

Analysis of the Convergence of Manufacturing Industry Structure in the Three Provinces of Northeast China

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Abstract: At present, China's economic development is in an important stage of transformation towards high-quality development. Realizing industrial structure adjustment, promoting rational regional industrial layout, and collaborative division of labor play an important role in promoting high-quality economic development. Therefore, conducting research on the convergence of regional industrial structure is of great practical significance for promoting sustainable economic development. This article takes the manufacturing industry in the three northeastern provinces as the research object, and analyzes the problem of industrial structure convergence in the manufacturing industry from multiple perspectives. By measuring the similarity coefficient of industrial structure, location entropy, and regional division of labor index, it was found that the manufacturing industry in the three northeastern provinces of China has intensified industrial homogeneity while the convergence of industrial structure is not obvious. Policy suggestions are proposed to address this phenomenon.

Keywords: Convergence of industrial structure, Similarity coefficient of industrial structure, Location entropy, Regional division of labor index.

1. Introduction

1.1. Research background

Since the reform and opening up, on the journey towards becoming a socialist modernized strong country, China has adhered to the principle of focusing on the economy and development, continuously achieving new achievements in economic development, and achieving significant improvement in international status and influence. In the early stages of economic development, the three northeastern provinces established a relatively complete industrial system, which became an important force in promoting the modernization of China's industrial development. However, their excessive reliance on resource advantages and disadvantages of being comprehensive but not superior gradually emerged, becoming a problem that hindered the economic development of the three northeastern provinces. As the Central Committee has successively issued a series of policy documents such as the Several Opinions of the Central Committee of the Communist Party of China and the State Council on Implementing the Revitalization Strategy of Old Industrial Bases such as Northeast China, realizing high-quality industrial development in Northeast China and promoting industrial revitalization in Northeast China has become an important part of the journey to achieve Chinese path to modernization.

Since the establishment of the People's Republic of China, the three northeastern provinces have always been important industrial bases in China due to their strong industrial foundation, injecting strong impetus into China's economic development and being an important force in promoting the path of industrialization. In industry, manufacturing plays a particularly important role. In 2022, the added value of China's manufacturing industry accounted for 27.4% of GDP, contributing significantly to the country's economic development. In 2021, the total output value of the manufacturing industry in the three northeastern provinces

accounted for over 85% of the total industrial output value, accounting for 30% of the total economic output. The development of the manufacturing industry in the three northeastern provinces is related to the industrial and even economic development of the entire province. Therefore, exploring and solving the problems in the current development process of the manufacturing industry in the three northeastern provinces is particularly important for achieving high-quality and sustainable development in the three northeastern provinces. After the reform and opening up, in the process of China's transition from a planned economy to a market economy, the Chinese economy has increasingly shifted towards a market direction, and management power has gradually been delegated from the central government to local governments. The division of management systems has led to a lack of unified planning for industrial planning in various provinces in Northeast China. In addition, the similarity in infrastructure, resources, energy, and transportation conditions for industrial development during the planned economy period is also evident. There are certain similarities in the development strategies, leading industry choices, and construction directions of the industries in the three provinces. Against the backdrop of achieving high-quality economic development in our country, exploring and solving the problems of inefficient and repetitive construction and industrial structure homogenization in the manufacturing industry development process of the three northeastern provinces has become an urgent need to promote high-quality economic development in the three northeastern provinces.

1.2. Research meaning

From a theoretical perspective, this article, based on the theory of industrial structure convergence, uses location entropy, similarity coefficient of industrial structure, and regional division of labor index to measure the degree of manufacturing industry convergence in the three northeastern provinces. The method application is relatively flexible and innovative, enriching the research on the problem of

manufacturing industry structure convergence in the Northeast Three Provinces. From a practical perspective, as important industrial bases in China, the Northeast Three Provinces have played a crucial role in the long history of economic development. However, in recent years, their economic development has gradually declined. After a golden decade of revitalizing the old industrial base in Northeast China, GDP and industrial growth rates have been consistently lower than the national average since 2013. Currently, many scholars have studied the reasons for the gradual decline of industry in Northeast China from different perspectives, while there are few scholars who have studied from the perspective of industrial structure convergence. Therefore, studying the current status of the manufacturing industry structure in Northeast China and providing scientific and reasonable explanations and explanations for its formation mechanism and impact has significant practical significance for promoting the harmonious and rapid development of regional economy and determining the industrial structure in the future development of the three northeastern provinces.

