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Research on the Evaluation of Comprehensive Logistics Capacity of Major Ports in Chengdu-Chongqing Economic Circle

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Abstract

Under the new development pattern with domestic circulation as the main body and domestic and international dual circulation promoting each other, it has become the general trend to promote the construction of the Chengdu-Chongqing Twin Cities Economic Circle and deeply integrate into the development of the Yangtze River Economic Belt. Located in the upper reaches of the Yangtze River, the Chengdu-Chongqing Economic Circle is an important hub connecting the east and west, and its port has become an important strategic resource for the economic development of the hinterland. Although the port has developed rapidly in recent years, there are still many shortcomings in the face of new situations and new requirements. By establishing an evaluation index system and using the entropy weight-TOPSIS method to evaluate the comprehensive logistics capacity of the main ports in the Chengdu-Chongqing Economic Circle, this paper finds that each port has problems such as unbalanced development and the level of collection and distribution to be improved, and gives corresponding countermeasures to provide reference for the future development and construction of inland ports.

Keywords

Chengdu-Chongqing Economic Circle; Port Logistics Capacity; Entropy Weight-TOPSIS Method.

1. Introduction

As an important opening window for inland areas, ports are not only comprehensive transportation hubs or logistics centers, but also an important part of the regional logistics supply chain [1]. Port logistics uses cities as the main carrier to support the logistics activities of related industries through coordinated transportation, enhance cooperation and connections between regions, and promote overall economic development[2]. The Chengdu-Chongqing region is located in the hinterland of the southwest inland and on the upper reaches of the Yangtze River. It is the region with the strongest comprehensive strength and the highest degree of openness in western my country.

In 2020, the Central Financial and Economic Commission held its sixth meeting. The meeting pointed out that promoting the construction of the Chengdu-Chongqing twin-city economic circle is conducive to forming an important growth pole of high-quality development in the west, and creating a strategic highland for inland opening-up is important for promoting high-quality development. meaning[3]. In October of the same year, the Political Bureau of the CPC Central Committee reviewed the "Outline Plan for the Construction of a Twin-City Economic Circle in the Chengdu-Chongqing Region" and clarified the goals and specific tasks of building a twin-city economic circle in the Chengdu-Chongqing Region. The development of the Chengdu-Chongqing Economic Circle is inseparable from port logistics. Promoting the high-quality

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development of port logistics in the Chengdu-Chongqing Economic Circle is of great significance to the construction of the Belt and Road Initiative and the new round of western development.

At present, domestic research on port logistics mainly focuses on three aspects: research on the relationship between port logistics and economy, research on the evaluation of port logistics capabilities, and research on the development level of port logistics[4]. Foreign countries have begun to study port logistics policies, port logistics forecasts, Research and exploration are carried out in many aspects such as port area borders. my country has made many achievements in the research of large coastal ports, such as Tianjin Port[5], Ningbo Port[6], etc.

However, few scholars pay attention to inland ports. Therefore, this article takes the major ports of the Chengdu-Chongqing Economic Circle as the research object. The entropy weight-TOPSIS method is used to evaluate the comprehensive capabilities of port logistics and analyze the development status, advantages and disadvantages of each port, hoping to provide reference for the development of ports in the Chengdu-Chongqing Economic Circle

2. Index System Construction

2.1. Indicator Setting Principles

(1) Scientific principle

The standard for measuring the scientificity of indicators lies in whether the selected indicators can objectively and scientifically reflect and express the current operating status and activity patterns in this area. It should be based on a large amount of real data as the basic support and be considered using scientific statistical methods to facilitate the final comprehensive evaluation. Obtain scientifically reasonable results.

(2) Principle of representativeness

Since there are many factors that affect port logistics capabilities, if each factor is analyzed and studied in detail, not only will the workload be too large, but some typical problems will not be well exposed. Therefore, when selecting and setting indicators, representative factors should be selected based on the main characteristics of port logistics, so as to ensure that the indicator system is simple and appropriate while also making the evaluation results true and reliable.

(3) Hierarchy principle

The setting of the indicator system should be logically hierarchical, which can better reflect the relationship between the target layer, the criterion layer and the indicator layer, ensure that each indicator is clearly organized, and facilitate the detailed analysis of key indicators at each level.

