

Comprehensive Evaluation and Influencing Factor Analysis of High-quality Foreign Trade Development in Four Municipalities based on Entropy Weight TOPSIS Grey Correlation Degree

Jing Yan^{1,*}, Liugu Zhou¹, Chenyang Dang¹, Tengfei Wu²

¹ School of International Trade and Economics, Anhui University of Finance and Economics, Bengbu 233030, China

² School of Accountancy, Anhui University of Finance and Economics, Bengbu 233030, China

*Corresponding Author e-mail: 3223605291@qq.com

Abstract

In recent years, with the rise of protectionism, global inflation, and the return of mid to high end manufacturing industries, the growth rate of China's foreign trade scale has been continuously slowing down. Moreover, due to the proposal of "dual circulation", the transformation and upgrading of China's foreign trade is urgent. Therefore, this article integrates existing research and selects five dimensions: innovative development, structural optimization, sustainability, open development, and shared development to construct a comprehensive evaluation index system for the high-quality development level of foreign trade, which includes 19 evaluation indicators. By using the TOPSIS model based on entropy weight approximation ideal solution ranking model, the high-quality development level of foreign trade in the four municipalities directly under the central government is measured, And use the grey correlation degree model to measure the grey correlation degree of various indicators, analyze the key factors affecting the high-quality development of foreign trade, and provide theoretical support and policy recommendations for the high-quality development of foreign trade in the four municipalities directly under the central government.

Keywords

High-quality Development of Foreign Trade; Entropy Weight TOPSIS; Grey Correlation Degree; Influence Factor.

1. Introduction

This study has important theoretical significance and practical value for achieving high-quality development of foreign trade. On the one hand, with the rise of trade protectionism in the United States and Europe, the return of high-end manufacturing industries, and the diversion of low-end manufacturing industries in underdeveloped countries, the growth rate of China's foreign trade scale continues to slow down. Under the new international situation and the background of "dual circulation", it is imperative for China to transform and upgrade its foreign trade. On the other hand, domestic and foreign scholars have made beneficial explorations in evaluating the high-quality development of foreign trade, but the current research is mainly based on the overall national level, and there are significant differences in the advantages, levels, and levels of foreign trade development among different regions in China. Therefore, this project research will be based on the four major municipalities directly under the central government, scientifically measuring the high-quality development level of foreign trade in each city, rigorously analyzing its spatiotemporal evolution characteristics and main influencing factors, in order to promote the transformation and upgrading of China's foreign

trade from "increment" to "improvement". After studying a large number of relevant literature, it is summarized that the existing research mainly focuses on the following two aspects.

Firstly, research on the connotation of high-quality development in foreign trade. The precise definition of connotation is not only the first priority for foreign trade to move towards high-quality development, but also the primary prerequisite for scholars to conduct in-depth research on the path of high-quality foreign trade development. Ma Linjing based on the new development concept proposed at the Fifth Plenary Session of the 18th Central Committee of the Communist Party of China, divided the theoretical connotation of high-quality development of foreign trade into five fundamental aspects, namely: having the ability to optimize a healthy development structure, achieve a stable and stable development pattern, maintain a continuous and sustained development momentum, create a high-level development model of opening up to the outside world, and uphold the development concept of inclusive sharing[1]. From the perspective of the main social contradictions, Wang Xicheng defines high-quality development as the improvement of resource efficiency, the optimization of supply system quality and stability, taking into account the transition from total quantity to structure[2]. Jinbei, is based on economic theory and believes that the intrinsic essence of high-quality development is driven by the pursuit of higher quality under certain qualitative conditions, more systematic cultivation of competitiveness, more practical and distinctive practices, and more efficient and green ways to meet the growing needs of the people[3].

