EWM-based Comprehensive Evaluation of Regional Logistics Development in Fujian Province

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Abstract: The authors have constructed an indicator system for evaluating the level of regional logistics development from six dimensions, including regional economy, regional logistics demand and regional logistics economy, and employed the entropy weight method (EWM) to construct a model for comprehensively measuring regional logistics development, followed by an empirical analysis of the level of logistics development in nine major cities of Fujian Province as of 2018. The results reveal that there are still significant differences in the level of logistics development among the nine major cities of Fujian Province, highlighting the pressing need for local governments to turn the spotlight on promoting balanced regional development of the logistics industry.

1. Foreword

Over the past years, with the accelerating construction of the Western Taiwan Straits Economic Zone and the burgeoning development of national economy, the overall scale of the logistics industry has been expanding in Fujian Province, with service level picking up continuously, development conditions and environment improving constantly, and regional logistics cooperation scaling up persistently. An objective and accurate analysis and evaluation of the level of regional modern logistics development and a comprehensive comparison of the same with the surrounding regions are of great significance for facilitating scientific decision-making, improving the modern economic development environment, revving up the thriving development of logistics operators and business logistics, enhancing the competitiveness of regional modern logistics and shoring up the prosperity of the entire regional economy.

Presently, domestic research focuses mainly on the impact of regional logistics on regional economy, forecast of the regional logistics demand, structural optimization of regional logistics, and the comprehensive evaluation of the level of regional logistics development [1]. Wang Bo applied the analytic hierarchy process (AHP) and fuzzy comprehensive evaluation (FCE) methods to evaluate the level of regional logistics development in Tianjin [2]; Zhu Bangzhu et al. utilized the principal component analysis (PCA) method to carry out horizontal and vertical comprehensively evaluation of the level of logistics development in Jiangmen City, Guangdong Province [3]; and Wang Zhenfeng Et al. employed the non-linear principal component analysis method to quantitatively measure the level of logistics development in Henan Province [4]. Different methods have different focuses in determining the weights for evaluation. In this paper, the authors have employed the entropy weight method (EWM) to construct a model for comprehensively evaluating the level of regional logistics development, and used the same model to comprehensively evaluate and analyze the level of logistics development in each major cities of Fujian Province.

2. Basic principles and implementation steps of EWM

EWM allows objective weighting of indicators based on the amount of information provided by the indicator data, thereby minimizing the influence of subjective factors. Therefore, the weights

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obtained by EWM boast higher credibility than those obtained using the subjective weighting methods.

2.1 Basic principles

In information theory, entropy is seen as a measure of uncertainty, and can be interpreted as the amount of information needed to eliminate the uncertainty of random events. According to the characteristics of entropy, we can determine the randomness and uncertainty of an event by calculating the entropy, or utilize the entropy to determine the degree of dispersion of an indicator. The lower the entropy of an indicator is, the greater the degree of dispersion will be, indicating that the same indicator provides greater amount of information and therefore has a greater weight, and vice versa.

2.2 Implementation steps

Assuming that we need to comprehensively evaluate the level of logistics development in p regions, and that the indicator system includes q indicators, the mathematical model constructed accordingly is as follows [5]:

Assuming that the domain of discourse is (1), and u_x is the data characterization of q indicators, the initial data matrix (2) of the evaluation model can be obtained via (3).

First of all, in order to eliminate the incommensurability caused by the different measurement units, the evaluation indicators must be standardized in the first place. Let m'_{xy} be the standardized indicator value. $m_{y\max}$ is the maximum value of the y-th indicator, while $m_{y\min}$ is the minimum value of the y-th index, with positively correlated indicators using the equation, as in (4) and negatively correlated indicators using the other equation, as in (5). After that, equation (6) is utilized to obtain proportion n_{xy} of each indicator value m'_{xy} in the same indicator, and then equation (7) is utilized to calculate the entropy of the y-th indicator. In the (7), the constant K is related to the number of samples p: when p samples are in a system with completely disordered information, the information entropy is 1, in which case (8). The redundancy of entropy d depends on the difference between the entropy of the indicator and 1, i.e. (9). Lastly, equation (10) is used to obtain weight z_y of the y-th indicator, and then equation (11) is used to calculate the comprehensive scores representing the level of logistics development in nine major cities of Fujian Province.

