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BIBLIOMETRIC ANALYSIS OF RESEARCH CONDUCTED BETWEEN 2000-2024 IN THE FIELD OF SYSTEM THEORY: CONCEPTUAL FOUNDATIONS

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ABSTRACT

This study provides a comprehensive bibliometric analysis of research in the field of system theory from 2000 to 2024, focusing on key concepts such as systems approach, systems thinking, and system dynamics. System theory offers a holistic framework for understanding complex, dynamic systems composed of interrelated components and feedback loops, emphasizing the importance of interdisciplinary approaches for managing complexity. By analyzing Scopus-indexed publications, this study maps conceptual relationships, knowledge flows, and research trends, highlighting influential authors, institutions, and emerging topics. The findings reveal that systems thinking and systems dynamics are crucial for understanding nonlinear and cyclical causal structures, enabling sustainable and adaptive management strategies. Overall, the study underscores the necessity of a holistic, flexible, and interdisciplinary perspective in systems research and provides a foundation for both theoretical advancement and practical application in managing complex systems. Limitations include reliance on Scopus-indexed publications, suggesting that future research could expand databases and integrate qualitative assessments of applied methods and models.

KEY WORDS

system theory, system thinking, system dynamics, bibliometric analysis

CLASSIFICATION

JEL: A12, B41, C88, D83, D85

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INTRODUCTION

The complexity of contemporary socio-technical environments presents significant challenges in understanding and managing complex systems. In this context, system theory and complexity science are fundamentally intertwined, as systemic behavior inherently emerges from underlying structural complexity. Foundational literature, dating back to von Bertalanffy's General System Theory, posits that interpreting complex, non-linear relationships is the core objective of the systems approach. This study maps the conceptual evolution of system theory, systems approaches, systems thinking, and system dynamics. It analyzes the current structure, publication momentum, and evolving trends in scientific communication within this domain through bibliometric methods. The findings are expected to provide critical insights into the developmental trajectory and cross-disciplinary applications of systems approaches.

While systems thinking provides a conceptual framework for analyzing the interdependent relationships between systemic components, system dynamics complements this framework by incorporating feedback loops and dynamic elements to model temporal behavioral trajectories. The primary objective of this study is to deliver a systematic overview of the field via bibliometric mapping, thereby identifying research trends, constructing knowledge networks, detecting research gaps, and evaluating interdisciplinary interactions to guide future theoretical inquiry. To achieve these objectives, a comprehensive bibliometric analysis of systems-related literature published between 2000 and 2024 was conducted. This study specifically operationalizes metadata indexed in the Scopus database, acknowledging that certain peripheral or non-indexed influential works may serve as avenues for future research.

CONCEPTUAL FRAMEWORK

A system consists of dynamic elements structured to fulfill certain functions and the relationships between these elements [1]. The parts/sub-systems that make up the system represent the elements of the system and the flows and connections between them represent the relationships [2]. Systems problems are complex questions that are related to the limitations of analytical procedures in science and often have non-linear and circular causal relationships. Since classical science is inadequate to solve these problems, a new perspective is needed. The systems approach is an approach that, in the face of increasing complexity of systems, takes into account the interaction between system states and emerging problems; accordingly, it is based on addressing system models from a holistic perspective, monitoring changes in system behaviors, and maintaining flexibility in response to changing conditions and phenomena. The behavior of systems results from the holistic interaction of parts, not individual parts. Therefore, it is important to understand the interdependence and interaction between parts [2].

Systems thinking is a holistic, dynamic and interdisciplinary approach that considers processes as a whole, focuses on the interrelationships and interactions of parts, seeks to understand complex elements such as customer behavior and firm-customer interactions, and emphasizes the dynamic and changing nature of processes [3]. Systems thinking is defined as a core competency in education for sustainable development in UNESCO's "Framework for Action for Education 2030" published in 2015. Therefore, systems thinking should express the holistic and systematic perspective necessary to achieve sustainable development goals. The fact that research is mainly concentrated in the field of science education suggests that systems thinking is an approach to understanding natural systems, ecological relationships and complex problems [4].

System dynamics is a subfield of systems thinking that emerged in the 1960s when Forrester and colleagues applied feedback theory to understand the structure and dynamics of industrial and urban systems [5]. System dynamics is an approach to systems thinking that focuses on

understanding and modeling dynamic interactions in complex systems [6]. In the last 50 years, system dynamics has become a comprehensive methodology used in various fields [5]. Introduced as a modeling and simulation methodology for long-term decision making in dynamic industrial management problems, system dynamics has since been applied to various business policy and strategy problems [7].

System theory provides an approach that considers all aspects of a problem and focuses on the interactions between components [8]. System theory is defined as a way of thinking in which everything in the world is interconnected, actions cause chain reactions in systems, and enables us to understand systems and solve problems with a holistic approach [9]. According to the theory, everything in the world and more specifically everything in a system is connected in some way. An action in a system made up of objects or parts is not an individual action, but an action that causes a series of reactions that cause changes in the system. System theory is defined as a thinking skill that identifies and understands the properties of various systems, predicts their behavior, and adjusts them to achieve desired effects. System theory helps to understand the whole system and to find and solve the underlying problems of the system [9]. There are many conflicting models and claims that need to be reconciled, and past attempts to reconcile the various models in the "population" of systems can be better described as methodological pluralism[10].

In this conceptual study, we focus on the concepts of system, systems approach, systems thinking, system dynamics, and system theory. The problem situation is analyzed within the framework of the functioning of the system and its structure, considering dynamic relationships and interactions among components; analytical examinations of causal links and feedback mechanisms are also conducted. Accordingly, the research combines a holistic perspective for understanding complex structures with the modeling and analysis capabilities of system dynamics, grounded in the interaction-oriented framework proposed by system theory. The purpose of the bibliometric analysis is to systematically identify the development of the literature, thematic concentrations, core concepts, and emerging trends in the field. Thus, the theoretical foundation of the study is substantiated through both conceptual discussions and collective empirical findings. In this way, the study aims to position and differentiate itself within the literature by providing a systematic and analytical evaluation of the field.

BIBLIOMETRIC ANALYSIS

Bibliometrics is defined as the quantitative analysis of written communication and publications, developing techniques to measure and analyze scholarly communication across a wide variety of fields [11]. It serves as a crucial mathematical and statistical tool to evaluate the output of scientific research [12, 13], tracking the quantity, distribution, and usage of publications since its emergence in the early 20th century [14, 15]. Ultimately, this quantitative approach is essential for reviewing past research directions and tracking general research trends within a particular field [16].

The idea of measuring scientific publications and citations is based on efforts to analyze bibliographic data of scientific literature. Although historical efforts to classify scientific publications date back centuries, the field advanced significantly with the development of citation indexes like the Scientific Citation Index (SCI) and modern computational technologies, establishing a systematic basis for large-scale bibliographic analysis [17].

Since claims over new discoveries in the modern publishing system are validated through publication [13], scholars utilize bibliometrics to uncover trends in article and journal performance, examine patterns of collaboration, and explore the intellectual structure of a field within existing literature [18].

Various methods are used in bibliometric research to evaluate scientific productivity and impact. The h-index and G-Index are indicators that measure researchers' productivity and their impact based on citations received. Trend analysis helps identify development tendencies within a specific field and predict potential future citation impact. Independent citation analysis aims to reveal the actual impact of studies by separating self-citations. While co-occurrence analysis determines relationships between articles, authorship analysis examines collaborations and network structures among researchers. Keyword co-occurrence analysis reveals connections between concepts. Citation burst analysis identifies rapidly increasing citations within certain periods and helps detect emerging research topics [19]. Executing these analytical methods through a structured workflow, from research design to data interpretation [20], significantly enhances the reliability of findings by minimizing subjectivity [21].

METHOD

RESEARCH MODEL

The research model is structured based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement by [22] and the bibliometric guidelines provided by [23]. In this context, the research process is grounded in a detailed analytical framework comprising specific steps. The PRISMA statement, as proposed by [22], divides the analytical process into five key stages. The research model for this study is similarly designed with reference to this approach. The study steps are as follows (Figure 1):

- **Research Design** – The first step involves outlining the overall framework of the study and creating a design to answer the research questions. This phase includes defining the research hypothesis and clarifying the scope of the study.
- **Data Collection** – This step determines which data sources will be used and details how the data will be collected.
- **Data Analysis** – Appropriate software or programs for analyzing the data are selected, and the collected data is loaded into these tools. The tools must align with the nature of the research.
- **Coding and Analysis** – This step involves processing the collected data in various ways to answer the research questions.
- **Evaluation** – The final step consists of interpreting the analysis results. At this stage, the findings are compared with the study's hypotheses, and conclusions are drawn[24].

According to [23] bibliometric analysis guide, each of these steps should be implemented meticulously and the analysis results should be [22, 23].

RESEARCH DESIGN

This study examines the research conducted between 2000 and 2024 in the field of system theory using the bibliometric analysis method. The selection of this specific timeframe is strategic, focusing on the 21st century to capture the contemporary evolution of the discipline rather than its historical 20th-century origins. Theoretically, the year 2000 represents a major milestone in system theory, marking a modern era defined by digital transformation, advanced computational modeling, and a deep integration with complexity science. The period concludes in 2024 to ensure that the analysis incorporates the most up-to-date and complete full-year dataset available at the time of data collection. At this stage, the research questions were first determined. The questions sought to be answered for the bibliometric analysis of studies on System theory are stated as follows.

RQ_1: What is the change in the number of publications in the field of 'system theory' in the journals in the Scopus database over the years?

RQ$_2$: What is the historical development of studies in the field of 'system theory' in the studies in the Scopus database?

