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Measurement and Research on Technical Complexity of Manufacturing Export in Three Northeast Provinces

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Abstract: As a pivotal industrial foundation within China, the Northeast region plays a vital role in the economic transformation and upgrade, as well as the pursuit of high-quality development. Consequently, this study employs export data from various provinces from 2013 to 2022 to assess the technical complexity of manufacturing exports within the three Northeastern provinces. The calculation results indicate that the overall technical complexity of manufacturing export in the three Northeast provinces shows an increasing trend year by year, which indicates that the technical level of export products in the three Northeast provinces is constantly improving. Specifically, the technical complexity of manufacturing exports in Liaoning Province surpasses the national average, while there exists a discernible disparity between Jilin Province and Heilongjiang Province in terms of technical complexity. Drawing insights from these findings, the paper delves into the pertinent issues and proposes strategies for augmenting the technical complexity of export technology in Northeast China.

1. Introduction

As the important old industrial bases in our country, the three provinces in Northeast China are in the key period of industrial transformation. Improving the technical level of manufacturing products is of great significance for promoting the development of the three Northeast provinces. By measuring the technical complexity of manufacturing export in the three Northeast provinces, this paper finds that the technical complexity of manufacturing export in the three Northeast provinces presents different characteristics and levels. A series of development problems are found through the technical complexity of manufacturing export in the three northeast provinces. This paper will provide suggestions for improving the technical complexity of manufacturing export in Northeast China according to the existing problems.

2. Measurement of Technical Complexity of Manufacturing Export

The technical complexity of manufacturing export is an important index to measure the technical content of regional manufacturing export products. The greater the technical complexity index, the higher the technical content of regional export products. Based on the practice of Yu Shan

(2021),this paper extends the method of calculating export technical complexity of Hausmann (2017) [1] et al., to the domestic provincial level, and calculates the manufacturing export technical complexity of the three northeastern provinces from 2013 to 2022 in two steps [2].

The specific calculation formula is as follows: This paper uses the export data of China's provinces from 2013 to 2022 in the UN Comtrade database, compares the 22 categories of industries classified in the HS code of the customs statistical data, and takes advantage of the export technology complexity of China's provinces. The formula is as follows:

Step 1: Calculate the export technical complexity level of k industry:

$$PRODY = \sum_i \frac{x_{it} / Xit}{\sum_i x_{ik}{}_t / X_{it}} Yit \tag{1}$$

In the formula, Xikt represents the export volume of k industry of province i in year, Xit represents the total export volume of manufacturing industry of province i in year t， and Yit represents the per capita income level of province i in year t (expressed by per capita GDP).

Step 2: Calculate the level of technical complexity of manufacturing export in each province:

The export technical complexity of the above sub-sectors is weighted and averaged to form the export technical complexity of the manufacturing industry in Province i in t years. The specific calculation formula is as follows:

$$EXPit = \sum i \, (Xkit / xit) \, PRODYkt \tag{2}$$

In the formula, EXPit represents the technical complexity of the overall manufacturing export of the province.

3. Analysis of Calculation Results of Technical Complexity of Manufacturing Export

According to the above calculation method, the technical complexity of manufacturing export in the three Northeast provinces is calculated, and the results are shown in Table 1.

Table 1: Average technical complexity of manufacturing export in the three Northeastern provinces and the whole country from 2013 to 2022

	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Liaoning (Province)	7366.01	7920.47	8266.59	8402.38	9095.62	10155.51	10433.10	10757.52	13280.40	13503.58
Ji Lin	7046.19	7805.72	8086.40	8191.36	8663.12	9717.59	10003.46	10187.30	12633.81	12696.00
Amur River	7046.29	7826.58	8308.52	8065.05	8795.87	9692.25	9899.44	10424.00	12721.30	12724.03
National average	7515.616	8151.642	8497.636	8567.652	9151.683	10269.36	10527.18	10829.1	13330.4	13532.09

The computed outcomes indicate a progressive uptrend in the technical sophistication of manufacturing exports across the three northeastern provinces. This signifies a consistent enhancement in the technological content of exported products over time, commonly associated with elevated product quality and innovation capabilities. The incremental growth in this metric is intricately related to the strategic economic development and policy orientation of China, particularly the national initiatives supporting the revitalization of the traditional industrial base in Northeast China, along with the promotion of high-tech and advanced manufacturing sectors.

On the whole, in the past ten years, the export technical complexity of the manufacturing industry in the three provinces of Northeast China has shown an obvious upward trend. The upward trend is shown in Figure 1. Specifically, the growth rate is 44.9 percent, from 7 152.83 in 2013 to 12 974.54 in 2022. This growth trend reflects the continuous improvement of China's manufacturing capacity and the significant increase in the technical content of products, and the position of manufacturing products in the three Northeast provinces in the export market is increasingly

prominent. From the perspective of growth rate, the growth rate is constantly fluctuating, with the growth rate dropping to 2.61% in 2019, which may be affected by the new coronavirus outbreak. In 21 years, the growth rate rose sharply, as high as 23.17%. Compared with 2021, the technical complexity level of manufacturing exports in 2022 has not changed much, and the growth rate is relatively gentle. This shows that the competitiveness of the manufacturing industry in the three Northeast provinces continues to increase.

