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Research trends of logistics system complex networks based on CiteSpace

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Abstract. With the expansion of global trade, the explosive growth of e-commerce, and the continuous improvement of logistics infrastructure, logistics systems have become increasingly large-scale and complex. Research on logistics systems based on complex network theory has provided effective approaches for addressing the complexity-related challenges faced by modern logistics operations. Drawing on core journal publications on logistics system complex networks indexed in the China National Knowledge Infrastructure (CNKI) and the Web of Science (WoS) from 2015 to 2024, this study employs the bibliometric visualization software CiteSpace to conduct a systematic visual analysis. The research examines publication trends, research institutions, countries, keyword co-occurrence, and keyword clustering to identify and compare major research hotspots in China and abroad. Based on these findings, the study summarizes the current state of research and discusses future development directions.

Keywords: logistics system, complex network, CiteSpace visualization

1. Introduction

Complex networks provide an abstract representation of complex systems, consisting of numerous nodes and the edges connecting them. In the field of logistics, the nodes and links within a logistics system can be abstracted into network models, enabling the application of complex network theory to investigate structural characteristics, dynamic behaviors, and optimization strategies. This study aims to systematically review the research status and emerging hotspots of logistics system complex networks from 2015 to 2025, thereby providing theoretical support for future research and further exploration in this field.

2. Research design

2.1. Data sources

The literature analyzed in this study was retrieved from the China National Knowledge Infrastructure (CNKI) and the Web of Science (WoS). The publication period was limited to 2015–2025, and the keywords logistics and complex network were used for the search. Ultimately, 63 Chinese-language articles were obtained from CNKI, while 115 English-language articles were retrieved from WoS.

2.2. Research methods

This study employs CiteSpace 6.3.R1 to conduct a visual bibliometric analysis of the current research status and major research hotspots in logistics system complex networks both in China and internationally. For the CNKI database, the search parameters were set as follows: the subject terms logistics and complex network; a time span from January 1, 2015, to March 26, 2025; and source categories including Peking University Core Journals, CSCD, CSSCI, WJCI, AMI, and EI-indexed publications. For the WoS database, the Web of Science Core Collection and the Social Sciences Citation Index (SSCI) were selected. The subject terms logistics and complex network were used, with the publication period restricted to 2015–2025 and the document type limited to Article. The retrieved records from both databases were subsequently imported into CiteSpace for deduplication and data processing.

3. Results and analysis

3.1. Analysis of publication trends

A publication trend analysis of the 63 Chinese-language and 115 English-language articles was conducted using CiteSpace. The results indicate that the overall volume of research on logistics system complex networks has remained relatively limited over the past decade. As shown in Figure 1, the trend lines for both CNKI and WoS exhibit a gradual upward trajectory, suggesting growing scholarly interest in logistics system complex networks. The number of publications in CNKI reached an initial peak in 2016, followed by a gradual decline and a relatively stable period before rising to another peak in 2023. In contrast, the WoS dataset shows three distinct peaks in publication output, occurring in 2020, 2022, and 2024. In terms of both publication volume and timing, WoS not only contains a larger number of publications overall but also exhibits more recent peaks in research activity, indicating sustained international attention to this field.