(4) Practicality principle

When selecting indicators, the availability and true accuracy of indicator data should be fully considered. The accuracy of the indicator data determines the referability of the final evaluation results. It is best to obtain the indicator data from official channels such as statistical yearbooks, and conduct further analysis and research with sufficient authoritative data based on the actual situation

2.2. Indicator Selection

This article consults and draws on the evaluation index system of port logistics capabilities by domestic and foreign scholars, and summarizes secondary indicators in three aspects: port scale capability, port city support capability, and port collection and distribution capabilities, and based on the characteristics and characteristics of inland ports Based on the actual situation, 13 indicators including cargo throughput, port city GDP, total import and export volume, and waterway freight volume were decomposed and selected to build a comprehensive port logistics capability evaluation system. See Table 1.

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Table 1. Port logistics comprehensive capability evaluation index system table

Target Layer	Criterion Layer	Indicator Layer	
First Level Indicator	Second Level Indicators	Third level Indicators	variable name
Comprehensive capabilities of port logistics	Port scale capacity	Cargo throughput (10,000 tons)	X1
		Container throughput (10,000 TEU)	X2
		Cargo throughput growth rate (%)	X3
		Container throughput growth rate (%)	X4
	Port city support capability	City GDP(billion yuan)	X5
		Added value of primary industry (100 million yuan)	X6
		Added value of the secondary industry (100 million yuan)	X7
		Total import and export volume (billion yuan)	X8
		Total retail sales of consumer goods (100 million yuan)	X9
		Number of fresh graduates (10,000)	X10
	Port collection and distribution capacity	Road freight volume (10,000 tons)	X11
		Railway freight volume (10,000 tons)	X12
		Waterway freight volume (10,000 tons)	X13

3. Entropy Weight-TOPSIS Method Introduction

The entropy weight method is a method derived from the concept of "entropy" in thermodynamics to evaluate the degree of dispersion of index information entropy. The lower the entropy value, the more stable the system is and the more information it carries. The TOPSIS method is a method based on the Euclidean distance calculation method to evaluate the proximity between the evaluation object and the ideal target. The combination of the two forms the entropy weight-TOPSIS method. First, the indicators are objectively weighted through the entropy weight method. Then the TOPSIS method is used to select the superior and inferior solutions of the weighted data matrix and calculate the scores. Finally, the items are sorted and compared.

The basic steps of the entropy weight-TOPSIS evaluation model are as follows:

1) Establish the original data matrix. Assuming m ports to be evaluated and 'n' evaluation indicators, the decision matrix is:

$$(M_{\mathrm{ij}})_{\mathrm{m\times n}} = \begin{pmatrix} A_{11} & A_{12} & \cdots & A_{1n} \\ A_{12} & A_{22} & \cdots & A_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ A_{1m} & A_{2m} & \cdots & A_{mn} \end{pmatrix} \tag{1}$$

2) Data standard normalization processing. In the multi-index evaluation system, due to the different magnitudes and dimensions of the selected indicators, direct calculation will produce

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deviations. Therefore, the original data are standardized and normalized to remove the dimensional influence and simplify the calculation. Get the normalized matrix R_{ij}.

$$r_{ij} = \frac{x_j - x_{\min}}{x_{\max} - x_{\min}} \tag{2}$$

$$r_{ij} = \frac{x_{\max} - x_j}{x_{\max} - x_{\min}} \tag{3}$$

Among them, xj is the j-th indicator value, xmax is the maximum value of the j-th indicator, xmin is the minimum value of the j-th indicator, and rij is the standardized value. If the larger the value of the indicator used, the better, then use formula (2), Otherwise, use formula (3).

3) Establish a probability matrix of data. Calculate the proportion of the indicator value p_{ij} of the i-th item under the j-th indicator, and establish the proportion matrix P of the data.

$$p_{ij} = \frac{r_{ij}}{\sum_{i=1}^{m} r_{ij}} (0 \le r_{ij} \le 1) \tag{4}$$

$$P = \left\{ p_{ij} \right\}_{m \times n} \tag{5}$$

4) Determine the entropy value of the evaluation index.

$$e_j = -k \sum_{i=1}^{m} p_{ij} \cdot \ln p_{ij} \tag{6}$$

in this,

$$k = \frac{1}{\ln m} \tag{7}$$

5) Determine the weight of each indicator

$$w_j = \frac{(1 - e_j)}{\sum_{j=1}^{n} (1 - e_j)} = \frac{d_j}{\sum_{j=1}^{n} d_j} \tag{8}$$

in this,

$$d_j = 1 - e_j \tag{9}$$

6) Construct a weighted normalized matrix

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$$B_{ij} = (W_j \cdot R_{ij})_{m \times n} \tag{10}$$

