e a Tecnologia; 14; 11%
Horizon 2020 Framework Programme; 13
Ministry of Higher Education, Malaysia; 8; 6%
National Research Foundation of Korea; 8; 6%
National Office for Philosophy and Social Sciences; 8; 6%
Seventh Framework Programme; 8; 6%
European Social Fund; 7; 6%

Figure 4. A cartogram showing the map of countries in accordance with the number of published papers
Figure 5. Citation of documents

Figure 6. Citation of authors
Figure 7. Recent discussion topics shift (2013–2022)

Figure 8. Co-occurrence map of author keywords of documents published in 1983–2022