

Evaluation of Cost Efficiency of Beibu Gulf Port based on Super Efficiency DEA

Kerong Jian^{1,2}

¹School of Management
Guilin University of Technology
Guilin, China

²Department of Finance
Guangxi University of Science and Technology
Liuzhou, China
jkr1027@126.com

Abstract—To study Chinese Beibu Gulf port's cost efficiency based on the cost evaluation index system, which is selecting net value of fixed assets, net assets, cost of prime operating, the number of employees as input indicators, and selecting prime operating revenue as well as net profit as the output indicators, we constructed a mode to evaluate the DEA' port company's cost-efficiency. The study found that the comprehensive efficiency of Beibu Gulf port DEA is effective compared with other 15 listed coastal port companies. It has large space in efficiency, longitudinally compared with Yantian port, Nanjing port, Xiamen port, Lianyungang port and Tangshan port, the top five port cities.

Keywords—Cost Efficiency; Beibu Gulf Port; Super Efficiency; DEA; Evaluation

I. INTRODUCTION

Ports play a pivotal role as an important infrastructure of national economic development. Developing the modern port logistics and improving the efficiency of port logistics have become an import issue related to the port modernization, comprehensive competitiveness of countries, and development of the regional economy sustainably. The efficiency of port logistics affects the whole process of logistics activities and other aspects of logistics system, which affect efficiency of the whole logistics network. Therefore, in order to improve the logistics efficiency and keep the port's sustainable competitive advantage, we need to understand what factors affect the efficiency of port logistics, and compare it with other ports, and put forward countermeasures to improve our country's international competitiveness of port logistics. The cost efficiency of port enterprises refers to the ability of port enterprises to obtain the best output with the least cost, and it is a measure to realize the minimum cost or maximum output of the port enterprises. With the rapid development of port business and diversification of services, the competition is becoming increasingly fierce, and the port enterprises are increasingly feeling the importance and urgency of improving their efficiency, thus cost efficiency of port enterprises has important practical significance.

There are a lot of literatures analyzing logistics efficiency in China. Wang Changjiang [1] combined with the current situation and development trend of port logistics in Ningbo-Zhoushan port, this paper studies the basic concepts of modern logistics, the measurement and

evaluation of modern logistics efficiency, and puts forward countermeasures of improving efficiency. Yun Jun and Zhang Fan [2] used the DEA model to evaluate eight ports. Li Tan [3] analyzed the port logistics efficiency of Liaoning Province in 2001-2009 in order to evaluate the port logistics efficiency in Liaoning Province, and through the construction of port logistics and hinterland economic cooperative development index system, calculated from 2002 to 2009 in Liaoning Province, port logistics and economic cooperation. Chen Shuangxi and Dai Minghua [4] analyzed main factors affecting the efficiency of port logistics as well as Northeast Asia port logistics development status and trends, and pointed out the current restricts the Northeast Asia port logistics efficiency improve the main bottleneck factor, put forward the technology of tapping the potential synergies, ring soft environment construction and operation of the integration strategy and countermeasures. Yu Hongsheng [5] expounds the relationship between port and port logistics, puts forward the concept of port service supply chain, and points out that the key to improve the efficiency of port logistics is to improve the management level. According to the connotation of logistics efficiency of international shipping center, Nin Chengcheng [6] established a multi-level port logistics competitiveness evaluation index system, using Delphi Method to determine the weight of all levels, and the use of fuzzy comprehensive evaluation method to evaluate the logistics efficiency of nine port cities: Shanghai, Tianjin, Qingdao, Nanjing, Suzhou, Xiamen, Ningbo and Shenzhen, Dalian international shipping center in logistics efficiency. Li Ying [7] established the index evaluation system for the container line density and hinterland freight demand as well as the coupling degree model and coordination model.

In this paper, we'll make empirical study on the efficiency of Beibu Gulf port of China from 2006 to 2013 by using the super efficiency DEA model, to study the change of the total factor productivity of each port during this period, to provide some data supporting the development of Beibu Gulf Port.

II. RESEARCH METHOD AND DATA SOURCE

A. Research Method

DEA improved model – the Super Efficiency DEA(SE-DEA) makes up the traditional CCR-DEA model and

BBC-DEA model because multiple simultaneous effective decision-making unit can't make further evaluation and comparison of the defect, so that effective decision-making unit can be compared, and inefficient decision-making unit efficiency value is consistent with the CCR-DEA model.