RQ$_3$: Which are the most frequently used words in the articles published with 'system theory' in the Scopus database?

RQ$_4$: Which universities and countries have the most responsible authors who wrote the articles published on the concept of 'system theory' in the Scopus database, and what is the relationship between them?

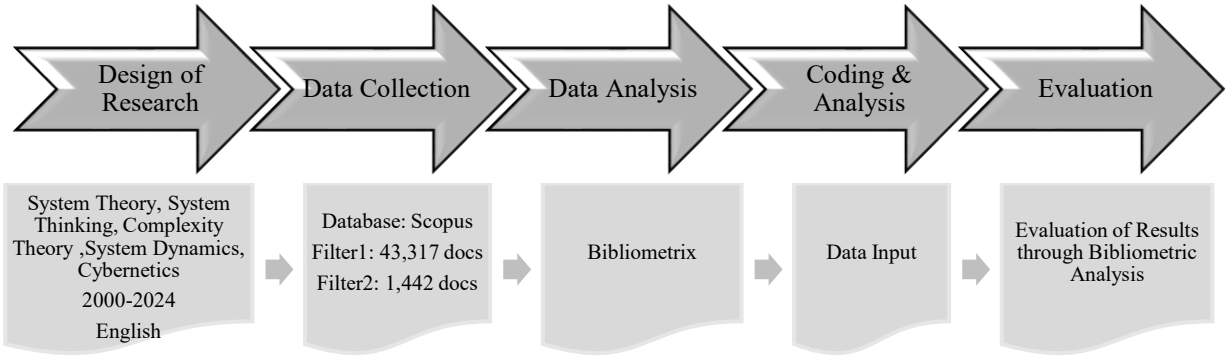


Figure 1. Bibliometric analysis research model of studies in the field of system theory.

As shown in Figure 1, the research model began with a Preliminary Literature Review conducted by scanning the studies carried out in the field of system theory. The study focuses on Scopus-indexed publications, which ensure consistency and comparability in bibliometric analysis due to their coverage of high-quality journals and provision of reliable citation information.

DATA COLLECTION

First, the population of the research topic was determined. Then, within this population, the topic was searched in the database according to various criteria. Data exported from Scopus were used in the data collection process. The keywords used for the search were "system theory", "systems dynamics", "cybernetics", "complexity theory" and "systems thinking". These concepts represent the main theoretical approaches in the systems research literature. In particular, systems thinking, system dynamics, cybernetics, and complexity theory are widely recognized in the literature as fundamental concepts used in the analysis of complex systems and in interdisciplinary systems research. Therefore, the keywords were selected to cover the most commonly used conceptual streams in the system theory literature. The research query was first created as follows:

> Query = "systems AND theory OR systems AND thinking OR complexity AND theory OR system AND dynamics OR cybernetics"

The search terms consist of the words "systems AND theory OR systems AND thinking OR complexity AND theory OR system AND dynamics OR cybernetics" as seen in the query text.

Boolean operators were used in the search strategy to capture different variations of key concepts in the literature. The "AND" operator was used to identify studies in which concepts appear together, while the "OR" operator was preferred to include cases where the same concept appears in the systems research literature with different expressions. This approach expands the scope of the search results while ensuring a systematic coverage of the relevant literature. Then, filtering was done according to various criteria to make the scope of the study examinable. Type: "Article", Time Range = 2000-2024, Field of study = "Engineering", "Computer Science", "Social Sciences", "Maths", "Business, Management And Accounting", "Decision Sciences", "Physics and Astronomy" were selected. Filtering was done by selecting keywords as "System Theory" "Systems Thinking" "Complexity Theory" "System

Dynamics", "Cybernetics" and finally publication language = "English". As a result of the query dated July 1, 2024, 1442 publications were reached.

The final version of the query recorded in the Scopus program is as follows:

> TITLE-ABS-KEY (system AND theory OR system AND thinking OR complexity AND theory OR system AND dynamics OR cybernetics) AND (LIMIT-TO (DOCTYPE , "ar")) AND (LIMIT-TO (SUBJAREA , "ENGI") OR LIMIT-TO (SUBJAREA , "COMP") OR LIMIT-TO (SUBJAREA , "MATH") OR LIMIT-TO (SUBJAREA , " PHYS") OR LIMIT-TO (SUBJAREA , "SOCI") OR LIMIT-TO (SUBJAREA , "BUSI") OR LIMIT-TO (SUBJAREA , "DECI")) AND (LIMIT-TO (EXACTKEYWORD , "System Dynamics") OR LIMIT-TO (EXACTKEYWORD , "System Theory") OR LIMIT-TO (EXACTKEYWORD, "Systems Thinking") OR LIMIT-TO (EXACTKEYWORD, "Cybernetics") OR LIMIT-TO (EXACTKEYWORD, "Complexity Theory").

As a result of the search conducted in Scopus using the determined keywords, 43 317 documents were obtained. In order to create an appropriate dataset for bibliometric analysis, the retrieved records were gradually narrowed down according to specific filtering criteria. These documents were filtered according to the criteria of Time, Type, Language, and Field of Study, and the number was reduced to 1442 documents. In the final stage, bibliometric analysis was performed using the bibliometrix package. Before proceeding to the analysis stage, the dataset was checked for possible duplicate records and missing metadata. Records that did not meet the previously determined inclusion criteria were removed from the dataset. This data cleaning process aims to increase the reliability and consistency of the dataset used in the bibliometric analysis.

DATA ANALYSIS

Data analysis and visualization were performed using R and R Studio programs, writing the bibliometric analysis code and using the Bibliometrix program, an R/R Studio add-on, with the help of the biblioshiny interface. The data obtained for analysis were loaded into the program, and an R data frame was created. In the created data frame, the first part of the analysis includes data loading and transformation processes and summarizing the main results of the bibliometric analysis. The second part includes the stage of creating a document x attribute matrix and mapping. At this stage, terms in the text fields were filtered and excluded from the scope.

CODING AND ANALYSIS

This study is a bibliometric analysis of the studies on system theory published between 2000-2024 in the Scopus database. In the bibliometric analysis of articles prepared on "system theory" (Table 1), a total of 1442 articles from the years 2000-2024 were obtained from the Scopus database.

Accordingly, the general results of the studies obtained in the analysis are shown in Table 1. The database obtained by downloading articles written in English between 2000-2024 on the subject of "system theory" from the Accordingly, the publication dates of the articles in the database are between 2000-2024 and a total of 1442 studies on system theory have been conducted, and the average age of these studies is 7.69. The authors of the single-authored documents are 271 people. The average number of citations per document was 19.05. Again, the number of single-authored documents was 318, the collaboration rate per document was 2.96%, and the international author collaboration rate was 24.41%. When the number of citations in the database used in Figure 2 is examined, the most cited authors are Uhl-Bien and Leadersh with 1237 citations, followed by Friston and Biol with 454 citations.

Table 1. Overview of the data.

Description	Result	Description	Result
Time Range	2000-2024	**Authors**	
Sources (journals, books, etc.)	642	Authors	3 520
Documents	1442	Authors of Single-Author Documents	271
Annual Growth Rate, %	8,34	**Authors Collaboration**	
Average Document Age	7,69	Single-Author Documents	318
Average Citations per Document	19,05	Co-Authors per Document	2,96
Document Content		International Co-Authorship Percentage	24,41
Keywords (ID)	8 006	**Document Types**	
Author's Keywords (DE)	4 548	Article	1442

The first study with the most citations in the current database with 1237 citations is the article titled "Complexity Leadership Theory: Shifting leadership from the industrial age to the knowledge era" published in The Leadership Quarterly in 2007, while the article titled "Action understanding and active inference" published by Friston, Mattout and Kilner in Biological Cybernetics in 2011 is the second with 454 citations.

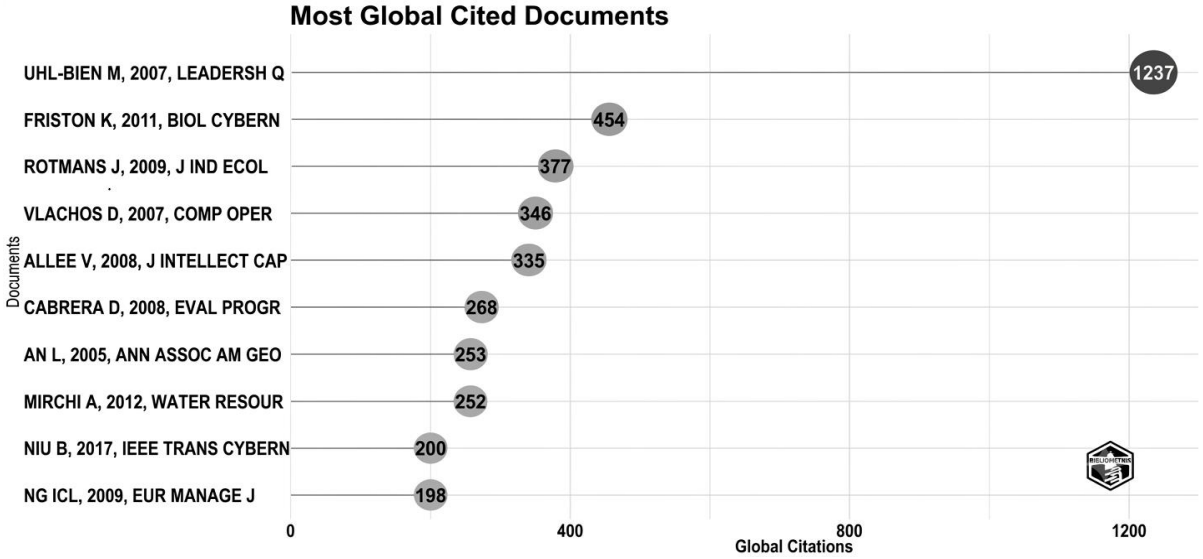


Figure 2. Number of citations of authors from other studies in the database used.

