Rural Logistics Management Evaluation and Influencing Factors Analysis -- Taking the Yangtze River Economic Belt as an Example

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Abstract. This paper uses the entropy weight TOPSIS to measure the rural logistics management in the Yangtze River Economic Belt from 2015 to 2021, and constructs the grey correlation model to explore the influencing factors of rural logistics management. The results show that: the level of rural logistics management in the Yangtze River Economic Belt has obvious spatial imbalance characteristics, showing the distribution state of Shanghai and Zhejiang as the core and decreasing outwards. In addition, the analysis of influencing factors shows that logistics infrastructure construction, informatization level and urbanization level are the core factors affecting rural logistics management.

Keywords: Rural logistics, Logistics management, Influencing factors;,Entropy weight topsis, Grey relational model.

1 INTRODUCTION

China has the largest logistics market in the world, but the logistics network is uneven, with rural and inland markets lagging[1] behind urban and coastal markets. As an emerging industry with great development potential, rural logistics is also an important link in the circulation of urban and rural commerce. At the same time, its development is faced with challenges[2] such as weak rural network infrastructure, imperfect rural logistics distribution service system and lack of modern logistics management concepts in rural logistics enterprises. It reflects the unbalanced and inadequate development of rural logistics. Therefore, improving the development level of rural logistics has important strategic significance[3] for promoting the flow of urban and rural elements, activating the rural consumer market and boosting rural integration into the new development pattern of double circulation. Studying the evaluation and influencing factors of rural logistics management in the Yangtze River Delta region can provide an important reference for improving the high-quality development of logistics, and at the same time provide new ideas and ways for the realization of the strategic goal of rural revitalization.

Rural logistics management is a hot research topic at home and abroad. ① In the theoretical research of rural logistics management, this paper tries to define the concept

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of rural logistics and discusses the research framework of rural logistics, which has the characteristics of seasonality, diversity and dispersion. [4,5,6][7,8,9](2) In terms of the measurement of rural logistics management, scholars evaluate the development level of rural logistics management by constructing a comprehensive index system, or use econometric models to measure the development level of rural logistics. [10,11]3) In terms of the influencing factors of rural logistics management, rural economy, farmers' income increase, residents' consumption level and consumption structure, urban-rural integration and other factors affect the level of rural logistics management to varying degrees. [12][13][14][15]To sum up, the existing research on rural logistics management has achieved fruitful results. Although there are differences in quantitative measurement methods, it is agreed that different research methods should be used to measure the development level of rural logistics according to the actual situation. When constructing the index system, it should also fit the characteristics and actual situation of the research object.

At present, the research on rural logistics management focuses on the indicators at the economic level, but pays less attention to the indicators of logistics and transportation level and government support, which play a basic role in the operation of rural logistics system. In addition, although the depth and breadth of quantitative research on regional rural logistics development level are constantly expanding, the discussion on the evaluation level and influencing factors of rural logistics management in the Yangtze River Delta still needs to be deepened. In view of this, this paper selects 18 prefecture-level cities in the Yangtze River Delta as the research object, constructs the index system of rural logistics management in the Yangtze River Delta region, quantitatively analyzes the level, spatio-temporal evolution characteristics and evolution trend of rural logistics management in each province and city from 2015 to 2021, and then analyzes the influencing factors of rural logistics, in order to provide theoretical basis for formulating countermeasures to improve the level of rural logistics management.

2 CONSTRUCTION OF THE EVALUATION INDEX SYSTEM AND DATA METHODS

2.1 Construction of Rural Logistics Management Index System in Yangtze River Delta Region

The research on rural logistics management has not been unified. Referring to the existing research[16,17,18], combining with the actual situation of rural areas in the Yangtze River Delta, and considering the principles of comprehensiveness, comparability and availability of indicators, this paper analyzes six dimensions: rural economic development level, agricultural output level, rural logistics and transportation level, rural logistics manpower level, rural logistics information level and rural logistics government support. To construct the evaluation index system of rural logistics management in the Yangtze River Delta region (Table 1), which includes 14 indicators.

