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Original article

Cooperation Performance Evaluation between Seaport and Dry Port; Case of Qingdao Port and Xi'an Port*

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Abstract

Along with the drastic competition among ports, the strive for the vast economic hinterland and the supply of goods have become strategic problems for port operators. At the same time, port enterprises are paying more and more attention to the construction of dry ports. This article establishes the port cooperation performance evaluation index based on the balanced score card method and uses the grey relational degree method to evaluate the cooperation performance between seaports and dry ports. Finally using Qingdao port and Xi'an port as an example, and Zhengzhou port and Lanzhou port as benchmarks, the application of this evaluation method is introduced in detail. The conclusion reveals that cooperation between Qingdao port and Xi`an port has deficiencies in customer satisfaction, financial cooperation and non-market tools. Alongside this, the author proposes related issues about information management in the supply chain, competition position and the scope of hinterland. This article, combined with the related theory of supply chain and performance evaluation, puts forward a set of relatively complete cooperation performance evaluations between seaports and dry ports, which provide scientific theory support for better cooperation.

Keywords: Seaport, dry port, cooperation performance, balanced score card, grey relational degree.

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I. Introduction

Recently, China's economy has developed rapidly, as well as its regional ports. With ports continuously strengthening their own construction and their cargo capacity increasing year by year, the competition between bordering seaports increases at the same time. The strive for the vast economic hinterland and the supply of goods has become a strategic problem for port operators. In addition, it has become an inevitable requirement for regional development for the inland areas to establish a low-cost and high-efficient transportation and customs clearance way. With the compulsion of these two demands, combined with the active participation of railway and highway transportation departments, the development of dry ports in China are taking shape.

Dry port is also known as inland port or land port. This concept derives from the United States. In recent years, the construction of domestic and international dry ports has made rapid headway . Relevant research includes the development and operation mode of dry port, as well as the actual development situation, etc.

With regard to foreign research on the development mode of dry port, Jean (2000) focuses on the history of its development, Violeta (2009) pays attention to the environmental impact, and Wothnius (2010) attaches importance to the efficient shipping of goods. In China, Lv (2007) classifies the patterns of existing dry ports combined with their developments. He summarizes the characteristics and operations of each mode. Because of the strong practical and realistic significance of dry port construction and development, most foreign scholars have been concerned about applying the construction theory of dry port into practice in recent years. Andrius and Aidas (2007) have put forward some measures to improve the operation management of dry port, to encourage more people to participate in its construction and development. . Wang (2008), Yang (2009) and Fan (2010) researched the construction, and development prospects some of the dry ports of China. They aim to guide the construction and development of dry port scientifically by doing theoretical research

From this research, we found that scholars pay more attention to the definition; roles, functions and operation modes of dry port, but research ventures based on on the cooperation between dry port and seaport by way of comparison are relatively few in number In the meanwhile, the development of dry port in China still has many problems. Therefore, this article will put forward a set of relatively complete cooperation performance evaluations between seaports and dry ports combined with the related theory of supply chain and performance evaluation.

II. Theoretical Basis

Dry port, just as its name implies, is a concept we can contrast with "water port". This term originated from western countries in the twentieth century and in 1991. the Council of Europe defined dry port as: a landlocked station which is connected to the seaport directly and geographically (Zou, 2009). But in Germany, dry port is usually referred to as inland cargo village. In China, Xi (2000) first introduced the concept of dry port .

But as research continues, dry port is endowed with more functions and significance. Combining related research both at home and abroad on dry port and its development features, and on the trends seen in seaports and dry ports in China, this article defines dry port as the following: Dry port is the transport station which relies on information technology and multimodal transport theories, established in an inland area and is connected with a seaport for goods transportation. Its main functions include cargo terminal services, customs clearance, inspection and quarantine and other logistics channel and platform facilities.

With the rapid development of the Chinese economy, coastal cities tend to consider a seaport as a boost to its local economy, and the competition among seaports has become increasingly competitive. Throughput has become a motivation for each port to become bigger and stronger. Where there is a supply of goods, there is competition among seaports. In addition, under the strategies of "Western Development" and "Central Rise" in China, these two regions have not only seen rapid development in their economies, but also a more hierarchical division of labor and industrial relocation (Liu, 2008). Thus, the seaport's freight hinterlands have to transfer to the central and western of China. Integrated for all sorts of reasons, we summarize the motivation for seaports constructing dry ports into three points: (1) a dry port enhances seaports' competitiveness (2) they resolve the contradiction between the rapid development and insufficient supply of goods, (3)tbey help to achiev a seamless connection between goings on of dry ports and seaports.

