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Analysis of Competitiveness of Dry Port based on AHP Multi-layer Fuzzy Comprehensive Evaluation

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Abstract

As the construction of dry ports is getting faster, It is crucial to develop a dry port in accordance with local conditions, and maximize competitiveness issue at present. Therefore, the evaluation of the competitiveness of the dry port is becoming more and more important. This paper adopts analytic hierarchy process and multi-level fuzzy comprehensive evaluation method, select typical dry port for comprehensive evaluation of competitiveness, establish a sound evaluation index system, and verify by comparison with the actual construction of the dry port.

Keywords

Dry port; Analytic Hierarchy Process; Fuzzy comprehensive evaluation.

1. INTRODUCTION

In recent years, with the continuous development of international trade, the process of globalization has intensified, and international multimodal transport has been in full swing. There is no doubt that the ocean is the main battlefield for container transportation, but the inland areas are gradually promoting the development of transportation. Especially after the "One Belt, One Road" strategic concept is put forward, China's dry port construction has shown a rapid development trend. In order to obtain a vast hinterland and a steady supply of goods, the competitiveness of the dry port is particularly critical [1].

The construction of a dry port is a long-term and systematic project that requires the cooperation of the government, customs, ports and other parties, as well as huge human and material resources and capital costs. The study of inland dry ports is conducive to the control of costs and risks, and is also of great significance to the operation and development of dry ports after completion.

This paper analyzes the competitiveness of the dry port by adopting a combination of qualitative and quantitative analysis, establishing a suitable comprehensive evaluation system, making recommendations on the development of dry ports from a macro perspective, and also analyzing the dry ports from the microscopic level. Advantages and disadvantages, providing advice for future development and planning.

2. EVALUATION INDEX SYSTEM CONSTRUCTION

2.1. Description of the Problem

Firstly, the internal and external environmental factors and the advantages and disadvantages of competition in the development of dry ports are qualitatively analyzed in general, and the competitiveness of the dry ports is roughly defined, which will lay the foundation for the quantitative analysis of the dry ports and the corresponding development

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strategies. Due to the common development of inland dry ports, SWOT analysis methods are used in qualitative analysis to discuss the advantages, disadvantages, opportunities and threats in the development and operation of dry ports. Then, the fuzzy comprehensive evaluation method is used to quantitatively analyze the competitiveness of each dry port, and the comprehensive performance of typical inland dry ports in China under the comprehensive evaluation system is determined. Through the evaluation results, suggestions and countermeasures for the future development of dry ports are proposed. Further promote the development of dry port from macro to micro, from extensive to meticulous development.

2.2. SWOT Analysis

China is currently at a stage of rapid development of foreign trade, and the momentum of construction and development of dry ports has increased. At this stage, the construction of China's dry ports should focus on quality and scale, and seek greater development on the basis of existing ports.

First, using the SWOT model to qualitatively clarify the competitiveness of each dry port, the advantages and disadvantages, opportunities and threats faced by China's dry port construction and development are shown in Figure 1.

