Measurement of High-Quality Development Level and Its Spatial Characteristics of Logistics Industry in China

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РАСЧЕТ ВЫСОКОГО УРОВНЯ РАЗВИТИЯ И ПРОСТРАНСТВЕННЫХ ХАРАКТЕРИСТИК ЛОГИСТИЧЕСКОЙ ОТРАСЛИ КИТАЯ*

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Аннотация. Метод TOPSIS на основе энтропийного веса используется для расчета высокого уровня развития логистической отрасли в 31 провинции Китая в 2011–2020 годах, а также для проверки пространственных различий и автокорреляции с использованием индекса Тейла и индекса *I Морана*. Результаты показывают, что: (1) высококачественный уровень развития логистической индустрии в Чжэцзяне, Гуандуне, Шанхае, Пекине и Цзянсу занимает первое место; (2) высококачественное развитие логистической индустрии ускоряется после 2014 года; (3) пространственные различия главным образом обусловлены дисбалансом в северо-западном Китае и Восточном Китае; (4) пространственная автокорреляция значительна и постепенно увеличивается. Наконец, в целях содействия высококачественному развитию и скоординированному развитию логистической отрасли предлагаются некоторые предложения и контрмеры.

Ключевые слова: логистическая индустрия; высокий уровень развития; метод TOPSIS на основе энтропийного веса; индекс Тейла; индекс Морана.

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MEASUREMENT OF HIGH-QUALITY DEVELOPMENT LEVEL AND ITS SPATIAL CHARACTERISTICS OF LOGISTICS INDUSTRY IN CHINA*

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Abstract. The entropy weight-TOPSIS method is used to calculate the high-quality development level of logistics industry in 31 provinces of China in 2011–2020, and to test its spatial differences and autocorrelation using Theil index and *Moran's I* index. The results show that: (1) the high-quality development level of logistics industry in Zhejiang, Guangdong, Shanghai, Beijing and Jiangsu ranks the top; (2) the high-quality development of logistics industry is accelerated after 2014; (3) the spatial differences mainly come from the imbalance in northwest China and East China; (4) the spatial autocorrelation is remarkable and gradually increasing. Finally, in order to promote the high-quality development and coordinated development of the logistics industry, some suggestions and countermeasures are put forward.

Keywords: logistics industry; high-quality development; entropy weight-TOPSIS; Theil index; *Moran's I* index.

1. Introduction

The report of the 20th National Congress pointed out that high-quality development is the primary task for building a modern socialist country in all respects. The premise of high-quality economic and social development is the high-quality development of the industry (Fang Ouyang, 2020), The high-quality development of the logistics industry is an important driving force to promote the high-quality development of China's economy (Yunchun Cao,2020). It is of great significance to analyze the high-quality development level of China's logistics industry from a macro perspective and explore its spatial characteristics to clarify the key elements in the process of high-quality development of regional logistics in China.

2. literature review

According to the research method, current research on the development of logistics quality can be divided into the following two categories: one is the qualitative research, aims to analyze a specific area of logistics quality development status and put forward scientific and reasonable suggestions. Liming He (2018), Bo Zhang (2020) pointed out the problems of logistics high-quality development and put forward the corresponding suggestions. The other is the quantitative research, aims

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to measure the high-quality development level of the logistics industry in different regions and influencing factors. For example, Yunchun Cao et al. (2020) measured the efficiency of the logistics industry with DEA-Malmquist method and explored the influencing factors of the high-quality development of the logistics industry with qualitative comparative analysis method. Weihua Gan et al. (2020) and Aoni Zhao (2022) evaluated the high-quality development level of logistics industry of six central provinces and Shanxi province by using the entropy weight-TOPSIS method. Zijing Liang et al. (2021) calculated the logistics productivity level of 13 cities in Jiangsu Province with functional data analysis method under high-quality development background.

To sum up, although the existing research results are relatively rich, there are still the following shortcomings: Firstly, most scholars only consider the total amount of indicators without considering the index productivity level when constructing the evaluation indicator system for the high-quality development of the logistics industry. Secondly, there is a lack of deep discussion on the spatial difference and autocorrelation of the high-quality development level of the logistics industry. Therefore this paper constructs the evaluation indicator system from the perspective of productivity, uses entropy weight-TOPSIS method to measure high-quality development level of logistics industry in 2011-2020, then uses the Theil index and global *Moran's I* index to test its spatial differences and autocorrelation characteristics, finally puts forward countermeasures according to the empirical results in order to promote the development of logistics industry in China.