Figure 3 shows the countries with the most cited articles. The USA ranks first in terms of the number of articles written, followed by the UK, China, Italy and Australia.

According to the thematic evolution analysis performed by selecting "author's keywords" as the parameter and "time slice 1" as the time period in Figure 4, the resulting article has the theme of the purpose of limited findings as the keyword, as seen in the lower left corner. There is a niche theme section in the upper left. The theme of daily policy factor stands out here. It is seen that the system document approach stands out in the engine themes section in the upper right corner of the graph. The basic themes are located in the lower right corner of the graph, and the theme of the complexity of system dynamics is here.

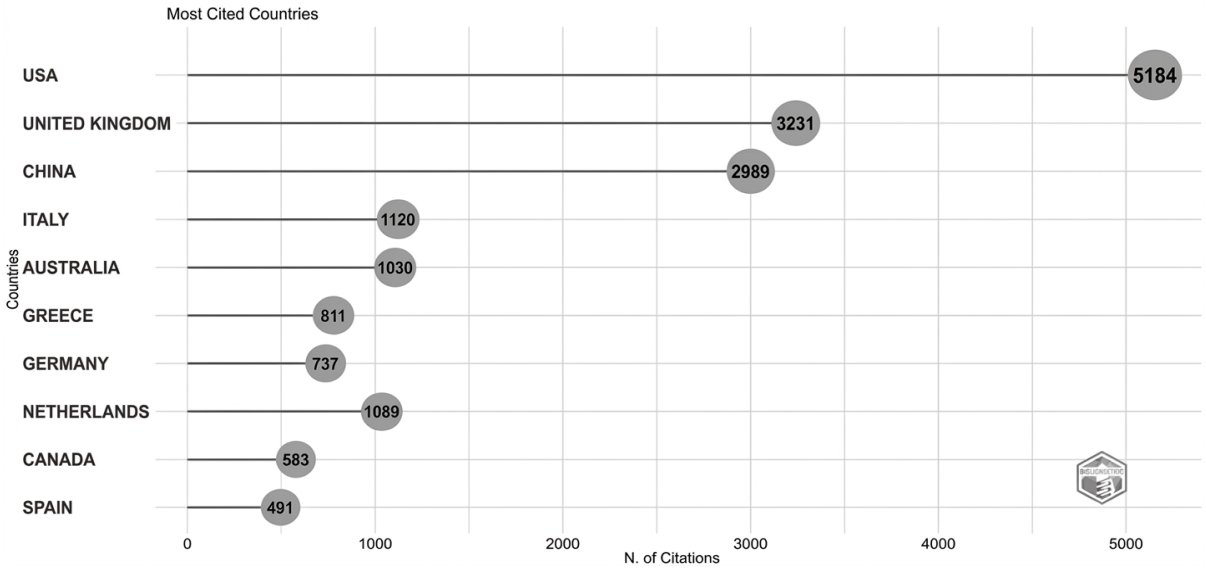


Figure 3. Most cited countries.

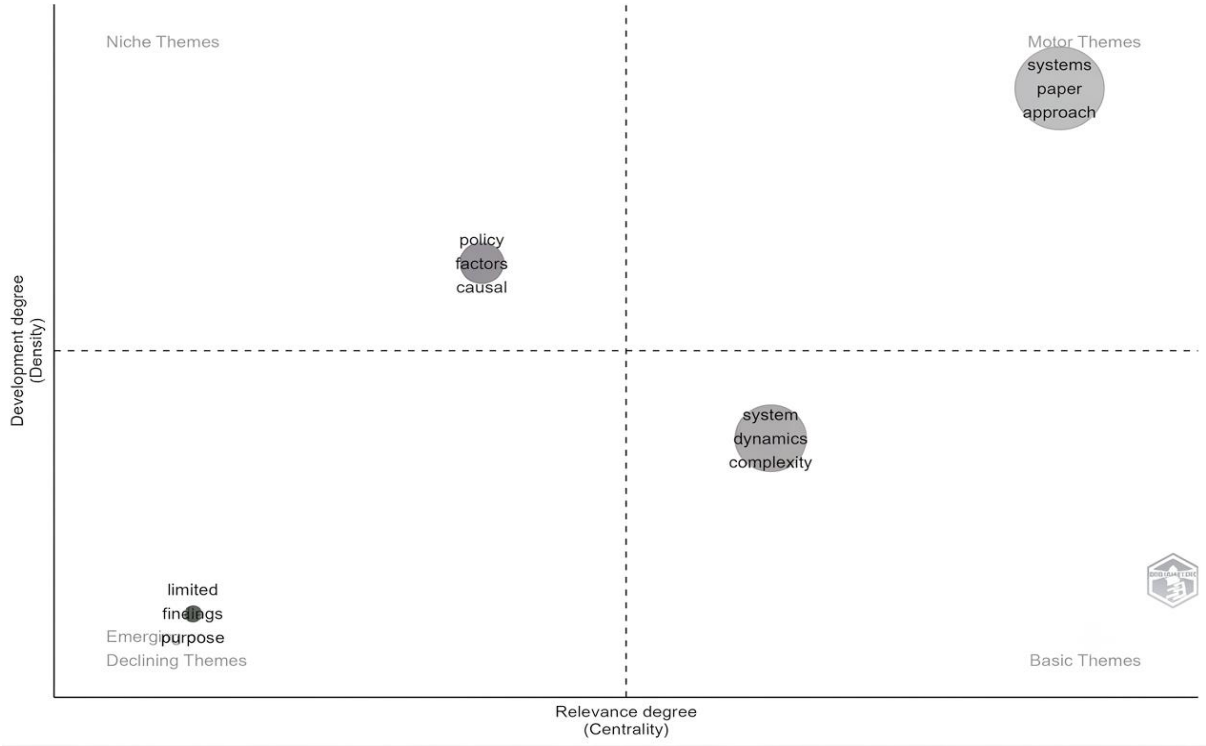


Figure 4. Thematic evolution – time slice 1 (parameters: author's keywords).

Thematic evolution analysis performed by selecting the Time Slice as "time slice 3" and the parameter as "author's keywords" presents the graph in Figure 5. The emerging and decreasing themes were group modeling, decision making, community-based system dynamics and community-based system dynamics. The basic themes are complexity, system theory and complex adaptive systems. Although cybernetics and information models stand out in the motor themes, system dynamics, systems thinking and causal loop diagram are positioned in a way that there is an equal distribution between the motor and basic themes. As niche themes, energy transition, scenario planning, business ethics and organizational ethical culture stand out.

Figure 6 shows the most cited sources-journals. Accordingly, Kybernetes, the journal with the most publications, ranks first with 182 articles, followed by Systems Research and Behavioral Science with 56 articles, and Sustainability (Switzerland) with 41 articles.

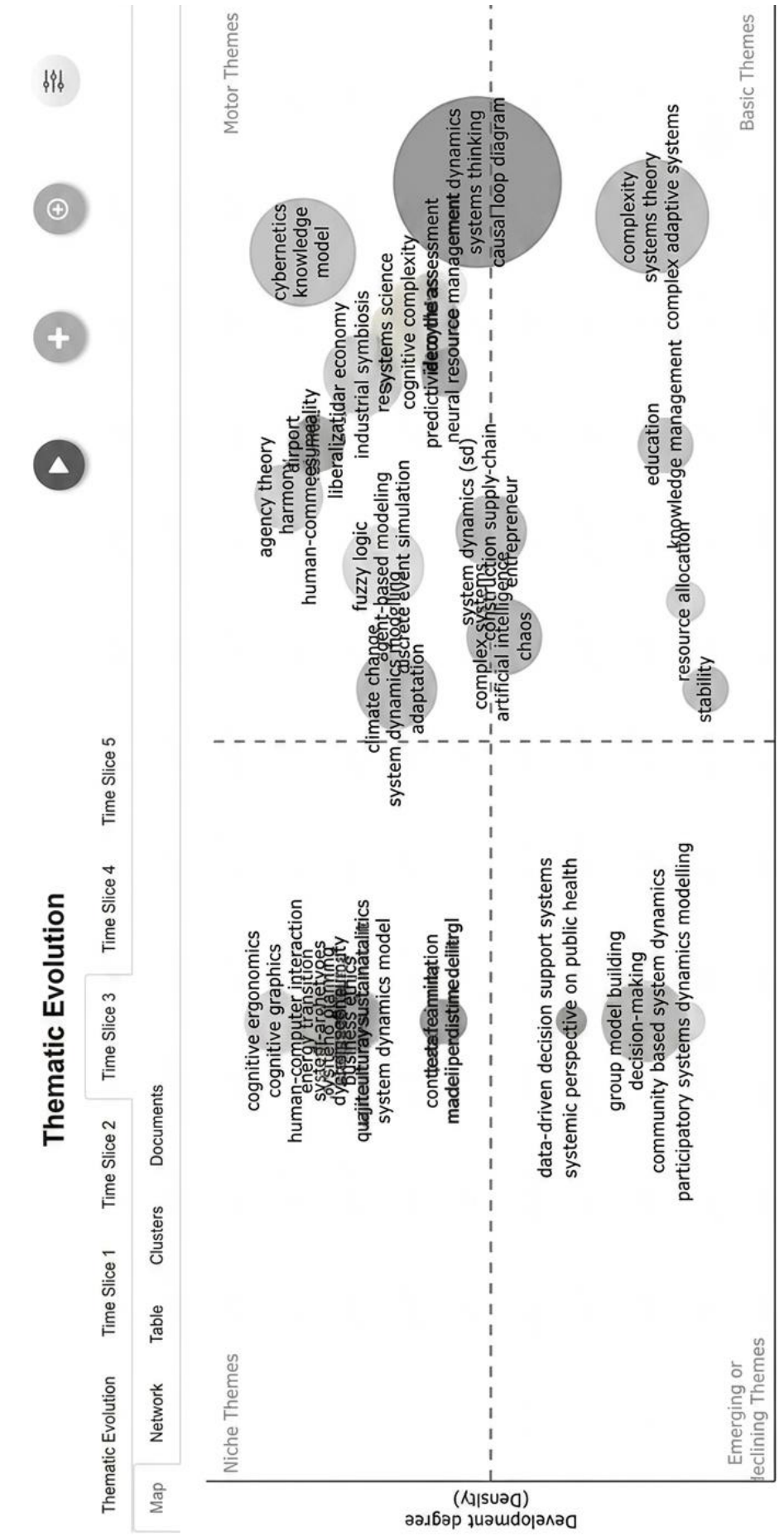


Figure 5. Thematic evolution – time slice 3 (parameters: author's keywords).