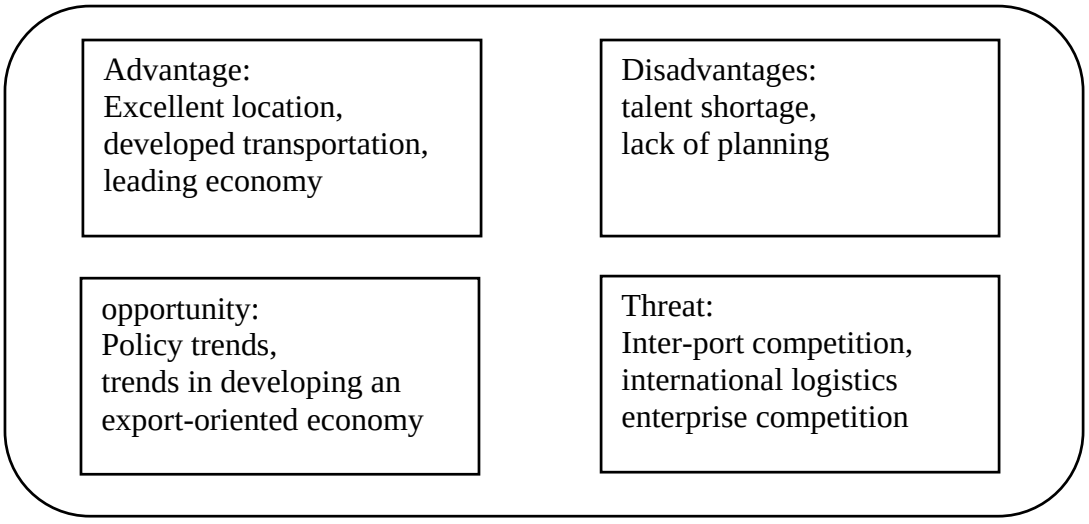

Figure 1. SWOT analysis of the development of China's dry port construction

(1) Advantage analysis

First of all, location and transportation are the most obvious advantages of inland dry ports. When selecting a site in a dry port, it is sure to choose a city with a superior geographical position and a sound transportation system. It can not only utilize the existing traffic advantages, but also further strengthen the role of urban transportation hubs on this basis to avoid Repeat construction to save resources. Secondly, the economic advantage is similar to the transportation advantage. When the dry port is established, the economically developed city can be selected to further strengthen the city's economic construction and promote the development of the surrounding area. In addition, since many dry ports are located inland and away from the coastal areas, it is difficult to enjoy the benefits of international trade for urban development, but the enormous resources of inland cities cannot be ignored, with the continuous deepening of multimodal transport and Development, inland dry ports will gradually play a huge role in international trade.

(2) Disadvantage analysis

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The process of construction, development and growth of a port requires many years of efforts to carry out the overall strategic planning. It needs to be constantly updated and built, and it is constantly improved from all aspects. However, the development history of China's dry ports is relatively short, so the problem of insufficient hardware facilities construction is more obvious. At present, the construction of many dry ports is relatively backward, and there is not yet a well-developed and mature land inland dry port. In addition, the lack of overall planning is also a short-term development of the current dry port, and the overall operation of the dry port has not yet formed a standardized system, which has not effectively promoted the development of surrounding areas.

The shortage of talent is also one of the difficulties faced by the construction of dry ports. Due to the short time for the construction of dry ports in China, the understanding of dry ports is not deep enough. Most of the relevant professionals have chosen the work of coastal ports, thus causing a shortage of talents in dry ports.

In addition, after years of exploration, the mature coastal ports have formed a set of information management systems suitable for China's coastal ports. However, due to the short development time of inland dry ports, the information management system is still in the primary stage of exploration and improvement. There is still a lot of room for construction.

(3) Opportunity analysis

Undoubtedly, the rapid development of the dry port at this stage is benefited from the support of the state and the preferential policies of the local government, which makes the inland dry port take this opportunity to develop rapidly. The dry port is deeply inland and away from international ports. It is inconvenient to conduct business with other countries and limit the speed of economic development. The construction of a convenient and fast international trade channel has always been a difficult development and an urgent hope for inland cities. With the implementation of various national strategies, some industries have also shifted from the eastern coastal areas to the central and western regions.

The development of inland dry ports is also inextricably linked to the support of coastal ports. Many coastal ports face problems such as insufficient space and traffic congestion. In order to better develop their own, they choose to establish a dry port in the inland areas, expand the economic hinterland, and attract more inland sources.

(4) Threat analysis

The most important threat to the development of China's inland dry ports is the increasingly fierce competition between the various dry ports. In order to compete for supply, the dry ports of various cities will establish dry ports in urban areas. This phenomenon of easy formation of dry ports will lead to fierce competition in the dry ports due to limited resources and economic hinterland.

In addition, with the development of China's economy, it has also attracted many international logistics companies to enter. Due to the strength of international logistics enterprises, advanced equipment, leading technology, and strong competitiveness, it has more advantages than domestic logistics companies, which brings greater competition and challenges to the development of inland dry ports.

