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Barriers to sustainable green innovation in meeting the challenges of the global economy of firms

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ABSTRACT

BACKGROUND AND OBJECTIVES: Sustainable innovation is crucial, because it is a key strategy for ensuring the long-term survival of companies in a world with limited resources. Consequently, understanding the barriers faced by companies in achieving sustainable innovation, such as high initial cost, lack of technical knowledge, or unclear regulations, is important for developing appropriate policies, strategies, and solutions that promote and facilitate its adoption.

METHODS: This study aims to analyze the relevant and most important scientific evidence and research topics on barriers to sustainable innovation through a bibliometric analysis combined with concurrence networks and cluster analysis using VOSViewer.

FINDINGS: Research on barriers to innovation was developed on a larger scale in 2012 with an average growth of approximately 43 percent until 2022. During this period, the study on green innovation has been predominant and on the social component of sustainable innovation to a lesser extent. Asia, specifically China, is leading the research on this topic mainly on the environmental component of sustainable innovation. In terms of barriers, the majority of the literature focus on financial constraints. The research agenda focus on the following areas or clusters: sustainability, barriers to sustainable innovation, and social innovation.

CONCLUSION: The major barriers to sustainable innovation are financial and government regulations. The current research tackles the environmental component of sustainable innovation. Therefore, future research should focus on market and knowledge barriers in developed and less developing countries and on the social component of sustainable innovation. Potential areas of research (which are underexplored) exist and can be important for future research on enhancing knowledge about barriers to sustainable innovation: applied research that considers regional effects and country-specific analysis, in particular in developing countries. Research on the social component of sustainable innovation could be relevant. Social innovation is essential, because it addresses concrete societal problems and promotes collective action and inclusion in novel ways within companies.

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8



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INTRODUCTION

Sustainable innovation is a complex concept that is frequently associated with other terms such as environmental innovation, eco-innovation, green innovation, or ecological innovation (Degler et al., 2021). However, elucidating that sustainable innovation is a broader aspect that encompasses the aforementioned terms and includes social components, which is known as social innovation, is essential (Schiederig et al., 2011). In other words, sustainable innovation consists of environmental and social components. In addition, sustainable innovation is defined as the introduction of novel, changed, or improved products, services, or processes within an organization that intends to generate long-term social and environmental benefits while considering commercial or economic gains (Shields, 2022; Degler et al., 2021; Fields and Huesig, 2019). The significant growth of the global economy has led to alarming environmental problems such as climate change and increased scarcity in energy and resource (Degler et al., 2021; Puno et al., 2021; Rodelo-Torrente et al., 2022). To understand the contribution of innovation to sustainability and to mitigate these issues, internalizing and apply concepts inherent to business management are essential aspects (Tidd and Bessant, 2020). Organizations are currently engaging in innovation ecosystems to fulfill the Sustainable Development Goals established by the United Nations (Nylund et al., 2021), typically with the help of new approaches such as frugal innovation (Ebolor et al., 2022). Nowadays, organizations must be sustainable by conducting their activities following economic, social, and environmental principles. The sustainable development of organizations relates to all forms of innovation, particularly those related to changes in organizational methods and management (Koziol and Beyer, 2021). With the increasing interest of stakeholders in sustainability-related issues (Awan and Sroufe, 2020), research focuses on the distinction between traditional and sustainable innovation with the objective of understanding their determinants (Moghadam and Samimi, 2022). However, the literature primarily highlights the determinants that drive sustainable innovation while it needs to pay more attention to research on the determinants that hinder or impede this type of innovation (Pinget et al., 2015; Nouri,

2022). With respect to firm size, the literature gap is increasingly pronounced on small- and medium-sized enterprises (SMEs) despite these types of companies representing approximately 90 percent (%) of total businesses worldwide (World Bank, 2019) and accounting for more than 60% of industrial pollution (Kumar et al., 2022). In this regard, SMEs play a crucial role in global sustainable development issues and are an important target for public policies to foster a sustainable society. However, SMEs face unique challenges, because as they are frequently constrained by relatively limited resources despite their desire to reduce environmental impacts (Pinget et al., 2015). This study aims to analyze research topics on barriers to innovation from the social and environmental perspectives to elucidate the most recent scientific developments and research gaps on this topic. The remainder of this document is organized as follows: the following section presents the methodology followed by the research findings and discussion. The final section highlights the main conclusions and limitations of the study. It also outlines future research directions that emphasize the social component of sustainable innovation, the role of knowledge and market barriers, and the analysis of this thematic area in developing countries. Furthermore, the study aims to analyze research topics on barriers to sustainable innovation in an effort to understand the most recent scientific developments and research gaps on this topic. In this sense, this study aims to answer the following research questions: What are the most relevant topics in the scientific literature on sustainable innovation? Do research gaps on sustainable innovation exist? What could be future research agenda? This study was conducted in Colombia in 2023.

