Cluster Analysis on the High Quality Development of Foreign Trade in Guangdong-Hong Kong-Macao Greater Bay Area

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Abstract-Based on the foreign trade development data of 11 regions in the Guangdong-Hong Kong-Macao Greater Bay Area in 2018, to establish a system of indicators for high-quality development of foreign trade. Combining the elbow rule and contour coefficient method, the foreign trade quality classification of 11 regions is obtained, and the k-means clustering algorithm is used to classify the high-quality development level of foreign trade in 11 regions. The differences in the high-quality development of foreign trade in 11 regions of the Guangdong-Hong Kong-Macao Greater Bay Area are studied, and the reasons for the differences are analyzed and appropriate suggestions are given.

Keyword-Guangdong-Hong Kong-Macao Greater Bay Area; High-quality development of foreign trade; cluster analysis

1 INTRODUCTION

China's foreign trade has developed by leaps and bounds since reform and opening up, but there are a series of quality problems. Compared with developed countries, China's foreign trade has only achieved quantitative growth, contributing less to economic development. China's development has entered a new historical juncture, shifting from a stage of high-speed growth to one of high-quality development, transforming its economic structure and driving forces for growth. As an important part of the national economy, foreign trade should be involved in the high-quality development.

The Central Committee of the Communist Party of China (CPC) has clearly defined the guiding ideology and strategic positioning of the Guangdong-Hong Kong-Macao Greater Bay Area since the official issuance of the it's Development launched. It is particularly important to promote the integrated development of the City cluster in the Guangdong-Hong Kong-Macao Greater Bay Area, make use of the unique advantages of Hong Kong and Macao, to enhance the country's economic development and open the international market. Guangdong, Hong Kong and Macao must realize the transformation of foreign trade development mode as soon as possible, and achieve high-quality foreign trade development, which is conducive to China's integration into the global market system. This paper establishes a set of scientific index system

to evaluate the development quality of foreign trade, using cluster analysis method to systematically classify the foreign trade development quality of 11 regions in the Guangdong-Hong Kong-Macao Greater Bay Area. This is conducive to exploring the problems existing in the quality of foreign trade development in the Guangdong-Hong Kong-Macao Greater Bay Area and putting forward reasonable suggestions.

2 LITERATURE REVIEW.

In the early years, scholars generally studied the development quality of foreign trade. However, in recent years, with the proposal of the concept of high-quality development, more scholars began to study the high-quality development of foreign trade, mainly focusing on the connotation, evaluation and path of high-quality development. Pan Yongyuan (2002)[1] put forward the concept of foreign trade quality for the first time, summarized the connotation, role and evaluation criteria of foreign trade quality, and analyzed the development quality of China's foreign trade through relevant data. Yu Zhijun and Jiang Wanjun (2013)[4] improved the connotation of foreign trade quality, pointed out that foreign trade quality is the role and effect of foreign trade on national economy and social development, and analyzed the situation of China's foreign trade quality from static and dynamic aspects. Geng Wei (2014)[6] used the econometric model to analyze the influence of factor market distortion on trade breadth and trade quality. The research shows that the trade gap between China's provinces is mainly in the quantity of trade, but not in the breadth and quality of trade, and points out that reducing factor market distortion can improve the quality of trade in China. By using the principal component analysis method, Huang Yiming (2015)[7] made a comprehensive evaluation and analysis of the high-quality development of Chongqing's foreign trade. His study showed that the development level and the quality of Chongqing's foreign trade had been constantly improved from 1997 to 2003. Qu Weixi, Cui Yanxin et al. (2019) evaluated the high-quality development level of China's foreign trade by using five indicators including the foundation, optimization, competitive position, integrated services status of foreign trade and international economic and trade rules. She has built a high-quality foreign trade development system in line with the concepts of "innovation, coordination, green, openness and sharing". Ruifeng wang, Lishuang(2019)points out that under the background of sino-us trade friction, related support industry and industry competition have an important influence on the development of Chinese foreign trade quality. She thinks that China should seize the opportunity to enhance international competitiveness, focus on the development of foreign trade related industries and supportive industry to actively promote foreign trade development with high quality. Ma Linjing (2020)[10] systematically summarizes the connotation, path and policy measures of high-quality development of foreign trade.

