



Global city data analysis using SciMAT: a bibliometric review

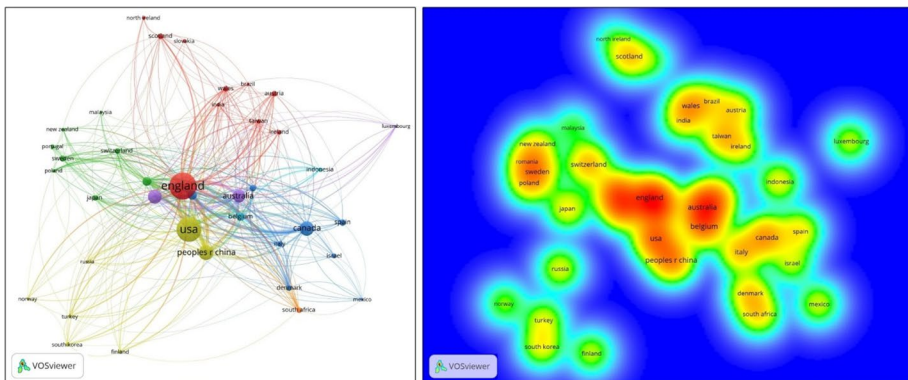
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Received: 2 November 2022 / Accepted: 13 April 2023
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Abstract

Global cities play a significant role in world economy as they serve as key hubs of economic activity and trade. These cities are centers of innovation, finance, culture, and commerce, attracting businesses and entrepreneurs from all over the world. They are characterized by their openness, diversity, and their ability to attract and retain talent. This paper includes a bibliometric analysis of the structure of global cities through examining the literature on global cities, including the document type, country/territory distribution, institution distribution, geographical distribution of authors, specially most active authors and their interests or research areas, relationships between principal authors and more relevant journals, and the research hot spots. The input data consists of journal articles archived by the Web of Science from 1991 to 2023, and the analysis is performed using SciMAT and VOS Viewer. The result of this paper would provide valuable insights into the state of research on this topic, including who is conducting research, where it is being conducted, what types of publications are being produced, and which themes are having the most impact on the field. Such an analysis would be useful for researchers, policymakers, and other stakeholders interested in understanding the role of global cities in the world economy.

Graphical abstract



Keywords Global cities · Web of science · Bibliometric review · Data analysis · SciMAT

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Published online: 19 May 2023

1 Background

A global city or a world city is a concept that assumes which globalization can be decomposed on the basis of strategic geographical locations that create, facilitate, and approve global processes. The global city is considered as one of the most complex entities, and the connections that bind a city through politics or culture and socioeconomic tools have a direct and significant impact on the world affairs (Vormann, 2021; Zhang et al., 2022).

Global cities support increased cultural exchange and understanding, contribute to the growth of the world economy, and open up new business and employment opportunities for people all over the world. These cities frequently serve as important hubs for business, finance, culture, and innovation, and they draw a wide range of companies, entrepreneurs, and talent from around the globe (Friedmann, 1986; Regnier and Wild, 2018). Due to their developed transportation systems and communication infrastructure, which facilitate cross-border movement of both people and goods, global cities typically serve as the centers of international trade and commerce (Chakravarty et al., 2021; Sassen, 2013). The capital and financial services required to support global trade are provided by global cities, which are residences of significant financial institutions. Businesses looking to grow internationally can benefit significantly from global cities as well. They have access to the most recent technological advancements and research, as well as established networks of suppliers, clients, and partners. As a result, businesses may experience cost-cutting, improved productivity, and a boost to their ability to compete on the international market (Kleibert, 2017).

Global cities around the world have a big impact on culture and society. A diverse and global population is drawn to them because they are frequently hubs of creative and intellectual innovation (Florida, 2002). A more connected and peaceful global society can be developed as a result of this cultural diversity by fostering greater understanding and cooperation across national boundaries (Warf, 2015).

Global cities are faced with a variety of difficulties, especially when it comes to resource management, social justice, and environmental sustainability. Energy, water, and food are some of the resources that are frequently consumed in global cities. This strains regional and global resources and may be a factor in climate change and environmental deterioration (Allan et al., 2022). Urban sprawl and the growth of suburbs dependent on cars are frequently the results of global cities expanding into suburban areas as they expand (Bagheri & Tousi, 2018; Bagheri & Soltani, 2023; Schneider & Woodcock, 2008). As a result, there may be more traffic congestion, pollution, and barriers to using public transportation and other necessary services. High pollution and carbon emission levels, which are a contributing factor in climate change and other environmental issues, are frequently found in global cities around the world. Natural resources may be depleted and local ecosystems may be harmed as a result of the rapid pace of urbanization and industrialization. Rising rents and property values are making it more challenging for low- and middle-income residents to find affordable housing (Marom & Carmon, 2015), which is causing a severe housing affordability crisis in many global cities.

Various factors are associated with globalization, including ideas related to spatial reorganization, information communication technology, finance, and principles that cities are becoming key locations in global production networks (Block et al., 2013; Moghadam et al., 2018a, b). Thus, in some global city expansion formulas, these cities are considered an important part of globalization. At the same time, these cities have become new privileged places of local politics as part of a larger project to reconfigure government institutions (Loureiro et al., 2017). These cities are combined to form a global urban network that

meets the needs of transnational capital over a wide area and having a research on them is necessary.

A brief review on the background of global cities shows that a various number of researches have been concentrated on qualitative and subjective aspects. Mental manifold and intellectual diversity are involved in shaping the global city literature, classifying criteria, tracing foci, and controlling directions. Therefore, in-depth review study, combined with quantitative and qualitative analysis, can lead to a clearer, more comprehensive, and more accurate view of global cities (Kanai et al., 2018).

There are several existing review documents (Chakravarty et al., 2021; Freestone et al., 2019; Furlan & Sinclair, 2021; Kanai et al., 2018) focusing on the global city and they only concentrate on a certain research area regarding the global city. For example, according to the Global Cities Investment Report by KPMG as well as the Paris Investment Agency, the top 35 global cities account for approximately 45% of the world's total international investment (Beaudouin et al., 2018). Based on the findings of Goerzen et al. (2013), 35% of foreign direct investment was located in ten global cities and 77% in 55 of these cities. Kanai et al.'s (2018) study illustrated that urban globalization lags behind in covering the geographical aspect of the city and has not been able to keep pace with economic and demographic trends that lead to urban change around the world to the south and east. An important step in the development of international trade knowledge in general, and investment behavior in particular, bridges this diverse literature to provide a solid platform for future research. Despite literature contributions, lack of bibliometric research on the global cities field is sensible to provide more complete, precise, and various data in this area from a holistic concept to decrease subjectivity and also reduce one-sidedness. Hence, the present study provides a broad overview of studies of global cities, which can contribute to the existing literature. The motivation of the study is not present at all and the only discussed one is the aim which is too fragmented and always posed by a technical perspective rather than a theoretical one. In addition, the bibliographic analysis method used in this study creatively implements a bright view of the progress of research in the field of global research in cities and can help researchers and practitioners to identify the underlying effects.