3. Methodology

(1) Entropy weight-TOPSIS model

Entropy weight method is an objective empowerment method. According to the variation degree of each index, it calculates entropy weight of each index using information entropy, and then corrects the weight of each index through the entropy weight, so as to get a more objective index weight. Assuming there are m items to be evaluated and n evaluation index to form the original data matrix: $R = (r_{ij})_{m*n}$

$$R = \begin{pmatrix} r_{11} & r_{12} & \dots & r_{1n} \\ r_{21} & r_{22} & \dots & r_{2n} \\ \dots & \dots & \dots & \dots \\ r_{m1} & r_{m2} & \dots & r_{mn} \end{pmatrix}_{m*n} \tag{1}$$

In the case of obtaining the original data matrix, the attributes of the index should usually be analyzed firstly. If there is a negative index, the data needs to be processed positively, and then the data should be standardized later. Since all the indicators selected in this paper are positive indicators, the data standardization method can be directly used to reduce the influence of different dimensions on the calculation results. At present, there are many methods of data standardization, including extremum method, normalization method, mean method, etc. Here, the mean method is selected to standardize the original data. The calculation formula is:

$$R_{ij} = \frac{r_{ij}}{\overline{r_{ij}}}$$

$R_{ij}, r_{ij}, \overline{r_{ij}}$ represent the standardized data of the i item of j index, the original data and mean of the standardized data respectively. After obtaining standardized data, the weight needs to be calculated for each indicator. Firstly, to calculate the proportion $P_{ij}(P_{ij} = \frac{r_{ij}}{\sum_{i-1}^{m} r_{ij}})$ of the i item of the j index, then to calculate the entropy value $e_j(e_j = -k\sum_{i=1}^{m} P_{ij} \cdot LnP_{ij})$, $k = \frac{1}{Lnm}$, m refers to the number of items, then to calculate the entropy weight $w_j(w_j = \frac{(1-e_j)}{\sum_{j=1}^{n}(1-e_j)})$ of the j index. The entropy weight is taken as the weight of the index, and then the TOPSIS model is used to calculate the relative closeness degree value which reflects the high-quality development level of the logistics industry. Entropy weight-TOPSIS model is a kind of comprehensive evaluation method, the model principle is to use the entropy weight method for the index empowerment, and identify the maximum value and the minimum value of the annual data, then calculate the "distance" of the maximum value and the minimum value, finally calculate the relative closeness degree of annual data and the maximum value (Tingjia Gou, 2020). The calculation method is provided as follows:

The weighting matrix is:

$$Z = \begin{bmatrix} Z_{11} \dots Z_{1n} \\ \dots \dots \dots \\ Z_{m1} \dots Z_{mn} \end{bmatrix} \quad (2)$$

$$Z_{ij} = R_{ij} * w_j$$

In the above equation, w_j is the weight of the j index.

Then the maximum value and the minimum value are determined, respectively:

$$Z^{+} = (maxZ_{i1}, \ maxZ_{i2}, \ \dots maxZ_{in}) \quad (3)$$

$$Z^{-} = (minZ_{i1}, \ minZ_{i2}, \ \dots minZ_{in}) \quad (4)$$

Then the distance $D_i^+ D_i^-$ between Z^+ and Z^- is calculated:

$$D_i^+ = \sqrt{\sum_{i=1}^{n}(maxZ_{ij} - Z_{ij})^2} \quad (5)$$

$$D_i^- = \sqrt{\sum_{i=1}^{n}(minZ_{ij} - Z_{ij})^2} \quad (6)$$

Then calculate the relative closeness degree of each evaluation object:

$$C_i = \frac{D_i^-}{D_i^+ - D_i^-}, 0 \le C_i \le 1C_i \quad (7)$$

The closer of C_i and 1 indicates the closer to the optimal level (Fei Liu, Ting Gong, 2021; Aiqin Zhang, Haichao Zhang, 2021). In this paper, the relative closeness degree of inter-provincial logistics industry is taken as the representative index, the larger the relative closeness degree, the higher the development quality of logistics industry.

(2) The Theil Index

The Theil Index was first used as an indicator to measure the income gap between countries or regions, but later most scholars gradually applied the Theil Index in other analysis of differences or inequalities. The index can not only decompose the overall gap into intra-regional gap and inter-regional gap, but also measure their importance and contribution rate in the overall gap. The calculation formula is as follows:

$$Theil = \sum_{i=1}^{n} \frac{y_i}{y} ln \frac{y_i/y}{p_i/p} \quad (8)$$

In the above formula $Theil$ is the Theil index, n is the number of regions, y_i the income of the i region, y is the total income of the region, p_i is the population of the i region, p is the total population of the region. On the basis of the Theil index, according to the decomposition method of Liang Zijing (2021), etc, the paper decomposes the Theil index into:

$$T_a = \sum_i \frac{y_i}{y_a} ln \frac{\frac{y_i}{y_a}}{\frac{p_i}{p_a}} (i = 1,2,3,4,5), \quad (9)$$

$$T_b = \sum_i \frac{y_i}{y_b} ln \frac{\frac{y_i}{y_b}}{\frac{p_i}{p_b}} (i = 1,2,3), \quad (10)$$

$$T_c = \sum_i \frac{y_i}{y_c} ln \frac{\frac{y_i}{y_c}}{\frac{p_i}{p_c}} (i = 1,2,3,4,5,6,7), \quad (11)$$

$$T_d = \sum_i \frac{y_i}{y_d} ln \frac{\frac{y_i}{y_d}}{\frac{p_i}{p_d}} (i = 1,2,3,4,5,6), \quad (12)$$

