A Bibliometric Analysis of Systems Modeling Research: Trends, Themes and Future Directions (2020–2025)

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Abstract

Our article consists of a bibliometric analysis of the research published in the timespan of 2020-2025 regarding systems modeling and their future tendencies. Our findings highlight the interdisciplinarity of systems modeling and also identify its inter-collaborative limitations. Leveraging Web of Science as our main source of data and VOSviewer for the graphic representation of networks, the present analysis is centered around four different studies: co-authorship relations, keyword co-occurrence, citation patterns, and sources of publication. Our analysis showcases the expansive nature of the systems modeling field, various domains such as environmental studies, engineering, information systems, and biomedicine vastly implementing the methodology in order to facilitate the abstracting process of systems holding high degrees of complexity. This scope expansion can be also noticed from the gradual evolution of the field into a more pragmatic one, systems modeling being largely implemented in niche impact-oriented projects. Despite the utility of systems modeling methodologies, collaboration between authors tends to be largely limited, the bibliometric analysis revealing a lack in co-authorship links and a tendency to have isolated highly cited publications in spite of dense interconnected networks. This article's findings highlight the need of stronger collaborative initiatives in the domain of systems modeling.

Keywords

Systems Modelling, Bibliometric Analysis, Interdisciplinarity

1. Introduction

It is notable that system modeling is of critical relevance across engineering and scientific fields. It provides the necessary tools for the mathematical abstraction of highly complex real-world systems and facilitates their analysis and simulation. From systems addressing climate variability and changes to those analyzing socio-technical networks (such as academic co-authorships) and energy infrastructures, modeling their interdependent variables improves planning and decision-making capabilities in a large variety of domains. A relevant part of the enhancement of the predictive capabilities in systems modeling was also rendered possible by the evolutions of artificial intelligence [1, 2, 3].

Beyond the acute applicability of systems modeling, exemplified by the utilization of modeling frameworks in manufacturing systems even capable of accounting for human variability [4], the methodology itself has also been largely innovated. Formal frameworks implemented in the restructuring process of system models have been introduced by model based systems engineering. They expand the modeling integration in highly complex workflows [5, 6]. At the same time, leveraging artificial intelligence within geological systems modeling methodologies has also broadened the utility of hybrid models, rendering them capable of combining large machine learning algorithms with physical laws, thereby enhancing their predictive performances and enriching a large number of modeling toolkits [7, 8, 9, 10].

Considering the rapidly mutable landscape of system modeling, the need to map the various research activities in the field is constantly increasing. Bibliometric analysis provides the relevant means of performing quantitative and qualitative studies on research patterns, knowledge gaps, and emerging

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trends in the domain of systems modeling. The present study proposes a comprehensive bibliometric analysis of research published between 2020 and 2025 regarding systems modeling and the domain's future tendencies. In order to do so, we leveraged peer-reviewed publications extracted from major scientific databases such as Web of Science and examined the field's development, interdisciplinarity, and emerging trends, offering insights into both its actual state and its future prospects.

2. Method

This study was carried out on the 30th of July, 2025, and it targets papers ranging in the span between 2020 and 2025 by leveraging the "all fields" selection in "Web of Science" utilizing the "Systems Modeling Research" keyword. In total a number of 837 results were reached, containing the specified word. The data were analyzed after generating graphs of different levels of density with the VosViewer software. The parameters of analysis consisted of: Co-authorship, Co-occurrence-all keywords, and Citation with documents and sources as the unit of analysis. These specific criteria were selected due to their inherent utility in the study of the literature of system modeling, providing relevant information regarding the most cited works, most popular sources, existing correlations between authors and keywords with the highest degree of co-occurrence.