MATERIALS AND METHODS

This study has been conducted through data identification, filtering, and systematization, to analyze research topics on barriers to sustainable innovation. Bibliometric and descriptive analyses were performed using the document analysis approach (Liniers and Cruz, 2020). Information search was conducted using the well-known citation database SCOPUS, which contains the most relevant scientific literature worldwide (Abdullah, 2021; Bass et al., 2020). This study followed the work

of scholars such as [Abdullah \(2021\)](#), which have conducted bibliometric studies. The bibliometric analysis was conducted following the selection strategy and research protocol adapted from the PRISMA flowchart ([Moher et al., 2009](#)). The adopted inclusion criteria are as follows, journal articles published in scientific journals, a time range from 1975 to 2023, and documents published in English and Spanish. The search strategy included the following descriptors: (“Eco? innovation” OR “Sustainable Innovation” OR “Innovación Sostenible” OR “green innovation” OR “Innovación verde” OR “environmental Innovation” OR “Innovación Ambiental” OR “Ecological Innovation” OR “Innovación Ecológica” OR “Social Innovation” OR “Innovación Social”) AND (barrier* OR Barrer* OR Obstacle* OR Obstacu* OR Constraint* OR Restricc* OR hinder* OR Difficult*)

For a better understanding of the strategy for document search, [Table 1](#) provides a description of the different logical operators used in SCOPUS.

After applying the search equation, the study obtained a total of 850 documents, specifically 628 journal articles, 98 conference papers, 58 book chapters, 35 reviews, 15 books, 8 letters to the editor, 5 conference reviews, and 3 notes. The research objective was to analyze topics in barriers to sustainable innovation; thus, only journal articles were selected for content analysis to identify the most scientifically impactful documents. In this regard, the following type of documents were excluded: conference papers given that access to an entire document is impossible ([Scherer and Saldanha, 2019](#)), books and book chapters, because not all books are academic or follow a well-defined methodological framework ([Edinger and Cohen,](#)

[2013](#)), reviews, editorials, notes, short surveys, and data documents that are not considered original research. Following the inclusion criteria, a sample of 628 articles was obtained. In addition, 27 documents were excluded for being written in languages apart from English or Spanish, which resulted in a final sample of 598 documents. Notably, in literature reviews, a few authors only use the language in which they are familiar to facilitate content analysis ([Bahji et al., 2022](#)). [Fig. 1](#) illustrates the document selection strategy and research protocol. The metadata of the final sample (598 documents) were exported in CSV format to Microsoft Excel and VOSviewer for analysis. The metadata included the information, document source, publication year, publication title, country, journal title, thematic area, abstract, and publication type of the authors. Using VOSviewer, which was developed by [Van Eck and Waltman \(2019\)](#), the study conducted analysis and mapping of publications on barriers to sustainable innovation. According to [Van Eck and Waltman \(2019\)](#), VOSviewer uses visual elements based on mapping techniques to transform CSV data into diagrams or clusters. The mapping techniques allow the researcher to analyze relevant information such as authors, co-occurrences, organizations, citations, and co-citations ([Khalil and Crawford, 2015](#)). To identify topics based on keyword co-occurrences, the core terms of the search equation (i.e., sustainable, environmental, eco-, ecological, and social innovation) were excluded. These terms represent the central terms of the search equation, and the objective is to discover other parallel research topics related to sustainable innovation. If these terms were included in the VOSviewer visualization, then they would form the

Table 1: Database logical operators in SCOPUS

Logical operator	Description
AND	Words separated by spaces will be processed with the AND operator. It retrieves documents that contain both words.
OR	Retrieves documents that contain at least one of the words.
""	By placing words in quotation marks, approximate results are sought. It searches for singular and plural forms (with exceptions).
*	The asterisk replaces any number of characters at the end of a word. Example: Innova* searches for innovation, innovative, etc.
()	This operator allows charging the order of priority of different logical operators.
TITLE-ABS-KEY	Indicates that it will only search for documents containing the required information in the title, abstract, and keywords.