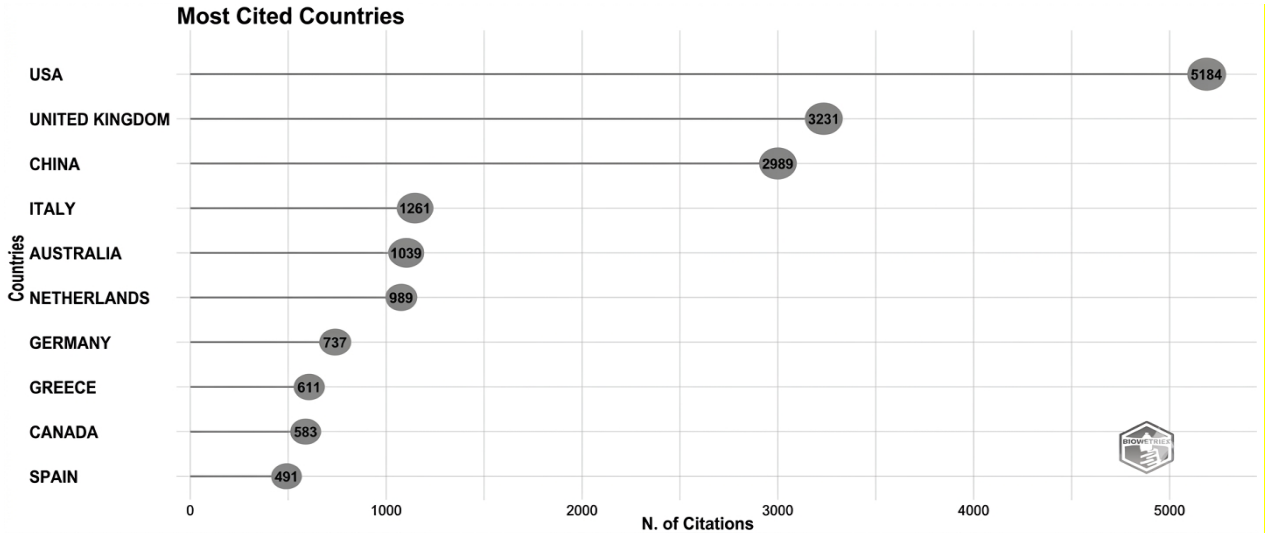


Figure 6. Most cited sources – journals.

In Table 2, the USA ranks first in the scientific publication production of countries with 5 047 articles, almost as many publications as the total of all other countries except the UK, while the UK ranks second with 2 888 articles, followed by China with 2 423 articles, Italy with 1117 articles, etc.

Table 2. Scientific publication production of countries.

Country	Number of articles	Serial No.
USA	5 047	1
England	2 888	2
China	2 423	3
Italy	1117	4
Australia	1116	5
Germany	1053	6
Netherlands	705	7
Canada	607	8
South Africa	447	9
Norway	437	10
Iran	422	11
India	421	12
Spain	420	13
France	398	14
Türkiye	181	31

FINDINGS AND RESULTS

The findings reveal a holistic, natural, and interdisciplinary perspective and emphasize the importance of flexible and dynamic mechanisms for understanding complex systems. Through citation network mapping (Research Map), the relationships between keywords and authors are analyzed, revealing research trends, influential authors, and emerging topics in the field. The study contributes to a fundamental theory framework that clarifies the relationships between concepts and promotes a shared vision for building academic communication on campus. It also documents bibliometric methods for capturing the intellectual structure and interdisciplinary connections of research and general theory.

Table 3. Most cited authors (continued on p.530).

Authors	Article Title	Source	Citations	Year
Uhl-Bien, M.; Marion, R. and McKelvey, B.	Complexity Leadership Theory: Shifting leadership from the industrial age to the knowledge era	The Leadership Quarterly **18**(4), 298-31	1237	2007
Friston, K.; Mattout, J. and Kilner, J	Action understanding and active inference	Biological Cybernetics **104**, 137-160	454	2011
Rotmans, J. and Loorbach, D.	Complexity and Transition Management	Journal of Industrial Ecology **13**(2), 184-196	377	2009
Vlachos, D.; Georgiadis, P. and Iakovou, E.	A system dynamics model for dynamic capacity planning of remanufacturing in closed-loop supply chains	Computers & Operations Research 34, 367-394	346	2007
Allee, V.	Value network analysis and value conversion of tangible and intangible asset	Journal of Intellectual Capital **9**, 5-24	335	2008
Cabreraa, D.; Colosic, L. and Lobdell C.	Systems thinking	Evaluation and Program Planning **31**, 299-310	268	2008
An, L.; Linderman, M.; Qi, J.; Shortridge, A. and Liu, J.	Exploring complexity in a human-environment system: an agent-based spatial model for multidisciplinary and multiscale integration	Annals of the Association of American Geographers **95**(1), 54-79	253	2005
Mirchi, A.; Madani, K.; Watkins, D. and Ahmad, S.	Synthesis of system dynamics tools for holistic conceptualization of water resources problems	Water Resources Management **26**, 2421-2442	252	2012
Niu, B.; Liu, Y.; Zong, G.; Han, Z. and Fu, J.	Command filter-based adaptive neural tracking controller design for uncertain switched nonlinear output-constrained systems	IEEE Transactions on Cybernetics **47**(10), 3160-3171	200	2017
Ng, I.C.; Maull, R. and Yip, N.	Outcome-based contracts as a driver for systems thinking and service-dominant logic in service science: Evidence from the defence industry	European Management Journal **27**(6), 377-387	198	2009
Ekinci, E.; Mangla, S.K.; Kazancoglu, Y.; Sarma, P.R.S.; Sezer, M.D. and Ozbiltekin-Pala, M.	Resilience and complexity measurement for energy efficient global supply chains in disruptive events	Technological Forecasting and Social Change **179**, No, 121634	22	2022
Ekinci, E. and Baykasoğlu, A.	Complexity and performance measurement for retail supply chains	Industrial Management & Data Systems **119**(4), 719-742	17	2019
Ekinci, E. and Baykasoglu, A.	Modelling complexity in retail supply chains	Kybernetes **45**(2), 297-322	14	2016
Ibrahim Shire, M.; Jun, G.T. and Robinson, S.	Healthcare workers' perspectives on participatory system dynamics modelling and simulation: designing safe and efficient hospital pharmacy dispensing systems together	Ergonomics **63**(8), 1044-1056	10	2020

Table 3. Most cited authors (continuation from p.529).

Authors	Article Title	Source	Citations	Year
Soydan, A.I. and Atilla Oner, M.	Timely resource allocation between R&D and marketing: a system dynamics view	International Journal of Innovation and Technology Management **9**(02), No. 1250012	6	2012
Gürsan, C.; De Gooyert, V.; De Bruijne, M. and Raaijmakers, J.	District heating with complexity: Anticipating unintended consequences in the transition towards a climate-neutral city in the Netherlands	Energy Research & Social Science **110**, No. 103450	2	2024
Bozkurt, E.	A Bibliometric Analysis of Systems Thinking Research in Science Education 1991-2022	Science Education International **34**(3), 225-234	1	2023

The study titled "Complexity Leadership Theory: Shifting Leadership from the Industrial Age to the Knowledge Era," published in 2007 in The Leadership Quarterly by Uhl-Bien, M.; Marion, R. and McKelvey, B., is the most cited work, with 1237 citations.

Table 3 was created by filtering the most cited studies in the field of "System Theory" from the Scopus database with the help of the Bibliometrix program in the R program and Table 3 was created. Accordingly, the most cited authors were Uhl-Bien, Marion and McKelvey, with 1237 citations to their study titled "Complexity Leadership Theory: Shifting leadership from the industrial age to the knowledge era" published in The Leadership Quarterly in 2007, which aimed to explain the foundations of the System Theory.

