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Research on the Evaluation and Spatial Difference of China's Regional Logistics Digital Innovation Ability Based on Entropy Weight — Toptsis

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Abstract: With the transformation of economic development and the innovation and promotion of high-tech, the logistics industry is also entering an important stage of transformation and upgrading. With the progress of science and technology, the traditional logistics industry is bound to transform to the direction of digital logistics. In this process, the digital innovation ability of logistics is the key to transformation and upgrading. After combing the relevant research, this paper constructs the evaluation index system of logistics digital innovation ability, uses entropy weight method to calculate the comprehensive weight of each index, and uses TOPSIS method to calculate the score, analyzes the index panel data of 30 provinces and cities in China from 2016 to 2020, and compares the four plates in space According to the logistics digital innovation ability of the eight special economic zones, this paper analyzes the spatial differences of China's logistics digital innovation ability, and puts forward the existing problems and future prospects.

Keywords: Entropy weight method, TOPSIS method, Spatial difference analysis, Logistics digital innovation, Evaluation index system.

1. Introduction

The "14th five year plan" period is the first key five years for the country to build a well-off society in an all-round way, and it is also a key stage to promote high-quality economic growth. At present, the new round of technological revolution is developing rapidly. Whether at home or abroad, the industrial revolution and technological revolution are undergoing earth shaking changes. The traditional logistics industry is also undergoing great changes in the digital era. During the 13th Five Year Plan period, China's total social logistics increased from 219.2 trillion yuan in 2015 to 300trillion yuan in 2020, with an average annual growth rate of 6.5%. The logistics industry has become one of the pillar industries of China's service industry [1]. At present, the development of the logistics industry is at a critical point in time. The logistics industry should seize the important strategic opportunity and continue to promote and accelerate the integration and collaborative development of itself and digital technology while the rapid development of various digital technologies such as big data and artificial intelligence.

During the "13th five year plan" period, China's logistics industry developed rapidly and achieved relatively good results. Now it is in the "14th five year plan" period, the state will continue to vigorously promote the development of China's logistics industry, promote the "cost reduction and efficiency increase" of logistics, and vigorously promote and support the intelligent, green, information, networking and modern development of the logistics industry. The Third Plenary Session of the 18th Central Committee of the Communist Party of China adopted the decision of the CPC Central Committee on several major issues concerning comprehensively deepening reform, which formally proposed to "develop the digital economy, encourage technological innovation, and enrich the market level and products of the digital economy" [2]. In recent years, with the advent of emerging digital technology and information technology, the logistics industry is gradually integrating with emerging digital technology and high-tech, and the logistics industry has also undergone new changes in the integration. At present, the logistics process is gradually automated, virtualized and intelligent, and the modern digital logistics management system is gradually taking shape. In the process of logistics distribution, information transmission and information sharing are playing a huge role. The gradual integration and application of digital technology and high-tech in various links of logistics, The logistics industry provides new development power and direction, and these technologies are promoting the rapid development of digital logistics. In the 14th five year plan for national economic and social development of the people's Republic of China and the outline of long-term goals for 2035, "figures" appear 81 times,Logistics" has appeared 20 times, which shows the importance of digital and logistics to economic development and the government's attention to digital economy and logistics development [3]. To sum up, digital technology will be fully integrated into logistics, and each link of logistics will become more intelligent, automated and modern. The digital development of logistics will be the main direction of logistics development in the future.

2. Literature Review

Logistics digital innovation capability refers to the innovation and creation of the logistics industry based on its own resources and under the guidance of national policies, through the support of digital technology, enabling digital technology to all business links of logistics, which is mainly reflected in the intelligence and automation of logistics, and has the characteristics of high efficiency, fast transmission and low cost. In recent years, with the continuous development of big data, intelligence and digital technology, the digital age has brought earth shaking changes to many traditional industries, including the logistics industry. The development and transformation of the traditional logistics

industry in the direction of digital logistics is in line with the trend of the times. From the content, logistics digital innovation mainly includes technology and information. From the perspective of process, logistics digital innovation is the digital empowerment of the whole process of logistics. From the perspective of the main body, logistics digital innovation is a process led by the government, with enterprises as the main body and market as the guidance, and all links cooperate to achieve the digital transformation of the logistics industry. At present, there is little research on Logistics digital innovation at home and abroad, and most of the research related to this field is logistics innovation and digital logistics.