According to the best of our knowledge, no study has analyzed the thematic evolution of research on global cities. Based on the Web of Science (WOS) core collection database, the current research used a visual analysis of the global cities' themes and their route of progression from 1991 to 2023. In the light of this, the current study seeks to determine the most significant research aspects, as well as the features of research topics, their history, degree of growth and efficacy, and the prerequisites for the evolution of research on global cities. This work identified and aggregated pertinent information regarding global cities, a topic of growing scholarly interest, by analyzing the content of scholarly articles published in a variety of fields. The primary contribution of the research is the classification of many interdisciplinary studies into a simple framework that underlines the significance of key issues in global cities. This study will address the technical implications of the framework to develop and oversee the global cities' research agenda in order to fill the gap left by earlier research aimed at enhancing the knowledge of subnational contexts and units of analysis. As a consequence, the major objective of this study was to conduct bibliometric research to give planners an overview of the structure and insight into the research elements of global cities. The research goal was to address the following research questions in relation to the primary objective:

- What evolutionary research processes have global cities undergone from 1991 to 2023?

- Which themes have contributed to the evolution of the corpus of study on global cities, and how have they crystallized?
- What topics can future studies on the evolution of global city research focus on?

Consequently, this work's principal contributions are:

The research analyzes the most relevant papers on global city for a comprehensive and impartial examination. Consequently, it manages enormous quantities of works automatically and considers all publications equally. Thus, the findings of this research are assured to be objective (based on computed metrics) and include (subject to certain restrictions) all relevant articles.

This article provides a quantitative evaluation of the diffusion and expansion of global city research. It also describes the applications, techniques, and relationships between fields and the existing articles, as well as demonstrating a network of interactions, identifying foundational works, and offering a unique perspective on global cities that could serve as an introduction to the research field.

2 Methodology

Bibliometric analysis as an effective technique provides an overview of the vast number of available literature (Peris et al., 2021). This technique can map the features and develop scientific production in a specific field like a global city. Bibliometric analysis can also determine and quantify which authors, journals, countries, and institutions contribute to the scientific development of the global city (Gil et al., 2020). Therefore, the amount of attention paid to a research subject by different groups and publications can be an indication of the multidisciplinary nature of that research domain (Benjaminsen et al., 2019; Nunen et al., 2018). Moreover, bibliometric analysis provides an exploration of gaps in this research discipline. It can also play an effective role in supporting decision makers and decision takers in various areas of urban planning by clarifying the main focus of research (Nunen et al., 2018).

This research is distinguished from earlier studies of global cities by three essential characteristics. First, a unique bibliometric approach combining SciMAT and VOSviewer tools which offers a suite of quantitative bibliometric analyses is applied to the topic of global cities in this research. This novel strategy is adaptable and combines statistical and graphical results. Second, the study presents an overview of global city research via a variety of metrological and metric analyses. Initially, this investigation used several measures (h-index, number of citations, centrality, density, total link strength, etc.). Utilizing several metrics may assist disclose more specific information about this subject. Thirdly, this research investigates the intellectual structure of the global city domain using keyword and citation analysis. A number of science maps, such as the overlapping items graph, strategic diagram, cluster network map, three-field plot for the top 20 most productive keywords, countries, and sources, countries network visualization, and density map, were created to illustrate the intellectual structure of the global city field from various angles. In contrast to prior research, this paper's scientific maps give a global perspective, structural details, and notable aspects of the global city field. This work unifies and expands the bibliometric results of prior studies on global city literature and establishes new benchmarks for future bibliometric analyses in other research fields, based on these three essential characteristics.

2.1 Selecting tool

Knowledge maps or bibliometric maps are one of the most influential aspects of bibliometric studies (van Eck & Waltman, 2010). This technique relies on quantitative analysis to assess the researcher's interest in a particular field and can examine characteristics such as research topics, authors, publications, citation counts, research foci and trends (Qing et al., 2022a, 2022b). In this regard, scientists have used various bibliometric methods and visualization tools such as HisCite, Citespace, Ucinet, SciMAT, VOSviewer, etc., to extract and visualize research frontiers and show the process and progress of research. It is clear that each software has its own characteristics and offers opportunities to achieve new attainment by discovering hidden aspects of the subjects and understanding them more clearly.

In this regard, compared to other applications, SciMAT can fairly include all the required modules to perform all the steps of configuring scientific maps. It can also provide the analyst the capability of monitoring, intervening, and selecting from the first step (i.e., data loading and raw data pre-processing) to the last step (i.e., visualization and interpretation of results) of scientific map production. For example, it can automatically merge the singular and plural versions of the thematic words and delete some words with high frequency and weak directivity. Therefore, SciMAT has a special and unique position in explaining and interpreting thematic principles and rules (Cobo et al., 2012). VOSviewer software is also very widely used in bibliometric studies and it has a very high capability in providing visual maps (Wang & Yang, 2019). Therefore, we have used a combination of SciMAT and VOSviewer software in our method.

2.2 Data collection

In this research, on February 6, 2023, the data were obtained from the Web of Science database. This search engine has been selected due to its wide acceptance, high usage frequency in bibliometric studies, and high accuracy in the journal classification system (Wang & Waltman, 2016). Considering the coverage of the most various patterns of Global cities, the following retrieval code is adopted in this paper: TS=(“global* city” OR “global* metropol*” OR “global* city-region*” OR “global* cities”) AND PY=(1990–2023). Here, ‘TS’ represents the topic of a publication (i.e., search in the fields of the title, abstract, and keywords), and ‘PY’ represents the year published. In this retrieval code, asterisk (*) means a fuzzy search. It represents any number of letters at the end of a word, which can be helpful in finding variations of spellings¹ (Shi et al., 2020). To search for an exact phrase and to ensure the robustness of search results, we purposely enforced a tighter condition by including quotation marks (Liu et al., 2013).

2.3 Choice of articles

Based on retrieval code, 2730 documents were searched. The literature type was limited to “urban journal articles” since this type of publication usually provides higher quality and more important research on Global cities. We found that some studies only mentioned global cities in their keywords, while their content was not directly related to global cities. We believe that only studies that directly address global cities in their titles and abstracts can focus on this field, and that increasing the scope of documents with irrelevant studies will affect the purity of the results. Therefore, regarding the filters and the exclusions

¹ *In the search formulae in WOS means that all the remaining possibilities of the word are searched.

of duplicate and non-firm-level documents, 1195 documents were identified that cover the time range from 1991 to 2023.

In order to compare the thematic evolution map between continents, this study considered only the countries that have had remarkable contribution to the development of global city research field based on VOSviewer outputs.

2.4 Time slicing of global city study

In this paper the research period division is based on three factors: period length, the number of published documents and the fixed time window. A long period involves fluctuations which leads to a decrease in homogeneity. On the other hand, short periods may overlap each other and this makes the analysis and interpretation of the results vague and difficult. Therefore, it is necessary to consider a balanced state. In addition, since the early stage of global city research field belongs to the burgeoning period of development, the number of publications is small. Therefore, 1991–2001 was considered as the first research period. In addition, a fixed time window was adopted to divide 2002–2023 into three time periods. Thus, overall, the entire study was divided into four research periods: 1991–2001, 2002–2008, 2009–2015, and 2016–2023.

2.5 Parameter settings

In this study, the words of the analysis unit include "author words" and "source words." The data reduction thresholds of the four time periods were 4, 4, 4 and 4, and the selection matrix was Co-occurrence matrix. The reduction in the network threshold was 1,1,1,1. The standard network similarity index, equivalence index and algorithm of the cluster were simple center algorithms. The maximum selection of the network was 10 and the minimum value was 2, which chose the Jacquard index for its evolution map similarity index and overlap diagram.

Furthermore, this study tested many parameter settings (particularly in the "data reduction thresholds" stage), but when confronted with unrelated outputs, the current settings produced the most appropriate and meaningful results. This study used the VOSviewer software, which is based on the citation network to visualize the countries' cooperation. Threshold values were selected by this study setting the maximum number of countries per document to 25 and the minimum number of documents for a country to 5, and there were 40 countries meeting the thresholds.