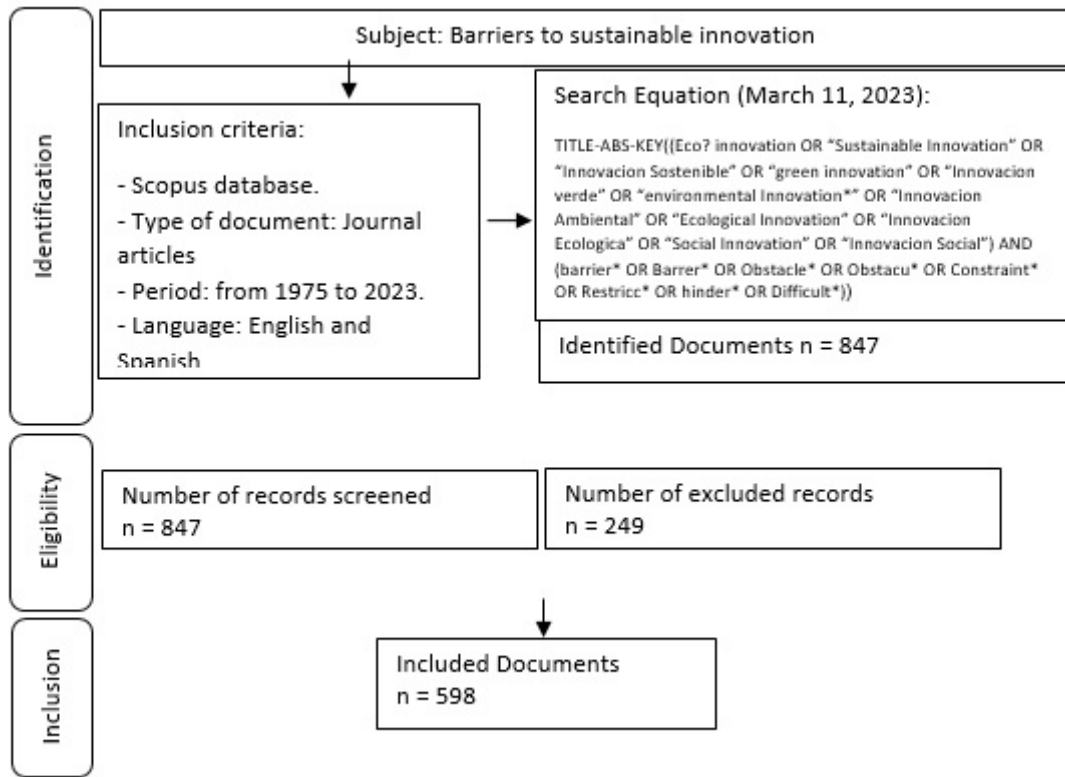


Fig. 1: Document selection strategy and research protocol

central clusters of the visualizations, because they are the keywords used in the search equation and would, therefore, appear most frequently. The number of co-occurrences applied to cluster and network visualization was seven compared with the default five co-occurrences set by the software. Co-occurrence intends to identify topics with greater significance. Additionally, two coauthorship visualizations were conducted to identify research networks and clusters.

RESULTS AND DISCUSSION

Eisenberg (1975) conducted the first publication on the topic in the field of medicine (Fig. 2) and found that social innovation in childcare is necessary for providing optimal conditions for child development during a period of transitioning family roles. The author highlighted that parents face psychological barriers to child care. Afterward, a 13-year period without publications occurred until Milton and Demment (1988) also published in medicine

and social innovation followed by intermittent periods of publication such as Stangvik (1989) and Wong *et al.* (1996). From the year 2000 onward, research publication increased with an average of 1.6 publications per year between 2000 and 2007. During this period, articles by Biondi *et al.* (2002) and Le *et al.* (2006) stand out with 116 and 103 citations and represent the two most cited documents during this period. Both articles emphasize the importance of environmental innovation in SMEs and the hospitality and hotel businesses. The most cited studies referred to environmental innovation; however, a few studies used the term sustainable innovation.

A significant increase in the number of publications began in 2012 with an average growth rate of 43% until 2022. During this period, Rizos *et al.* (2016) was the most relevant publication in terms of citations (435 citations) and focused on the barriers and facilitators faced by SMEs in implementing a circular economy as a green innovation strategy. The results

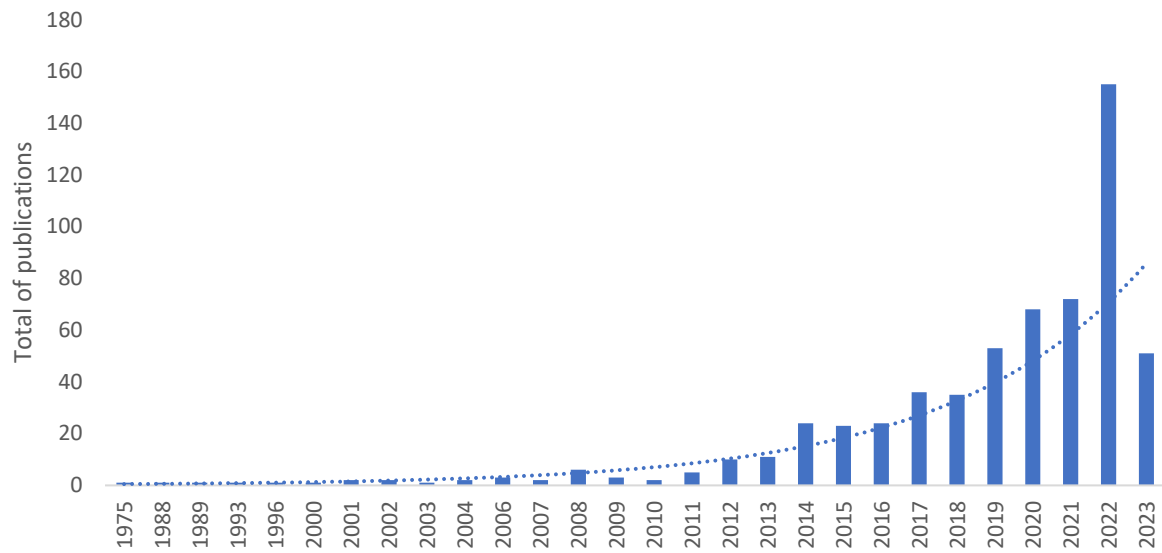


Fig. 2: Number of journal articles published (1975–2023)