When looking at the articles written on system theory by year in Figure 7, it is seen that while the numbers are close to each other between 2000-2008, there has been an increase every year since 2009 compared to the previous year. Although there was a slowdown after 2015, studies have increased as of 2017. The year with the most articles was 2023. This shows that system theory studies are gaining momentum. However, the increase in the total number of publications shown in Figure 3 should not be evaluated independently of the overall trend in the growth of scientific publications worldwide. It is well known that the total number of articles published across all academic disciplines has been growing rapidly in recent years. This suggests that this system cannot be integrated into a robust theoretical framework. This system reflects its proportional share (relative growth) in the total number of publications, and its dynamics relative to overall scientific output may have stagnated or slowed. This situation predisposes the implementation of an organizational structure, and in community applications, it is recommended to analyze this information. This analysis is hindered by normalizing the data relative to the overall growth rate of the Scopus database. This analysis is performed as outlined in **RQ1**. As a result of this analysis, **RQ1** was answered.

Figure 8 illustrates the thematic development across four distinct time periods (2000-2011, 2012-2018, 2019-2022 and 2023-2024). Rather than applying arbitrary or strictly equal temporal divisions, these intervals were determined through a data-driven approach based on publication density and major paradigm shifts observed in the keyword evolution. The baseline period (2000-2011) establishes the foundational era, while subsequent blocks capture the acceleration of the literature and the integration of new methodological tools.

Initially (2000-2011), this field of expertise was shaped around a relatively limited number of core topics, foremost among which were 'system dynamics', 'cybernetics' and 'socio-technical systems'. These topics reflect the field's origins in systems thinking and control theory; they were of great intellectual significance and, as the flow lines indicate, served as the primary source for the emergence of subsequent thematic complexes.

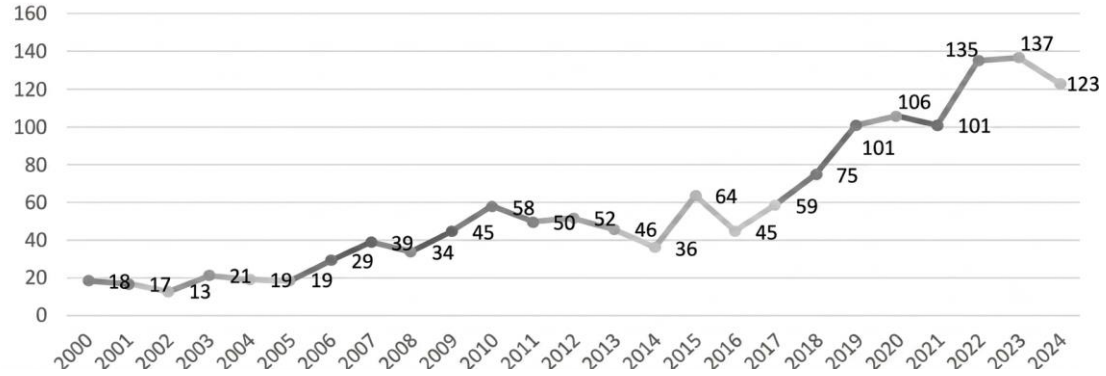


Figure 7. Annual scientific production.

Between 2012 and 2018, the range of topics expanded significantly. Whilst 'System Dynamics' and 'Cybernetics' retained their central importance, new topics such as 'action research', 'education', 'non-linear dynamics', 'causality diagrams' and 'complexity theory' gained prominence. As researchers increasingly explore both the theoretical foundations (non-linear dynamics, complexity theory) and the applied dimensions (action research, education), this diversity serves as an indicator of the field's methodological maturity.

The 2019-2022 period has been shaped by a notable shift. 'Fuzzy logic' has emerged as a central theme linked to various currents of the previous period; this suggests that the theme in question summarises previous methodological currents or bridges the gaps between them. Interestingly, "complexity theory", which was present between 2012 and 2018, has not emerged as a defining theme during this period; instead, "complex systems", "dynamic complexity" and "systems science" – concepts that are interconnected yet independent – have come to the fore. This suggests a fragmentation or differentiation within the body of research on complexity. "Cybernetics" and "education" have also shifted into this period and retained their significance.

A certain degree of re-consolidation is observed during the 2023-2024 period. Whilst 'system dynamics', 'complex systems' and 'system theory' are re-emerging as dominant topics, 'complexity theory' – which was virtually absent in practice between 2019 and 2022 – is making a comeback. Its re-emergence in the previous period in connection with "Fuzzy Logic" suggests that "Fuzzy Logic" may have served as a conceptual bridge, combining the previous discourse on complexity with a contemporary reformulation. The fact that the topic of "Cybernetics" has persisted throughout the four periods highlights its pioneering role in the methodological development of the field.

Overall, this thematic development demonstrates that the field has successfully managed to integrate new methodological perspectives whilst simultaneously preserving certain fundamental concepts; this reflects broader trends observed in systems research and the science of complexity [25, 26]. These findings address **RQ2** by demonstrating that methodological issues in this field do not develop in a linear fashion, but rather re-emerge cyclically over time and undergo conceptual transformation. As a result of this analysis, **RQ2** was answered.

When looking at the authors with the most publications within the time period of the research, the publication numbers of the first 10 authors are seen in Figure 9. The bubble size shows the number of documents produced by the authors per year. The lines represent the production interval (timeline) over time. The intensity of the bubble color shows its importance, while the size of the bubble increases according to the number of articles published [24]. According to the graph showing the productivity of the authors, Yanmin Wang from the School of Information Engineering Minzu University of China is at the top of the most cited authors, followed by Khurram Iqbal Ahmad Khan from the National University of Sciences and Technology (NUST) and Huixiong Wang from the China Academy of Launch Vehicle Technology.

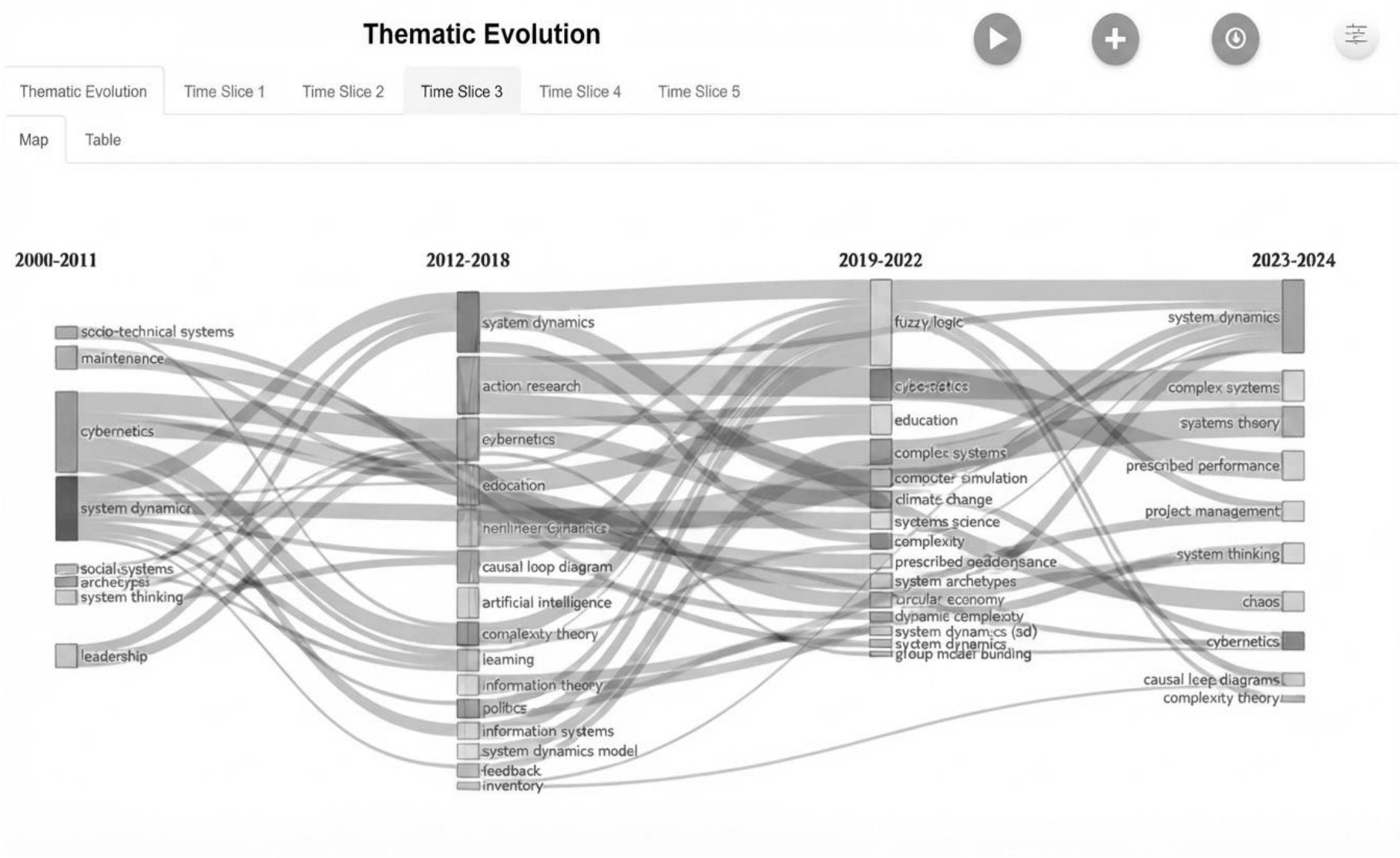


Figure 8. Thematic development according to time periods (parameters: abstracts-bigrams).