Eventually, Fig. 1 depicts the overall process of research.

3 Results and discussion

3.1 General analysis of the global city data in different time windows

According to Fig. 2, the number of documents in these four time windows is 78, 192, 319, and 606, respectively. Even though the number of documents published in the first and second time window has an increasing trend, the growth rate of document production has been very low in these time windows, sometimes fluctuating, and even declining. Interestingly, it reached its peak in 2007 and it can be called an oscillatory period. Compared to these two periods, a relatively increasing trend in document production can be observed in

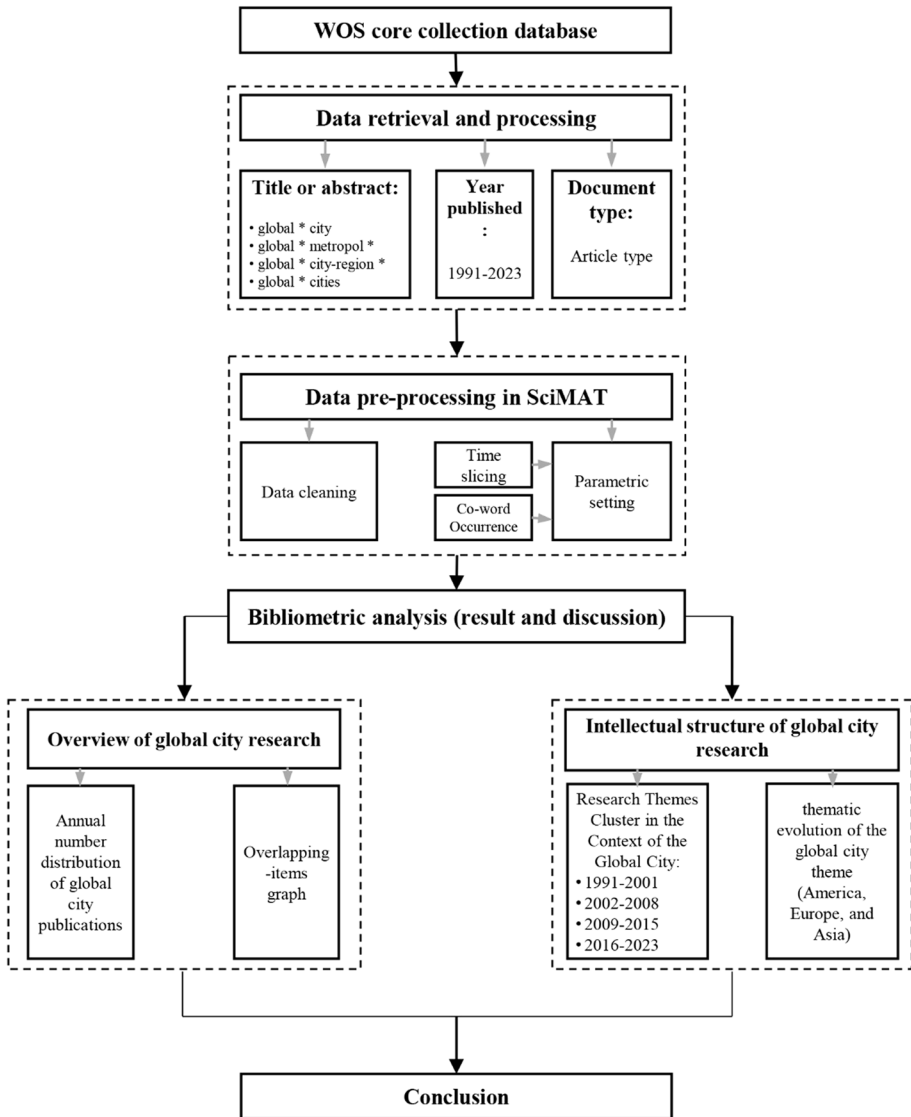


Fig. 1 The main research steps

the third period. Although the relative development of the subject is being formed in this period, the comparison of the number of documents published during this period does not show much difference; therefore, this period can be referred to as a constant period. The increasing trend of documents published in the fourth period is significant. A comparison of the number of documents published during this period (with an average of 75.75) with that of previous periods (with an average of 7.09 in the first, 27.43 in the second periods, and an average of 45.57 in the third period) indicates the activity level of this period. Logically, experts and researchers have focused on this subject, so this period can be called a

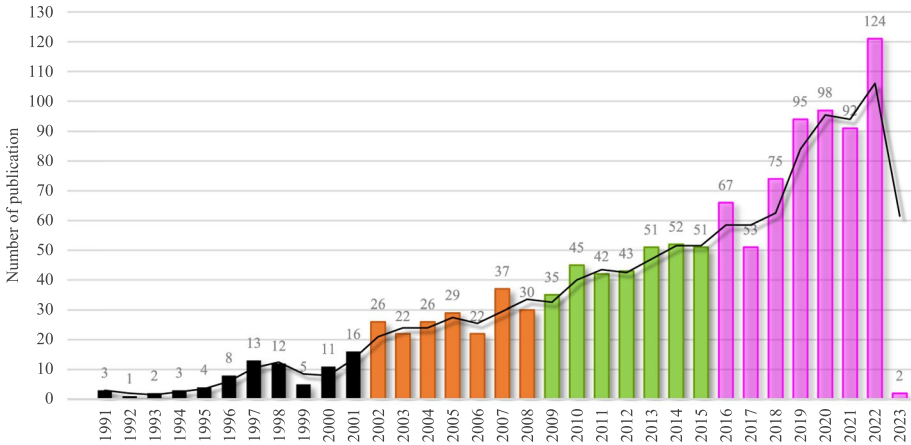


Fig. 2 Global city research documents published from 1991 to 2023

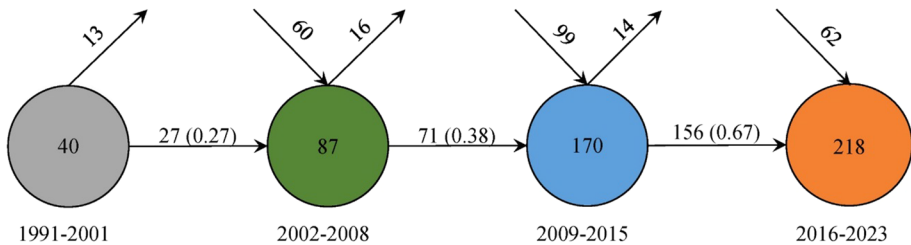


Fig. 3 Overlapping-items graph of the global city research field from 1991 to 2023

period of productive growth on the global city level in the field of document production. In this regard, the number of published documents reached its peak (124 documents) in 2022, which includes 20.46% of the number of documents of the last period and 10.37% of the total number of published documents (e.g., Perry & Atherton, 2017; Kleibert, 2017; and Houllier Binder et al., 2017).