$$T_e = \sum_i \frac{y_i}{y_e} ln \frac{\frac{y_i}{y_e}}{\frac{p_i}{p_e}} (i = 1,2,3,4,5), \quad (13)$$

$$T_f = \sum_i \frac{y_i}{y_f} ln \frac{\frac{y_i}{y_f}}{\frac{p_i}{p_f}} (i = 1,2,3,4,5), \quad (14)$$

$$T_B = \frac{y_a}{y} \times ln \frac{y_a/y}{p_a/p} + \frac{y_b}{y} \times ln \frac{y_b/y}{p_b/p} + \frac{y_c}{y} \times ln \frac{y_c/y}{p_c/p} + \frac{y_d}{y} \times ln \frac{y_d/y}{p_d/p} + \frac{y_e}{y} \times ln \frac{y_e/y}{p_e/p} + \frac{y_f}{y} \times ln \frac{y_f/y}{p_f/p} \quad (15)$$

$$T_I = \frac{y_a}{y} \times T_a + \frac{y_b}{y} \times T_b + \frac{y_c}{y} \times T_c + \frac{y_d}{y} \times T_d + \frac{y_e}{y} \times T_e + \frac{y_f}{y} \times T_f, \quad (16)$$

$$T = T_B + T_I, \quad (17)$$

$$\frac{T_B}{T} + \frac{T_I}{T} = 1, \quad (18)$$

Due to the lack of statistical data, this study does not analyze the following regions: Hong Kong Special Administrative Region of China, Macao Special Administrative Region of China, Taiwan Province of China. Except for the above-mentioned regions, according to the regional division method on the official website of the National Bureau of Statistics for 31 provinces, autonomous regions and municipalities directly under the Central Government, the 31 provincial administrative units are divided into North China, Northeast, East China, Central China, Southwest and Northwest. North China includes Beijing, Tianjin, Hebei, Shanxi, Inner Mongolia, Northeast includes Heilongjiang, Jilin and Liaoning, East includes Shanghai, Jiangsu, Zhejiang, Anhui, Fujian, Jiangxi, Shandong, Central China includes Henan, Hubei, Hunan, Guangdong, Guangxi and Hainan, Southwest includes Chongqing, Sichuan, Guizhou, Yunnan, Tibet, Northwest includes shaanxi, Gansu, Qinghai, Ningxia and Xinjiang. $T_a, T_b, T_c, T_d, T_e, T_f$ represent the $Theil$ Index of North China, Northeast, East China, Central China, Southwest and Northwest respectively. T_B refers to the $Theil$ Index between the six regions, T_I refers to the. $Theil$ Index within the six regions, and T refers to the $Theil$ Index of 31 provincial administrative units (not including Hong Kong, Macao and Taiwan), $y_a, y_b, y_c, y_d, y_e, y_f$ refer to the high-quality development level of the logistics industry in North China, Northeast, East China, Central China, South China, Southwest and Northwest respectively.$p_a, p_b, p_c, p_d, p_e, p_f$ represent the number of logistics employees in North China, Northeast , East China, Central China, Southwest and Northwest. p means the sum of the number of logistics employees in the above regions. $\frac{T_B}{T}$ can reflect the contribution rate of inter-regional differences to the total difference, $\frac{T_I}{T}$ can reflect the contribution rate of intra-regional differences to the total difference (Zijing Liang, Haiyan Ma, 2021).

(3) The Moran's I index model

The *Moran's I index* test was first proposed in 1950 to test the spatial correlation between variables by $Moran$. It is divided into global spatial autocorrelation and local spatial autocorrelation (Zhiyin Fan, et al. 2021). This paper uses the global $Moran's\ I$ to test the spatial autocorrelation of high-quality development of provincial logistics industry. The formula is as follows (Huijun Long, et al. 2017):

$$Moran's\ \ I = \frac{\sum_{i=1}^{n}\sum_{j=1}^{n} W_{ij}(Y_i - \bar{Y})(Y_j - \bar{Y})}{S^2 \sum_{i=1}^{n}\sum_{j=1}^{n} W_{ij}} \tag{19}$$

In the above equation, n represents the total number of provinces. $W_{ij}$is the binary adjacent space weight matrix.

$$S^2 = \frac{1}{n}\sum_{i=1}^{n}(Y_i - \bar{Y}), \quad \bar{Y} = \frac{1}{n}\sum_{i=1}^{n} Y_i \tag{20}$$

Y_i represents the high-quality development index of the logistics industry of the i province. W_{ij} is the element of the spatial weight matrix$W$, refers to the spatial weight between the region or position$i$and. If the space unit $i$and j are adjacent, $W_{ij} = 1$, otherwise $W_{ij} = 0$. Generally, *Moran's I* is between $[-1，1]$. $[-1，0)$ represents the degree of negative correlation and $(0，1]$ represents the degree of positive correlation. The larger the value, the greater the degree of spatial autocorrelation. If *Moran's I* is 0, the spatial distribution of geographic variables is a random state. When verifying the significance of the statistical analysis results, a null hypothesis is proposed. The null hypothesis represents a statistical distribution resulting in a random distribution, and the *Moran's I* determines whether to reject the null hypothesis by *P* value and *Z* vlaue. *P* value represents the reliability of the data, *Z* value and *Moran's I* indicate significant aggregation or discrete phenomena in the data. Table 1 shows the relationship between the *P* value, *Z*value, and the degree of confidence (Yike Sun, et al, 2020).