The second is the measurement and evaluation of foreign trade quality. The quality of foreign trade can be studied from both macro and micro perspectives. From a micro perspective, the quality of foreign trade can be understood as the quality of products in import and export trade. Scholars such as Khandelwal, Szczygielski&Grabowski, Liao, etc. mainly use the unit value method, income weighted index method, and a combination of price and quantity methods to measure and evaluate[4-6]. From a macro perspective, the quality of foreign trade is the evaluation of the level of foreign trade development. To comprehensively and accurately measure the high-quality development level of foreign trade, digital scholars construct a comprehensive evaluation index system based on multiple dimensions, and use subjective or objective assignment methods to measure and analyze the high-quality development level of foreign trade in provinces or regions. Zhang Jincan et al. constructed an evaluation index system based on the five new development concepts, used entropy method for measurement, and comprehensively used kernel density function, spatial correlation analysis, Dagum Gini coefficient and its decomposition and spatial convergence model to analyze the spatiotemporal evolution characteristics of China's high-quality foreign trade development level[7]. Hu Zhangting used an indicator system covering five aspects, including trade scale, trade sustainability, and trade openness, to measure and rank the quality of trade development in Tianjin, Fujian, and Guangdong provinces using the entropy method[8]. Zhang Yue takes Jiangsu Province as the research object, evaluates and analyzes the quality of foreign trade development in the province using the grey correlation method, and proposes countermeasures and suggestions based on this [9]. Wang Wei focuses on building an indicator system from the five dimensions of innovation, coordination, green, openness, and sharing, and uses Analytic Hierarchy Process and Efficiency Coefficient Method to measure the high-quality economic development index of major provinces in China[10].

In summary, most existing literature defines the level of high-quality foreign trade development based on the new development concept, and constructs an evaluation index system based on it. The entropy method is used to measure the comprehensive index, and then the spatiotemporal evolution characteristics are analyzed and summarized. Therefore, this article integrates existing research and selects five dimensions of innovative development, structural optimization, sustainability, open development, and shared development to design a comprehensive evaluation index system. With the TOPSIS model based on entropy weight

approximation, the high-quality development level of foreign trade in the four major municipalities is measured. The grey correlation model is used to analyze the key factors affecting the high-quality development of foreign trade, Thus providing theoretical support and policy recommendations for the high-quality development of foreign trade in the four major municipalities directly under the central government.

2. Methodology

2.1. Variable Selection

Based on the new development concept, this article divides the high-quality development level of foreign trade into five subsystems: innovative development, structural optimization, sustainability, openness to the outside world, and welfare sharing. Based on this, a comprehensive evaluation index system is constructed, which includes dimension layer, element layer, and indicator layer. Innovative development is the driving force behind high-quality foreign trade development. This article evaluates the innovation driven development capabilities of the four municipalities through the input costs and output results of innovative elements. Structural optimization is closely related to the quality and efficiency of foreign trade development. This article examines the foreign trade structure of the four municipalities from three perspectives: import and export structure, mode structure, and main structure. Sustainability represents the degree to which regional resources and environment are affected by foreign trade, and is an important guarantee for high-quality development of foreign trade. This article mainly measures the sustainable development level of the four municipalities from three aspects: energy consumption, environmental protection investment, and pollution emissions. Opening up to the outside world, as a basic national policy of China, is an inevitable requirement for high-quality development of foreign trade. This article measures the degree of opening up to the outside world using three major factors: export dependence, import dependence, and foreign investment dependence. Welfare sharing is related to whether the achievements of foreign trade development benefit the whole nation. This article selects economic development, employment promotion, and quality of life to examine the social benefits of foreign trade development. The evaluation index system for the high-quality development level of foreign trade in the four major municipalities constructed in this article is shown in Table 1.

The data related to the high-quality development level of foreign trade in the four major municipalities directly under the central government mainly comes from the 2007-2020 Beijing Statistical Yearbook, Tianjin Statistical Yearbook, Shanghai Statistical Yearbook, and Chongqing Statistical Yearbook. The high-tech related data is obtained from EPS global statistical data and China Economic Network. During the data compilation process, for the missing annual data of wastewater and waste, the annual average growth rate was selected to supplement.

2.2. Entropy Weighted TOPSIS Model

(1) Data standardization. Indicators can be divided into positive indicators and negative indicators, with the former being the larger the better indicator and the latter being the smaller the better indicator. Standardize two types of indicators using the range standardization method as follows:

$$\varepsilon_{ij} = \frac{x_{ij} - \min(x_i)}{\max(x_i) - \min(x_i)} \quad \varepsilon_{ij}' = \frac{\max(x_i) - x_{ij}}{\max(x_i) - \min(x_{ij})} \quad (1)$$

Wherein, ε_{ij} ($i = 1, 2, \dots, n; j = 1, 2, \dots, m$) represents the standardized value of the j evaluation index for the i evaluation object.

