The Characteristics of China 's Regional Industrial Chain Resilience

Yanrong Jiang

School of Entrepreneurship, Wuhan University of Technology, Wuhan, China

15281067@bjtu.edu.cn

Abstract. This paper introduces the definition and classification of regional industrial chain resilience. Based on the supply chain data of listed companies, an inter-regional manufacturing industry chain network is constructed. The PageRank algorithm model is used to measure the resilience of the manufacturing industry chain, and cluster analysis is carried out from the value and the variation characteristics of the time series. The research shows that the number of regions above the high resilience level in the horizontal direction is small, and the resilience of the manufacturing industry chain in each region in different classification regions fluctuates around a specific level.

Keywords: regional industrial chain; manufacturing; industrial chain resilience.

1 Introduction

Resilience is defined as the ability of a system or individual to recover from an external shock or disturbance[1]. In the field of industrial economics, in addition to the study of industrial resilience and industrial cluster resilience, there are also studies from the perspective of industrial chain supply chain resilience[2-4]. In other academic research, the concept of supply chain resilience is more used[5]. Some studies suggest that the current world is changing and there are many unpredictable events. When these events occur, the supply chain has the risk of efficiency reduction or even interruption[6].As a stakeholder, enterprises should consider dealing with potential risks or uncertain events within their capabilities, and reduce or avoid the losses caused by extreme events through the management of supply chain resilience[7,8]. Based on the previous literature, the research on the resilience of the industrial chain has attracted widespread attention from the academic community. And the stability of the industrial chain and supply chain of manufacturing industry plays an important role in the development of the national economy. Therefore, it is of great significance for us to study the resilience of manufacturing regional industrial chain. However, there are few studies on the measurement of regional industrial chain resilience.

Z. Zhan et al. (eds.), *Proceedings of the 2024 10th International Conference on Humanities and Social Science Research (ICHSSR 2024)*, Advances in Social Science, Education and Humanities Research 858,
https://doi.org/10.2991/978-2-38476-277-4_11

2 The Regional Industrial Chain Resilience

2.1 The Definition of Regional Industrial Chain Resilience

At present, the academic research on supply chain resilience and industrial chain resilience are all involved. Among them, each research has a relatively consistent understanding of resilience, such as: the ability to resist, adapt, recover and rebound in the face of external shocks, etc.

From the perspective of the formation mechanism of the industrial chain, the industrial chain is a chain formed by the organic combination of the four dimensions of supply and demand chain, enterprise chain, spatial chain and value chain[9]. Among them, the enterprise chain is the core. Huang et al. believe that the industrial chain and supply chain is a kind of relationship and spatial-temporal distribution formed by upstream and downstream enterprises or entities in the process of association, division of labor, and coordination[10]. Song et al. pointed out that the industrial chain and supply chain, as an ecosystem of industrial supply and demand network, realizes the unity of value creation, process coordination and space-time layout[11]. Zhang et al. decomposes the network system of the industrial chain supply chain into two types of components: elements and structures[12]. The main elements as nodes are not limited to the transaction logic. They can be enterprises that are market players, or a country and region. The definition of structures breaks the relationship between industrial links or systems, reflecting the spatial layout of the spatial attributes of the participants in the industrial chain supply chain in reality. The above research provides a theoretical basis for the unity of industrial chain resilience and supply chain resilience.

The COVID-19 epidemic, changes in international trade rules, and a new round of industrial revolution have promoted the reconstruction of the industrial chain, further changed the characteristics of industrial division of labor and agglomeration, and accelerated the development trend of localization, diversification and regionalization of the industrial chain[13]. Therefore, we define the two components of the industrial chain network, the regional industrial chain as the main body, and the relationship between the spatial attributes of the participants as the structure of the network link. Importantly, the resilience of regional industrial chain is defined as the ability of regional industrial chain to be embedded in industrial chain network in the face of internal and external disturbances and shocks. When the industrial chain is impacted by internal and external shocks, the region with strong resilience can continue to penetrate the important links such as raw material supply, processing and manufacturing, production and sales, logistics and transportation of enterprises in the enterprise chain within the region. When some important links or enterprises in the chain are seriously disturbed by shocks, they can quickly respond in a complex and changeable environment to find solutions to minimize or even eliminate the losses caused by shocks, and even seize opportunities in the crisis to promote the innovation and upgrading of the industrial chain and enhance the embedding of the regional industrial chain in the network system.