2.1. Concept and core of Digital Logistics

So far, few scholars at home and abroad have constructed the evaluation index system of logistics digital innovation ability. In the empirical literature on the construction of index system related to this field, lixiaomei et al. [4] constructed the coupling coordination index system of digital logistics, regional economy and carbon environmental governance, and conducted empirical analysis through the fixed effect regression model. Luo Rui [5] and others built an index system for the high-quality development of digital logistics around the five dimensions of Digital Logistics Innovation security, structural optimization, green and efficient, open cooperation and environmental sharing. Based on the panel data in recent years, they used entropy method to determine the weight, dagum Gini coefficient, Moran index method and spatial convergence model to conduct empirical research and Analysis on the index data, The regional differences and spatial convergence of high-quality development level of digital logistics are analyzed.

2.2. Reform and development of Logistics Innovation

In the field of logistics innovation, the research direction of foreign scholars mainly focuses on theoretical research. Flint et al. [6] used grounded theory to study logistics innovation. He believed that logistics innovation was mainly driven by customers of logistics service providers. Domestic logistics innovation mainly focuses on theoretical research and empirical research. Based on the nature and connotation of logistics innovation driven in 2018, Liu Yan [7] et al .The logistics innovation driven index system is constructed in the direction of input and output, and the data is empirically studied. Jiangmingzhu [8] in 2015, based on the actual situation of the development of the logistics industry at that time, integrated the regional logistics ability and logistics innovation ability, constructed the index system of the relationship between regional logistics ability and innovative development, and analyzed the correlation between the two data. Under the background of high-quality economic development and the transformation of the logistics industry itself, Jian Lingxiang [9] and others built an evaluation index system for the development quality of the logistics industry from seven dimensions, including cost, service level and green level.

3. Construction of Evaluation Index System of Logistics Digital Innovation Ability

3.1. Index selection

In the selection of indicators, we should first consider its scientificity and at the same time consider the availability of indicators, so on this basis, according to the relevant research, this paper constructs the evaluation index system of logistics digital innovation ability. Since the index system of logistics digital innovation has not been proposed by predecessors, the index system of this paper will determine the index dimension and detailed index of this paper through collection and induction based on the relevant literature in the field of digital logistics and logistics innovation. By collecting the relevant index literature of scholars on digital logistics and logistics innovation, it is found that the indicators in this field mainly focus on logistics informatization ability, logistics networking ability and logistics intelligence. Logistics informatization includes logistics informatization Capacity infrastructure construction and related technology input and capital output. Logistics networking mainly includes logistics network capacity and information transmission and sharing in the logistics process. Therefore, in this paper, the selection of logistics digital innovation indicators draws on the literature indicators such as logistics innovation and digital logistics. It is proposed to use logistics informatization and logistics networking as the primary indicators of logistics digital innovation ability evaluation indicators, and the secondary indicators are determined through literature collection and screening.

In the literature on logistics informatization indicators, guomingde and others [10] believed that the logistics informatization indicators should reflect the latest development trend of logistics information technology. New development trends, the input and output level of informatization and other indicators are important indicators of logistics informatization related indicators. In addition, it also includes the macro development level of logistics informatization. On the basis of Guo Mingde's index, yanghuiying and others [11] defined the logistics informatization index as the investment in logistics informatization infrastructure, the development scale of logistics informatization and the macro development level. Mafei et al. [12] built a logistics informatization index system from four dimensions of logistics informatization infrastructure, resources and technology. To sum up, logistics informatization aims to enhance and improve logistics performance through modern technical means. It is a collection of all kinds of people, money and materials invested by the logistics industry in informatization. The main indicators include the input and output of logistics in information transmission, the business volume of postal services and telecommunications, and the basic setting of logistics informatization. Therefore, investment intensity, business volume, investment in human and material resources, etc. are mainly set in the logistics informatization sub indicators in this paper. In this paper, 10 secondary indicators are selected in the logistics informatization indicators.

