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Bibliometric Analysis of Research Literature on Industrial Chain Resilience

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Keywords: Industrial Economics; industrial chain resilience; bibliometrics; research hotspots; evaluation of resilience

Abstract: Based on the Web of Science core collection database and the Chinese journal CNKI full-text database, this article uses programming software to crawl the keywords of the main literature in the field of industrial chain resilience research, focusing on domestic and foreign literature in the field of industrial chain resilience research from 2012 to 2023, analyzing the research status and hotspots in the field of domestic and foreign industrial chain resilience research, and summarizing relevant research institutions, main authors, and the number of publications, and use Gephi software for visual analysis. The research literature on industrial chain resilience both domestically and internationally is in a period of rapid growth, with an overall upward trend in the number of publications, which has sharply increased in the past three years. Before 2021, the number of publications and citations in English literature in the field of industrial chain resilience research were higher than those in Chinese literature; But in 2022, the number of Chinese literature publications surpassed that of English literature for the first time. The current regional and institutional distribution of authors in the study of industrial chain resilience is relatively scattered, and there has not yet been a centralized situation, which indirectly confirms that research in this field is still in its early stages. Finally, the future research prospects in this field will be explored with a focus on quantitative research on the evaluation of industrial chain resilience. The bibliometric analysis of the research on industrial chain resilience has certain theoretical reference value and practical guidance significance for theoretical explorers and practical promoters in this research field.

1. Introduction

Resilience refers to the ability of a system to maintain its functional and structural stability under pressure or impact [1]. The industrial chain is an industrial activity chain composed of multiple links. Each link is an independent industrial field, which is interdependent and mutually supportive. Through the close connection and efficient collaboration of all links, the production efficiency is improved and the cost is reduced, thus enhancing the competitiveness of the entire industry [2]. Literature shows that the term "industrial chain" began to appear in academic journals in the 1980s, but the research focusing on "industrial chain resilience" as a chain has only risen in the past decade at home and abroad [3]. The academic research of Chinese scholars in this field is still in its infancy

[4]. Since Chinese government in 2019 stated to enhance the resilience of the industrial chain, improve the level of the industrial chain, and form an industrial chain with stronger innovation and higher added value in open cooperation, the concept of industrial chain resilience began to appear in national policy documents. In the context of increasing global economic instability and uncertainty, as a major manufacturing country in the world, China's industrial chain resilience has attracted much attention. In the past few decades, with the sustained and rapid development of China's manufacturing industry, China's manufacturing industry chain has become increasingly important in the global context. At the same time, the resilience of China's industrial chain is facing challenges and tests from various factors, such as cyclical fluctuations in the global economy, geopolitical conflicts, and natural disasters [5].

Due to the impact of the outbreak of COVID-19 in 2020, the uncertainty of globalization and the pressure in the public health field have brought potential risks to the stability of the industrial chain and supply chain, and the industrial chain as well as supply chain at all levels have broken [6]. Taking listed companies as an example, the COVID-19 epidemic has a significant negative impact on listed companies, which is reflected in lower stock returns. The risk of supply chain disruption can directly impact the company's market value [7]. The COVID-19 epidemic has affected various industries, sectors and enterprises in China to varying degrees, and consumption, trade, employment and industrial ecology will become the main pressure points [8]. The epidemic also led to the weakening of global demand and the uncertainty of the market. In addition, the negative impact on China's import and export trade, including the year-on-year growth rate of China's import and export will decline, and foreign trade enterprises will face greater pressure [9]. Some enterprises are difficult to operate normally due to production and logistics constraints, which has led to the disruption of the global supply chain and market disturbance [10]. How to prevent major external shocks by building a "resilient economy" system has become a common concern of all circles [11].

Although there are a large number of research literature in the field of industrial chain or supply chain research, there are few literature reviews on the research of industrial chain resilience, and domestic research on this field started late. It can be seen from the statistical data that in the past ten years, domestic and foreign scholars have gradually done some research work in the field of industrial chain resilience, and published relevant papers and works. This paper uses the Web of Science core set database and China Journal Full Text Database (CNKI) as the data source to retrieve relevant papers and literature on industrial chain resilience at home and abroad from 2012 to 2023, analyzing the number of papers, authors, institutions, highly cited papers and other measurement objects, and systematically summarize the research situation in the field of industrial chain resilience. It is expected to provide some reference for researchers to understand the development process and degree of industrial chain resilience at home and abroad, as well as the future research direction.