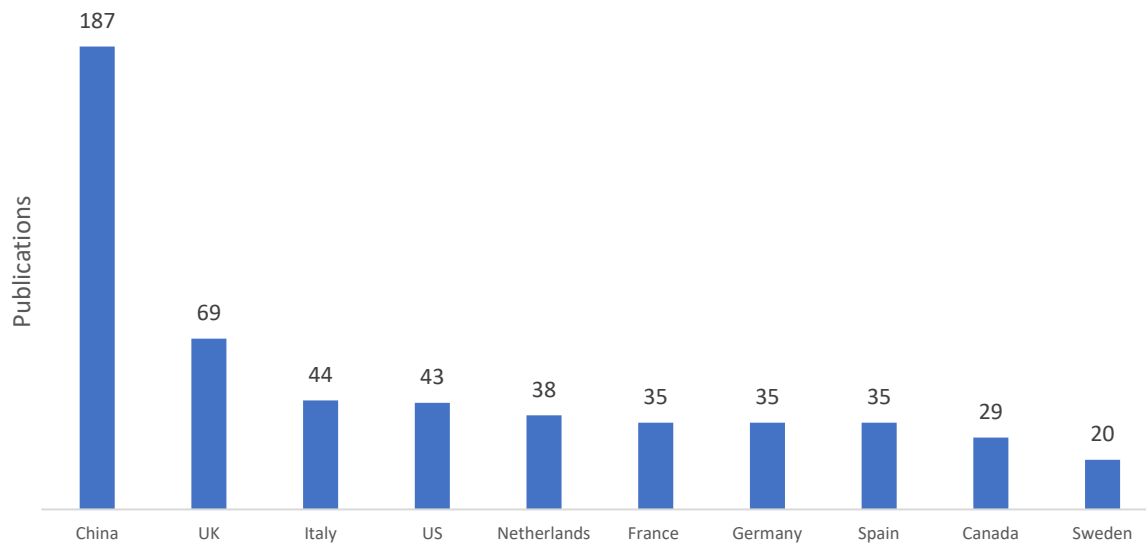


Fig. 3: Number of publications by selected countries (top 10; 1975–2023)

demonstrated that the lack of demand, capital, and government support are the main barriers for firms. Other influential studies (based on citations) focused on the determinants of green innovation in low-tech SMEs; green/environmental innovation and service capabilities; relationship among green innovation, external sources of knowledge, and organizational performance; and social and environmental

innovation. In this sense, the most relevant studies in this period addressed the topic of green innovation. As of March 2023, 50 articles were published, and the most cited ones include that of [Ramzan et al. \(2023\)](#), who identified the contribution of green innovation to sustainability and energy transition, and of [Liang and Xu, \(2023\)](#), who analyzed the efficiency of the implementation of sustainable innovation in China.

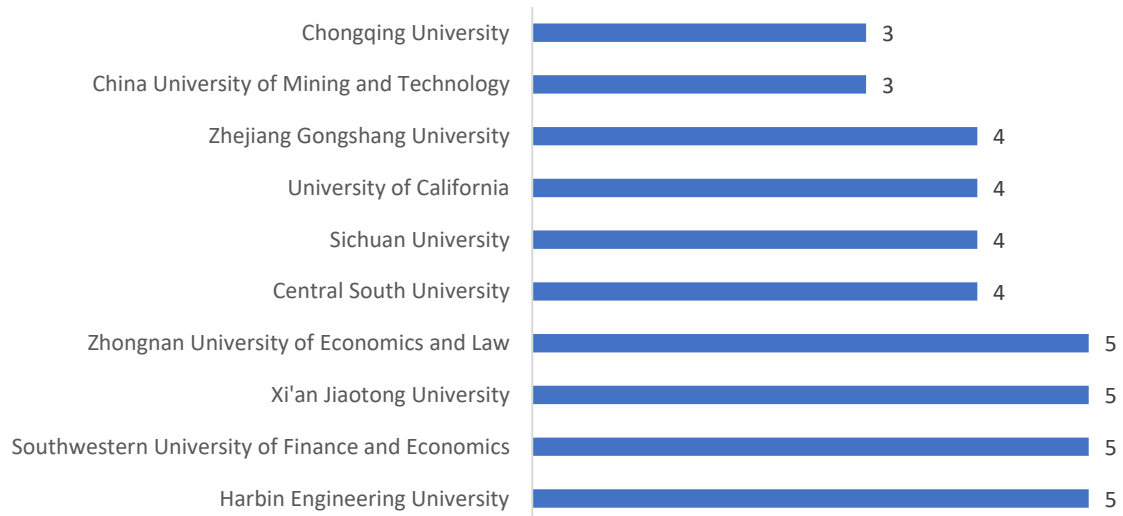


Fig. 4: Number of publications by institution (top 10; 1975–2023)