Figure 3 shows the overlapping map for four time periods in the global city. This figure clearly demonstrates the number of words emerging from each period. In this map, the beginning to end period is arranged from left to right, respectively. Some new words are added in each period and the number of these words specifies the depth of the level of studies in each period. However, studies in each period have a profound connection with later periods due to the low rate of output words and the high and constant stability coefficient. Therefore, each word has been shaped in the form of other new words in the next period, and the changes and evolutions are intense. It is clear that the scope of the literature on this issue has continuously increased and followed an evolutionary path, and each word shows itself as the root and basis of several other words in later periods. This is due to the special attention that experts give to the properties of the global city and its complex role as the lever of economic development in each country. According to Buckley & Strange (2015), Goerzen & Beamish (2005); Goerzen (2007), Sassen (2001) and Storper & Scott (2009), one of the paradoxes of the process of economic globalization is that, instead of a more even distribution of economic activity, certain locations continue to receive

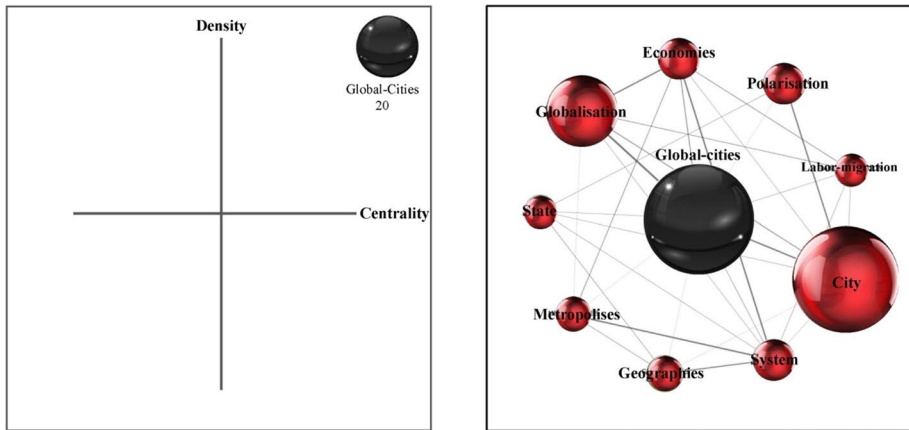


Fig. 4 Strategic diagram for the subperiod of 1991–2001

disproportionate levels of investment. As shown by Sassen (2011), this is counterintuitive given that the communication technologies that were predicted to reduce agglomeration have instead enabled it. These observations have led to a heightened interest in the physical sites of economic globalization with a particular emphasis on subnational locations such as regions, clusters and, more specifically, cities. Large cities, in particular, became of significant interest across several disciplines as their economic roles as centers of command and control became apparent (Cohen, 2018).

3.2 Analysis of the research themes cluster in the context of the global City

3.2.1 The period between 1991 and 2001

Figure 4 illustrates that the global cities theme is located in the first quadrant and has a position with high values of centrality (0.33) and density (33.4) with 1323 references. This theme has both strong external links in various fields and strong internal links among its elements. In Fig. 4, the map of the cluster's network shows that the global city is closely related to some keywords such as economies, globalization, labor migration, and city. These relations indicate the clear nature of global cities based on the existing literature. For example, supportive studies indicate that global cities are emerging as a result of changes in the social and economic structures that result from migration (e.g., Hof, 2019), the accumulation of financial industries (e.g., Robinson, 2019; Taylor et al., 2006), and specialized services (e.g., Pereira & Derudder, 2010; Shackleton, 2021) in the context of cities. Performance of these cities has significant effects on the global economic activities (Chikhladze et al., 2021).

3.2.2 The period between 2002 and 2008

This period has three new themes including migration, state, and governance as it is also shown by Wang et al. (2020) (see Fig. 5). The migration theme is in the first quadrant (motor themes) with a centrality score of 23.26 and a density score of 38.12. This theme is very mature, basic, and influential in the research field and has strong internal and external

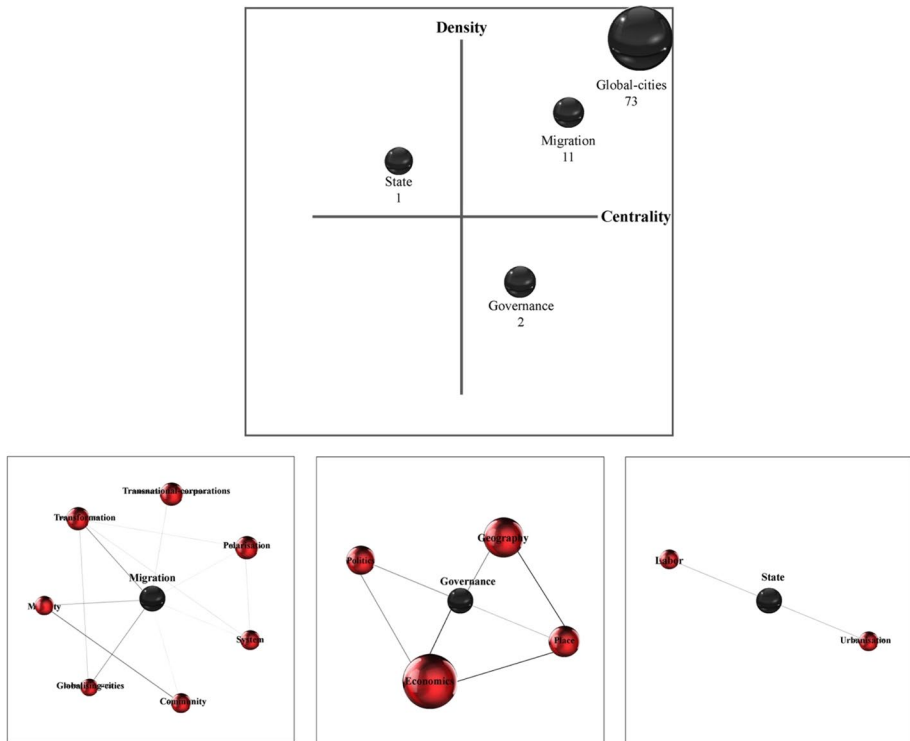


Fig. 5 Strategic diagram for the subperiod of 2002–2008

links with other themes. This theme is linked to themes such as globalizing- cities, transformation, polarization, system, mobility, and community in one network (see Fig. 5). Migration in the field of global cities can lead to changes in the structures of the urban economy, understanding the effects of globalization, change of job and income variables, and finally social polarization (Hamnett, 1996; Siemund et al., 2020 and Villani & Talamini, 2021). In this context, the role of each group and social gender can be different.

The state theme is positioned in the second quadrant, indicating that it is in the highly developed but isolated area. The centrality and density values for this theme are 14.11 and 16.32, respectively. This theme has poor relationships with external themes. However, despite its maturity and excellent stability in the global city, it does not play a pivotal role. This theme has attracted low attention. Thematic words that are related to this theme are urbanization and labor. The governance theme is in the fourth quadrant, i.e., basic and transversal themes. This theme has a centrality index of 16.07 and a density value of 11.94. This theme is one of the most well-established, basic, and effective themes in the research field; even though it is not well-developed, it has a high potentiality for development.