Data statistics show that up to now, there are many studies on "industrial chain", "supply chain" and "resilience", but there are relatively few studies on the combination of industrial chain or supply chain and resilience as well as the evaluation of this resilience index system. This paper searches the subject, abstract and key words of the literature from SCI Expanded and CNKI. The Chinese and English literature searches around the subject words such as "industry chain resilience", "supply chain resilience", "industry chain resilience evaluation index" and their variants or synonyms. The relevant literature since 2012 has been collected and sorted out. The retrieval literature type is all literature types about the resilience of the industrial chain, and the retrieval time is April 2023. Finally, 4225 English papers were collected in the Web of Science core collection database, and 2296 papers were collected in the Chinese journal full-text database.

2. Overview of research on industrial chain resilience

The publishing trends of papers in the field of industrial chain resilience research in the past decade are shown in Figure 1.

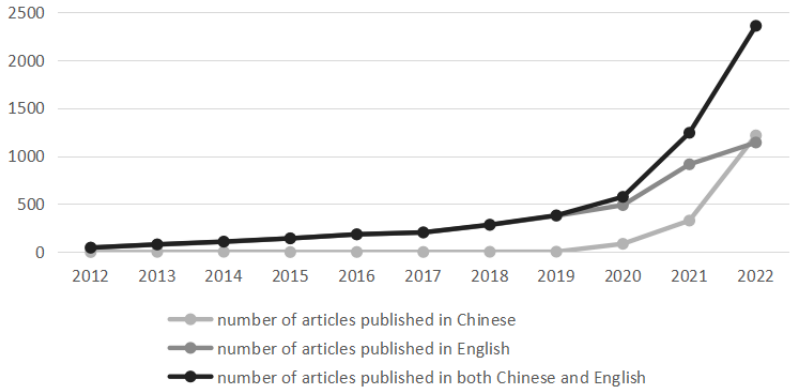

Figure 1: In the field of industrial chain resilience, the publication of papers in the past 10 years

The overall trend of the total number of documents issued in the past decade is similar in Chinese and English (up to 2022). Before 2019, there were few Chinese documents. Although the number of English documents is not large, they have certain advantages over Chinese documents. In general, both Chinese and English documents have not awakened in this field. After 2020, due to the impact of the global epidemic, the research on industrial chain resilience in both Chinese and English literature has increased rapidly. The number of Chinese literature has risen from 86 in 2020 to 328 in 2021, with an increase rate of about 280%; It increased from 328 in 2021 to 1215 in 2022, with an increase rate of about 220%. It is worth mentioning that in 2022, the number of Chinese papers will surpass the number of English papers for the first time in the past decade. The increase in the number of papers can be seen from the great change in domestic cognition of this aspect. In terms of the overall trend, the number of Chinese and English articles is still rising rapidly, coming to the hot spot in this research field.

3. Analysis of research subjects of industrial chain resilience

3.1 Main publishing institutions

The top 10 institutions in terms of the number of published Chinese literature related to industrial chain resilience and their issuance are shown in Figure 2.

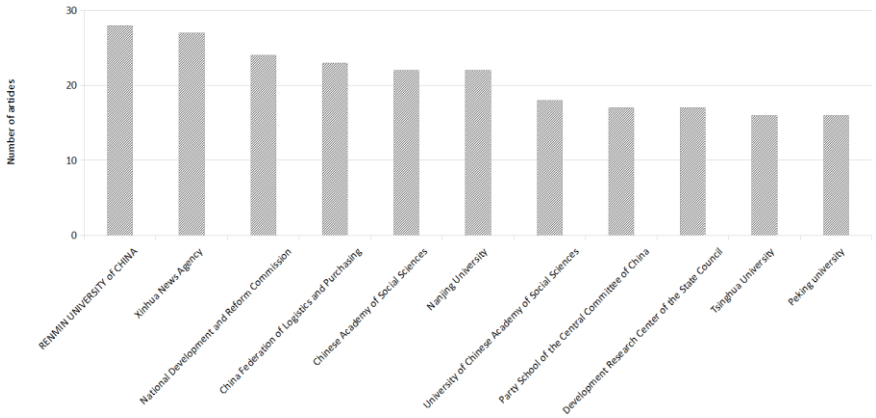

Figure 2: Top 10 institutions in the Chinese literature of industrial chain resilience research

