

Progress in Industry Chain Resilience Research

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Abstract: In order to cope with economic globalization and informatization and the increasing risks of global economy, the resilience of industrial chain has become a hot topic. This paper summarizes the existing industrial chain, toughness and relevant domestic and foreign literature on industrial chain toughness, analyzes the connotation and characteristics of industrial chain toughness, summarizes the measurement method of industrial chain toughness, and refines the path to improve industrial chain toughness. Therefore, the paper analyzes the problems existing in the study of industry chain toughness and provides some references for future research.

1. Introduction

The current global economic situation is grim, and the industrial chain has become an important engine to promote economic transformation and upgrading. Scholars at home and abroad have begun to pay attention to the study of industrial chain resilience. To ensure the driving role of the industrial chain, it is necessary to enhance and enhance the toughness of the industrial chain. At the same time, the establishment of a resilient industrial chain is one of the important measures to ensure the stable and high-quality development of China's economy^[1]. This means that the CPC Central Committee has made improving the resilience of China's industrial chain an important task and placed it at an unprecedented strategic height. Domestic and foreign scholars have carried out relevant studies on the toughness of the industrial chain. This paper summarizes the relevant studies on the toughness of the industrial chain, summarizes the concept and connotation of the toughness of the industrial chain, summarizes the characteristics and measurement methods of the toughness of the industrial chain, analyzes the existing studies, and looks into the future on this basis.

2. Defining concepts related to industry chain resilience

2.1 Definition of industry chain-related concepts

The related idea of industrial chain was firstly embodied in Adam Smith's "The Wealth of Nations" (1776), and the related idea of industrial chain mainly referred to the utilization of resources within enterprises^[2]. Later, Marshall extended the coordinated utilization of

resources to the division of labor among enterprises, which can be called the formal origin of industrial chain theory. The concept of industrial chain is a brand-new concept proposed by economists in China, which combines the foreign ideas of industrial chain with the theories of supply chain and value chain.

As for the domestic research on industrial chain, according to Jiang Guojun, the concept of "industrial chain" was first proposed by Yao Qiyuan and other scholars in China.^[3] Jin Yuyan applied the concept of industrial chain to the field of agriculture and proposed to build agriculture, farmers and rural areas into an industrial chain.^[4] At present, with the deepening of social division of labor, the formation of industrial chains has become inevitable. The research on industrial chains in China has penetrated into various fields. The definition of industrial chain can be divided into the following aspects: First, it is defined from the function of industrial chain, Yu Yihong^[5] (2005), Jiang Guojun, etc. (2004)^[6] (2004) define the industrial chain as the entire production chain from the initial natural resources to the final product reaching the consumer in the production and processing process of a final product. Ming Qingzhong (2022) mainly studied the chain transmission function of industrial chain, and defined industrial chain as a special chain transmission system, through which the whole system transmits resources, elements, products, benefits, values, ideas, etc.^[7]. Secondly, from the perspective of the structure of industrial chain, Wang Qiuyu (2012) believes that the structure of industrial chain includes supply and demand chain, organizational chain, value chain, knowledge chain and spatial chain, thus defining industrial chain as a chain network organization of enterprises in the same industrial sector or different industrial sectors in a certain economic region.^[8] From the basic structure of industrial chain, Zeng Yuanxiang (2022) believes that industrial chain is a chain containing related enterprise subjects and their relations,

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intermediate goods and final products in the circuitous production link, and the value and return of income added by different industrial chain subjects to the output of final products of industrial chain.^[9] In this paper, the industrial chain is defined as the whole industrial chain from raw materials to consumers. It is a form of chain correlation relationship objectively formed among various departments based on certain technical and economic correlation and specific logical relations and spatial-temporal layout relations. For example, the industrial chain of food manufacturing industry includes the purchase, processing, wholesale and retail, after-sales service of food raw materials and a series of commodity, technology and money flow process.

