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Analysis on Regional Logistics Competitiveness of Fujian Province based on Entropy Weight TOPSIS Method

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Abstract:

In this paper, the entropy method was introduced to evaluate the influence weight of regional logistics indicator, and on this basis, the empirical analysis was made on the competitiveness of regional logistics in Fujian Province with TOPSIS method. The results show that: (1) the main factors that affect the competitiveness of logistics are water freight volume, total import and export volume, port cargo throughput and railway freight volume; (2) The regional logistics competitiveness of Fujian Province is polarized, with Fuzhou, Xiamen and Quanzhou as a whole having strong logistics competitiveness, while Zhangzhou, Putian, Sanming, Ningde, Longyan and Nanping having relatively weak logistics competitiveness, and their closeness to the four first-level indicators of economic development level, logistics demand, logistics infrastructure, human resources and information construction is far lower than the provincial average. Finally, some suggestions are put forward, such as increasing logistics infrastructure, developing intelligent logistics, exerting logistics hub effect, and attaching importance to the introduction of logistics talents.

***Keywords**: Regional Logistics, Competitiveness, Entropy Weight, TOPSIS.*

I. INTRODUCTION

Logistics industry, as an important part of the national economy, is a basic, strategic and leading industry to support the development of the national economy. The *Opinions on Promoting the High-quality Development of Logistics to Promote the Formation of a Strong Domestic Market* promulgated in 2019 and the *Outline of the 14th Five-Year Plan (2021-2025) for National Economic and Social Development and Vision 2035 of the People's Republic of China* promulgated in 2021, General Secretary Xi Jinping stressed at the 2nd UN Global Sustainable Transportation Conference in October of the same year that we should vigorously develop the intelligent logistics system. In December, the General Office of the State Council issued the *14th Five-Year Plan for Cold Chain Logistics Development*, which called for strengthening top-level design and work guidance to promote the high-quality development of cold chain logistics. Obviously, the high-quality development of logistics is the key deployment work of the state and various provinces and cities.

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In recent years, Fujian Province has attached great importance to the development of modern logistics industry and has successively issued a series of policies regarding the construction of modern logistics system as an important strategic task. In 2020, the total mileage of highways in the province exceeded 110,000 kilometers, the mileage of railways under construction and operation exceeded 5,000 kilometers, 421 productive berths in coastal ports and 135 foreign trade routes opened, and the revenue of logistics business in the province was 481 billion yuan. Although the logistics demand increased rapidly, its logistics competitiveness still had a certain gap compared with Guangdong and Zhejiang provinces [1]. Therefore, it is of great significance to analyze the regional logistics competitiveness of Fujian Province in order to rationally distribute the logistics industry, optimize the allocation of logistics resources, and reduce the logistics cost to promote the high-quality development of logistics in Fujian Province.

It is always a hot topic for scholars to study regional logistics competitiveness. Although the objects of research and evaluation differ, there are two similar research methods: one is single evaluation method, such as factor analysis method[1-3], principal component analysis method[4], niche method[5], etc., and the other is a combination of two or more analysis methods, such as Rong Luqing's analysis of Guangxi's urban logistics competitiveness with entropy-grey correlation method[6], Guo Zixue's empirical analysis of Hebei's logistics competitiveness using G1 and entropy-weighted TOPSIS method[7], Cao Bingru and others using ANP-TOPSIS to analyze the logistics development capacity of Jiangsu Province[8], Gan Weihua and others using PCA-RSC sequence analysis to empirically analyze the regional logistics development level of 9 provinces and cities in the Silk Road Economic Belt[9]. Compared with the single evaluation method, the combination method makes the results of the analysis more comprehensive and scientific. Based on this, in order to eliminate the subjectivity of the calculation process, the entropy weight method was introduced to evaluate the impact weight of logistics indicators, and on this basis, combined with TOPSIS method, the empirical analysis was made on the regional logistics competitiveness in Fujian, and the corresponding suggestions are put forward, which provide a reference for improving the regional logistics competitiveness.