2. Theoretical Concepts

The convergence of industrial structure refers to the situation in which leading industries are chosen due to the lack of unified planning and effective communication among regional entities in the development process between regions, resulting in weak regional division of labor and low specialization of advantageous industries. The convergence of industrial structure is a dynamic process that changes with the development of regional industries. The convergence of industrial structure can be divided into rational convergence and irrational convergence. Reasonable convergence will gradually reduce the differences in consumption demand and production factor conditions between regions, promote moderate and comprehensive regional economic development, and thus promote regional economic development; Unreasonable convergence can lead to low efficiency in regional markets, vicious competition between regions, and is not conducive to the overall development of regional economy.

3. Literature Review

Chinese scholars have conducted extensive and in-depth research on the issues related to the convergence of industrial structure in China. Wang Shufang believes that regional industrial structure convergence includes both rational convergence and irrational convergence. Rational convergence will gradually reduce the differences in consumption demand structure and production factor conditions between regions, while irrational convergence will lead to malicious competition in the development of industries between regions, resulting in a decrease in the overall efficiency of industries between regions. Shi Tao et al. believe that the convergence of industrial structure is mainly manifested by the increase in similarity of industrial structure and the narrowing of differences in industrial product structure among different regions. Li Rongguo believes that the convergence of industrial institutions is reflected in the similarity of leading industry choices, high similarity in industrial sector structures between regions, and weakened division of labor and cooperation between regions. Domestic scholars also use location entropy, grey correlation degree,

and other indicators to study the convergence of industrial structure in their research. Wang Wenju et al. used game theory to study the convergence of regional industrial structure driven by political promotion, and believed that there are advantages and disadvantages to industrial structure convergence. Shi Tao et al. studied the issue of regional industrial structure convergence in China from the perspective of market segmentation. Zhou Liquan et al. studied Shanghai, Jiangsu, Zhejiang, and Beijing Tianjin Hebei provinces respectively, and believed that the convergence of industrial structure in the former is due to technological driven industrial agglomeration and market conditions brought about by geographical location, while the latter is due to similar resource advantages and government promotion. Xing Zizheng et al. measured the phenomenon of industrial structure convergence in the manufacturing industry within the Beijing Tianjin Hebei region using indicators such as regional allocation coefficient and location entropy, and believed that the industrial structure in the Beijing Tianjin Hebei region did not generate vicious competition due to repeated construction. Zhao Feng et al. used methods such as deviation from one share analysis to study the phenomenon of industrial isomorphism in northern Jiangsu, and believed that the current industrial isomorphism in northern Jiangsu has a promoting effect on economic development to a certain extent, which is a reasonable convergence. Zhang Wenhui et al. used similarity coefficient of industrial structure and location entropy to study the Bohai Rim region and found that there is a serious convergence situation in certain industries.

4. Research Method

4.1. Similarity coefficient of industrial structure

$$P_{cd} = \frac{\sum_{i=1}^n G_{ci}G_{di}}{\sqrt{\sum_{i=1}^n G_{ci}^2 \sum_{i=1}^n G_{di}^2}} \quad (1)$$

The calculation formula is shown in (1), where P_{cd} represents the similarity coefficient of industrial structure between region c and d . The c and d respectively represent different regions, where $c=1, 2, 3... n$, $d=1, 2, 3... n$. i represents the industrial sector of the studied area, $i=1, 2, 3... n$. The proportion of the i industry in regions c and d of G_{ci} and G_{di} to the overall i industry in the region. When P_{cd} is 0, it indicates that the industrial structure between the two regions is completely different. The closer it is to 0, the weaker the phenomenon of industrial convergence. On the contrary, the closer it is to 1, the more severe the phenomenon of industrial isomorphism between the two regions.