Assume that there are an independent decision-making unit (DMU), the j DMU has m kind of resource input x and s kind of output y , and it is the basic idea of super efficiency DEA model: during the j DMU efficiency evaluation, so that the input and output of the j DMU would be replaced by all other inputs and outputs of decision-making unit and a linear combination, so the j decision-making unit will be excluded, avoiding the traditional DEA model for multiple simultaneous effective decision-making unit cannot be further compared. Super Efficiency DEA model is:

$$\begin{aligned} \min \theta_0 \\ s.t. \sum_{j=1}^n \lambda_j x_{ji} + s_i^- = \theta_0 x_{j_0} \quad i=1, 2, \dots, m \\ \sum_{j=1}^n \lambda_j y_{jr} - s_r^+ = y_{r0} \quad r=1, 2, \dots, s \\ \lambda_j \geq 0, j=1, 2, \dots, n \\ s_r^+ \geq 0, s_i^- \geq 0 \end{aligned}$$

In the formula, θ_0 is the efficiency value of decision-making unit, λ_j is related to DMU_0 , which is j decision-making unit combination proportion in a reconstruct effective DMU combination. S_r^+ and S_i^- are slack variables. When $\theta_0 \geq 1$, $S_r^+ = S_i^- = 0$, DMU_0 is the DEA effective technology, the formation of the efficient frontier surface is constant returns to scale, and decision-making unit is technology effectively and scale efficiently; when $\theta_0 \leq 1$ or $S_r^+ \neq 0$, $S_i^- \neq 0$, the decision-making unit is not effective, if $S_r^+ = S_i^- = 0$, the

technology effectively, making $k = \frac{1}{\theta_0} \sum_{j=1, j \neq j_0}^n \lambda_j$, when $k=1$, the decision-making unit is the constant return to scale; when $k < 1$, the decision-making unit is the increasing return to scale; when $k > 1$, the decision-making unit is the decreasing return to scale.

B. Data SOURCE

There are many methods to evaluate the efficiency of a port, but there is no uniform standard for the input and output of the cost efficiency of the listing Corporation. Among them, Liu (1995) [8] selected input indicators including per capita wages, the carrying accounting of the fixed assets and total assets, and the output index is the total throughput, analysis and evaluation of the model used for SFA stochastic frontier production function;

Martinez (1999) [9] of the input indicators including wage, costs, depreciation, and other expenses, such as the total cargo throughput, output index port profit, evaluation model for the CCR-DEA model and BCC-DEA model; Chen Junfei (2004) [10] choose the index from the financial perspective, the input indicators include the assets of the company, the cost of circulation shares, the number of employees, and cost of prime operating, including the output index of earnings per share, net profit, prime operating revenue, using the evaluation model for the CCR-DEA model; Kuang Haibo (2007)[11] selects 4 input indicators: net value of fixed assets, net assets, cost of prime operating, the number of employees and 3 output indicators: prime operating revenue, net profit, earnings per share. In summary, from the availability of data we'll get the following input-output index.

1. The setting of input variables. Net value of fixed assets is (X_1), net assets are (X_2), cost of prime operating is (X_3), and the number of employees is (X_4).

2. The setting of output variable. Prime operating revenue is (Y_1) and net profit is (Y_2).

3. Sample selection. This paper we'll select the sample during the main longitudinal dynamic data samples from 2007 to 2013, transverse data is the 16 listed coastal ports companies in 2014. All the data are from "Statistical Yearbook of China Port" and the "Shanghai Stock Exchange" and "Shenzhen Stock Exchange" released each listed company's financial report.

III. DATA AND DATA ANALYSIS

TABLE I. THE DATA OF THE INPUT AND OUTPUT VARIABLES
UNIT: TEN THOUSAND YUAN

Name of port	Y_1	Y_2	X_1	X_2	X_3	X_4
Yantian	3008 5	43999	16531	512121	13292	537
Nanjing	1520 27	2045	36525	63552	9773	705
Lianyungang	1529 37	10371	194592	321361	120158	4550
Chiwan A	1804 77	41759	331984	422062	98389	1744
Chongqing	1895 30	9558	353764	328099	149393	2254
Jinzhou	2126 99	22083	799606	580600	160815	1482
Zhuhai	2139 04	1714	176722	245011	182028	1259
Yingkou	3910 48	53967	118180 5	951931	269305	4454
Beibu	4237 73	59659	614548	395347	309571	2466
Rizhao	5083 60	57251	989957	995610	376230	5394
Tangshan	5126 63	108899	782759	768533	307952	3224
Xiamen	7502 33	28666	83081	254052	712480	3731
Dalian	7942 46	52067	147663 9	137179 4	656756	6820
Ningbo	1341 521	281863	195186 0	307571 2	926278	1169 8
Tianjin	2552 830	115191	137050 5	135523 8	221522 2	7867
Shanghai	2877 870	676655	356377 3	556289 6	182496 5	1904 4

