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THE RESEARCH ON THE EVALUATION OF LOGISTICS COMPETITIVENESS IN QINGDAO CITY, SHANDONG PROVINCE, CHINA

Abstract: This paper employs the evaluation model of factor analysis to calculate, analyze, and rank the factor scores of the socio - economic environment and communication development level at each time point of Qingdao's logistics development from 2012 to 2022. According to the total score of logistics competitiveness in the factor analysis results, Qingdao achieved the highest comprehensive score of 1.45 in 2022, ranking first in the decade. Over the ten - year period, the logistics competitiveness showed an overall upward trend, which is consistent with Qingdao's social development level. In 2018, Qingdao's comprehensive score was 0.25, and the score turned from negative to positive that year, indicating that Qingdao made significant progress in logistics competitiveness in 2018. Meanwhile, the public factor Y1 encompasses the vast majority of indicators, demonstrating that the socio - economic environment factor plays a dominant role in logistics competitiveness.

Keywords: Qingdao City; Logistics Competitiveness; Factor Analysis Method

1. Introduction

In recent years, with the deepening of economic globalization, the modern logistics industry, as the main source of "third-party profit", has played an increasingly important role in economic development. On this basis, the Qingdao Municipal Government proposed in the "14th Five-Year Plan for the National Economy and Social Development and the Long-Term Goals for 2035" to build an "international comprehensive transportation hub" and create a new platform for international cooperation under the "Belt and Road Initiative". The logistics industry in Qingdao has thus received excellent development opportunities and policy support. Logistics competitiveness is an important indicator for measuring regional and industrial development, and it is also a concentrated manifestation of regional logistics competitiveness and industrial economic competitiveness. Therefore, accurately evaluating the development level of logistics is conducive to measuring the logistics development level of Qingdao and Shandong Province, and is of great significance for optimizing the industrial structure and promoting urban economic development.

2. Materials

Liu Zhigang[6] (2024) et al. based on the relevant theories of urban logistics, believe that regional logistics competitiveness is determined by the criteria layer of industrial scale, infrastructure, green and low-carbon, economic development, logistics demand, and information talents. Through cluster analysis and factor analysis, they concluded that Chengdu has the highest logistics competitiveness.

Feng Bianying[7] (2023) et al. based on the analysis of the competitiveness influencing factors of the logistics industry, constructed an evaluation system for the logistics industry of port cities from four dimensions: urban economic development level, urban logistics demand scale, urban logistics infrastructure, and urban informatization level and talent environment. Through cluster analysis, they proposed relevant suggestions for competitive cities and less competitive cities.

Nian Luyun[8] (2014) et al. constructed a first-level indicator from four aspects: urban economic development level, urban logistics infrastructure, urban logistics operation capacity, and urban logistics support system. From this, 21 secondary indicators were derived, and a logistics competitiveness evaluation system was constructed. Based on the results of factor analysis, relevant policy suggestions were proposed for the deficiencies of Jiangmen City.

Memari P[9] (2022) proposed to use DEMATEL, ANP, VIKOR, etc. to construct a city competitiveness model and successfully implemented it in Belgrade. This model applies the participation of decision-makers and expresses the interests and demands of different groups, compensating for the problem of the coverage of city competitiveness research, and more scientifically reflecting the calculation of logistics competitiveness from different perspectives. Using MCDM to rank the schemes, reducing energy consumption, and improving the evaluation of urban logistics competitiveness.

Lozano A[10] (2012) believes that the development of basic facilities in strategic nodes in the city is conducive to achieving the logistics connectivity and accessibility of logistics nodes. Using the identification of logistics nodes based on SLN, based on market and related commercial activity variables, the overall construction plan for logistics nodes was pointed out in Mexico. At the same time, based on the national conditions of Mexico, the intermediate area, infrastructure, and logistics facilities were planned.