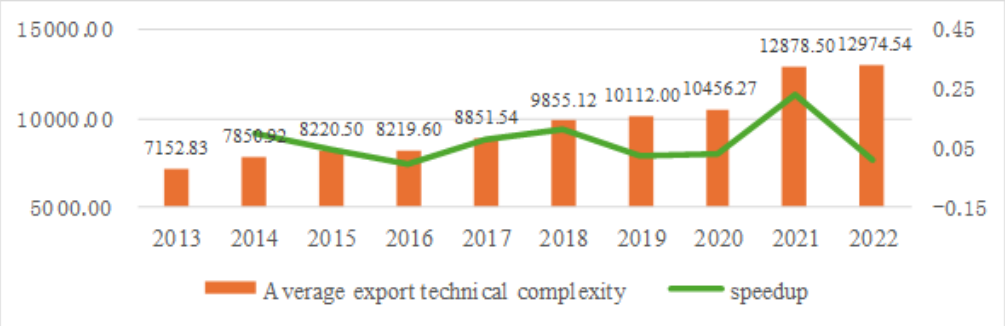

Figure 1: Average technological complexity and growth rate of manufacturing export in the three Northeast provinces from 2013 to 2022

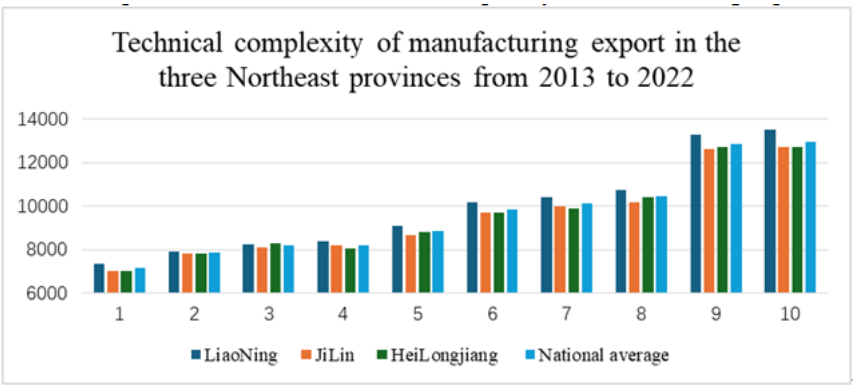

Figure 2: Comparison of the mean technical complexity of manufacturing exports in the three northeastern provinces and China from 2013 to 2022

Figure 2 shows the comparison of the average technical complexity of manufacturing exports between the three northeastern provinces and China. Among the three northeastern provinces, Liaoning maintains the lead, registering the highest level of technical complexity in manufacturing exports at 12,974.54 in 2022. The technical complexity of Liaoning's manufacturing exports has consistently exceeded the national average, with notable increases observed in 2021 and 2022. In contrast, Jilin and Heilongjiang provinces hold the last two positions, with their manufacturing export technical complexities below the national average, though the discrepancy is minimal. The aggregate technical complexity of manufacturing exports in the three eastern provinces is substantially lower than the national average. At the same time, despite the consecutive high-quality development of China's foreign trade, the pace of technological complexity advancement in Northeast China's manufacturing exports has fallen behind the national level progress.

4. The Problem of Technical Complexity of Export in Northeast China

A strong positive correlation exists between the technical complexity of manufacturing exports and economic development. The spatial distribution of this complexity aligns closely with the current status of economic development levels regionally. The technical sophistication of

manufacturing exports in Northeast China is substantially inferior to the national average. In comparison with more economically developed regions within China, the level of openness to the global market, the optimization of industrial structure, and the capacity for scientific and technological innovation among the three northeastern provinces are notably lower. The evolution of technical complexity in manufacturing exports within Northeast China has failed to keep pace with the rest of the nation.

4.1. Outstanding Industrial Structure Contradictions

The development of export trade in the three northeastern provinces was delayed, and its level of development remains inadequate. The export structure is relatively straight forward, dominated by low-technology, labor-intensive products, which contributes to the persistently low level of export technology. The industrial makeup of Northeast China is characterized by a lack of diversity, with traditional heavy industries predominant. Presently, the foreign trade commodities from the three northeastern provinces are predominantly composed of raw materials, primary processed goods, and labor-intensive products, whereas high-tech exports are scarce. Furthermore, the region is grappling with overcapacity, lacks a discernible growth trajectory, and exhibits a deficient capacity for innovation. Such a configuration of foreign trade commodities positions the three northeastern provinces at the lower rungs of the international labor division during a period of economic globalization. Concurrently, the import and export commodity structure of the three provinces exhibits marked convergence, a homogenization that while beneficial for leveraging regional comparative advantages, also precipitates low-level repetitive construction, inefficient resource allocation, heightened inter-regional vicious competition, and perpetuates the challenge of elevating the technical sophistication of manufacturing exports.

