



Research on the measurement and influencing factors of the integration of China's industrial chain and innovation chain

Lili Yang, Yue Bian*

School of Finance and Economics, Jiangsu University, Jiangsu, China

`zjyll@ujs.edu.cn`, `*bianyueai@163.com`

Abstract. The integrated development of the industrial chain and the innovation chain is the key to the transformation and upgrading of traditional industries and building the new development paradigm. This paper constructs a regional industrial-innovation chain integration index system from three dimensions: the integration of innovative and production entities, the integration of scientific and technological innovation and industrial development, and the integration of original innovation and industrial application, calculates the degree of industrial-innovation chain integration in 30 provinces in China from 2003 to 2021, and analyzes its time-space evolutionary trend and influencing factors. The results show, during the study period, the integration of industrial-innovation chain was on the rise; while the separation between original innovation and industrial application is the weak link of the integrating development of industrial chain innovation and chain. Industrial agglomeration, R&D investment, human capital, foreign direct investment and regional marketization have all promoted the integrating development of China's industrial-innovation chain.

Keywords: Industrial chain and innovation chain integration development; Coupling coordination degree model; Spatial econometric model.

1 Introduction

In recent years, under the influence of factors such as rising global trade protectionism, geopolitical conflicts and the deepening development of a new round of scientific and technological revolution, developed countries have accelerated the localization and localization of industrial chains and diversified international supply chains in order to maintain their monopoly position in the global industrial chain. The development of China's industrial chain is faced with the double squeeze of "high-end reflux" in developed countries and "mid-to-low-end diversion" in developing countries, and relying on independent innovation to promote the upgrading of the industrial chain has become an urgent requirement to cope with various risks and challenges. Exploring the integrated

development of industrial chain innovation and chain is an important measure to promote the upgrading of China's industrial base, the modernization of industrial chain, and the realization of high-end and intelligent development of manufacturing industry.

The academic community and the government are highly concerned about the docking and integration of the industrial chain innovation chain, and the existing research mainly focuses on two aspects: first, the connotation and path exploration of the integration of the industrial chain innovation chain. The industrial chain and innovation chain are like the DNA double helix structure, interdependent, integrated with each other, and co-evolving¹, which is the organic unity of the integration of innovation and production subjects, scientific and technological innovation and industrial development, and original innovation and industrial application. The development path of industrial chain innovation integration includes two models: "innovation chain promotes industrial chain integration" and "industry chain pulls innovation chain integration"². Second, some scholars have empirically explored the positive effects and driving factors of the development of double-chain integration. Double-chain integration will promote green technology innovation³, promote low-carbon transformation development⁴, and enhance the level of high-quality regional development⁵. The digital economy is the driving factor for double-chain integration⁶.

At present, the research on "two-chain integration" and "industrial chain modernization" is still in the stage of qualitative analysis, and the relevant quantitative analysis needs to be further supplemented and studied. Only some quantitative studies mainly focus on the positive effects of "double-chain" integration development, but there are few studies on the driving factors of the development of double-chain integration, and no consensus has been reached on the construction of evaluation index system. In view of this, this paper constructs China's inter-provincial double-chain integration development rating index system from three dimensions: the integration of innovation and production, the integration of scientific and technological innovation and industrial development, and the integration of original innovation and industrial application, and uses entropy method and coupling coordination degree model to measure the development degree of China's inter-provincial double-chain integration. The spatial model is used to examine the factors influencing the development of double-chain fusion in China.

2 Construction and measurement of index system

2.1 Index system construction

The industrial chain and the innovation chain are like the DNA double helix structure, interdependent, integrated and co-evolving, the industrial chain relies on the innovation chain to upgrade, and the innovation chain relies on the industrial chain to achieve value. The integration of industrial chain innovation chain not only requires the integration between the main body, but also needs to pay attention to the coordination of scientific and technological innovation and industrial development, and the transformation of original innovation achievements is also a key link of double-chain integration. Therefore, when evaluating the development degree of double-chain integration, it is necessary to reflect not only the regional industry and innovation situation, but also

a scientific and reasonable evaluation index system that can reflect the collaborative transformation of innovation and industry. Therefore, this article constructs an indicator system for the degree of integration and development of China's industrial chain and innovation chain (*III*), which includes three dimensions: the integration of innovation and production entities (*IIP*), the integration of technological innovation and industrial development (*ITI*), and the integration of original innovation and industrial application (*IIA*). The specific details are shown in Table 1.