This theme has weak internal relations; however, it has strong external relations with other themes. In addition, this theme is one of the superficial themes in the field of global city studies in this period. For the map of the cluster's network, governance is related to topics such as politics, economics, geography, and place. Studies show that the type of governance that dominates global cities and the policies extracted from them can be very effective in the field of global competition. The results show that although relative

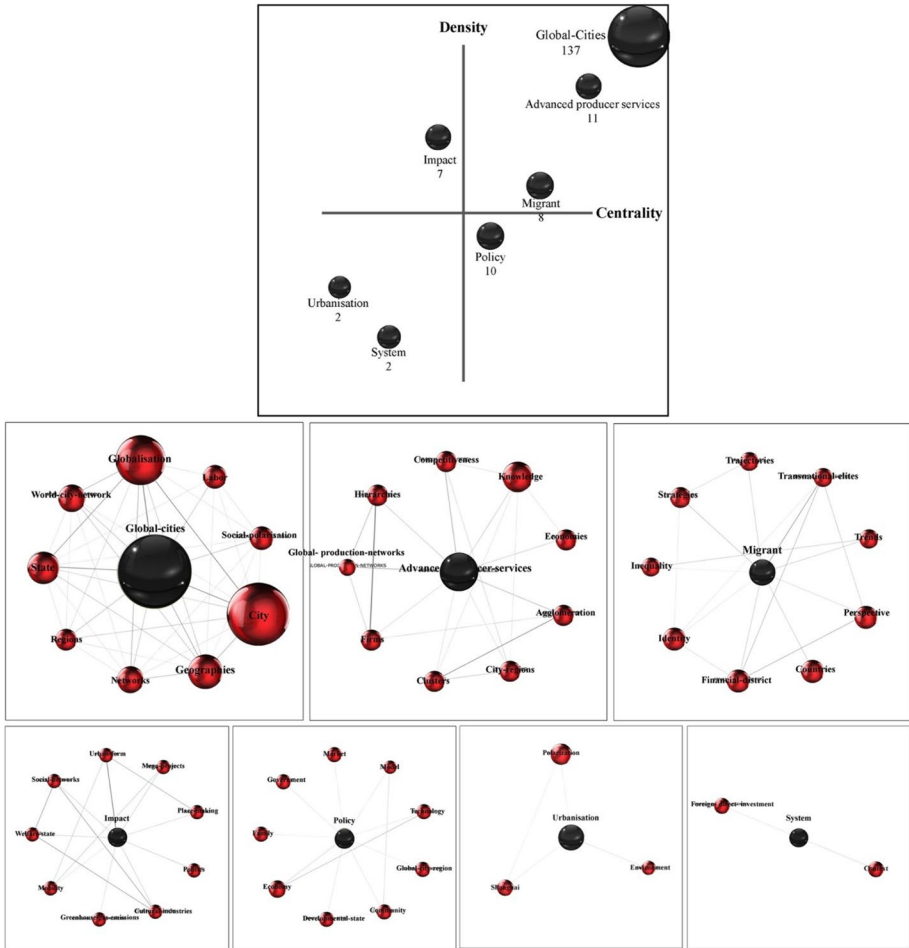


Fig. 6 Strategic diagram for the subperiod of 2009–2015

improvements have been made in strategies, perspectives and leadership, the weak structures of the current government ultimately perform an almost small role in determining economic development and addressing the challenges of future economic growth due to inequality and social connection.

3.2.3 The period between 2009 and 2015

This period has eight themes as follows: global cities, advanced producer services, migrant, Impact, urbanization, system, and policy (Fig. 6). Generally, since the high number of themes increased the strength and intensity of the research topic in comparison with the previous period, the number of motor themes strengthens the specialized and specific aspect of the research field, decreases the number of extremely developed and separate themes, and reduces the maturity of research development. On the other hand, an increase in the number of themes in the third quadrant indicates

the emergence of new words and topics, as well as the decline of previous topics in research. Finally, the stability of the number of basic and superficial themes in the fourth quadrant retains the potential for research development. The theme of migration and from the previous period have been crystallized in the form of migrant theme in this period, and the theme of global cities has maintained its initial place as two previous periods. Other themes in this period have been considered as new themes with new subjects. The themes of the motor themes quadrant are global cities, advanced producer services, and migrant. Compared to other themes, the theme of global cities has high values of centrality (42.72) and density (17.82) and therefore has a high relative position, which shows that global cities have become the major focus in this period, having strong relationships with other themes and high evolution capabilities. After global cities the theme of advanced producer services is highly developed and mature and has strong internal relations (density = 10.6), and due to its high centrality values (28.76), it plays a vital role in the research field.

The migrant theme is also one of the pivotal themes in the research field due to its relatively high centrality (24.58) value; however, it has a lower level of maturity (density = 7.7) than the other two themes. This theme also has a minimum number of citations among motor themes, which indicates that it has a very low impact. Based on the map of the cluster's network on the theme of advanced producer services, this theme has strong relationships with knowledge, competitiveness, firms, clusters, agglomeration, economies, and city regions. In economics, advanced producer services increasingly depend on growing implicit knowledge in individuals, companies, networks, clusters, or local contexts (Cano-Kollmann et al., 2018); on the other hand, Asheim and Coenen (2007) showed that urban areas are the main centers for innovation and subsequently the competitiveness of knowledge-based industries and companies. Moreover, industries, companies, and enterprises have a strong desire to establish themselves in global cities because these cities provide a good opportunity for them to promote investment incentives and business strategies.

The next map of the cluster's network is related to impact theme. This theme is related to concepts such as welfare state, politics, urban form, social networks, mega projects, place making, and cultural industries. Chiu and Lui (2009) refer to the concentration of foreign industries and investments in the Pearl River Delta, which has had profound effects on urbanization in Hong Kong, resulting in the employment of 3 million people. They informed us of the social consequences of globalization and the social polarization in the structures of urban households and referred to the mediating role of the local welfare regime in intensifying social polarization. They see the typology of the welfare state in Hong Kong in close relation with American models with policies that ensure low wages and a passive approach to employment.

The theme of policy is one of the basic themes in this period, which does not have a high level of development, but has a high potentiality for development. This theme has a relatively high number of citations (i.e., 782) which makes it one of the most influential themes in research. In its network map, this theme is linked to themes such as economy, technology, government and global city region. The two themes of urbanization and system are in the area of marginal and undeveloped themes in this period and are considered ineffective themes due to their low values of centrality, density, number of citations, and h-index.