2.2 Definition and classification of resilience-related concepts

2.2.1 Definition of resilience-related concepts

Resilience is thought to have originated from the Latin word "resilio". The concept of resilience was first applied to the physical field and was defined as "the ability of an object to recover its original form after being subjected to external pressure".^[10] In the 1970s, ecologist Holling summarized the characteristics of resilience and defined the concept of engineering resilience, based on which Holling also introduced the concept of resilience into the ecological field, defining ecological resilience as "the amount of disturbance that a system can withstand without changing its structure, function and homogeneity. Since then, the idea of resilience has emerged in the discipline of ecology. In 2002, economist Rrggiani introduced the concept of resilience into the field of economics, forming evolutionary resilience, which is used in studies related to the dynamic processes of spatial economic systems. Since then, resilience has become a hot topic of research in the field of economics.^[11]

2.2.2 Classification of economic domain resilience

(1) Macroeconomic resilience

Aiginger (2009) innovatively incorporates resilience into the framework of macroeconomic policy, defining it as having a more resilient economic structure; economic growth; focus on long-term goals; and resilience to economic crises. Su, Hang (2015)^[12], Liu (2021)^[13] et al. summarize the domestic and foreign research results that macroeconomic resilience is the ability of a country's economy to withstand external shocks.

(2) Regional economic resilience

In the early stages of the development of the concept of regional economic resilience, with Hill^[14] et al. and Christopherson et al.^[15] The scholars, represented by Hill et al. and Christopherson, mainly focused on the ability of regional economies to withstand external shocks. Later, Martin et al.^[16] Eraydin (2014) defines economic resilience as the ability to respond to and adapt to crises based on the characteristics of the region's economic

resilience, including the ability to absorb shocks, the ability to recover from shocks, the ability to reintegrate and adapt to new environments, and the ability to create economic paths^[17].

(3) Urban Resilience

Arup defines urban resilience as the ability of a city to survive, adapt and thrive in the face of any sustained chronic stress or sudden catastrophic shock.^[18] Arup (2020) Zhao, Ruidong (2020)^[19], Torabi (2022)^[20] both consider urban resilience as a highly complex coupled system consisting of infrastructure, ecology, society, economy, and institutions.

3 Industry chain resilience connotation and characteristics

3.1 Definition of the connotation of industry chain resilience

The current definition of industry chain resilience is still vague. On the one hand most of the literature defines it in terms of withstanding external shocks; Qin (2020) defines chain resilience as the ability of the supply side to form corresponding capacity within a short period of time when there is a major change in demand^[21]; Li Shenghui (2022) draws on Martin^[22]'s idea, he understands industrial chain resilience as the ability of an industrial chain to continuously improve its mobility and adaptability to cope with external environmental changes, discover new paths and achieve sustainable growth under acute shocks and long-term pressure, with knowledge innovation and technology upgrading as the core driving force. Chen (2022) defines industrial chain as the ability to maintain chain stability, prevent breakage, adjust and adapt to return to the operating state before the shock, and even turn crisis into opportunity to achieve chain upgrade when the chain is disturbed by domestic and international market and environmental shocks^[23] The chain can be upgraded. On the other hand, it can be defined by the characteristics of industrial chain resilience, which is defined by Liu Yue (2022) as the ability of industry to resist, adapt and reorganize in the face of shock perturbations^[24].

3.2 Characteristics of Industry Chain Resilience

3.2.1 Ex ante resistance absorption capacity

In order to ensure the safety and smoothness of the industrial chain, it is necessary to build an independent and controllable industrial chain with strong resistance capability. Li Liangang^[25] (2019) and Ming-Dou Zhang (2022)^[26] define resistance capacity as the ability to predict risks and avoid economic downturns caused by the economic system deviating from its current development trajectory. While Jinpei (2021) does not talk about risk when describing the resilience of the industrial chain in terms of resistance and absorption capacity, but emphasizes the autonomous and controllable capacity of

the industrial chain to ensure that the chain does not lose its own execution and maintains a high competitiveness under the interference of external adverse factors^[27]. Combined with the summary of the above literature, ex ante absorption resistance refers to the ability to predict external risk shocks and to resist absorbing shocks within a certain limit to ensure the normal and efficient operation of the industrial chain.

