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Industrial cluster and knowledge creation: a bibliometric analysis and literature review

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Abstract

The interaction between the development of industrial clusters and knowledge generation has become a fundamental element in driving innovation systems. Examining industrial clusters in knowledge creation terms is interesting for policymakers, investors, businesses, and academia. This article provides a thematic and intellectual overview of the existing scientific literature on industrial clusters, their evolution, and their relationship with knowledge creation. The aim is to identify the scientific literature foundations in this area, different intellectual, conceptual, and social structures, and trends in the research field. The study is a bibliometric analysis, whose results show that researchers' topics of interest have considerably evolved over the last four decades. Initially, most studies focus on policies for efficient clusters management and later, starting in the 2010s, they evolve towards the importance of the networks of resources and knowledge that clusters provide, and how to promote learning and innovation as a key activity for economic development.

Keywords: industrial cluster; cluster association; innovation; knowledge creation

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1. Introduction

Industrial clusters, or districts, are particularly relevant for their innovation capacity and as a focus of regional development (Kihombo et al., 2021; Hoffmann et al., 2023). Interaction within clusters not only benefits collaborating companies, but also drives national competitiveness. Since Porter highlighted the industrial clusters concept in the 1980s, researchers have analysed clusters as an important factor in innovation, entrepreneurship, and technological development (Simmie & Sennett, 1999; De Groot et al., 2009; Dumais et al., 2002). The importance of clusters has been linked with collaboration networks and knowledge diffusion generated in companies, technological centres and local universities (Aiello et al., 2008; Audretsch et al., 2020). Clusters are broad networks that share knowledge, which includes not only companies of different nationalities, but also institutions like universities and government agencies. Therefore, industrial clusters are considered knowledge incubators that promote learning, and are described as a network of associated and interconnected companies, institutions, and social relationships within geographical boundaries (Li et al., 2017; Mo et al., 2020).

The vast number of studies that explore the relation between clusters and knowledge creation, and the impact on innovation and regional development (Cantner et al., 2019; Hoffmann et al., 2023, call for a general analysis of the published studies. It is crucial to identify emerging trends in this specific research field (Cooke, 2002; Aiello & Cardamone, 2008; Altunbas et al., 2013) to keep researchers and decision makers informed of the most relevant current topics. Furthermore, researchers need to understand the structure of research conducted into clusters, including the relations among authors, institutions, keywords, and research topics.

This study aims to identify the structure of scientific knowledge on clusters and knowledge creation from the perspective of associated themes, institutions, and authors. Four research questions are formulated to address this objective:

RQ1. How has research into industrial clusters evolved in relation to knowledge creation from 1982 to 2022?

RQ2. Which countries and authors publish about the industrial clusters' topic?

RQ3. What contexts and research topics related to industrial clusters and knowledge creation have been explored in the existing literature?

RQ4. What are the present and future research trend topics?

To answer these questions, a bibliometric analysis was carried out. This methodology allows trends in research lines to be identified (Donthu et al., 2021). This work contributes to synthesize the current research body on industrial clusters and their relationship with knowledge creation by providing an overview of the foundations, thematic structures, and future research trends in this field.

The structure of this article is as follows: firstly, the fundamentals of industrial clusters are addressed in relation to knowledge creation. Next the bibliometric method applied to the literature is explained. Subsequently, the research method and the results are presented, including an analysis of variables like co-citations, author keywords, among others. Finally, the main conclusions of the study and its limitations are presented, and possible future research areas are identified.

2. Theoretical background

Of the advantages associated with industrial clusters, the ability to gain efficiency through productive specialization stands out. Researchers consider the institutions that make up the cluster, and the forms of collaboration between these institutions in a specific geographical region, to be of particular importance for achieving this efficiency (Boix et al., 2014; Giusti et al., 2020). By forming a cluster, companies can reduce investment costs, access skilled labour and improve their competitiveness through collaboration in innovative activities (Frenken et al., 2015; Giusti et al., 2020). A fundamental element for the competitiveness of the companies in an industrial cluster is the capacity to create technological and organizational innovations that can generate competitive advantages. This is because the relationships within the cluster foster the circulation of information and the development of technological absorption capabilities (Miguelez & Moreno, 2015; Giusti et al., 2020) by facilitating the creation of new knowledge on a local or regional scale. In the cluster, therefore, companies collaborate with other entities to acquire knowledge and resources, to engage

in interorganizational learning and to improve innovation performance (Jiang, 2020; Ode & Ayavoo, 2020; Devece et al., 2022).

In the last few decades, the scientific community has explored the relation between knowledge creation in industrial clusters and innovative performance (Chong-Moon Lee et al., 2000). Knowledge generation in clusters can vary depending on the interaction with the surrounding social environment, and on the robustness of the links among the university, technological centres and companies. University-industry (U-I) collaboration facilitates the creation and transfer of knowledge and technology (Roger-Monzó et al., 2015; García-Hurtado et al., 2022). The relevance of this collaboration in cluster development lies in knowledge generation, where universities contribute expertise and research infrastructure, while industry offers development, commercialization and market knowledge. This collaboration leads to the creation of innovation centres, academic spin-offs and other joint projects that contribute to technological and economic progress (Molina-Morales et al., 2022; García-Hurtado et al., 2022b). Collaboration with universities and research centres emerges as a crucial factor for knowledge creation in the cluster, and comes in various forms regarding organizations and individuals, knowledge and technology transfer, and social and professional networks.