Through literature review, it is found that scholars have not yet established a scientific and effective index system, resulting in the lack of comparability of research conclusions. In addition, scholars' research on high-quality development focuses on the national macro level, but less on the mesoscopic and micro levels. Taking the Guangdong-Hong Kong-Macao Greater Bay Area as the research object, this paper establishes a scientific and reasonable indicator system with provincial characteristics, which can improve the research on the high-quality development of foreign trade at the medium level. This is of great practical significance for the

local government to implement the main strategies and promote the high-quality development of foreign trade in the Guangdong-Hong Kong-Macao Greater Bay Area.

3 CONNOTATION

Since the 18th National Congress of the Communist Party of China (CPC), China's economic development mode has changed from extensive growth mode to high-efficiency and high-quality growth mode. The development of foreign trade has also been changed to a certain extent, from focusing on the scale of foreign trade base to focusing on the high-quality development of foreign trade. The fifth Plenary Session of the 18th CPC Central Committee proposed the need to build a new development concept in line with "innovation, coordination, green, open and sharing". Guided by the new development concept, the connotation of high-quality development of China's foreign trade is rich and diversified. It basically in the following five aspects.

3.1 Better Development Structure

Having a high-quality, reasonable and more optimized foreign trade development structure is the first condition for the high-quality development of foreign trade, which is mainly reflected in three aspects. Firstly, the trade mode is more optimized. Secondly, the commodity structure of foreign trade is more optimized. Thirdly, the industrial structure was further optimized.

3.2 Achieve a More Balanced Development Pattern

The more balanced development pattern means that the trade development of different regions in China is more balanced and the international market abroad is more diversified. That is, the multiple balance between the domestic market and the foreign market. Actively exploring new industrial markets and reducing dependence on traditional markets will help promote high-quality development of foreign trade and create a more balanced pattern of domestic and foreign market development.

3.3 Sustained Sevelopment Momentum.

In essence, high-quality development is to obtain more efficient economic and social benefits with the least production input and the lowest cost of resources and environment. High-quality development is a concept of sustainable development. As the name implies, the high-quality development of foreign trade is to have sustainable growth power to achieve efficient sustainable development. At present, China proposes to take innovation as the driving force for economic growth and realize the development requirement of replacing old growth drivers with new ones.

3.4 To Pursue a More Open Model of Development.

Over the past 40 years of reform and opening up, China has continuously promoted the breadth and depth of opening up, deepened the international division of labor system and the international economic and trade system, and its status in the international economic and trade rules has been rising, from the former "follower" to the current "leader". Practice has proved that continuous opening up is one of the important conditions for the rapid growth of China's foreign trade in the past decades. However, no matter in terms of trade in goods or services,

there is no end to opening-up. A more open foreign trade market and environment must be established in order to better integrate into the international market and reduce the impact of trade protectionism on China's foreign trade development.

3.5 To Pursue More Inclusive Development.

In order to achieve sustainable and high-quality development in the fierce international competition, China's foreign trade concept of more inclusive development is mainly reflected in two aspects as follows. First of all, the opening of a country's domestic market is conducive to the sustainable development of international trade, the circulation of global resources and the promotion of world productivity, sharing, inclusive trade development concept provides a broader trade market and trade space for all countries in the world, but also promotes the more balanced and stable development of domestic trade. However, trade protectionism hinders the circulation of global factors of production and leads to the risk of shrinking and stagnation of international trade, which is not only bad for the development of global trade, but also a potential threat to domestic trade. Secondly, we need to provide more international public goods. Providing more international public goods can strengthen China's voice in international trade rules, and also help speed up China's transformation from a trading power to a trading power.