2.2 Classification of Regional Industrial Chain Resilience

First of all, the nodes of the network system of the industrial chain can be both the country and the region. The resilience of the industrial chain is determined by the ability of the main elements to be embedded in the network system. The industrial chain of the country 's internal region is directly embedded in the internal network, and then embedded in the broader global value network. The more the regional industrial chain can be embedded in the larger value network, the stronger the industrial chain resilience.

Secondly, structures can reflect the spatial layout relationship of subject attributes. In the face of external shocks, enterprises can respond flexibly and efficiently according to changes in market information. The more the enterprise chain has stronger resistance and adjustment adaptability[14]. The agglomeration of upstream and downstream enterprises within the region that have stable relationships and master core technologies and control key resources within the region makes the regional industrial chain have stronger self-control ability and market competitiveness[15], making the entire industrial chain have stronger network embedding ability.

Finally, the types of shocks pose different degrees of threat to the regional industrial chain. First, the impact of global public health events such as the COVID-19 epidemic far exceeds the resistance of regional industrial chains. So huge restrictions and destructions suffered by the main elements and structures in the industrial chain and supply chain network system that the enterprise chains and enterprises in any country and region cannot bear it alone. The ability of enterprise risk management plans is limited and can only rely on the regulation and control of the government and the state. Secondly, when the impact is limited to the industry in the region, the corresponding industrial chain will face the serious threats. Therefore, it is very important to realize the independent and controllable industrial chain and have a complete, diversified and local independent industrial chain. Thirdly, when the impact of shock disturbance only involves micro-enterprises, the resilient supply chain of the industrial chain depends on the substitutability at both ends of procurement and sales. Enterprises can have a good correlation effect with the upstream and downstream enterprises of the enterprise chain through supply chain management from the matching of supply and demand, maintenance and improvement of supply quality, so as to enhance the resilience of the whole industrial chain.

3 Industrial Chain Division and Industrial Chain Network

The existing research results show that the industrial chain has a complex network division of labor and shows a significant network correlation. Especially in the multi-stage production model of the open economy, the problem of enterprises participating in the global division of labor is more complex. The research of Baldwin and Venables shows that there are both snake-like and spider-like division of labor paths in the complex industrial chain division of labor network[16], as Fig.1 shows.

Referring to Li et al.[17]and Antràs et al.[18], a set of industrial chain division paths including J production stages is defined:

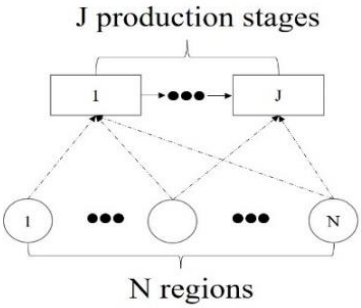

Fig. 1. Industrial chain division network

$$l_k = \{l_k(1), l_k(2), \ldots, l_k(J)\} \tag{1}$$

Where l_k set represents the division of labor path of a specific industrial chain k, because the final product will experience a series of specialized production before being consumed, and there are J elements in the set $l_k(j)$ denotes that the enterprises in the region $n \in \{1,2, \ldots, N\}$ bear the j stage of the division of labor in the industrial chain, and also indicates that the regional $l_k(j)$ is embedded in the division of labor in the j stage. Therefore, $l_k(j)$ has the dual attributes of enterprises and regions in the division of labor in the industrial chain. In the process of the j-stage division of labor in the directed industrial chain network, because the flow of intermediate products of $l_{k_0}(j)$ are not unique, they may flow to $l_K(j+1)$, $K \in \{k_1, k_2, \ldots, k_n\}$,at the same time, so there is a complex relationship in the industrial chain network. Based on this, define this multiple reference relation by mathematical formula, which is expressed as:

$$l_{k_0}(j) \ltimes \{l_{k_1}(j+1), l_{k_2}(j+1), \ldots, l_{k_n}(j+1)\} \tag{2}$$

Where $\ltimes$ is a directed multi-reference relation, which is used to represent the reference relation of the node set of the next production stage pointed by a single node in the directed industrial chain network. Similarly, the multi-referential relationship of industrial chain network can be defined. When the production is in stage j, if the intermediate products of $l_K(j-1)$, $K \in \{k_1, k_2, \ldots, k_n\}$ flow to $l_{k_0}(j)$ at the same time, the multiple referent relationship can be expressed as follows:

$$l_{k_0}(j) \rtimes \{l_{k_1}(j-1), l_{k_2}(j-1), \ldots, l_{k_n}(j-1)\} \tag{3}$$

Where $\rtimes$ is a directed multi-referential relation, which is used to represent the referent relation that a single node in the directed industrial chain network is directed by a set of multiple nodes in the previous production stage. In the real industrial chain network, the enterprises in the region n and the region n have multiple references and referred relations in the j stage, and it is difficult to use mathematical formulas to calculate the embedding probability of enterprises or regions in the industrial chain network.