II. EVALUATION INDICATOR SYSTEM AND MODEL

2.1 Constructing the Evaluation Indicator System of Regional Logistics Competitiveness in Fujian Province

At present, there is no uniform academic definition of regional logistics competitiveness, which mostly originates from the theory of comparative advantage of David Ricard and the theory of competitive advantage of Michael E.Porter. Wang Xueliang et al. evaluated it from four aspects: economic environment, logistics base, industrial scale and logistics growth ability [4]. Guo Xuesong believes that the main factors affecting logistics competitiveness are production factors, market competitiveness, enterprise competitiveness, innovation competitiveness and supporting industrial competitiveness [1]. Zhu Fangyang et al. constructed an evaluation system from three dimensions of resources, technology and market in terms of talents, logistics facilities, capital, economy, logistics development and scientific research information technology [5]. From the perspective of "diamond model" competition, Jiang Minglin et al. believed that

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the factors affecting regional logistics competitiveness include logistics demand, economic level, logistics resources, logistics enterprise level, government capacity and informatization [10]. Different scholars have constructed the evaluation system from different perspectives, but found common points among them, namely, economy, logistics demand, infrastructure, manpower and information level, etc. Referring to the achievements of relevant scholars [1-12] and considering the availability of data, an evaluation system of 4 first-level indicators and 16 second-level indicators of economic development level, logistics demand, logistics infrastructure and manpower informatization was constructed, as shown in TABLE I below.

TABLE I. Evaluation indicator system of regional logistics competitiveness in Fujian Province

First-level indicators	Second-level indicators
Economic development level	Gross regional product (x_1), investment in fixed assets (x_2), total import and export volume (x_3), total retail sales of social consumer goods (x_4), gross industrial output value above designated size (x_5), added value of transportation, warehousing and postal services (x_6)
Logistics infrastructure	Road mileage (x_7), port cargo throughput (x_8), transportation, warehousing and postal fixed assets investment (x_9)
Logistics demand	Highway freight volume (x_{10}), railway freight volume (x_{11}), water freight volume (x_{12}), post and telecommunications business volume (x_{13})
Human resources informatization	Number of Internet users (x_{14}), number of mobile phone users (x_{15}), number of employees in transportation and post and telecommunications industry (x_{16})

2.2 Indicator Weighting Model Based on Entropy Value

Entropy is a measure of information uncertainty with probability theory, which can objectively reflect the numerical variability of quantitative indicators. Compared with subjective weighting methods such as expert survey, brainstorming and analytic hierarchy process, entropy can objectively weight to avoid the influence of subjective factors and improve the accuracy and reliability of analysis.

First, the data were standardized, and the obtained data of each indicator were subject to dimensionless processing. If $x_{ij}(i=1,2,\cdots,m; j=1,2,\cdots,n)$ is the data of the i-th city on the j-th logistics indicator, the proportion of the j-th indicator of the i-th city is $r_{ij}\in[0,1]$.

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$$r_{ij} = \frac{x_{ij}}{\sum_{i=1}^{m} x_{ij}} \quad (1)$$

Secondly, according to the definition of information entropy, the entropy value of the j-th indicator was calculated as $e_j = -\frac{1}{\ln m}\sum_{i=1}^{m} r_{ij} \ln r_{ij}$ (2)

Finally, the w_j entropy weight the j-th indicator was calculated, $w_j = \frac{1-e_j}{\sum_{j=1}^{n}(1-e_j)}$ (3)

2.3 The Evaluation Model of Regional Logistics Competitiveness Based on Weighted TOPSIS

TOPSIS method is a multi-attribute decision-making method that approaches the ideal state according to the nearness degree between the evaluation object and the ideal state target. The weighted TOPSIS makes the evaluation results more scientific by empowering indicators to show the importance of different indicators to the evaluation object. The specific steps are as follows:

First, build a weighted decision matrix, and normalize the original data due to the different types and dimensions of evaluation indexes.

Effect-type indicators: $f_{ij} = \frac{x_{ij}}{\max_i x_{ij}} \quad (j = 1,2,\cdots n)$ (4)

Cost-type indicators: $f_{ij} = 1 - \frac{x_{ij}}{\max_i x_{ij}} \quad (j = 1,2,\cdots n)$ (5)

The weighted decision matrix V_{ij} is obtained by multiplying the normalized matrix F with the weight w_j of logistics indicator.

$$V_{ij} = \begin{bmatrix} f_{11}w_1 & \cdots & f_{1n}w_n \\ \vdots & \vdots & \vdots \\ f_{m1}w_1 & \cdots & f_{mn}w_n \end{bmatrix} \quad (6)$$

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Secondly, Calculate positive ideal solution V^+ and negative ideal solution V^-.

$$
\begin{aligned}
V^+ &= (v_1^+, v_2^+ \cdots, v_n^+) = (\max_i v_{i1}, \max_i v_{i2} \cdots, \max_i v_{in}) \\
V^- &= (v_1^-, v_2^- \cdots, v_n^-) = (\min_i v_{i1}, \min_i v_{i2} \cdots, \min_i v_{in})
\end{aligned}
\tag{7}
$$