(2) Determine indicator weights. Considering the considerations of scientificity and accuracy, the entropy weight method is used to determine the weights as follows:

$$\omega_j = \frac{1 - H_i}{n - \sum_{i=1}^n H_i} \tag{2}$$

Wherein, H_i is information entropy, and $H_i = -\frac{1}{\ln m} \sum_{j=1}^m f_{ij} \cdot \ln f_{ij}$, $f_{ij} = \frac{\varepsilon_{ij}}{\sum_{j=1}^m \varepsilon_{ij}}$.

(3) Construct a weighted decision matrix. To meet the requirements of objectivity, the indicator weights are adjusted ω_j introduce decision matrix:

$$B = (b_{ij})_{n \times m} \tag{3}$$

Wherein, $b_{ij} = \omega_j \times \varepsilon_{ij}$.

(4) Determine positive and negative ideal solutions. Calculate the positive and negative ideal solutions X^+ and X^- based on the weighted decision matrix, using the following formula:

$$\begin{aligned} X^+ &= (\max\{b_{11}, b_{21}, \dots, b_{i1}\}, \max\{b_{12}, b_{22}, \dots, b_{i2}\}, \dots, \max\{b_{1j}, b_{2j}, \dots, b_{ij}\}) \\ &= (X_1^+, X_2^+, \dots, X_j^+) \end{aligned} \tag{4}$$

$$\begin{aligned} X^- &= (\min\{b_{11}, b_{21}, \dots, b_{i1}\}, \min\{b_{12}, b_{22}, \dots, b_{i2}\}, \dots, \min\{b_{1j}, b_{2j}, \dots, b_{ij}\}) \\ &= (X_1^-, X_2^-, \dots, X_j^-) \end{aligned} \tag{5}$$

(5) Calculate the distance. Using the Euclidean distance formula, calculate the Euclidean distance S from the high-quality development level of foreign trade in each city to the positive and negative ideal solution S_i^+ and S_i^- :

$$S_i^+ = \sqrt{\sum_{j=1}^m (X_j^+ - b_{ij})^2} \tag{6}$$

$$S_i^- = \sqrt{\sum_{j=1}^m (X_j^- - b_{ij})^2} \tag{7}$$

(6) Calculate the overall score. Calculate the relative closeness K of the high-quality development level of foreign trade in each K_i . The comprehensive evaluation score is obtained:

$$K_i = \frac{S_i^-}{S_i^+ + S_i^-} \tag{8}$$

2.3. Grey Correlation Degree Model

This article uses a grey correlation model to quantify the degree of impact of various indicators on the high-quality development level of foreign trade in the four municipalities directly under the central government. By ranking the obtained correlation degrees, the most critical influencing factors are identified. The specific calculation formula is as follows:

(1) Non dimensional processing. This article initializes variables by dividing the data of each sequence by the initial value of that column.

(2) Calculate the grey correlation coefficient. The calculation formula is as follows:

$$\xi_i(k) = \frac{\min_i \min_k |x_0(k) - x_i(k)| + \rho \cdot \max_i \max_k |x_0(k) - x_i(k)|}{|x_0(k) - x_i(k)| + \rho \cdot \max_i \max_k |x_0(k) - x_i(k)|} \quad (9)$$

Among them, $x_0(k)$ is a reference sequence, referring to the high-quality development level of foreign trade; $x_i(k)$ is a comparative sequence, which refers to the indicator value that affects the high-quality development level of foreign trade; $\rho \in [0,1]$ is the resolution coefficient, and in this paper, the median is taken as 0.5; $k = 1, 2, \dots, n$; $i = 1, 2, \dots, n$.

(3) Calculate the correlation degree based on the grey correlation coefficient. The calculation formula is:

$$\varphi_i = \frac{1}{n} \sum_{k=1}^n \xi_i(k) \quad (k = 1, 2, \dots, n) \quad (10)$$

3. The Empirical Results

3.1. Comprehensive Score Evaluation

Using the above methods to process the obtained data, this paper calculates the weight of each indicator in the comprehensive evaluation index system of high-quality foreign trade development of four municipalities from 2007 to 2020 (Table 1) and the comprehensive evaluation score line chart (Figure 1).

