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Evaluation of Beijing-Tianjin-Hebei Logistics Development Level and Suggestions for Improvement

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Abstract: In view of the accelerated pace of regional integration, the issue of city clusters has increasingly emphasized its importance in economic development. The Beijing-Tianjin-Hebei City Cluster, as the core of the Capital Economic Circle and the hub of logistics in the north, has seen a remarkable integration process, but the imbalance of logistics development among the cities within the cluster and its challenges should not be ignored. Therefore, based on this background, this paper constructs a set of logistics development level assessment system, and analyzes the logistics development status of each city in the Beijing-Tianjin-Hebei city cluster by using principal component analysis. By calculating the composite score, we rank the logistics development level of each city, aiming to accurately identify the problems faced by each city in the field of logistics, and accordingly put forward targeted improvement strategies and enhancement suggestions.

Keywords: Beijing-Tianjin-Hebei; Logistics Development Level; Principal Component Analysis.

1. Introduction

As China's economy moves towards a new stage of high-quality development, the pace of regional economic integration has accelerated significantly, and the construction of urban agglomerations has become an important part of national strategic planning. With the in-depth implementation of the new development pattern of double-cycle, the development strategy of city clusters is not only a key path to strengthen the national economic strength, but also an important driver to promote inter-regional synergy, accelerate the pace of new urbanization and strengthen the construction of ecological civilization. According to the Opinions on Building a New Mechanism for Efficient Regional Coordinated Development issued by the Central Committee of the Communist Party of China (CPC) and the State Council, in the future, China will focus on the core city clusters, including Beijing-Tianjin-Hebei, Yangtze River Delta, Guangdong-Hong Kong-Macao Bay Area, Chengdu-Chongqing, the middle reaches of the Yangtze River, the Central Plains, and the Central Guanzhong Plain, to promote them to become the engines of the integration of the country's major regional strategies. This strategy aims to strengthen the leading role of central cities, drive the synergistic development of the entire urban agglomeration, thereby realizing in-depth integration and interaction between regions and jointly drawing a new blueprint for synergistic regional development [1].

Among the many challenges to accelerate the "integration" process of Beijing-Tianjin-Hebei, logistics integration occupies a central position [2]. Logistics industry, as the cornerstone and strategic pillar of the national economy's solid development, has an inestimable value for industrial upgrading and transformation. In the grand blueprint of Beijing-Tianjin-Hebei coordinated development, the logistics industry plays a key role in connecting the past and the future, and its efficient operation not only injects a strong impetus to the regional economic growth, but also becomes an effective tool and prerequisite for promoting the coordinated development of the region. A sound and efficient transportation and logistics system is not only the "gas pedal" for regional economic take-off, but also an important means to lead regional harmony and achieve balanced development. Therefore, deepening the process of logistics integration is of far-reaching significance for promoting the comprehensive and coordinated development of the Beijing-Tianjin-Hebei region [3].

This paper focuses on the level of logistics development within the Beijing-Tianjin-Hebei city cluster. By constructing an evaluation index system containing three dimensions, namely, the scale of the logistics industry, the development environment and the potential for development, the level of logistics development of 14 cities in Beijing-Tianjin-Hebei was comprehensively evaluated by using the principal component analysis method. The study finds that there are significant differences in the level of logistics development within the Beijing-Tianjin-Hebei city cluster, with Beijing and Tianjin leading the way and other cities lagging behind. The article puts forward enhancement suggestions such as strengthening policy leadership, improving the core competitiveness of logistics enterprises and introducing high-tech talents to promote the synergistic development of the logistics industry in Beijing-Tianjin-Hebei.