Thirdly, Calculate the distance between regional logistics competitiveness and positive ideal solution and negative ideal solution.

$$
\begin{cases}
D_i^+ = [\sum_{j=1}^{n} (v_{ij} - v_j^+)^2]^{1/2} \\
D_i^- = [\sum_{j=1}^{n} (v_{ij} - v_j^-)^2]^{1/2}
\end{cases}
,(i = 1,2,\cdots m)
\tag{8}
$$

Finally, Calculate the relative nearness degree between the logistics competitiveness of each region and the ideal solution.

$$
C_i = \frac{D_i^-}{D_i^- + D_i^+} \qquad i = 1,2,\cdots,m
\tag{9}
$$

According to the degree of nearness, the larger the C_i value, the closer it is to the ideal state, and the stronger the competitiveness of regional logistics.

III. EMPIRICAL ANALYSIS

According to TABLE I, the evaluation indicator system of regional logistics competitiveness in Fujian Province, nine cities in Fujian Province were studied, and the data of *Fujian Statistical Yearbook*, *Local City Statistical Yearbook* and statistical bulletin in 2020 were selected for empirical analysis.

3.1 The Entropy Weight Calculation of Logistics Competitiveness Evaluation Indicator

According to the entropy weight formulas (1), (2) and (3), the relevant data of logistics indicators of cities in Fujian Province in 2020 were calculated, and the entropy weight values of these 16 logistics indexes are shown in TABLE II below.

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TABLE II. Entropy weight of each logistics indicator

Indicators	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8
w_j	0.0351	0.0186	0.1502	0.0642	0.0451	0.0445	0.0195	0.1282
Indicators	x_9	x_{10}	x_{11}	x_{12}	x_{13}	x_{14}	x_{15}	x_{16}
w_j	0.0154	0.0582	0.0333	0.0936	0.1635	0.0320	0.0307	0.0678

The calculation of entropy weight in TABLE II shows that the average value of entropy weight of these 16 indicators is 0.0625, and the indicators higher than the average entropy value from high to low are respectively water freight volume (x_{13}), total import and export volume (x_3), port cargo throughput (x_8), railway freight volume (x_{12}), the number of employees in the transportation, post and telecommunication industry (x_{16}), and total retail sales of social consumer goods (x_4), which are much higher than the remaining 10 indicator factors, indicating that these six factors have a greater impact on the regional logistics competitiveness of Fujian Province. Particularly, the entropy weights of the top three indicators are higher than 0.1, which also provides the decision basis for cities in Fujian to improve the logistics competitiveness.

3.2 Analysis on Regional Logistics Competitiveness Based on Entropy Weight -TOPSIS

The data of 9 cities in Fujian Province in 2020 were selected. The original data were normalized and the weighted evaluation matrix was calculated to get the positive ideal solution V^+ and the negative ideal solution V^- respectively:

$$V^+ = (0.0351, 0.0186, 0.1502, 0.0642, 0.0451, 0.0445, 0.0195, 0.1282, 0.0154, 0.0582, \\ 0.0333, 0.0936, 0.1635, 0.0307, 0.0678)$$

$$V^- = (0.0076, 0.0041, 0.0025, 0.0082, 0.006, 0.0061, 0.0024, 0.0001, 0.0038, 0.0076 \\ 0.0059, 0.0026, 0.0009, 0.008, 0.0088)$$

By using the formulas (8) and (9), the distance between the logistics competitiveness of each city in Fujian Province and the positive and negative ideal solutions, and the relative nearness to the ideal solutions can be obtained. The results are shown in TABLE III below.

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TABLE III. Distance between logistics competitiveness of cities and positive and negative ideal solutions and its relative nearness to ideal solutions

Cities	D_i^+	D_i^-	C_i	Ranking
Fuzhou	0.1128	0.2048	0.6448	3
Xiamen	0.0757	0.2579	0.7730	1
Putian	0.2714	0.0352	0.1147	6
Sanming	0.2792	0.0703	0.2011	4
Quanzhou	0.1222	0.2378	0.6605	2
Zhangzhou	0.2561	0.0520	0.1687	5
Nanping	0.2930	0.0178	0.0571	9
Longyan	0.2904	0.0193	0.0622	8
Ningde	0.2753	0.0295	0.0969	7

According to TABLE III, the logistics competitiveness of nine cities in Fujian Province was ranked in descending order, namely Xiamen, Quanzhou, Fuzhou, Sanming, Zhangzhou, Putian, Ningde, Longyan and Nanping. According to the relative nearness of each city, clustering analysis was performed using GeoDa software. The first category included Fuzhou, Xiamen and Quanzhou, indicating that the logistics competitiveness of these three cities was stronger than that of the other six cities, as shown in the dark blue area in Fig. 1. The second category included Zhangzhou, Putian, Sanming, Longyan, Ningde and Nanping, whose logistics competitiveness was poorer compared with that of Fuzhou, Xiamen and Quanzhou, as shown in the light blue area in Fig. 1.

