Economics & Business Management
ISSN Print: 3079-5214
ISSN Online: 3079-5222
https://doi.org/10.63313/EBM.2019

Empirical Study on Evaluation of Urban Logistics Competitiveness Based on Factor Analysis--A Case Study of Shandong Province

Yuning Hu. Rui Zhang
Southwest Petroleum University, Chengdu 610000, China

How to cite this paper: Hu, Y. N., & Zhang, R. (2025). Empirical Study on Evaluation of Urban Logistics Competitiveness Based on Factor Analysis--A Case Study of Shandong Province. Economics & Business Management, 2(1), 197-207. ISSN Print: 3079-5214; ISSN Online: 3079-5222.
https://doi.org/10.63313/EBM.2019
Published: 2025-06-24

Abstract

The efficient operation of logistics industry plays an irreplaceable role in promoting commodity circulation, accelerating industrial upgrading, enhancing urban competitiveness and promoting regional economic integration. However, the development of logistics industry in various cities is unbalanced. This paper takes 16 cities in Shandong Province as the research object, and analyzes 12 key factors affecting urban logistics competitiveness by factor analysis. The empirical research results show that Qingdao ranks first in logistics competitiveness and Dongying ranks last. And for different cities logistics development put forward the corresponding recommendations.

Keywords

Factor analysis; logistics competitiveness; Shandong Province

1. Introduction

1.1. Research background

With the acceleration of globalization and informatization, logistics industry has become an indispensable part of modern economy, which has a significant impact on regional economic growth and industrial restructuring. In China, logistics industry as one of the ten revitalization industries, its importance is increasingly prominent, especially in promoting domestic and foreign trade, improve the efficiency of industrial chain, enhance regional economic competitiveness and other aspects play a key role.

Shandong Province as an important economic province in China, its logistics industry development has an important impact on regional economy. However, the level of logistics development in Shandong Province is not balanced, some cities have problems such as unbalanced supply and demand, lagging infrastructure construction, etc., which restrict the overall development of logistics industry.

Factor analysis method, as an effective data simplification technique, can extract a

few key factors to reflect the main information of original variables by deeply studying the internal structure of multiple complex variables. This method has a wide application prospect in the evaluation of regional logistics competitiveness, which can help us understand the logistics development status of cities in Shandong Province more objectively and comprehensively, and provide strong support for making scientific and reasonable logistics development planning.

Taking Shandong Province as an example, this paper uses factor analysis method to evaluate the competitiveness of urban logistics, aiming to reveal the inherent law and characteristics of logistics development in Shandong Province through constructing scientific evaluation index system, and provide decision-making reference for improving the overall competitiveness of logistics industry in Shandong Province and promoting the coordinated development of regional economy.

1.2. Research significance

From the theoretical aspect, this paper enriches the theoretical system of logistics competitiveness evaluation by introducing factor analysis method, and analyzes the key factors affecting urban logistics competitiveness and their relationships by constructing a comprehensive and systematic evaluation index system of logistics competitiveness, which provides a new perspective and idea for related research in logistics field.

From the practical aspect, this paper evaluates the logistics competitiveness of cities in Shandong Province scientifically, and tries to provide important basis for local governments to formulate logistics development planning and optimize logistics resource allocation. By identifying the advantages and disadvantages of logistics development in each city, this paper also hopes to help local governments make precise policies, strengthen logistics infrastructure construction, improve logistics service level and improve logistics policy environment, so as to promote the overall upgrading of logistics industry and coordinated development of regional economy in Shandong Province. In addition, the research results of this paper can also provide reference for other provinces or regions to carry out logistics competitiveness evaluation, and have a positive role in promoting the sustainable and healthy development of China's logistics industry.

1.3. Research contents

Firstly, this paper will construct the evaluation index system of urban logistics competitiveness in Shandong Province, which will comprehensively consider the economic level of logistics development, logistics infrastructure level, logistics human resources level, logistics development industry scale layout, logistics informatization level and other dimensions, and comprehensively reflect the actual situation of urban logistics competitiveness in Shandong Province by selecting representative and quantifiable indicators.