Five well-known universities at home and abroad: Renmin University of China, Nanjing University, University of the Chinese Academy of Social Sciences, Tsinghua University, Peking University are among them. The number of documents issued by the top 10 institutions is very close, and the total number of documents issued accounts for a small proportion of the overall number, accounting for only 10% of the total number of Chinese documents issued within the statistical range. Among them, Renmin University of China has the largest number of articles with 28, without obvious institutional advantages. This shows that the research in this field is still in its infancy, the number of papers issued by different research institutions is relatively average, and the total number of papers issued is at a low level, which still does not usher in a period of centralized issuance.

The eleven (including parallel) research institutions with the highest number of published English literature on industrial chain resilience and their number of papers are shown in Figure 3.

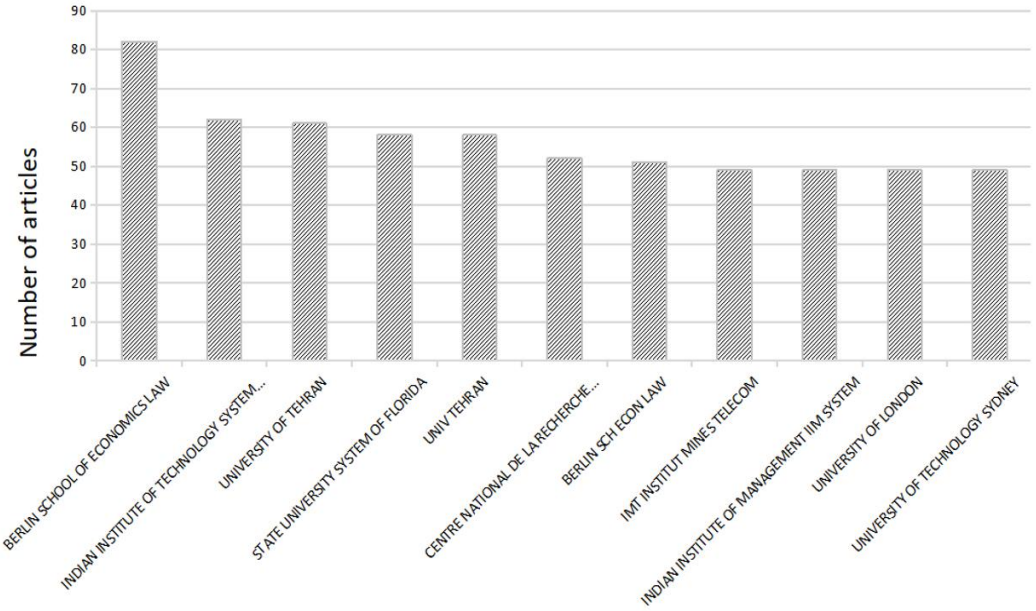

Figure 3: Top 10 institutions in the English literature of industrial chain resilience research

Among the top ten institutions in terms of the number of English documents published, there are 8 universities and 3 research institutes including the National Science Research Center. Similar to the Chinese literature, the English literature also has no prominent research institutions. The Berlin School of Economic Law, which has the highest number of publications, has only published 82 articles, which does not have a big gap with institutions ranking lower. It also means that this field has not been highlighted and research institutions have not focused on this field at the current stage. It will still take some time for institutions with outstanding number of papers to emerge in this field.

3.2 Main researchers

The data source has collected and collated high-yield authors related to Chinese literature on the study of industrial chain resilience. However, as shown in Table 1, as the research in this field is in the initial growth stage, the number of papers issued by researchers is not large. The 10 authors are from 10 different institutions, and there are no relatively authoritative researchers in this field. He Liming from China Federation of Logistics and Purchasing ranks first with 14 articles. Compared with other mature research fields, the number of high-yield authors in the industry chain resilience research field is less, which confirms that the theoretical research in this field is still in its infancy.