Si Hyun Kim[11] (2020) et al. analyzed the location competitiveness of logistics distribution centers in Northeast Asia, and established an evaluation model for the main ports in Northeast Asia using a combination of qualitative and quantitative methods. Using the evaluation methods of analytic hierarchy process and factor analysis, it was concluded that logistics factors were the most critical factors. Through the comparison of qualitative and quantitative methods, the differences between the two were revealed.

Through literature review, it was found that previous scholars have constructed logistics competitiveness evaluation systems based on the characteristics of regional logistics, or conducted empirical analysis using the relevant logistics development data of the selected region at a certain time point. In empirical research, many experts used verification methods such as analytic hierarchy process, entropy weight method, and principal component analysis for the comprehensive evaluation of logistics competitiveness. At the same time, by constructing the "diamond model" of the logistics industry, a competitiveness model applicable to different regions was developed to analyze the relevant data of the logistics industry. Based on the current research status at home and abroad, this paper summarizes the influencing factors of urban logistics competitiveness and constructs an index system suitable for evaluating the logistics competitiveness of Qingdao City. Through factor analysis method, the logistics competitiveness of Qingdao City is comprehensively evaluated.

3. Methods

3.1 Construction of the Evaluation Index System for Logistics Competitiveness

Based on previous research results, this paper will construct a logistics competitiveness evaluation system for Qingdao from dimensions such as industrial economic structure, logistics infrastructure and logistics service level. The selected ten secondary indicators can comprehensively reflect the evaluation of Qingdao's logistics competitiveness. However, these ten indicators have significant differences from each other. Factor analysis method provides a good solution to this problem. It summarizes and generalizes most of the indicators into fewer but representative common factors, increasing feasibility and convenience. At the same time, the determination of common factors is based on contribution rates, which to some extent overcomes the subjective arbitrariness.

Table 1 Evaluation Index System for Logistics Competitiveness of Qingdao City

Primary indicators	Secondary indicators
A. Industrial economic structure	A1 Total GDP of the city (billion yuan) A2 Total retail sales of consumer goods in the city (billion yuan) A3 Per capita regional GDP (yuan) A4 Added value of the tertiary industry (billion yuan) B1 Number of civilian cargo vehicles (units)

B.	logistics infrastructure	B2 Length of roads at the end of the year (kilometers) B3 Number of mobile phone users at the end of the year (thousand units)
C.	logistics service level	C1 Total freight volume (thousand tons) C2 Port throughput (thousand tons) C3 Number of students enrolled in universities (thousand units)

3.2 Evaluation and Analysis of Logistics Competitiveness

3.2.1 Data collection

This article selects the data from Qingdao from 2012 to 2022 as the sample to comprehensively evaluate the logistics development level of Qingdao. The research will be conducted based on the following ten variables: regional GDP X1 (billion yuan), retail sales of consumer goods X2 (billion yuan), total freight volume X3 (thousand tons), per capita regional GDP X4 (yuan), number of civilian passenger vehicles X5 (units), length of roads at the end of the year X6 (kilometers), added value of the tertiary industry X7 (billion yuan), number of students in higher education institutions X8 (thousand people), port throughput X9 (thousand tons), and number of mobile phone users at the end of the year X10 (ten thousand units). The data comes from the statistical yearbook released by the Qingdao Bureau of Statistics, as shown in the table below.