Secondly, this paper will use factor analysis method to process and analyze the col-

lected data. Through factor extraction, factor rotation and other steps, extract the key factors affecting the logistics competitiveness of cities in Shandong Province, and calculate the scores and rankings of these factors.

Further, this paper will combine the actual situation of each city in Shandong Province, analyze the result of factor analysis, compare the differences of different cities in logistics economy level, logistics infrastructure, human resources, enterprise development and informatization level, analyze the influence mechanism of these differences on logistics competitiveness, and put forward corresponding countermeasures and suggestions.

Finally, this paper will summarize the research results and propose the overall strategies and specific paths to enhance the competitiveness of urban logistics in Shandong Province, which will focus on improving the economic level of logistics development, strengthening the construction of logistics infrastructure, increasing the supply of logistics talents, cultivating logistics leading enterprises, improving the level of logistics information, etc., aiming to provide useful reference for the development of logistics industry in Shandong Province and other regions of the country.

2. Literature Review and Theoretical Analysis

Yan Wang et al.(2024) used factor analysis method to test and analyze with SPSS software, constructed regional logistics capacity evaluation index system, carried out evaluation research on regional logistics capacity of Inner Mongolia Autonomous Region, classified 12 league cities according to regional logistics capacity level, and put forward different development suggestions for different types.

Zhang Rui (2024) combined with the logistics development status of Shandong Province, constructed the intelligent logistics performance evaluation system, and ranked the influencing factors of logistics performance in Shandong Province by SPSS27.0 software and factor analysis method. It was found that the number of large-scale logistics enterprises had the greatest impact on the intelligent logistics performance of Shandong Province, followed by the GDP of Shandong Province. Through research and analysis, relevant suggestions were put forward for the development of intelligent logistics in Shandong Province.

Wang Runnan (2018) used factor analysis method to process and analyze relevant indicators of selected cities and counties in Jiangxi Province by SPSS19.0, established corresponding regional logistics capacity evaluation indicators, obtained logistics capacity grades of various urban areas in Jiangxi Province, and put forward corresponding development strategies according to the actual conditions of three areas in Jiangxi Province.

Xia Fan (2018) conducted a comprehensive comparative evaluation of China's logistics competitiveness by means of selection factor analysis and K-means cluster analysis, and obtained a conclusion consistent with the actual situation. He believed that the level of regional logistics competitiveness depends on the level of in-

ter-regional trade to a large extent, while coastal areas are easier to improve. Therefore, it is confirmed that the index system and method proposed in this paper are scientific and feasible.

Sun Guozhao (2018) took the Yangtze River Economic Zone as a case to comprehensively evaluate the logistics capacity of different regions in the Yangtze River Economic Zone, and on this basis, evaluated the overall logistics capacity of the Yangtze River Economic Zone, providing reference for improving the comprehensive logistics capacity of the Yangtze River Economic Zone.

Jiang Wei (2017) started from the importance of the Silk Road Economic Belt, combined with the importance of the Silk Road Economic Belt and the constraints of the "low-carbon economy" on the development of the logistics industry, and conducted an empirical study on the low-carbon logistics capacity of the nine provinces of the Silk Road Economic Belt by using factor analysis and cluster analysis.

On the whole, the current research methods on logistics competitiveness are mature, but the existing research on the logistics competitiveness of Shandong cities is very few, less quantitative analysis of data. Therefore, based on the basic situation of Shandong cities, this paper constructs the evaluation index of logistics competitiveness, including the economic level of logistics development, the level of logistics infrastructure, the level of logistics human resources, the scale of logistics development, the industrial layout, the level of logistics informatization, and calculates the ranking of logistics competitiveness of each city, and puts forward corresponding development countermeasures for different cities.

3. Index System Construction and Data Description

3.1. Construction of Evaluation Index System of Urban Logistics Competitiveness in Shandong Province

There are many factors influencing the competitiveness of urban logistics, and the key first step is to establish the evaluation index of logistics competitiveness, which will directly affect the evaluation results.