Table 2: Number of publications by journal title

Journal title	Number of research articles	Journal H-index	Journal SJR quartile
<i>Sustainability</i> (Switzerland)	61	136	Q1
<i>Journal of Cleaner Production</i>	40	268	Q1
<i>International Journal of Environmental Research and Public Health</i>	18	167	Q2
<i>Environmental Science and Pollution Research</i>	15	154	Q1
<i>Frontiers in Environmental Science</i>	11	61	Q1
<i>Energy Economics</i>	10	187	Q1
<i>Technological Forecasting and Social Change</i>	9	155	Q1
<i>Business Strategy and the Environment</i>	8	131	Q1
<i>Ecological Economics</i>	8	236	Q1
<i>Resources, Conservation, and Recycling</i>	6	170	Q1

Fig. 3 depicts the top 10 countries with the most number of publication on the barriers to sustainable innovation. China leads with 187 publications followed by the United Kingdom (69), Italy (44), the United States (43), the Netherlands (38), France (35), Germany (35), Spain (35), Canada (29), and Sweden (20). Unsurprisingly, China has the highest number of publications given that it is one of the largest CO₂ emitters worldwide (Shpak et al., 2022). When analyzing the top five articles published in China with the highest impact in terms of citations, all of them refer to the environmental component of sustainable innovation and explicitly use the term green innovation. These articles addressed the following research questions: Can green innovation

mitigate financial barriers? What are the regional differences in green innovation efficiency? What is the role of green innovation in mitigating barriers to accessing green credits and government incentives? What is the effect of green innovation on industrial agglomeration? What is the mediating effect of financial barriers on environmental, social, and governance rating events with corporate green innovation?

Consequently, the universities with the highest number of publications are from China. Nine out of ten universities (Fig. 4) that published the most (90%) are Chinese, which focus on green innovation. The University of California can be found in the list (top 10) of universities with a higher number of

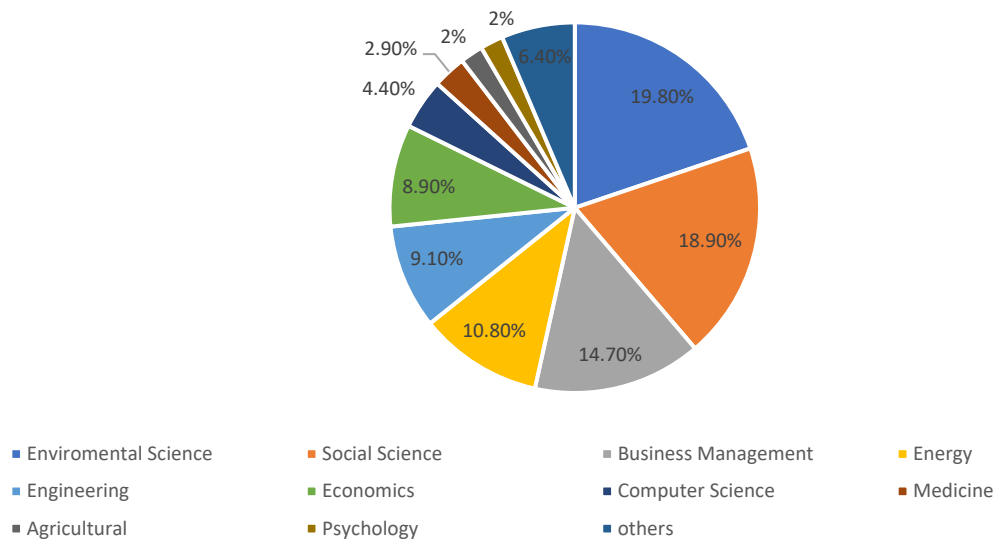


Fig. 5: Publication by thematic areas (%)

publications, and one of its research articles focus on the Chinese industry.

With respect to scientific journals, Table 2 present the most prestigious journals that published the most number of articles. Specifically, *Sustainability* published relevant and influential research articles such as *Rizos et al. (2016)* with 435 citations and *Feng and Chen (2018)* with 163 citations. Notably, the majority of the publications in these journals focus on the environmental components of sustainable innovation: green innovation and eco-innovation. However, a few articles address the social component of innovation from the perspective of government barriers. The most cited works in the *Journal of Cleaner Production* are *Cuerva et al. (2014)* and *Foxon and Pearson (2008)* with more than 100 citations. These articles analyzed the barriers to sustainable innovation in low-tech SMEs and companies with circular economy processes. With respect to journal quality, nine journals in the top-10 list exhibited the highest scientific impact (quartile 1) based on the Scimago Journal Report. The *International Journal of Environmental Research and Public Health* is in the second quartile (Q2), and its most cited articles are on green innovation in China. Alternatively, considering the Hirsch Index (or H-index) of scientific impact,

the *Journal of Cleaner Production* and *Ecological Economics* stand out with H-indexes of 268 and 236, respectively.

The thematic areas or disciplines (Fig. 5) that published on the barriers to sustainable innovation are Environmental Sciences (19.8%), Social Sciences (18.9%), Business Management (14.7%), Energy (10.8%), and Engineering (9.1%).