4 Data Source and Processing

China has become the world 's largest manufacturing country for many years. Based on the availability of data, the supply chain data of CSMAR listed companies in China from 2010 to 2021 are used. The industrial chain network should contain representative main elements and structures, reflecting the relationship between upstream and downstream enterprises, etc. Combined with previous research and the characteristics of listed companies, the selection of listed companies as the research object can meet the requirements of the main elements. In addition, the customers and suppliers of listed companies are not all listed companies, there are also many unlisted small and medium-sized enterprises, so it can reflect the structural elements of the real industrial chain network.

In terms of data processing, the basic information table of the company in the supply chain database are used to match, and the key information such as the industry code and the provinces and cities of the enterprise nodes in the network are completed. At the same time, the links with missing key information are eliminated. The process is divided into three steps: Firstly, construct the manufacturing enterprise chain network from 2010 to 2021 respectively. Secondly, constructing inter-regional industrial chain network based on manufacturing enterprise chain network; Thirdly, the PR algorithm is used to calculate the resilience of regional manufacturing industry chain, and the PR value represents the resilience of the industrial chain.

5 Results and Discussion

The basic characteristics of the network show that: Firstly, the enterprise chain network can fully reflect the structural elements of the real enterprise chain network. Secondly, in the manufacturing enterprise chain network, the number of non-manufacturing enterprises accounts for a large proportion, showing that non-manufacturing enterprises have good service and support for the manufacturing industry. At the same time, the integration degree of the manufacturing industry in the process of integration with other industries is increasing, and the industrial ecology becomes more diverse. Thirdly, the number of listed non-manufacturing enterprises remains at a low level, indicating that the chain owner enterprise in the non-manufacturing industry have not been well integrated with the manufacturing enterprises. Finally, the manufacturing industry chain within the region has a relatively complete structure, and most of the enterprises are mainly localized. The upstream and downstream enterprises in the same region undertake multiple continuous stages in production.

Table 1. The average PR value and ranking of China 's regional manufacturing industry chain

Province	PR	Rank	Region	Province	PR	Rank	Region	Province	PR	Rank	Region
Guangdong	5.012	1	Eastern	Liaoning	1.677	12	Northeast	Jiangxi	0.915	23	Central
Beijing	3.900	2	Eastern	Anhui	1.551	13	Central	Yunnan	0.897	24	Western

Jiangsu	3.859	3	Eastern	Xinjiang	1.312	14	Western	Guangxi	0.891	25	Western
Shandong	3.492	4	Eastern	Fujian	1.273	15	Eastern	Neimenggu	0.864	26	Western
Zhejiang	3.315	5	Eastern	Shanxi	1.198	16	Central	Guizhou	0.652	27	Western
Shanghai	2.961	6	Eastern	Ningxia	1.109	17	Western	Hainan	0.601	28	Eastern
Sichuan	2.004	7	Western	Shaanxi	1.008	18	Western	Gansu	0.580	29	Western
Hunan	1.924	8	Central	Tianjin	0.998	19	Eastern	Xizang	0.519	30	Western
Hubei	1.844	9	Central	Chongqing	0.988	20	Western	Qinghai	0.301	31	Western
Henan	1.837	10	Central	Jilin	0.981	21	Northeast				
Hebei	1.717	11	Eastern	Hei-longjiang	0.918	22	Northeast				

The panel data of 31 regional industrial chain resilience in 12 periods are calculated. The average value and ranking of each regional group are shown in Table 1. It can be seen that: There is a big difference in the resilience of manufacturing industry chain among different regions in China, and the overall standard deviation is 1.151. Among them, Guangdong has the highest PR value of 5.012 from 2010 to 2021, which is 16.65 times that of the last Qinghai; According to the regional distribution, the average PR values of the eastern region, the central region, the northeast region, and the western region were 2.713,1.545,1.192, and 0.927, respectively, with obvious regional differences. The standard deviation of the group was 1.397, 0.373, 0.344, and 0.419; The manufacturing industry chain resilience of Hainan Province in the eastern region is only 0.601, ranking 28, which is far lower than the average level of the eastern region. The PR value of Liaoning in Northeast China is much higher than that of Jilin and Heilongjiang; in the western region, Sichuan has the strongest resilience in the manufacturing industry chain, followed by Xinjiang; Hunan, Hubei and Henan are leading the manufacturing industry chain resilience of the six provinces in the central region.