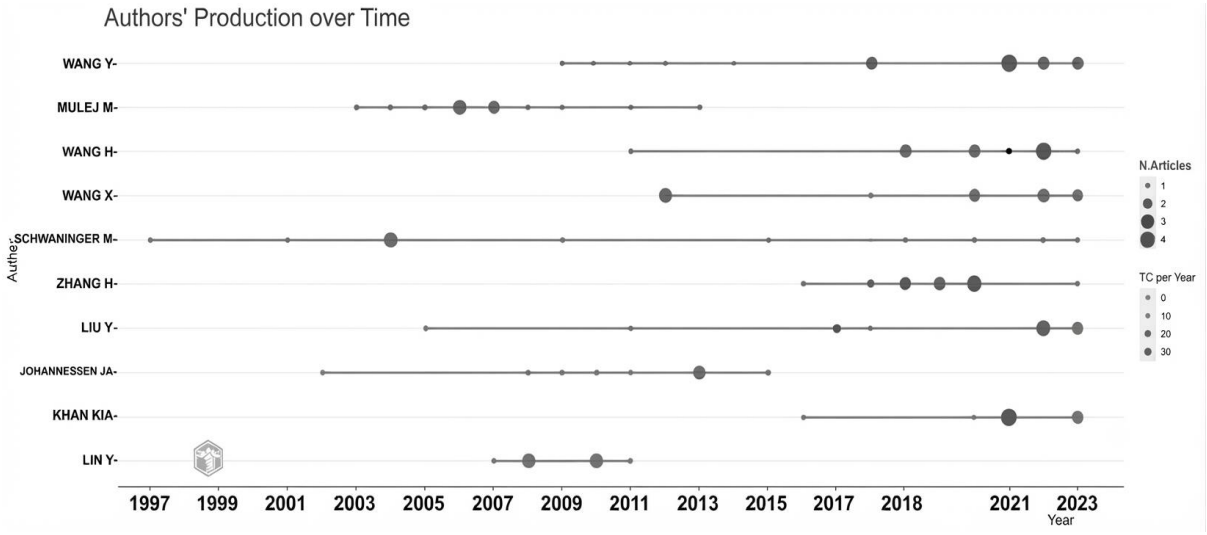


Figure 9. Authors with the most publications-by year.

The most repeated words are shown in Table 4 according to the most frequently used words according to various parameters in titles, keywords and abstracts. Accordingly, when the word clouds according to the titles in the leftmost column are examined, the analysis made by selecting the abstracts of the key source articles for the most repeated words shows that "system theory" comes first with 402 repetitions, followed by system dynamics with 339 repetitions. When the keyword section of the articles is selected as a parameter, according to the results, system dynamics comes first, followed by system thinking and cybernetics. When the key source titles are selected, the most repeated words are system, dynamics and systems, respectively.

Table 4. Most repetitive words by keywords and titles.

Vocabulary	Frequency	Vocabulary	Frequency	Word	Frequency
Systems theory	402	System dynamics	527	System	421
Systems dynamics	339	Systems thinking	297	Dynamics	373
Cybernetics	268	Cybernetics	228	Systems	352
Complexity theory	144	Complexity theory	111	Approach	186
Decision making	137	Complexity	84	Model	168
Systems thinking	136	Simulation	63	Thinking	131
Design/methodology /approach	132	System theory	59	Complexity	112
Sustainable development	94	Sustainability	42	Analysis	97
Computer simulation	74	Causal loop diagram	37	Dynamics	94
Matter	73	Modeling	28	Manage	92
Keyword plus-unigram		**Author keywords-unigram**		**Titles-unigram**	

In Figure 10, where the usage rate of words in articles is shown according to years, system theory, which is at the top of the words with the highest usage rate, shows a regular increase graph, while the word system dynamics started to increase between 2006-2014, and this increase followed a rapid course from 2014. This sharp increase in system dynamics can be attributed to the rising integration of computer-based simulation models and data-driven forecasting in modern operational systems. Cybernetics, on the other hand, has made a more stable progress compared to the first two. This stability suggests that while cybernetics remains a foundational theoretical pillar of systems research, contemporary scholarship has increasingly shifted towards applied frameworks like system dynamics rather than traditional control-theory approaches. As a result of this analysis, **RQ_3** was answered.

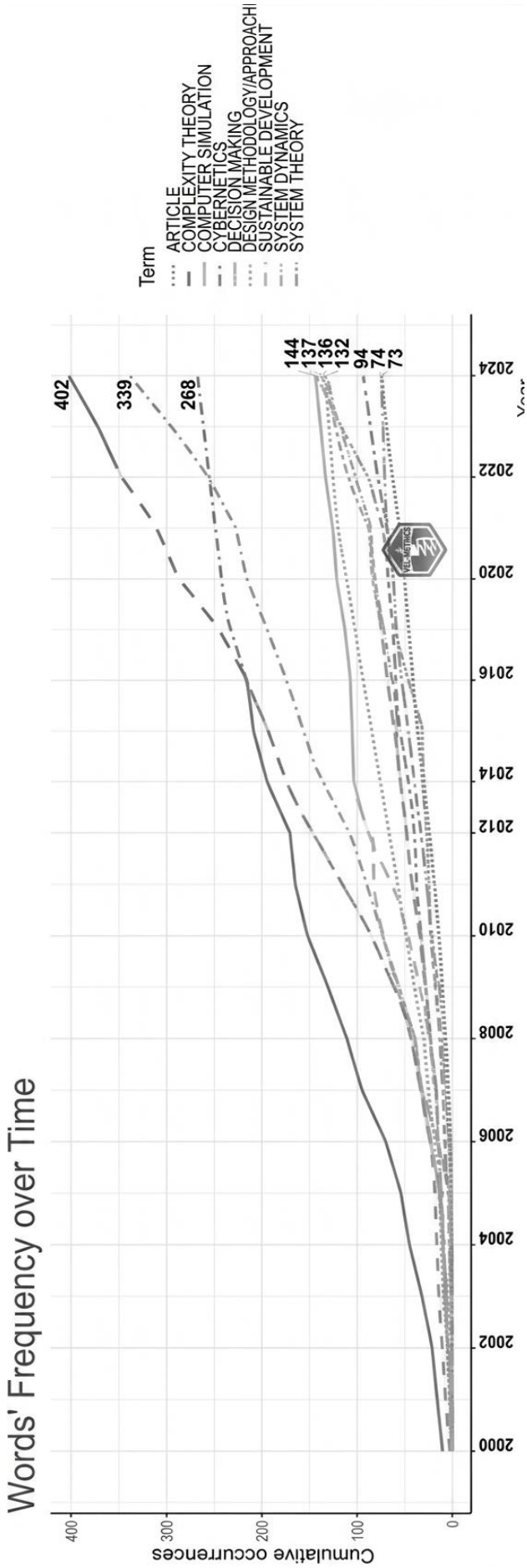


Figure 10. Most frequently used words in the last 15 Years (parameter: abstract).

When the countries of the responsible authors are examined in Figure 11, the USA ranks first in single- and multi-authored articles, while China ranks second in multi-authored articles. China is followed by the UK, Italy, Australia and India. Ukraine, Japan and Hungary are at the bottom of the list, while Türkiye ranks 12th, ahead of these countries.

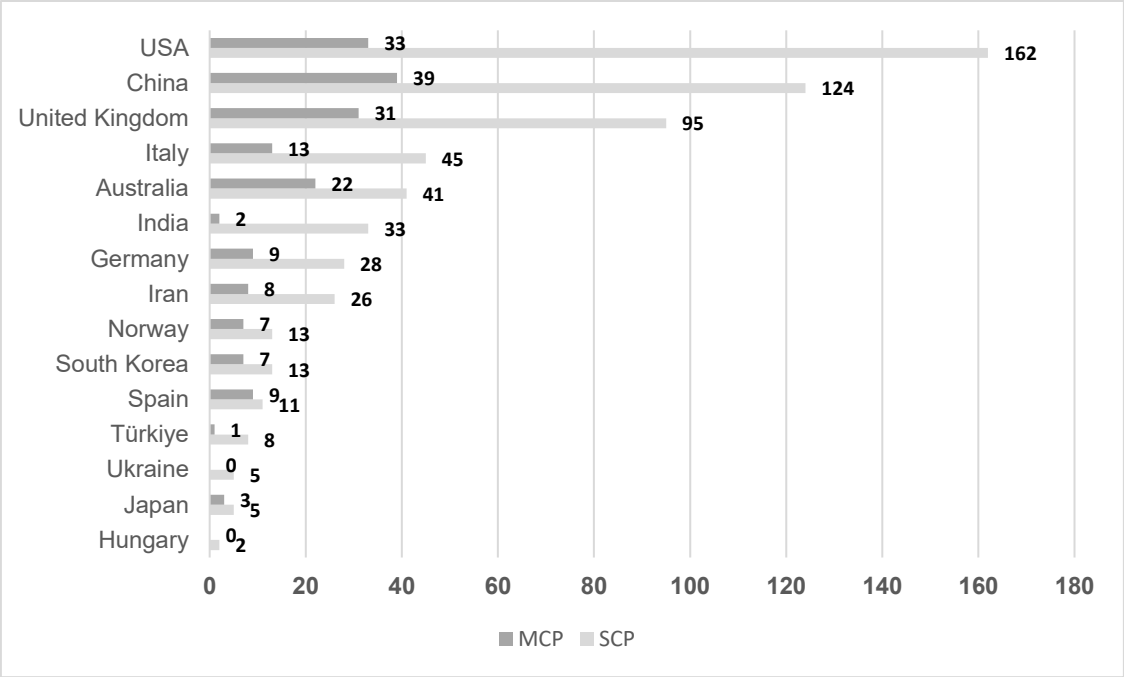


Figure 11. Articles by country (single- and multi-author) countries of the responsible authors. SCP – single-country publication, MCP – multiple-country publication.

In Figure 12, the University of Maribor in Slovenia is at the top of the universities where the authors of the most cited articles work, with 17 authors. The University of Queensland in Australia is in second place with 16 authors. The university that follows these universities in third place is University College London, which entered the list with the works of 15 authors.