Therefore, in order to understand the logistics competitiveness of cities in Shandong Province, this paper designs an index system from five aspects: logistics development economic level, logistics infrastructure level, logistics human resources level, logistics development scale industrial layout and logistics development informatization level (see Table 3-1):

Table 3-1. Evaluation Index System of Logistics Competitiveness of Cities in Shandong Province

	Level 1 indicator	serial number	Level 2 indicator	unit
Evaluation System of Urban Logistics Competitiveness in Shandong Province	Logistics development economic level	X_1	Region GDP	100 million yuan
		X_2	total retail sales of consumer goods	100 million yuan
		X_3	per capita consumption expenditure of residents	yuan

	Logistics infra-structure level	X_4	highway mileage	kilometre (km.)
		X_5	Expressway mileage	kilometre (km.)
		X_6	Civilian vehicle ownership	million
	Logistics human resource level	X_7	Employment in transport, storage and postal services	thousands of people
	Logistics devel-opment scale Industrial layout	X_8	volume of freight traffic	million tons
		X_9	cargo turnover	billion ton-km
		X_{10}	Total postal and telecommunications services	100 million yuan
	Logistics in-formatization level	X_{11}	Broadband Internet access subscribers	million
		X_{12}	Number of mobile phone subscribers at year-end	million

3.2. Data description

$$W_{ij} = \alpha + \beta_1 * X_1 + \beta_2 * X_2 + ... + \beta_{12} * X_{12} + \varepsilon_{ij}$$

Where W_{ij} is the logistics competitiveness score of a certain city in a certain year; α is the basic score, which has nothing to do with the evaluation index in this paper; β_i is the score coefficient of the corresponding evaluation index X_i; ε_{ij} is the random variable of the logistics competitiveness score of a certain city in a certain year.

4. Empirical analysis

4.1. Method selection and data sources

This paper uses factor analysis to evaluate the competitiveness of urban logistics in Shandong Province, which includes five specific steps: data collection and standard-ization, data inspection, data analysis, scoring and ranking, and obtaining results.

This paper analyzes the latest statistical data of cities in Shandong Province issued from 2023 to 2024. Relevant data are taken from Statistical Yearbook of Shandong Province (2023), Statistical Yearbook of Cities in Shandong Province in 2023 and Statistical Bulletin of Cities in Shandong Province in 2022.

4.2. Factor analysis

4.2.1. Suitability tests

In this paper, SPSS is used to standardize the data of 12 indicators in 16 cities of Shandong Province in 2022, and Bartlett sphericity test and KMO test are carried out on the sample data. The results are as follows:

Table 4-1. KMO and Bartlett Test

KMO sampling appropriateness measure.		0.622
Bartlett's sphericity test	approximate chi-square	242.222
	degree of freedom	66

significance	0.000

The KMO value of sample data is 0.622, which is greater than 0.5 and can be used for factor analysis. The significance of sphere test is much less than 0.05, which indicates that there is significant correlation among 12 indexes and is suitable for factor analysis.

4.2.2. Principal factor extraction

Principal component analysis is used to extract principal factors, and the extraction basis is shown in the total variance interpretation (Table 4-2). Then, the number of principal factors is determined based on the rough judgment of the gravel map and the principle that the eigenvalue is greater than 1, and the principal factors are extracted.

Table 4-2. Total variance explanation

	initial characteristic value			Extract Load Squares			sum of squares of rotational loads		
ingredient	aggregate	% Variance	Cumulative %	aggregate	% Variance	Cumulative %	aggregate	% Variance	Cumulative %
1	8.106	67.548	67.548	8.106	67.548	67.548	7.779	64.825	64.825
2	1.509	12.575	80.123	1.509	12.575	80.123	1.836	15.298	80.123

Extraction method: principal component analysis.

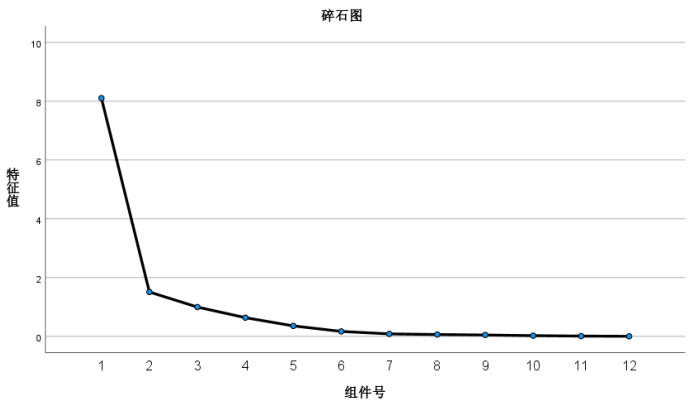

Figure 4 – 1. Gravel Map

As shown in Table 4-2, two principal factors with eigenvalues above 1 can be extracted by principal component analysis. The contribution rates of these two principal factors are 67.548% and 12.575% respectively, and the cumulative variance contribution rate is 80.123%, which is greater than 80%. It shows that these two principal factors can better represent the information represented by the 12 indicators in the original indicator system to a certain extent.