Table 1. Evaluation index system of rural logistics management in the Yangtze River Economic Belt

	First-level indicators	Secondary indicators	Units	Attributes
Evaluation index system of rural logistics management	Output level of agricultural products	Output of major agricultural products	Ten thousand tons	(+)
		Output value of agriculture, forestry, animal husbandry and fishery services	100 million yuan	(+)
		Total farm machinery power	Kilowatt	(+)
	Level of rural logistics and transportation	Mileage of rural roads	Km	(+)
		Total road freight	10,000 tons	(+)
		Road cargo turnover	10,000 ton-km	(+)
	Rural logistics manpower level	Number of rural logistics employees	Ten thousand	(+)
		Number of permanent rural residents at the end of the year	Ten thousand	(+)
	Level of rural logistics information	Revenue from postal services	100 million yuan	(+)
		Rural postal industry delivery lines	Kilometers per kilometer	(+)
		Number of rural broadband access users	Ten thousand households	(+)
		Number of mobile phones in rural areas	Ten thousand	(+)
	Rural logistics government support	Per capita local fiscal expenditure on transportation	RMB '000	(+)
		Per capita local financial support for agriculture	RMB '000	(+)

2.2 Research Methodology

Entropy weight TOPSIS method is the combination of entropy weight method (entropy value method) and TOPSIS method, which is often used for comprehensive evaluation of multiple targets and multiple indicators. It not only combines the advantages of entropy weight method to standardize the index and exclude human factors to determine the weight according to the degree of variation. In addition, it combines the advantages[19, 20] of TOPSIS method to quantify the ranking by comparing the proximity between the evaluation object and the ideal solution.

The calculation of entropy-weighted TOPSIS method is divided into two stages. In the first stage, the entropy weight method is used to construct the weighting matrix. Suppose that there are n evaluation objects and m evaluation indexes in period t, and xij (i,j=1,2,⋯,n) is the JTH index of the ith object in a certain period, then the original data matrix X of this period is:

$$X = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1m} \\ x_{21} & x_{22} & \cdots & x_{2m} \\ \vdots & \vdots & \ddots & \vdots \\ x_{n1} & x_{n2} & \cdots & x_{nm} \end{bmatrix} \tag{1}$$

Since the unit of evaluation index is not uniform and there are negative indicators, the range method is used to standardize the original data and obtain a new matrix R. Let rij be the normalized value of Xij in matrix x, rij∈[0,1].

$$\text{Positive indicator: } r_{ij} = \frac{x_{ij} - \min x_{ij}}{\max x_{ij} - \min x_{ij}} \tag{2}$$

$$\text{Negative indicators: } r_{ij} = \frac{\max x_{ij} - x_{ij}}{\max x_{ij} - \min x_{ij}} \tag{3}$$

According to the entropy weight, the weighted matrix Y is:

$$Y = W \cdot R = \begin{bmatrix} w_1 r_{11} & w_2 r_{12} & \cdots & w_m r_{1m} \\ w_1 r_{21} & w_2 r_{22} & \cdots & w_m r_{2m} \\ \vdots & \vdots & \ddots & \vdots \\ w_1 r_{n1} & w_2 r_{n2} & w_1 r_{11} & w_m r_{nm} \end{bmatrix} = \begin{bmatrix} y_{11} & y_{12} & \cdots & y_{1m} \\ y_{21} & y_{22} & \cdots & y_{2m} \\ \vdots & \vdots & \ddots & \vdots \\ y_{n1} & y_{n2} & \cdots & y_{nm} \end{bmatrix} \tag{4}$$

In the second stage, the TOPSIS method is used to judge the closeness between the evaluation object and the ideal solution. Euclidean distance between evaluation object and positive and negative ideal solution is calculated.

$$D_i^+ = \sqrt{\sum_{j=1}^{m} (y_{ij} - y_j^+)^2} \tag{5}$$

$$D_i^- = \sqrt{\sum_{j=1}^{m} (y_{ij} - y_j^-)^2} \tag{6}$$

Finally, the relative closeness degree Ci between the evaluation object and the ideal solution is obtained. The larger the value is, the closer it is to the ideal state.

$$C_i = \frac{D_i^-}{D_i^+ + D_i^-} (0 \le C_i \le 1, i = 1,2 \ldots n) \tag{7}$$

2.3 Measurement of Rural Logistics Management in Yangtze River Economic Belt

Considering the availability of data, this paper selects the panel data of 11 provinces and cities in China's Yangtze River Economic Belt from 2015 to 2021. The data mainly come from China Statistical Yearbook, China Urban Statistical Yearbook, China Rural Statistical Yearbook and the statistical yearbooks of each province over the years. For some missing data, adjacent average method and linear interpolation method were used to adjust and fill in the data.

Based on the evaluation index system constructed above, this paper uses the entropy weight TOPSIS method to calculate the evaluation scores of rural logistics management in 11 provinces and cities in the Yangtze River Economic Belt, and lists the calculation results of representative years for display. The results are shown in Table 2.