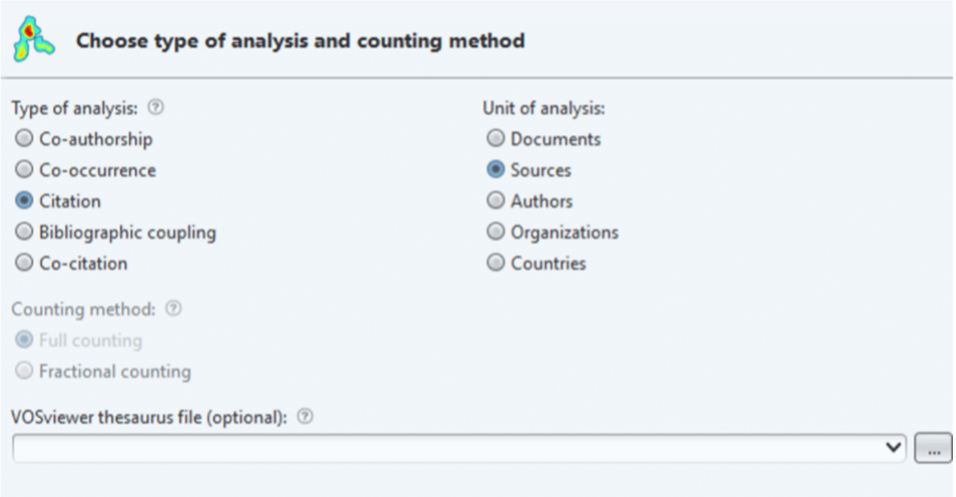

Figure 1: Choosing the type of desired analysis and the counting method in VOSviewer.

3. Findings

3.1. Co-authorship analysis

We conducted the co-authorship analysis in order to identify collaborative relationships among researchers in the field of systems modeling. The threshold for inclusion was set to a minimum of 2 documents per author and 0 citations. Thus, this process resulted in a total of 3 authors meeting the criteria, namely Jeyaraj Anand, Keller Mignonette N., and Zhang Tao, who were selected for the visualization based on their number of publications, although no significant co-authorship link strength was detected (each had a total strength of 0).

Figure 2 showcases the distribution of authors based on the publication year, the color spectrum ranging from 2020 to 2022. The lack of graphical connections indicates the absence of collaboration ties, suggesting that while these authors are individually contributing to systems modeling research, their work remains unconnected.

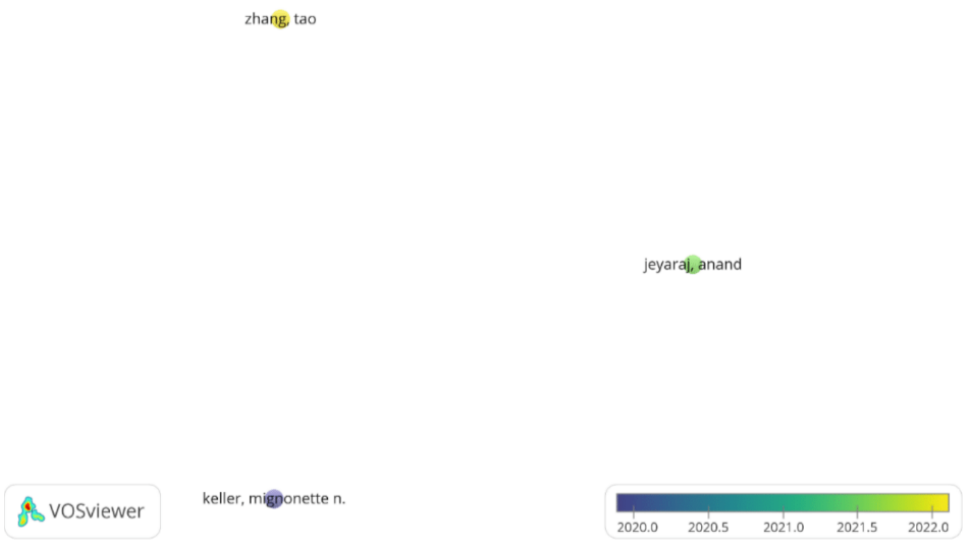

Figure 2: Figure generated with VosViewer for the co-authorship analysis, each node representing one author.

Table 1
Table representing co-authorship data.