Table 1. Index system of the degree of integration of China's industrial chain innovation and chain

Dimension	Subsystem	Indicator
Innovation main body and production main body integration(<i>IIP</i>)	Innovation body	Number of research and development institutions
		Number of colleges and universities
		Number of industrial enterprises with R&D activities
	Main body of production	Number of industrial enterprises above designated size
		Main business income/Number of enterprises
		Number of employed persons in industrial towns
Integration of scientific and technological innovation and industrial development (<i>ITI</i>)	Scientific and technological innovation	Total social expenditure on research and development
		The whole society R & D personnel at that time
		Number of high-tech enterprises
		New product sales revenue of industrial enterprises
	Industrial development	Industrial paid-in capital
		Industrial main business income
		Industrial main business income/Industrial main business cost
		Industrial value added/Industrial average employment
		Energy consumption of industrial added value
Integration of original innovation and industrial application (<i>IIA</i>)	Original innovation	Investment in basic research
		Number of authorized invention patents
		Number of R&D personnel in colleges and universities
		R&D expenditure of research and development institutions
	Industrial application	Utility model patent authorization
		Contract turnover of technology development activities
		Technology market turnover

2.2 Selection of influencing factors

Based on the realistic scenario that the development degree of double-chain integration in China is affected by multiple factors, and referring to the relevant research results of the industrial chain and innovation chain⁷⁻⁹, this paper selects the level of industrial agglomeration, foreign direct investment, R&D input, marketization degree, and human capital level as the main influencing factors of the integrated development of the manufacturing industry chain and innovation chain. (1) Industrial agglomeration (*IA*): This

paper uses location entropy to calculate the level of industrial agglomeration. (2) Foreign Direct Investment (*FDI*): This paper uses the actual foreign direct investment of each provincial administrative region to study. (3) Research and development investment (*R&D*): This paper uses research and experimental development expenditure to measure R&D investment. (4) Degree of marketization (*Market*): This paper draws on Fan Gang et al. 's algorithm for marketization index to obtain the marketization level of each region. (5) Human capital (*Educate*): The level of human capital is measured using the per capita educational level of the area.

2.3 Research method

The coupling coordination degree model is an effective research tool for evaluating the development degree of a region or a society, and can reflect the quality of the coordination among subsystems. Therefore, this paper uses the coupling coordination degree model to estimate the development degree of double-chain fusion in China's provinces. The steps are as follows: firstly, the comprehensive evaluation index of each subsystem is calculated, then the coupling coordination degree of each dimension is measured, and finally, the equal weight assignment is used to calculate the development degree of double-chain fusion. The specific formula is as follows:

$$C_i = \frac{2^2 \sqrt{U_1 U_2}}{U_1 + U_2} \quad (1)$$

$$D_i = \sqrt{C_i T_i} \quad (2)$$

Among them, U_1, U_2 is the comprehensive evaluation index of each subsystem, calculated by the entropy value method, C_i is the coupling degree of each subsystem. $T_i = \sum_{i=1}^n V_i U_i$ is the comprehensive coordination index. V_i is the weight of each first-level index. $V_i = \frac{1}{2}$, D_i is the coupling coordination degree of three dimensions.

3 Spatial and temporal characteristics analysis of the development degree of double-chain fusion in China

3.1 Time series analysis of China's industrial chain innovation chain integration

In order to investigate the temporal differentiation characteristics of the development degree of double-chain fusion in China, the average development degree of double-chain fusion in China and various regions from 2003 to 2021 was calculated, and the results were shown in Fig. 1. Trend chart of the integration degree of industrial chain innovation in China and various regions. The development degree of double-chain integration in China shows a trend of forward expansion to the coordinate axis. From a regional perspective, with the exception of Northeast China, the integration of industrial chain innovation and chain in various regions of China has gradually improved over time. The eastern region has the highest degree of integration of the innovation chain

of the manufacturing industry chain, which is related to the good economic development environment and superior location conditions in the eastern region, followed by the central region, the Northeast region and the western region.