3.2. Index selection

Scholars' definition of logistics networking is summarized as using the Internet and network to realize information

transmission and sharing in the process of logistics. Between regions, in each link of logistics, the data and indicators of logistics can be shared in the shortest and fastest time, so as to quickly calculate the best logistics route through the Internet, making the logistics shortest, optimized and automated in transportation. Wangchunhao et al. [13] integrated Xujie et al. [14]'s views on three-dimensional classification of logistics network, and built the evaluation index of logistics network level in consideration of China's diverse geographical factors and complex terrain. Starting from the above literature research, this paper integrates other logistics networking related literature, sets up some indicators, and obtains the logistics networking indicators of this paper, which mainly include network infrastructure, regional logistics freight volume, turnover and road network density, and fully reflects the sharing and transmission of logistics information on the network, making logistics transportation automated and accurate.

To sum up, this paper takes the logistics digital innovation ability as the criterion layer, takes the logistics informatization and logistics networking as the primary index, and collects and references various literatures to form the secondary index.

Table 1. Evaluation index system of logistics digital innovation ability

Secondary index	Tertiary indicators	unit	source
Logistics informatization	Optical cable length	kilometre	Ma Fei [12]
	Number of mobile phone base stations	10000 PCs.	set up by myself
	Mobile phone penetration	100 persons	Guomingde [10]
	Information transmission, software and information technology services Business income	CNY 100 million	Guomingde [10]
	Postal business volume	100 million yuan	Guomingde [10]
	Telecom business volume	100 million yuan	Guomingde [10]
	Number of Regional Express	10000 pieces	set up by myself
	E-commerce purchase amount	100million yuan	Yanghuiying [10]
	E-commerce sales	100million yuan	Yanghuiying [10]
	Total production of transportation, storage and postal industry value	10000 yuan	Guomingde [10]
Logistics networking	Internet broadband access port	individual	set up by myself
	Number of mobile Internet users	ten thousand people	set up by myself
	Number of postal outlets	place	set up by myself
	Number of websites owned by enterprises	individual	set up by myself
	Freight volume	10000 tons	Wangchunhao [13]
	rotation volume of freight transport	100 million ton kilometer	Wangchunhao [13]
	Highway operating mileage	kilometre	Wangchunhao [13]
	Railway operating mileage	kilometre	Wangchunhao [13]
	Road network density	Km / km2	Wangchunhao [13]
	Railway network density	Km / km2	Wangchunhao [13]

3.3. Research scheme design

3.3.1. Research methods

Subjective weighting method, such as analytic hierarchy process, has a certain subjectivity because it does not require a high number of samples. The entropy weight method, TOPSIS method and grey relational analysis are classical methods for multi-objective decision-making and evaluation. The entropy weight method can objectively and truly reflect the index information [15]. The entropy weight method can reflect the utility value of the index by calculating the index information entropy, and determine the index weight according to the utility value [16], while the TOPSIS method can calculate the optimal solution and the worst solution of the data on the basis of determining the weight, calculate the logistics digital innovation ability score of each Province in recent years through software, and the difference analysis calculates the mean, standard deviation and significance of the regional plate data of 30 provinces, So as to better analyze the data in different dimensions and directions. Therefore, in order to ensure the effectiveness of the research results, this paper will use the entropy weight method to determine the weight of the obtained panel data. After determining the weight, the data will be analyzed by TOPSIS method, and the scores will be calculated and ranked. Finally, according to the authoritative regional plate classification of 30 provinces and cities in China, the data of different regions will be analyzed in different plates.

3.3.2. Data processing

Data standardization processing: the original panel data of the evaluation indicators are different in units, orders of magnitude, etc., and the different dimensions of the indicators will lead to certain errors in the final comprehensive evaluation results. Therefore, the original panel data should be normalized and standardized at the first time after the data are obtained. The calculation formula of forward indicator and reverse indicator are respectively:

$$x'_{ij} = \begin{cases} x_{ij} = \frac{x_{ij} - \min(x_1 \cdot j)}{\max(x_{ij}) - \min(x_{ij})} + 0.0001 \\ x_{ij} = \frac{\max(x_{ij}) - x_{ij}}{\max(x_{ij}) - \min(x_{ij})} + 0.0001 \end{cases} \quad (1)$$

The formula is interpreted as: the jth indicator of item i is the difference between the minimum value of each indicator and all indicators of item i/ the difference between the maximum value and the minimum value of all indicators of item i.

