ISSN 2616-7433 Vol. 5, Issue 8: 63-69, DOI: 10.25236/FSST.2023.050808

Construction and Evaluation of a High-Quality Logistics Development System in Five Southeast Coastal Provinces under the Background of the Digital Economy

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Abstract: *With the rapid development of the digital economy, the logistics industry, as one of the key infrastructures supporting the development of the digital economy, is also facing the challenge of high-quality development. This article takes five provinces and cities along the southeast coast as the research object and uses the entropy weight TOPSIS method to evaluate the development level of the logistics industry in each province and city under the background of digital economy from four dimensions: development scale, innovative development, green development, and information development. The research results show that Guangdong Province has the highest level of logistics industry development, followed by Jiangsu Province, Shanghai City, and Zhejiang Province, with Fujian Province ranking relatively low. This study can provide a decision-making reference for the high-quality development of the logistics industry in the southeastern coastal areas.*

Keywords: *high-quality development of logistics industry, Digital economy, Entropy Weighted TOPSIS Method*

1. Introduction

The digital economy is a rapidly emerging industry in recent years, playing an increasingly important role in promoting national and regional economic development. The logistics industry is one of the infrastructures of the digital economy, connecting production, circulation, sales, and other links, providing a solid guarantee for the digital economy. In this context, the high-quality development of logistics has become one of the focuses of competition in various regions.

The 14th Five-Year Plan clearly states that the digital economy is an important driving force for promoting high-quality logistics development. Under the background of the digital economy, the trend of Digital transformation of modern logistics enterprises has become increasingly prominent. Zhang Weida believes that seizing the opportunity of digital development is the key to achieving cost reduction, quality improvement, efficiency enhancement, transformation and upgrading, and seeking high-quality development in China's logistics industry[1]. Xu Jing believes that the rise of the digital economy has given new impetus and engines to the development of the modern logistics industry[2]. Wu Xieling believes that the cross-border development of the logistics industry with other industries has become a trend, and digital collaboration across regions, systems, and businesses has become the norm, indicating that the logistics industry has begun to fully enter the era of digital economy[3]. Lu Yahe believes that smart logistics is an important product of the integration of the digital economy and logistics industry[4].

This article aims to use the entropy weight method to comprehensively evaluate the level of high-quality logistics development in the five provinces along the southeast coast, and explore the factors that affect high-quality logistics development and their differences in different provinces. The research in this article, can provide decision-making reference and scientific basis for the high-quality development of logistics in the five provinces along the southeast coast, and also provide reference and inspiration for the high-quality development of logistics in other regions.

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2. Research Design

2.1. Index System Construction

Due to the late start of high-quality development in China, the research on the logistics high-quality indicator system is still incomplete, making it difficult to conduct dynamic research on logistics high-quality development. Therefore, this article only selects cross-sectional data from 2021 to conduct static measurement and comprehensive evaluation analysis on the level of logistics high-quality development in five provinces and cities along the southeast coast.

The construction of a comprehensive evaluation index system mainly involves three important aspects: firstly, the framework design of the comprehensive evaluation index system; second is the principle of constructing a comprehensive evaluation index system; The third is the selection of specific secondary evaluation indicators. The selection and determination of secondary evaluation indicators will directly affect the final evaluation results. This article comprehensively considers the relationship between factors related to the high-quality development of the logistics industry and economic activities in the context of the digital economy. Following the principles of systematicity, scientificity, and comparability, the following indicators are constructed from four perspectives: development scale, innovation ability, green development, and information development.

2.1.1. Development scale

(1) Freight volume is the basic indicator of the logistics industry. With the increase in freight volume, logistics enterprises need to adopt more advanced technological means to improve transportation efficiency and service quality. With the increase in freight volume, various links in the logistics supply chain will be affected, leading to more demand and supply of logistics services. (2) Freight turnover reflects the capital turnover rate of the logistics industry, The increase in freight turnover will drive the development of logistics finance, which will improve the efficiency of fund utilization for logistics enterprises and promote the healthy development of the logistics industry. (3) Compared to other transportation methods such as road transportation, railway transportation has the advantages of large capacity and low cost, so the railway operating mileage is selected. With the increase in railway operating mileage, the railway transportation network has been further improved, and logistics enterprises can more conveniently choose suitable routes and transportation methods to improve logistics efficiency. (4) The total import and export volume of goods is one of the indicators that best reflect the level of international trade, indirectly reflecting the degree of foreign trade goods flow.