2.3. Evaluation Model

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There are many factors affecting the development of dry ports, and the relationship between the value of each factor and its interaction is also uncertain. Therefore, the analytic hierarchy process and fuzzy comprehensive evaluation are used to evaluate the competitiveness of dry ports. Firstly, the analytic hierarchy process is used to determine the weight of the evaluation

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index, and then the fuzzy comprehensive evaluation method is used to establish the evaluation model to enhance the objectivity and credibility.

On the basis of comprehensive consideration of the overall factors affecting the competitiveness of dry ports and the necessary conditions for successful dry ports, an indicator evaluation system has been established, including qualitative and quantitative indicators. The specific indicators are shown in Table 1 [2].

Table 1. Index system for the assessment of the competitiveness of dry ports

	Primary indicator	Secondary indicators	Quantitative indicator
Water Freeport Competitiveness Index System A	Economic factor B1	Development status C1	x_1 GDP
		Industrial level C2	x_2 Industrial output
		Business level C3	x_3 Retail sales of social consumer goods
		Foreign trade level C4	x_4 Total value of imports and exports
	Traffic factor B2	Traffic demand C5	x_5 Total freight
		Traffic volume C6	x_6 Traffic congestion
	Policy factor B3	Policy advantage C7	x_7 Policy orientation

3. MODEL CALCULATION AND SOLUTION

3.1. Analytic Hierarchy Process to Determine Indicator Weights

In order to enhance the objectivity of the evaluation, factors between different levels should be compared in pairs to construct a judgment matrix.

Judgment matrix: $A=\begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ a_{n1} & a_{n2} & \cdots & a_{nn} \end{bmatrix}$, $a_{ij}=1,2,\ldots,n$

The elements of the judgment matrix a_{ij} are given by the 1-9 scale method [3].

Table 2. The elements of the judgment matrix A

Competitiveness A	Economic factor B1	Economic factor B1	Economic factor B1	Economic factor B1
Economic factor B1	1	3	1	0.4434
Traffic factor B2	1/3	1	1/2	0.1692
Policy factor B3	1	2	1	0.3874

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Table 3. The elements of the judgment matrix B1

Economic factor B1	Development status C1	Development status C1	Development status C1	Development status C1	Development status C1
Development status C1	1	2	3	2	0.4231
Industrial level C2	1/2	1	1/3	1/2	0.1222
Business level C3	1/3	3	1	1	0.2274
Foreign trade level C4	1/2	2	1	1	0.2274

Table 4. The elements of the judgment matrix B2

Traffic factor B2	Traffic demand C5	Traffic demand C5	Traffic demand C5
Traffic demand C5	1	1	0.5
Traffic volume C6	1	1	0.5

Calculate the relative weights of the various factors in the judgment matrix and perform a consistency test.

Table 5. The relative weights of the various factors in the judgment matrix

Order	3	4	5	6	7	8	9
RI	0.58	0.90	1.12	1.24	1.32	1.41	1.45

$$MW_1=\begin{bmatrix}1 & 3 & 1\\ 1/3 & 1 & 1/2\\ 1 & 2 & 1\end{bmatrix}\begin{bmatrix}0.4434\\ 0.1692\\ 0.3874\end{bmatrix}=\begin{bmatrix}1.3384\\ 0.5107\\ 1.1692\end{bmatrix},\quad \lambda_{1\max}=\frac{1}{3}\left[\frac{1.3384}{0.4434}+\frac{0.5107}{0.1692}+\frac{1.1692}{0.3874}\right]=3.0183,$$