It can also be seen from the gravel chart that the slope of 1-2 is relatively large, indicating that the eigenvalues of 1-2 are obvious, and only the eigenvalues of the first two factors are greater than 1. However, the slope of 3- 1 - 2 is relatively gentle, indicating that the extracted main factors are not among them, which verifies the accuracy of Table 4-3.

4.2.3. Factor Rotation and Principal Factor Score Calculation

In order to distinguish the principal factors clearly, orthogonal rotation is per-

formed on the component matrix by using the variance maximization method, and coefficients with absolute values less than 0.50 are not displayed. The rotated component matrix and component score matrix are shown in Table 4-3.

Table 4-3. Rotational Component Matrix and Component Score Matrix

	rotated component matrix		component score matrix	
index	F1	F2	F1	F2
X1	0.944		0.138	-0.088
X2	0.975		0.135	-0.051
X3		-0.811	0.116	-0.532
X4		0.778	-0.046	0.459
X5	0.856		0.087	0.127
X6	0.933		0.108	0.066
X7	0.804		0.137	-0.185
X8	0.880		0.095	0.100
X9	0.758		0.122	-0.135
X10	0.766		0.128	-0.163
X11	0.908		0.100	0.091
X12	0.904		0.095	0.117

It can be obtained that X_1、X_2、X_5、X_6、X_7、X_8、X_9、X_{10}、X_{11}、X_{12} have higher loads on the main factor F_1, F_1 covers economy, transportation, communication informatization, logistics human resources, etc., which can be summarized as economic development and logistics demand capacity indicators; X_3、X_4 have higher loads on the main factor F_2, which can be summarized as logistics infrastructure and livelihood level indicators.

Use the component score coefficient (as shown in Table 4-3) to calculate the common factor score. Taking F1 index as an example, the function expression is:

$$F_1 = 0.138*ZX_1 + 0.135*ZX_2 + 0.116*ZX_3 - 0.046*ZX_4 + 0.087*ZX_5 + 0.108*ZX_6 + 0.137*ZX_7 + 0.095*ZX_8 + 0.122*ZX_9 + 0.128*ZX_{10} + 0.100*ZX_{11} + 0.904*ZX_{12}$$

Similarly, we can obtain the expression of F2 function:

$$F_2 = -0.088*ZX_1 - 0.051*ZX_2 - 0.532*ZX_3 + 0.459*ZX_4 + 0.127*ZX_5 + 0.066*ZX_6 - 0.185*ZX_7 + 0.100*ZX_8 - 0.135*ZX_9 - 0.163*ZX_{10} + 0.091*ZX_{11} + 0.117*ZX_{12}$$

where $ZX_i(i = 1,2,..,12)$ is the data normalized from the original data.

After calculating F1 and F2, the score of the comprehensive factor F can be calculated by the following formula:

$$F = (0.64825*F_1 + 0.15298*F_2)/0.80123$$

According to the formula, the comprehensive evaluation score of logistics competitiveness of each city is obtained and sorted. The results are as follows:

Table 4-4. Principal factor scores and total scores of cities in Shandong Province

	F_1		F_2		F	
	score	ranking	score	ranking	score	ranking
Qingdao	2.42379	1	-0.85666	14	1.8	1
Jinan	2.00162	2	-0.2147	9	1.58	2
Linyi	0.86353	3	0.48166	6	0.79	3
Weifang	0.35571	4	1.49859	1	0.57	4
Yantai	0.33443	5	0.50523	5	0.37	5
Jining	0.02002	6	1.2945	2	0.26	6
Heze	-0.32964	8	1.111	3	-0.05	7
Dezhou	-0.49342	10	0.45565	7	-0.31	8
Liaocheng	-0.60956	13	0.71652	4	-0.36	9