Entropy weight method: Step 1: calculate the index weight after obtaining the standardized data x'ij. First, get the normalized value Pij of the index. The specific calculation formula of P is:

$$P_{ij} = \frac{x'_{ij}}{\sum_{i=1}^{n} x'_{ij}} \quad (2)$$

The dimensionless value of the j-th indicator of item i/ the sum of dimensionless values of all indicators of item i. n is the number of research units, that is, the number of provinces. In this paper, n=30.

Step 2 is calculate the entropy eij of the jth index. The specific calculation formula of eij is:

$$e_j = -\frac{1}{\ln n} \Sigma_{i=1}^{n} P_{ij} \ln(P_{ij}) \quad (3)$$

Step 3: is calculate the indifference coefficient gj.

The index information utility value depends on the difference between the index information entropy and 1, so the information utility and information entropy are converted [17]. Therefore, the calculation formula of indifference coefficient gj of the index is:

$$g_j = 1 - e_j \quad (4)$$

Step 4: calculate the index weight wj.

$$w_j = \frac{g_j}{\Sigma_{j=1}^{n} g_j} \quad (5)$$

wj is the final weight of each indicator.

Finally, the weighted sum method is used to obtain the comprehensive value of samples in t period.

$$Dt = \Sigma_{j=1}^{n} w_j \times x_{ij} \quad (6)$$

The weight of each index is calculated by entropy method, and finally the comprehensive value of logistics digital innovation capability in various regions of China can be obtained.

4. Cempirical Research

4.1. Weight determination

The sample of this paper is 30 provinces in China from 2016 to 2020 (excluding Tibet, Hong Kong and Macao Panel data of station area). The original panel data are mainly from the 2016-2020 China Statistical Yearbook, the statistical yearbook of China's tertiary industry, the statistical yearbook of China's information industry, CEIC China economic database, China's economic and social big data research platform, China economic network and national research network. For some missing data, this paper uses interpolation method to supplement.

Table 2 shows the comprehensive weight of each evaluation index of China's logistics digital innovation ability. From the comparative analysis of primary indicators, the proportion of logistics informatization is more than logistics networking. This shows that in the field of logistics digital innovation, informatization has a greater impact on Logistics digital innovation ability, while networking has a smaller impact on innovation ability. The reason may be that in the process of logistics networking, the construction cycle of business outlets and logistics highways, railways and roads is long, the cost of funds is high, and innovation is difficult, so the weight is small.

Further analysis and development shows that in the logistics informatization section, information transmission, software and information technology service industry revenue, postal business volume and the number of express delivery in the region occupy more weight. In the process of postal business and express delivery, digital technology is constantly integrated, and the automated and intelligent logistics processes are also constantly advancing, Thus, the impact of these indicators on Logistics digital innovation ability is larger than that of other logistics informatization indicators, while in the logistics networking section, the weight of the ten indicators has little difference, and the impact is relatively balanced. The reason may be that the country has vigorously promoted the development of logistics informatization in recent years. With the continuous promotion of the digital era, the development of e-commerce has been rapidly improved, and the comprehensive weight of e-commerce sales and e-commerce procurement volume also ranks in the top five of the ten indicators of logistics informatization. With the continuous infiltration of digital technology into the logistics industry, these digital technologies have also been applied to all aspects of logistics. The business volume of postal services has also increased, and the income of information transmission, software and information technology services has also increased. This shows that the logistics link and logistics related business volume in e-commerce play a greater role in improving the logistics digital innovation ability, but the weight of indicators such as optical cable strength and mobile phone penetration is less. This result emphasizes the important role of logistics e-commerce and postal industry, and weakens the role of logistics infrastructure construction and investment.

