Analysis of Port Logistics Development Trend in Shenzhen

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Abstract. Port logistics has become one of the key drivers of economic growth due to economic globalization. However, port logistics in Shenzhen still requires further development and refinement because of gaps with world-class ports. This paper conducts a quantitative evaluation of Shenzhen Port's logistics development process to identify its strengths and weaknesses, thereby providing targeted recommendations for improvement. The study selects 12 key indicators related to port logistics performance and competitiveness across four dimensions—hinterland economy, port cargo throughput, infrastructure, and development potential—to assess Shenzhen Port's development trends. Using principal component analysis (PCA) and SPSS software, an evaluation model is constructed based on port logistics data from 2005 to 2022. The results indicate that Shenzhen Port's comprehensive evaluation score showed an upward trend. However, in 2022, the growth rate slowed. In response to this slowdown, the paper examines existing challenges and corresponding recommendations.

Keywords: Port Logistics; Port of Shenzhen; Principal Component Analysis.

1 Introduction

With the rapid development of economic globalization, interactions between countries are becoming more and more frequent. Ports as nodes in the global transportation network, play an increasingly important role in modern logistics [1], driving the growth of trade in its radiation area. As the port logistics of maritime connection, according to statistics, more than two-thirds of the total international trade relies on marine transportation, which means that port logistics has become a key factor affecting the development of trade and economy.

At present, many port cities take the logistics industry as a new backbone industry for economic growth. However, the competitiveness of China's port logistics is still ranked lower. So this paper takes on Shenzhen Port as a case study, researching the development trend of its port logistics, and targeting at policy commendation according to the corresponding problems.

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2 Methodology

In this paper, multiple variabls are used to analyze the current situation of port logistics development in Shenzhen with Principal Component Analysis (PCA), which is a commonly used data dimension reduction technique. It can retain the original information as much as possible, and reduces the dimension of multiple indicators, i.e., condenses the data so that the overall indicator score is fully reflected by the composite score [2]. The PCA algorithm has the limitation of identifying the directions of larger variations. In order to avoid this, before calculating the principal components, all the variables in this paper are processed to have a mean of 0 and a standard deviation of 1.

This paper collects data including Shenzhen GDP, tertiary industry's share of urban GDP, total retail sales of consumer goods, total import and export trade, freight volume, port cargo throughput, port container throughput, number of berths, number of 10,000-ton berths, and length of wharves, number of people enrolled in tertiary education, and science and technology expenditures for the period of 2005 to 2022. The sources of these data include Shenzhen Statistical Yearbook [3],the website of Shenzhen Bureau of Science, Technology and Innovation (SZBSTI) [4], and Shenzhen Education Official website of Shenzhen Education Bureau[5]. Linear interpolation method is used for some missing values in the data.

3 Construction of Port Logistics Evaluation Indicator System

The construction of port logistics evaluation index system is the foundation premise for studying the development trend of port logistics, which can make the final result more objective and better reflect the current status of port logistics. The main principles of the index evaluation system constructed in this paper are objectivity, representativeness and data availability[6].

Based on the above principles, this study has selected four primary indicators - hinterland economy, port flow, infrastructure, and development potential - to comprehensively evaluate the current status and development level of Shenzhen Port's logistics system. Under each primary indicator, corresponding 12 secondary indicators (i.e. variables) have been carefully chosen.

4 Results and Discussion

4.1 Principal Components Calculation

After the standardization of the data, the correlation coefficient matrix table R of the standardized evaluation index data was calculated using SPSS software, and the variance of the common factor was calculated. Next, the proportion of the original information content λ_i represented by the *i*-th principal component F_i to the total original information content of all principal components was calculated as the variance contribution ratio.

According to the principle that the corresponding eigenvalue of the principal components is greater than 1 and the cumulative variance contribution rate of the principal components is at least 85% [7], there are two of them, and the cumulative contribution rate reaches 89.396%, indicating that the two principal components can represent 89.396% of the information. These two proposed principal components, labeled as Y_1 and Y_2 with variance contribution rates are 79.719% and 89.396%, respectively, can basically reflect most of the information of the original variables.

In the principal component Y1, the absolute values of the coefficients for GDP, the proportion of the tertiary industry in GDP, the total amount of import and export trade, the amount of freight transported, the cargo throughput in ports, the container throughput in ports, the number of 10,000-ton berths, the length of wharves, the total retail sales of consumer goods, the expenditures on science and technology, and the number of students in tertiary educationare larger than those for other variables. Thus, principal component Y1 can be regarded as reflecting the level of cargo sources and development potential of port logistics in Shenzhen.

In the principal component Y_2, the coefficient of the number of berths is larger than those for other variables, indicating that Y_2 reflects the infrastructure capacity of port logistics and its ability to handle goods.

4.2 Principal Component Coefficients and Scores Calculation

Determine the eigenvectors of the two principal components using formula (1) as follows.

$$f_{ij} = \frac{u_{ij}}{\sqrt{\lambda_j}} (j=1,2,\ldots\ldots,m) \tag{1}$$

The principal component scores for each sample were calculated using SPSS software by inputting the standardized data into a principal component expression. Through these calculations, the scores for the two principal components can be obtained.