Taian	-0.44436	9	-0.59956	12	-0.47	10
Zibo	-0.52466	11	-0.27523	10	-0.48	11
Bingzhou	-0.58375	12	-0.29358	11	-0.53	12
Weihai	-0.31838	7	-2.40169	16	-0.72	13
Rizhao	-0.68955	14	-1.02398	15	-0.75	14
Zaozhuang	-1.06882	16	0.26954	8	-0.81	15
Dongying	-0.93696	15	-0.66728	13	-0.89	16

4.3 Result analysis

From the calculation results: Firstly, according to the total factor F ranking, Qingdao ranks first in the logistics competitiveness of cities in Shandong Province in 2022, followed by Jinan and Linyi, and they are all positive, indicating that the logistics competitiveness of these three cities in 2022 is higher than the average level of 16 cities in Shandong Province. Ten cities are negative, which means they are lower than the average level of logistics competitiveness in Shandong Province. Heze scores close to 0, which is relatively at the whole average level. Dongying is the lowest, ranking last among 16 cities in Shandong Province. Secondly, according to the ranking of main factor F1, Qingdao, Jinan and Linyi are the top three cities, and Zaozhuang is the last. At the same time, Qingdao ranks first based on main factor F1 and total factor F, but it ranks fourteenth based on main factor F2. It can be seen that Qingdao's logistics infrastructure and people's livelihood level are not in an ideal state.

5. Conclusions and recommendations

5.1. Conclusions

By summarizing and sorting out the existing research results on logistics competitiveness evaluation, combined with the actual situation of logistics development in Shandong Province, this paper establishes the evaluation index system of logistics competitiveness in Shandong Province, which includes 5 first-class indexes and 12 second-class indexes. Further analysis of the two main factors shows that F1 economic development and logistics demand capacity index have great influence on the evaluation of logistics competitiveness in Shandong Province, which indicates that the logistics demand capacity of cities determines the development level of urban logistics to a great extent.

5.2. Recommendations

The logistics development level of cities in Shandong Province is uneven. Qingdao, Jinan and Linyi have strong logistics competitiveness, Heze has slightly lower logistics competitiveness than the average level of Shandong Province, and Tai 'an, Zibo, Binzhou, Weihai, Rizhao, Zaozhuang and Dongying have lower logistics competitiveness than the average level of Shandong Province in terms of economic development and logistics demand capacity, logistics infrastructure and people's livelihood. According to the results of factor analysis, the following suggestions are put

forward:

5.2.1. Suggestions for Cities with Strong Logistics Competitiveness

Qingdao should strengthen highway infrastructure construction, optimize logistics network layout and improve residents 'income level. On the one hand, although Qingdao has strong logistics competitiveness, the lower ranking of highway mileage may affect logistics efficiency. It is suggested that Qingdao increase investment in highway infrastructure, especially the connecting roads with neighboring cities and ports, so as to improve the convenience and efficiency of logistics transportation. At the same time, Qingdao can also take advantage of the natural advantages of the port, strengthen the linkage between the seaport and the hinterland, build a multi-modal transport system, and improve the comprehensive logistics service capacity. On the other hand, the per capita consumption expenditure of residents is closely related to the income level. It is suggested that Qingdao should improve the income level of residents by developing high-tech industries and modern service industries, so as to promote the growth of consumption expenditure. Improve the consumer environment, improve the quality and service level of commercial facilities, attract more consumers to consume, and at the same time, strengthen the protection of consumer rights and interests and enhance consumer confidence.

Jinan should continue to promote the construction of logistics network projects and strengthen the construction of international logistics channels such as China-Europe train. Jinan should continue to increase investment and construction of logistics network projects and upgrade the modernization level of logistics infrastructure. Meanwhile, it should accelerate the construction and upgrading of logistics parks and logistics centers to enhance the agglomeration effect of logistics industry. Jinan should continue to expand international logistics channels such as China-Europe train, strengthen trade with Europe and other regions, and enhance the internationalization level of logistics.