Table 1: Top 10 authors in terms of the number of publications in the Chinese of industrial chain resilience

Ranking	Author	Author Affiliation	Number of papers
1	He Liming	China Federation of Logistics and Purchasing	14
2	Ren Baoping	Northwestern University	10
3	Liu Kun	Ministry of Finance of China	9
4	Hao Peng	State owned Assets Supervision and Administration Commission of the State Council	8
5	Cheng Qingqing	Haimen Municipal Party School of the CPC Jiangsu Province	7
6	Sun Ruizhe	China Textile Industry Federation	6
7	Anbei	Xinhua News Agency	6
8	Xiao Yaqing	Ministry of Industry and Information Technology of China	6
9	Jiang Changyun	Industrial Economy and Technology Research Institute of National Development and Reform Commission	5
10	Shen Guobing	Fudan University	5

4. Research hotspots and highly cited papers on industrial chain resilience

4.1 Research hotspot of Chinese and English literature

In the statistical scope, more than 2000 Chinese literatures were captured through software programming, and nearly 10000 keywords were collected. According to the frequency statistics of all keywords, the top 20 keywords are "high-quality development", "Chinese style modernization", "new development pattern", "industrial chain", "supply chain", "digital economy", "resilience", "supply chain resilience", "manufacturing industry", "digital transformation", "industrial chain supply chain", "industrial chain resilience", "Small and medium-sized enterprises", "double circulation", "specialization and innovation", "common prosperity", "rural revitalization", "COVID-19 epidemic", "global value chain", "COVID-19 epidemic". The author used Gephi software to integrate these keywords and their related words, and obtained the map of related words as shown in Figure 4.

In the research field of industrial chain resilience, the key words "high-quality development" and "Chinese style modernization" appear frequently, which is the focus of scholars' research. In addition, keywords such as industrial chain and supply chain also have high relevance and frequency in the relevance map. At the same time, the distribution of connectives is detailed and scattered, which indicates that the research attention of scholars on industrial chain resilience has not been relatively focused or the consensus is not obvious. According to the analysis of the English literature on industrial chain resilience within the statistical scope, the subject areas closely related to Engineering, Agriculture, Computer science and other topics are relatively more output, as shown in Figure 5.