Author	Documents	Citations
jeyaraj, anand	2	57
keller, mignonette n.	2	3
zhang, tao	2	5

3.2. Keyword co-occurrence

Our present analysis puts emphasis on the high importance co-occurrence of keywords has in documents. Such a study can provide great insight into the current trends of systems modeling. The unit of analysis is represented by all the keywords, used complementarily with a full counting method (if a keyword appears in a document, it is counted as one occurrence for each link or connection it contributes to, regardless of how many keywords or connections are in the same document). In order for a keyword to be taken into account, a minimum of 2 occurrences had to be found; thus, out of a total of 269 keywords, only 12 met the threshold.

The resulting graph, displayed in Figure 3, shows how frequently pairs of keywords co-occurred within documents, revealing connected research interests. Among the most closely linked terms are “topic modeling”, “information systems”, and “impact”, indicating that these concepts occupy a central position within the discourse. Over time, the focus of these terms has shifted. Recent studies lean more toward impact assessment and application-specific investigations, whereas earlier works tended to revolve around foundational concepts. This suggests growing interest in systems modeling’s applicability.

3.3. Citation analysis (documents)

The citation study on documents is highly relevant, as some of the greatest insight comes from it, essentially linking works and providing an extended knowledge base for future research. With the threshold set at 5 citations of one document, out of 50 documents, only 15 met the necessary criterion for further analysis.

The resulting graph illustrates which documents have received the highest citation counts in systems modeling between 2020 and 2024, with a color gradient indicating the average year of publication. Among the most cited are works by Jayaraj (Information systems research through topic modelling using

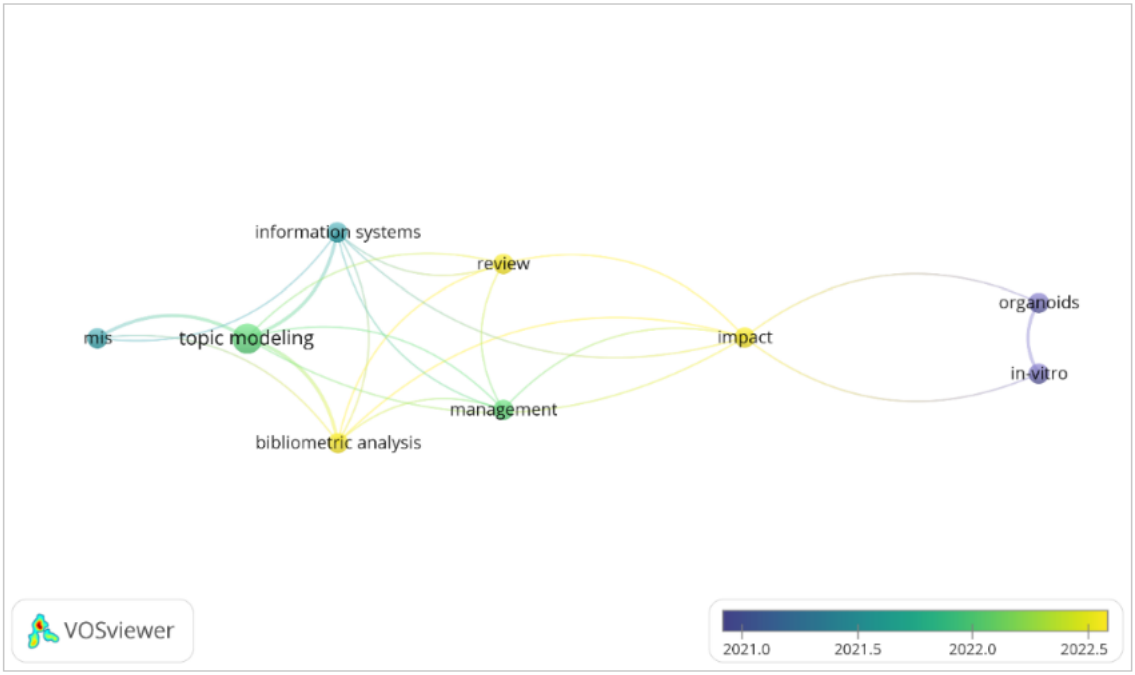

Figure 3: Figure generated with VosViewer for the keyword co-occurrence, each node representing a specific keyword.

Table 2
Table representing keyword co-occurrence data.