Another crucial aspect for the cluster's development and evolution is the proximity of the organizations that make up the industrial district. Empirical studies support the importance of geographical proximity in knowledge creation (Audretsch & Feldman, 1996). However, more recent research has extended this notion by suggesting that proximity can be both geographical and organizational (Jia et al., 2015; Boix et al., 2014). Geographical proximity fosters face-to-face interactions between organizations and facilitates knowledge exchange, while organizational proximity with geographically distant partners broadens access to diverse knowledge sources (Gordon & McCann, 2005; Boix et al., 2014). By taking into account this first general review of the most prominent studies about clusters, we can proceed with the detailed bibliometric analysis.

3. Methods

This study employs the bibliometric analysis to assess the most influential research into industrial clusters and to identify opportunities for future research in the field. The bibliometric

analysis is a research technique that enables the evaluation of extensive scientific literature sets (Donthu et al., 2021). This technique is valuable for conducting analysis in a research area and for interpreting scientific knowledge and evolutionary nuances by allowing an examination of the social, conceptual, and intellectual structure to, thereby, map the scientific knowledge boundaries in a given research field.

The choice of the bibliometric technique in this study was motivated by its interdisciplinary nature, and by it effectively mapping directions and topics addressed while developing a research field. Consequently, our study focuses on understanding how research into industrial clusters has evolved.

A bibliometric analysis is conducted using citation bibliography, co-occurrence, and a network analysis, along with graphical maps based on bibliometric data. We utilise the VOSviewer software (version 1.6.15 (0)) (Van Eck & Waltman, 2010) and the Bibliometrix software (Dervis, 2019) to create and visualize these maps. These programs enable graphical representation and data analyses, such as citations, journal co-citations, bibliographic coupling by authors and countries, author keyword co-occurrence, among others (Zupic & Čater, 2015), by visualizing connections between these variables (Merigó et al., 2016). These combined techniques allow the intellectual structure of a research field to be presented (Donthu et al., 2021).

Initially, the Web of Science (WOS) was selected for being the leading database for scientific citation searching and analytical information (Li et al., 2018). Then three keywords were searched: "industrial cluster," "cluster association" and "cluster innovation." The results yielded 4,305 research articles. The inclusion criteria were not limited by language, country, or year of publication to minimize any bias in the search results as much as possible. Exclusion criteria based on document type were applied. Works published in conferences, books and working papers were excluded. The research process flow chart is illustrated in Figure 1.

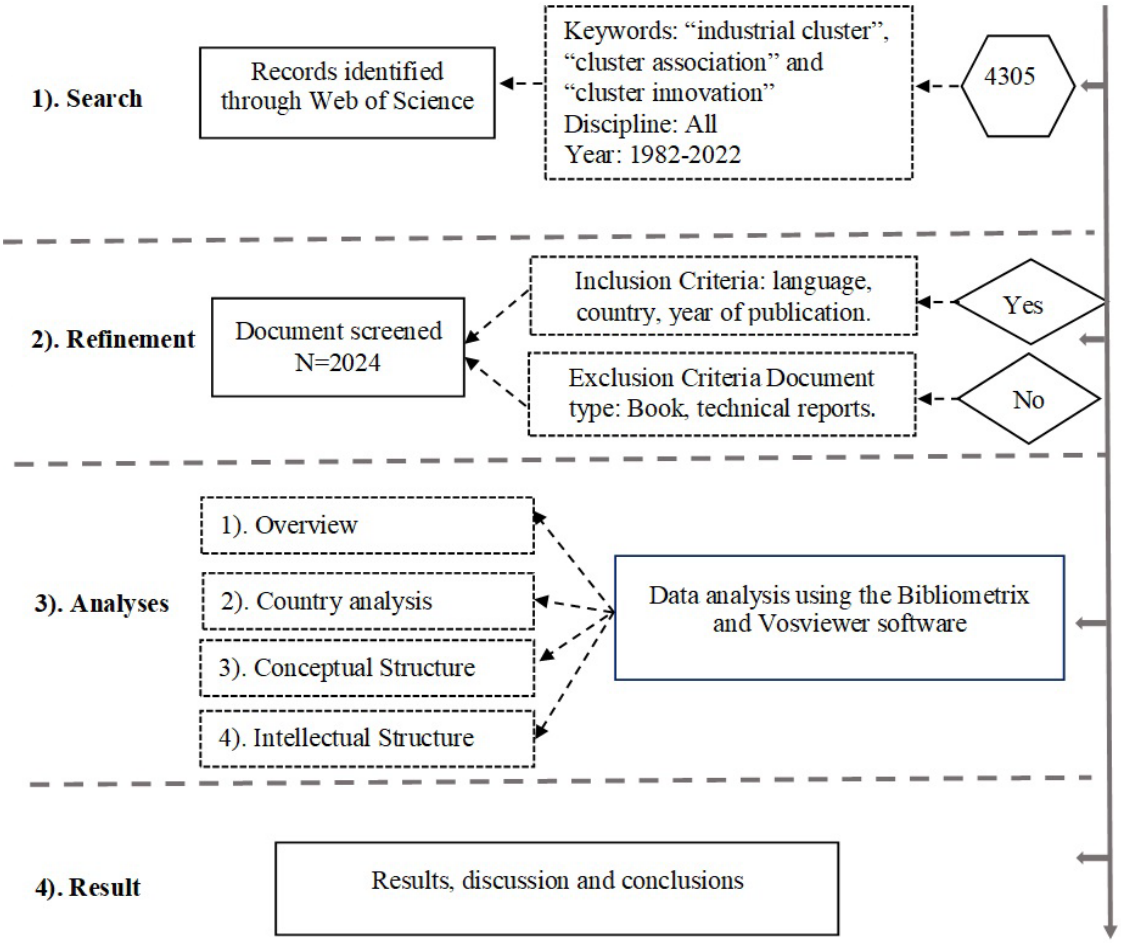


Figure 1. Research Process Flowchart.