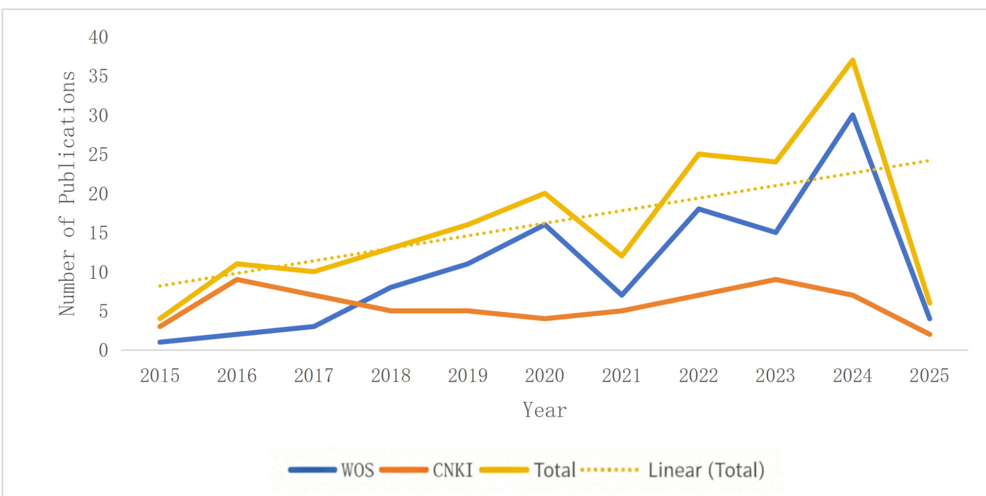

Figure 1. Annual number of publications in CNKI and WoS

3.2. Analysis of research institutions and countries

CiteSpace was employed to analyze the collaboration networks of research institutions and countries. The institutional collaboration network derived from CNKI consists of 89 nodes and 54 links, with a network density of 0.0138, indicating that 89 Chinese institutions have conducted research on logistics system complex networks to varying degrees. Among them, Southwest Jiaotong University ranks first with five publications and is the only institution with a non-zero betweenness centrality, highlighting its pivotal influence within the domestic research community. The institutional collaboration network based on WoS comprises 157 nodes and 176 links, with a density of 0.0144, indicating the participation of 157 research institutions worldwide. Shanghai Maritime University and Shanghai University each lead with six publications. However, only Shanghai Maritime University demonstrates relatively high betweenness centrality (0.02), suggesting a more active role in international academic collaboration. The country collaboration network in WoS contains 37 nodes and 57 links, with a density of 0.0856, indicating that researchers from 37 countries have contributed to this field. China ranks first with 78 publications and a betweenness centrality of 0.69, outperforming all other countries in both research output and network influence. The United States and India rank second and third, respectively, underscoring China's dominant position and its close international research collaborations.

Overall, China occupies a central position in the study of logistics system complex networks. Domestically, institutions such as Southwest Jiaotong University and Shanghai Maritime University play leading roles, although the level of inter-institutional collaboration remains relatively low. Internationally, China leads both in publication output and betweenness centrality, while institutions such as Shanghai Maritime University maintain strong visibility in both domestic and global research networks. Nevertheless, international collaboration is still concentrated among a limited number of countries, particularly China and the United States, indicating the need to further expand collaborative networks to strengthen and sustain the field's development.

3.3. Keyword co-occurrence analysis

CiteSpace was employed to conduct a keyword co-occurrence analysis. This approach identifies the relationships among high-frequency keywords and reveals the major research hotspots in a given field. Based on keyword frequency, the top five keywords were ranked in descending order, as presented in Tables 1 and 2. As shown in Table 1, the keyword co-occurrence network in CNKI indicates that complex network, logistics network, robustness, and logistics engineering occur most frequently, representing major research topics in China's logistics system complex network studies. Considering both keyword frequency and betweenness centrality, complex network, logistics network, and robustness emerge as the primary domestic research hotspots. As shown in Table 2, the WoS keyword co-occurrence network highlights complex network, model, centrality, logistics, and design as the most frequently occurring keywords. Combining frequency with betweenness centrality, complex network, model, and logistics are identified as the principal international research hotspots.

Table 1. High-frequency keywords in CNKI research on logistics system complex networks

Frequency	Centrality	Keyword
29	1.01	Complex network
7	0.1	Logistics network
7	0.08	Robustness
5	0.05	Cascading failure
4	0.00	Logistics engineering

Table 2. High-frequency keywords in WoS research on logistics system complex networks

Frequency	Centrality	Keyword
62	0.7	Complex network
17	0.31	Model
14	0.1	Centrality
11	0.23	Logistics
11	0.15	Design

3.4. Keyword cluster analysis

Keyword clustering analysis was performed using CiteSpace. By statistically grouping related keywords, keyword clustering effectively reflects the major research themes and developmental trends within a field. Cluster quality was evaluated using the Modularity Q and Mean Silhouette S indices. Modularity Q measures the degree of network modularity, while Mean Silhouette S evaluates intra-cluster homogeneity and inter-cluster heterogeneity. Clustering results are generally considered reliable when $Q > 0.3$ and S > 0.7. The clustering results for CNKI demonstrate high quality, with $Q = 0.7515$ and $S = 0.9584$. Ten major research themes were identified, including complex networks, robustness, optimization, logistics networks, global logistics, and dynamic evolution. Similarly, the WoS clustering results exhibit excellent quality, with $Q = 0.8317$ and $S = 0.9415$. Thirteen major research themes were identified, including connectivity, risk assessment, low-carbon waste management, discrete-event simulation, the Belt and Road Initiative, and supply chain design.