4 INDICATION SYSTEM

In order to build a great modern socialist country, high-quality development of foreign trade refers to more efficient, more balanced and more sustainable development, so it is necessary to build in line with the concept of "innovation, coordination, green, open, sharing" high-quality development index system of foreign trade. In this paper, based on the principle of scientific, comprehensive, feasibility and gradation, according to the quality of foreign trade development target, from the foreign trade development foundation, the optimization of foreign trade and foreign trade structure and foreign trade have benefit from four aspects, build 4 first-level indicators, which covers 14 secondary indicators, 29 three-level indicators, as shown in table 1.

TABLE I. THE INDICATION SYSTEM

The First-level Indicators	The First-level Indicators	The Third-level Indicators	Units
Foreign Trade Foundation	Foreign Trade Competitiveness	Trade Competitive Index	-
		TC Index of High-tech Products	-
	Industrial Structure	Proportion of Output Value of Secondary Industry	%
		Proportion of Output Value of Tertiary Industry	%
	Scientific and Technological Innovation	R&D Investment as Proportion of GDP	%
	Economic Foundation	GDP	Mil

The First-level Indicators	The First-level Indicators	The Third-level Indicators	Units
Foreign Trade Optimization Indicators	Scale Index	Gross Export	Mil
		Gross Import	Mil
		The Total Net	Mil
	Velocity Index	Growth Rate of Export	%
		Growth Rate of Import	%
		Growth Rate of Import and Export	%
	Stability Index	Volatility of Export Growth	%
		Volatility of Import Growth	%
	New Driving Force for Trade Development	Proportion of Cross-border E-commerce Exports	%
		Actual Foreign Direct Investment	Mil
Structural Indicators of Foreign Trade	Structure of Commodity	Proportion of Mechanical and Electrical Products Exported	%
		Proportion of High-tech Products Exported	%
	Structure of Trade Subject	Proportion of Exports of Foreign-funded Enterprises	%
		Share of Domestic Enterprises' Exports	%
	The Structure of Trade Patterns	Share of General Trade Exports	%
		Proportion of Processing Trade Exports	%
Foreign trade efficiency indicators	Economic Benefit Index	Export Marginal Propensity	-
		Import Marginal Propensity	-
	Social Benefit Index	Degree of Dependence upon Foreign Trade	%
		Foreign trade Contributes to Employment	%
	Ecological Benefit Index	Industrial Emission Intensity of Export	-
		Industrial Wastewater Discharge Intensity of Export	-
		Industrial Waste Emission Intensity of Export	-

5 CLUSTER ANALYSIS

Cluster analysis is an important data analysis tool in data mining technology. The principle of cluster analysis is to divide several transactions into several categories according to some standard rules, among which those with similar properties are classified into one category. In this paper, elbow rule and contour coefficient method are combined to determine the optimal number of clusters. Elbow rule is first used to estimate the number of clusters, and then contour coefficient method is used to determine the final number of clusters.

5.1 Data Sources and Processing

This paper takes 9 cities and 2 special administrative zones involved in the Guangdong-Hong Kong-Macao Greater Bay Area as research objects. The sample year is 2018. All data come from the Statistical Yearbook of Guangdong Province in 2019, the statistical yearbook of prefectural cities and the Statistical Bulletin of National Economic and Social Development, the Statistics Bureau of Hong Kong and the Bureau of Statistics and Census of Macao.

There are positive and negative effects in 29 tertiary indicators, that is, the positive and negative effects of each indicator on the high quality development level of foreign trade. In order to avoid the uncertain influence of inverse indexes on the results, all inverse indexes in the data set were taken as opposite values.

5.2 Introduction to Clustering Algorithm

Elbow rule, also known as intra-cluster error variance (SSE), is calculated as follows:

$$\text{SSE} = \sum_{i=1}^{k} \sum_{pec_i} |p - m\_i|^2 \tag{1}$$

Where, c_i represents the ith cluster, p is the sample point in c_i, m_i is the center point in c_i, p-m_i is the distance from the sample point to the center point. The first sum is the sum of the distances from all sample points in the ith cluster to the center point, and the last sum is the sum of the distances from all sample points in all clusters to the center point.