4. Analysis and Results

4.1. Scientific Production Process

Figure 2 depicts the distribution of the publications during the 1982-2022 period related to "industrial cluster," "cluster association" and "cluster innovation." Any changes in article production in this field can be divided into two distinct periods. During 1982-2002, article production was very limited. The first articles emerged in 1982 and were related to the development of the "industrial

clusters" concept proposed by Porter (1990, 1998). This period was characterized by profound transformations in production organization, with more flexible and decentralized forms of organization becoming increasingly predominant. The first studied industrial clusters emerged in North America and Western Europe in the late 1970s, where small- and medium-sized enterprises in regional clusters rapidly developed. The Italy and Silicon Valley clusters have become typical examples of world-class industrial clusters today. These first studies led to a research series that raised concepts, such as industrial districts (Becattini, 1979), flexible specialization (Piore and Sabel, 1984), new industrial spaces (Scott, 1988) and industrial clusters (Porter, 1990).

The trend of the articles related to industrial clusters increased significantly during the 2002-2022 period, with an evident upward slope in scientific production. This period can be considered the most important one in literature production terms. This could have been due to the competitiveness of the enterprises in industrial clusters worldwide, and to the relation with innovation and national competitiveness. In the last 20 years, scientific production has focused on knowledge diffusion in clusters in fields like strategic management (Arvanitis et al., 2013; Foray, 2016), innovation systems (Brenner et al., 2011; Belussi et al., 2010; Fitjar et al., 2019) and economics (Czarnitzky & Hussinger, 2018).

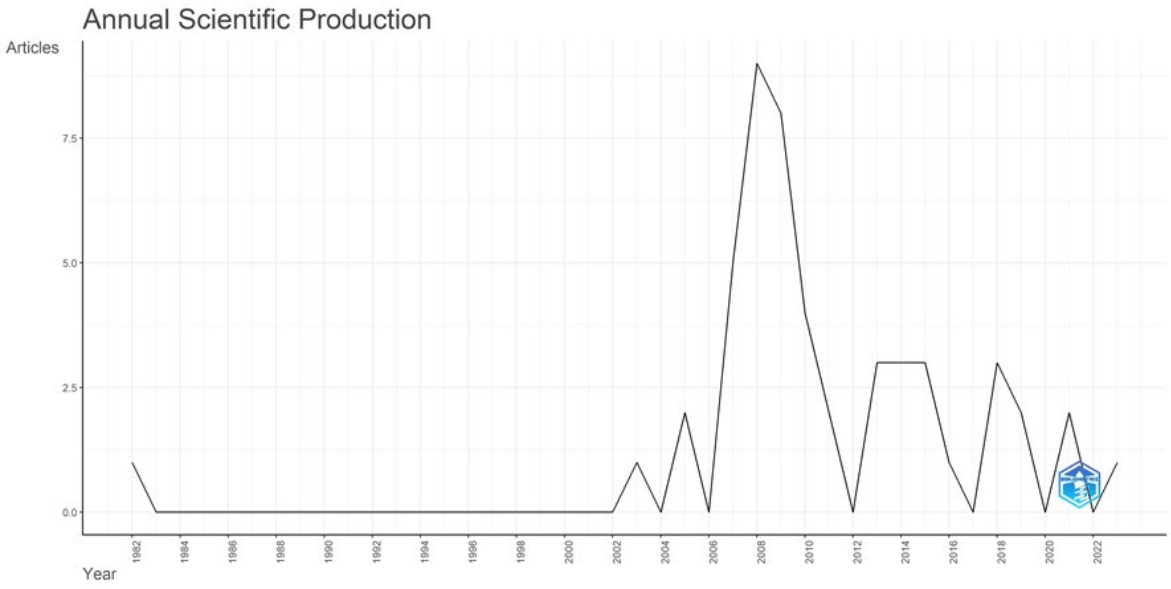
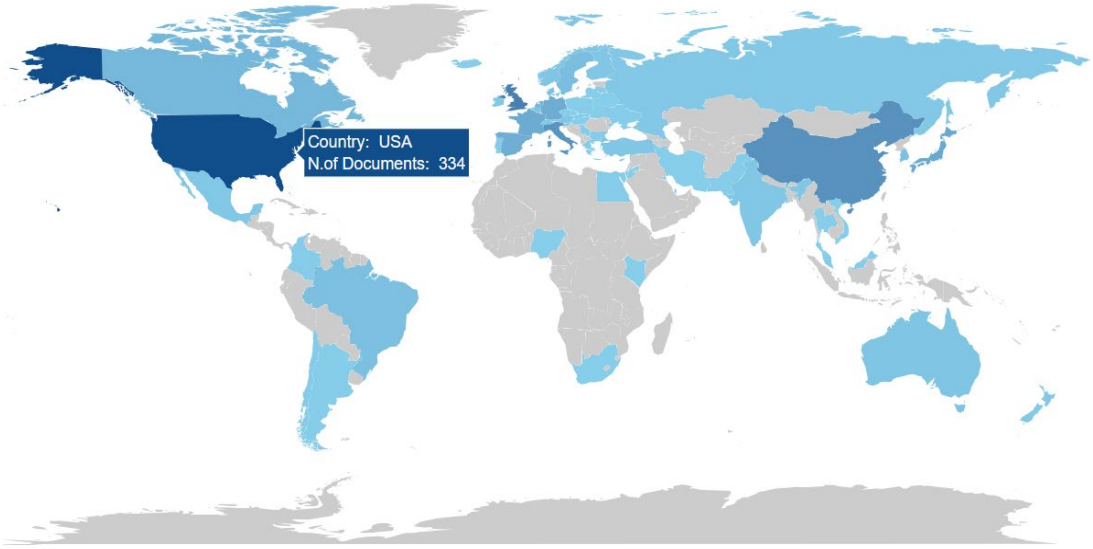


Figure 2. Annual Scientific Production Estimated Using Bibliometrix, 2023.