$$U = \{u_1, u_2, \cdots, u_x\} (x = 1,2,\cdots,p) \tag{1}$$

$$M = \{m_{xy}\}_{pxq} \tag{2}$$

$$u_x = \{m_{x1}, m_{x2}, \cdots, m_{xy}\} (x = 1,2,\cdots,p; y = 1,2,\cdots q) \tag{3}$$

$$m'_{xy} = \frac{m_{xy} - m_{y\min}}{m_{y\max} - m_{y\min}} \tag{4}$$

$$m'_{xy} = \frac{m_{y\max} - m_{xy}}{m_{y\max} - m_{y\min}} \tag{5}$$

$$n_{xy} = \frac{m'_{xy}}{\sum_{x=1}^{p} m'_{xy}} \tag{6}$$

$$e_y = -K \sum_{x=1}^{p} \left(n_{xy} \ln n_{xy} \right) \tag{7}$$

$$K = \frac{1}{\ln p} \tag{8}$$

$$d_y = 1 - e_y \tag{9}$$

$$z_y = \frac{d_y}{\sum_{y=1}^{q} d_y} \tag{10}$$

$$t_x = \sum_{y=1}^{q} (z_y m'_{xy}) \tag{11}$$

3. EWM-based comprehensive evaluation of regional logistics development and the corresponding Results

3.1 Construction of an indicator system for the comprehensive evaluation of regional logistics development

On the basis of carrying out systematic analysis and integration of existing domestic studies and ensuring the rationality and scientificity of various indicators, the authors have constructed a comprehensive evaluation indicator system that includes 1 master indicator, 6 primary indicators and 13 secondary indicators. The specific indicator system is shown in Table 1. Since China has not yet given a clear definition for the logistics industry, based on the existing research, the authors include transportation, warehousing and postal services as the logistics industry [6].

Table 1 Indicator system for the comprehensive evaluation of logistics development in Fujian Province

Master Indicator	Primary Indicators	Secondary Indicators
Indicator System for the Comprehensive Evaluation of Regional Logistics Development	Regional economy	GDP
		per capita GDP
	Regional logistics demand	Postal & mail services
		Volume of express delivery
	Regional logistics economy	Total retail sales of consumer goods
		Turnover of postal and telecommunications services
	Regional logistics transportation	Total highway mileage
		Passengers carried
		Cargos delivered
		Total number of vehicles
	Regional logistics manpower	Logistics practitioners
	Regional logistics informatization	Internet users
		Mobile phone users

3.2 Empirical study

3.2.1 Data source and processing

Our research targets include nine major cities of Fujian Province: Fuzhou City, Xiamen City, Quanzhou City, Putian City, Sanming City, Zhangzhou City, Longyan City, Ningde City, and Nanping City.

Through the use of EWM, the weights obtained for respective indicators are shown in Table 2 below.

Table 2 Weights Obtained for Respective Indicators

Primary Indicators	Secondary Indicators	Weight	Weights for the primary indicators
Regional economy	GDP	8.21%	13.58%
	per capita GDP	5.37%	
Regional logistics demand	Postal & mail services	8.79%	19.72%
	Volume of express delivery	10.93%	
Regional logistics economy	Total retail sales of consumer goods	11.05%	17.76%
	Turnover of postal and telecommunications services	6.71%	
Regional logistics transportation	Total highway mileage	2.48%	30.15%
	Passengers carried	7.86%	
	Cargos delivered	7.88%	
	Total number of vehicles	11.93%	
Regional logistics manpower	Logistics practitioners	5.29%	5.29%
Regional logistics informatization	Internet users	6.25%	13.50%
	Mobile phone users	7.25%	

Table 3 shows that "Regional logistics transportation" has the highest weight. Specifically, "Total number of vehicles" has the highest weight of 11.93%, indicating that transportation capacity of a city imposes stronger impact on its level of logistics development. "Regional logistics manpower" has the lowest weight of only 5.29%, indicating that this indicator imposes weaker impact on the level of logistics development in nine major cities than other indicators.

Lastly, the scores of respective primary indicators and the combined scores of the nine major cities of Fujian Province are shown in Table 3 below.

Table 3 Scores of respective primary indicators and combined scores of nine major cities of Fujian Province in 2018

Province	Regional economy	Regional logistics demand	Regional logistics economy	Regional logistics transportation	Regional logistics manpower	Regional logistics informatization	Combined Score
Fuzhou	0.1118	0.1039	0.1757	0.2267	0.0249	0.0812	0.7241
Sanming	0.0221	0.0022	0.0001	0.0540	0.0122	0.0119	0.1025
Xiamen	0.0906	0.1218	0.1047	0.1394	0.0529	0.0756	0.5850
Putian	0.0170	0.0088	0.0194	0.0370	0.0001	0.0391	0.1214
Quanzhou	0.1143	0.1502	0.1454	0.2016	0.0148	0.1350	0.7613
Zhangzhou	0.0370	0.0270	0.0559	0.0339	0.0101	0.0514	0.2153
Nanping	0.0001	0.0083	0.0201	0.0277	0.0153	0.0022	0.0738
Longyan	0.0326	0.0077	0.0122	0.0340	0.0481	0.0035	0.1382
Ningde	0.0017	0.0083	0.0058	0.0547	0.0032	0.0201	0.0939