2. Literature Review

Yue Qi (2019) used gray correlation analysis, entropy weight method, and principal component analysis to comprehensively evaluate the logistics competitiveness in 2011 and 2016, and verified the consistency of the three methods by Kendall synergy coefficient test. Further, systematic cluster analysis was used to divide the logistics competitiveness of each region into three tiers, and the current situation and reasons for changes in the level of logistics development in each region were analyzed [4]. Jiang naturally et al. (2020) studied the logistics development level of 14 port cities in the Yangtze River Delta region in 2017. The study constructed an evaluation index system from four dimensions: logistics operation, infrastructure, urban support, and information technology, and measured the logistics development level score of each city. By analyzing and comparing the measurement results, it reveals the echelon differences, regional characteristics, and problems of logistics development in Yangtze River Delta port cities, and puts forward corresponding policy recommendations [5]. Lun Jiaxing (2022) studied the development level of logistics industry in 31 provinces and cities in China, and conducted a comprehensive evaluation and analysis by constructing an evaluation index system containing four dimensions: logistics resource input, logistics development demand, logistics development benefit and logistics informationization development, and adopting entropy value method and TOPSIS method [6]. Chen Yu (2022) studied the level of logistics development in North China, through the principal component analysis method of logistics development level evaluation indicators for dimensionality reduction processing, and measured the level of logistics development scores of each region, for the quantitative evaluation of the level of logistics development in North China to provide a scientific basis [7].

With the rapid development of China's economy and logistics industry, scholars in China have gradually invested in the study of logistics development level. With the accumulation of research literature on the level of logistics development in urban agglomerations, the imbalance of logistics development within the urban agglomerations has gradually surfaced, but most of the research still tends to focus on the province as a unit to conduct a macroscopic exploration, and rarely focus on the in-depth analysis of the specific city level. To address this research gap, this paper takes a unique approach to assess the logistics development level of each city and quantify it into a comprehensive score by using principal component analysis (PCA) with the help of SPSS software, taking 14 cities in the Beijing-Tianjin-Hebei region as the perspectives. On this basis, this paper analyzes the problems in the development of logistics in each city, and aims to put forward a series of practical countermeasures.

3. Modeling and Data Description

3.1. Modeling

Assuming that there are p indicators in the actual problem we are discussing, we regard these p indicators as p random variables, denoted as X1, X2, ..., Xp, principal component analysis is to transform the problem of these p indicators into a problem of discussing linear combinations of p indicators, and these new indicators F1, F2, ..., Fk (k≤ p), fully reflect the information of the original indicators according to the principle of retaining the main amount of information and are independent of each other. μ: factor loading.

$$F_1= \mu_{(11)} x_1+ \mu_{(21)} x_{(2)} +...+\mu_{(p1)} x_p$$

$$F_2= \mu_{(12)} x_1+ \mu_{(22)} x_{(2)} +...+\mu_{(p2)} x_p$$

$$F_3= \mu_{(13)} x_1+ \mu_{(23)} x_{(2)} +...+\mu_{(p3)} x_p$$

......

$$F_p= \mu_{(1p)} x_1+ \mu_{(2p)} x_{(2)} +...+\mu_{(pp)} x_p$$

3.2. Data Description

3.2.1. Data sources

This paper analyzes the cities involved in Beijing-Tianjin-Hebei based on the cross-section data of 2020, and the relevant data are taken from the 2021 China Statistical Yearbook, Hebei Provincial Statistical Yearbook and Henan Provincial Statistical Yearbook.

3.2.2. Construction of the evaluation index system for the level of logistics development

Reasonable indicators are conducive to the construction of the evaluation system for the level of logistics development, and the principles to be followed are as follows:

Principle of comprehensiveness: the selected indicators should reflect well the cities involved in the regional integration of Beijing-Tianjin-Hebei region, and the dimensions of the indicators reflecting the level of logistics development should be considered from various aspects when they are selected.

Principle of comparability: Although the regional integration of Beijing-Tianjin-Hebei is being gradually implemented, there are still great differences in the development of the cities involved in Beijing-Tianjin-Hebei, for example, Beijing and Tianjin, Beijing does not have water transportation, while Tianjin has very developed water transportation, if water transportation is selected as an evaluation indicator, it will lead to no comparability between Tianjin and other cities involved in Beijing-Tianjin-Hebei. Therefore, this aspect should be fully considered when selecting indicators.

Principle of representativeness: The selected indicators should be representative enough to analyze and judge the problem more accurately.

Principle of accessibility: Also known as the principle of operationalization, indicators are selected to ensure that the required data are available [8].

Principle of scientificity: subjectivity should be avoided to ensure that the data are true and reliable.