$$CI_1=\frac{3.0183-3}{3-1}=0.00915\quad CR_1=\frac{0.00915}{0.58}=0.0158<0.1,$$

$$MW_2=\begin{bmatrix}1 & 2 & 3 & 2\\ 1/2 & 1 & 1/3 & 1/2\\ 1/3 & 3 & 1 & 1\\ 1/2 & 2 & 1 & 1\end{bmatrix}\begin{bmatrix}0.4231\\ 0.1222\\ 0.2274\\ 0.2274\end{bmatrix}=\begin{bmatrix}1.8045\\ 0.5233\\ 0.9624\\ 0.9108\end{bmatrix}\quad \lambda_{2\max}=\frac{1}{4}\left[\frac{1.8045}{0.4231}+\frac{0.5233}{0.1222}+\frac{0.9624}{0.2274}+\frac{0.9108}{0.2274}\right]=4.1962$$

$$CI_2=\frac{4.1962-4}{4-1}=0.065\quad CR_2=\frac{0.065}{0.90}=0.072<0.01,$$

$$MW_3=\begin{bmatrix}1 & 1\\ 1 & 1\end{bmatrix}\begin{bmatrix}0.5\\ 0.5\end{bmatrix}=\begin{bmatrix}1\\ 1\end{bmatrix},\quad \lambda_{3\max}=\frac{1}{2}\left[\frac{1}{0.5}+\frac{1}{0.5}\right]=1,\quad CI_3=0,\quad CR_3=0$$

The consistency test is passed, that is, the weight coefficient is allocated reasonably and can be used as the result of the index weight.

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3.2. Application of Fuzzy Comprehensive Evaluation

Set the comment collection as $V = \{v_1(\text{excellent}), v_2(\text{good}), v_3(\text{general}), v_4(\text{Poor}), v_5(\text{difference})\}$. For the determination of the membership degree of the indicator, the method of fuzzy statistics can be used. Experts and relevant practitioners are invited to score the evaluation indicators of each object, and the corresponding membership degree is obtained by frequency.

Table 6. The score of the evaluation indicators

Index	Rating description	Xi'an		Zhengzhou	
		Frequency	Membership	Frequency	Membership
Development status	excellent	2	0.2	3	0.3
	good	4	0.4	3	0.3
	general	3	0.3	3	0.3
	Poor	1	0.1	1	0.1
	difference	0	0	0	0
Industrial level	excellent	5	0.5	2	0.2
	good	3	0.3	2	0.2
	general	1	0.1	3	0.3
	Poor	1	0.1	2	0.2
	difference	0	0	1	0.1
Business level	excellent	1	0.1	1	0.1
	good	3	0.3	2	0.2
	general	4	0.4	4	0.4
	Poor	2	0.2	2	0.2
	difference	0	0	1	0.1
Foreign trade level	excellent	1	0.1	2	0.2
	good	3	0.3	4	0.4
	general	5	0.5	3	0.3
	Poor	1	0.1	1	0.1
	difference	0	0	0	0
Index	Rating description	Chengdu		Jinan	
		Frequency	Membership	Frequency	Membership
Development status	excellent	4	0.4	1	0.1
	good	3	0.3	4	0.4
	general	2	0.2	2	0.2
	Poor	1	0.1	2	0.2
	difference	0	0	1	0.1
Industrial level	excellent	2	0.2	2	0.2
	good	3	0.3	2	0.2
	general	3	0.3	3	0.3
	Poor	1	0.1	3	0.3
	difference	1	0.1	0	0
Business level	excellent	2	0.2	2	0.2
	good	3	0.3	3	0.3
	general	3	0.3	4	0.4
	Poor	2	0.2	1	0.1
	difference	0	0	0	0
Foreign trade level	excellent	3	0.3	3	0.3
	good	4	0.4	3	0.3
	general	3	0.3	3	0.3
	Poor	0	0	1	0.1
	difference	0	0	0	0

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Table 7. The score of the evaluation indicators