Table 2 Original Values of Indicators in Qingdao from 2012 to 2022

Year	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10
2022	14920.75	5891.8	39711	144870	340964	8474	9245.36	47.23	65754	1345.3
2021	14136.56	5975.4	39969	138849	330943	6352	8721.36	45.72	63029	1295.3
2020	12400.56	5203.5	36516	123828	302652	6374	7593.71	43.07	60459	1257
2019	11741.31	5126.6	37779	124282	273308	6315	7148.57	41.58	57736	1246
2018	10949.38	4742.72	36235	128459	248075	5770	6529.14	39.8	54250	1259
2017	10136.96	4321.43	32537	119357	219533	4865	5920.06	34.62	51314	1291.3
2016	9283.17	3914.19	27955	109407	192364	4484	5332.96	34.09	51463	1445.6
2015	8658.57	3548.16	26965	102519	172376	4375	4798.98	32.23	49749	1335.5
2014	8120.66	3218.25	26040	96524	177931	4393	4389.87	31.35	47701	1301.08
2013	7508.7	2865.02	31299	89797	175373	4334	3950.68	30.02	45782	1262.1
2012	6869.61	2533.16	29229	82680	164931	4281	3553.33	29.66	41465	1178.9

Data source: Qingdao Municipal Bureau of Statistics

Table 3 Standardized Values

Year	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10
2022	1.69	1.34	1.28	1.51	1.57	2.26	1.64	1.55	1.62	0.77
2021	1.39	1.41	1.33	1.21	1.42	0.67	1.37	1.32	1.26	0.04
2020	0.74	0.76	0.66	0.46	1.00	0.69	0.78	0.91	0.92	-0.52
2019	0.49	0.69	0.90	0.48	0.56	0.64	0.54	0.68	0.56	-0.68
2018	0.20	0.37	0.60	0.69	0.18	0.24	0.22	0.40	0.10	-0.49
2017	-0.11	0.01	-0.11	0.24	-0.25	-0.44	-0.10	-0.40	-0.29	-0.02
2016	-0.43	-0.33	-1.00	-0.26	-0.66	-0.73	-0.40	-0.48	-0.27	2.24
2015	-0.67	-0.64	-1.19	-0.60	-0.96	-0.81	-0.68	-0.77	-0.50	0.63
2014	-0.87	-0.91	-1.37	-0.90	-0.88	-0.80	-0.90	-0.91	-0.77	0.13
2013	-1.10	-1.21	-0.35	-1.24	-0.91	-0.84	-1.13	-1.11	-1.03	-0.45
2012	-1.34	-1.49	-0.75	-1.59	-1.07	-0.88	-1.33	-1.17	-1.60	-1.66

3.2.2 Factor Analysis Method

Before conducting factor analysis, the standardized data need to undergo a feasibility test. Based on the results, it is determined whether the data is suitable for factor analysis. In this paper, KMO and Bartlett's sphericity test are used. The test results are shown in Table 4. The KMO value is 0.714, which is greater than 0.6; the approximate chi-square value is large while the corresponding degrees of freedom are small, indicating that the research is suitable for using factor analysis.

Table 4 KMO and Bartlett's Sphericity Test

KMO and Bartlett's Test		
KMO Sampling Adequacy Index		.714
Bartlett's sphericity test	Approximate Chi-square	213.142
	Degree of freedom	45
	Significance	.000

Factor analysis was conducted on the selected 10 indicators, and the common factors with eigenvalues greater than 1 were selected. Since the cumulative total variance explained by the first two factors reached 97.184%, the first two factors could replace the original 10 evaluation indicators. After rotation, the cumulative variance percentage of the two common factors did not change. Therefore, it can be judged that they can summarize the vast majority of the indicators of the original data. Since the eigenvalue of component 10 was lower than 0.01, it was deleted. The total variance explained by the remaining factors is shown in Table 5.

Table 5 Total Variance Explained by Factor Analysis

Total variance explanation									
	Initial eigenvalue			Extracted load squared sum			Rotated load squared sum		
Component	Total	Percentage Variance	Cumulative %	Total	Percentage Variance	Cumulative %	Total	Percentage Variance	Cumulative %
1	8.571	85.708	85.708	8.571	85.708	85.708	8.535	85.355	85.355
2	1.148	11.476	97.184	1.148	11.476	97.184	1.183	11.829	97.184
3	.140	1.395	98.579						
4	.068	.677	99.256						
5	.050	.500	99.756						
6	.012	.119	99.875						
7	.008	.082	99.957						
8	.003	.028	99.985						
9	.001	.014	99.999						