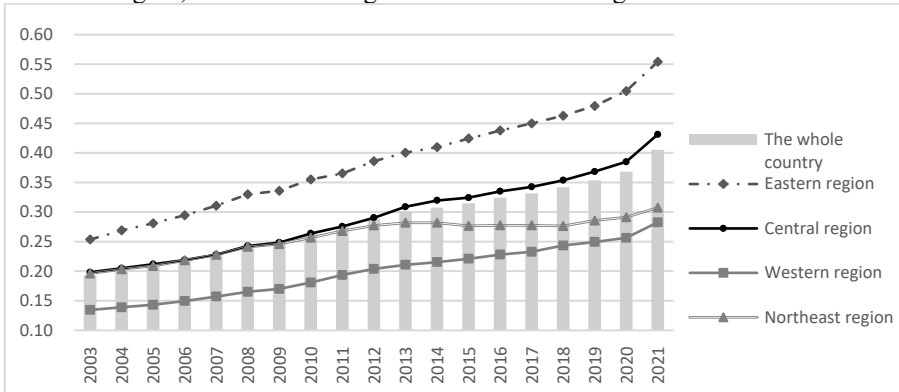


Fig. 1. Trend chart of the integration degree of industrial chain innovation in China and various regions

3.2 Spatial differentiation of the development degree of China's industrial chain innovation chain integration

Fig. 2. Tridimensional spider diagram of industrial chain innovation and integration development of sample regions in 2021 shows the spatial differentiation of coupling coordination degree in three dimensions of double-chain fusion development in each region in 2021, which is sorted clockwise according to the development degree of double-chain fusion.

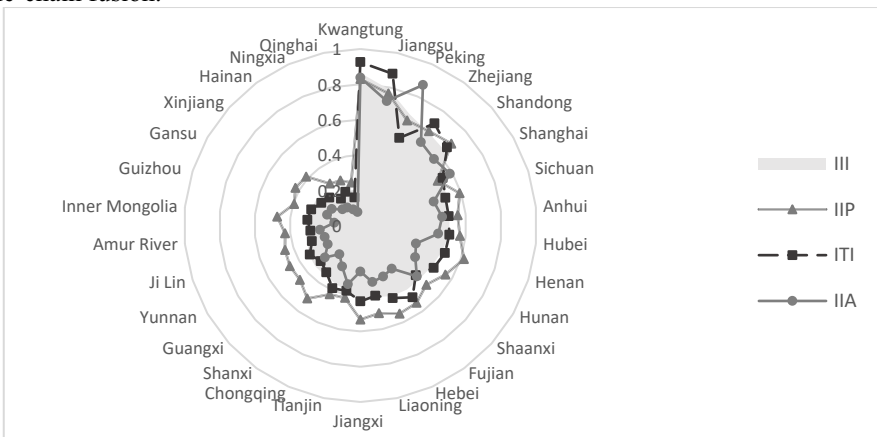


Fig. 2. Tridimensional spider diagram of industrial chain innovation and integration development of sample regions in 2021

In 2021, the three dimensions of the sample area maintain a relatively coordinated development degree. The connection of the integration of innovation and production is basically located in the outer layer of the radar map, and the connection of the integration of original innovation and industrial application is basically located in the inner part of the radar map, indicating that the integration of innovation and production is the best. The degree of coupling coordination in the three dimensions varies greatly among provinces, and the degree of development in the three dimensions of industrial chain innovation and chain integration in the high degree of development is small, and the degree of integration of original innovation and industrial application is relatively high. The region with the medium degree of water will have a low degree of coupling and coordination, which restricts the integrated development of the overall industrial chain innovation and chain; The coupling coordination of original innovation and industrial application integration in areas with poor development of industrial chain innovation and chain integration is much lower than the other two dimensions.

4 Analysis of influencing factors on the development degree of China's industrial chain innovation and chain integration

4.1 Model construction

By measuring Moran's I of the development degree of double chain fusion in China, it is found that Moran's I index is greater than 0.199, Z value is in the range of [2.500,3.411], and P value is significant at 5% significance level, indicating that the spatial distribution of the development degree of double chain fusion in China has a positive spatial correlation. Therefore, this paper constructs a spatial econometric model to analyze the factors affecting the development degree of double-chain fusion. After the Hausman test, LM test, Wald test and LR test, the double fixed spatial error model is used for regression analysis.

4.2 Regression results and analysis

According to the estimated results in Table 2, the coefficients of industrial agglomeration, R&D input, human capital, foreign direct investment and marketization degree are tested at the significance level of 1%, and are all significantly positive.