Table 2. Evaluation index weight of logistics digital innovation ability

Secondary index	Tertiary indicators	Comprehensive weight
Logistics informatization(0.6432)	Optical cable length	0.0301
	Number of mobile phone base stations	0.0292
	Mobile phone penetration	0.0318
	Information transmission, software and information technology services Business income	0.1069
	Postal business volume	0.1078
	Telecom business volume	0.0350
	Number of Regional Express	0.1087
	E-commerce purchase amount	0.0860
	E-commerce sales	0.0732
	Total production of transportation, storage and postal industry value	0.0335
Logistics networking (0.3568)	Internet broadband access port	0.0319
	Number of mobile Internet users	0.0314
	Number of postal outlets	0.0361
	Number of websites owned by enterprises	0.0596
	Freight volume	0.0328
	rotation volume of freight transport	0.0628
	Highway operating mileage	0.0247
	Railway operating mileage	0.0229
	Road network density	0.0240
	Railway network density	0.0307

Table 3. Evaluation results of logistics digital innovation capability in different regions from 2016 to 2020

region	2020 Score ranking	2019 Score ranking	2018 Score ranking	2017 Score ranking	2016 Score ranking
Beijing	0.4154	0.4044	0.3996	0.4226	0.4275
Tianjin	0.17614	0.17115	0.17615	0.18415	0.18615
Hebei	0.2639	0.2579	0.2609	0.2639	0.2619
Shanxi	0.14522	0.14322	0.14520	0.14620	0.14919
Neimenggu	0.16616	0.16218	0.17116	0.17516	0.17516
Liaoning	0.17515	0.18714	0.20114	0.21513	0.22712
Jilin	0.09426	0.08926	0.09926	0.10425	0.10626
Heilongjiang	0.11124	0.10525	0.11124	0.11724	0.11824
Shanghai	0.4135	0.4025	0.4085	0.4255	0.4474
Jiangsu	0.4653	0.4683	0.4733	0.4893	0.5033
Zhejiang	0.5442	0.5432	0.5322	0.5282	0.5292
Anhui	0.24510	0.24210	0.24510	0.24510	0.25010
Fujian	0.20012	0.20812	0.21812	0.22012	0.22711
Jiangxi	0.15619	0.15519	0.15019	0.15519	0.14720
Shandong	0.3756	0.3846	0.4294	0.4254	0.4216
Henan	0.2728	0.2698	0.2777	0.2747	0.2837
Hubei	0.20711	0.22411	0.22311	0.22311	0.22613
Hunan	0.19513	0.19213	0.20313	0.19914	0.20014
Guangdong	0.8211	0.8491	0.8471	0.8401	0.8381
Guangxi	0.14921	0.14421	0.14322	0.13722	0.13921
Hainan	0.08228	0.08527	0.08428	0.08328	0.08628
Chongqing	0.16417	0.16417	0.16318	0.15818	0.15918
Sichuan	0.2817	0.2767	0.2748	0.2698	0.2698
Guizhou	0.12723	0.13023	0.13323	0.13023	0.13023
Yunnan	0.15120	0.14520	0.14421	0.13921	0.13722
Shanxi	0.16418	0.16616	0.16617	0.16317	0.16317
Gansu	0.08427	0.08428	0.08827	0.09027	0.08727
Qinghai	0.04430	0.04430	0.05130	0.04730	0.04630
Ningxia	0.05929	0.06229	0.07429	0.06829	0.06829
Xinjiang	0.10825	0.10724	0.11025	0.10226	0.10825

4.2. Comprehensive evaluation by TOPSIS method

TOPSIS evaluation method is to calculate the score of each evaluation object of the index in the original data matrix after normalizing the index, and evaluate and rank the innovation ability of digital logistics. This paper uses SPSS Pro software to calculate the data of 30 provinces and cities in the past five years. Table 3 shows the evaluation results of logistics digital innovation capability in different regions from 2016 to 2020. Table 3 comprehensive score value according to d+ (distance between evaluation object and optimal solution) and D calculated by SPSS Pro software (the distance between the evaluation object and the worst solution) is calculated according to the formula comprehensive score c=d-/ (d-+d-). The greater the comprehensive score C, the better the research object.