Table 1 – **The relationships between the *P* value, *Z* value and confidence scores**

***Z* value**	***P* value**	**confidence /%**
$Z > 1.65$	$P < 0.10$	90
$Z > 1.96$	$P < 0.05$	95
$Z > 2.58$	$P < 0.01$	99

4. Empirical Analysis

(1) Selection of indicators and data sources

This paper uses transportation, warehousing and postal service to replace the logistics industry, added value of transportation, warehousing and the postal service to replace the logistics industry added value, employees number of transportation, warehousing and postal service to replace the logistics labor input, transportation spending to replace logistics capital investment. The average salary and per capita express are also included in the evaluation system, shown as Table 2, all the data are from the official website of the National Bureau of Statistics.

Table 2 – **Evaluation index system of high-quality development level of regional logistics industry**

name of index	**The method of representation**	**Meaning**
Unit labor force output value (ten thousand yuan)	Added value of logistics industry (100 million yuan) / employees of logistics industry urban units (ten thousand people)	The logistics industry output value created by the unit of labor force
Unit capital output value (ten thousand yuan)	Added value of logistics industry (100 million yuan) / local financial transportation expenditure (10 thousand yuan)	Created per unit of capital Logistics industry output value
Logistics industry practitioners on average Salary (ten thousand yuan)	Average salary of urban employees in transportation, warehousing and postal services (ten thousand yuan)	Logistics industry practitioners wage level
Freight volume per unit road mileage (ton / km)	Highway freight volume (ten million tons) / highway operating mileage (ten thousand kilometers)	Highway freight capacity
Freight volume per unit railway mileage (ton / km)	Railway freight volume (10,000 tons) / railway operating mileage (10,000 km)	Railway freight capacity
Express volume per capita (piece)	Express delivery volume (10,000 pieces) / permanent resident population at the end of the year (thousands of people)	Express delivery business capability

(2) Measurement of the high-quality development level of the logistics industry

First, the mean method is used to standardize the original data, and then the entropy weight-TOPSIS model in SPSSAU online analysis software is used to calculate the relative closeness degree of the development quality of the logistics industry. The weight and relative closeness degree calculation results are sorted into Table 3 and Table 4. The weight reflects the importance of indicators in the whole evaluation system. Table 3 reflects that increasing labor or capital investment alone has a relatively small impact on promoting high-quality development of the logistics industry in the current development process. In contrast, the importance of improving the express logistics system in promoting high-quality development of the logistics industry is more significant. Similarly, railway transportation is more important to the logistics system than road transportation, mainly because the current railway transportation efficiency is still more than that of road transportation. The lowest weight among all the indicators is the average salary of the employees in the logistics industry (ten thousand yuan), which may be because the current logistics industry is still a labor-intensive industry, and the overall salary level is still not high. This also affects the labor enthusiasm of the employees, resulting in the importance of the unit labor force output value (ten thousand yuan) is lower than the unit capital output value (yuan).

According to Table 4, the quality of logistics industry development in the vast majority of the 31 provincial administrative units in China has significantly improved from 2011 to 2020. From 2011 to 2013, the development quality of Shanxi's logistics industry ranked first in the country, followed by Shanghai. From 2014 to 2016, Shanghai ranked first, followed closely by Beijing and Zhejiang. At this time, Shanxi's ranking had shown a clear downward trend. From 2017 to 2020, Zhejiang has remained at the top of the country for four consecutive years, while Shanghai has declined from second to third, Beijing has declined from third to fourth, Guangdong has risen from fourth to second, and Jiangsu has remained at fifth for four consecutive years. This has formed a relatively stable development pattern, with Zhejiang, Guangdong, Shanghai, Beijing, and Jiangsu ranking among the top five provinces in terms of development quality in the national logistics industry. Zhejiang, Shanghai, and Jiangsu all belong to East China, while Beijing and Guangdong belong to North China and South China respectively, indicating that the quality of logistics industry development in East China is higher than that in other regions.

In 2020, compared with 2011, the development quality of logistics industry in a few areas stagnated or even decreased. Shanxi, Inner Mongolia, Guizhou, Gansu, Qinghai all showed a slight downward trend, while Tibet and Ningxia almost stagnated, and the relative closeness degree of the development quality of logistics industry only increased by 0.005 and 0.001 respectively in ten years. In addition, other regions have different degrees of improvement, but the development speed is different. From the national perspective, the average relative closeness degree of high-quality development of inter-provincial logistics industry has increased year by year from 0.044 in 2011 to 0.118 in 2020, reflecting the overall development of China's logistics industry and the gradual improvement of the quality of development. Looking at the "increase" line data in Table 4, it is not difficult to find that the relative closeness degree increment of measuring the high-quality development of the logistics industry was 0.003,0.004 and 0.005 in 2014 respectively. After 2014, the increment began to increase significantly, with the annual increment remained at 0.017, and the high level was as high as 0.028. 2014 became an important watershed, which may be closely related to the adoption of the "Medium and long-term Logistics Industry Development Plan" at the Executive meeting of The State Council in June 2014 and the determination of 12 key projects. Under the call of the central policy, the local governments actively respond to the issuance of relevant policy documents to support and promote the development of the logistics industry, resulting in the obvious improvement of the development quality of the logistics industry.