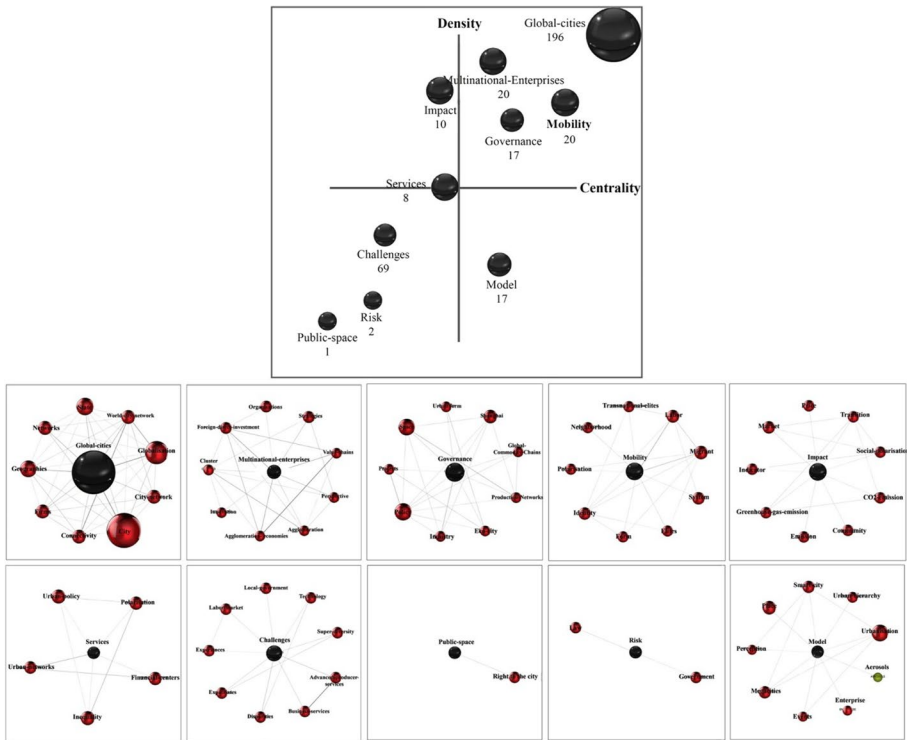


Fig. 7 Strategic diagram for the subperiod of 2016–2023

3.2.4 The period between 2016 and 2023

Cluster themes during this period represent global cities, governance, mobility, multinational enterprises, impact, services, challenges, risk, public space, and model (Fig. 7). In this period, multinational enterprises, services, challenges, risk, public space, and model are among the new concepts, indicating that although in each period new words may be observed, there are several fixed sets of words that show the stability of mainstream thematic evolution and its progress in the form of an efficient aura, when viewed holistically. The clustering themes of the motor themes quadrant include global cities, governance, mobility, and multinational enterprises. Governance as the fourth quadrant during the period of 2002–2008 has been transferred to the first quadrant in this period. While the intensity of research is augmenting rapidly, the level of maturity (21.55) and centrality (24.52) of this theme has also enhanced dramatically, making it the most effective hotspot research. This theme, within its cluster network, has been recently associated with themes such as production networks, industry, policy, and global commodity chains. Supportive studies reveal that manufacturing services are considered not only as essential tactics for production networks but also as tools that can manipulate the world economy. Among the themes of this period, multinational enterprises theme enjoys the high density (12.93). Therefore, its highly developed and mature nature implies strong evolutionary capabilities in the field of global cities; it compasses, nevertheless, the least degree of centrality (17.9) among the themes of the first quadrant leading to a low provocative power among stimulus

themes. Consequently, it undermines the research reputation to some extent. This theme, within its cluster network map, is related to themes such as innovation, value chains, perspective, agglomeration economies, and strategies. The supportive literature suggests that the establishment of multinational enterprises in global cities is because of its indisputable features. Furthermore, studies conducted in this period seek to find the reason for multinational enterprises' strong tendency to be established in global cities.

The mobility theme is connected to the migrant, labor, and transnational elite themes in its cluster network. This theme is considered a crystallized theme of migration. Therefore, compared to other motor themes, it is the only theme that has maintained its position compared to the two former periods. So, it can be considered as one of the most prominent topics in the field of global cities.

The impact theme, compared to the themes of this period, displays a relatively good h-index value (8) and number of citations (138). Considering the cluster network of this theme, its connection with the themes of greenhouse- gas- emission and CO₂- emission can be regarded as one of the reasons why this theme has received widespread attention from scholars. Cities produce a large amount of carbon dioxide. Given the complex pattern of consuming energy in cities and the absence of enough information, the mechanisms influencing urban energy efficiency are not entirely understood. Wang et al. (2017) studied 25 global cities and showed that in European cities the average efficiency of energy has the greatest possible rates. The viability, sustainability, and research and development capability of cities are among the crucial factors affecting the efficiency of energy. The findings of this study show that the most effective measures to increase energy efficiency are threefold: optimizing the structure of the industry, increasing public concerns about sustainability and energy consumption, and enhancing energy-efficient appliances and technologies.

Services theme is located in the area of highly developed and isolated themes that exhibits little impact on research. It can be considered as an emerging theme, even though its closeness to the centrality and density axis intersection stipulates its low values in these two indicators. Furthermore, it presents that this theme is not mature enough to maximize research impact and enjoys a general performance. In the cluster network, this theme indicates a connection with urban policy, inequality, and financial centers themes. Wang et al. (2020) believe that Shanghai is facing problems of unbalanced and unfavorable spatial fragmentation. This was due to the fact that urban development strategies have affected spatial fragmentation. The Shanghai state, in order to become a distinguished global city, employs a sovereignty path to rehabilitate its spatial structure and enhance its global and regional influence.

There are three themes in the third quadrant: Challenges, risk, and public space. The public space and risk themes have extremely low values in centrality, density, h-index, number of citations, and number of documents. Therefore, they are not only isolated and underdeveloped but also impossible to be considered as research centers. Hence, they are among the declining themes. The challenges theme displays a relatively better position since it is slightly closer to the center axis. As a further matter, it enjoys relatively stronger indicators compared to the other two themes in this area. Accordingly, it is likely to be flourished and promoted to higher levels in later periods. This theme is linked to the experiences, super-diversity, technology, and local government in its cluster network. Experiences in individual places have a different nature; the synergy of these experiences, however, might be fruitful in transferring and sharing knowledge among global cities. Doyle et al. (2017), in their study, addressed the empirical and knowledge poverty in promoting health through economic and social cooperation in global cities. Moreover, they note the growing acceptance of this issue by scholars and consider future research in this field

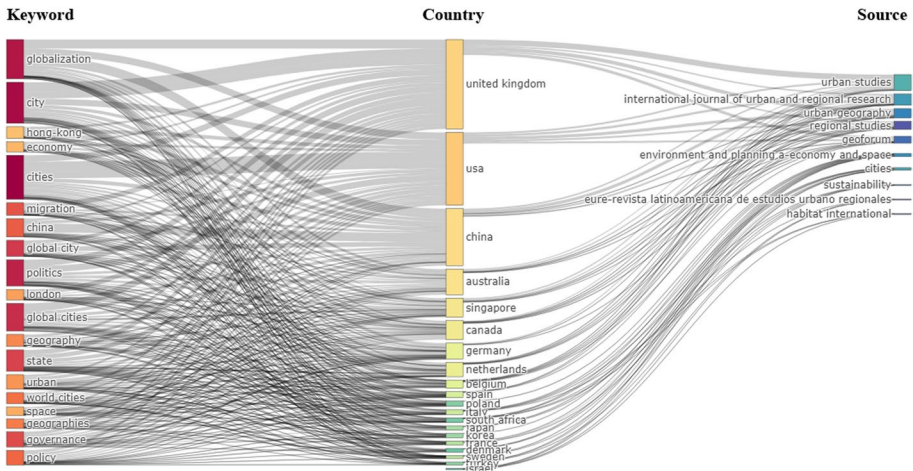


Fig. 8 Three-field plot for the top 15 most productive keywords, countries, and sources in the research field of global city. (Source: R studio results)

possible. This study compares three cities viz. London, New York, and Paris in dealing with public health challenges. The results reveal that all three cities face similar health challenges. However, they have different legal, political, and financial resources to promote and protect health. Furthermore, there is no unique pattern for the three cities to adopt.

Model theme is among the most important but not highly developed themes. Therefore, it has a superficial nature but implies a high potential to achieve higher levels of maturity in later periods to be one of the central themes. In its cluster network, some connections with concepts such as smart city and urban hierarchy are observed.