4.2. Location entropy

$$O_{hj} = \frac{m_{hj}/m_h}{m_j/m} \quad (2)$$

Location entropy is used to measure industrial agglomeration and is one of the indicators for measuring the degree of industrial specialization, its calculation method is

equation (2). In the formula, O_{hj} represents the location entropy of industry j in region h . The m_{hj} represents the total output value of industry j in region h , and m_h represents the total output value of industry j in region h , in this article, both represent the output value of manufacturing sub industries and the total output value of manufacturing in a certain province, respectively. The m_j refers to the output value of the j industry in the region, in the text, it refers to the output value of the manufacturing industry in the Northeast Three Provinces. The m represents the total output value of the regional industry, in the text, it refers to the total output value of the manufacturing industry in the Northeast Three Provinces. The larger the O_{hj} value, the higher the degree of specialization in industrial development in the region. If O_{hj} is greater than 1, it indicates that the degree of specialization in the j industry in the h region is greater than the regional average, and the region has relatively better development benefits. Conversely, the development benefits are poorer.

4.3. Regional division of labor index

$$Z_{er} = \sum_{u=1}^n \left| \frac{q_{eu}}{q_e} - \frac{q_{ru}}{q_r} \right| \quad (3)$$

The regional division of labor index is usually used to measure the situation of industrial division of labor, and the calculation method is shown in equation (3). In the formula, Z_{er} represents the regional division of labor index, with a value range of 0-2. The closer it is to 0, the lower the degree of division of labor between the two regions. When the value is 0, it indicates that there is no division of labor between the two regions. Otherwise, it is considered that the higher the division of labor and cooperation between the two regions, the more reasonable the industrial structure between the regions. Among them, q_{eu} and q_{ru} respectively represent the output value of manufacturing industry u in provinces e and r , while q_e and q_r represent the total output value of manufacturing industry in provinces e and r .

4.4. Data sources

The three northeastern provinces mentioned in the article refer to Liaoning, Jilin, and Heilongjiang provinces. All measurement indicators are calculated based on the total output value (current year prices) of each industry. Based on the statistical yearbooks and data availability of the Northeast Three Provinces, this article selects data indicators from 2002 to 2016. To unify the total output value of the manufacturing industry, the Classification and Code of National Economic Industries (GB/T4754-2017), and the category data released in the statistical yearbooks of the Northeast Three Provinces before and after 2012, 29 manufacturing categories were selected, including agricultural and sideline food processing industry, food manufacturing industry, alcohol, beverages, and refined tea manufacturing industry, tobacco products industry, textile industry, textile and clothing industry, leather, fur, feathers and their products, and footwear industry, Wood processing and wood, bamboo, rattan, palm, and grass products industry, furniture manufacturing industry, papermaking and paper products industry, printing and recording media replication industry, cultural and educational, artistic, sports and entertainment equipment manufacturing industry, petroleum processing, coking and nuclear fuel

processing industry, chemical raw material and chemical product manufacturing industry, pharmaceutical manufacturing industry, chemical fiber manufacturing industry, rubber and plastic products industry, non-metallic mineral products industry, black metal smelting and rolling processing industry, Nonferrous metal smelting and rolling processing industry, metal products industry, general equipment manufacturing industry, specialized equipment manufacturing industry, transportation equipment manufacturing industry (data merged from automobile manufacturing industry, railway, shipbuilding, aerospace and other transportation equipment manufacturing industries after 2012), electrical machinery and equipment manufacturing industry, computer, communication and other electronic equipment manufacturing industry, instrument and meter manufacturing industry, and other manufacturing industries, Comprehensive utilization of abandoned resources. The data is sourced from the statistical yearbooks of various provinces from 2002 to 2016 and the China Industrial Economic Statistical Yearbook.