3.2.3 Component Matrix

Since the unrotated component matrix cannot provide a reasonable interpretation of the data, the Cauchy normalization maximum variance method needs to be used to rotate the component matrix, so as to obtain more obvious results. As shown in Table 6. From the table of the rotated component matrix, it can be seen that the first common factor is jointly determined by variables X8, X5, X7, X1, X2, X9, X4, X6, X3, with factor loadings of 0.994, 0.992, 0.992, 0.991, 0.980, 0.973, 0.957, 0.946, 0.935 respectively. The second common factor is determined solely by X10, with a factor loading of 0.994.

Table 6 Rotated Component Matrix

The rotated component matrix		
	Component	
	1	2
Zscore(X8)	.994	
Zscore(X5)	.992	
Zscore(X7)	.992	.114
Zscore(X1)	.991	.119
Zscore(X2)	.980	.130

Zscore(X9)	.973	.195
Zscore(X4)	.957	.192
Zscore(X6)	.946	
Zscore(X3)	.935	-.273
Zscore(X10)		.994

The first common factor, X8, X5, X7, X1, X2, X9, X4, X6, X3 mainly includes the number of students in higher education institutions, the number of civilian cargo vehicles, the added value of the tertiary industry, regional GDP, total retail sales of consumer goods, port throughput, per capita regional GDP, and the total length of roads and freight volume at the end of the year. All of these are highly correlated with the first factor, so it is named the social economic environment factor.

The second common factor, X10, has a high load on the number of mobile phone users at the end of the year, which means that the second factor represents the factors related to the level of communication development. It is named the communication development level factor.

Based on the component scoring coefficient matrix, the following factor scoring function can be derived:

Y1=0.113 * ZX1 + 0.111 * ZX2 + 0.127 * ZX3 + ……- 0.044 * ZX10.

Y2=0.052 * ZX1 + 0.062 * ZX2 - 0.286 * ZX3 + ……+ 0.859 * ZX10.

Table 7 Coefficient Matrix of Component Scores

Component scoring coefficient matrix

	Component	
	1	2
Zscore(X1)	.113	.052
Zscore(X2)	.111	.062
Zscore(X3)	.127	-.286
Zscore(X4)	.105	.117
Zscore(X5)	.121	-.081
Zscore(X6)	.115	-.069
Zscore(X7)	.113	.047
Zscore(X8)	.118	-.027
Zscore(X9)	.107	.118
Zscore(X10)	-.044	.859

4. Results

Substitute the standardized original data into the expression of the above common factor, and calculate Y1 and Y2. By weighted summation based on the weights of the common factors, a comprehensive scoring model for the logistics competitiveness of Qingdao from 2012 to 2022 can be obtained, that is: Y = 0.85355 * Y1 + 0.11829 * Y2. After calculation, the logistics competitiveness of the city in Qingdao can be obtained.

Table 8: Urban Logistics Competitiveness Scores of Qingdao City from 2012 to 2022

The urban logistics competitiveness scores of Qingdao City from 2012 to 2022

Year	Y1 Score	Y2 Score	Y (Overall Score)
2022	1.62	0.59	1.45
2021	1.3	-0.03	1.11
2020	0.82	-0.5	0.64
2019	0.67	-0.73	0.49

2018	0.37	-0.5	0.25
2017	-0.17	0.06	-0.14
2016	-0.63	2.21	-0.28
2015	-0.82	0.8	-0.6
2014	-0.96	0.31	-0.78
2013	-0.99	-0.57	-0.91
2012	-1.2	-1.64	-1.21