2.1.2. Innovation capability

(1) The number of patent invention applications and authorizations in the logistics industry is the most commonly used output indicator to measure technological innovation.[5] The increase in the number of patents in the logistics industry may indicate that the industry is continuously promoting technological innovation and strengthening its competitiveness. (2) The number of logistics employment reflects the vitality of the logistics competition market. With the increase in logistics employment, logistics enterprises will have more opportunities for employee training and skill enhancement and can attract more professional talents to join the logistics industry, promoting the construction of logistics talent teams and the improvement of skill levels. (3)The number of R&D personnel is the most commonly used indicator to measure the investment of technical personnel in a region. Although data on the number of R&D personnel in the logistics industry is not available, the economy and the logistics industry are inherently inseparable. Directly using R&D personnel can also reflect the region's investment in technological innovation to some extent. If the number of R&D personnel is more, the corresponding number of R&D personnel in the logistics industry will also be more. [5] (4) The investment in R&D funds is similar to the number of R&D personnel. If enterprises in the logistics industry invest more in R&D, it usually means that the industry is actively promoting technological innovation, improving its competitiveness, and adapting to changes in market demand.

2.1.3. Green development

(1) Exhaust emissions are one of the important indicators for evaluating the high-quality development of the logistics industry. If the logistics industry can control and reduce exhaust emissions, it can better protect the environment and promote sustainable development. (2) The energy consumption of the logistics industry can reflect the efficiency of energy utilization and the application of clean energy in the transportation process, as well as indirectly reflect the innovative ability of the logistics industry in transportation organization, management, and other aspects.

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2.1.4. Information development

(1) The number of mobile phone users at the end of the year reflects the popularity of logistics informatization. With the increase of mobile phone users at the end of the year, more people will use their phones for logistics information queries, online shopping, and other operations, which will promote the popularization of logistics information and improve the efficiency of logistics services. (2) The number of mobile Internet users is similar to the number of mobile phone users at the end of the year. The increase in the number of mobile Internet users will accelerate the Digital transformation of logistics enterprises, thus realizing the upgrading and intelligent upgrading of logistics information systems. (3) E-commerce sales reflect the degree of Digital transformation. With the rapid development of the e-commerce industry, more and more logistics enterprises use e-commerce platforms to conduct online sales and online transactions, strengthen online and offline integration, and optimize the layout of the global supply chain. (4) The number of employees in the information transmission, software, and information technology service industries reflects the potential for digital development in the logistics industry. With the increase in employment in the information transmission, software, and information technology service industries, logistics enterprises will actively develop emerging businesses based on information technology, such as logistics apps, e-commerce platforms, etc., to expand their digital application scope.

Based on the literature review and the actual development of the logistics industry, this article constructs a high-quality development of the logistics industry in the digital economy with four primary indicators of the development scale, innovation capability, green development, and information development, and 14 secondary indicators (see Table 1).

Table 1: Indicator system for high-quality development of logistics industry

Target layer	Primary indicators	Secondary indicators	direction
Evaluation index system for the high-quality logistics development	Development scale	the volume of freight transport	+
		rotation volume of freight transport	+
		Railway operating mileage	+
		Total import and export volume of goods	+
	innovation ability	Number of patents	+
		Employment in the logistics industry	+
		Number of R&D personnel	+
		R&D funding input	+
	Green development	Waste emissions of nitrogen oxides	−
		Energy consumption in the logistics industry	−
	Information development	Number of mobile phone users at the end of the year	+
		Number of mobile internet users	+
		E-commerce sales	+
		Number of personnel in the information transmission, software, and information technology industries	+