Horizontally, the rural logistics management of 11 provinces and cities in China's Yangtze River Economic Belt has been continuously improved, and the average level of rural logistics management has increased from 0.283 in 2015 to 0.337 in 2020. The "Belt and Road" Initiative proposed by China in 2013 and the "13th Five-Year Plan for the Development of Western China" in 2017 have brought new opportunities to the development of logistics industry. Thanks to the increase of government investment and policy support, the rural logistics management level of Sichuan Province has increased rapidly, increasing by 0.2735. Vertically, there are significant differences in the level of rural logistics management among provinces in the Yangtze River Economic Belt, such as Yunnan, Chongqing and Shanghai. On the whole, the level of rural logistics management in Shanghai, Jiangsu, Zhejiang and other provinces is relatively strong, while Guizhou, Yunnan and other provinces have been in a weak position.

Table 2. Evaluation value of rural logistics management in provinces and cities along the Yangtze River Economic Belt

	2015	2017	2019	2021	Mean	Ranking
Shanghai	0.489	0.534	0.627	0.643	0.575	1
Jiangsu	0.472	0.508	0.584	0.607	0.547	2
Zhejiang	0.358	0.395	0.402	0.441	0.403	3
Anhui	0.133	0.199	0.231	0.275	0.205	9
Jiangxi	0.197	0.220	0.236	0.281	0.234	8
Hubei	0.331	0.348	0.374	0.377	0.358	6
Hunan	0.323	0.358	0.365	0.386	0.362	5
Chongqing	0.118	0.137	0.172	0.198	0.158	11
Sichuan Province	0.311	0.347	0.461	0.449	0.400	4
Yunnan	0.151	0.169	0.222	0.212	0.190	10
Guizhou	0.235	0.252	0.299	0.320	0.277	7
Mean	0.283	0.315	0.361	0.381	0.337	

In order to further explore the spatial distribution of the competitiveness level of the logistics industry, the ArcGIS software was used to visualize the rural logistics management level in 2015, 2017, 2019 and 2021, and the rural logistics management level was divided by the natural break method, and the distribution of rural logistics management level was listed respectively, as shown in Table 3.

It can be seen that the catch-up effect of rural logistics management level in the middle and lower reaches of the Yangtze River Economic Belt is obvious, and the evaluation value of rural logistics management is gradually transferred from the high level area of rural logistics management to the middle and lower reaches of the Yangtze River. The reason may be that with the promotion of the "Belt and Road" Initiative and the coordinated development strategy of the Yangtze River Economic Belt, the three regions of the Yangtze River Economic Belt, the middle and lower reaches, especially some provinces in the central and western regions, have good development opportunities. In addition, the hot spot of rural logistics management level has gradually shifted to the middle and lower reaches of the Yangtze River, which has greatly improved the level of rural logistics management in the central and western regions. In 2015, the high-level rural logistics areas include Shanghai, Jiangsu and other provinces, mostly

concentrated in the upper reaches of the Yangtze River Economic Belt. In 2019, the high-level rural logistics areas are mainly concentrated in the middle and lower reaches of the Yangtze River Economic Belt. In 2021, the high-level rural logistics areas are mainly concentrated in the middle and lower reaches of the Yangtze River Economic Belt. It shows that the rural logistics situation in the Yangtze River Economic Belt is good, the development speed and specialization degree of the logistics industry are constantly improving, and the catch-up effect is obvious. However, Yunnan, Guizhou and other regions in the western region in 2021 are still at a low level due to the relatively low number of rural logistics employees and the mileage of rural roads, indicating that there is a spatial imbalance in rural logistics. Although the growth trend of rural logistics level in the middle and lower reaches of the Yangtze River Economic Belt is better than that in the upstream areas, Although the growth trend of rural logistics level in the middle and lower reaches of the Yangtze River Economic Belt is better than that in the upstream areas, not all the provinces in the lower reaches of the Yangtze River Economic Belt have higher rural logistics level than that in the middle and upper reaches of the Yangtze River Economic Belt.