This paper sets up three dimensions of logistics industry scale, logistics industry development environment, logistics industry development potential, and then according to the characteristics of these three dimensions themselves and unfolded to set up nine specific evaluation indicators, respectively, for the number of legal entities in transportation, highway freight volume, the number of employed people, the average wage, GDP per capita, Internet broadband access ports, the total amount of goods imported and exported, investment in fixed assets (excluding farmers) growth over the previous year, and R&D expenditure, and the final evaluation system is shown in Table 1.

Table 1. Indicators for evaluating the level of logistics development

Level 1 indicators	Secondary indicators	Nature of the indicator	variant
Scale of the logistics industry	Number of legal entities in transportation (thousands)	forward	X1
	Freight transported by road (one hundred million tons)	forward	X2
	Number of employed persons (10,000)	forward	X3
	Average wage (10,000RMB)	forward	X4
Logistics Industry Development Environment	GDP per capita (10,000RMB)	forward	X5
	Internet broadband access ports (10,000 ports)	forward	X6
	Total import and export of goods (one hundred million yuan)	forward	X7
Logistics Industry Development Potential	Growth in investment in fixed assets (excluding farm households) over the previous year (%)	forward	X8
	R&D expenditure (one hundred million yuan)	forward	X9

3.2.3. Descriptive statistical analysis

Table 2. Analysis of descriptive statistics

	N	minimum	maximum	average	Standard deviation
X1: Number of legal entities in transportation (thousands)	14	1.30	20.66	5.3936	5.86306
X2: Freight transported by road (one hundred million tons)	14	.39	5.13	1.9907	1.43788
X3: Number of employed persons (10,000)	14	.38	56.00	6.5206	14.70840
X4: Average wage (10,000RMB)	14	4.70	12.29	7.5064	2.09661
X5: GDP per capita (ten thousand yuan)	14	2.90	16.50	5.8643	3.73128
X6: Internet broadband access ports (10,000 ports)	14	209.20	2084.10	591.6357	508.93079
X7: Total import and export of goods (one hundred million yuan)	14	16.30	23216.00	2503.3000	6257.29577
X8: Growth in investment in	14	-50.80	129.70	14.1857	50.02373
X9: R&D expenditure (one hundred million yuan)	14	6.400	297.400	74.28571	88.240884
Valid N (list status)	14				

4. Beijing-Tianjin-Hebei Logistics Development Level Empirical Analysis

4.1. Empirical Analysis

4.1.1. Data normalization and standardization

Since all the indicators selected in this paper are normalized so there is no need to do the normalization process, and in the process of using SPSS software, SPSS can standardize the non-standard data by itself. Therefore, here no longer standardized processing.

4.1.2. KMO test and Bartlett's test of sphericity

In order to test the significance and suitability of the data for constructing the evaluation indicators of logistics development level, KMO test and Bartlett's ball test are needed, and the results are shown in Table 3:

Table 3. KMO and Bartlett's test

	KMO and Bartlett's test	
KMO		.720
Bartlett’s Test of Sphericity	Approximate chi-square	191.418
	Degrees of freedom	36
	significance	.000

The KMO value is between 0 and 1. The higher the KMO value, the stronger the commonality of the variables and the more appropriate the principal component analysis, the general criteria are as follows: KMO>0.9, very suitable for principal component analysis; 0.8<KMO<0.9, more suitable for principal component analysis; 0.7<KMO<0.8, suitable for principal component analysis; 0.6<KMO<0.7, reluctantly accepted to do principal component analysis; KM0 < 0.6 is not suitable for principal component analysis [9]. The calculation results are shown in Table 3, from which it can be seen that the KMO value is 0.720, which is greater than 0.6; the value of Bartlett's spherical test statistic is 191.418, and the p-value obtained from the analysis is 0.000, which is less than 5% of the significance level. In conclusion, it shows that it is suitable for principal component analysis.

4.1.3. Determination of principal components

SPSS was used to analyze the data to get the eigenroot and cumulative variance contribution rate (see Table 4), according to the principle that the eigenvalue is greater than 1 and the cumulative variance is greater than 70%, it means that the components are useful and able to carry out the subsequent analysis. After principal component analysis, this paper can extract 2 principal components from the logistics development level rating system.