3.5. Analysis of research hotspots

Combining the results of keyword co-occurrence analysis, keyword clustering analysis, and publication chronology, the major research frontiers in China can be summarized as follows:

(1) Research on the robustness of complex networks is of great significance for enhancing the resilience of logistics systems. Cui et al. innovatively proposed a robustness criterion based on "network operability," which significantly improved the capability of directed weighted networks to withstand cascading failures [1]. Shen et al. enhanced the robustness of engineering logistics networks by 38% under three attack scenarios through the introduction of a congestion-effect allocation strategy [2]. Feng et al. developed a dynamic recovery strategy based on the NK model and effectively optimized network robustness by adjusting network size (N) and node relationship density (K) parameters [3].

(2) Research on complex freight networks contributes to understanding the evolutionary characteristics of logistics systems. Huang et al. analyzed intercity freight transport data in Zhejiang Province and revealed its spatiotemporal evolution patterns, providing a basis for freight network optimization [4]. Jia et al. innovatively established a "point–line–network" analytical framework based on data from 110 national logistics hubs to investigate the evolutionary mechanisms of freight networks [5]. Gao and Wei focused on the characteristics of urban freight networks in the Yangtze River Delta, providing empirical support for regional logistics planning [6].

(3) Research on complex production logistics can improve shop-floor logistics efficiency. Yin et al. established a dual-weight directed network model combined with dynamic time-window analysis, providing an optimization scheme for logistics operations in discrete manufacturing workshops [7]. Liang et al.

developed an intelligent warehouse scheduling system that significantly improved logistics efficiency in machining workshops through modular integration [8].

In addition, the major international research frontiers can be summarized as follows:

(1) Research on the vulnerability of complex networks helps enhance the risk resilience of logistics systems. Calatayud et al. modeled more than 80 liner shipping networks and simulated attacks on seven strategic nodes in the Americas. Their study explored the risks faced by international freight flows arising from the multilayered complexity of maritime transport networks and revealed the relationship between the vulnerability of international freight transport and a country's position in the global maritime network [9]. Yang et al. combined grounded theory with complex network analysis to identify seven categories of vulnerability factors in fresh produce supply chains. They found that market supply–demand imbalances and human resource issues constituted the core risks and proposed optimization strategies, including information sharing, based on network characteristics [10]. Khakifirooz et al. developed an entropy-based supply chain resilience assessment framework. By constructing a multidimensional disruption model and integrating Value at Risk (VaR) and Conditional Value at Risk (CVaR) approaches, they established a resilience optimization framework that incorporates both local node analysis and global risk propagation assessment [11].

(2) Research on complex network risk assessment provides innovative approaches for ensuring supply chain security in critical sectors. Mogale et al. investigated Fourth-Party Logistics (4PL) pharmaceutical supply chains in the United Kingdom. They developed a three-dimensional risk assessment framework for pharmaceutical supply chains and proposed three major resilience enhancement strategies [12]. Lam et al. applied network modeling techniques to construct a factor–impact association network for hydrogen logistics accidents. Their study revealed the topological characteristics of accident risks and provided data-driven support for accident prevention and risk management [13].

4. Conclusions and future prospects

4.1. Conclusions

This study selected literature on logistics system complex networks published in the China National Knowledge Infrastructure (CNKI) and the Web of Science (WoS) from 2015 to 2025 and conducted a visual bibliometric analysis using CiteSpace. The results show that: (1) In terms of publication output, the number of domestic publications has remained relatively stable but is lower than that of international publications, while international research has exhibited two significant peaks over the past five years. (2) In terms of research institutions and countries, Chinese institutions maintain close collaborative relationships and occupy a leading position in international research. (3) According to the keyword co-occurrence and clustering analyses, domestic research mainly focuses on the robustness and diversity of logistics networks, whereas international studies place greater emphasis on the vulnerability of network models and risk assessment.

4.2. Future prospects

Future research on logistics system complex networks should place greater emphasis on risk-related issues. Through interdisciplinary integration and innovation, intelligent optimization models can be developed, and cross-national collaborative mechanisms can be established to further investigate the impacts of emerging risks, such as geopolitical tensions and climate change, on multi-scale logistics networks. Such efforts will contribute to a deeper understanding of the underlying mechanisms of risk propagation and ultimately enhance the resilience and risk resistance of logistics systems.

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