3.3 Analysis of the evolutionary path of the global city theme (a comparison view among America, Europe, and Asia)

At the beginning of this section, in order to obtain an overview of countries' contribution in the development of global cities research area, the paper has presented a three-field plot (Fig. 8). Then more details in this regard are provided using the VOSviewer software. The Three-field plot of keywords, countries, and sources has been created to depict the proportion of research topics for each country and the recency of the sources based on the most published documents. In this diagram the rectangle's size describes the importance of a keyword, country, and journal. According to Fig. 8, the relationship between the UK, USA, and China with the keywords (left column) indicates that these countries have a pervasive view on global cities, and on the other hand, strong connections with the words globalization, cities, politics, and migration show that these countries have published most of their documents around these themes and consider them as key levers in this regard. While a country like Canada focuses on policies, other countries address one or a limited number of these topics. According to the right column, the most important sources that have a significant role in advancing the studies in the field of global cities are shown. Meanwhile, journal of Urban studies has published the most documents and has received a wide spectrum of documents from the UK. However, the existence of links between Urban studies, international journal of urban and regional research, urban geography, and regional studies

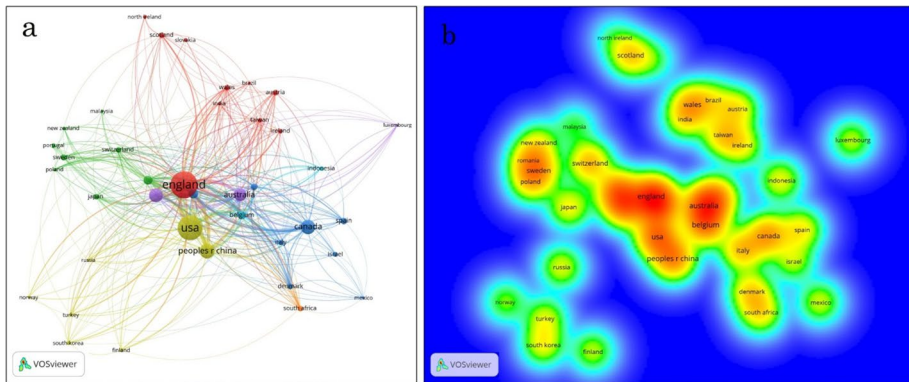


Fig. 9 VOSviewer outputs: **a** network visualization based on citation weight. **b** density visualization based on link weight

and major countries indicates the high popularity level of this resource among writers in different countries.

Totally, it can be observed that the UK, USA, and China showed a maximum collaborative trends for both keywords and sources.

VOSviewer can construct the network visualization based on citation, bibliographic coupling, co-citation, or co-authorship relations (Ye, 2018). Figure 9 illustrates the VOSviewer outputs. In Fig. 9a, the number of documents is shown according to the size of the bubbles, the width of links indicates the co-citation robustness between countries, and the number of country's links shows the level of citation popularity by other countries. Moreover, based on density visualization (Fig. 9b), we could see the most influential research hotspots.

The outputs of this software are summarized in Table 1. The information in Table 1 refers to top countries from each continent, having the highest number of referrals (to other countries) and being referred (by other countries). Overall, in the case of America, only four countries had the most contribution of global city studies. Moreover, due to the large difference between the number of documents published in Asia-Pacific and that of America and Europe, Oceania was considered in conjunction with Asia.

Table 1 shows the following information:

(1) Documents reveal that the USA, England, China, and Australia have the highest number of published documents with 263, 248, 161, and 109, respectively. The results suggest that the issue of global cities has been the focus of attention by countries with superior and stronger economic structures. All in all, Europe has been a leader in the field of global cities with the release of 441 documents compared to the other two continents. (2) With regard to the number of collaborations in publishing documents, England has the most cooperation with 39 links. In the intercontinental comparison, in general, European countries with a score of 158 have a high level of cooperation in the field of global cities. Thus, although the USA have published the highest number of documents (263), the American countries have had the lowest level of cooperation (90) with other countries. This low level of cooperation and exchange with other countries indicates lack of interdisciplinary research, inability to interpret and resolve complicated problems and lack of disciplinary extension global city research. (3) The total link strength column of the relationship includes two concepts, namely the number of citations that a country has to other

Table 1 Top countries in number of publications in global city research by continent

Continent type	Country	Documents	Links	Total link strength	Rank	Main research themes
America	USA	263	37	963	1	Social Polarization, Strategies, Governance, Migration, Urbanization, Policies, Education, States, Cities, Political Economy
	CANADA	71	28	411	6	
	BRAZIL	11	12	29	13	
	MEXICO	6	13	29	14	
Total		351	90	1432		
Europe	ENGLAND	248	39	1413	2	Migration, Globalization, Geographies, Knowledge, States, Financialization, Business Services, Population, Multinational Enterprises, Impact, Region, Places, Management
	GERMANY	57	33	324	7	
	NETHERLANDS	57	31	289	8	
	BELGIUM	47	32	577	9	
	DENMARK	32	23	134	10	
	Total		441	158	2737	
Asia	CHINA	161	33	672	3	Cities, Migration, Inequality, Multinational Enterprises, Networks, Urbanization, Spaces, Policy, Urban Growth
	AUSTRALIA	109	36	658	4	
	SINGAPORE	86	32	439	5	
	JAPAN	24	16	72	11	
	TAIWAN	18	19	93	12	
Total		398	136	1934		

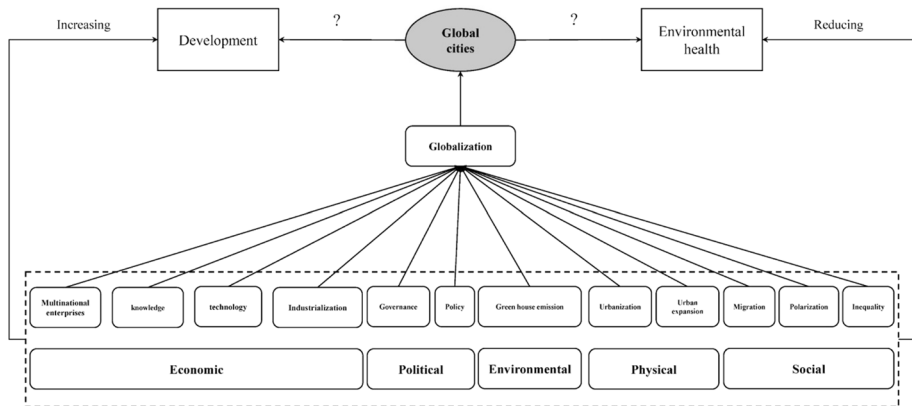


Fig. 10 The dilemma of global cities, development, or environmental health?

countries and the number that a country was cited to by other countries. This column also represents the combined evolution of the previous two columns. Hence, the high value of England with a score of 1413 in this regard shows both the breadth of studies (with a high number of citations to other countries), high depth and quality (with a high number of citations by other countries), and its high impact in this field. Nevertheless, the intercontinental comparison suggests that Europe, Asia, and America have a value of 2737, 1934, and 1432, respectively. To put it in a nutshell, the important point in the comparison between columns is the existence of a direct relationship between the number of documents, the number of links and their influence (total link strength). This relationship represents that European countries are superior in the quantity and quality of published documents compared to Asian and American countries. (4) With respect to research themes orientation, migration is the only common theme among the three continents. In addition, America and Asia enjoy the most common themes (urbanization, politics, and cities). Therefore, the nature of global cities in America and Asia appears to be more similar than in Europe. In Europe, however, the situation differs in that the themes which are driving in nature emphasize more strongly the management and impact of the policies adopted on the economic aspect (e.g., themes of knowledge, financialization, business services, and multinational enterprises) of global cities.

This article was able to identify the most significant issues that global cities face in many social, economic, environmental, political, and physical dimensions and geographical settings. Some studies feel that the application of the themes shown in Fig. 10 is a tool for globalization and, as a consequence, the growth of cities (Oduwaye & Abdul-Rahman, 2018; Kara, 2019), but others argue that globalization fosters a culture of consumption and production (Loo et al., 2014; Ottelin et al., 2014) and the industrial structure's glasshouse gas emissions damage the environmental health of cities (Dagestani & Qing, 2022).

In this respect, investigations have produced varying outcomes. In their research on developing nations, Yang et al. (2019) rate the impacts of globalization on the environmental health of cities as neither fully beneficial nor bad. In contrast, Ma & Wang, 2021, in a comparison of industrialized and developing nations, demonstrate that emerging nations may lower the intensity of their pollution emissions by engaging in international commerce. In addition, emerging nations with a higher degree of industrialization (like green economic growth) make more strides toward cleaner manufacturing (Wang et al., 2022).