Linyi should continue to consolidate its position as the "No.1 Express City in Shandong" and promote the transformation and upgrading of the logistics industry. It should continue to give full play to its advantages in the field of express logistics, strengthen the construction of logistics infrastructure, and improve the level of logistics informatization. It should encourage logistics enterprises to adopt new technologies and new models for transformation and upgrading, and improve the intelligent and green level of logistics services. At the same time, it should strengthen the cultivation and introduction of logistics talents to provide strong support for the development of the logistics industry.

5.2.2. Suggestions for cities with weak logistics competitiveness

First, improve the logistics transportation network and optimize the layout of logistics parks. Cities should enhance their comprehensive transportation capacity by road, rail, water and air, build efficient and convenient logistics channel networks,

strengthen transportation interconnection with neighboring cities, and improve the accessibility and efficiency of logistics transportation. A number of modern logistics parks integrating warehousing, transshipment and distribution should be established nationwide. Through the transformation of traditional logistics park, promote its infrastructure and service level.

Second, improve logistics information platform and promote intelligent logistics technology. Cities can use modern information technology to build logistics information platform integrating information exchange, logistics tracking, data analysis and other functions. Promote logistics enterprises to connect with information platform to realize logistics information sharing and collaboration. Encourage logistics enterprises to adopt intelligent logistics technologies such as Internet of Things, big data and artificial intelligence to improve the automation and intelligence level of logistics operations. Support logistics companies to intelligently transform existing facilities and equipment to improve the efficiency and accuracy of logistics services.

Third, promote the integrated development of logistics and manufacturing industry. At the same time, we should strengthen cooperation with manufacturing enterprises and promote close contact and cooperation between upstream and downstream enterprises in the industrial chain. Provide customized and integrated logistics services for manufacturing enterprises, reduce logistics costs and improve the efficiency of the entire supply chain.

Fourth, strengthen policy support and guidance. Each city should formulate scientific and reasonable logistics development plans in light of local actual conditions, define the development goals and paths of logistics industry. Provide some preferential treatment to logistics enterprises in terms of taxation, land and capital, reduce their operating expenses, and carry out technological innovation and model innovation to improve their core competitiveness. On this basis, we should strengthen the supervision and enforcement of law to ensure the fair, just and orderly development of China's logistics industry.

Fifth, strengthen professional training for logistics industry, introduce high-level logistics talents. Strengthen exchanges and cooperation with colleges and universities, vocational colleges and other institutions, and become a logistics employee team with both theoretical foundation and practical work experience. Each city government can issue attractive talent introduction policies to attract high-end logistics talents from home and abroad to work and live in Shandong. At the same time, it should also provide a good working environment and development space for the introduced talents and give full play to their professional advantages and innovation ability.

To sum up, Shandong cities need to start from many aspects in improving logistics competitiveness, including strengthening logistics infrastructure construction, upgrading logistics informatization level, promoting logistics industry integration development, strengthening policy support and guidance, and strengthening talent

cultivation and introduction. The implementation of these measures will help improve the comprehensive strength and market competitiveness of local logistics industry to a certain extent.

References

[1] Yan Wang, Meng Fanli, Gao Fangyu, et al. Evaluation of Regional Logistics Capacity Based on Factor Analysis--A Case Study of Inner Mongolia Autonomous Region [J]. Traffic Construction and Management, 2024 (02):122-124+129.

[2] ZHANG Rui. Analysis of intelligent logistics performance and influencing factors in Shandong Province [J]. Straits Science, Technology and Industry, 2024, 37 (01):17-22.

[3] Wang Runnan. Study on regional logistics capability evaluation system based on factor analysis--taking Jiangxi Province as an example [J]. Logistics Engineering and Management, 2018, 40 (05):42-43.

[4] Xia Fan. Comprehensive Evaluation and Comparison of Regional Logistics Competitiveness--Based on Factor Analysis and Cluster Analysis [J]. Chinese and Foreign Entrepreneurs, 2018 (12):47-50.

[5] SUN Guozhao. Evaluation of Regional Urban Logistics Competitiveness in Yangtze River Economic Belt [D]. Chongqing University of Technology, 2018.

[6] Jiang Wei. Evaluation of Regional Low Carbon Logistics Capacity [D]. East China Jiaotong University, 2017.