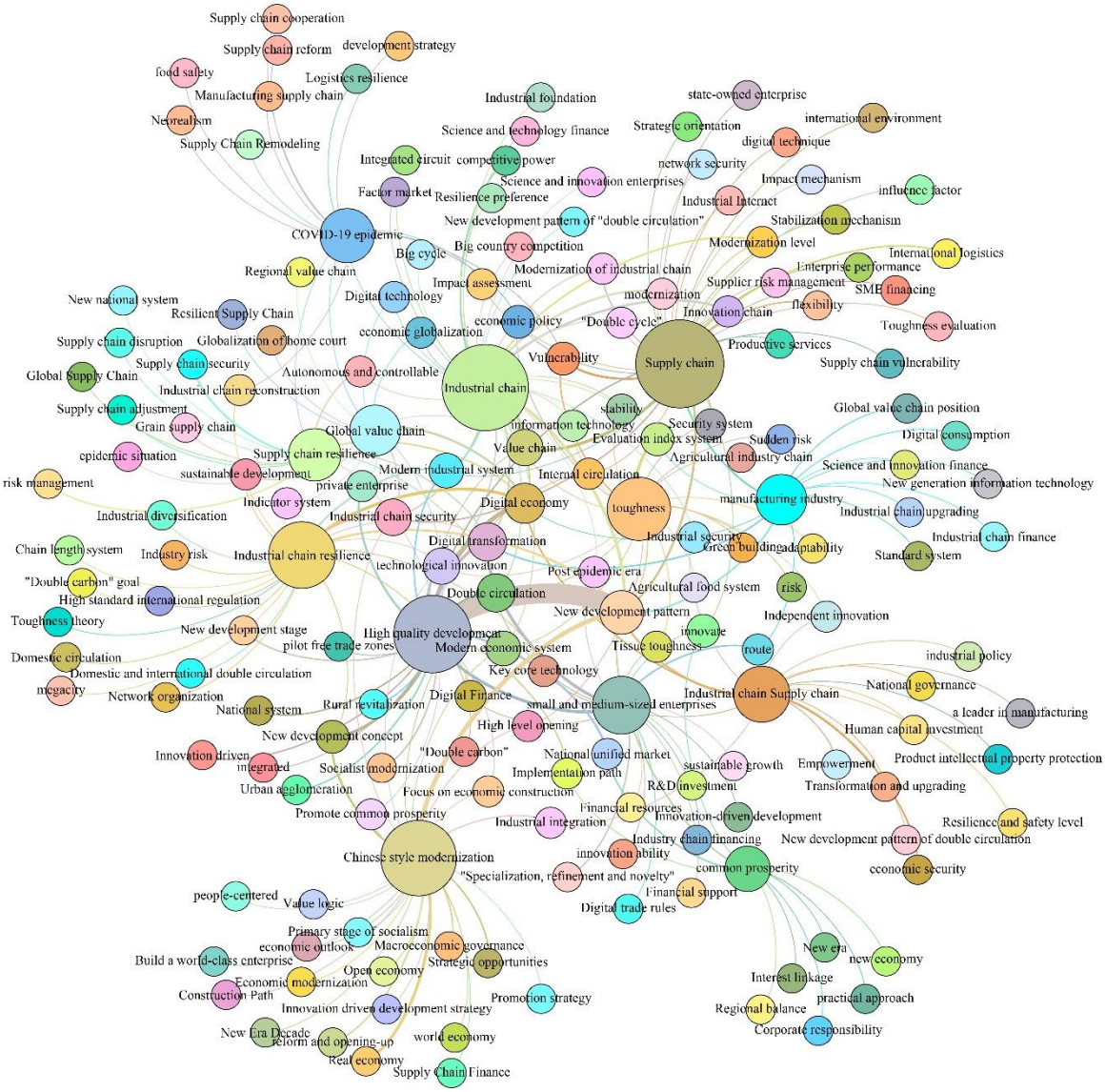

Figure 4: Hot keywords in industrial chain resilience research: based on Chinese literature

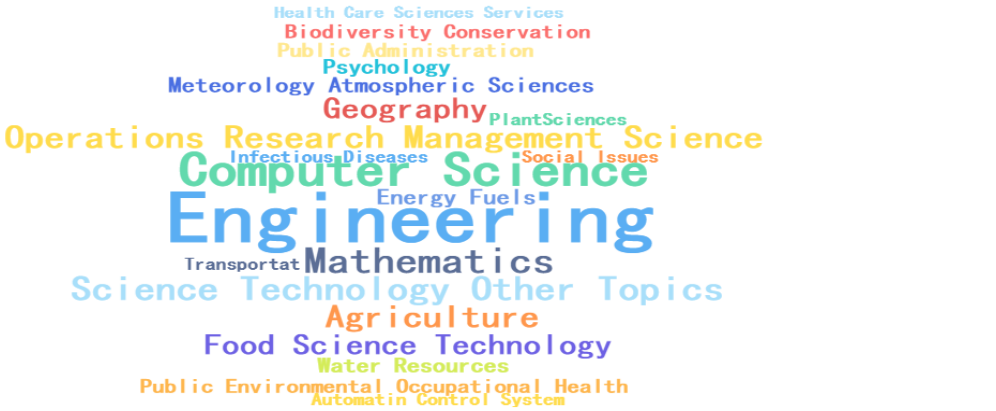

Figure 5: Hot topics in industrial chain resilience research: based on English literature

4.2 Chinese and English highly cited papers

The Chinese literature in the field of industrial chain resilience research ranked among the top ten in terms of citation frequency, as shown in Table 2.