On the overall level, the high-quality development level of foreign trade in the four major municipalities is gradually approaching. In the early stage, it was manifested as uneven development among regions, while in the later stage, Tianjin and Chongqing saw strong growth, significantly narrowing the gap in high-quality development of foreign trade between regions.

At the regional level, considering that the new development concept was proposed in 2015, this article uses 2015 as a reference point to divide the high-quality development of foreign trade in the four municipalities into two stages. In the first stage (before 2015), due to the gradual recovery of China's foreign trade after the impact of the financial crisis, the high-quality development level of foreign trade in the three municipalities directly under the central government, Beijing, Tianjin, and Shanghai, showed a fluctuating state. Compared to Chongqing, which has a lower level of foreign trade compared to the other three major cities, the conflict between the growth of foreign trade openness and the decline of sustainability level may be due to the latter being stronger, and its high-quality development level of foreign trade continues to decline. In the second stage (after 2015), the proposal of the new development concept received a positive response. In the process of actively implementing this concept, the four municipalities directly under the central government will inevitably make certain breakthroughs in innovative development, structural optimization, sustainability, opening up to the outside world, and welfare sharing. However, due to the differences in resource endowment, geographical location, ecological environment, and other aspects among the four

cities, as well as the imbalanced and insufficient development within the municipalities, It is natural for the high-quality development level of the four municipalities to experience a decline in the early stages of transformation and upgrading, while the steady increase in the later stage will be a natural accumulation and precipitation in the early stage. From this, observing Figure 1, it is not difficult to find that the downward trend of Tianjin and Chongqing, two major municipalities directly under the central government, has reversed with 2018 as the turning point, and entered a positive transformation stage after 2018. However, the high-quality development level of Beijing and Shanghai, two major municipalities directly under the central government, is still fluctuating, indicating that the two cities should be in the early stage of adjustment, but the successful transformation and upgrading of the two cities in the later stage is also foreseeable.

Table 1. Weights of various indicators for high-quality development of foreign trade in the four major municipalities directly under the central government

Dimension layer	Element layer	Indicator layer	Indicator layer weight	Dimension layer weight
Innovation-driven development	Innovation investment	R&D funding intensity C1	0.084	0.269
		Proportion of scientific expenditure C2	0.070	
	Innovation achievements	Number of patent applications authorized per 10000 people C3	0.080	
		Proportion of high-tech product exports C4	0.035	
Structural optimization	Difference optimization	Absolute value of import and export trade balance C5	0.039	0.229
	Method optimization	Proportion of general trade imports and exports C6	0.090	
	Subject optimization	Export proportion of foreign-funded enterprises C7	0.100	
Sustainability	Energy consumption	Unit export energy consumption C8	0.016	0.120
	Environmental protection investment	Proportion of energy conservation and environmental protection expenditure C9	0.061	
		Pollution discharge	Discharge of "wastewater" per unit export amount C10	
	Unit export sulfur dioxide emissions C11		0.015	
	Unit export volume "waste" emissions C12		0.013	
Opening up to the outside world	Export dependence	Export Dependency C13	0.066	0.197
	Import dependency	Import Dependence C14	0.078	
	Foreign investment dependence	foreign capital dependence C15	0.053	
Benefit sharing	economic development	Contribution rate of foreign trade to GDP C16	0.026	0.185
		The pull of foreign trade on GDP C17	0.018	
	Employment driven	The Contribution of Trade to Promoting Employment C18	0.068	
	Improving quality of life	Trade affects people's material life C19	0.073	