In the elbow rule, the larger the k value, that is, the more classifications, the smaller the SSE and the smaller the error. If k value is large enough, the resulting SSE is infinitely close to 0. However, in reality, it is impossible to achieve a sufficiently large k value, so as long as the error can be taken to a reasonable value, that is, the slope of SSE decline does not significantly change the k value of small.

Contour coefficient method is a kind of hierarchical clustering algorithm, which aims to improve the efficiency of hierarchical clustering. The contour coefficient quantifies the similarity between any object in the data set and other objects in the cluster as well as the similarity between the object and objects in other clusters, and combines the two similarity after quantization in some form to obtain the evaluation standard of clustering. The calculation formula is as follows:

$$s_i = \frac{b_i - a_i}{\max(a_i, b_i)} \qquad (2)$$

For the ith object, a_i represents the average distance between the ith data point and all other points in the cluster, and b_i represents the minimum average distance between the ith object point and all points in other clusters.

If $s_i=1$, it indicates that the data of object i is relatively different from that of other clusters. If $s_i=0$, it indicates that the classification of object i is not obvious. If $s_i=-1$, object i is assigned to an incorrect cluster. The value of contour coefficient is $s_i \in [-1,1]$. When $a_i < b_i$, s_i is positive for the ith data, and negative on the contrary.

5.3 The Empirical Process

Python was used to read the data set, and elbow rule was used to calculate the three-level index to determine the optimal number of clusters. The results are shown in Figure 1, when k=2,3,4, the slope of SSE value changes greatly, when k≥5, the slope of SSE value changes not significantly.
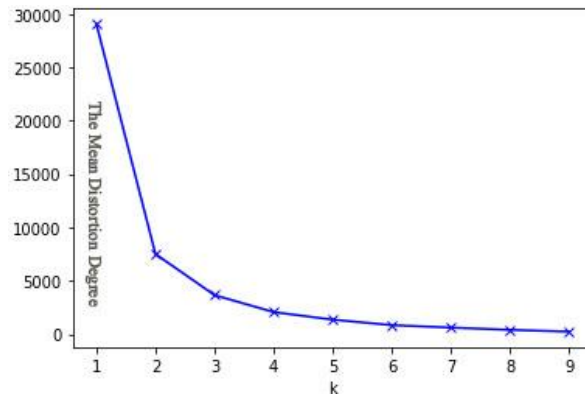

Figure 1. THE ELBOE FUNCTION

Use the elbow rule to determine the optimal k value. Since there is no obvious inflection point in the result obtained by elbow rule, the three-level index is calculated by contour coefficient method to determine the optimal number of clusters. The results are shown in Figure 2. It can be seen that the slope changes the most when K =3 or k=7. Therefore, combining the results of elbow rule and contour coefficient method, it can be determined that the optimal K value is 3, that is, the optimal clustering is 3.
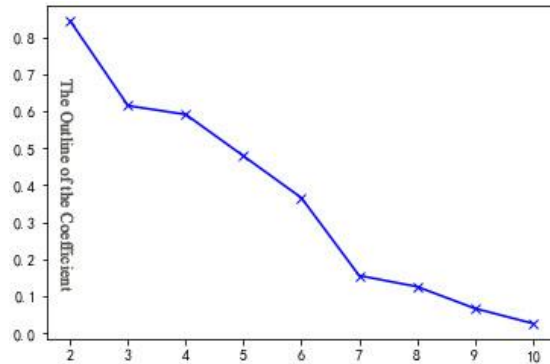
Figure 2. CONTOUR COEFFICIENT LINEAR DIAGRAM

Finally, k-means clustering algorithm was used to classify 11 regions, 29 index data were selected as variables, and the number of clustering was set to 3, and the classification groups were obtained as shown in Table 2. It can be seen that the 11 regions are divided into three categories, among which Macao, Zhuhai, Foshan, Zhongshan, Huizhou, Dongguan, Jiangmen and Zhaoqing are divided into one category, Shenzhen is in its own category and Guangzhou and Hong Kong are grouped together.