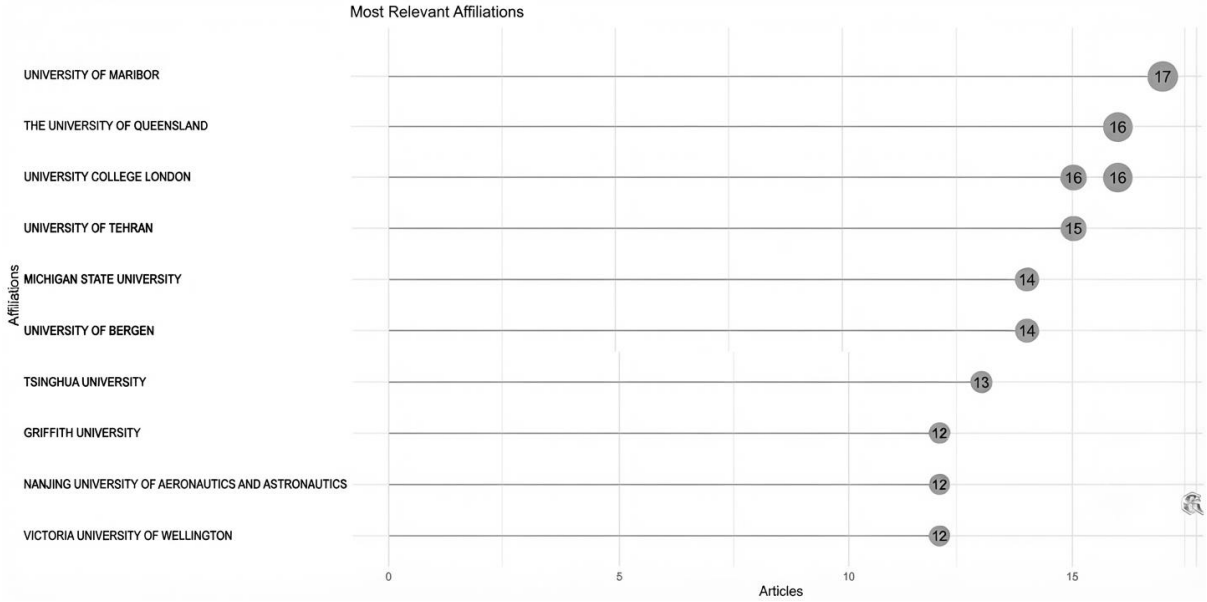


Figure 12. Universities where the authors of the most cited articles work.

The most productive universities are shown in Figure 13. The academics who published the most articles in the field of system theory were from Michigan State University. They were followed by academics working at The University of Queensland and University College London.

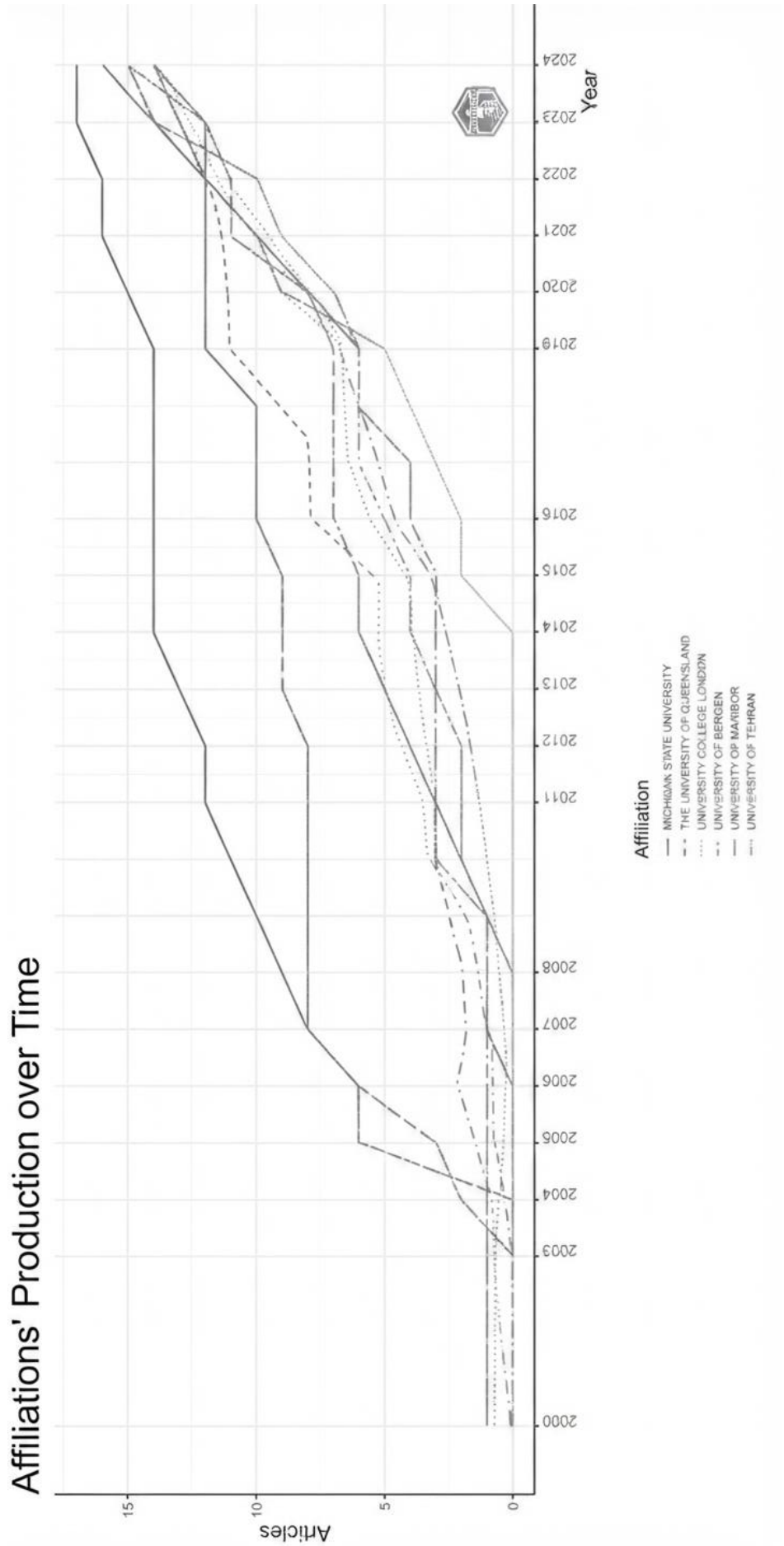


Figure 13. Most productive universities.

Figure 14, which shows the collaboration between authors, shows that authors working at the same university or in the same country are clustered together more as authors in an article. While Brent from Slovenia and Khan from India stand out in single-authored studies, author collaborations are seen to be more common in the USA and China.

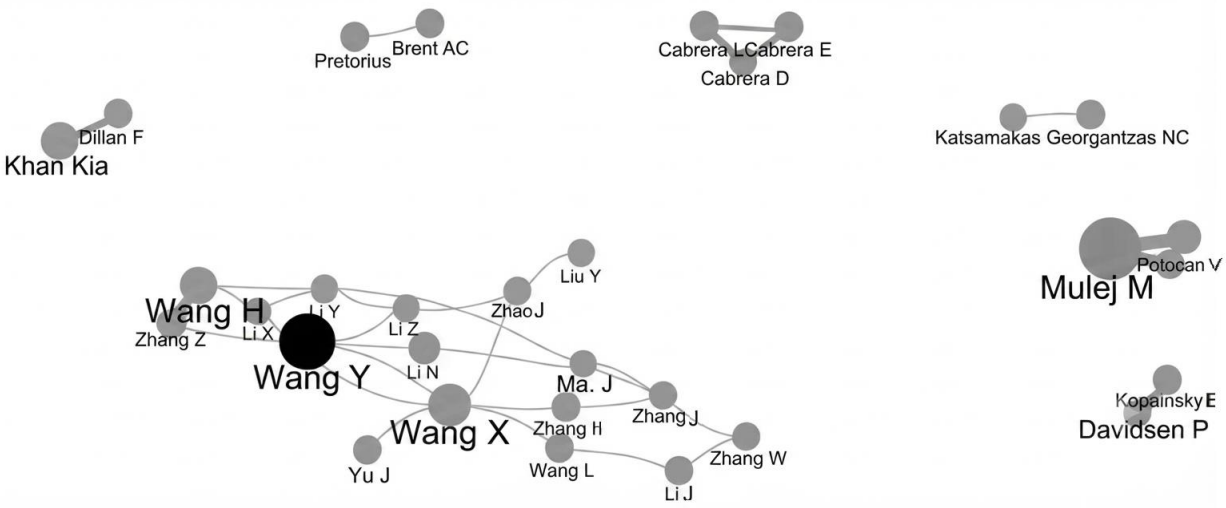


Figure 14. Collaboration network of authors.

According to the cross-country collaboration graph in Figure 15, the USA and China have the most collaborations with other countries on "system theory". While China generally cooperates intensively with Asian countries, the USA cooperates equally with Asian and European countries. European countries, except for the USA, mainly cooperate with each other. While the countries that Türkiye cooperates the most with are the USA, China, India and Australia, it is noteworthy that cooperation with European countries is low.