3.2.2 Evaluation results

According to the above table, it can be seen that there are still significant differences among the nine cities of Fujian Province in regard to the level of logistics development. Quanzhou ranks first in terms of "Regional economy", "Regional logistics demand" and "Regional logistics informatization", and also performs well on the other three indicators, thereby getting the highest combined score. Fuzhou ranks first in terms of "Regional logistics economy" and "Regional logistics transportation", and also ranks 2nd or 3rd in the remaining indicators, thereby getting the second highest combined score. Xiamen leads only in "Regional logistics manpower", and therefore it ranks 3rd in the combined score. Ranking 4th, Zhangzhou performs relatively weak on economy and manpower given its notable gap with Xiamen. As a mountainous city, Longyan outperforms Putian and Ningde by dint of its competitive edge in economy and manpower against the two coastal cities. Both Ningde and Nanping have no much advantage in all aspects, and hence they rank 8th and 9th respectively.

On the basis of combined scores, a further clustering analysis can be carried out on the overall status of logistics development in the nine major cities of Fujian Province. Using SPSS 20.0, the authors have performed Q-type clustering analysis on the combined scores of the nine major cities of Fujian Province [7,8] to derive a dendrogram, as shown in Figure 1. The nine major cities of Fujian Province can be divided into three categories, with the first category consisting of Fuzhou and Quanzhou, the second category consisting of Xiamen, and the third category consisting of Sanming, Ningde, Nanping, Putian, Longyan and Zhangzhou. Falling within the first category, Fuzhou and Quanzhou are both coastal cities having many ports. Furthermore, Fuzhou as the capital city of Fujian Province and Quanzhou as the starting point of the Maritime Silk Road are both pioneers and highly developed in terms of economic development, transportation, foreign trade, service industry and other aspects, which give them certain competitive edge, and hence the two cities enjoy a significantly higher level of logistics development than other major cities. In the second category, as one of the first four special economic zones established in China, Xiamen is relatively advantaged in industry and trade. Still, due to its smaller land area and population than Quanzhou and Fuzhou, and given the faster pace of economic development in Quanzhou and Fuzhou over the past years, Xiamen remains at the average level of logistics development, though it's blessed with great potential. Six cities including Zhangzhou and Putian in the third category have relatively fewer advantages, which inevitably lead to the lower level of logistics development. All these facts point to the imbalanced logistics development among the nine major cities of Fujian Province.

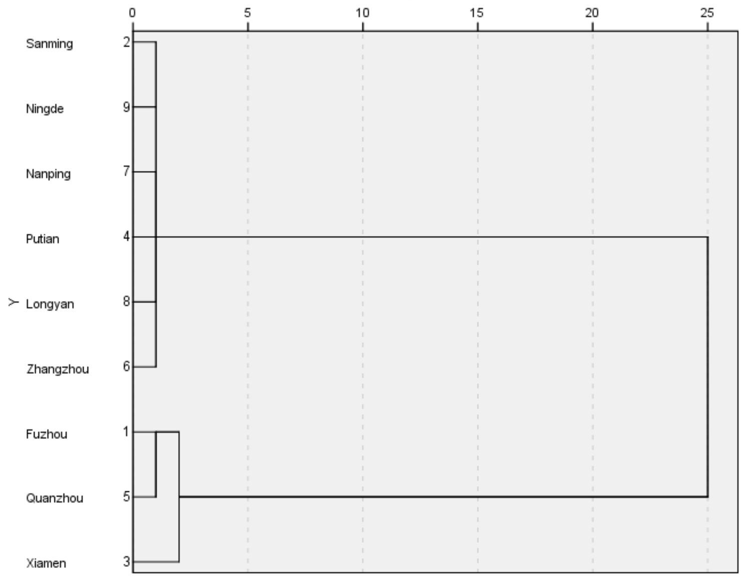

Figure 1 Dendrogram obtained through clustering analysis

4. Conclusion

For the purpose of constructing an indicator system for comprehensively measuring regional logistics development, the authors carried out an empirical analysis of the level of logistics development in nine major cities of Fujian Province as of 2018 through the use of the entropy weight method (EWM). The results reveal that there are still significant differences in the level of logistics development among various regions of Fujian Province, pointing to the stark fact of imbalanced logistics development across the province.

In order to promote balanced logistics development among the nine major cities of Fujian Province, the governments of first- and second-category cities, namely Fuzhou, Quanzhou and Xiamen, should actively address themselves to their own shortcomings and weaknesses, and make further moves to consolidate and strengthen their existing level of logistics development in order to avoid the degradation of existing achievements in the coming years. Meanwhile, they should also give full play to their "strengths" in a bid to drive the shared development of neighboring cities. In keeping up with the pace of the first- and second-category cities, the governments of the third-category cities should draw on the successful experience of these pacesetting cities and pragmatically tailor their logistics development strategies and policies for the current stage to the local conditions, in addition to further efforts to promote socioeconomic development, to push up the demand for logistics services, to rev up IT applications in the transportation sector, and to foster logistics professionals, thereby contributing to the balanced logistics development across the province.

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