4.2. Social Structure and Country Productivity

In Figure 3, the collaboration between different countries worldwide is analysed using a geographical map. The analysis was conducted during two periods following the temporal division of publications shown in Figure 2. During the first period (see Fig. 3A), the United States led academic productions with 334 articles published between 1982 and 2009. Next China ranked second in number of publications. The second scientific productions period was more significant as far as volume of works was concerned. As Figure 3B depicts, during this period the United States lost its leadership, and China occupied first place with 589 publications between 2010 and 2022. Although the United States has historically been a leader in innovation and technological development, there has been a relative decrease in its specific investment in the study of industrial clusters. China's leadership in publications terms is because it has significantly invested in R&D, its government has prioritized strategic sectors, rapid industrial and urban growth, with clear governmental support for scientific and technological research, and the promotion of international research collaboration.



A) 1982-2009

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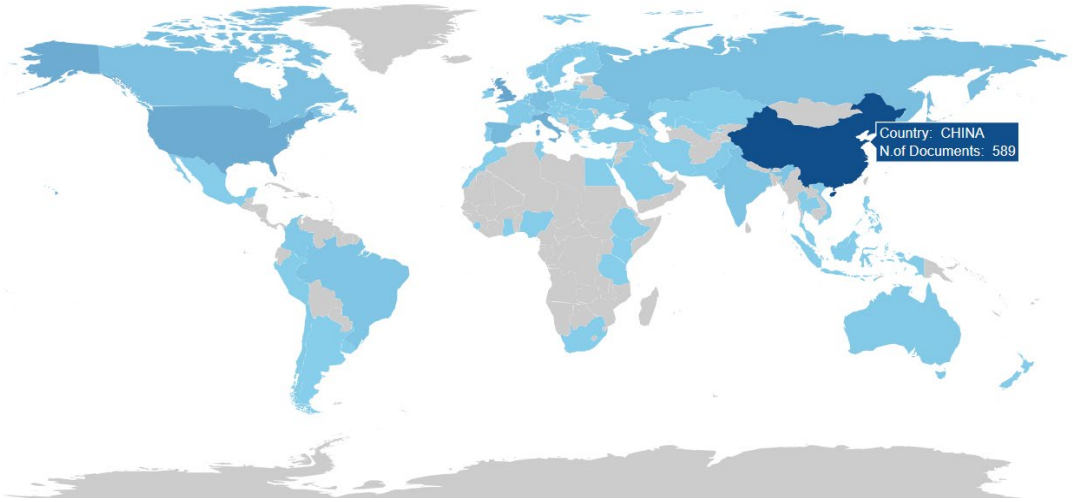
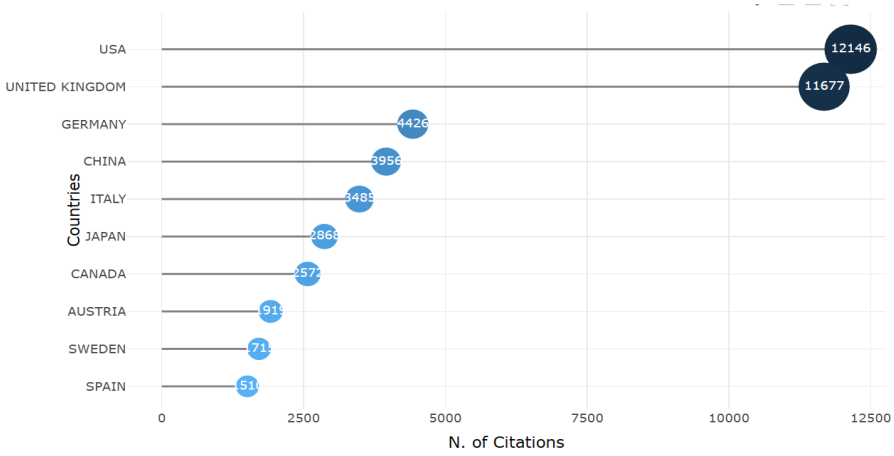


B) 2010-2022

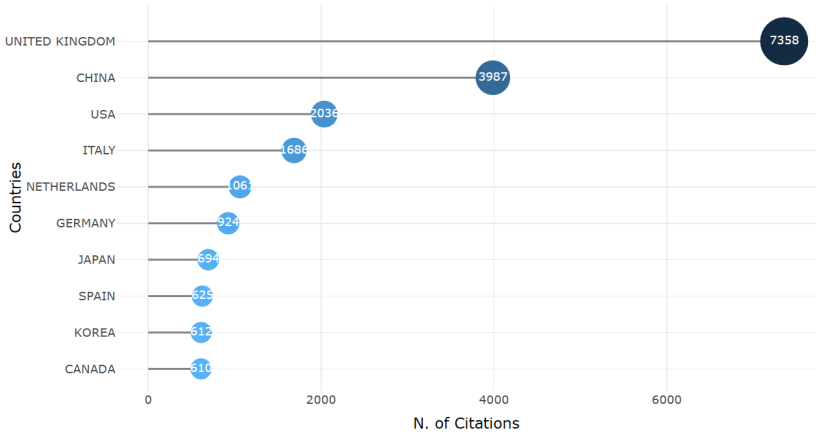
Figure 3. Country Scientific Production Estimated Using Bibliometrix, 2023

The next presented analysis was the classification of countries by considering received citations (Fig. 4). Citation analysis-based indicators were calculated to identify the prominent countries. During the first period (1982-2009), there was a correspondence between the country with the most and the most cited scientific productions, in this case the United States. Of the most relevant works during this period, there are those of Porter (1990), "The Competitive Advantage of Nations", published in Harvard Business Review. This seminal article argues that industrial clusters are the basis for national competitive advantage. Another notable work is that of Krugman (1991), "Increasing Returns and Economic Geography", published in the Journal of Political Economy. In his work, Krugman presents the model of economic geography, which shows how increasing returns can explain the formation of industrial clusters. During this period, the examination of how cultural factors and networks of relations contribute to cluster success is also notable. Indeed the work of Saxenian (1994), "Regional Advantage: Culture and Competition in Silicon Valley and Route", stands out. In summary, early academic works on industrial clusters established the theoretical basis for understanding how geographic proximity among related firms can result in significant competitive advantages and can lead to focus on the role of location and interfirm relationships in industrial competitiveness.

