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Analysis on the operational efficiency of port logistics listed companies based on DEA

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Abstract: This paper studies the operating efficiency of port logistics enterprises, selects the operating indicators of 14 A-share port logistics listed companies for 2014-2018, uses the CCR and BCC two basic models in the Data Envelopment Analysis to analyze the operating efficiency, and finds the shortcomings in the operation of port logistics listed companies through three aspects: technical efficiency, pure technical efficiency and scale efficiency. The results show that the technical efficiency of the listed companies of port logistics in China is generally not high, but it has been rising steadily, which shows that enterprises have been improving the allocation of resources and looking for the best state. From the pure technical efficiency and scale efficiency can be found that most of the enterprise technology ineffectiveness is affected by the scale efficiency ineffective, the reason is that there is no logistics park between enterprises, in the case of fierce competition, enterprises are still blindly investing in construction, need to operate reasonably according to their own conditions.

Keywords: Operating efficiency; Data Envelopment Analysis; Port logistics listed companies.

1. Introduction

With the rapid development of the economy, China has focused on increasing support for the service industry, and the modern logistics industry, as the main service industry, has received support in many aspects, which has greatly promoted the development of the national economy, driven the national economic income, and promoted international trade and development. Port logistics is the most important part of modern logistics and has played a great role in recent years. Under the strategic background of the "Belt and Road", port logistics has become a window for foreign trade, and it is also an important connection point for waterway, road and air transportation, occupying an important position in the modern logistics industry and gaining key support from the Ministry of Transport. However, with the growth and development of China's port logistics, many deficiencies are also reflected in it, China's port logistics capital operation preparation is not perfect enough, many large ports are still relying on bank loans and short-term financing, the capital chain is not perfect enough, so that many port logistics enterprises have problems in operation. In addition, in the process of the development of port logistics enterprises, China's hardware equipment compared with foreign countries still have a certain gap, the infrastructure is relatively weak, the level of technical informatization is not high, lack of professional talents, these all affect the development of China's port logistics, limit the long-term development of China's port logistics.

There is still a certain gap between the emerging port logistics in China in recent years and the development of foreign port logistics, and how to further improve the operational efficiency of port logistics has become the focus of attention, which is of great significance to the logistics industry and the development of the national economy.

This paper mainly studies the operational efficiency and influencing factors of listed companies with port logistics as its main business, studies the operational efficiency and influencing factors through DEA (Data Envelopment Analysis) method, and studies the problems existing in China's major port logistics enterprises through comprehensive efficiency, pure technical efficiency and scale efficiency, so as to provide strong support for the development of enterprises and lay a foundation for further promoting the development of port logistics.

The remainder of this paper is organized as follows. In Section 2, we review the relevant literature. In Section 3, we present our models. We give a solution analysis for the model in Sections 4. Finally, in Section 5, we make some conclusions with a summary of the key findings and future research directions.

2. Literature review

Our research mainly focuses on the operational efficiency of port logistics enterprises, and the foreign research on operational efficiency related issues is relatively early, among which the use of DEA method in the operation efficiency of logistics enterprises has many research results worthy of reference.

Roll and Hayuth (1993) first used the DEA method to study port logistics efficiency, and studied the performance of 20 ports by establishing a port technical efficiency and scale efficiency evaluation model, which solved the problem of unity of evaluation indicators [1]. Amer Hamdan et al. (2007) used the data envelopment analysis method to analyze the efficiency of 19 similar warehouses operated by third-party logistics companies in the United States, and developed and solved a "limited DEA model" by attaching constraints to the unrestricted DEA model [2]. Shiu-Wan Hung et al. (2009) conducted a study on the operational efficiency of major container ports in Asia and ranked Asian ports, pointing out the superiority of the DEA method by comparing multiple efficiency methods, and the results provided port managers with methods for optimizing operational performance [3]. James Odeck et al. (2012) summarized and analyzed 40 literature using SFA and DEA methods to evaluate port operation efficiency, and used the Tobit model to regression analysis the calculated port average technical efficiency value,