3.2.2 *Recovering adaptive capacity in the event*

When the structure of the chain has been damaged and "broken", another characteristic of a resilient chain becomes evident, namely its ability to recover and adapt. From the perspective of enhancing the adaptation of the chain, Zhang Mingdu (2022) emphasizes that the adaptive capacity means that the chain will adjust its structure and function after the shock to ensure the operation of infrastructure and adapt to environmental changes.^[26] From the perspective of enhancing the resilience of the industrial chain, Li Liangang (2019) believes that resilience is the ability of the economic system to adapt to the transformation so that the system can quickly restore the original path or use the shock to break the original path to achieve a "path breakthrough"; therefore, the resilience in the middle of the event is the ability to adapt to the change.^[25] Therefore, the resilience of the industry chain is the ability to adapt to the new environment after a shock, to resist the disturbing factors in the new environment, and to quickly return to the original state of operation, or even to a more efficient state of operation.

3.2.3 *Post-event update innovation capability*

A resilient industrial chain will update the structure and function of the chain in time after the impact to better adapt to the changing environment and make certain innovations to seek a higher level of development. The renewal and innovation of the industrial chain are mainly reflected in two aspects: modernization and advanced. From the perspective of modernization, Li Shenghui (2022)^[28], Sheng Chaoxun (2019)^[29] The modernization of industrial chain is one of the effective ways to enhance the humanity of industrial chain, and the modernized industrial chain refers to the industrial chain with knowledge integration and innovation perspective and high-end leadership, so as to avoid the phenomenon of "necking" in the industrial chain. Therefore, the ability to modernize and innovate afterwards refers to the ability of the industrial chain to update its structure and function in a changing environment, and the ability to innovate to improve the modernization and advanced level of the industrial chain.

4 Measurements of chain resilience and conclusions

4.1 Single Indicator Measurements

The single-indicator measure is mainly used to determine resilience by drawing on regional economic resilience studies that use the decline in employment or output in a region versus the decline in the nation as a measure of each region's resistance to economic downturns. Sheng Li will refer to Davies^[30], Brakman^[31] and others to measure regional resilience in European countries after the 2008 financial crisis to study the impact of intellectual property rights on the resilience of industrial chains, so he uses the industrial diversification indicator and the urban innovation capacity indicator to refer to industrial chain resilience.^[22] In measuring the strength of industrial chains, Chen measures and measures mainly from the perspective of value, which is calculated as the ratio of value added of industrial chains to total inputs of industrial chains^[32]. The single-indicator measurement method mainly uses the ratio of the rate of change to represent. On the one hand, most of the relevant data of GDP are used, the data source is real and reliable the causal relationship is clear. On the other hand, firstly, it cannot reflect the uniqueness of different fields of study; secondly, it cannot reflect all the characteristics of resilience.

4.2 Multi-indicator measurement

The multi-indicator measurement method of industrial chain resilience is mainly developed from the following dimensions: first, according to the characteristics of resilience measurement, Zeyu Wang^[33] Referring to Martin^[16] In the way of measuring the resilience of regional economy, the resilience of ship industry chain is divided into resilience, recovery ability, reorganization ability and renewal ability and the indicators related to ship industry are measured separately to determine the resilience of industry chain. Liu Yue^[24] The resilience is expressed in terms of shock resistance capacity, shock adaptation capacity, and recovery and reorganization capacity. Second, the index system is established according to the industrial characteristics of specific industrial chains, and Zhang Hu^[34] In the study of China's industrial chain resilience, three aspects are measured from the high-end leadership, chain control and profitability of the manufacturing industry chain. The advantages of multi-indicator measurement are firstly, it describes the resilience from multiple dimensions and better reflects the characteristics of resilience; secondly, it can select the suitable indicators according to the specificity of the field of study. The shortcomings of the multi-indicator system are: firstly, there is no recognized and reasonable evaluation indicators, and the weight of each indicator is controversial. Secondly, the causal relationship between each indicator and resilience may confuse cause and effect; finally, some selected indicators may be difficult to measure or inaccurately measured.