Id	Keyword	Occurrences	Total Link Strength
17	bibliometric analysis	2	7
55	design	2	2
100	impact	2	7
104	in-vitro	2	3
110	information systems	2	7
128	management	2	5
141	mis	2	4
148	modeling	3	1
168	organoids	2	3
190	quality	2	1
210	review	2	5
250	topic modeling	3	9

latent semantic indexing applied to author-supplied keywords) and Tang (Summary of Earth–Climate System Models (ECSMs) research and development in China), which have accumulated 52 and 50 citations, respectively.

Although presenting high citation counts, the documents analyzed in our bibliometric study show limited or even no linkage to the other documents present in the Web of Science dataset, indicating a fragmented citation landscape, where impactful studies contribute individually, or in connection to different subfields, rather than forming citation clusters in systems modeling research.

3.4. Citation analysis (sources)

To identify the most influential publication channels in systems modeling research, a citation analysis was performed using sources (journals) as the unit of analysis. The threshold was set to at least one published document and a minimum of 4 citations, resulting in 15 sources selected for analysis, out of a total of 45.

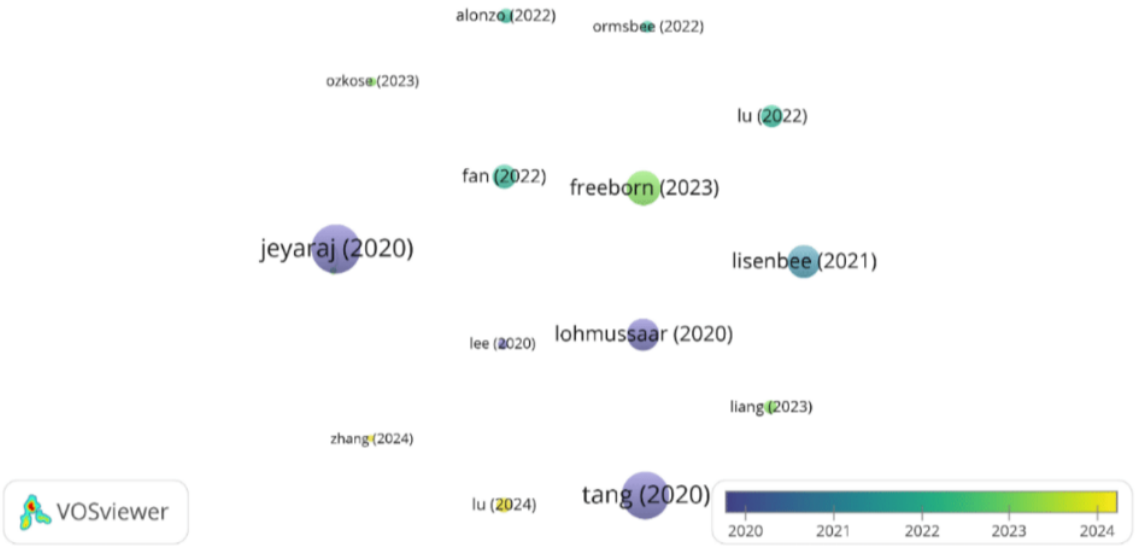

Figure 4: Figure generated with VosViewer for the citation analysis (documents), each node representing a specific document.

Table 3
Table representing the number of citations utilizing documents as unit of analysis.

Id	Document	Citations	Total Link Strength
3	Lisenbee (2021) [11]	34	0
9	Lohmussaar (2020) [12]	33	0
12	Lu (2022) [13]	22	0
16	Fan (2022) [14]	24	0
26	Jeyaraj (2020) [15]	52	1
31	Freeborn (2023) [16]	35	0
33	Ormsbee (2022) [17]	11	0
34	Zhang (2024) [18]	5	0
35	Lee (2020) [19]	9	0
38	Zareravasan (2023) [20]	5	1
42	Liang (2023) [21]	12	0
43	Lu (2024) [22]	14	0
45	Tang (2020) [23]	50	0
47	Ozkose (2023) [24]	8	0
50	Alonzo (2022) [25]	14	0

The visualization maps out key sources according to both their citation influence and their average year of publication. Standing out at the center is the “Information & Management”, which emerges as the most frequently cited source, underscoring its significant role in presenting research on systems modeling. “Renewable & sustainable energy reviews” is a very close second place in number of citations, with 50 of them.