Hierarchical clustering was performed on the data in Table 1, and all regions were divided into 4 categories, including 5 in category 1, 1 in category 2, 18 in category 3, and 7 in category 4., which are defined as ultra-high resilience, high resilience, medium resilience and low resilience regions, respectively. Among them, Guangdong has a resilience value of 5.012 because its manufacturing industry chain resilience is much higher than that of other regions belonging to the ultra-high resilience region; Beijing, Jiangsu, Shanghai, Zhejiang and Shandong are high resilience areas, with a mean value of 3.506 and a standard deviation of 0.350. Hebei, Liaoning, Anhui, Henan, Hubei, Hunan and Sichuan were medium resilience with a mean of 1.793 and a standard deviation of 0.144. The remaining 19 provinces and cities are low resilience areas, with a mean value of 0.889 and a standard deviation of 0.262.

6 Conclusions

There are significant differences in the performance of different regions in China. The research conclusions show that: The manufacturing industry chain of each province has

obvious aggregation characteristics; The service and support ability of non-manufacturing enterprises to manufacturing enterprises is increasing, and the degree of integration is increasing. However, the leading enterprises and chain enterprises of non-manufacturing and manufacturing enterprise chains have not been deeply integrated. Thirdly, there is a large gap in the resilience of the manufacturing industry chain between regions. The number of provinces and cities with medium and high resilience is small and mainly in the eastern part of the central region.

References

1. Rose A. Economic resilience to natural and man-made disasters: Multidisciplinary origins and contextual dimensions[J]. Environmental Hazards, 2007, 7(4): 383-398.
2. Zheng Tao, Yang Ruxue. Technological innovation, industrial upgrading and industrial resilience of high-tech manufacturing [J]. Techno-economy, 2022,41(02): 1-14.
3. Luo Liping Research on the improvement of industrial cluster resilience from the perspective of collaborative governance [J]. Seeking, 2018(06): 43-50.
4. Tao Feng, Wang Xinran, Xu Yang, Zhu Pan. Digital transformation, industrial chain supply chain resilience and enterprise productivity [J]. China 's industrial economy, 2023(05): 118-136.
5. Li Xiaohua. The supporting foundation of industrial chain resilience: from the perspective of industrial embeddedness [J]. Gansu Social Sciences, 2022(06): 180-189.
6. Bogataj D, Bogataj M. Measuring the supply chain risk and vulnerability in frequency space[J]. International Journal of Production Economics, 2007, 108(1-2): 291-301.
7. Ponomarov S Y, Holcomb M C. Understanding the concept of supply chain resilience[J]. The international journal of logistics management, 2009, 20(1): 124-143.
8. Soni U, Jain V, Kumar S. Measuring supply chain resilience using a deterministic modeling approach[J]. Computers & Industrial Engineering, 2014, 74: 11-25.
9. Wu Jinming, Shao Chang. Research on the formation mechanism of industrial chain - ' 4 + 4 + 4 ' model [J]. China 's industrial economy, 2006(04): 36-43.
10. Huang Qunhui, Ni Hongfu. Research on the improvement of industrial basic ability and industrial chain level based on value chain theory [J]. Economic system reform, 2020(05): 11-21.
11. Song Hua, Yang Yudong. Analysis on the connotation and development path of China 's industrial chain supply chain modernization [J]. Journal of Renmin University of China, 2022, 36(01): 120-134.
12. Zhang Qizai, Research Group, Institute of Industrial Economics, Chinese Academy of Social Sciences. Research on the path to improve the modernization level of industrial chain supply chain [J].China 's industrial economy, 2021(02) : 80-97.
13. Li Tianjian, Zhao Xuejun. New China 's exploration of ensuring the safety of industrial chain supply chain [J]. Managing the world, 2022,38(09): 31-41.
14. Hosseini S, Morshedlou N, Ivanov D, et al. Resilient supplier selection and optimal order allocation under disruption risks[J]. International Journal of Production Economics, 2019, 213: 124-137.
15. Chu Y, Tian X, Wang W. Corporate innovation along the supply chain[J]. Management Science, 2019, 65(6): 2445-2466.
16. Baldwin R, Venables A J. Spiders and snakes: Offshoring and agglomeration in the global economy[J]. Journal of International Economics, 2013, 90(2): 245-254.

17. Li Meng, He Yu, Pan Jiahua. Double carbon target, carbon tax policy and resilience of China 's manufacturing industry chain [J]. China 's population, resources and environment, 2022,32 (09): 22-34.
18. Antràs P, De Gortari A. On the geography of global value chains[J]. Econometrica, 2020, 88(4): 1553-1598.