and the results showed that location, data type and scale affected the average port technical efficiency value [4]. Ding (2015) took 21 coastal ports in China as a sample and measured comprehensive efficiency, pure technical efficiency and scale efficiency by DEA method, and the results showed that Rizhao Port and Lianyungang were the most effective ports [5]. Ancor et al. (2016) studied the operational efficiency of container ports in developing countries through stochastic frontier analysis, which showed a difference between scale efficiency and technological efficiency [6]. Chen and Lam (2018) studied the impact of port logistics on their cities based on a two-stage DEA model, and the authors selected 20 of the world's leading container port cities for comprehensive evaluation, the results showed that they had relative differences, and finally referred to the best ports to provide suggestions for port cities [7]. Salman Zarbi et al. (2019) studied the impact of international sanctions on the efficiency of Iran's container ports through window DEA analysis, and used DEA to analyze and study the 10-year data of five Iranian container ports, and found that each port efficiency has decreased [8].

There are many applications of DEA methods in port logistics, mainly macroscopic analysis, rarely used for a certain characteristic group, and the sample is too large, which will lead to large errors in the DEA model. We refine on the basis of the existing literature, focusing on the analysis of China's port logistics listed

3. The model

3.1. DEA model

The basic idea of DEA model is to first determine the evaluation goal, in the determination of the decision-making unit, the decision-making unit to be representative, the most important is to determine the input and output indicators, between the input indicators and the output indicators cannot have a strong correlation, after the DEA model is selected, the effective efficiency value of DEA is 1, if it is relatively inefficient, the efficiency value is between 0 and 1.

3.2. Sample picking

This paper studies the operational efficiency of port logistics listed companies, uses the DEA method to conduct research, and the sample selection should meet the following sample selection principles:

(1) Meet the DEA model requirements for sample size. Assuming that the sample is N, the number of input indicators is X, and the number of output indicators is Y, the sample size should be satisfied $2(X+Y) \le N \le 3(X+Y)$.

(2) The sample data is complete. To select samples with complete data for research, since the data released by various listed companies in 2019 is not comprehensive, this paper mainly studies the operating efficiency of port logistics listed companies from 2014 to 2018. Guangzhou Port and Qingang shares entered the A-share main board market in 2017, and lack research data, so they are not within the scope of research. Shenchiwan A was restructured in the third quarter of 2018 and later changed to China Merchants Port as a security short, so Shenchiwan A was not used as a research sample.

(3) The sample companies are representative. Port logistics companies listed in version A were selected as samples, and the data were authentic and accurate, followed by listed companies accounting for most of the cost of the industry, and their operating efficiency was representative. China's port logistics enterprises are mainly distributed in coastal and inland rivers, according to the "National Coastal Port Layout Plan" coastal parts are mainly distributed in five major port groups, namely the Bohai Rim, the Yangtze River Delta, the southeast coast, the Pearl River Delta, and the southwest coast.

3.3. Sample determination

Through the above sample selection principle, the final sample is 14 listed companies, which is the decision-making unit in the DEA model, as shown in Table 1

Table 1. List of decision-making units

Decision unit	abbreviation
DMU_1	Yantian Port
DMU_2	Beibuwan Port
DMU_3	Xiamen Port
DMU_4	Nanjing Port
DMU_5	Rizhao Port
DMU_6	SIPG Group
DMU_7	Jinzhou Port
DMU_8	Chongqing Port Kowloon
DMU_9	Yingkou Port
DMU_{10}	Tianjin Port
DMU_{11}	Tangshan Port
DMU_{12}	Lianyun Port
DMU_{13}	Ningbo Port
DMU_{14}	Dalian Port

3.3. Indicator selection

This paper selects the salary, operating cost and total assets payable to employees as input indicators, in the selection of output indicators, the selection of the above table is mainly operating income, net profit, total profit, and the output indicators of this paper select operating income and net profit, as shown in Table 2.

Table 2. Selection of input-output indicators

Metric type	Specific indicators
Enter the metric:	Remuneration payable to employees (X_1)
	Operating costs (X_2)
	Total assets (X_3)
Output metrics:	Operating income (Y_1)
	Net profit (Y_2)

4. Empirical analysis of operational efficiency

4.1. Technical efficiency analysis

We evaluate the DEA method of 14 listed port logistics enterprises from 2014 to 2018, and uses DEAP 2.1 software to do technical efficiency analysis, pure technical efficiency analysis and scale efficiency analysis. Technical efficiency refers to the state of configuration between input and output elements. If the overall efficiency value is 1 and the relaxation variable is 0, the DEA is effective, and if the relaxation variable is not 0, the DEA is weakly effective. If the efficiency value is less than 1, the DEA is invalid.