Index	Rating description	Xi'an		Zhengzhou	
		Frequency	Membership	Frequency	Membership
Traffic demand	excellent	2	0.2	3	0.3
	good	4	0.4	3	0.3
	general	2	0.2	2	0.2
	Poor	1	0.1	2	0.2
	difference	1	0.1	0	0
Traffic	excellent	3	0.3	1	0.1
	good	2	0.2	3	0.3
	general	3	0.3	4	0.4
	Poor	2	0.2	1	0.1
	difference	0	0	1	0.1
Index	Rating description	Chengdu		Jinan	
		Frequency	Membership	Frequency	Membership
Traffic demand	excellent	3	0.3	3	0.3
	good	4	0.4	4	0.4
	general	2	0.2	2	0.2
	Poor	1	0.1	1	0.1
	difference	0	0	0	0
Traffic	excellent	3	0.3	3	0.3
	good	4	0.4	4	0.4
	general	1	0.1	1	0.1
	Poor	1	0.1	1	0.1
	difference	1	0.1	1	0.1

Table 8. The score of the evaluation indicators

Index	Rating description	Xi'an		Zhengzhou	
		Frequency	Membership	Frequency	Membership
political advantage	excellent	5	0.5	2	0.2
	good	3	0.3	3	0.3
	general	2	0.2	3	0.3
	Poor	0	0	1	0.1
	difference	0	0	1	0.1
Index	Rating description	Chengdu		Jinan	
		Frequency	Membership	Frequency	Membership
political advantage	excellent	3	0.3	3	0.3
	good	3	0.3	3	0.3
	general	3	0.3	3	0.3
	Poor	1	0.1	1	0.1
	difference	0	0	0	0

For the four cities of Xi'an, Zhengzhou, Chengdu and Jinan, the subsequent steps are completely consistent. Therefore, Xi'an is taken as an example for detailed calculation. Therefore, Xi'an's primary indicator evaluation matrix is as follows:

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$$R_1 = \begin{bmatrix} 0.2 & 0.4 & 0.3 & 0.1 & 0 \\ 0.5 & 0.3 & 0.1 & 0.1 & 0 \\ 0.1 & 0.3 & 0.4 & 0.2 & 0 \\ 0.1 & 0.3 & 0.5 & 0.1 & 0 \end{bmatrix}$$

$$R_2 = \begin{bmatrix} 0.2 & 0.4 & 0.2 & 0.1 & 0.1 \\ 0.3 & 0.2 & 0.3 & 0.2 & 0 \end{bmatrix}$$

$$R_3 = \begin{bmatrix} 0.5 & 0.3 & 0.2 & 0 & 0 \end{bmatrix}$$

The evaluation index system of this paper is a secondary evaluation index system, so it is divided into two steps in the calculation.

$$B_1 = W_1 \bullet R_1 = \begin{bmatrix} 0.4231 & 0.1222 & 0.2274 & 0.2274 \end{bmatrix} \bullet \begin{bmatrix} 0.2 & 0.4 & 0.3 & 0.1 & 0 \\ 0.5 & 0.3 & 0.1 & 0.1 & 0 \\ 0.1 & 0.3 & 0.4 & 0.2 & 0 \\ 0.1 & 0.3 & 0.5 & 0.1 & 0 \end{bmatrix}$$

$$= \begin{bmatrix} 0.1912 & 0.3423 & 0.3428 & 0.1228 & 0 \end{bmatrix}$$

$$B_2 = W_2 \bullet R_2 = \begin{bmatrix} 0.5 & 0.5 \end{bmatrix} \bullet \begin{bmatrix} 0.2 & 0.4 & 0.2 & 0.1 & 0.1 \\ 0.3 & 0.2 & 0.3 & 0.2 & 0 \end{bmatrix} = \begin{bmatrix} 0.25 & 0.3 & 0.25 & 0.15 & 0.05 \end{bmatrix}$$

$$B_3 = W_3 \bullet R_3 = \begin{bmatrix} 1 \end{bmatrix} \bullet \begin{bmatrix} 0.5 & 0.3 & 0.2 & 0 & 0 \end{bmatrix} = \begin{bmatrix} 0.5 & 0.3 & 0.2 & 0 & 0 \end{bmatrix}$$

$$B = \begin{bmatrix} B_1 \\ B_2 \\ B_3 \end{bmatrix} = \begin{bmatrix} 0.1912 & 0.3423 & 0.3428 & 0.1228 & 0 \\ 0.25 & 0.3 & 0.25 & 0.15 & 0.05 \\ 0.5 & 0.3 & 0.3 & 0 & 0 \end{bmatrix}$$