III. Research Methods

3.1. Indicator System

This article puts the cooperation between seaports and dry ports into the thoughts of supply chain management, in which seaports are thecore area of business. Considering the strategic position of ports in China, as well as the smooth operation of supply chains which rely on the dry port's facilities, this article, based on the balanced score card method, establishes a cooperation performance evaluation system. It mainly consists of four aspects: customer satisfaction, finance, cooperative relations and non-market tools. On the basis of the above factors, this article builds the following index system for further analysis of cooperation between dry and sea ports.

According to the 4 first-class indicators selected above, this article builds a cooperation performance evaluation index system and selects 12 main second-class indicators. See table 1.

Table 1: Performance Evaluation Indicator System of Cooperation between Seaport and Dry Port

First-class	Second-class	Indicators
Customer satisfaction	Market share	The ratio of fright provided by port logistics services to all freight volume in the area (%)
	Customer satisfaction	The value-added of the tertiary industry (hundred million yuan)
		The growth rate of value-added of the tertiary industry (%)
	Generalized transport costs	The ratio of the sum of dry port-Qingdao port transport costs and non-monetary costs to the sum of dry port-Tianjin Port's (%)
	Passing time	Clearance time in existing dry port (hours)
Finance	Trends in import and export	Volume growth of import and export (thousand dollars)
		The rate of volume growth of import and export (%)
Cooperative relations	Customs clearance and quarantine	Grade cooperation performance of customs clearance and quarantine
	Transport	Number of dedicated railway freight line (article)
	Information sharing	Grade accuracy and timeliness of information sharing
	Bilateral cooperation degree	Grade different intents of cooperation and agreements signed
Non-market tools	Volume of regional transport	Volume of cargo transport in the whole society (ten thousand tons)
	Regional policies and measures	Number of related promotional policies (article)
	Facilities and equipments	Total investments in fixed assets in the whole society (hundred million Yuan)

3.2. Selecting the Benchmark

Benchmarking is a process like this: first, select a representative enterprise in a certain industry, and then compare the research subject with the selected enterprise in several aspects (such as manufacturing, customer, distribution, management). At the same time, sum up why the performance of the selected enterprise is better and where their advantages lie. On the basis of this, we can find the shortcomings in the research subject, learn from the base enterprise and put forward an optimal improvement scheme. Repeating this comparative method will help enterprises to solve their business problems. Generally speaking, the main criterion for benchmarking is as follows: firstly, benchmarks should be enterprises with the best performance in the industry; secondly, benchmarks should be selected among competitors in the same industry and enterprises with similar functions and management.

3.3. Calculation Methods

This article applies a grey relational degree method to analyze the data collected, and calculates R value in accordance with the following model: R=E*W.

In the formula: $R = \begin{bmatrix} r_1 & r_2 & \cdots & r_m \end{bmatrix}^T$ is a vector of the whole-appraise result of m evaluated objects;

$W = \begin{bmatrix} w_1 & w_2 & \cdots & w_n \end{bmatrix}^T$ is a vector of weight distribution of n evaluation indicators, and $\sum_{j=1}^{n} w_j = 1$. In this article, analytic hierarchy process will be used to determine the weight of each index.

E is a judgment matrix of indicators:

$$E = \begin{bmatrix} \xi_1(1) & \xi_1(2) & \cdots & \xi_1(n) \\ \xi_2(1) & \xi_2(2) & \cdots & \xi_2(n) \\ \vdots & \vdots & & \vdots \\ \xi_m(1) & \xi_m(2) & \cdots & \xi_m(n) \end{bmatrix}$$

$\xi_i(k)$ is the correlation coefficient of the kth indicator and the kth optimum indicator in the programme i.

3.3.1. Calculating W

This paper applies the analytic hierarchy process. Comparing the elements in each layer one by one, and by relatively constructing the judgment matrix. Relative indicators can be weighted on the scale of 1, 2, ..., 9 and their reciprocals used as a scale. The judgment values used in this article are primarily based on a comprehensive balance of research data and expert opinions. Then calculating the judgment matrix's characteristic value and the characteristic vector, and drawing the maximum eigenvalue λ. However, due to the influence of various factors, it is difficult for the judgment matrix to achieve consistency. Therefore, it's still essential to do judgment matrix consistency checking. Define consistency index CI= (λ-n)/ (n-1). If CI=0, the consistency of the judgment matrix is completely satisfied. Larger CI, less consistency satisfied and then let CR=CI/RI, and RI is the mean random consistency index. If CR<0.1, the judgment matrix is consistent.