5. Measurement Result

5.1. Calculation of similarity coefficient of industrial structure

Table 1. Similarity coefficient of manufacturing industry structure in the three northeastern provinces

Time	Liaoning Province - Jilin Province	Liaoning Province - Heilongjiang Province	Jilin Province - Heilongjiang Province
2002	0.580	0.690	0.771
2003	0.545	0.649	0.675
2004	0.622	0.640	0.679
2005	0.575	0.656	0.671
2006	0.591	0.686	0.700
2007	0.603	0.686	0.706
2008	0.632	0.678	0.757
2009	0.621	0.647	0.715
2010	0.583	0.641	0.645
2011	0.608	0.635	0.701
2012	0.650	0.679	0.730
2013	0.641	0.678	0.705
2014	0.673	0.695	0.732
2015	0.711	0.706	0.769
2016	0.615	0.528	0.753
average value	0.620	0.660	0.714

From the calculation results, it can be seen that the similarity coefficients of the manufacturing industry structure among the three provinces in Northeast China are not at a very high value. Among them, the similarity coefficient of the manufacturing industry structure between Jilin and Heilongjiang is relatively high, and the convergence of the manufacturing industry structure between the two provinces is relatively obvious. From the perspective of development trends, the similarity coefficient of manufacturing industry structure in various provinces showed a trend of first decreasing and then increasing from 2002 to 2016, which is generally consistent with the economic development status of the three northeastern provinces. In the process of promoting industrial revitalization in Northeast China, the Central Committee of the Communist Party of China has issued a

series of guiding policies. Under the dual effects of macro policy guidance and market resource allocation, the industrial development of the three provinces in Northeast China tends to be rational, and market resource elements flow towards departments and industries with greater development potential and sustainable development. This has improved the degree of specialization of the industrial industry in the three provinces, and the convergence of industrial structure has also

decreased. But since 2011, the similarity coefficient of the manufacturing industry structure in the three northeastern provinces has been increasing year by year, with an increase in redundant construction. The problem of industrial structure convergence in later development has gradually become apparent

5.2. Location entropy calculation

Table 2. The average value of manufacturing location entropy in the three northeastern provinces of China

Industry	Liaoning Province	Jilin Province	Heilongjiang Provinc
Agricultural and sideline food processing industry	0.6746	1.0983	2.0302
Food manufacturing industry	0.6433	0.9248	2.5219
Liquor, beverage, and refined tea manufacturing industry	0.5824	1.3502	1.8353
Tobacco industries	0.4558	1.4238	2.4073
Textile industry	0.9644	0.8836	1.1310
Textile and apparel industry	1.3712	0.5880	0.3159
Leather, fur, feathers and their products, and footwear industry	1.1833	0.2667	1.6778
Wood processing and wood, bamboo, rattan, palm, and grass products industry	0.4799	1.5204	1.7201
Furniture manufacturing industry	0.9778	0.8751	1.1386
Paper and Paper Products Industry	0.9933	0.9161	1.0681
Printing and Recording Media Reproduction Industry	0.8525	1.1296	0.9858
Manufacturing of cultural, educational, artistic, sports, and entertainment products	0.9775	0.5037	1.8782
Petroleum processing, coking, and nuclear fuel processing industries	1.3912	0.1246	1.6935
Chemical raw material and chemical product manufacturing industry	0.9842	1.1136	0.8601
Pharmaceutical industry	0.4695	1.9755	0.9467
Chemical fiber manufacturing industry	0.7318	1.8830	0.1560
Rubber and plastic products industry	1.2471	0.5892	0.8279
Non metallic mineral products industry	0.9603	1.0709	0.8179
Black metal smelting and rolling processing industry	1.5160	0.5025	0.3163
Nonferrous metal smelting and rolling processing industry	1.5348	0.4581	0.2337
Fabricated metal products	1.2995	0.5904	0.6379
General equipment manufacturing industry	1.4316	0.3815	0.7030
Special Equipment Manufacturing Industry	1.1525	0.7526	0.8604
Transport equipment	0.93975	1.4410	0.4892
Electrical machinery and equipment manufacturing industry	1.3348	0.5257	0.7284
Computer, communication, and other electronic equipment manufacturing industry	1.6419	0.3163	0.1872
Instrument manufacturing industry	1.3755	0.5411	0.6291
Other manufacturing industries	0.7711	1.0684	1.5730
Comprehensive utilization of abandoned resources industry	1.2658	0.9120	0.3488