Table 2. Estimation results of influencing factors model for China's double-chain fusion rate

<i>variable</i>	<i>coefficient</i>	<i>Standard deviation</i>	<i>p-value</i>
<i>IA</i>	0.038	0.004	0.000
<i>FDI</i>	0.109	0.148	0.001
<i>Market</i>	0.471	0.010	0.010
<i>RD</i>	0.097	0.002	0.000
<i>Educate</i>	0.107	0.253	0.002

Specifically, industrial agglomeration promotes industrial upgrading through economies of scale and technology spillovers, strengthens the exchange and dissemination of hidden knowledge among enterprises, and provides the industrialization foundation for the integrated development of industrial chain innovation and chain. R&D investment is an important way to improve regional independent innovation ability and promote industrial upgrading, and has a positive impact on regional basic research, enterprise independent innovation and personnel training system. Increasing R&D investment can improve regional innovation capacity, promote the transformation of scientific and technological achievements, and optimize the industrial structure. High-quality human capital provides high-quality labor for regional development, and delivers high-quality human capital and intellectual support for industrial development, which is the driving force for the integrated development of the double chain. Foreign direct investment promotes the integrated development of the double chain by promoting product upgrading and improving the innovation capacity of enterprises. A higher degree of marketization provides a good market environment for the development of dual integration.

5 Conclusion and suggestion

5.1 Conclusion

This paper constructs an evaluation index system for the development degree of China's "double chain" integration from three dimensions: the integration of innovation and production, the integration of scientific and technological innovation and industrial development, and the integration of original innovation and industrial application, and analyzes the characteristics of the development degree of China's "double chain" integration. Furthermore, the influence of industrial agglomeration, foreign direct investment, R&D input, marketization degree and human capital on the integration development degree of industrial chain innovation and chain is discussed. The conclusion is as follows: From 2003 to 2021, the development degree of China's industrial chain innovation chain integration and the coupling coordination degree of the three dimensions show an overall upward trend; The integrated development level of the industrial chain innovation and chain of the four regions shows an overall upward trend, the differences between regions are constantly expanding, and the evolution of each region is unbalanced, showing a gradient distribution characteristic that gradually decreases from the eastern region to the central and western region. In 2021, China's industrial chain innovation and chain integration development degree is significantly different among regions. The regions with a high degree of industrial chain innovation and chain integration development are Guangdong, Jiangsu, Zhejiang and Shanghai, mainly located in the eastern coastal areas, while the regions with a low level of industrial chain innovation and chain integration development are mainly located in the western region. In areas with better industrial chain innovation integration development, the development of the three dimensions of coupling coordination degree is relatively balanced, and the

"integration of original innovation and industrial application" is an important factor restricting the integration development of the manufacturing industry chain innovation chain.

5.2 Suggestion

Based on the conclusions, in order to improve the integration and development of China's "double chain", the following suggestions are put forward:(1) Promote the deep integration and development of "double chain". First, establish a new model of industry-university-research cooperation. Establish an industry-university-research collaboration organization with universities as the core, enterprises as an important starting point, and deep cooperation between research institutes, and enhance the innovation capacity of the industrial chain. Second, establish a mechanism for transforming scientific and technological achievements. We will guide government investment and procurement funds to be diverted to scientific and technological innovation enterprises, and strengthen the construction of scientific and technological service institutions and human resources. Finally, strengthen basic research and enhance original innovation capability. (2) Promoting coordinated development among regions in light of local conditions. On the one hand, we should narrow the development gap among the four major regions. The eastern region should play the role of "growth pole" and provide experience for the integrated development of "double chain" in the central and western regions. The central region should pay attention to its own resource endowment, take advantage of national policies and geographical advantages, undertake industrial transfer in the eastern region, and promote industrial transformation and upgrading in the central region. The western region should take advantage of its own low cost and resource advantages, combined with the regional situation, do a good job in industrial development planning; For the Northeast region, we should take multiple measures at the same time, and gradually promote the transformation and upgrading of traditional industries in a circular manner, so as to form a new driving force for integrated development of "double chain". On the other hand, we should strengthen cooperation and exchanges among the four regions, promote the complementarity of regional resource advantages, promote the flow of inter-regional production factors, and build a new pattern of "double-chain" integrated development in the eastern, central, western and northeastern regions.

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