The dispersion and diversity of journals, from “Trends in Cancer” to “Library Hi Tech”, show the broad applicability of systems modeling across technical, environmental, and biomedical fields. Further weak interconnectivity among sources seems to again suggest fragmentation across more specific domains.

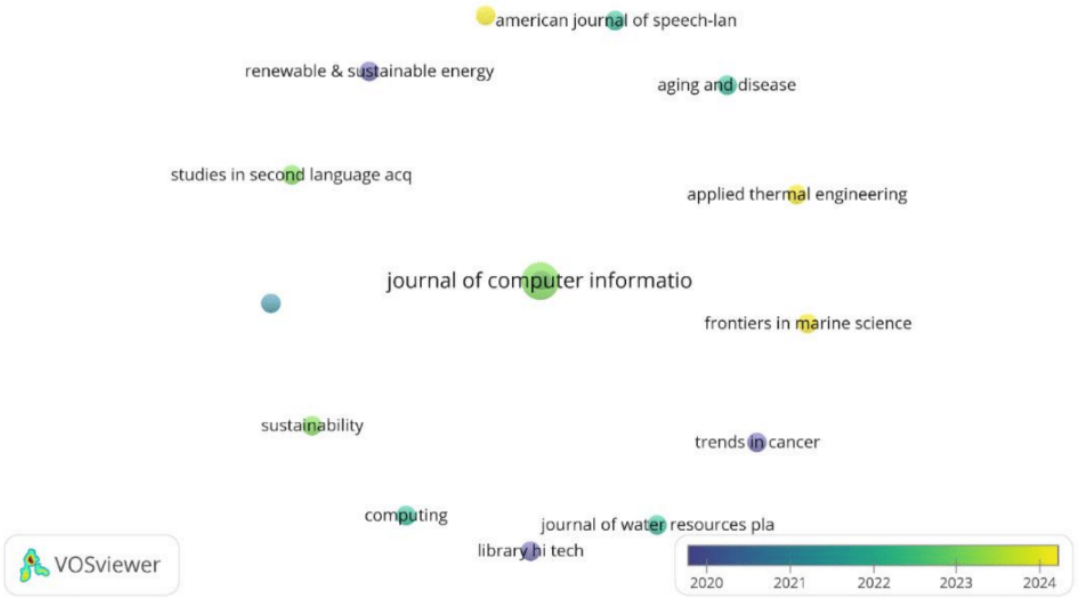

Figure 5: Figure generated with VosViewer for the citation analysis (sources), each node representing a specific source.

Table 4
Table representing the number of citations utilizing sources as the unit of analysis.

Id	Source	Document	Citations	Total Link Strength
7	aging and disease	1	22	0
8	american journal of speech-language pathology	1	14	0
9	applied thermal engineering	1	5	0
14	computing	1	24	0
17	environmental modeling & software	1	34	0
19	frontiers in marine science	1	4	0
22	information & management	1	52	1
27	journal of computer information systems	2	13	1
31	journal of water resources planning and management	1	11	0
33	library hi tech	1	9	0
36	physics of life reviews	1	14	0
42	renewable & sustainable energy reviews	1	50	0
43	studies in second language acquisition	1	35	0
44	sustainability	1	12	0
45	trends in cancer	1	33	0

4. Discussion

The findings from our bibliometric analysis provide a detailed snapshot of how systems modeling research has evolved between 2020 and 2025. As outlined in the previous chapter, the reviewed studies present an insightful perspective on research patterns and thematic priorities. Together, they highlight how strongly the field continues to draw from multiple disciplines.

The co-authorship review reveals relatively modest levels of collaboration among researchers who meet the established publication threshold. Although authors such as Jeyaraj, Keller, and Zhang have made steady, individual contributions, the broader network of partnerships appears noticeably fragmented. This does align with the broader trends in interdisciplinary fields, where domain overlap is limited. The fact that even the most frequently published authors exhibited no co-authorship link strength highlights the need for the formation of greater academic networks.