TABLE II. THE COST EFFICIENCY OF THE PORT COMPANIES

S N	Name of Port	The Comprehensive Efficiency	The Pure Technical Efficiency	The Scale Efficiency	The Returns to Scale
1	Yantian	1.000	1.000	1.000	-
2	Nanjing	1.000	1.000	1.000	-
3	Lianyungang	0.364	0.509	0.714	drs
4	Chiwan A	0.872	0.878	0.993	irs
5	Chongqing	0.382	0.566	0.676	drs
6	Jinzhou	0.650	0.681	0.954	drs
7	Zhuhai	0.632	0.633	0.998	irs
8	Yingkou	0.504	0.722	0.698	drs
9	Beibu	1.000	1.000	1.000	-
10	Rizhao	0.502	0.756	0.664	drs
11	Tangshan	1.000	1.000	1.000	-
12	Xiamen	1.000	1.000	1.000	-
13	Dalian	0.507	0.784	0.647	drs
14	Ningbo	0.778	0.878	0.886	drs
15	Tianjin	1.000	1.000	1.000	-
16	Shanghai	1.000	1.000	1.000	-
	Average	0.762	0.838	0.889	

IV. THE COST EFFECTIVENESS ANALYSIS

DEA efficiency is 1: Yantian port, Nanjing port, Beibu gulf port, Tangshan port, Xiamen port, Tianjin port and the Shanghai port account for about 37.5% of the sample; The increasing returns to scale with deep Chiwan A, Zhuhai port, diminishing returns to scale in Lianyungang port, Chongqing port, Jinzhou port, Yingkou port, Rizhao port, Dalian port, Ningbo port, the rest of the port company keeps returns to scale unchanged. In the case of the input, the port company should achieve comprehensive efficiency, and the output can improve the space such as in Table 3, in the case of the output to maintain the same, its investment targets can be reduced as shown in Table 4.

TABLE III. OUTPUT INDICATORS SLACK VARIABLE VALUE (LESS OUTPUT VALUE)

Serial Number	Name of Port	Output 1	Output 2
1	Yantian	0.000	0.000
2	Nanjing	0.000	0.000
3	Lianyungang	0.000	9193.163
4	Chiwan A	10867.154	0.000
5	Chongqing	0.000	16270.897
6	Jinzhou	0.000	0.000
7	Zhuhai	0.000	8090.387
8	Yingkou	0.000	23733.374
9	Beibu	0.000	0.000
10	Rizhao	0.000	39174.129
11	Tangshan	0.000	0.000
12	Xiamen	0.000	0.000
13	Dalian	0.000	90612.373
14	Ningbo	0.000	21548.417
15	Tianjin	0.000	0.000
16	Shanghai	0.000	0.000
	Average	679.197	13038.921

TABLE IV. THE SE-DEA VALUE OF THE PORT COMPANIES

SN	1	2	3	4
DMU	Yantian	Nanjing	Xiamen	Lianyungang
Score	1361.54%	835.40%	225.09%	124.29%
SN	5	6	7	
DMU	Tangshan	Beibu gulf	Shanghai	
Score	112.18%	109.67%	101.26%	

V. CONCLUSION

In this paper, we evaluate the cost efficiency of Beibu Gulf port by using the improved model of DEA, super efficiency DEA (SE-DEA), analyze the logistics cost of the Beibu Gulf 2006-2013, make up the shortcomings of the traditional CCR-DEA model and BBC-DEA model, and provide some data support to the development of the Beibu Gulf port.

Through the SE-DEA model established in this paper of Beibu Gulf and the other 15 listed coastal port companies, the pure technical efficiency, scale efficiency, further evaluation of the returns to scale and comprehensive efficiency analysis that Beibu Gulf port relative Yantian port, Nanjing port, Xiamen port, and Lianyungang, not only for the DEA efficiency, but there is also still a lot of room to improve the efficiency.

But this paper only focuses on northern Gulf port and its port input indicators: fixed assets, net assets, the main business costs, the number of employees and output indicators: the main business income and net profit are compared, and the financial aspects of the port company's comprehensive assessment of net assets yield is also worth further study.

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