4.2. Low Technical Level of Export Products

In recent years, the pace of opening up in Northeast China has been sluggish, with a moderate level of integration into the international market. The regional openness structure is imbalanced, and there is a lack of harmony among trade, investment, logistics, and platforms, which hampers the revitalization and development driven by external engagement [3]. In terms of opening up in Northeast China, the majority of initiatives involve bilateral trade, primarily relying on traditional sectors such as agriculture, heavy industry, and manufacturing. The bulk energy products imported from Russia are seldom processed domestically, while the exports to Japan and South Korea are predominantly primary commodities, resulting in limited value addition to exported products. Traditional manufacturing is mostly exported through simplified assembly methods, such as processing of parts or semi-finished products, by small and medium-sized enterprises that lack independent core technology research and development capabilities, have short industrial chains, and produce low-value added goods, thus can not improve market competitiveness in foreign trade.

4.3. The Loss of High-end Talents and Weak Technology Research and Development Capability

The issue of brain drain in Northeast China remains severe, particularly the loss of scientific and technological achievements and innovative talents, posing a significant challenge to the old industrial base seeking transformation and development through innovation. High-end talents, equipped with profound professional knowledge and skills, are instrumental in promoting technology research, development, and application, as well as industrial upgrading. The outflow of such talents will decelerate the local industrial upgrading process, making it challenging for export

products to maintain or improve their technical standards. Consequently, this creates bottlenecks in the local manufacturing industry's technological innovation and product modernization, thereby affecting the complexity and competitiveness of export product.

5. Improve Export Technology Complex Countermeasures and Suggestions

The competitive pressure in the export market also forces enterprises to continuously improve their technical level and product competitiveness, and enhance the technical complexity of manufacturing exports to meet the needs of the international market. Therefore, in order to achieve the further development of foreign trade in the three Northeast provinces, the three Northeast provinces need to continue to optimize the industrial layout, strengthen scientific and technological innovation, and train and attract more highly skilled personnel.

5.1. Improve Weak Links in the Industrial Structure and Replace Old Growth Drivers with New Ones

The northeast region should accelerate the transformation and upgrading of traditional pillar industries to make up for the short board of development and continue to promote supply-side structural reform. Initially, it is crucial to eliminate obsolete production capabilities and concentrate on alleviating the issue of overcapacity in heavy industries such as energy、steel and chemicals within the established industrial bases [4]. Secondly, there should be a concentrated effort to endow traditional industries with “new” production capacities by integrating these sectors into a research and development and industrial ecosystem that fosters key equipment manufacturing enterprises critical to national security. Thirdly, the fusion of informatization and industrialization should be promoted: harnessing cutting-edge information technologies, including the Internet of Things, big data, artificial intelligence, and cloud computing, to transform and modernize traditional industries, thereby achieving intelligent, networked, and digitalized production processes.

5.2. Increase Support for Technological Innovation and Improve the Technical Content and Added Value of Products.

Through policy incentives and financial support, enterprises are encouraged to invest in research and development, such as formulating preferential policies, promoting intellectual property protection, and implementing innovation-driven development strategies [5]. The production department should accelerate the pace of technological innovation, improve the technical content and added value of products. And then enhance the technical complexity of export and enhance the international competitiveness of regional economy.

5.3. Cultivate and Attract more Highly Skilled Personnel

To address the issue of brain drain in the three northeastern provinces, it is imperative to incentivize technological innovation and attract a pool of talents. By augmenting investments in higher and vocational education, the objective is to foster high-caliber individuals who are adept at navigating the demands of the high-tech sector. Favorable policies, coupled with financial subsidies, are essential in luring both domestic and international high-end talent to engage in professional and entrepreneurial activities within the three northeastern provinces. This is to be achieved by integrating and optimizing the educational and training resources in the region, with a particular focus on the specialized training programs for skilled personnel. To remain competitive, it is crucial to offer attractive packages including improved welfare benefits and advancement opportunities to

entice and retain outstanding recent graduates, as well as to draw external high-end talents.

6. Conclusion

An analysis based on the measurement of manufacturing export technology complexity from 2013 to 2022 in the three northeastern provinces reveals a consistent upward trajectory. Although the overall trend is positive, the three provinces continue to grapple with challenges in the transition and upgrading of the manufacturing sector, including stark contradictions in the industrial structure, the moderate level of exported products, and the outflow of high-end talent. Consequently, for sustainable development, the three Northeast provinces are called upon to refine their industrial structure, foster the transformation of traditional and emerging drivers, and enhance support for technological innovation to elevate the technological content and added value of their products. Moreover, there is a pressing need to cultivate and attract a greater number of highly skilled individuals. To sum up, in the future, the three Northeast provinces need to continue to adhere to the high-quality development path to maintain and enhance their competitiveness in the international market.

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