According to the ranking and dynamic trend of digital logistics innovation ability of various regions from 2016 to 2020, the level of digital logistics innovation ability of each province has shown an increasing trend year by year. Guangdong has been in the first position in recent years, and Jiangsu and Zhejiang have been in the second and third respectively. As major economic provinces, Guangdong, Jiangsu and Zhejiang are also major logistics provinces, and the intensity of infrastructure construction of logistics informatization is greater than that of other provinces and cities. In recent years, Beijing, Shandong and Shanghai have changed their comprehensive ability rankings alternately, with fierce competition. Sichuan, Henan, Hebei and Anhui are in the top ten, with the exception of Anhui, the other three provinces alternately hovering between the seventh, eighth and ninth places. The western provinces of Qinghai, Ningxia and Gansu have been in a backward state.

4.3. The difference analysis of logistics digital innovation ability

According to the overall trend and development of logistics digital innovation capability, 30 provinces and cities can be divided into five echelons: the first echelon is Guangdong. The second tier is Zhejiang, Jiangsu, Shanghai and Beijing. The third echelon is Shandong, Sichuan, Henan, Hebei, Anhui, Hubei and Fujian. The fourth echelon is Hunan, Tianjin, Liaoning, Inner Mongolia, Chongqing, Shaanxi, Jiangxi, Yunnan, Guangxi, Shanxi, Guizhou, Heilongjiang and Xinjiang. The fifth echelon is Jilin, Gansu, Hainan, Ningxia and Qinghai (Table 4). It is easy to see from table 4 that the cities and regions with strong logistics digital innovation ability in 30 provinces and cities in China are mainly concentrated in the eastern region and coastal areas, and the strength of logistics digital innovation ability is not obvious in internal regions. According to the four plates and eight special economic zones defined by China, this paper divides the logistics digital innovation ability scores of 30 provinces and cities into regions, and analyzes the differences of the divided regional comprehensive data using SPSS Pro software. See Table 5 for details.

Table 5 shows the analysis results of the differences of logistics digital innovation capability among 30 provinces and cities in China. Among the four major economic sectors in China, the eastern sector has the strongest innovation capability, because the eastern region has superior geographical conditions and developed economy, bordering the Pacific Ocean in the East, central and central China in the west, and Southeast Asia in the south. High and new technologies and digital technologies are developing rapidly, Both the introduction of overseas technology and the development of domestic technology are the most advantageous regions in the four regions, and the government policy support is also more in other regions, with high level of logistics development and strong digital innovation ability. The second is the central region. The central region is mostly the intersection of plains and mountains, but the central region is located in the Yangtze River and the Yellow River Basin and has convenient transportation, so it ranks second in the four major regions. In terms of logistics information infrastructure construction, it is inferior to the Eastern Plain region but superior to the western region. The logistics digital innovation ability of the central region also ranks second in the four major regional regions as a whole. The logistics digital innovation ability of the western region is relatively backward on the whole. The possible reason is that the western region is the first step in China, with high altitude and numerous mountains and rivers, whether it is the construction of mobile Internet base stations in logistics informatization or logistics networking

The construction of roads and railways in Chongqing is not as good as that in the East, West and northeast regions. However, due to the western development policy, Sichuan and Chongqing have rapid economic development and strong economic strength. The construction of the Chengdu Chongqing dual city economic circle has made Sichuan and Chongqing become the "leaders" in the western region, and Chongqing's local digital economy "14th five year plan" and other policy outlines have made Chongqing's digital technology develop rapidly in recent years, so from a macro perspective, The development of digital technologies such as big data and intelligence in Sichuan and Chongqing has generally improved the logistics digital innovation ability in the West. Finally, the northeast region is a heavy industry region in history, while the tertiary industry is not outstanding in the northeast region. In addition, in terms of policy support and geographical location, the northeast region is not dominant, so the economic development is less than that of the coastal and central regions, and the development of digital technology and high-tech is relatively slow, which makes the development of logistics industry and logistics digital innovation ability lag behind other regions. From the perspective of geographical distribution trend, the logistics digital innovation ability shows the characteristics of strong in the East and weak in the west, strong in the South and weak in the north. Its comprehensive ability gradually increases from west to East, which is opposite to the sea level height in the East and west central regions. It can also be seen that the logistics ability and logistics digital innovation ability in coastal and plain areas are stronger.