Table 4. Total Variance Explained

ingredient	Initial eigenvalue			Extract the sum of squares and load		
	add up the total	% of variance	Cumulative %	add up the total	% of variance	Cumulative %
1	6.502	72.239	72.239	6.502	72.239	72.239
2	1.218	13.536	85.775	1.218	13.536	85.775
3	0.812	9.027	94.802			
4	0.273	3.035	97.837			
5	0.091	1.016	98.853			
6	0.083	0.922	99.775			
7	0.012	0.130	99.904			
8	0.008	0.088	99.992			
9	0.001	0.008	100.000			

Table 5. Component Matrix

	ingredient	
	1	2
Zscore (X1: number of legal entities in transportation (thousands))	0.971	-0.026
Zscore (X2: Road freight volume (one hundred million tons))	0.381	-0.709
Zscore (X3: Number of employed persons (10,000))	0.943	0.085
Zscore (X4: average wage (10,000RMB))	0.898	-0.018
Zscore (X5: GDP per capita (10,000RMB))	0.962	0.071
Zscore (X6: Internet broadband access ports (10,000))	0.976	0.074
Zscore (X7: total exports and imports of goods (one hundred million yuan))	0.953	0.108
Zscore (X8: Growth in investment in fixed assets (excluding agriculture) over the previous year (%))	-0.054	0.827
Zscore (X9: R&D spending (one hundred million yuan))	0.964	0.034

4.1.4. Interpretation of principal components

The first principal component contains a large amount of indicator information, with a variance contribution rate of 72.239%, including the number of legal entities in transportation, the number of employed persons, the average wage, the GDP per capita, the Internet broadband access ports, the total amount of goods imported and exported, and the R&D expenditures; and the second principal component, with a variance contribution rate of 13.536%, contains the amount of highway freight transported and the investment in fixed assets (excluding farm households) over the previous year's Growth.

4.2. Empirical Analysis

4.2.1. Composite score calculation

The scores of the principal components were calculated using SPSS as well as Table 5:

F1=0.971/sqrt(6.502)*ZX1+0.381/sqrt(6.502)*ZX2+0.943/sqrt(6.502)*ZX3+0.898/sqrt(6.502)*ZX4+0.962/sqrt(6.502)*ZX5+0.976/sqrt(6.502)*ZX6+0.953/sqrt(6.502)*ZX7-0.054/sqrt(6.502)*ZX8+0.964/sqrt(6.502)*ZX9

F2=-0.026/sqrt(1.288)*ZX1-0.709/sqrt(1.288)*ZX2+0.085/sqrt(1.288)*ZX3-0.018/sqrt(1.288)*ZX4+0.071/sqrt(1.288)*ZX5+0.074/sqrt(1.288)*ZX6+0.108/sqrt(1.288)*ZX7+0.827/sqrt(1.288)*ZX8+0.034/sqrt(1.288)*ZX9

The scores of the two principal components are obtained, and then the variance explained ratio is used as a weight to calculate the composite score for each city, i.e.

F=0.72239*F1+0.13536*F2

4.2.2. Composite Score Ranking

Finally, the comprehensive scores of the 14 cities involved in the Beijing-Tianjin-Hebei city cluster can be obtained, according to the order of the scores from the largest to the smallest, as shown in the table below:

Table 6. Composite Score Ranking Table

rankings	municipalities	aggregate score
1	Beijing, capital of People's Republic of China	5.46
2	Tianjin	2.5
3	Tangshan prefecture level city in Hebei	0.4
4	Shijiazhuang prefecture level city in Hebei	0.02
5	Cangzhou prefecture level city in Hebei	-0.37
6	Langfang prefecture level city in Hebei	-0.45
7	Baoding prefecture level city in Hebei	-0.48
8	Handan prefecture level city in Hebei	-0.55
9	Qinhuangdao prefecture level city in Hebei	-0.67
10	Chengde prefecture level city in Hebei	-1.02
11	Anyang prefecture level city in Henan	-1.07
12	Xingtai prefecture level city in Hebei	-1.25
12	Zhangjiakou prefecture level city in Hebei	-1.25
13	Hengshui prefecture level city in Hebei	-1.26