During the second period (2010-2022), and conversely to behavior during the first period, where the country with the most citations was also the most productive, the country with the most citations was the United Kingdom. During the 2010-2022 period, the number of papers on industrial clusters significantly increased. Of the most outstanding publications during this period is that of Boschma and Frenken (2011) entitled "The Emerging Empirical Agenda of Evolutionary Economic Geography". It provides an overview of the emerging empirical research agenda of economic geography by focusing on the role of geography in shaping the spatial organization of economic activities. Another notable work is that of McCann and Ortega-Argilés (2015), which explores the application of smart specialization in regional cohesion policies and its relationship with industrial clusters. In summary, academic works about industrial clusters between 2010 and 2022 emphasized the central role played by clusters in promoting innovation, economic resilience, and regional collaboration. These studies suggest that understanding and fostering industrial clusters may be crucial for driving economic growth and competitiveness.



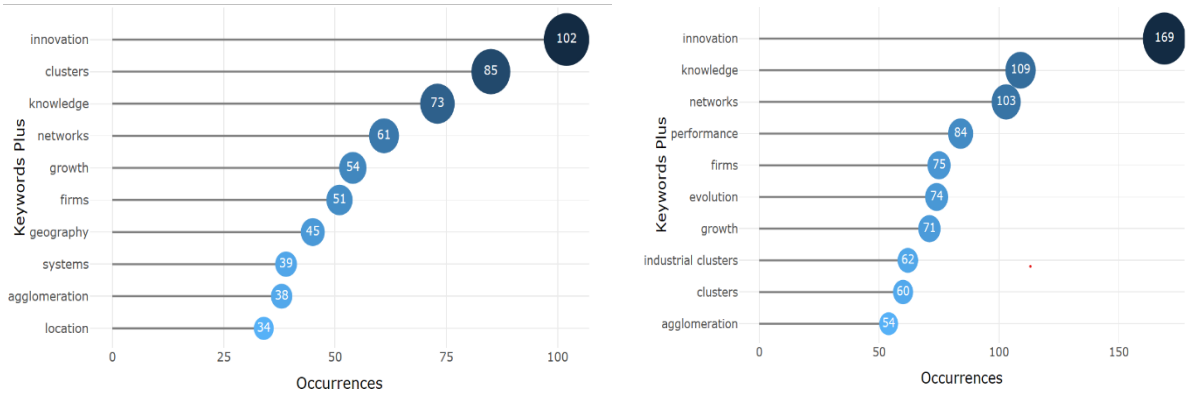
A) 1982-2009



B) 2010-2022

Figure 4. Country citation estimated using Bibliometrix, 2023

An analysis of the most frequent keywords per period revealed that the presence of "knowledge" was prominent. For the 1982-2010 period, "knowledge" occupied the third position, preceded by "cluster" and "innovation". During the second period (2010-2022), "knowledge" moved to second place, surpassed only by "innovation". This shift in the relevance of keywords is because knowledge exchange plays a crucial role in innovation and competitiveness. Industrial clusters are environments in which knowledge creation and exchange play a fundamental role in innovation, collaboration, and competitiveness. Therefore, it is not surprising that scientific studies into industrial clusters tend to focus on the role played by knowledge in the development of industrial environments.



A) B)

4.3. Analysis of the Conceptual Structure

Thematic mapping was conducted using the approach proposed by Cobo et al. (2011) to analyze the conceptual structure of the industrial cluster's topic. Thematic mapping consists of a graphical map where two perpendicular axes are used on a Cartesian plane to divide the space into four quadrants. This map displays the strength values of the association between different words.