TABLE II. CLASSIFICATION OF RESULTS

Num	Region	Category
1	Macao	0
2	Zhuhai	0
3	Foshan	0
4	Zhongshan	0
5	Huizhou	0
6	Dongguan	0
7	Jiangmen	0
8	Zhaoqing	0
9	Shenzhen	1
10	Guangzhou	2
11	Hongkong	2

6 CLUSTER ANALYSIS

6.1 Explain the Results

Combined with the classification results obtained after determining the optimal K value by elbow rule and contour coefficient method, it can be seen that 11 regions in the Guangdong-Hong Kong-Macao Greater Bay Area can be divided into three categories according to the level of foreign trade development from high to low:

First of all, shenzhen, as the first special economic zone since China's reform and opening up, has unique innate advantages and is one of the important Windows of opening-up. As the economic center of China and the core city of the Pearl River Delta region, Shenzhen has attracted a lot of talents and overseas investment by virtue of the policy advantages of reform and opening-up over the years and as an important industrial and scientific research base in China. These factors can be used as the basis to explain the high quality development level of Shenzhen foreign trade is classified as the first category.

The second category is Guangzhou and Hong Kong. First, as an international business center, Guangzhou's gross regional product reached 2.285935 billion yuan in 2018, and its total net export was 140,341 billion yuan. Although the trade basis and scale are not superior to Shenzhen, Guangzhou's cross-border e-commerce export enjoys a good momentum of development. In addition, There are 8 key universities in Guangzhou, including 2 in 985 universities and 4 in 211 universities, which have excellent education level and large amount of talent introduction. Secondly, Guangzhou has its own comparative advantages in resources, environment, science and technology and talents. However, as a special economic and administrative zone and a free trade port, Hong Kong has a high degree of openness to the outside world and has a strong international influence. Hong Kong has the advantage of geographical location. It started from transit trade in goods, and later developed service trade with financial industry as the main force. Hong Kong has become a world famous international trade center and international shipping center. As Hong Kong's industrial structure tends to be service-oriented, its industrial economy is still in the stage of traditional industry, and its structural transformation is difficult, so Hong Kong's foreign trade lacks competitiveness.

Finally, the third category-Macau, Zhuhai, Foshan, Zhongshan, Dongguan, Huizhou, Jiangmen and Zhaoqing. The high-quality development of foreign trade in these areas is far from the first and second categories. The third category is the follower of the Guangdong-Hong Kong-Macao Greater Bay Area city group. As these regions are still second - and third-tier cities, their economic development conditions are worse than those of Guangzhou, Shenzhen and Hong Kong, so few enterprises invest and build factories there. In addition, the development of emerging industries is still in the preliminary stage and the development model is conservative, which is also an important reason for the low level of high-quality development of foreign trade.

7 CONCLUSIONS

As a key development plan, the Guangdong-Hong Kong-Macao Greater Bay Area is an integral whole. Only paying attention to the development of developed areas is not enough to promote the overall development of the Guangdong-Hong Kong-Macao Greater Bay Area. According to the research, the following problems still exist in the high-quality development of foreign trade in the Guangdong-Hong Kong-Macao Greater Bay Area. Firstly, the quality development of regional foreign trade is unbalanced. Secondly, the level of green development is limited. Although the ecological dimension has been strengthened in recent years, environmental degradation is still increasing. Based on the above deficiencies, this paper puts forward appropriate suggestions for improving the quality development level of foreign trade in the Guangdong-Hong Kong-Macao Greater Bay Area. First of all, it is urgent to strengthen coordination and cooperation between different regions, give full play to the comparative

advantages of various regions and narrow the economic development gap between more regions, so as to narrow the gap in the development of foreign trade quality. Secondly, continue to adhere to the green development model, attach importance to the protection of natural resources, improve the overall benefits of foreign trade. To sum up, we need to focus on holistic development, the efficiency of growth and the internal driving force for sustainable development.

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