To enrich the analysis, a visual keyword co-occurrence evaluation of documents (Fig. 6) was conducted. The figure depicts a keyword network diagram in which color, node, font size, and line thickness illustrate the relationship with other keywords (Sweileh et al., 2017). A total of 16 keywords are identified and grouped into four nodes (i.e., presented in green, red, yellow, and blue). The keyword “sustainability” in the red nodes is the most relevant, which is indicated by node size and font (Sweileh et al., 2017). In addition, the networks of authors are important for identifying the most relevant contributions, clusters, and co-authorships on barriers to sustainable innovation. Fig. 7 presents the minimum number of articles per author (set as one) to determine all potential links between authors. Chinese researchers lead the research networks that published the most on barriers to sustainable innovation. This finding corroborates that the majority of academic literature on this

Sustainable for the firms' global economy

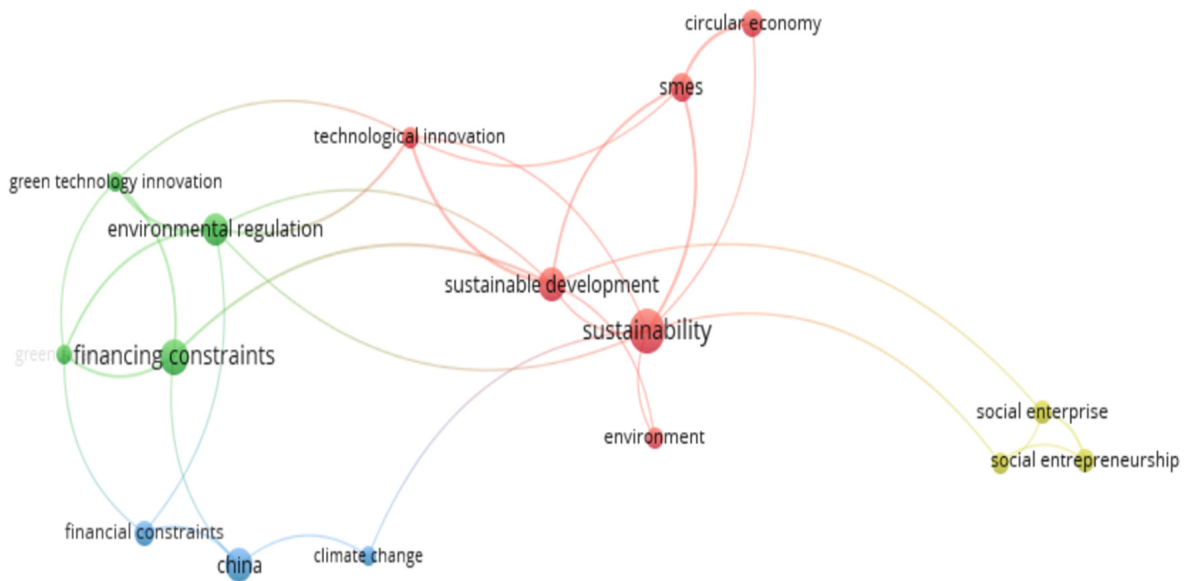


Fig. 6: Visualization of keyword co-occurrence

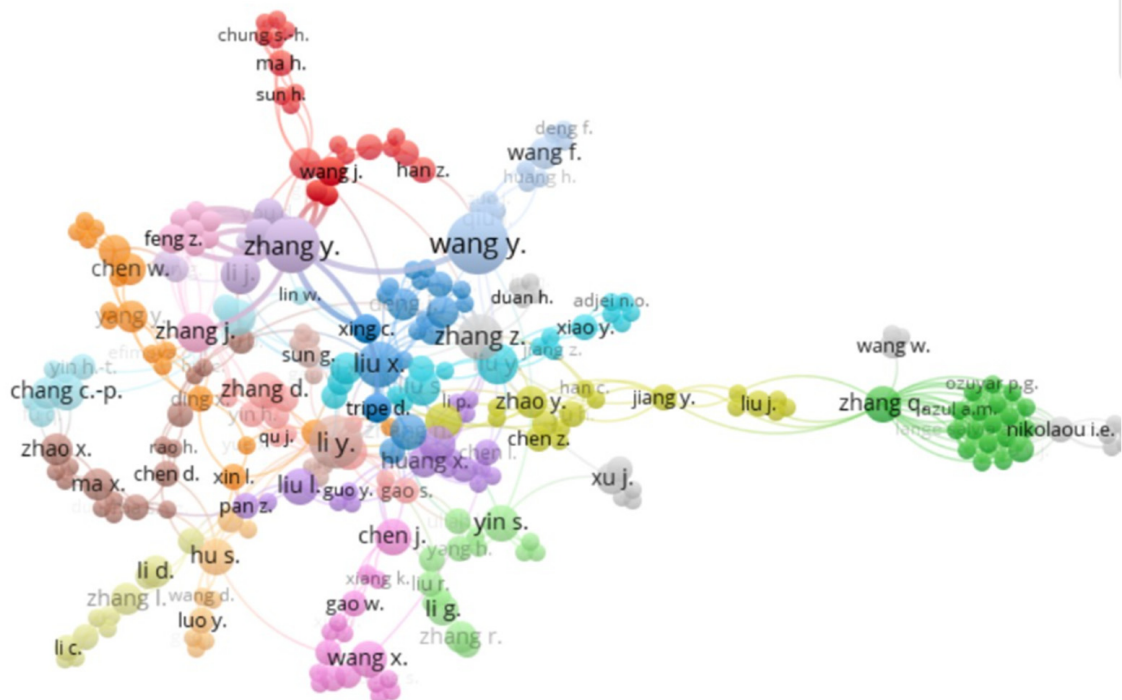


Fig. 7: Visualization of co-authorship (one document)