4.3 Calculating the Composite Score

Firstly, the weights of the selected two principal components are determined by $W_i = \frac{K_i}{\sum_{i=1}^{2} K_i}$, and i=1. Secondly, the comprehensive score for the port logistics level evaluation is calculated using the following formula.

$$Z = \sum_{i=1}^{2} W_i Y_i \tag{2}$$

where, K_i is the principal component variance, W_i is the principal component weight, Y_i is the principal component score value, and Z is the composite score.

Finally, it results in 89.2% of principal component Y_1 and 10.8% of principal component Y_2, which leads to a comprehensive model for principal component calculation as formula (3).

$$Y=0.892*Y_1 +0.108*Y_2 \quad (3)$$

Subsequently, the evaluation index data for Shenzhen Port is integrated into the principal component synthesis model as $Y=0.892*Y_1 +0.108*Y_2$. to calculate its synthesis score, which is shown as the bar chart in Fig. 1. The fluctuating line displays the bar chart reflecting the growth of the composite score.

Fig. 1. Composite Score of Shenzhen Port Indicators and its yearly growth, 2005-2022

4.4 Interpretation of Results and Discussion

From 2005 to 2011, the comprehensive score of the evaluation index for the port logistics development level of Shenzhen Port was negative. However, the overall trend was upward. The growth of Shenzhen Port from 2006 to 2008 exhibited a decline, with a sharp drop in 2009 when growth fell to only 0.01. However, there was a marked recovery in 2010, with growth rebounding to 0.94. This fluctuation was influenced by the global financial crisis in 2009 [8]. Following necessary adjustments and transformations, the economy began to recover in 2010, marking the beginning of a golden period for China's economic development.

From 2006 to 2022, the only year that saw negative growth in the composite score was 2013, when the score dropped to -0.37. This decline was largely due to the well-known "620 Money Shortage," which significantly affected Shenzhen's economy [9].

Between 2014 and 2022, the comprehensive score of the evaluation index for the development level of Shenzhen Port logistics consistently increased. However, in 2020, the growth rate was the slowest during this period, at only 10.24%, primarily due to the outbreak of the COVID-19 pandemic in early 2020[10]. Despite these challenges, the concerted efforts of the public and active measures taken by major enterprises, along with supportive national policies, allowed the comprehensive score for Shenzhen Port logistics to continue rising, albeit slowly.

Since 2015, the composite score evaluating Shenzhen Port's logistics development level has transitioned from negative to consistently positive values, demonstrating an overall upward trend throughout the 18-year period. Particularly after 2014, the comprehensive score has shown year-on-year growth, with the most significant increase

occurring in 2006. However, in 2022, the port's composite score growth rate decelerated, with the increment decreasing from 0.85 to 0.63.

According to the comprehensive scoring model of Shenzhen Port, the primary contribution to its composite score stems from the first principal component - cargo source level and development trend - accounting for 89.2% of the total weight. Through relevant data analysis, it becomes evident that Shenzhen Port faces constraints in expansion potential and requires service function enhancements, which indirectly impact the growth of its cargo throughput.

4.5 Problems and Solutions

The development Space. The insufficient development space of Shenzhen Port has been a longstanding issue for the Shenzhen government. The total length of the shoreline for production terminal berths is 31.38 kilometers [11]. Short-term countermeasures include the integration and management of the eastern and western sections of Shenzhen Port, ensuring rational distribution of functions and coordination. Long-term strategies should also considered such as looking for development space in the adjacent cities.

Types of Cargoes. The service pattern at Shenzhen Port primarily focuses on container logistics, supplemented by bulk cargo logistics [12]. While the port has a robust capacity for container logistics, its bulk cargo service capacity still needs improvement. First, it is essential to enhance the infrastructure and equipment for bulk cargo services. Secondly, developing port-specific services with differentiated functional positioning can help Shenzhen Port establish a competitive edge over nearby major ports.

Intelligence Construction by Innovation. Compared to some developed foreign maritime cities, the intellectualization of Shenzhen port still requires enhancement. So it is essential to promote its intelligent upgrading and enhance its information infrastructure by innovation, e.g. a big data platform connecting the six port areas.

Transition into Green Development. In recent years, Shenzhen Port has prioritized green construction and has outpaced other coastal ports in the country. However, its environmental protection services still have significant shortcomings.

The corresponding countermeasures are as follows. First, build a clean and low-carbon port energy system Secondly, strengthen the control of ship pollution in Shenzhen Port.

5 Conclusions

With the development of the economic community, international trade at ports is flourishing, highlighting the increasing significance of port logistics. Exploring the

development trends in port logistics can provide insights into its competitiveness and investment potential, facilitating a deeper understanding of port development. This paper focuses on Shenzhen Port, examining four aspects including the port hinterland economy, port logistics, infrastructure, and development potential. The analysis revealed a positive development trend in Shenzhen Port's logistics, with enhanced competitiveness in recent years. To sustain and accelerate the growth of this comprehensive score, the paper discusses the principal component model of Shenzhen Port's logistics and offers recommendations.

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