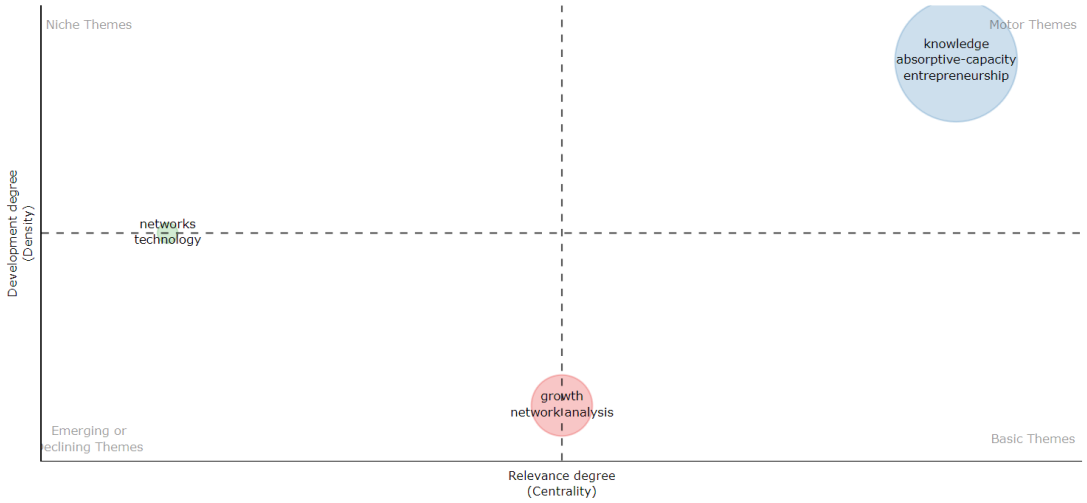


Figure 5: Thematic Map Louvain Network

Figure 5 shows the association values between different words from three clusters. These three clusters are denoted as: "Knowledge Absorptive Capacity and Entrepreneurship", "Network Technology" and "Growth, Network Analysis". The keyword associations are based on the degree of relevance on the abscissa axis and the degree of development on the ordinate axis. The upper right quadrant indicates central themes for the field (well-developed), where themes have strong centrality and high density. In this case, the node that appears in the upper right quadrant contains the words: Knowledge Absorptive Capacity and Entrepreneurship (blue node). Notably, the works of Zhou et al. (2007) and Xu et al. (2019) stand out in this node. Zhou et al. (2007) emphasize the importance of industrial clusters for promoting a collaborative environment by highlighting knowledge exchange and skilled labor. Zhou et al. (2007) also associate the absorptive capacity concept with industrial clusters. Xu et al. (2019) consider that there is a close relation between clusters and entrepreneurship

because collaboration and exchange within a network facilitate the evolution from micro-enterprises into small businesses. The text addresses the importance of industrial clusters in the industrialisation process by focusing on the transition from a planned economy to a market economy in China. In line with this, companies' geographical proximity and the links among universities, technological institutions and companies are fundamental factors.

The lower right quadrant presents basic cross-cutting themes that are important for the field but are underdeveloped for having strong centrality and low density. In this case, the pink node, which includes the keywords "growth" and "network analysis", is partially located in this quadrant. The articles in this node link industrial clusters with regional development strategies. It is interesting to note that the pink node is partially present in the lower left quadrant (present in the lower right quadrant), as is the green node (present in the upper right quadrant). This indicates that the keywords "growth" and "network" (pink node) and "network technology" (green node) are emerging or disappearing themes because they have low density and weak centrality.

Finally, the upper left quadrant indicates highly developed themes, but with irrelevant external links for having high density, but weak centrality. So, their importance for the field is marginal for being specialized and peripheral topics. This is the case of the green node ("network technology"), which is partially present.

4.4. Thematic evolution

Figure 6 shows the evolution of the thematic groups over two periods. During the first period (1982-2002), five thematic blocks are identified: cluster, chain, innovation, clustering, and industry. For the second period (2003-2022), the thematic blocks include the words cluster, economic, activities and improvement.

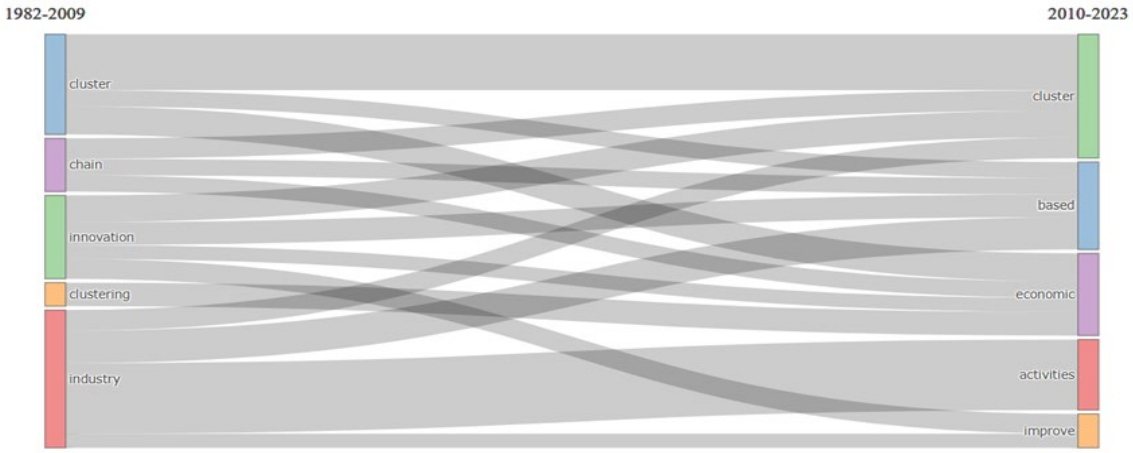


Figure 6: Thematic Evolution.

Figures 7 and 8 provide more detailed insight into clusters' thematic evolution during two periods. From 1982 to 2009 (Figure 7), the most important and developed themes (driving themes) were related to the keyword "innovation development cluster". This makes sense if we analyze the major works published during this period, when several theories about industrial clusters were developed and refined. One key article is "The Competitive Advantage of Nations" by Porte (1990), which discusses the importance of clusters for national competitiveness. Additionally, during this period, the policies that aimed to promote the development of industrial clusters and their impact on the regional economy were assessed. "The Silicon Valley Edge: A Habitat for Innovation and Entrepreneurship" by Chong-Moon Lee et al. (2000) is an example of an article that analyzed the case of Silicon Valley and the policies behind its evolution. These are only a few examples of the main themes and relevant scientific articles about industrial clusters during the period from 1990 to 2009. The academic literature on this topic has continued to evolve, which has led to a second period with new perspectives and approaches. During the period spanning from 2010 to 2022 (Figure 8), the most relevant and developed themes were related to "network" (blue node) and "economic growth" (purple node). These studies showed the degree of agglomeration of industrial clusters as an important variable that influenced regional innovation capacity. For example, Delgado et al. (2014) examined how industrial clusters could positively affect regional economy by stimulating innovation,

increasing productivity, and fostering collaboration between companies and other local institutions. Other authors like McCann and Ortega-Argilés (2015) reviewed various theories and models to explain how industrial clusters were able to drive regional economic growth through mechanisms, such as business agglomeration, specialization, and localized learning.