5. Conclusions and Recommendations

5.1. Conclusion

As can be seen from Table 6, there is still a big gap between the 14 cities in the Beijing-Tianjin-Hebei city cluster, which roughly shows that the core cities represented by Beijing and Tianjin have better comprehensive scores, while other cities with smaller economies have worse comprehensive scores. Beijing's comprehensive score ranks first. As the core city of Beijing-Tianjin-Hebei coordinated development, Beijing's logistics development strategy needs to be closely centered on the strategic positioning of the capital and the needs of people's livelihood. With its superior economic strength and policy advantages, Beijing has demonstrated strong leadership in the logistics sector, topping the list in terms of comprehensive logistics development, significantly outperforming other cities in the region. This leading position not only supports the city's daily operations, but also contributes to the improvement of residents' quality of life. However, despite the diversified trends in enterprise-level logistics planning in Beijing, some challenges remain, such as the integration and management of some logistics resources and services that have yet to be strengthened. Tianjin, with an overall score of 2.5 points, comes in second place, showing strong strength. Tianjin not only supports Beijing's function relocation, but also promotes its own logistics development. Although the secondary industry is still dominant, the tertiary industry, especially port logistics, is developing rapidly, but despite this, there is still a gap compared with international ports such as Hong Kong Port. In addition, Tianjin faces the challenge of a shortage of highly educated logistics professionals, and needs to strengthen its talent support in order to promote the continued prosperity of the logistics industry. Tangshan and Shijiazhuang are leading the way in logistics development in Hebei, with composite scores of 0.4 and 0.02, respectively. Tangshan leads Hebei in GDP based on its resource-based industries and labor strengths, and its easy access to transportation is also conducive to logistics, while Shijiazhuang has become a major logistics hub in the north, thanks to its early transportation infrastructure and accelerated circulation after reforms and opening up. Both are in the process of transformation and upgrading, and it is expected that the tertiary industry, especially the logistics industry, will accelerate the development, but the third-party logistics has yet to be upgraded. The rest of the cities in Hebei and Anyang are lagging behind in logistics development, with small economies and insufficient self-driven power. Although Langfang and Qinhuangdao have developed, they still lack in industrial upgrading and talent introduction, and their logistics foundation is weak. The gap with Beijing and Tianjin is large, internal development is limited, and the role in Beijing-Tianjin-Hebei integration is less than that of subordinate cities in the Yangtze River Delta.

5.2. Recommendations

This paper evaluates the logistics development level of 14 cities in the Beijing-Tianjin-Hebei city cluster by using principal component analysis to get the comprehensive score of each city and puts forward suggestions for improvement accordingly.

In terms of policy, it has strengthened policy orientation and optimized the macro environment to build a policy cornerstone for the coordinated development of logistics in Beijing, Tianjin and Hebei. Refine the specifications for the construction of logistics parks, commercial bases and ports to improve operational efficiency. Digging deep into the advantages of local characteristics, precisely planning Zhangjiakou, Xingtai and other marginal cities, combining industrial characteristics and natural resources, promoting the integrated development of logistics and related industries, narrowing the gap with the core cities, and jointly promoting the synergistic upgrading of regional logistics.

From the perspective of logistics enterprises, strengthen the core competitiveness of logistics enterprises, as the key node of Beijing-Tianjin-Hebei logistics development, need to actively innovate technology, improve the level of service, combined with the characteristics of each city to formulate a personalized development strategy. Promote industrial upgrading, transfer of traditional logistics, the application of modern technology, to achieve the staggered and complementary development. In the face of the epidemic and market fluctuations, logistics enterprises should transform into learning organizations, optimize the allocation of human resources, anticipate trends, flexibly adjust their strategies and enhance environmental adaptability.

From the perspective of talent management, the introduction of highly skilled personnel and the strengthening of talent support is the key to activating urban vitality and driving transformation and upgrading. The national "14th Five-Year Plan" emphasizes the importance of talents in the innovation system and industrial transformation. Beijing-Tianjin-Hebei cities should take advantage of the talent policy, not only to absorb the labor force, but also to focus on senior logistics talents, to accelerate the process of logistics modernization with talent as a wing.

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