The average value of the relative closeness degree of the logistics industry is taken as the representative index to measure the high-quality development level of the logistics industry in the six regions, and the collated results are drawn into Figure 1. As can be seen from the figure, from 2011 to 2014, the development level of logistics industry in North China was the highest but the growth rate was lower than that in East China. In 2015, the development quality of logistics industry in East China and North China was basically the same, and from 2016 to 2020, the development quality of logistics industry in East China continued to rise rapidly more than that in North China. Before 2015, except for North China and East China, the development gap of the logistics industry in other regions was small. However, after 2015, the development quality of logistics industry in Central and South China has increased steadily, while the development quality of logistics industry in Northeast, Southwest and Northwest of China has also shown a slow upward trend, but the development speed is too slow, among which Northeast of China is slightly higher than that in Southwest and Northwest of China.

Table 3 – **Weight of the evaluation index of the high-quality development level of the regional logistics industry**

evaluating indicator	Indicator weight
Unit labor force output value (ten thousand yuan)	0.0469
Unit capital output value (RMB)	0.0971
Average salary of logistics industry employees (ten thousand yuan)	0.0207
Freight volume per unit road mileage (ton / km)	0.1248
Freight volume per unit railway mileage (ton / km)	0.2129
Express volume per capita (piece)	0.4975

Table 4 – **Relative closeness degree of logistics industry from 2011 to 2020**

area	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	change
Beijing	0.063	0.084	0.137	0.181	0.227	0.312	0.362	0.352	0.364	0.379	0.316
Tianjin	0.085	0.093	0.091	0.098	0.108	0.128	0.153	0.170	0.199	0.255	0.170
Hebei	0.052	0.051	0.050	0.049	0.048	0.062	0.070	0.092	0.118	0.180	0.128
Shanxi	0.155	0.160	0.164	0.135	0.124	0.113	0.130	0.144	0.143	0.143	-0.012
Nei Monggol	0.067	0.066	0.063	0.063	0.047	0.048	0.055	0.060	0.062	0.056	-0.011
Liaoning	0.056	0.051	0.050	0.050	0.045	0.055	0.061	0.070	0.079	0.103	0.047
Jilin	0.023	0.023	0.020	0.019	0.018	0.023	0.028	0.035	0.045	0.066	0.043
the Hei-longjiang River	0.029	0.028	0.025	0.021	0.019	0.027	0.030	0.035	0.041	0.053	0.024
Shanghai	0.094	0.113	0.153	0.194	0.250	0.372	0.443	0.492	0.445	0.474	0.380
Jiangsu	0.044	0.049	0.054	0.070	0.100	0.122	0.153	0.185	0.240	0.290	0.246
Zhejiang	0.046	0.061	0.091	0.149	0.226	0.346	0.449	0.558	0.706	0.841	0.795
Anhui	0.050	0.050	0.048	0.049	0.042	0.053	0.064	0.078	0.096	0.130	0.080
Fujian	0.028	0.033	0.045	0.062	0.080	0.114	0.145	0.182	0.223	0.290	0.262
Jiangxi	0.026	0.027	0.026	0.026	0.027	0.036	0.041	0.055	0.064	0.089	0.063
Shandong	0.061	0.061	0.057	0.049	0.049	0.063	0.074	0.091	0.113	0.154	0.093
Henan	0.039	0.036	0.033	0.033	0.035	0.043	0.053	0.069	0.082	0.114	0.075
Hubei	0.024	0.026	0.025	0.027	0.034	0.049	0.065	0.083	0.102	0.110	0.086
Hunan	0.023	0.024	0.023	0.025	0.027	0.033	0.039	0.048	0.058	0.080	0.057
Guang-dong	0.044	0.057	0.075	0.107	0.153	0.228	0.294	0.369	0.470	0.604	0.560
Guangxi	0.030	0.033	0.029	0.029	0.026	0.031	0.035	0.044	0.049	0.061	0.031
Hainan	0.018	0.018	0.018	0.017	0.016	0.020	0.024	0.028	0.030	0.039	0.021
Chong-qing	0.023	0.022	0.023	0.024	0.028	0.036	0.040	0.053	0.062	0.081	0.058
Sichuan	0.027	0.027	0.028	0.027	0.027	0.037	0.049	0.063	0.077	0.091	0.064
Guizhou	0.033	0.031	0.031	0.027	0.022	0.022	0.023	0.027	0.028	0.031	-0.002
Yunnan	0.022	0.020	0.021	0.019	0.021	0.021	0.023	0.031	0.036	0.049	0.027
Xizang	0.005	0.006	0.006	0.006	0.007	0.008	0.007	0.008	0.008	0.010	0.005
Shaanxi Province	0.070	0.074	0.077	0.079	0.072	0.081	0.086	0.095	0.102	0.116	0.046
Gansu	0.027	0.026	0.025	0.020	0.017	0.018	0.018	0.019	0.019	0.023	-0.004
Qinghai	0.018	0.019	0.019	0.017	0.012	0.013	0.016	0.017	0.017	0.017	-0.001
Ningxia	0.062	0.068	0.065	0.056	0.048	0.051	0.051	0.061	0.057	0.063	0.001
Xinjiang	0.016	0.016	0.018	0.018	0.016	0.018	0.022	0.028	0.027	0.027	0.011
mean	0.044	0.047	0.051	0.056	0.064	0.083	0.100	0.117	0.134	0.162	0.118
increase		0.003	0.004	0.005	0.007	0.020	0.017	0.017	0.017	0.028	