2.2. Comprehensive evaluation method

There are many logistics performance evaluation methods, such as the Delphi method, analytic

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hierarchy process (AHP), entropy weight method, topsis method, etc. Among many methods, the Delphi method and AHP method are mainly based on the knowledge of expert groups, with a certain degree of subjectivity. Compared with these two methods, the entropy weight method is an objective weight method based on objective data, which eliminates the impact of subjectivity. Although TOPSIS method can objectively evaluate the advantages and disadvantages of comparative objects, it generally uses empirical decision-making and expert scoring methods to quantify the weight of indicators, which weakens the objectivity of the evaluation results [6]. Therefore, this article adopts the entropy weight topsis method for evaluation, which avoids the requirement for sample data and preserves the objectivity of the evaluation.

1) For each decision indicator, calculate the dimensionless value of each decision object.

Assuming the Decision Matrix Y for Multiple Attribute Decision Problems= $\{y_{ij}\}$

$$\begin{bmatrix} y_{11} & y_{12} & \cdots & y_{1n} \\ y_{21} & y_{22} & \cdots & y_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ y_{m1} & y_{m2} & \cdots & y_{mn} \end{bmatrix} \tag{1}$$

Use the method of vector normalization to obtain the canonical decision matrix.

$$z_{ij} = y_{ij} / \sqrt{\sum_{i=1}^{m} y_{ij}^2}, i = 1, \cdots, m; j = 1, \cdots, n \tag{2}$$

Normalized matrix Z= $\{z_{ij}\}$

$$\begin{bmatrix} z_{11} & z_{12} & \cdots & z_{1n} \\ z_{21} & z_{22} & \cdots & z_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ z_{m1} & z_{m2} & \cdots & z_{mn} \end{bmatrix} \tag{3}$$

2) Calculate the weight of each decision object using the entropy weight method.

The entropy weight method is a common multi-index comprehensive evaluation method, which uses the information entropy theory to weight the indexes, to obtain the contribution degree of each index to the comprehensive evaluation results. Specifically, the method first needs to calculate the information entropy value of each index. The larger the information entropy value is, the higher the degree of random variation of the index is, and the greater the impact on the comprehensive evaluation results is; On the contrary, indicators with small information entropy have relatively little impact on the comprehensive evaluation results. Therefore, the information entropy value can be used as the weight coefficient to reflect the importance of each index in the comprehensive evaluation. Calculation of information entropy of index i:

$$H_i = -\frac{1}{\ln(n)} \sum_{j=1}^{n} R_{ij} \ln(P_{ij}) \tag{4}$$

P_{ij} refers to the proportion of each item to the total number, i is the index, n is the number of records, and H is between 0 and 1

Calculate the difference in indicators:

$$k_i = 1 - H_l \tag{5}$$

Calculate indicator weights:

$$w_i = \frac{k_i}{\sum_{i=1}^{n} k_i} \tag{6}$$

3) Multiply the normalized data by the corresponding weights to obtain the weighted normalization matrix X= $\{x_{ij}\}$。

$$x_{ij} = w_i * z_{ij}, i = 1, \cdots, m; j = 1, \cdots, n \tag{7}$$

4) Determine the ideal value x * and negative ideal value x^0

$$\text{ideal value } X^* = (maxx_1, maxx_2, maxx_3 \cdots \cdots maxx_n) \tag{8}$$

$$\text{Non ideal value } x^0 = (minx_1, minx_2, minx_3 \cdots \cdots minx_n) \tag{9}$$

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5) Calculate the distance between each decision object and the ideal solution and negative ideal solution.