7) Determine positive and negative ideal solutions

$$Z^+ = (Z_1^+, Z_2^+, \cdots, Z_m^+) = \left\{ \max B_{ij} \mid i = 1, 2, \cdots, m \right\} \tag{11}$$

$$Z^- = (Z_1^-, Z_2^-, \cdots, Z_m^-) = \left\{ \min B_{ij} \mid i = 1, 2, \cdots, m \right\} \tag{12}$$

8) Calculate the distance between the evaluation object and the ideal solution

$$d_i^+ = \sqrt{\sum\nolimits_{j=1}^{n} (B_{ij} - Z^+)} (i = 1, 2, \cdots, m) \tag{13}$$

$$d_i^- = \sqrt{\sum\nolimits_{j=1}^{n} (B_{ij} - Z^-)} (i = 1, 2, \cdots, m) \tag{14}$$

9)Calculate the relative proximity of the evaluation object

$$S_i = \frac{d_i^+}{d_i^+ + d_i^-} (i = 1, 2, \cdots, m) \tag{15}$$

4. Empirical Analysis

With the continuous advancement of the construction of the Chengdu-Chongqing Economic Circle, the Sichuan Provincial Government and the Chongqing Municipal Government jointly issued the "Implementation Plan for Jointly Building the Port Logistics System of the Chengdu-Chongqing Economic Circle" to jointly build a high-quality shipping center on the upper reaches of the Yangtze River. Jointly build an international logistics channel that connects trunk lines and branches and directly connects rivers and seas. Promote the linkage of the Chengdu Economic Development Zone Dry Port and Chongqing Orchard Port. Work together to strive for the country to conduct research and start construction of a new channel for water transportation in the Three Gorges. It strives to increase the cargo throughput of ports on the upper reaches of the Yangtze River in the Chengdu-Chongqing region to 310 million tons by 2025. Give full play to the advantages of the Yangtze River's golden waterway, support Chongqing Port, Lu-Zhou Port, Yi-Bin Port, Guang-An Port, etc. to strengthen cooperation and create a riverside port logistics development belt that links ports, industries and cities. This article collects and integrates the evaluation index data of the seven major ports in the Chengdu-Chongqing Economic Circle in 2022 through relevant statistical data websites such as Sichuan Statistical Yearbook, China Port Yearbook, Sichuan Transportation Yearbook, and Municipal Statistical Bulletins, and provides a comprehensive analysis of the port logistics in the Chengdu-Chongqing Economic Circle. Ability to conduct empirical analysis.

4.1. Raw Data Standard Normalization Processing

Since the dimensions of the collected data are different, standard normalization processing is performed on the original data, and because the indicators are all positive, that is, the larger the

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numerical value, the better, so formula (2) is used for normalization processing. The processed results are as follows. See Table 2.

Table 2. Standardization results table of port logistics indicators

	Chongqing Port	Luzhou Port	Yibin Port	Leshan Port	Nanchong Port	Guang'an Port	Guangyuan Port
X1	1.0000	0.0623	0.0435	0.0000	0.0701	0.0142	0.0122
X2	0.0000	0.4002	0.3859	0.0181	1.0000	0.3826	0.4970
X3	1.0000	0.1681	0.0885	0.0000	0.0000	0.0000	0.0000
X4	0.0000	1.0000	0.9756	0.5611	0.5611	0.5611	0.5611
X5	1.0000	0.0522	0.0817	0.0418	0.0552	0.0102	0.0000
X6	1.0000	0.0351	0.1012	0.0484	0.1602	0.0185	0.0000
X7	1.0000	0.0788	0.1137	0.0487	0.0506	0.0000	0.0001
X8	1.0000	0.0572	0.0547	0.0319	0.0751	0.0106	0.0000
X9	1.0000	0.0218	0.0371	0.0117	0.0063	0.0029	0.0000
X10	1.0000	0.0597	0.0202	0.0183	0.0572	0.0000	0.0112
X11	1.0000	0.0510	0.0723	0.0630	0.0809	0.0000	0.0025
X12	1.0000	0.1711	0.3351	0.0119	0.1482	0.0000	0.0100
X13	1.0000	0.0838	0.0168	0.0000	0.0024	0.0005	0.0162

4.2. Entropy Value and Weight of Evaluation Indicators

According to formula (4) (6) (8), the entropy value of the standardized matrix is calculated and the index weight is determined. The results are as follows. See Table 3.