Emerging nations with a greater degree of democracy are more concerned with addressing local environmental issues. In addition, optimizing and developing awareness in industrial structures to reduce the emission of pollutants, such as clean transportation in the tourist sector, establishing stringent regulations on environmental protection (Yang et al., 2019; Gosling, 2017), and modifying policies are necessary. In order to increase the level of environmental health in global cities, management activities by the government and lifestyle modifications in the direction of environmental protection (Dagestani et al., 2022; Qing et al., 2022a, b) are regarded as methods.

Clarifying the effects of globalization on cities in the two dimensions of development level and environmental health requires additional research in order to reach a more logical conclusion. In addition, the proposed solutions are primarily intended for emerging nations; therefore, the experiences of rich nations might be instructive.

4 Conclusion

This paper seeks to present a new panoramic perspective as a complement to previous studies of global cities. Compared to prior bibliographic researches in this field, this paper performs a comprehensive analysis based on the developed bibliometric tools from a comprehensive perspective. The overview, the key features of the issues, thematic progression, and research centers in this field are drawn through a set of visual and intuitive scientific maps. This new effort can integrate and expand the findings of previous studies on the global city. The research framework created in this article can also serve as a guide for other research areas. Below are the suggestions and recommendations of this study based on the main findings.

First, researchers from different disciplines perceive the issues of global cities differently; sometimes they have contradictory scope and interpretations. Geographers express differences based on boundaries and spatial features of global cities. Economists focus on the driving mechanisms and kinetic factors of the global city. Officials in political arenas on a large-scale concentrate on controlling the global city process. Sociologists examine social dimensions. Moreover, environmentalists study the major environmental challenges with which global cities are faced. In the field of global city studies, there is somehow a lack of interdisciplinary studies, and as a result, interdisciplinary discontinuity is felt. Furthermore, most studies have focused on large-scale governance mechanisms and strategies. In addition, the management of global cities and discourses about them has often evolved from assumptions and suggestions. As recent studies have shown (examples of which were mentioned earlier in the text), using tests and scientific methods reveals obvious contradictions in the context of many of their hypotheses. Many studies have been conducted to either confirm or reject fundamental theories and hypotheses of the global city. On the one hand, this may indicate that studies in different disciplines have not covered each other, and the discrepancy among studies is obvious; on the other hand, it implies the vital and decisive role of future studies in the strength or instability (if studies do not meet expectations) of the foundations of the global city.

Second, a wide range of studies have focused on strengthening the economic structures of a city in the process of globalization. In comparison to other aspects of globalization, many scholars have paid attention to this issue in such a way that studies have experienced a propaganda aspect. Although a city may incur a lot of expenses in the process of globalization (such as infrastructure expenses due to population attraction), this issue has been

mentioned in fewer studies. Furthermore, from a psychological point of view, issues such as environmental and behavioral psychology in a global city compared to non-global cities have been taken for granted. Hence, part of future studies can be attributed to measuring the impacts of globalization on life quality parameters.

Third, a wide range of studies in the field of the global city are focused on London, New York, Shanghai, and Sydney. Although these cities can be considered as the representatives of their pertaining continent, it is obvious that according to the specific geographical-spatial conditions of each place, the studies of such cities cannot be generalized to all other global cities. Furthermore, since the nature of the global city is largely location-dependent, we seem to be dealing with a much more complex and dynamic structure than what we have seen so far. As a result, given the contradictions that recent studies have discovered in the field of global cities, future studies may emphasize that the definition of a global city in any geographical location may differ with respect to its location-specific characteristics, as each factor can have a unique impact on a global city.

The findings of this study have an interaction with states and other international actors, pursue objectives that are often intertwined with global economic agendas, and are crucial to questions related to climate change, mobility and migration, technological innovation, economic development and infrastructure. This study presents the evidence that the greater power hierarchy of cities in the global economy explains municipal government engagement in global governance networks. This study shows that patterns of participation are explained by varied measures of city-level connectivity to economic networks. In addition, findings suggest that city participation in global governance is shaped and stratified by city-level hierarchical power within the global economy. Therefore, it will play an important role in planning and policy making in global cities.

To sum up, global cities are complex entities that have multiple dimensions, including economic, political, cultural, social, and environmental factors. Therefore, researching global cities requires a multidisciplinary approach that incorporates both quantitative and qualitative methods (Chakravarty et al., 2021). Collecting data from multiple sources is important for capturing the diverse and dynamic nature of global cities. This includes data from formal and governmental sources, such as census data and economic indicators, as well as data from non-formal sources, such as social media and online platforms. It is also essential to take into account the perspectives of citizens and stakeholders when researching global cities (Musso et al., 2011). This involves engaging with the community and incorporating their experiences and opinions into the research process. Citizens' participation can help provide a more comprehensive understanding of the city and its various dimensions (Ingrams et al., 2020), as well as identifying areas of concern and potential solutions. Overall, research on global cities should be comprehensive, inclusive, and multidimensional, incorporating multiple perspectives and sources of data to provide a holistic understanding of these complex urban environments.

5 Directions for future research

In the study, the retrieval string did not include the term “world city/ies” and thus could be seen as a limitation. Although strongly interrelated, world cities are more seen as centres of dominance and power, whereas global cities are production centres for the inputs that constitute the capability for global control (Derudder et al., 2012). Here, we focused primarily on the latter. Moreover, WOS does not cover all publications related to global

cities. The other limitation is related to code retrieval for the collection of data. Although attempts have been made to consider special codes related to global cities, many of them have been ignored to prevent data bulking. Future studies could include a review of the pivotal authors, journals, and institutions in their bibliometric analysis. The scope of research in future studies can also include other databases such as Scopus and JSTOR. In addition, in future studies, the use of a wide range of keywords in peer-reviewed journal articles can be the most appropriate option for bibliometric and citation analysis rather than book chapters and reports.

The COVID-19 pandemic has had a tremendous influence on the economy, infrastructure, social ecology, and cultures of global cities (Dagestani, 2022; Zhu et al., 2022). As a consequence of the pandemic lockdowns and other steps to limit the spread of the virus, many global cities have seen substantial economic disruptions, resulting in job losses and financial difficulties for many companies and people. The pandemic has also pushed the trend toward remote work, with an increasing number of individuals opting to work from home rather than commute to workplaces in major cities. The pandemic has also revealed infrastructural issues in a number of global cities, notably in the healthcare and public transit sectors (Huang & Li, 2022). Significant societal effects have also resulted from the pandemic, notably in terms of social isolation and mental health (You et al., 2022). In global cities, the pandemic has also had political repercussions, as governments have been forced to make tough choices over how to combine public health and economic interests. Future studies might concentrate on the literature's reflection of the COVID-19 pandemic effects on global cities. The COVID-19 pandemic has shown the need for improved planning and preparedness for future pandemics. By studying the economic effects of the epidemic on global cities, policymakers may establish measures to encourage economic recovery and guarantee that cities are well-positioned to prosper in the aftermath of the pandemic. The pandemic has also underlined the significance of urban planning and design in constructing resilient and sustainable global cities (Angiello, 2021). By examining the pandemic's effects on cities throughout the world, experts may find best practices for urban planning and design that might help alleviate the effects of future pandemics and other crises.

Acknowledgements Thanks to Kaifeng Duan for help in reviewing and revising the final version.

Data availability Data will be made available upon request by the first author.

Declarations

Conflict of interest There is no conflict of interest.

Informed consent All authors have read the manuscript and agreed to its submission.

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