Fig. 1: Regional cluster map of logistics competitiveness in Fujian Province

IV. RESULT ANALYSIS

4.1 Analysis on Entropy Weight of Regional Logistics Competitiveness Indicator in Fujian Province

First, the entropy weights of water freight volume and port cargo throughput were more than 0.12, ranking first and third among the 16 indicators, indicating that Fujian Province should make full use of the

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coastal geographical advantages, vigorously develop water transport and port construction, and thus promote the competitiveness of Fujian regional logistics.

Second, the entropy weights of total import and export and total retail sales of social consumer goods ranked second and sixth, which were higher than the average, indicating that the level of economic development and consumption directly stimulated the demand for logistics and played an important role in promoting the competitiveness of logistics.

Third, among the six logistics indicators higher than the average entropy value, the five indicators of water freight volume, total import and export volume, port cargo throughput, railway freight volume and total retail sales of social consumer goods were directly related to the demand side of the logistics industry, further illustrating that the logistics demand plays a positive role in promoting the regional logistics competitiveness and the development of the logistics industry.

Fourthly, the entropy weight of the number of employees in the transportation, post and telecommunication industry ranked fourth, which proves that the reserve of logistics talents is closely related to the high-quality development of logistics and directly affects the competitiveness of logistics.

4.2 Kmeans-Based Cluster Analysis

According to the relative nearness between the logistics of each city and the ideal solution, the Kemans clustering analysis was carried out with GeoDa software, and it was concluded that Xiamen, Quanzhou and Fuzhou, which have relatively strong competitiveness in the first category of logistics, had their nearness above 0.6, while Sanming, Zhangzhou, Putian, Ningde, Longyan and Nanping, which have relatively weak competitiveness in logistics, fell into the second category. Sanming ranked fourth with a relative nearness of 0.2011, which was 0.4437 lower than Fuzhou of 0.6448 ranked third, indicating that although there was a difference of one place in the ranking, there was a big difference in its logistics competitiveness. Nanping ranked ninth with a relative closeness of 0.0571, which was 0.7159 different from Xiamen ranked first, further illustrating the polarization of regional logistics competitiveness in Fujian.

4.3 Comparative Analysis of Regional Logistics Competitiveness in Fujian Province

TABLE IV shows the relative nearness and ranking of nine cities in Fujian Province, and Fig. 2 shows the comparison results of logistics competitiveness of nine cities in Fujian Province. Figure 2 shows that Xiamen, Fuzhou and Quanzhou ranked the top three in terms of urban economic development level, logistics demand, logistics infrastructure, human resources and information construction. Xiamen had relatively small difference and concentration in these four first-level indicators. Compared with the other three indicators, Fuzhou's economic development level was relatively weak in competitiveness. The logistics demand of Quanzhou ranked first in the province among all indexes, far higher than that of other cities, but there was a certain gap between the human resources and information construction of Quanzhou and Fuzhou and Xiamen. The relative nearness of the four first-level indicators of Putian, Sanming,

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Zhangzhou, Nanping, Longyan and Ningde was lower than the average of the whole province, especially those of Nanping, Longyan and Ningde, which were far from the average. Generally speaking, the logistics competitiveness of these six cities was lower than the average of the whole province, and the logistics competitiveness was relatively weak.

TABLE IV. Relative nearness and ranking of first-level indicators of logistics competitiveness of cities

Cities	**Economic development level**		**Logistics infrastructure**		**Logistics demand**		**Human resources and information construction**	
	C_i	Ranking	C_i	Ranking	C_i	Ranking	C_i	Ranking
Fuzhou	0.4946	2	0.7300	3	0.7499	3	0.7230	2
Xiamen	0.7324	1	0.8827	1	0.7669	2	0.7997	1
Putian	0.0528	7	0.1927	5	0.1126	5	0.0442	6
Sanming	0.0554	5	0.1051	7	0.2829	4	0.0162	9
Quanzhou	0.4247	3	0.7952	2	0.9671	1	0.4458	3
Zhangzhou	0.1413	4	0.2984	4	0.1084	6	0.1084	4
Nanping	0.0151	9	0.1051	8	0.0435	9	0.0328	7
Longyan	0.0536	6	0.0960	9	0.0506	8	0.0324	8
Ningde	0.0387	8	0.1879	6	0.0732	7	0.0484	5
Average	0.2232		0.3770		0.3506		0.2548	