5. Discussion

According to the public factor scores shown in Table 8, it can be seen that the differences in the scores of the two public factors over the years in Qingdao and the degree of their impact on the logistics competitiveness of Qingdao. The first social economic environment factor includes the vast majority of indicator variables and has the greatest impact on the logistics competitiveness of Qingdao. Among the factor scores over the years, 2022 had the highest score, and the original values of its indicators such as the number of students in higher education institutions, the number of civilian cargo vehicles, the added value of the tertiary industry, the regional gross domestic product, the total retail sales of consumer goods, the port throughput, the per capita regional gross domestic product, and the length of roads at the end of the year, as well as the total freight volume, were all higher than those in other years. This indicates that the social economic environment in Qingdao was the best in 2022. The communication development level factor includes the indicator of the number of mobile phone users at the end of the year, which describes the communication level of logistics development in Qingdao. In 2016, the communication development level factor had the highest score, indicating that the logistics communication capability in 2016 achieved a leapfrog development, with the number of mobile phone users growing rapidly at the end of the year, which to some extent compensated for the lack of logistics competitiveness in that year.

Based on the overall score situation, it can be seen that the factor score turned negative to positive in 2018, indicating that the logistics competitiveness of Qingdao achieved a leapfrog development. Although the communication development level factor remained negative, it did not affect the overall progress. This indicates that the social economic environment is the main influencing factor.

In conclusion, the overall level of urban logistics development in Qingdao showed a rapid growth phenomenon from 2012 to 2022, and the logistics competitiveness of Qingdao continued to improve, which was basically consistent with the actual rapid economic development situation of Qingdao.

6. Conclusion

Based on the existing research results, the industrial economic structure, logistics infrastructure, and logistics service level are selected as the first-level indicators, and corresponding 10 second-level indicators are selected to construct the evaluation system for the logistics competitiveness of Qingdao City. The evaluation model using factor analysis method is adopted to calculate and analyze the logistics competitiveness of Qingdao City. The results show that in 2022, the comprehensive score of Qingdao City was the highest at 1.45, and the logistics competitiveness of Qingdao City showed an overall upward trend from 2012 to 2022. In 2018, the comprehensive score of Qingdao City was 0.25, and the score turned negative to positive in that year. The public factor Y1 includes the vast majority of indicators, indicating that the social economic environment factors play a dominant role in logistics competitiveness. Based on the evaluation results, the following countermeasures and suggestions are proposed to improve the logistics competitiveness of Qingdao City:

(1) Optimize infrastructure. Logistics infrastructure is an important component of the social economic environment factors. As a port city, the infrastructure of Qingdao City is particularly crucial. Implement modernization renovations of Qingdao Port to improve the efficiency of cargo handling, optimize the layout of the logistics network, and achieve the connection of multimodal transportation by sea, land, and air. At the same time, strengthen the construction of emerging

infrastructure such as smart logistics parks to enhance the level of logistics informatization and intelligence.

(2) Enhance logistics information technology innovation. Technological innovation is a key link in improving logistics competitiveness and service level. The corresponding factor is the level of communication development. Qingdao City should actively introduce emerging technologies such as the Internet of Things, big data, artificial intelligence, and cloud computing, build an information-based logistics service platform and management system, and improve the accuracy of logistics. At the same time, increase the number of educated people in higher education to form a high-quality labor force. In terms of services, Qingdao City should vigorously develop third-party logistics to reduce the proportion of self-operated logistics and improve the quality and efficiency of logistics services.

(3) Increase policy support and industrial cooperation. Government policy support is an important guarantee for the development of the logistics industry. The Qingdao Municipal Government should vigorously introduce incentive policies related to logistics to create a favorable business environment. The government should improve relevant laws and regulations, standardize the development of the logistics industry, and provide institutional guarantees for promoting the healthy development of the logistics industry. In terms of industrial cooperation, encourage logistics enterprises to compete with each other to avoid a dominant situation, achieve resource sharing among logistics enterprises, and improve the overall logistics competitiveness and service ability of Qingdao City through win-win cooperation. In addition, enterprises themselves should strengthen their awareness of customer service, improve their logistics level, and provide customized and diversified logistics solutions to meet the diverse needs of different customers.

7. Literature

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