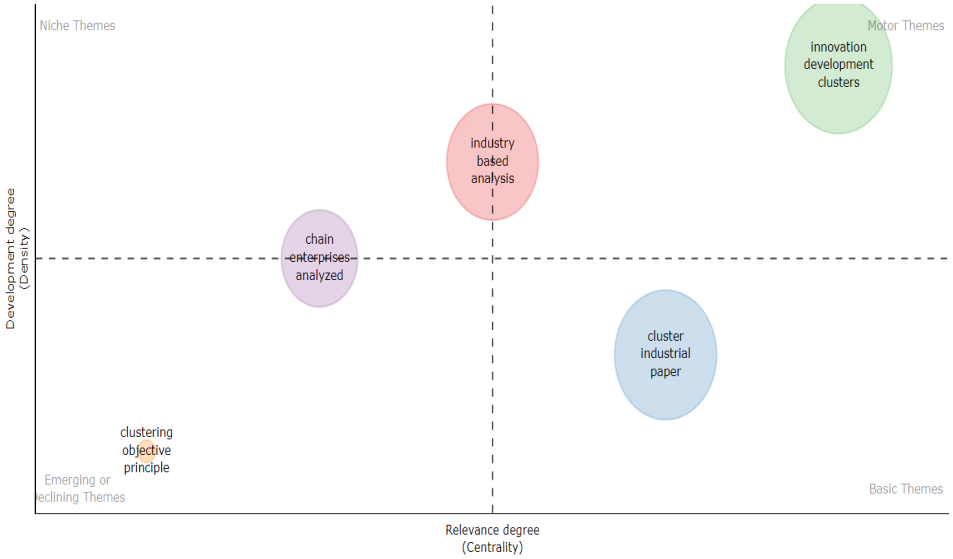


Figure 7: Thematic evolution. Period 1982-2009.

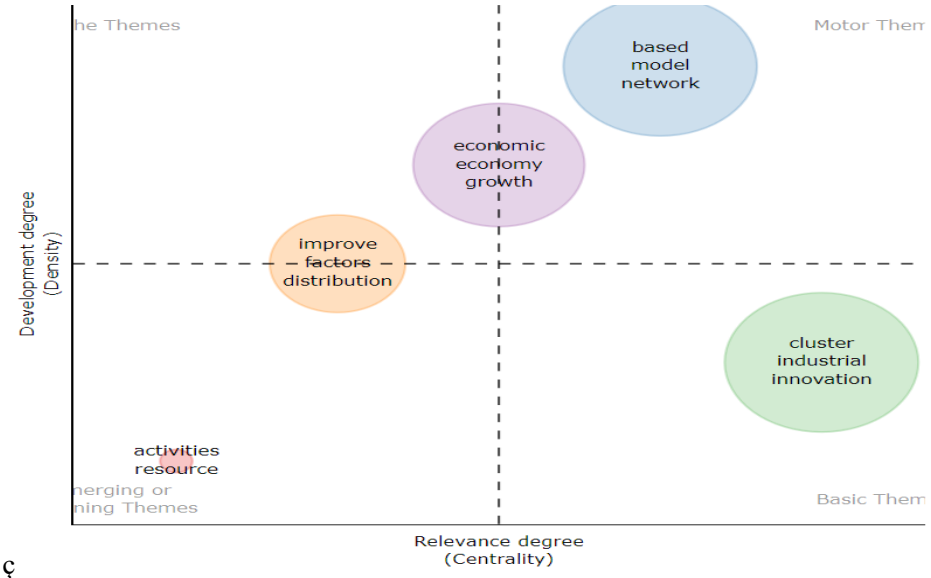


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Figure 8: Thematic evolution. The 2010-2023 period.

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4.5. Analysis of Intellectual Structure

Co-citation occurs when two documents receive a citation from a third document. The co-citation analysis of authors allows us to understand how authors, as experts in the field, connect ideas across published works and, thereby, establish the existence of similar themes (Boyack & Klavans, 2010). Figure 9, obtained with VOSviewer, shows four clusters. The larger the node, the more citations the reference has; the thicker the line connecting two references, the greater the total strength of the link.