The distance from alternative xi to the ideal value is

$$d_i^* = \sqrt{\sum_{j=1}^{n} \left(x_{ij} - x_j^*\right)^2}, i = 1, \cdots m \tag{10}$$

The distance from alternative xi to the negative ideal value is

$$d_i^0 = \sqrt{\sum_{j=1}^{n} \left(x_{ij} - x_j^0\right)^2}, i = 1, \cdots m \tag{11}$$

6) Calculate the comprehensive evaluation index of each decision object, which is the ratio of its distance from the negative ideal solution to the distance from the ideal solution.

$$c_i^* = \frac{d_i^0}{d_i^0 + d_i^*}, i = 1, \cdots m \tag{12}$$

7) Rank the advantages and disadvantages of the plan in descending order according to the comprehensive evaluation index.

3. Empirical Analysis of High-Quality Logistics Development in Five Southeast Coastal Provinces and Cities

The research object of this article is 5 provinces and cities along the southeast coast. The required statistical indicator data mainly comes from the "Statistical Yearbook", "China Logistics Statistical Yearbook", "Science and Technology Statistical Yearbook", and statistical bulletins of each province. Some of the data cannot be collected from the logistics industry, so data from the postal, warehousing, and transportation industries are used. The entropy weight TOPSIS method is used to evaluate the impact of four factors - provincial and municipal development scale, innovation capacity, green development, and information development on the high-quality development of the logistics industry. The entropy weight method is used to calculate the weight results and summarize the weights (as shown in Table 2)

Table 2: the weight result of high-quality development in the logistics industry

Serial number	Indicator Name	weight	Serial number	Indicator Name	weight
one	the volume of freight transport	7.92%	eight	R&D funding input	5.02%
two	rotation volume of freight transport	10.11%	nine	Waste emissions of nitrogen oxides	4.94%
three	Railway operating mileage	4.11%	ten	Energy consumption in the logistics industry	9.81%
four	Total import and export volume of goods	5.62%	eleven	Number of mobile phone users at the end of the year	9.11%
five	Number of patents	8.62%	twelve	Number of mobile internet users	9.25%
six	Employment in the logistics industry	5.29%	thirteen	E-commerce sales	6.17%
seven	Number of R&D personnel	8.12%	fourteen	Number of personnel in the information transmission, software, and information technology industries	5.91%

From the weight calculated by the entropy weight method, it can be seen that freight turnover is the indicator with the highest weight among the secondary indicators. Next is the energy consumption of the logistics industry. The weight of the number of mobile Internet of Things users and the number of mobile phone users at the end of the year is greater than 9%, with a relatively high weight. The weight of patents, R&D personnel, and freight volume is similar, while the weight of railway operating mileage and nitrogen oxide emissions is the lowest. Before this, many scholars conducted research on the evaluation

ISSN 2616-7433 Vol. 5, Issue 8: 63-69, DOI: 10.25236/FSST.2023.050808

of the high-quality development of the logistics industry. For example, Quan Chunguang scholars believe that economic foundation and innovation ability are important indicators for testing the high-quality development of the logistics industry[7]. Gan Weihua scholars believe that innovation and coordination are the main indicators for testing the high-quality development of the logistics industry[6]. Meng Mengjun scholars believe that power conversion Network layout and achievement sharing are important standards for testing the high-quality development of the logistics industry[8]. In the first level indicators of this article, the highest weight of information development is 30.44%, followed by development scale, innovation ability, and green development. The reason for this is that the development of the digital economy in the context of today's digital economy has brought more opportunities and challenges to the logistics industry. The rapid development of information technology enables logistics enterprises to manage their supply chains and transportation networks more efficiently, improve transportation efficiency, and reduce costs. At the same time, digital technology also provides customers with more intelligent and customized logistics services. Therefore, information development is crucial for the high-quality development of logistics. By utilizing emerging technologies such as the Internet of Things, cloud computing, and big data, full-process digital management can be achieved, logistics resource allocation can be optimized, operational efficiency and service quality can be improved, and information development has gradually become the main standard for measuring the high-quality development of the logistics industry.