Through the comparison between enterprises, it can be seen that the technical efficiency of Yantian Port, Xiamen Port, SIPG Group, Chongqing Port Kowloon and Ningbo Port in the past five years is 1, and the relaxation variable is 0 with reference to the appendix, that is, DEA is effective, enterprise

resources have been optimally allocated, in the best production state, there is no need to increase investment, and most of China's port logistics listed companies still have room for improvement. In addition to the enterprises that have been DEA effective for five consecutive years, Beibuwan Port, Nanjing Port, Rizhao Port, Yingkou Port, Tianjin Port, Tangshan Port all have DEA effective years, but they are all volatile, and the cyclical characteristics of operation indicate that these enterprises have certain resource allocation defects during this period, and the company needs to strengthen resource management according to its own situation.

Table 3. Technical efficiency

	2014	2015	2016	2017	2018	mean
DMU_1	1.000	1.000	1.000	1.000	1.000	1.000
DMU_2	0.991	0.861	1.000	1.000	0.969	0.964
DMU_3	1.000	1.000	1.000	1.000	1.000	1.000
DMU_4	0.882	0.927	1.000	1.000	1.000	0.962
DMU_5	1.000	0.930	0.876	1.000	1.000	0.961
DMU_6	1.000	1.000	1.000	1.000	1.000	1.000
DMU_7	0.779	0.776	0.757	0.840	0.815	0.793
DMU_8	1.000	1.000	1.000	1.000	1.000	1.000
DMU_9	0.990	1.000	1.000	0.978	1.000	0.994
DMU_{10}	1.000	1.000	1.000	1.000	0.947	0.989
DMU_{11}	1.000	1.000	1.000	1.000	0.991	0.998
DMU_{12}	0.762	0.880	0.903	0.958	0.897	0.880
DMU_{13}	1.000	1.000	1.000	1.000	1.000	1.000
DMU_{14}	0.771	0.809	0.864	0.828	0.792	0.813
mean	0.941	0.942	0.957	0.972	0.958	

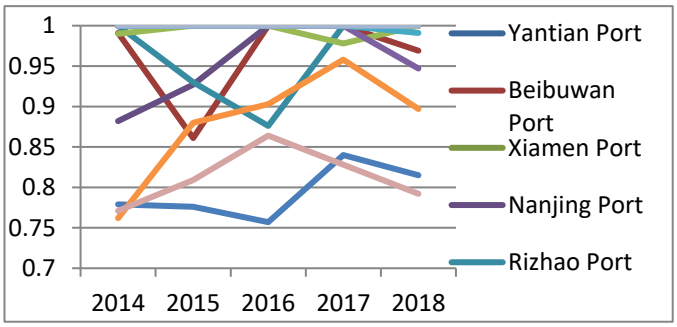

Figure 1. Trends in technical efficiency of various port logistics enterprises

As can be seen from the above figure, all DEAs of Jinzhou Port, Lianyungang and Dalian Port in the past five years are invalid, and it is necessary to focus on improving input indicators to achieve DEA effectiveness. Among them, Lianyungang can be seen from the figure that the technical efficiency has improved, but the technical efficiency of Dalian Port and Jinzhou Port has not been significantly improved for five consecutive years.

4.2. Scale efficiency analysis

Scale efficiency is the production efficiency affected by the scale factor of the enterprise, that is, the ratio of technical efficiency to pure technical efficiency

From the perspective of scale efficiency, Yantian Port, Xiamen Port, SIPG Group, Chongqing Port Kowloon and Ningbo Port have all had a scale efficiency value of 1 in the past five years, while Nanjing Port has a pure technical efficiency of 1, and the poor technical efficiency is caused by the scale of the enterprise. From the perspective of average scale efficiency year by year, the scale efficiency from 2014 to 2017 showed a fluctuating increase, affected by the Sino-US trade war, and the scale efficiency decreased in 2018, mainly due to the decline in scale efficiency of Beibu Gulf Port, Tianjin Port, Tangshan Port, Lianyungang and Dalian Port, and the port logistics enterprises in the Bohai Rim region are the majority, mainly with the impact of US route traffic, Busan Port has further intensified the competitive pressure on ports such as the Bohai Rim.