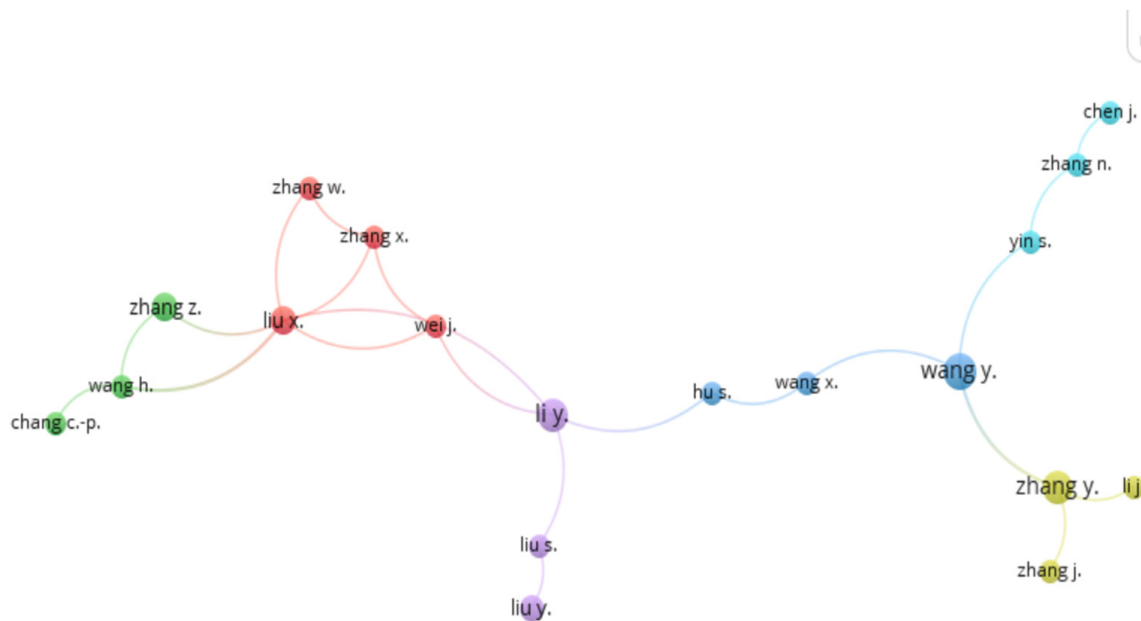


Fig. 8: Visualization of coauthorship (four documents)

topic is conducted by Chinese institutions and illustrates their commitment to sustainable development and to address these phenomena. To identify consolidated clusters related to barriers to sustainable innovation, the minimum number of documents per author in the co-authorship network was increased to four using VOSViewer (Fig. 8). It shows six main co-authorship clusters with a number of interconnections. The blue cluster (Hu, S.; Wang, X. and Wang Y.) is the central cluster, because it connects with three of the five remaining clusters. An important researcher is Wang Y., who addresses financial, regulatory, and market barriers in the manufacturing and logistics sectors. Another notable researcher is Li Y., who focuses on efficiency and green innovation in China. Nevertheless, Chinese researchers lead all clusters and collaborate within institutions.

The central aspect of the results is that the majority of the academic literature on barriers to innovation is concentrated in China based on the number of published research articles (Fig. 3), the largest number of institutions publishing on the subject (Fig. 4), and the most extensive participation in coauthorship networks (Figs. 7 and 8). Their work focuses on the emergence of green finance

as an alternative solution to financial barriers to green innovation, on regulatory barriers on green innovation and sustainable industrial development, and the stimulation of green innovation using green credit policies, which, consequently, decreases the pollution of Chinese companies. Apart from research that is developing mainly in China, it primarily focuses on the environmental component of sustainable innovation, which leaves the social component in the background. However, citing that non-Chinese authors have developed relevant research on the social component of innovation is essential; notably, Westley *et al.* (2015) analyzed the barriers to social innovation among non-profit organizations in Canada. Here, we can also mention the works of Avila and Campos (2018) in Europe and Chalmers (2013) in the United Kingdom, among others. Another notable aspect that research conducted by western scholars, such as Rizo *et al.* (2016), focuses on SME companies in the European Union. They argue that a number of barriers still need to be addressed despite public policies for companies to innovate and join the circular economy. Other relevant research includes Cuerva *et al.* (2014) in Spain, Foxon and Pearson (2008) in the United Kingdom, and Fernando *et al.*