In addition, from the perspective of the spatial distribution of the eight special economic zones, China's logistics digital innovation ability increases from west to East and from north to south. The eastern coastal and southern coastal comprehensive special economic zones have the strongest logistics digital innovation ability. The eastern coastal special economic zones are ahead of other special economic zones in terms of geographical location and policy support. All technologies and industries rank first among the special economic zones in terms of development scale and growth rate. The southern coastal special economic zones rank second among the eight major special economic zones.

Guangdong has great advantages in logistics digital innovation ability, The overall logistics digital innovation capability of the southern coastal special economic zones has been improved. The comprehensive special economic zones along the northern coast and the middle reaches of the Yangtze River follow closely, ranking third and fourth among the eight major special economic zones. The fifth and sixth special economic zones are the comprehensive special economic zones in the middle reaches of the Yellow River and the southwest, and finally the Northeast Comprehensive Economic Zone and the Northwest Economic Zone. From the perspective of the differential distribution of the eight special economic zones, the coastal areas' logistics digital innovation ability is stronger, and the coastal provinces and cities have many ports, convenient transportation and developed economy, which is also one of the reasons why the three coastal special economic zones' logistics digital innovation ability is strong. In addition, foreign investment and policy support have also strengthened the logistics competitiveness and digital technology development ability of these regions. The comprehensive special economic zones in the middle reaches of the Yangtze River and the Yellow River have also been facilitated in the development of logistics digital innovation due to convenient transportation and neighboring coastal provinces and cities. The southwest and northwest special economic zones are vast and sparsely populated. The geographical conditions are not convenient enough and the geographical characteristics are complex, which makes the logistics digital innovation ability of these two special economic zones weak. Similarly, the Northeast comprehensive special economic zone also has no strong logistics digital innovation ability due to geographical reasons. To sum up, China's logistics digital innovation capability is strong in the East and weak in the west, strong in the South and weak in the north in terms of spatial differences, and shows regional and phased development characteristics.

Table 4. Classification of logistics digital innovation capability in some regions of China

Echelon	First echelon	Second echelon	The third echelon	The fourth echelon	The fifth echelon
region	Guangdong	Zhejiang, Jiangsu, Shanghai, Beijing	Shandong, Sichuan, Henan Hebei, Anhui, Hubei, Fujian	Hunan, Tianjin, Liaoning, Neimenggu, Chongqing Shaanxi, Jiangxi, Yunnan, Guangxi, Shanxi, Guizhou, Heilongjiang, Xinjiang	Jilin, Gansu, Hainan, Ningxia, Qinghai

Table 5. Analysis results of differences in logistics digital innovation capability among regions in China

region	plate	Data volume	mean value	standard deviation	sort	F	Significance	result
Four region	Eastern section (1)	54	0.363	0.209	1	21.570	0.000	1 > 3 > 4 > 2
	Middle section (2)	34	0.303	0.045	2			
	Western plate (3)	45	0.131	0.064	4			
	Northeast section (4)	15	0.137	0.047	3			
Eight special economic zones	Northeast comprehensive special economic zone (1)	15	0.137	0.047	7	17.69	0.000	4 > 2 > 3 > 7 > 5 > 1 > 6 > 8
	Northern coastal comprehensive economic zone (2)	20	0.315	0.100	3			
	Eastern coastal comprehensive economic zone (3)	15	0.415	0.086	1			
	Southern coastal comprehensive economic zone (4)	15	0.379	0.330	2			
	Comprehensive economic zone in the middle reaches of the Yellow River (5)	20	0.189	0.051	5			
	Comprehensive economic zone in the middle reaches of the Yangtze River (6)	20	0.204	0.034	4			
	Southwest comprehensive economic zone (7)	25	0.170	0.053	6			
	Northwest comprehensive economic zone (8)	20	0.077	0.023	8			

5. Conclusion

5.1. Research conclusion

This paper is based on the panel data of 30 provinces and cities in China from 2016 to 2020. Relevant conclusions are drawn through entropy weight method, TOPSIS method and difference analysis.