3.3.2. Calculating E

Due to too many indicators selected in the evaluation system and their different orders of magnitude and dimension, we cannot run a comparative analysis directly. Thus we need to standardize the raw data in order to turn it into dimensionless values. After that, define $\{C^*\} = [C_1^*, C_2^*, \cdots, C_n^*]$ as reference series and $\{C\} = [C_1^i, C_2^i, \cdots, C_n^i]$ as compared data, combining with the grey relational degree theory, and then we can find the correlation coefficient of programme i by using correlation analysis, namely:

$$\xi_i(k)=\frac{\min_i\min_k\left|C_k^*-C_k^i\right|+\rho\max_i\max_k\left|C_k^*-C_k^i\right|}{\left|C_k^*-C_k^i\right|+\rho\max_i\max_k\left|C_k^*-C_k^i\right|},\ \rho\in[0,1] \quad \text{------- (formula 1)}$$

3.3.3. Calculating R

Knowing $\xi_i(k)$, we can get the value of E. Therefore, we can also get whole-appraise result: R=E*W, namely, $r_i=\sum_{k=1}^{n}W(k)\times\xi_i(k)$.

If the calculated correlation r_i is the largest, the i is the optimal scheme.

IV. Examples

In recent years, with regard to the development of ports, the ports around Tianjin Port and Dalian port have been the most powerful competitors for Qingdao port. Fighting for the supply of more goods and developing inland hinterlands have become a major objective of Qingdao port's future development. Up to now, Qingdao port has established 16 offices in many dry ports in China, including Zhengzhou, Xi'an, Taiyuan, Lanzhou and Xinjiang, etc. To learn more about the cooperation situation between Qingdao port and its dry ports, this article selects Xi'an dry port as research subject and carries out a case study. Its calculation is as follows:

4.1. Select the Benchmark Dry Port

This article focuses on Lanzhou dry port and Zhengzhou dry port which are in close cooperation with Qingdao port as benchmark dry ports. For following reasons: (1) compared with Xi ' an dry port, Lanzhou dry port and Zhengzhou dry port have similar construction modes---- both invested in by the cities which they are in. In the meantime, for the owners of cargo in these three cities, Qingdao port is their key port for export, and the research background is similar too; (2) for Zhengzhou dry port and Lanzhou dry port, their construction, as well as their cooperation with Qingdao port both began early and their operation system and cooperation mode with the seaport has taken shape which is worth learning about; (3) although the cooperation between these three dry ports and Qingdao port has many similarities, their respective advantages differ in areas such as customer relationship management, financial management, cooperation management and non-market conditions, etc. It's worth finding out the shortcomings existing in cooperation between Xi'an dry port and Qingdao port. Hence, in this article, we select the cooperation modes of Lanzhou dry port and Zhengzhou dry port as the benchmarks to evaluate the cooperation performance between Xi'an dry port and Qingdao port.

4.2. Select the Benchmark Dry Port

Based on the performance evaluation indicator system of cooperation between the seaport and dry port mentioned above, the evaluation indicators and data are collected and preliminary calculations carried out. The data is shown in table 2. At the same time, optimal data for each indicator is selected as the optimal value, providing the basis for grey relational degree analysis in the following text.

Table 2: the Data of Performance Evaluation Indicators of Cooperation between Ports and Dry Ports

Port city	Xi'an	Zhengzhou	Lanzhou	Optimal values
Market share (%)	40	60	33	60
The value-added of the tertiary industry (hundred million yuan)	1,993.91	1,882.60	663.48	1,993.91
The growth rate of value-added of the tertiary industry (%)	12.1	8.5	14.3	14.3
Generalized cost (%)	1.000	0.825	0.923	1.000
Passing time (hours)	4.5	1	3	1
Volume growth of import and export (thousand dollars)	30,634,206	35,858,350	3,291,000	35,858,350
The rate of volume growth of import and export (%)	99.22	123.80	100.38	123.80
Customs clearance and quarantine(qualitative)	8	7	5	8
Number of dedicated railway freight line (article)	3	4	1	4
Information sharing (qualitative)	7	7	5	7
Bilateral cooperation degree(qualitative)	6	9	4	9
Volume of cargo transport in the whole society(ten thousand tons)	65,888	227,873	35,367	227,873
Number of related promotional policies (article)	3	3	4	4
Total investments in fixed assets (hundred million Yuan)	3,141	2,900	951	3,141

4.3. Weighting by Analytic Hierarchy Process

According to table1, integrating the performance evaluation indicators of the cooperation between seaports and dry ports, and considering each indicator's characteristics and expert's advice, this article weighs the evaluation indicators through an analytic hierarchy process. Based on the performance evaluation system of cooperation between sea ports and dry ports, we compare the elements in each layer one by one, and relatively construct the judgment matrix. Relative indicators can be weighed using the scale of 1, 2, ..., 9 and their reciprocals are used as a scale. Judgment values used in this article are primarily based on a comprehensive balance of research data and expert opinions. Judgment values are shown from table 3 to table 7:

Table 3: Judgment Matrix A-B

A	B1	B2	B3	B4	W
B1	1	1	1	1	0.25
B2	1	1	1	1	0.25
B3	1	1	1	1	0.25
B4	1	1	1	1	0.25

$\lambda=4.01; CI=0.003459; CR=0.003843<0.1$

Table 4: Judgment Matrix B1-C

B1	C1	C2	C3	C4	C5	W
C1	1	3	2	4	4	0.410
C2	1/3	1	1/2	2	2	0.157
C3	1/2	2	1	2	2	0.222
C4	1/4	1/2	1/2	1	2	0.115
C5	1/4	1/2	1/2	1/2	1	0.096

$\lambda=5.115; CI=0.0287; CR=0.0256<0.1$

Table 5: Judgment Matrix B2-C

B2	C5	C6	W
C5	1	1/2	0.667
C6	2	1	0.333

$\lambda=2; CI=0; CR<0.1$

Table 6: Judgment Matrix B2-C

B2	C5	C6	C7	C8	W
C5	1	1	2	4	0.456
C6	1	1	2	3	0.221
C7	1/2	1/2	1	2	0.202
C8	1/4	1/3	1/2	1	0.121

$\lambda=4.05; CI=0.015265; CR=0.016961<0.1$

Table 7: Judgment Matrix B4-C

B3	C14	C15	C16	W
C14	1	2	2	0.490
C15	1/2	1	2	0.311
C16	1/2	1/2	1	0.199

$\lambda=3.05$; CI=0.026871; CR=0.046329<0.1

The matrix above all passed consistency testing, and the weight of each element was also obtained.

4.4. Calculating the Grey Correlation Degree

Once grey relational coefficients and weights of indicators are determined, we can do a single-layer grey management degree evaluation on grass-root indicators respectively, such as on customer satisfaction, finance, cooperative relations and non-market tools. Then do a single-hierarchy grey relational degree to the indicators that follow the first-class indicators, and regard evaluation results as raw data of each first-class indicator. This raw data can be defined as R_i, a component that may influence the performance of the cooperation between sea portsand dry ports. Namely, those judgment results are based on the performance index of cooperation between sea ports and dry port.

After calculating of grey relational degree, we get a performance index of cooperation between seasports and dry ports: customer satisfaction index (R_1): (0.9997, 1.0000, 0.8077); financial index (R_2): (0.9896, 1.0000, 0.5553); cooperative relations index (R_3): (0.8309, 0.8023, 0.7064), non-market tools index (R_4): (0.8667, 0.9881, 0.9115).

4.5. Determining the Grey Relational Degree of Dry Ports

According to R=W*E, we will do the final single-layer evaluation using the four components of cooperation performance evaluation: This article evaluates the cooperation performance of Qingdao port and three dry ports by using the recursive grey operation method. The data collected by this method will be the comprehensive cooperation performance indicator of each dry port. We Then can determine the advantages and disadvantages of those three dry ports. The weight vector of those four components is: w = (W1, W2, W3, W4) = (0.25, 0.25, 0.25, 0.25). The grey relational degree calculation results show an overall cooperation performance between three dry ports and seaports R as: R=W*E= (0.9217, 0.9476, 0.7452).

4.6. The Analysis of the Results

The grey relational degree results show us the result of the overall cooperation performance comes in with Zhengzhou at the top, followed by Xi'an, Lanzhou. Compared with Zhengzhou dry port and Lanzhou dry port, the cooperation between Qingdao port and Xi'an dry port still has some weaknesses. Weaknesses have been identified in customer satisfaction, finance and non-market tools. So the way to direct of further research of this nature can be summarized as follows: (1) The way to manage the information in entire supply chain should be looked at more closely and also ways to better cooperation between participants. (2) The way to improve the competitiveness of Qingdao port in Xi'an dry port in increasing the goods volume. (3) The way to break regional restrictions and extend the hinterland scope of Qingdao port in Xi'an dry port.

V. Conclusions

At present, most of the studies of dry port and seaport in China focus on the location of dry port, but there is little on cooperation performance evaluation. Besides, the construction of dry port in China has just started, the management is relatively chaotic and there are no specific metrics to measure. This article, combined with supply chain management and performance evaluation theories, presents a more complete set of cooperation performance evaluation methods between seaports and dry ports. From the perspective of the seaport, this article uses a balanced score card method to establish the evaluation indicator system of cooperation performance between seaports and dry ports. Through a comparative study of cooperation performance, we found out the weaknesses in cooperation and put forward an improvement strategy for expanding hinterland and cargo throughput. It can be seen from the example that this evaluation method is simple and provides a better way to evaluate the cooperation between seaports and dry ports.

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