Table 2: Top 10 cited Chinese literature for industrial chain resilience

Ranking	Article Name	Author & Year	Cited frequency
1	Impact of COVID-19, economic resilience and high-quality development in China	Wang&Gao, 2020 [12]	118
2	Research on the Path to Improve the Modernization Level of Industrial Chain Supply Chain	Zhang et al., 2021 [13]	115
3	The Concept and Analysis Framework of Urban Network Resilience	Wei&Xiu, 2020 [14]	70
4	High quality development trend of small and medium-sized enterprises and path selection	Dong&Li, 2021 [15]	54
5	Accelerate the construction of new development pattern and the transformation and upgrading path of manufacturing industry	Guo&Tian, 2021 [16]	50
6	Automobile enterprises' supply chain resilience under the new coronal epidemic Influencing factors and evaluation	Fan&Lu, 2020 [17]	42
7	Formation mechanism of organizational resilience of enterprises in the context of counter globalization ----Huawei Case Study	Song et al, 2021 [18]	39
8	Promoting the modernization level of industrial chain supply chain Research on the path of integration	Wang, 2021 [19]	35
9	The Theoretical Logic, Historical Logic and Practical Logic of China's Food Security Strategy	Han, 2022 [20]	34
10	The Connotation Discrimination and Index System Construction of Regional Economic Resilience	Zeng, 2020 [21]	33

The English literature in the field of industrial chain resilience research ranked among the top ten in terms of citation frequency, as shown in Table 3.

The highest cited article in English literature is Hosseini's “A review of definitions and measures of system resiliency”, with 833 citations; The lowest citation is Heckmann's “A critical review on supply chain risk - Definition, measure and modeling”, with a frequency of 486, which is close to the number of references in semi mature fields. The most frequently cited article in Chinese literature is Mr. Wang Yonggui's "Impact of COVID-19, Economic Resilience and China's High Quality Development", which was cited only 118 times; Zeng Bing's Analysis of the Connotation of Regional Economic Resilience and Construction of the Index System ranked 10th, with only 33 citations. There is a huge gap between Chinese literature and English literature in terms of the number of citations, which indicates that China started late in the field of industrial chain resilience research compared with foreign countries, and high-quality literature was also produced late. With the improvement of the academic level of Chinese and the acceleration of the trend of internationalization, as well as the increase of domestic attention to the field of industrial chain resilience, it is believed that more and more domestic researchers will have an important impact in the international academic community.

Table 3: Top 10 English literature cited in industrial chain resilience

Ranking	Article Name	Author & Year	Cited frequency
1	A review of definitions and measures of system resilience	Hosseini et al, 2016 [22]	833
2	A comparative literature analysis of definitions for green and sustainable supply chain management	Ahi & Searcy, 2013 [23]	723
3	Predicting the impacts of epidemic outbreaks on global supply chains: A simulation-based analysis on the coronavirus outbreak case	Ivanov, 2020 [24]	653
4	Viability of intertwined supply networks: extending the supply chain resilience angles towards survivability. A position paper motivated by COVID-19 outbreak	Ivanov&Dolgui, 2020 [25]	629
5	The impact of digital technology and industry 4.0 on the ripple effect and supply chain risk analytics	Dmitry et al., 2018 [26]	591
6	Food supply chains during the COVID-19 pandemic	Hobbs, 2020 [27]	534
7	Risk assessment and risk management: Review of recent advances on their foundation	Aven, 2016 [28]	519
8	A Contingent Resource-based Perspective of Supply Chain Resilience and Robustness	Brandon- -Jones et al, 2014 [29]	493
9	Resilience in Business and Management Research: A Review of influential Publications and a Research Agenda	Linnenluecke, 2017 [30]	491
10	A critical review on supply chain risk - Definition, measure and modeling	Heckmann et al, 2015 [31]	486

5. Policy text of industrial chain resilience in China

In recent years, governments at all levels, from the central government to the local government, have attached great importance to the creation of business environment related to the resilience and stability of the industrial chain. Relevant policies and news are constantly emerging. Some typical policies or relevant notices are shown in Table 4 below.

Due to the limitations of the scope of data collection, the policy texts listed in Table 4 are only examples. There are not a few relevant policy documents actually issued by local governments at all levels, most of which are implementation work plans, methods or notices under the central guiding policies. The "Letter of Congratulation to the 2022 International Forum on the Resilience and Stability of the Industrial Chain Supply Chain" listed in Table 4 is highly known and has been cited for many times, playing a leading role in the research field of industrial chain supply chain resilience in recent years.