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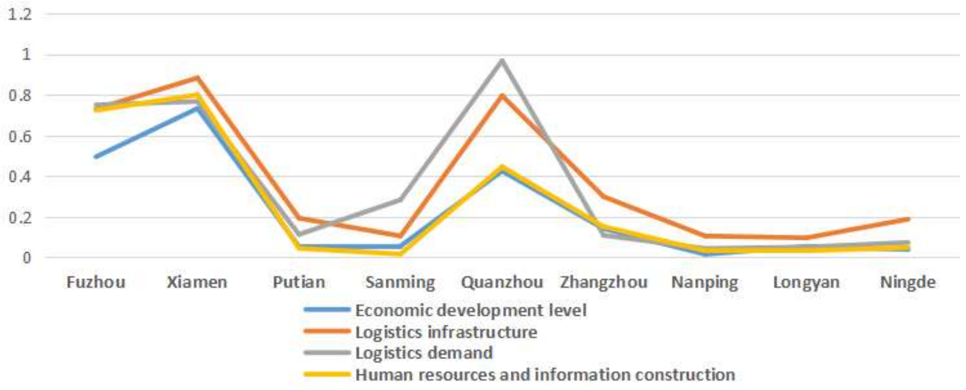

Fig. 2: Comparison of sub-indicators of logistics competitiveness of nine cities in Fujian Province

V. CONCLUSION

The above empirical analysis shows that the logistics competitiveness of different regions in Fujian Province is quite different. In order to promote the rapid development of the regional logistics industry in Fujian Province, it is necessary to further optimize the allocation of resources, consolidate the logistics infrastructure, give full play to the advantageous regional logistics industry, and promote the enhancement of the competitiveness of the logistics in other regions, so as to enhance the overall logistics competitiveness of Fujian Province and realize the high-quality development of modern logistics. The following recommendations are made:

First, the logistics infrastructure should be established. The coastal geographical advantages of Fujian should be fully utilized to vigorously develop water transport and port construction, strengthen port integration, and develop multimodal transport such as sea transportation, shipping, highway transport and rail transport to promote large circulation. Infrastructure interconnection with Guangdong, Jiangxi, Zhejiang and other provinces should be promoted to open up logistics and transportation channels. The upgrading of the cold chain logistics industry should be promoted, and the distribution network at the end of urban and rural areas should be improved to consolidate the basic conditions of high-quality logistics in Fujian Province.

Second, the construction of intelligent transportation and logistics should be vigorously developed by seizing the opportunity of digital Fujian and digital economy development, transforming the traditional logistics development mode, practicing the green and low-carbon concept, transforming to digital logistics, and promoting the coordinated development of logistics Internet, information Internet and energy Internet, so as to realize the smooth flow of goods, effectively reduce logistics costs, and build an intelligent logistics system with the characteristics of Fujian Province.

Third, the agglomeration and radiation role of logistics hub cities should be brought into play by making full use of the resource advantages of Fuzhou, Xiamen, Quanzhou, Sanming and Pingtan as national logistics hub cities (districts). The linkage development between logistics industrial clusters in each city and hub cities should be strengthened, and the interconnection of hubs should be promoted. The above empirical analysis shows that Fujian Province has formed three logistics center nodes, namely Fuzhou, Xiamen and Quanzhou. Therefore, it is necessary to make full use of the logistics agglomeration and radiation effects of the cities with the logistics center nodes of Fuzhou and Quanzhou to promote the promotion of logistics competition in other regions. A layout of "one-province, three-ring logistics development circle" with Fuzhou as the center to radiate Putian, Ningde, Nanping and Sanming, Xiamen as the center to radiate Zhangzhou and Longyan, and Quanzhou as the center to radiate Zhangzhou, Longyan, Sanming and Putian should be established, and be actively integrated into the integration development of Guangdong-Hong Kong-Macao Greater Bay Area and Yangtze River Delta, so as to drive the rapid development of regional logistics in southeast Fujian and northwest Fujian.

Fourth, the introduction and training of logistics talents should be strengthened because logistics talents are an important guarantee for the high-quality development of modern logistics. Cities in Fujian Province should increase their investment in the introduction of logistics talents and educational resources, especially in the training and introduction of high-level logistics talents, and at the same time establish a mechanism to attract and retain talents to create a good environment for logistics practitioners.

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