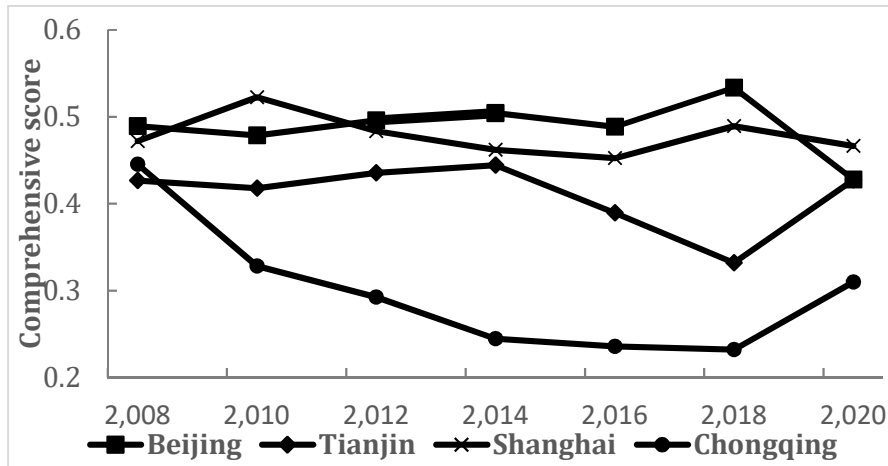


Figure 1. Comprehensive Evaluation Results of the High Quality Development Level of Foreign Trade in Four Major Municipalities from 2007 to 2020

3.2. Index Layer Correlation Analysis

To further explore the underlying reasons for the fluctuations in the high-quality development level of foreign trade in the four municipalities directly under the central government, this article uses the grey correlation method to calculate the grey correlation degree between the indicator layer and the high-quality development level of foreign trade. According to formulas (9) to (10), the calculation results are shown in Table 2.

Table 2. Calculation results of the correlation degree of evaluation indicators for the high-quality development level of foreign trade in the four major municipalities directly under the central government

Indicator layer	Bei jing		Tian jin		Shang hai		Chong qing	
C1	0.993	1	0.995	12	0.973	6	0.947	8
C2	0.988	2	0.998	6	0.991	2	0.976	3
C3	0.772	18	0.962	16	0.917	15	0.759	17
C4	0.977	4	0.999	1	0.995	1	0.604	18
C5	0.877	15	0.969	15	0.635	19	0.595	19
C6	0.965	9	0.999	4	0.987	4	0.99	1
C7	0.961	10	0.986	14	0.988	3	0.857	14
C8	0.954	11	0.998	7	0.971	8	0.973	4
C9	0.844	17	0.955	18	0.904	16	0.977	2
C10	0.98	3	0.997	9	0.968	10	0.961	7
C11	0.929	14	0.995	11	0.933	14	0.961	6
C12	0.949	12	0.997	8	0.966	11	0.97	5
C13	0.945	13	0.996	10	0.958	13	0.905	13
C14	0.971	6	0.999	3	0.97	9	0.934	9
C15	0.971	7	0.995	13	0.98	5	0.907	12
C16	0.734	19	0.955	17	0.792	18	0.775	16
C17	0.864	16	0.642	19	0.864	17	0.826	15
C18	0.977	5	0.999	2	0.973	7	0.908	11
C19	0.965	8	0.998	5	0.959	12	0.934	10

Rank the grey correlation between 19 evaluation indicators and the high-quality development level of foreign trade in various cities. Among them, the main influencing indicators for Beijing are C1 (R&D investment intensity), C2 (scientific expenditure proportion), and C10 (unit export wastewater discharge); The main impact indicators of Tianjin are C4 (proportion of high-tech product exports), C18 (contribution of trade to employment promotion), and C14 (import dependence); The main influencing factors in Shanghai are C4 (proportion of high-tech product exports), C2 (proportion of scientific expenditure), and C7 (proportion of foreign enterprise exports); The main impact indicators of Chongqing are C6 (proportion of general trade imports and exports), C9 (proportion of energy conservation and environmental protection expenditure), and C2 (proportion of scientific expenditure). From this, it can be seen that the factors that affect the high-quality development of foreign trade vary among different municipalities. Therefore, each municipality should formulate effective plans based on its main influencing factors and implement targeted policies.