Table 3. Spatial distribution of rural logistics management level in each province

Status	2015	In 2017	2019	2021
low	Yunnan, Chongqing, Anhui, Jiangxi	Yunnan, Anhui, Chongqing	Chongqing	Chongqing
Lower	Guizhou	Guizhou and Jiangxi	Anhui, Jiangxi, Yunnan and Guizhou	Anhui, Jiangxi, Yunnan
Higher	Zhejiang, Hubei, Hunan, Sichuan	Zhejiang, Hubei, Hunan, Sichuan	Hubei and Hunan	Hubei, Hunan and Guizhou
high	Shanghai, Jiangsu	Shanghai, Jiangsu	Shanghai, Jiangsu, Zhejiang, Sichuan	Shanghai, Jiangsu, Zhejiang, Sichuan

3 ANALYSIS OF INFLUENCING FACTORS OF RURAL LOGISTICS MANAGEMENT LEVEL IN YANGTZE RIVER ECONOMIC BELT

3.1 Construction of Grey Relational Model

In order to further explore the influencing factors of rural logistics management in the Yangtze River Economic Belt, this paper uses the grey correlation analysis method for research.

Dimensionless processing. The measurement value sequence and each influencing factor sequence of rural logistics after the initial value method are denoted as $X_0^{'}(k,t)$、$X_{\mathrm{i}}^{'}(k,t)$

The correlation coefficient is calculated as follows:

$$r_i(k,t)=\frac{\min\limits_{i,k,t}\left|X_0^{'}(k,t)-X_i^{'}(k,t)\right|+\rho\max\limits_{i,k,t}\left|X_0^{'}(k,t)-X_i^{'}(k,t)\right|}{\left|X_0^{'}(k,t)-X_i^{'}(k,t)\right|+\rho\max\limits_{i,k,t}\left|X_0^{'}(k,t)-X_i^{'}(k,t)\right|},\rho=0.5 \tag{8}$$

Calculate grey correlation degree:

$$r_i=\frac{1}{K\cdot T}\sum_{k=1}^{K}\sum_{t=1}^{T}r_i(k,t),r_{i,k}=\frac{1}{T}\sum_{t=1}^{T}r_i(k,t),r_{i,t=}\frac{1}{M}\sum_{m=1}^{M}r_i(k,t) \tag{9}$$

3.2 Analysis of the Influencing Factors of Rural Logistics Management Level

Based on the previous research results[19, 20, 21] and considering the actual urban-rural development of the 11 provinces along the Yangtze River Economic Belt, this paper finally determines five influencing factors, which are as follows: (1) The level of logistics infrastructure: Logistics infrastructure has become one of the important conditions to promote the development of rural logistics, providing logistics network support to solve the problem of agricultural product transportation. This paper is measured by the ratio of highway, railway and highway mileage to regional area. (2) Urbanization level: the promotion of urbanization brings continuous good policy incentives and industrial support for the construction of new countryside, and enhances the localization power of rural logistics, which is measured by the ratio of urban population to total population at the end of the year. (3) The degree of informatization is measured by the number of Internet broadband access users; (4) the degree of market opening is represented by the total amount of foreign-invested enterprises; (5) the degree of government support: this paper takes the per capita government fund for agriculture as the measurement index.

In this paper, the grey correlation model is used to calculate the effect of various influencing factors on rural logistics in each province of the Yangtze River Economic Belt, and the results are shown in Table 4. The higher the grey correlation degree is, the greater the influence of this factor on rural logistics is.

Table 4. Grey correlation degree of rural logistics influencing factors in provinces along the Yangtze River Economic Belt

	Logistics infrastructure	Level of urbanization	Level of informatization	Degree of market openness	Government support
Shanghai	0.906	0.786	0.897	0.764	0.677
Jiangsu	0.839	0.612	0.796	0.712	0.654
Zhejiang	0.801	0.669	0.754	0.619	0.629
Anhui	0.768	0.595	0.624	0.518	0.547
Jiangxi Province	0.634	0.451	0.619	0.582	0.529
Hubei	0.625	0.517	0.579	0.544	0.412

Hunan	0.628	0.549	0.613	0.452	0.328
Chongqing	0.575	0.438	0.479	0.319	0.218
Sichuan	0.620	0.579	0.499	0.519	0.189
Yunnan	0.598	0.319	0.329	0.431	0.342
Guizhou	0.579	0.325	0.189	0.216	0.531
Mean	0.688	0.531	0.580	0.516	0.460

(1) The gray correlation between the level of logistics infrastructure and rural logistics management is the highest, with an average value of 0.688, indicating that the level of logistics infrastructure has the greatest effect on it. Four provinces with higher gray correlation degree than the mean value are in the upper reaches of the Yangtze River Economic Belt, indicating that the level of logistics infrastructure plays a higher role in rural logistics management in the upper reaches than in other areas. The main reason is that the upstream region of the Yangtze River Economic Belt has the location advantage of radiation driving. Perfect logistics infrastructure can promote the flow of resources and factors, thus effectively promoting the development of rural logistics.