Table 4: Examples of China's policy texts in terms of industrial chain resilience

S/N	Title Content	Source	Year of release
1	A congratulatory letter to the International Forum on the Resilience and Stability of Industrial Chain Supply Chain	Xinhua Daily Telegraph	2022
2	Notice of the General Office of Shaanxi Provincial People's Government on Printing and Distributing Several Policies and Measures to Improve the Development Level of Key Industrial Chains in the Province	General Office of Shaanxi Provincial People's Government	2021
3	Notice of Chaoyang Municipal People's Government Office on Printing and Distributing Specific Measures of Chaoyang City to Ensure the Stability of Industrial Chain Supply Chain	Liaoning Chaoyang Municipal People's Government Office	2020
4	Eight departments jointly issued the Opinions on Standardizing the Development of Supply Chain Finance to Support the Stable Circulation, Optimization and Upgrading of Supply Chain Industry Chain	People's Bank of China; Ministry of Industry and Information Technology; Ministry of Justice; Ministry of Commerce; SASAC; General Administration of Market Supervision; CBRC; Foreign Exchange Bureau	2020
5	Notice on Holding the Special Activity of "Ensuring the Stability of Production and Demand in the Industrial Chain Supply Chain in 2020 - Digital Service"	Anhui Wuhu Economic and Information Bureau	2020
6	Notice of Jiangmen Municipal Bureau of Industry and Information Technology on Printing and Distributing the Work Plan on Ensuring the Stability of the Industrial Chain Supply Chain	Guangdong Jiangmen Industry and Information Bureau	2020

6. Research prospect: quantitative evaluation of industrial chain resilience

The strength of industrial chain resilience will become an important indicator to examine the stability of the industrial chain. At present, the discussion on industrial chain resilience is mostly carried out at the qualitative level, while quantitative research is relatively rare. Quantifying industry chain resilience is one of the important methods to measure the reliability and flexibility of industry chain. Resilience evaluation index can help enterprises better understand risks and opportunities when formulating strategies, and can help enterprises better maintain business continuity when responding to crises. In order to quantify the resilience of the industrial chain, quantitative indicators can be determined from multiple dimensions. Industry related diversity can enhance regional economic resistance, resilience, integration and creativity through risk dispersion, knowledge spillover, new growth path cultivation, etc. Few studies reveal its transmission mechanism [32]. Quantifying the resilience of the industrial chain needs to be considered from many aspects, such as the reliability, flexibility, sustainability and synergy and cooperation capabilities of the industrial chain. Evaluating these indicators can help enterprises understand the

overall resilience of the industrial chain and provide support when formulating supply chain strategies and responding to crises.

Whether the industrial development can effectively respond to the impact of internal and external factors, the resilience of the industry must rely on an objective evaluation index system to scientifically reflect the dynamic relationship [33]. An important research direction in the future of the research field of industrial chain resilience should be the construction of the index system for the evaluation of industrial chain resilience. The evaluation indicators should be quantifiable, measurable, comparable and representative. According to the importance of the concept of resilience and the actual needs, appropriate weights are allocated to each sub indicator of the indicator system. Through fuzzy comprehensive evaluation, analytic hierarchy process and other methods to give a comprehensive evaluation. The quantitative evaluation results of industrial chain resilience based on external interference, risk impact and other factors can be used to structurally analyze the resilience of the industrial chain under the interference of internal and external factors.

7. Conclusions

This paper makes a bibliometric analysis of the research literature on the resilience of the industrial chain, summarizes the previous studies in this field, summarizes and analyzes the number of Chinese and English literature issues, issuing agencies, authors, highly cited papers, etc. What's more, it draws the conclusion that the research in this field is in the initial stage of development. At present, the main characteristics of this research field are that there are relatively few studies, and the issuing agencies and authors are not concentrated. There is no leading authority and there are still great limitations in this study. Future related research can be in-depth analyzed in terms of research methods, theoretical background and innovative findings of each work. The future entry points of the research on industrial chain resilience include but are not limited to the following aspects: Firstly, establish the relationship between the two chains that are inseparable from each other, and jointly study the impact of their resilience; Secondly, quantify the resilience of the industrial chain, establish a model, digitize the indicators of resilience, quantitatively analyze the strength of the industrial chain resilience, and expect to establish a model system to preliminarily judge the anti-interference ability of an industry when risks come; Thirdly, systematic, modular and structured research on the influencing factors of industrial chain resilience of different industries.

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