4. Conclusions and Recommendations

This article constructs a comprehensive evaluation index system from five dimensions: innovative development, structural optimization, sustainability, openness to the outside world, and welfare sharing. The entropy weighted TOPSIS method is used to measure the high-quality development level of foreign trade in four major municipalities from 2007 to 2020, and the grey correlation model is used to explore the influencing factors of foreign trade quality. The conclusions and suggestions are as follows:

4.1. Vertical Time Dimension Analysis.

The high-quality development level of foreign trade in the four major municipalities shows a trend of catching up with each other and gradually approaching. In the early stage, it was manifested as uneven development among regions. In the later stage, the proposal and effective implementation of new development concepts led to strong growth trends in Tianjin and Chongqing. As a result, the gap in high-quality development of foreign trade among the four municipalities has significantly narrowed. However, taking the average of the comprehensive scores of the high-quality development level of foreign trade in the four municipalities in 2020, the average value obtained is 0.4079, which is at a relatively low level. Therefore, there is still significant room and potential for improvement in the overall high-quality development level of foreign trade in the four municipalities. The road to high-quality transformation and upgrading of foreign trade is a long and arduous one. Everything is based on ideals, and implementation is the result. The fruits of high-quality development cannot be separated from the complete, accurate, and comprehensive implementation of the new development concept. The four major municipalities directly under the central government should actively explore how to translate strategic guidance into effective concrete measures. To this end, the evaluation index system for the high-quality development level of foreign trade can be used as a theoretical reference, starting from the five dimensions of innovative development, structural optimization, sustainability, opening up to the outside world, and welfare sharing, to formulate and implement a comprehensive development plan and policy system to promote the high-quality quantification of foreign trade in the four municipalities directly under the central government.

4.2. Analysis of the Correlation Degree of Each Indicator.

Grasping the top priority of high-quality development in foreign trade is crucial for transformation and upgrading. Therefore, by analyzing the correlation between various indicators, it can be concluded that the main influencing indicators in Beijing are C1 (R&D expenditure intensity), C2 (scientific expenditure proportion), and C10 (unit export wastewater discharge); The main impact indicators of Tianjin are C4 (proportion of high-tech

product exports), C18 (contribution of trade to employment promotion), and C14 (import dependence); The main influencing factors in Shanghai are C4 (proportion of high-tech product exports), C2 (proportion of scientific expenditure), and C7 (proportion of foreign enterprise exports); The main impact indicators of Chongqing are C6 (proportion of general trade imports and exports), C9 (proportion of energy conservation and environmental protection expenditure), and C2 (proportion of scientific expenditure). Therefore, each municipality should formulate effective plans based on their main influencing factors and implement targeted policies.

Acknowledgments

Supported by Anhui University of Finance and Economics Undergraduate Scientific Research and Innovation Fund Project (XSKY23109).

References

- [1] Ma Linjing. High quality development of foreign trade: connotation, path, and countermeasures [J]. *Modern Economic Exploration*, 2020, No. 463 (07): 84-91.
- [2] Wang Xicheng On the Path and Focus of Promoting High Quality Development [J]. *Henan Social Sciences*, 2018,26 (09): 1-6.
- [3] Jinbei Economic Research on "High Quality Development" [J]. *China Industrial Economy*, 2018, No.361 (04): 5-18.
- [4] Amit Khandelwal. The Long and Short of Quality Ladders. *Review of Economic Studies* [J], 2011, 77(4):1450-1476.
- [5] Szczygielski K, Grabowski W . Are Unit Export Values Correct Measures of the Exports' Quality? [J]. *Economic Modelling*, 2011, 29(4):1189-1196.
- [6] Liao C H. Measuring Quality in International Trade [J]. *Economic Systems*, 2011, 35(1):125-138.
- [7] Zhang Jincan, Deng Yunjie, Zhang Juntao. Measurement and spatiotemporal evolution characteristics of high-quality development of China's foreign trade [J]. *Business Economics Research*, 2023, No.861 (02): 128-131.
- [8] Hu Zhangting, Huang Zhengsong. Measurement and Evaluation of the High Quality Development Level of Trade in Tianjin, Fujian, and Guangdong Provinces [J]. *Foreign Trade and Economic Cooperation*, 2022, No.340 (10): 62-65.
- [9] Zhang Yue. Analysis of the Quality of Foreign Trade in Jiangsu Province from the Perspective of High Quality Development [J]. *Jiangsu Business Review*, 2023, No. 461 (03): 52-54.
- [10] Wang Wei. Measurement and Evaluation of High Quality Development of China's Economy [J]. *East China Economic Management*, 2020,34 (06): 1-9.