Note: The "changes" in the table is the difference between the relative closeness degree in 2020 and 2011. The value is positive indicating the increase of the development quality of regional logistics industry, and the value is negative indicating the decline of the development quality of regional logistics industry. "Increase" is the difference between the mean relative closeness degree of the year and the mean relative closeness degree of the previous year, the larger the value, the faster the growth.

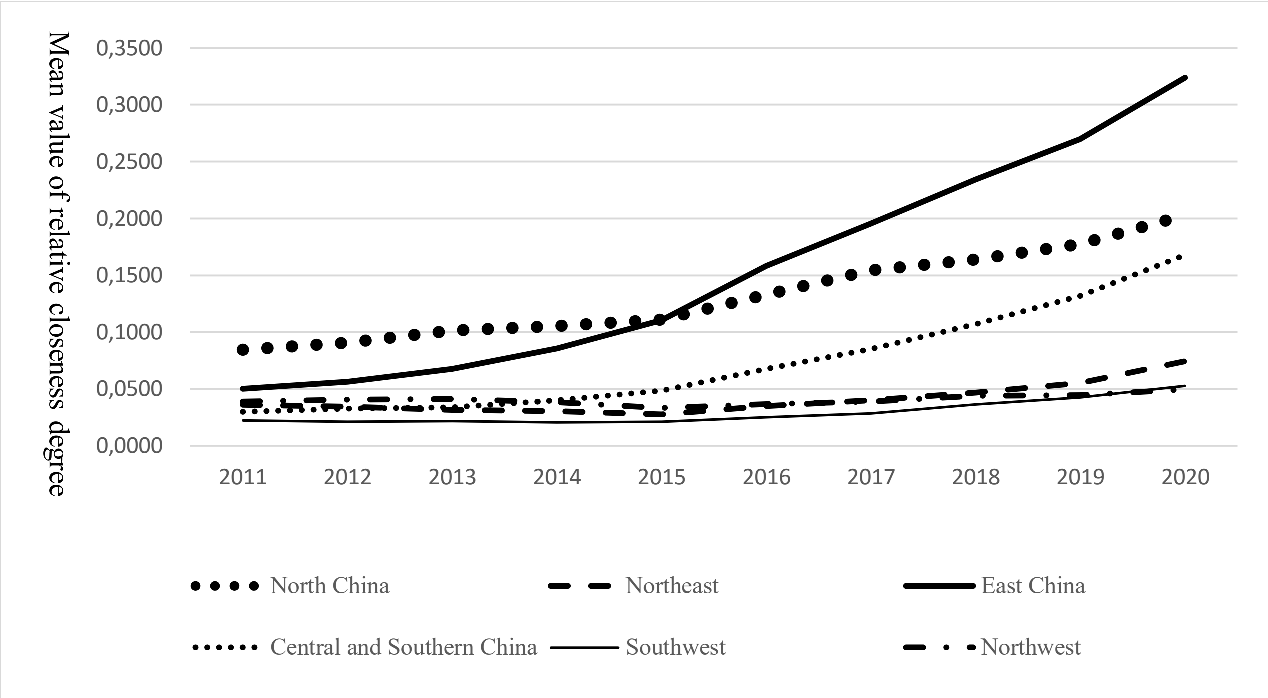

Figure 1 mean average of relative closeness degree of logistics industry in six regions of China from 2011 to 2020

(3) Analysis of the spatial difference of the high-quality development level of the logistics industry

In order to deeply analyze the spatial differences in the development quality of logistics industry within and between regions, the paper calculated the Theil index, intra regional Theil index, inter regional Theil index, and the contribution of intra regional differences to the total difference, as well as the contribution of inter regional differences to the total difference, the calculation results are compiled into Figures 2 and 3. As seen from Figure 2, the spatial difference of the high-quality development of the logistics industry in each region is very obvious.