The research shows that, from the perspective of spatial differences, there are great differences in the level of China's overall logistics digital innovation ability, which is generally strong in the South and weak in the north, strong in the East and weak in the West. Moreover, the logistics digital innovation ability of coastal areas is stronger than that of inland areas, and the areas flowing through the Yangtze River and the Yellow River are stronger than those in mountain areas. The overall spatial differences are regional and phased. Guangdong, Jiangsu and Zhejiang have the strongest and relatively stable ability of logistics digital innovation. In recent years, they have been in the top three in China. Guangdong is also the first tier of logistics digital innovation ability classification. Provinces in the southwest and northwest regions rank last in the country in the score of logistics digital innovation. Due to geographical and policy factors, the technology of logistics digital innovation in regions closer to the inland is also increasingly backward. Jiangnan and coastal areas benefit from excellent geographical location and more developed high-tech, and the level of logistics digital innovation is also better. In a word, geographical location is an important factor affecting the level of logistics digital innovation. In the process of opening to the outside world and economic development, including the introduction of high-tech and foreign investment, inland areas and mountainous areas are in a weak position compared with coastal and plain areas, The investment and construction of infrastructure, the integrated allocation of resources, and the introduction and application of high and new technologies are the key to strengthen the digital innovation ability of inland and mountainous logistics.

From the perspective of different indicator dimensions, the logistics digital innovation ability is more dependent on the level of logistics informatization development. From the perspective of comprehensive weight, information transmission, software and information technology service industry revenue, postal business volume and regional express delivery volume account for a larger proportion, indicating that compared with other indicators, the changes of these three indicators have a greater impact on the logistics digital innovation ability in the region, The weight of highway and railway operating mileage is small, indicating that the change of these two indicators has little impact on the logistics digital innovation ability in the region.

5.2. Inspiration and suggestions

In view of the problem that China's logistics digital innovation ability is strong in the South and weak in the north, and strong in the East and weak in the west, first of all, from the perspective of the government, we can support and accelerate the introduction and application of logistics high-tech and digital technology in inland areas, and strengthen the construction of logistics information infrastructure in inland areas and mountainous areas. Secondly, for the inland areas, we should increase the investment in the use of high-tech logistics and scientific and technological innovation, rely on high-tech logistics technology and technology to optimize the logistics operation process, save manpower and improve the logistics mechanization rate and operation efficiency. For the more developed coastal areas, we should consolidate the foundation of logistics digital innovation and strengthen cooperation with surrounding provinces and cities. Finally, according to the geographical differences, the cooperation among provinces and cities and enterprises should be strengthened, the exchange and cooperation of digital technology between provinces should be strengthened, the exchange and collaborative development between logistics and other industries should be strengthened, and the development and application of digital enabled logistics technology should be accelerated. At the same time, according to the actual development of each region, a hierarchical logistics digital innovation and development system should be established.

For the logistics industry itself, the government should strengthen the guiding role, support the internal innovation of logistics and the collaborative development with other high-tech industries, and strengthen the development of logistics digitization. The future development route of logistics should be more digital, intelligent and modern, and promote Smart logistics upgrading and smart new infrastructure will promote the "smart + sharing" coupling and collaborative development of the logistics industry. The sharing of logistics information, the construction of logistics network and the development of high-tech logistics are the top priorities in the field of logistics digital innovation. The intelligent innovation of logistics, the unmanned means of logistics and the green measures of logistics are also the key to the development of logistics digital.

5.3. Deficiencies and Prospects

Because there are few literatures in the field of logistics digital innovation, the indicators in the field of logistics digital innovation have not been proposed yet. The selection of the indicator system can only be selected through logistics informatization and logistics networking on the premise that the indicators are available. The existing research is more inclined to the evaluation of the scientific and technological innovation ability of logistics and the research of logistics competitiveness. In the future, according to different logistics high-tech digital technologies and the modern development and innovation of logistics, we can build different evaluation index systems of logistics digital innovation ability, and the indicators of the system will develop in a diversified and multi-dimensional direction.

From the perspective of future development, the field of logistics digital innovation should be more intelligent and digital. From a macro perspective, the world should strengthen the exchange in the field of logistics, including technology and management experience. From a micro perspective, logistics should also develop in coordination with other high-tech industries, introduce digital technology and strengthen digital innovation. In a word, the digital innovation of logistics is the future direction of logistics development, and it is also an important topic of related research and projects in the field of logistics.

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