Table 2 shows the average location entropy of the manufacturing industry in the three northeastern provinces of China from 2002 to 2016. Among them, there are 13 manufacturing industries in Liaoning Province with a location entropy greater than 1 (usually considered to have a higher level of specialization when the location entropy is greater than 1), and the industries with absolute advantages are computer, communication, and other electronic equipment manufacturing; There are 13 manufacturing industries in Jilin

Province with a high level of specialization, among which the pharmaceutical manufacturing industry has absolute advantages; There are 12 manufacturing industries in Heilongjiang Province with a high level of specialization, among which the food manufacturing industry has an absolute advantage. Among the manufacturing industries with a location entropy higher than 1 in the three northeastern provinces, there are 0 advantageous industries shared by the three provinces, and 5 advantageous industries shared by the

two provinces. The overlap of advantageous industries among the three northeastern provinces is relatively low, and there is a certain degree of differentiated development. However, the development of the manufacturing industry in the three northeastern provinces faces problems such as weak key core technologies, weak independent innovation capabilities, and weak competitiveness in some mid to high end industries such as general equipment manufacturing, computer and other electronic equipment manufacturing. On the other hand, in terms of time span, there are 17, 11, and 10 industries in the manufacturing industry of Liaoning Province, Jilin Province, and Heilongjiang Province showing a downward trend in location entropy, while 4, 5, and 3 advantageous industries show a downward trend in location entropy. The development of manufacturing industry specialization is hindered, and the level of specialization is declining.

5.3. Calculation of regional division of labor index

Table 3. Regional division of labor index for manufacturing industry in the three northeastern provinces of China

Time	Liaoning Province - Jilin Province	Liaoning Province - Heilongjiang Province	Jilin Province - Heilongjiang Province
2002	1.078	0.647	0.976
2003	1.142	0.658	1.012
2004	1.082	0.600	1.029
2005	1.210	0.593	1.010
2006	1.043	0.561	0.975
2007	1.001	0.581	0.947
2008	0.937	0.573	0.828
2009	0.915	0.633	0.848
2010	0.892	0.677	0.842
2011	0.857	0.686	0.818
2012	0.856	0.689	0.753
2013	0.837	0.738	0.784
2014	0.815	0.730	0.793
2015	0.753	0.726	0.723
2016	0.810	0.881	0.754
average value	0.948	0.665	0.873

From the calculation data, it can be seen that the average regional division of labor index between Liaoning and Heilongjiang is relatively low, but it has gradually increased since 2009, and the division of labor connection between the two provinces has gradually strengthened. The regional division of labor index of Liaoning Jilin and Jilin Heilongjiang showed a decreasing trend year by year. The regional division of labor index of Liaoning Jilin decreased from 1.078 in 2002 to 0.810 in 2016, a decrease of 24.9%; Jilin Heilongjiang decreased from 0.976 in 2002 to 0.754 in 2016, a decrease of 22.7%, and the inter industry division of labor has shown a decreasing trend year by year.

6. Conclusion and Policy Recommendations

In the calculation results of the similarity coefficient, location entropy, and regional division of labor index of the manufacturing industry structure in the three northeastern provinces, it was found that although there is a certain degree of convergence in the current manufacturing industry in the

three northeastern provinces, there is no unreasonable convergence. The development of the manufacturing industry in the three provinces has not been hindered by the low efficiency of regional assistance division of labor caused by isomorphism. This may be due to a series of planning guidance and regulation among the three provincial governments under the national strategy of revitalizing industrial development in Northeast China. However, we should also fully see that in the measurement results, the similarity coefficient of the manufacturing industry structure in the three northeastern provinces is on the rise, the phenomenon of industrial structure convergence is gradually intensifying, and the degree of industrial specialization and regional industrial division of labor are showing a decreasing trend year by year. Therefore, in the face of the increasingly obvious trend of industrial structure convergence in the manufacturing industry of the three northeastern provinces, it is particularly important to reduce or even eliminate the negative impact of unreasonable industrial structure convergence on the economy of the three northeastern provinces, prevent economic problems caused by duplicate construction and vicious competition, and enhance the level of cooperation and specialization in development among the three provinces.