The Theil index in Northwest was the highest, followed by the Theil index in North China and Southwest before 2014, and after 2014, the index in East China gradually expanded and was second only to northwest China. The Theil index in Southwest of China showed a trend of the first increasing and then decreasing, while the Theil index in North China maintained a steady advance after a sharp decline, while the Theil index in Northeast and Central China was relatively stable. As seen from Figure 3, the regional index in 2011-2020 is higher than the regional index in the current year, and the regional difference contribution in the same year is higher than the current year, which shows that the spatial difference of high-quality development of the logistics industry mainly comes from the internal region, and the unbalanced development within regions is more than the unbalanced development among regions. On the whole, the Theil index of the whole region shows a dynamic trend of increasing first and then decreasing, and the regional Theil index in 2020 has decreased slightly compared with 2011, indicating that the overall logistics industry in China is good and the gap between regions has decreased.

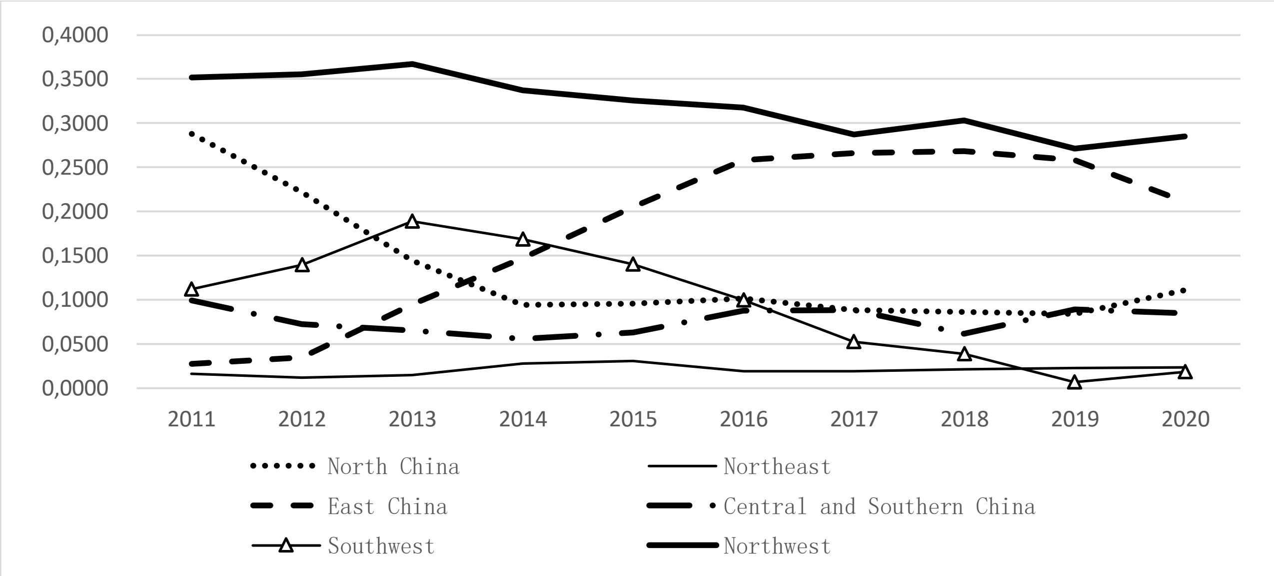

Figure 2 Thier Index chart of logistics industry development quality in six major regions in China from 2011 to 2020

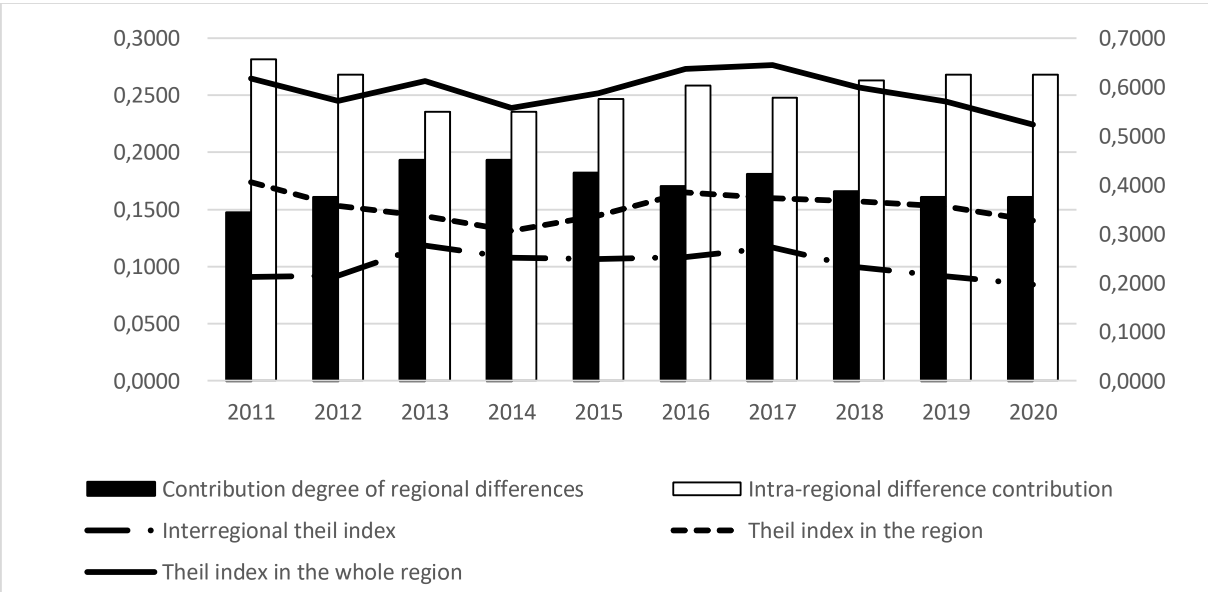

Figure 3 Tyre index and differential contribution in 2011-2020

(4) The spatial autocorrelation analysis of the high-quality development level of the logistics industry