(2019) in Malaysia, whose research focused on how clean technologies mitigate the barriers to green innovation as well as generate economic growth. Despite the majority of authors and research being related to China, the top 10 journals that published on barriers to innovation are European journals (and only one from the United States). The journal *Sustainability* from Switzerland stands out with research on sustainable innovation. For instance, Feng and Chen (2018) found that green product innovation plays a particular promotional role in the absence of environmental regulatory barriers, while green craftsmanship innovation exerts a significant inhibitory effect. However, in the presence of environmental regulatory barriers and market-based environmental regulations, promoting green craftsmanship innovation instead of green product innovation positively impacts the ecological development of the industry. Through cluster analysis (Fig. 6), a number of hot topics on barriers to sustainable innovation emerge. Cluster 1 (red) depicts sustainability as an important area of research, as organizations frequently pursue sustainable innovation to improve their social and environmental impacts and achieve sustainable development (Cirone et al., 2023; Feng et al., 2022). Within this topic, many authors examined the contribution of these types of innovation to the development of circular economy systems (Herrero et al., 2022; Austin and Rahman, 2022). Cluster 2 (green) indicates research that focuses on financial and regulatory barriers to sustainable innovation, such as financial barriers (Zhai et al., 2022; Zhao et al., 2023) and barriers related to government regulations (Zhang et al., 2023). Cluster 3 (blue) refers to climate change issues. The majority of research in Clusters 2 and 3 focus on China. Finally, Cluster 4 (yellow) depicts the lowest number of nodes and refers to the social component of sustainable research, in which social entrepreneurship (Jarrar, 2022; Yeasmin and Koivisto, 2017) and social enterprise (Zainol et al., 2019; Kim and Lim, 2017) stand out. The nodes in this cluster are related to sustainability and sustainable development, thus, identifying research such as that conducted by Zainol et al. (2019), who found that social innovation helps to identify social problems and guide actions for addressing complex social issues through the

capabilities of social enterprises. Additionally, the authors argue the potential of the capabilities of social enterprises to expand social innovation in the economy.

CONCLUSION

The current study aimed to elucidate the barriers faced by companies in achieving sustainable innovation. The bibliometric analysis led to certain significant conclusions which are described as follows.

First, notably, the literature on barriers to sustainable innovation has been growing since the 2000s; however, it began to develop on a larger scale in 2012 with an average growth of approximately 43% until 2022. During this period, research on green innovation has become predominant and on the social component of sustainable innovation to a lesser extent. In the first quarter of 2023, a total of 50 research articles were published; if this trend persists, then scholars expect that approximately 200 articles will be published by the end of 2023. The latter exhibits an increasing interest in green innovation and the barriers that may constrain this development. Asia is leading the research on this topic. For instance, China takes the lead with the most number of research on barriers to sustainable innovation, as one of the most polluted countries in the world. Research in China also focuses on the environmental component of sustainable innovation; in terms of barriers, the majority of the literature highlight financial constraints. The predominance of China as the country with the largest number of research published illustrates the relative importance of Chinese institutions and researchers toward working on barriers to innovation. Nevertheless, European academic journals are those that published the most in these topics, specifically on the environmental component of innovation. Analysis of the clusters points to the major topics related to sustainable innovation. One of the key areas of research focuses on sustainability, especially on its environmental component, and the barriers faced by firms to achieve sustainable development under climate change conditions. Alternatively, research focuses on the barriers to innovation, which illustrates that it emphasizes financial and regulatory barriers. Finally, the social component of sustainable development remains underexplored, specifically on entrepreneurship

and social enterprises. Accordingly, future research agenda should consider potential areas of work to enhance knowledge about barriers to sustainable innovation, that is, applied research that considers regional effects and country-specific analysis, particularly in developing countries. Research on the social component of sustainable innovation could be relevant given the current bias toward the environmental components. Social innovation is essential, because it addresses concrete societal problems and promotes collective action and inclusion in novel ways within firms. Finally, research could be conducted on market and knowledge barriers to sustainable innovation given the current focus on financial and institutional barriers. Notably, bibliometric analysis provides a comprehensive view of a specific topic. However, this type of analysis has certain limitations related to the research protocol and the selection and inclusion of the final documents. The limitation of this study is related to the inclusion of only journal articles for analysis and the use of only one comprehensive citation index. In this regard, considering other citation indexes, such as the *Web of Science*, would be valuable for future studies.

AUTHOR CONTRIBUTIONS

A. Escobar performed the literature review and research design and analyzed and interpreted the data and prepared the manuscript text and manuscript edition. J. Luna conducted the literature review and research design and analyzed and interpreted the data, prepared the manuscript text and manuscript edition. A. Caraballo helped in the literature review and manuscript preparation.

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CONFLICT OF INTEREST

The authors declare no conflict of interest regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancy, were observed by the authors.

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ABBREVIATIONS	DEFINITION
%	Percent
CO ₂	Carbon dioxide
CSV	Comma separated values
Fig.	Figure
H INDEX	Hirsch index
PRISMA	Preferred reporting items for systematic reviews and meta-Analyses
SDG	Sustainable development goals
SJR	Scimago journal rank
SME	Small medium enterprises
UN	United nations
VOSviewer	Visualizing scientific landscapes: It is a software tool for constructing and visualizing bibliometric networks

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