Then, a secondary evaluation is performed to obtain a membership vector of the overall evaluation target to the comment set.

$$Y_1 = W_1 \bullet B_1 = \begin{bmatrix} 0.4434 & 0.1692 & 0.3874 \end{bmatrix} \bullet \begin{bmatrix} 0.1912 & 0.3423 & 0.3428 & 0.1228 & 0 \\ 0.25 & 0.3 & 0.25 & 0.15 & 0.05 \\ 0.5 & 0.3 & 0.3 & 0 & 0 \end{bmatrix}$$

$$= \begin{bmatrix} 0.3208 & 0.3188 & 0.3105 & 0.0798 & 0.0085 \end{bmatrix}$$

The same is available:

$$Y_2 = \begin{bmatrix} 0.2087 & 0.2943 & 0.3101 & 0.1240 & 0.0627 \end{bmatrix}$$

$$Y_3 = \begin{bmatrix} 0.3033 & 0.3240 & 0.2559 & 0.1000 & 0.0139 \end{bmatrix}$$

$$Y_3 = \begin{bmatrix} 0.1805 & 0.3301 & 0.2805 & 0.1668 & 0.0423 \end{bmatrix}$$

The above is the evaluation result of the competitiveness of typical inland dry ports in China through the integrated method of analytic hierarchy process and fuzzy comprehensive evaluation.

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3.3. Evaluation Result and Analysis

According to the obtained competitiveness evaluation result (subordinate vector), the score of the competitiveness of each evaluation object can be obtained by comparison with the comment set. Taking Xi'an dry port as an example, the competitiveness belongs to the excellent result accounted for 32.08%, the competitiveness belongs to the good result accounted for 31.88%, the competitiveness belongs to the general result accounted for 31.05%, and the competitiveness belongs to the poor result. 7.98%, the result of competitive subordination is 0.85%.

To make a horizontal comparison of different dry ports, it is necessary to assign a comment set to make the vague comments specific. When creating a comment set, the interval corresponding to "excellent" is that the interval corresponding to "good" is that the interval corresponding to "general" is, the interval corresponding to "poor" is, and the interval corresponding to "difference" is. Therefore, take the median value of each interval as the corresponding value of the comment, that is, "excellent" is 95, "good" is 85, "general" is 72.5, "poor" is 57.5, "poor" is 25, and the score matrix is obtained. . The comprehensive competitiveness score of Xi'an dry port is as follows:

$$V_1 = Y_1 \bullet M^T = \begin{bmatrix} 0.3208 & 0.3188 & 0.3105 & 0.0789 & 0.0085 \end{bmatrix} \bullet \begin{bmatrix} 95 \\ 85 \\ 72.5 \\ 57.5 \\ 25 \end{bmatrix} = 84.83$$

Similarly, the comprehensive score of Zhengzhou dry port is 76.02, the comprehensive score of Chengdu's dry port is 81.00, and the comprehensive score of Jinan dry port is 76.19.

Combined with the qualitative analysis of the previous article, the four typical dry ports selected in this paper are at the critical stage of construction and development, and they are in a leading position in many domestic dry ports, and each has advantages in different aspects. According to the evaluation results, the construction and operation of Xi'an and Chengdu dry ports are better and have stronger competitiveness.

4. CONCLUSION

This paper uses the combined model of AHP and Fuzzy integration to establish a dry port competitiveness evaluation system. The application analysis of the example shows that the evaluation of the competitiveness of the model for the dry port is scientific and reasonable. The evaluation system constructed in this paper quantifies the influencing factors of all aspects of the construction of the dry port, and analyzes the waterless from the qualitative and quantitative perspectives. The comprehensive competitiveness of the port provides certain reference and guidance for the construction, operation and development of the dry port.

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