According to the calculation results of entropy weight-TOPSIS method, in 2020, Zhejiang, Jiangsu, and Shanghai, among the top 5 provinces are all located in the East China and are adjacent to each other. This indicates that there may be spatial autocorrelation in the high-quality development process of regional logistics industry. This shows that the regional high quality logistics development process is likely to exist space autocorrelation. Therefore, after analyzing the spatial differences of high-quality development of regional logistics industry, it is necessary to calculate the *Moran's I* index of the relative closeness degree of inter-provincial logistics industry in 2011-2020 with GeoDa software, so as to test the spatial autocorrelation of high-quality development of regional logistics industry, shown as Table 5. According to Table 5, the P value of 2011-2013 was less than 0.05 but greater than 0.01, and the Z value was less than 2.58 except for the value of 2011 but greater than 1.96. According to the evaluation criteria given in Table 1, the global *Moran's I* index results in these three years passed the significance test of 0.05. Since 2014, the P values are all less than 0.01 and the Z values are all greater than 2.58. It is known that the global *Moran's I* index in 2014-2020 has passed the significance test of 0.01. It can be seen that all the data are positive, indicating that there is obvious spatial autocorrelation in the high-quality development process of regional logistics industry, that is, the high-quality development process of regional logistics industry has a benign spillover effect of continuous spreading to the surrounding areas. Among them, it became an important watershed in 2014. In the first three years, the global *Moran's I* index remained at 0.241 and 0.242, which has increased significantly since 2014. Although there was a slight decrease during this period, the overall index still showed an upward trend, and has increased rapidly to 0.367 by 2020. This is basically consistent with the situation where the relative closeness degree to the high-quality development of the logistics industry began to significantly improve after that year. It is precisely because the development speed of logistics industry in various regions has significantly accelerated and the quality of development has significantly improved since 2014, effectively promoting industrial linkage and economic correlation between regions, and significantly enhancing the spatial autocorrelation of high-quality development of logistics industry.

Table 5 – **The Global Moran's I Index and its test results of the high-quality development of the national interprovincial logistics industry from 2011 to 2020**

variable	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
$Moran's\ I$	0.242	0.241	0.241	0.302	0.347	0.345	0.353	0.374	0.358	0.367
P	0.012	0.014	0.016	0.009	0.007	0.008	0.009	0.007	0.006	0.006
Z	2.5816	2.5214	2.4116	2.8471	3.2325	3.2558	3.3166	3.5185	3.4920	3.6313

5. Research conclusions and countermeasures

(I) Study conclusions

The high-quality development of the logistics industry is an important driving force to promote the high-quality development of China's economy, and also an important prerequisite for achieving high-quality economic and social development. This paper measures the logistics industry development quality level of 31 provincial administrative units, and further analyzes the spatial differences and the correlation characteristics, mainly draw the following conclusions: firstly, from a spatial perspective, the high-quality development level of the logistics industry in Zhejiang, Guangdong, Shanghai, Beijing, and Jiangsu ranks among the top. In addition, the high-quality development level of the logistics industry, from high to low, is respectively in East China, North China, Central South, Northeast, Southwest, and Northwest. Secondly, from a temporal perspective, 2014 has become an important watershed for the high-quality development of the logistics industry. That year, the State Council issued the "Medium and Long Term Plan for the Development of the Logistics Industry", which effectively promoted the high-quality development of the logistics industry. Thirdly, the spatial differences in the high-quality development of the logistics industry mainly come from within the region, with uneven development within the region rather than between regions. Fourthly, there is a clear spatial autocorrelation in the high-quality development process of the logistics industry, which has become more significant and shows a gradually increasing trend since 2014.

(2) Recommended countermeasures

According to the above conclusions, in order to promote the high-quality development of regional logistics in China, especially to narrow the development gap between different regions, and realize the coordinated development of logistics industry, the following suggestions are put forward: Firstly, improve the express logistics system. Express logistics, especially e-commerce logistics, occupy a crucial position in the current logistics system. Further developing and strengthening express logistics through e-commerce and improving the e-commerce logistics system are important paths to achieve high-quality development of regional logistics. Secondly, strengthen industrial linkage and integration. By leveraging emerging information technologies such as big data, cloud computing, artificial intelligence, and 5G communication, we aim to accelerate the linkage, integration, and effective interaction between the logistics industry, manufacturing industry, and information industry. Thirdly, promote effective cross regional cooperation. Establish an effective coordination mechanism among departments to promote cross departmental logistics business cooperation, create an intelligent logistics information platform to integrate cross regional logistics resources, reduce resource idle and waste, and improve logistics resource utilization.

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