Table 3. Entropy value and weight table of port logistics indicators

index		Entropy value e	Weight w
Cargo throughput (10,000 tons)	X1	0.3553281	0.0897237
Cargo throughput growth rate (%)	X2	0.7987092	0.0280151
Container throughput (10,000 TEU)	X3	0.3277456	0.0935626
Container throughput growth rate (%)	X4	0.9007948	0.0138071
City GDP (100 million yuan)	X5	0.4001148	0.0834904
Added value of primary industry (100 million yuan)	X6	0.4845495	0.0717390
Added value of the secondary industry (100 million yuan)	X7	0.4281574	0.0795875
Total retail sales of consumer goods (100 million yuan)	X8	0.3884181	0.0851183
Total import and export volume (Billion Yuan)	X9	0.1853108	0.1133863
Number of fresh graduates (10,000)	X10	0.3146529	0.0953848
Road freight volume (10,000 tons)	X11	0.4199337	0.0807321
Railway freight volume (10,000 tons)	X12	0.5873243	0.0574351
Waterway freight volume (10,000 tons)	X13	0.2238827	0.1080179

4.3. Relative Proximity and Score Ranking of Evaluation Objects

1) Compute the normalized weighting matrix. Use formula (10) to substitute each indicator matrix calculated by the entropy value method into the original matrix, and perform a weighting operation to obtain the standardized weighted matrix Bij. The data is as follows. See Table 4.

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Table 4. Weighted results of port logistics indicators

	Chongqing Port	Luzhou Port	Yibin Port	Leshan Port	Nanchong Port	Guang'an Port	Guangyuan Port
X1	0.0897	0.0056	0.0039	0.0000	0.0063	0.0013	0.0011
X2	0.0000	0.0112	0.0108	0.0005	0.0280	0.0107	0.0139
X3	0.0936	0.0157	0.0083	0.0000	0.0000	0.0000	0.0000
X4	0.0000	0.0138	0.0135	0.0077	0.0077	0.0077	0.0077
X5	0.0835	0.0044	0.0068	0.0035	0.0046	0.0009	0.0000
X6	0.0717	0.0025	0.0073	0.0035	0.0115	0.0013	0.0000
X7	0.0796	0.0063	0.0090	0.0039	0.0040	0.0000	0.0000
X8	0.0851	0.0049	0.0047	0.0027	0.0064	0.0009	0.0000
X9	0.1134	0.0025	0.0042	0.0013	0.0007	0.0003	0.0000
X10	0.0954	0.0057	0.0019	0.0017	0.0055	0.0000	0.0011
X11	0.0807	0.0041	0.0058	0.0051	0.0065	0.0000	0.0002
X12	0.0574	0.0098	0.0192	0.0007	0.0085	0.0000	0.0006
X13	0.1080	0.0091	0.0018	0.0000	0.0003	0.0001	0.0017

2) To calculate the positive and negative ideal solutions of each indicator, use formula (11) (12). See Table 5.

Table 5. Positive and negative ideal solutions for port logistics indicators

index		Positive ideal solution Z+	Negative ideal solution Z-
Cargo throughput (10,000 tons)	X1	0.0897	0.0000
Cargo throughput growth rate (%)	X2	0.0280	0.0000
Container throughput (10,000 TEU)	X3	0.0936	0.0000
Container throughput growth rate (%)	X4	0.0138	0.0000
City GDP (100 million yuan)	X5	0.0835	0.0000
Added value of primary industry (100 million yuan)	X6	0.0717	0.0000
Added value of the secondary industry (100 million yuan)	X7	0.0796	0.0000
Total retail sales of consumer goods (100 million yuan)	X8	0.0851	0.0000
Total import and export volume (Billion Yuan)	X9	0.1134	0.0000
Number of fresh graduates (10,000)	X10	0.0954	0.0000
Road freight volume (10,000 tons)	X11	0.0807	0.0000
Railway freight volume (10,000 tons)	X12	0.0574	0.0000
Waterway freight volume (10,000 tons)	X13	0.1080	0.0000

3) Calculation of distance and score between evaluation object and positive and negative ideal solutions. See Table 6.