Figure 16, which shows the collaboration between universities, shows that the highest collaboration is between Slippery Rock University in the USA and Nanjing University of Aeronautics and Astronautics in China. This intense cross-border collaboration highlights the strong academic ties between US and Chinese institutions, which dominate global research funding and publication output in systems science. Furthermore, the prominent position of a technical institution like Nanjing University of Aeronautics and Astronautics demonstrates a critical shift in the field: contemporary system theory is increasingly being operationalized within applied engineering, aerospace, and complex logistical frameworks, rather than remaining confined to purely abstract or philosophical domains. As a result of this analysis, **RQ4** was answered.

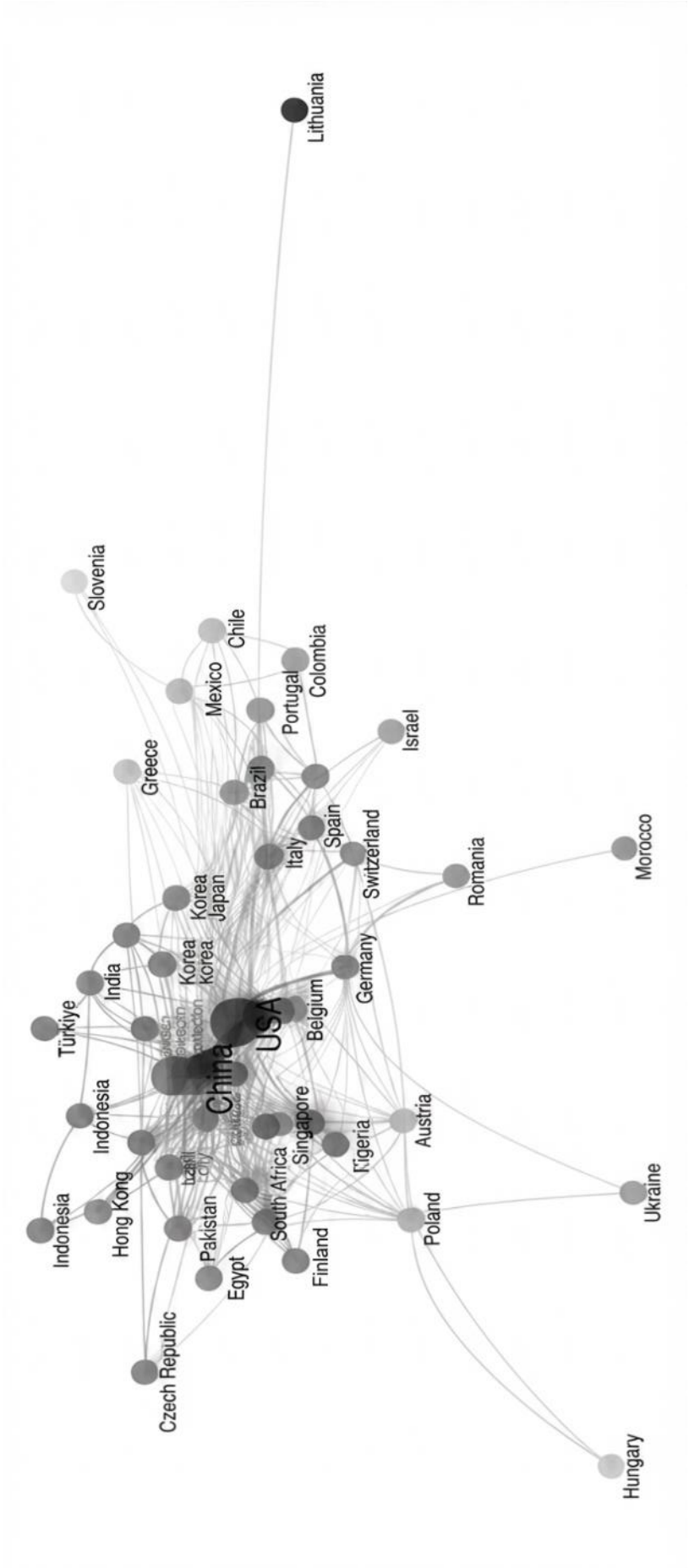


Figure 15. International cooperation map.

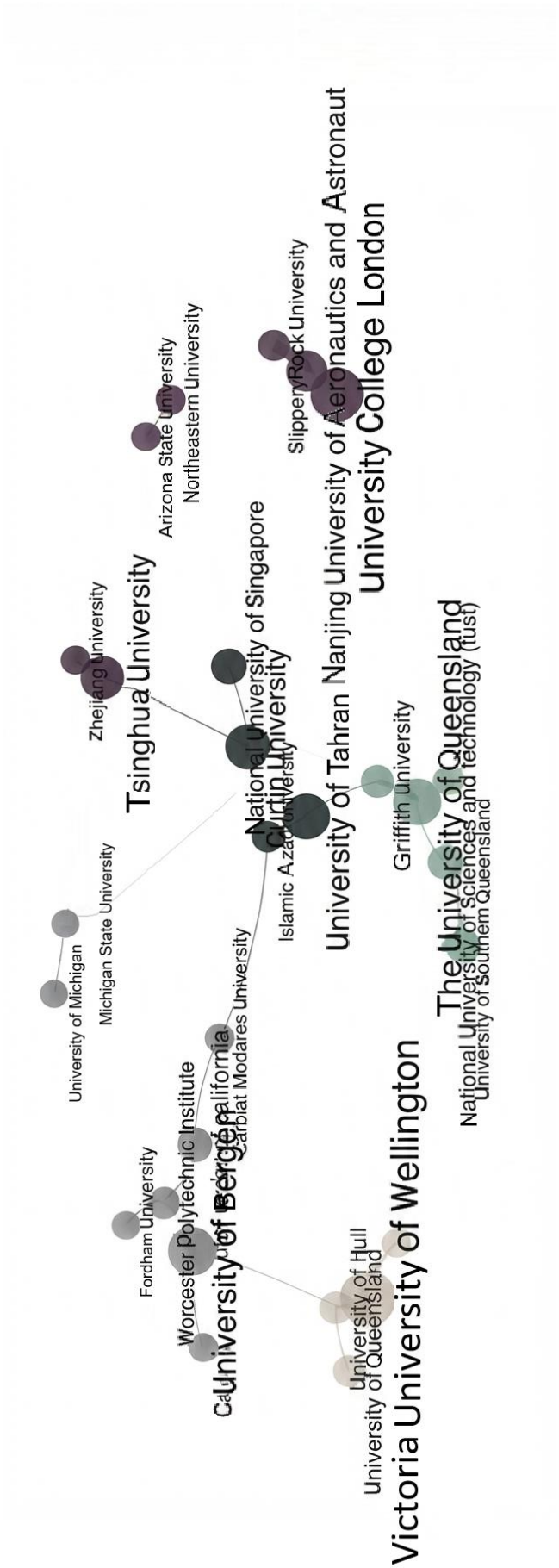


Figure 16. Collaboration network of universities.

CONCLUSIONS AND DISCUSSIONS

The findings clearly demonstrate the powerful conceptual framework that system theory provides for understanding and managing complex systems. Systems typically contain nonlinear, cyclical causal structures, and the dynamics of these structures emphasize the importance of the systems approach and systems thinking. While system theory provides a holistic approach to problems, the systems approach provides a flexible perspective on changing phenomena. Systems thinking encourages examining a process as a whole and focusing on the relationships of the parts. This provides a holistic understanding of the system by considering system dynamics, feedback loops and dynamic elements and can be used to design sustainable policies.

The first of the most important contributions of this study is the explanation of research trends and developments. This bibliometric analysis, which aims to provide a comprehensive overview of the research conducted in the field of system theory in the last 25 years, provides information about the focus, direction and development trends of the research field. This comprehensive review of system theory can help identify current knowledge and gaps in the research field. In addition, identifying research trends can help guide future research and support progress in the field.

Another contribution is the emphasis on important concepts. Concepts such as systems approach, systems thinking and system dynamics are important for the holistic understanding and management of complex systems. By mapping citation networks, keyword co-occurrences, and authorship patterns, this study highlights specific trends and emerging areas in system theory, offering guidance for future research directions. This study clearly demonstrates the importance and necessity of these concepts. It emphasizes the importance of a holistic, flexible and interdisciplinary approach to understanding and managing complex systems. In particular, the application of systems approaches and systems thinking can promote interdisciplinary integration and provide innovative solutions to complex problems.

Finally, in order to understand the value of bibliometric methods, this study contributes to the development of a holistic understanding of interdisciplinary fields such as system theory, bibliometric methods used to measure scientific communication. This method contributes to a better understanding of the field by systematically presenting research trends and developments. In addition, bibliometric analysis can provide valuable information for understanding the dynamics of the field and developing strategic research plans.

A limitation of this study is the reliance on Scopus-indexed publications, which excludes other major databases such as Web of Science and Google Scholar. Including these databases in future research can expand the scope of analysis, capture additional influential studies, and improve the generalizability of results. Future studies may also incorporate qualitative assessments of methods and models used in the analyzed studies to provide deeper insights and guide the development of new research directions.

The findings reveal a holistic, natural, and interdisciplinary perspective and emphasize the importance of flexible and dynamic mechanisms for understanding complex systems. Through citation network mapping (Research Map), the relationships between keywords and authors are analyzed, revealing research trends, influential authors, and emerging topics in the field. The study contributes to a fundamental theory framework that clarifies the relationships between concepts and promotes a shared vision for building academic communication on campus. It also documents bibliometric methods for capturing the intellectual structure and interdisciplinary connections of research and general theory.

Integrating qualified assessments of methods and models implemented in research laboratories could provide a deeper understanding of the practical applications of desystematic theory. This

could help guide new research areas and foster interdisciplinary collaboration, advancing existing policy solutions and innovative solutions to complex systemic problems.

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