5 The mechanism of influence of chain resilience enhancement.

5.1 Digital economy and industry chain resilience

The world has entered the era of digital economy and the industry chain is facing the challenge of digital transformation. Chen Xiaodong^[32] believes that the digital economy can improve the autonomy and controllability of the industrial chain by enhancing the level of human capital and innovation capacity, and thus improve the resilience of the industrial chain. He also clarifies the dynamic mechanism of the digital economy to improve the resilience of the industrial chain, and outlines the new elements, new models, new industries and new business models of the digital economy to improve the resilience of the industrial chain.^[23] He also outlined the new elements, new models, new industries and new patterns of the digital economy to enhance the resilience of the industrial chain. Liu Yue^[24] He takes an alternative approach to take industrial chain resilience as an intermediate variable of the digital economy to promote the high-quality development of manufacturing industry, showing a new research idea.

5.2 Innovation capacity and industry chain resilience

The main shortcomings of our industrial chain are the existence of low-end locking and the lack of innovation capacity. Li Shenghui^[22] Through the study of intellectual property rights to improve the resilience mechanism of industrial chain, Li Shenghui proposed to ensure the market-oriented mechanism of intellectual property rights, innovation and integration of existing resources to enhance innovation capacity; at the same time, Li Shenghui^[28] At the same time, Li Shenghui proposed to vigorously develop "specialized and special new" enterprises, strengthen the cooperation between the industry chain and national laboratories and other key research institutions, realize the production capacity and commercialization of breakthrough basic innovation achievements, and drive the chain enterprises to build technical standard barriers. Zhang Hu believes that the innovation of industrial chain is the core of the modernization of industrial chain, and the higher the level of innovation, the stronger the competitiveness of industrial chain, which in turn can enhance the toughness of industrial chain^[34].

5.3 Domestic and international dual cycle and industry chain resilience

In the context of the "double-cycle" goal, Liao Han^[35] In the context of the "double cycle" goal, Liao Han believes that we should extend the length of the domestic industrial chain and enhance the resilience of the industrial chain, mainly through the internal cycle. The vertical extension of the length of the industrial chain,

the construction of a more complete industrial chain, based on modern organizations, the formation of a complete and efficient industrial cycle chain, reduce the interference of external shocks on the industrial chain, so as to improve the ability of the industrial chain to resist shocks and enhance the resilience of the industrial chain.

6 Summary and Outlook

This paper systematically compares the relevant research on industrial chain resilience this year, summarizes the concepts of industrial chain and resilience, and then discusses the connotation, characteristics and enhancement mechanism of industrial chain resilience in detail.

It can be found that the current research around industrial chain resilience is not perfect, which can be mainly summarized as the following problems: First, the theoretical framework of industrial chain resilience still needs to be refined. Secondly, the measurement method of industrial chain toughness needs to be improved. The current measurement methods of toughness all have their own limitations. At the same time, the current research on the measurement of industrial chain toughness is mostly focused on static evaluation, and there is still a lack of research on the dynamic process, mechanism of action and regulation of toughness, and there is no measurement method that can measure toughness well; thirdly, the existing research on industrial chain toughness is mostly focused on specific industrial chains, and there is less research on the overall macroeconomic industrial chain toughness. At the same time, there is less empirical research on industrial chain toughness, and more research on industrial chain toughness stays in the stage of qualitative analysis. Future research on industrial chain resilience needs to continue to be carried out in depth.

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