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Table 6. Euclidean distance table between the evaluation object and positive and negative ideal solutions

Evaluation object	D+	D-	Score
Chongqing Port	0.0312	0.2932	0.9038
Luzhou Port	0.2731	0.0303	0.0999
Yibin Port	0.2746	0.0318	0.1039
Leshan Port	0.2883	0.0117	0.0392
Nanchong Port	0.2789	0.0352	0.1121
Guang'an Port	0.2924	0.0134	0.0439
Guangyuan Port	0.2921	0.0161	0.0523

4) The relative proximity of each port and the score of each capability level. Calculate the port scale capacity, city support capacity, collection and distribution capacity and logistics comprehensive capacity according to formula (13) (14) (15), and convert the final score into a 10-point scoring system. See Table 7.

Table 7. Relative proximity and score ranking of each port

Port	Port scale capacity		Port city support capabilities		Port collection and distribution capacity		Comprehensive logistics capabilities		Sort
	S	U	S	U	S	U	S	U	
Chongqing Port	0.8059	10.000	0.9998	10.000	0.9997	10.000	0.9038	10.000	1
Lu Zhou Port	0.1739	2.1582	0.0514	0.5143	0.0946	0.9462	0.0999	1.1050	4
Yi bin Port	0.1379	1.7106	0.0680	0.6800	0.1298	1.2985	0.1039	1.1498	3
Leshan Port	0.0553	0.6859	0.0327	0.3274	0.0345	0.3452	0.0392	0.4333	7
Nan Chong Port	0.1915	2.3766	0.0699	0.6996	0.0714	0.7138	0.1121	1.2404	2
Guangan Port	0.0927	1.1499	0.0084	0.0843	0.0003	0.0035	0.0439	0.4854	6
Guangyuan Port	0.1096	1.3593	0.0049	0.0490	0.0126	0.1262	0.0523	0.5786	5

5. Conclusion

According to the port logistics capability rating table, it is not difficult to conclude that due to its innate location advantages and hinterland economic foundation, Chongqing Port is far superior to the other major ports in Sichuan in terms of scale capability, urban support capability, and collection and distribution capabilities. In order to facilitate comparison, the six major ports in Sichuan were observed after removing Chongqing Port. In terms of port scale and capacity, Nanchong Port, Luzhou Port and Yibin Port rank among the top three. Due to their innate geographical advantages, Luzhou Port and Yibin Port are located on the main line of the Yangtze River, with good channel conditions and strong navigation capabilities. Nanchong Port has been affected by With strong policy support, it is gradually becoming an important gateway to and from the Yangtze River in the northwest and northeastern Sichuan regions; in terms of

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port city support capacity, the top three are Nanchong Port, Yibin Port and Luzhou Port. Yibin has the highest ranking in urban GDP and secondary industry added value. The total import and export volume are higher than the other two ports, but the number of fresh graduates from colleges and universities in the port city is insufficient. Port construction and development require the investment of talents. Subsequent port construction should focus on talent introduction; in terms of port collection and distribution capacity, Yibin Port bears the brunt. , followed by Luzhou Port and Nanchong Port. The port's collection and distribution capacity determines the port's comprehensive service capabilities. Promoting the development of multimodal transport will help expand the port's comprehensive logistics capabilities. Based on the above three aspects of capabilities, the ranking of comprehensive port logistics capabilities from high to low is Chongqing Port, Nanchong Port, Yibin Port, Luzhou Port, Guangyuan Port, Guang'an Port, and Leshan Port.

In recent years, Sichuan has focused on promoting the infrastructure construction of "Four Rivers and Six Ports", striving to build a province with large inland river ports and a strong shipping province in the upper reaches of the Yangtze River and the western region. Inland river ports have achieved rapid development, but there is still a gap between port development and Chongqing Port. gap. Excluding factors such as the economic development of port cities, Sichuan's inland river ports have problems such as insufficient development and unbalanced functional structure. The overall situation is "scattered, small, and weak"[7]. The port facilities and equipment are old, and the degree of mechanization and informatization is On the low side; at the same time, Sichuan Port’s collection and distribution channels have prominent bottlenecks, which are far lower than the collection and distribution capacity of Chongqing Port.

The Yangtze River Channel is the most core east-west axis in terms of land and space development in China and has important strategic value for the entire regional development plan. The golden waterway should be used to promote the further development of the Chengdu-Chongqing Economic Circle, and port logistics should be used to drive the rapid development of the hinterland economy. The key role of Chongqing Port in the entire Yangtze River water transport system should be grasped, and a Chongqing Port should be the leader, with Yibin Port and Luzhou Port as the core, the Chengdu-Chongqing economic circle water transport port system supplemented by Nanchong Port, Guangyuan Port, Guang'an Port and Leshan Port.

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