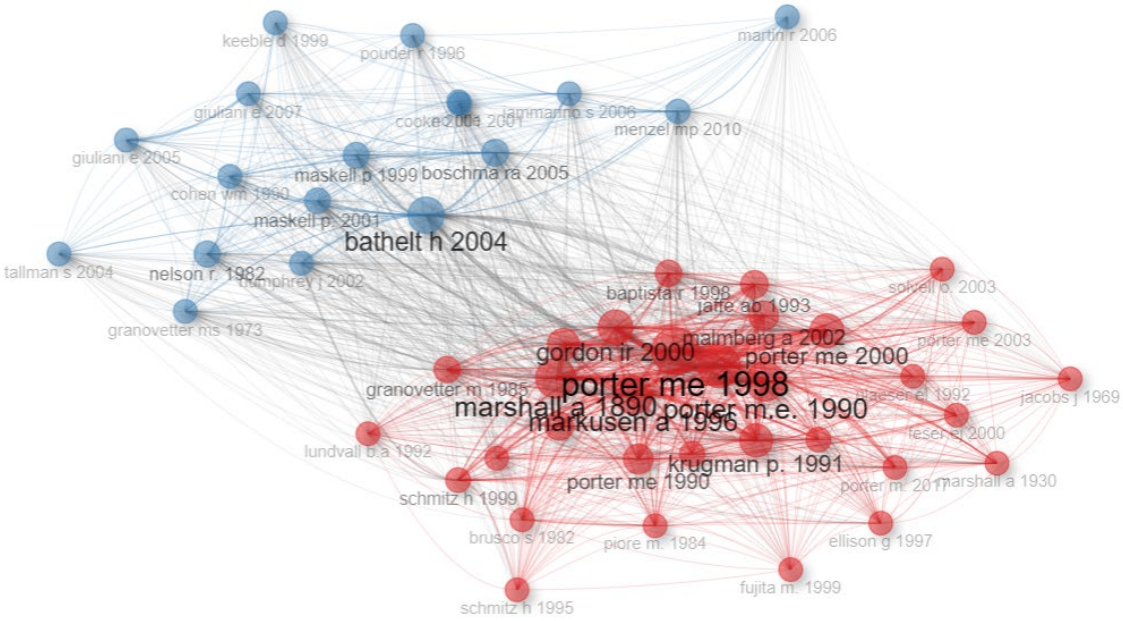

Figure 9. Co-cited Reference Clusters in the Database.

In Figure 9 we can see the relation of the co-cited references from the 1982-2022 period. Two clusters are clearly distinguished: the more theoretical cluster, denoted by red, and the blue cluster. In the red cluster, the most cited work is "The Competitive Advantage of Nations", published in 1990 by Porter, who introduces the industrial clusters concept and argues that these play a fundamental role in nations' competitiveness. This cluster also contains the work of Krugman (1991) "Increasing Returns and Economic Geography". Krugman presents the model of economic geography, which shows how increasing returns can explain the formation of industrial clusters.

The second (blue) cluster contains works like that of Bathelt (2002), "Clusters and knowledge: local buzz, global pipelines and the process of knowledge creation". Clusters facilitate knowledge creation through two complementary processes: "local buzz" and "global pipelines". Harald Bathelt's work provides a comprehensive perspective on how industrial clusters facilitate knowledge creation through intensive local interaction and global connections by emphasizing the importance of both processes for economic development and innovation.

5. Conclusions

The creation of industrial clusters helps to create significant local technological advancements by facilitating both domestic and foreign companies to share advanced technologies and management practices. This phenomenon strengthens economies of scale and scope by enhancing national industries' technological and economic performance. This study identifies the fundamentals of the scientific literature in this area, different intellectual and conceptual structures, and trends in the field.

The analysis covers the evolution of research into industrial clusters from 1982 to 2022, which are divided into two phases. The first phase (1982-2002) shows scant article production and focuses on the conceptual development of clusters. The second phase (2002-2022) evidence significant research growth and highlights the importance of innovation and competitiveness.

The results also reveal a shift in research leadership in industrial clusters between the United States and China. This change is attributed to the relative decrease in US investment in this research field and China's strong push towards R&D as reflected by it rising as a key player in global innovation. Additionally, when considering the number of received citations, researchers from the Netherlands and Italy top the list with studies on industrial dynamics and clusters. This analysis highlights the global relevance of industrial clusters as drivers of innovation and economic competitiveness (Molina-Morales et al., 2022; Hoffmann et al., 202).

One of the most relevant findings is the presented structure of the interconnected network of keywords, which provides a deeper understanding of the topic. This structure highlights the importance of the "industrial cluster" in relation to terms like "competitive analysis," "competitive advantage," "cooperative relationships" and "innovation networks." These connections show the

intrinsic relation among industrial clusters, business competitiveness and relationships within clusters.

Analyzing the evolution of themes over two periods allows us to conclude that the academic literature on industrial clusters has significantly evolved over time. During the first period (1982-2009), it focuses on theory and policy development, which are influenced by key works (Porter, 1990, 1998) and case studies. During the second period (2010-2022), attention shifts towards topics like networks and economic growth by highlighting the importance of business agglomeration in regional innovation capacity and economic development. Recent studies examine how industrial clusters can stimulate innovation, increase productivity, and foster collaboration among companies and other local institutions by providing a more nuanced and sophisticated understanding of these phenomena (Xu et al., 2019; McCann and Ortega-Argilés, 2015).

5.1. Practical Implications

The findings of this study can also be of practical interest to conduct future research to extend the current body of knowledge on industrial clusters. This research provides an overview of the intellectual, conceptual, and social structure of the relation between industrial clusters and knowledge creation. A detailed understanding of the main themes and contributions in the industrial clusters field is offered and shows the multidimensionality and complexity of this study area.

It is also worth noting that the connection of industrial clusters with the "knowledge spillover" phenomenon is not as solid as in other cases. This suggests that the relation between industrial clusters and knowledge transfer is an underdeveloped topic. Despite the importance of knowledge for innovation in industrial clusters, its role is not a mainstream issue in the research topic.

This study serves as a strategic guide for researchers, professors, university administrators and policymakers by enabling them to better understand and address the challenges and opportunities associated with the development of industrial clusters.

5.2. Research Limitations and Future Scope

This study was limited by the coverage bias inherent in its methodology. The bibliometric analysis was based on the available scientific literature, which implies a bias towards certain types of publications, such as journals indexed in specific databases, while unpublished research or

research published in other formats may have been overlooked. Additionally, including only the studies with the search terms in the title reduces the possibility of finding other relevant works on the topic. Secondly, the study may have been limited by its methodology. Although the bibliometric analysis provides an overview of the research field, it lacks the level of detail that a deeper analysis could offer, such as a systematic review performed by an expert researcher.

For future research works, it would be beneficial to consider a more holistic approach to identify sources and publication domains, which could contribute to develop a more inclusive perspective. Furthermore, this work points out the need to delve further into the connection of industrial clusters with the "knowledge spillover" phenomenon because this topic is underdeveloped in the current research. Exploring this aspect could help to better understand its impact on innovation and economic development and to, thus, address the last research question about possible future research avenues or themes.

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