The keyword co-occurrence study provides a snapshot of dominant research themes and their evolution. Some of the keywords display centrality, indicating a base interest and need for approaching foundational parts of the field ("information systems", "topic modelling"). The presence of more niche terms, like "organoids" or "in vitro", suggests that systems modeling continues to expand into more experimental research contexts, for example, biomedical. The temporal positioning of keywords also suggests a transition towards applied and impact-focused themes. This could happen due to trends in real-world deployment scenarios.

The citation analysis based on documents reveals that some highly influential papers, like those by Jeyaraj (2020) [15] and Tang (2020) [23], appear to be recognized for their standalone contributions, but show limited connection to other key papers. Again, a fragmented landscape is highlighted, aligning with the earlier observations of author fragmentation, reinforcing the idea of a highly domain-specific field of research. The pattern is indicative of the field's diversity and more niched subfields, convergence happening at a slower pace, parallelism in approach being more visible.

Finally, a closer look at the analysis of sources underlines the field's interdisciplinary scope, as impactful studies appear in a wide range of journals in many fields, like computer science, environmental studies, biomedical domains, and engineering. Journals such as "Information and Management" and "Renewable & Sustainable Energy Reviews" stand out for their strong citation records, underscoring the considerable relevance of systems modeling in both applied and societal settings. At the same time, the relatively weak link strength between these publications points to the absence of a central, unifying outlet for the field. Depending on perspective, this gap may be viewed as a drawback, limiting thematic coherence, or as an advantage, allowing for a broader and more diverse body of work.

Overall, our study reaches a concrete idea: the field is widely applied and very diverse, but it lacks a strong collaboration structure. However, the observed fragmentation also signals an opportunity for more integration, through extended shared methodological elements and collaborative networks and frameworks, thus bringing strength and more scalability in systems modeling research.

5. Conclusions and Future Work

Our bibliometric analysis proposes an overview of the research conducted in the field of systems modeling that spans from the year of 2020 to 2025. The study showcases the field's interdisciplinarity, but also its tendency to lack internal collaborations between authors. By leveraging VOSviewer for the visualization of networks in the form of graphs and utilizing Web of Science as the main source of data, we investigated co-authorship relations, keyword co-occurrences, citation structures, and sources of publication.

Our article demonstrates the utility of system models in engineering, information systems, biomedical research, and environmental science due to both the analysis on keywords co-occurrences and source of publication in VOSviewe,r indicating the widely spread utility of systems modeling. It also highlights a weak cross-journal connectivity deduced by the low total link strength of the articles studied in the "Number of citations" section.

Several central insights emerged from our study: the interdisciplinarity of the field of systems modeling highlighted by publications across journals in different fields; the limited number of co-authorship links, even the most prolific authors lacking collaborations; and the absence of interconnected citation clusters in favour of singular highly cited works such as those of Jeyaraj (2020) [15] and Tang (2020) [23].

Further studies could be made utilizing the insights presented in this analysis. The bibliometric analysis could be extended beyond the selected timeframe, capturing the change in the field's emerging themes over future time periods. Increasing the specificity of the field's studied domains may also provide a relevant perspective, an analysis performed only in domains such as energy or biomedical systems modelling plausibly uncovering hidden patterns within aggregations of data. The bibliometric analysis may also be complemented by targeted studies of specific institutions for a more accurate understanding of the reasons behind the authors' collaboration tendencies.

The discovered patterns suggest the need for the encouragement of collaborative initiatives in the systems modeling field, whose coherence and speed of growth could vastly benefit from strengthened interconnections between specialized subfields.

This study relies exclusively on data obtained from the Web of Science (WoS) database. Alternative academic databases such as Scopus, Dimensions, and IEEE Xplore provide broader coverage across certain disciplines and document types, but WoS was selected due to its strict inclusion criteria, high-quality indexing, and standardized metadata formats, which ensure reliability in bibliometric analysis. Additionally, Web of Science offers great integration with VOSviewer. To overcome this exclusivity limitation, future studies could expand the analysis by incorporating data from multiple sources, enabling a more comprehensive and broader view of the systems modeling research landscape.

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Declaration on Generative AI

The authors have not employed any Generative AI tools.

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