Table 4. Scale efficiency

	2014	2015	2016	2017	2018	mean
DMU_1	1.000	1.000	1.000	1.000	1.000	1.000
DMU_2	0.991	0.999	1.000	1.000	0.971	0.992
DMU_3	1.000	1.000	1.000	1.000	1.000	1.000
DMU_4	0.882	0.927	1.000	1.000	1.000	0.962
DMU_5	1.000	0.995	0.934	1.000	1.000	0.986
DMU_6	1.000	1.000	1.000	1.000	1.000	1.000
DMU_7	0.999	0.999	0.947	0.989	0.988	0.984
DMU_8	1.000	1.000	1.000	1.000	1.000	1.000
DMU_9	0.990	1.000	1.000	0.983	1.000	0.995
DMU_{10}	1.000	1.000	1.000	1.000	0.955	0.991
DMU_{11}	1.000	1.000	1.000	1.000	0.998	0.999
DMU_{12}	0.990	0.906	0.903	0.958	0.897	0.931
DMU_{13}	1.000	1.000	1.000	1.000	1.000	1.000
DMU_{14}	0.974	0.978	0.986	0.999	0.930	0.973
mean	0.988	0.986	0.995	0.995	0.981	

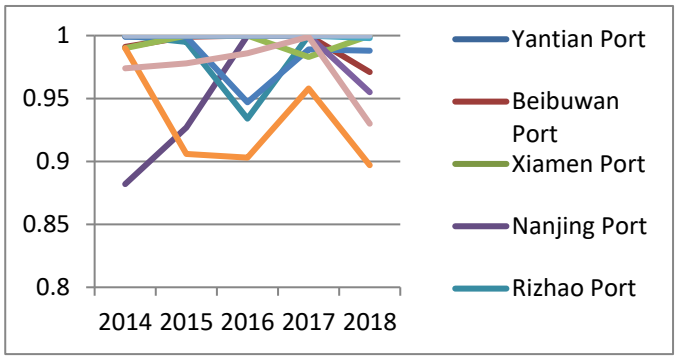

Figure 2. Scale efficiency trend of various port logistics enterprises

The chart of 14 port logistics listed companies from 2014 to 2018 is shown in the figure, from which it can be seen that most ports have increased their scale efficiency in 2017, but their scale efficiency has declined in 2018, especially the scale efficiency of Lianyungang has fallen too fast. The overall quality, efficiency and effectiveness of the development of Lianyungang Port still need to be improved, and there are still weak links in the development process, and it is necessary to optimize the allocation of resources such as funds and land and expand the scale.

5. Conclusion

With the development of China's economy, foreign trade continues to expand, the development of port logistics industry has received more and more attention, and the development of port logistics industry has an important impact on the urban economy, so it is particularly important to study the operational efficiency of the port logistics industry and find the problems in operation. Considering the availability of data and the representativeness of the sample, this paper selects 14 listed companies mainly engaged in port logistics, and uses the DEA model to analyze the efficiency of enterprise operation data from 2014 to 2017, and obtains the following conclusions:

(1) Through the measurement of the relative efficiency of port logistics listed companies, it can be seen that the technical efficiency of most listed companies is relatively ineffective, and the technical ineffectiveness of enterprises is caused by scale invalidity, and the scale efficiency of most enterprises is insufficient, indicating that enterprises do not reasonably plan and build port logistics activities according to their own characteristics, but only think that the expansion and random construction, enterprises should avoid blindly pursuing enterprise scale.

(2) From the perspective of individual enterprises, the operating efficiency of individual enterprises is relatively backward, and the regional competition is greater, such as the technical efficiency of many enterprises in the Bohai Rim region, indicating that they are subject to great competitive resistance in operation and restrict the development of enterprises. In line with the development of the hinterland, the establishment of logistics parks is an inevitable trend.

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