(2) The grey correlation between the level of information technology and rural logistics management is second only to the level of logistics infrastructure, which indicates that the level of information technology plays a greater role in rural logistics management. There are 6 provinces with higher gray correlation degree than the average, most of which are in the Yangtze River economic Belt and the middle reaches of the region, and a few are in the lower reaches of the region. It can be seen that the effect of information technology level on rural logistics management in the Yangtze River Economic Belt and the middle reaches of the Yangtze River is higher than that in other areas. The reason may be that compared with the downstream areas, the information technology talents in the Yangtze River Economic Belt and the middle reaches of the Yangtze River are clustered, and the degree of digitalization is higher, so the effect of information technology level on rural logistics management is more sensitive and effective.

(3) The mean value of gray correlation degree between urbanization level and rural logistics management is 0.531, indicating that urbanization has become an important factor to promote the improvement of rural logistics management level. There are 6 provinces with higher gray correlation degree than the average, mainly the cities in the upper reaches of the Yangtze River Economic Belt, which indicates that the upper reaches of the Yangtze River Economic Belt pay more attention to the management of coordinated urbanization development, so as to promote the development of rural logistics.

(4) The mean value of grey correlation degree between market openness and rural logistics is 0.516, which indicates that foreign investment, as an important guarantee to improve rural logistics management, is conducive to the improvement of rural logistics to a certain extent. There are 7 provinces that are higher than the mean value of grey correlation degree, indicating that the effect of market openness on the upper reaches of the Yangtze River Economic Belt is higher than that of other regions. The reason is that the provinces in the upper reaches of the Yangtze River Economic Belt have attracted

more investment under the guidance of "One Belt and One Road" and other policies, which is more conducive to the improvement of rural logistics management.

(5) The mean value of grey correlation degree between government support and rural logistics management is 0.460, which indicates that government financial expenditure plays an important role in rural logistics management as an important fund guarantee for the development of rural logistics management, which is conducive to boosting the development of rural logistics. In the upper reaches of the Yangtze River Economic Belt, local government finance is more sufficient, which is more conducive to the development of rural logistics management, promoting the development of rural logistics.

4 CONCLUSIONS AND SUGGESTIONS

This paper takes 11 provinces and cities in the Yangtze River Economic Belt from 2015 to 2021 as the research object, and measures the level of rural logistics management and its influencing factors. The results show that there is a significant overall spatial imbalance in the development of rural logistics in the Yangtze River Economic Belt, that is, it shows a declining distribution state from inside to outside, with Shanghai and Zhejiang as the center. The research on the influencing factors shows that logistics infrastructure, informatization level and urbanization level are the core variables affecting rural logistics management in the Yangtze River Economic Belt, and they have a high correlation degree with rural logistics.

Based on the above research results, this paper draws the following suggestions: first, according to the research content, the following suggestions are put forward: (1) Improve the infrastructure construction. To upgrade the comprehensive transportation service of towns and villages, and accelerate the construction of "four good rural roads". We will improve the development of network warehousing and distribution centers, distribution centers and express delivery centers at the county, township and village levels. We will give special attention to poor and remote areas and encourage areas where conditions permit to develop a cold chain logistics system for rural origin, so as to convert logistics flows into economic growth and effectively ensure the two-way flow of industrial products to rural areas and agricultural products to cities. (2) Improve the level of informatization. On the one hand, we should actively promote technologies such as unmanned vehicles, drones, robots, intelligent sorting systems and intelligent coding equipment, gradually carry out 5G network construction in rural areas along the Yangtze River Economic Belt, and improve the digital infrastructure conditions for "mobile Internet plus" and "smart consumption" in rural areas. On the other hand, it is necessary to strengthen the construction of rural logistics information platform, realize the interconnection of "production, supply and marketing" information of agricultural products, improve the traceability of cold chain logistics information of agricultural products, reduce the unnecessary loss of agricultural products in transportation, so that farmers can sell their agricultural products through rural logistics platform, and at the same time, can conveniently buy agricultural materials and consumer goods. (3) Improve urban-rural integration. Establish a two-way flow system of

urban and rural elements, narrow the urban-rural information gap, focus on the logistics industry, gather and develop rural logistics, smooth urban-rural supply and demand information, and guide the production and circulation of agricultural products.

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