6.1. Coordinate macroeconomic regulation and promote coordinated development of industries

Coordinating the development of manufacturing industry in the three northeastern provinces, optimizing industrial layout, and breaking through protectionism and administrative system intervention in the process of local government development should become the focus of manufacturing industry development in the three northeastern provinces in the future. At present, China is in a strategic period of building a unified domestic market. The three northeastern provinces should actively seize this opportunity period, promote the integrated planning and development of the three northeastern provinces under the demand of expanding domestic demand, abandon the original local protectionism ideas, and fully recognize that only by strengthening macroeconomic regulation between regions and fully complementing each other's strengths and weaknesses can we better stimulate market vitality and effectively seize this opportunity period. The three provincial governments should strengthen industrial development cooperation, effectively play the guiding role of the government in promoting industrial development, strategically determine the unified direction and focus of industrial structure adjustment in the three provinces, clarify the competition, market pattern, and development plan of the manufacturing industry in the three northeastern provinces, and carry out refined industrial regional layout based on regional resource endowment differences, promoting the alignment of the development focus of the manufacturing industry in each province with the functional positioning of each city. Differentiated selection of "assistance" industries and manufacturing clusters for agglomeration development can effectively enhance the driving and agglomeration effects of key industries by protecting and supporting them, enhancing their specialization, and promoting their sustainable development.

6.2. Promote factor flow and achieve effective allocation of resources across provinces

The market is a key means to achieve effective resource allocation, and the three provinces in Northeast China need to further strengthen the flow of resource elements and transparency of market information between provinces, breaking down the obstacles to resource allocation caused by regional market protection and administrative segmentation. In the process of development, we should not only focus on government policy guidance, but also fully leverage the role of market mechanisms in resource allocation, allowing the market to guide the flow of various production resource factors into various industries. This is conducive to forming a competitive and development potential industrial structure, and also helps reduce the low efficiency of resource allocation caused by government administrative intervention. Strengthening the full flow of resources such as talents and technology requires not only focusing on local resources, relying on universities and enterprises within the region, vigorously cultivating local regional talents, strengthening technological research and innovation, but also fully attracting talents from other provinces outside the region to work in the province, achieving dual development of knowledge and technology, promoting the extension of the industrial value chain to high-end technology, and increasing the technological added value of the industry.

6.3. Strengthen regional linkage and promote the construction of cross provincial integrated industrial chains

For industries with high similarity, the three provinces should explore a collaborative division of labor network, establish a cross provincial integrated industrial chain, and strengthen the linkage effect of regional industrial development by creating a regional integrated technology innovation and cooperation network connecting the upstream, midstream, and downstream of the industrial chain. We should focus on supporting the absolute advantage industries of each province, making them more refined and strong, strengthening the research and development of key core technologies, and increasing the technological added value of each link in the industrial chain. In the analysis based on indicators such as location entropy, Liaoning should focus on strengthening the development of industries such as computer, communication, and other electronic equipment manufacturing; Jilin should focus on developing industries such as pharmaceutical manufacturing and automobile manufacturing; Heilongjiang focuses on developing industries such as agricultural and sideline food processing and food manufacturing. At the same time, the three provinces should focus on building an integrated and coordinated industrial chain system for the construction of key industries, connecting the upstream and downstream of the industrial chain, providing policy support and supporting

facility construction, integrating technological innovation into all aspects of the industrial chain, and enhancing the added value of the industrial chain.

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