4. Analysis of evaluation results

According to the comprehensive evaluation method mentioned earlier, a comprehensive evaluation was conducted on the high-quality development level of logistics in five provinces and cities along the southeast coast in 2021, and the comprehensive scores of each province and city were obtained as shown in Table 3

Table 3: Comprehensive Scores of High-Quality Logistics Development

Index value	Positive Ideal Solution Distance (D+)	Negative ideal solution distance (D -)	Comprehensive score index	sort
Shanghai	zero point seven two five	zero point five four zero	zero point four two seven	three
Jiangsu	zero point six two seven	zero point five five two	zero point four six eight	two
Zhejiang	zero point six four eight	zero point four three five	zero point four zero two	four
Fujian	zero point eight nine six	zero point three six eight	zero point two nine one	five
Guangdong	zero point three one nine	zero point eight nine five	zero point seven three seven	one

As shown in Table 3, in the context of the digital economy, Guangdong Province has the highest score among the five provinces and cities in the high-quality development of the logistics industry, followed by Jiangsu, Shanghai, and Zhejiang, and Fujian Province has the lowest score. It shows that Guangdong Province is a province with a high level of high-quality logistics development, mostly because its information development level is higher than that of other provinces and cities. Among them, the number of mobile phone users at the end of the year, mobile Internet users, e-commerce sales, information transmission, software and information technology service employment, and other indicators are higher than those of other provinces and cities. This is because Guangdong Province is located in the Pearl River Delta Economic Zone, which has convenient transportation and is adjacent to Hong Kong and Macao. Moreover, the Province is closely related to one of the earliest and most active regions in China's opening up to the outside world. At the same time, the Guangdong Provincial Government attaches great importance to the development of information technology and has introduced a series of policies to promote the development of the information industry, such as the "13th Five Year Plan for Informatization in Guangdong Province", which has increased the popularity of information technology applications and provided guarantees for the high-quality development of its logistics. Jiangsu, Shanghai, and Zhejiang have similar levels of high-quality development, ranking second to fourth respectively, while Fujian Province ranks last, mostly due to its low level of information development and relatively backward infrastructure. Among them, indicators such as freight turnover and R&D are lower than those of other provinces and cities. Although Fujian Province is located on the southeast coast of China and

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close to Southeast Asia, there is still a certain gap in the supporting capacity of transportation and logistics compared to major economic provinces and central cities such as Guangdong and Shanghai. At the same time, compared to Guangdong and Shanghai, the Fujian Provincial Government has relatively few policies and measures to promote the development of the abortion industry. In the context of relatively backward information development and infrastructure construction in the logistics industry in Fujian Province, clear development goals and corresponding plans should be established, and emphasis should be placed on cultivating professional talents to promote information sharing and connectivity, thereby improving the high-quality development of the logistics industry.

5. Conclusion

This article takes five provinces and cities along the southeast coast as examples, selects 14 indicators from four dimensions: development scale, innovation capability, green development, and information development, and constructs an evaluation index system for the high-quality development of the logistics industry in the context of the digital economy in the five provinces and cities along the southeast coast in 2021. Then, the weight of these 14 indicators and the comprehensive score of the high-quality development of the logistics industry in each province and city were calculated using the entropy weight TOPSIS method, objectively reflecting the degree of high-quality development of the logistics industry in the five provinces and cities along the southeast coast. Summarize the following conclusions:

(1) There is a significant difference in the development level of the logistics industry among the five provinces and cities along the southeast coast. Guangdong Province has a higher development level than other provinces and cities due to its geographical location and good policies, while Fujian Province needs to improve the high-quality level of the logistics industry.

(2) The degree of information development plays an increasingly important role in evaluating the high-quality development of the logistics industry in various provinces and cities. With the development of the digital economy, Digital transformation of the logistics industry is imminent.

(3) Although Guangdong and Jiangsu provinces have a higher level of development in the logistics industry than other provinces and cities, the green development effect of the logistics industry is relatively low, which is an aspect that needs attention to improve the high-quality development level of their logistics industry in the future.

Acknowledgements

This work was sponsored by the Hunan Provincial Self Science Fund(2022JJ30209) and Key Research Project of Hunan Provincial Education Department(22A0445).

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