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Evaluation of Logistics Efficiency of Chongqing Port and Its Countermeasure

Lemei He

Institute of Logistics Engineering and Science, Shanghai Maritime University, China

201830510133@stu.shmtu.edu.cn

Abstract: The evaluation of port logistics efficiency is of great significance to the study of port operation activities, and is an important index to measure the efficiency, competitiveness and economic effects of port logistics. This paper will evaluate the logistics efficiency of Chongqing Port from the macro and micro levels. At the macro level, the linear regression method of parametric method and DEA method of non-parametric method are used to analyze the logistics efficiency of Chongqing Port. The linear equation between GDP and container throughput of Chongqing Port can be obtained by this method. By analyzing the linear relationship, the actual situation of logistics efficiency of Chongqing Port can be reflected at the macro level to some extent. At the macro level, the DEA method is used to analyze the impact of the input of industrial economy and transportation system in the hinterland of the port on the port throughput. At the micro level, DEA method based on non-parameterized method is adopted, which can determine the technical and scale effectiveness of port production by analyzing the production input and output of Port-related indicators. By analyzing the effectiveness of DEA in ports, we can evaluate the actual development of logistics efficiency in Chongqing Port from the micro level. Through the macro and micro evaluation results of Chongqing Port, this paper puts forward the factors affecting the logistics efficiency of Chongqing Port and puts forward specific countermeasures to improve its logistics efficiency.
Keywords: Port logistics efficiency, linear regression method, DEA method, efficiency evaluation, Countermeasures Analysis.

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1. INTRODUCTION

After years of development, Chongqing Port has successfully ranked among the national first-class ports, and its throughput accounts for a certain proportion of the total throughput of the national ports. The evaluation of port logistics efficiency is of great significance to the study of port operation activities, and is an important index to measure the efficiency, competitiveness and economic effects of port logistics. This paper will evaluate the logistics efficiency of Chongqing Port from the macro level and micro level through linear regression analysis and data envelopment analysis. The results are of great significance to the correct strategic deployment of port-related work in the future, including the rational arrangement of port infrastructure, port layout, information platform and other hardware conditions, as well as the improvement of handling quality, port environment and the expansion of port service scope.

There are two main methods to evaluate the efficiency of port logistics at home and abroad. One is parameterized method, the other is non-parameterized method. This paper will adopt the method of combining parametric analysis with non-parametric analysis, and adopt the linear regression method of parametric method and DEA method of non-parametric method at the macro level. Linear regression can intuitively reflect the degree of interaction between data. However, if only the linear regression method is used at the macro level, because the evaluation data are relatively single, the evaluation results can not reflect the logistics efficiency of the port comprehensively from the macro level. Therefore, in the macro level, DEA method should be used to evaluate the port logistics efficiency. By analyzing the impact of the input of port hinterland industry economy and transportation system on port throughput, we can more comprehensively reflect the port logistics efficiency in the macro level. At the micro level, DEA method of non-parametric method is adopted. This method can determine the effectiveness of DEA at the port production level by analyzing the production input and output of Port-related indicators. Through the evaluation results, this paper puts forward the factors affecting the logistics efficiency of Chongqing Port and the corresponding countermeasures to improve its logistics efficiency.

2. OVERVIEW OF THE PROPOSED METHOD

2.1 Construction of Model

A. Charnes, W. W. Cooper and E. Rhodes proposed data envelopment analysis (DEA) for short. Data envelopment analysis (DEA) is a dual simplex method in operational research. It is a quantitative analysis method to evaluate the relative effectiveness of comparable units of the same type by using linear programming method based on multiple input and output indicators. It can evaluate projects with multiple indicators. The DEA model is as follows, while the scale reward remains unchanged.

$$\min \theta$$

$$s.t\begin{cases} \sum_{j=1}^{n} \lambda_j \mathrm{X}_j + \mathrm{s}^- = \theta x_0 \\ \sum_{j=1}^{n} \lambda_j Y_j - s^+ = y_0 \\ s^+ \geq 0, \mathrm{s}^- \geq 0, \lambda_j \geq 0 \\ \theta \text{ Unconstrained}, \quad j = 1, 2, \cdots, n \end{cases}$$

Among them, theθ is the technical efficiency value of DMU, λ_j is the dual variable of DMU, s^+,s^- is the relaxation variable. Under the condition of variable returns to scale, DEA model is as follows:

Among them, β is the pure technical efficiency value of decision making unit, andλ_1 ,λ_2 ,… ,λ_n is a dual variable, s^+,s^- is a relaxation variable. According to the technical efficiency value and pure technical efficiency value, the scale efficiency value of each DMU can be obtained. The technical efficiency = pure technical efficiency * scale efficiency.

$$\min \beta$$

$$s.t.\begin{cases} \sum_{j=1}^{n} \lambda_j X_j + s^- = \beta x_0 \\ \sum_{j=1}^{n} \lambda_j Y_j - s^+ = y_0 \\ s^+ \geq 0, s^- \geq 0, \lambda_j \geq 0 \\ \sum_{j=1}^{n} \lambda_j = 1, j = 1,2,\cdots,n \end{cases}$$

2.2 DEA Validity Judgment

According to the definition of DEA validity, we can use CCR model to determine whether simultaneous technology validity and scale validity are as follows:

(1)Definition 1: Ifθ=1, and s^+=0 ,s^-=0, then the decision making unit is DEA effective, and the economic activities of the decision making unit are both technology effective and scale effective.

(2)Definition 2: Ifθ=1, but at least one input or output is greater than 0, then the decision making unit is weak DEA efficient, and the economic activity of the decision making unit is not the best for both technical efficiency and scale.

(3)Definition 3: Ifθ<1, the decision making unit is not DEA efficient, and economic activity is neither the best in technical efficiency nor the best in scale.

3. CASE STUDY: A CASE STUDY OF CHONGQING PORT

3.1 Assessment of Logistics Efficiency of Chongqing Port at Macro Level

3.1.1 Linear Regression Assessment at Macro Level

(1) Relevant Data of Evaluation Indicators

Because Chongqing GDP is an important index reflecting Chongqing's economic development, and the cargo throughput of Chongqing Port is an important index reflecting port economic effect, logistics efficiency and operation status. Therefore, this paper chooses two groups of basic data of GDP and cargo throughput of Chongqing Port in the six years from 2013 to 2018 as the research object, as shown in Table 3.1.

Table 3.1 Data required for linear regression analysis

year	GDP in Chongqing(RMB 100 million)	Cargo throughput of Chongqing Port (10,000 tons)
2013	11410	12603
2014	12783	13676
2015	14263	14665

2016	15700	15750
2017	17558	17372
2018	19191	19836

(2)Establishing Linear Model of Univariate Regression

Using SPSS statistical analysis software to establish a linear regression model, as shown in Figure 3.1, the horizontal coordinate represents the throughput of Chongqing Port from 2013 to 2018, and the vertical coordinate represents the GDP of Chongqing from 2013 to 2018. Through regression analysis of two sets of data, the linear regression equation of one variable is obtained, which is Y=1.094X+2067.036.

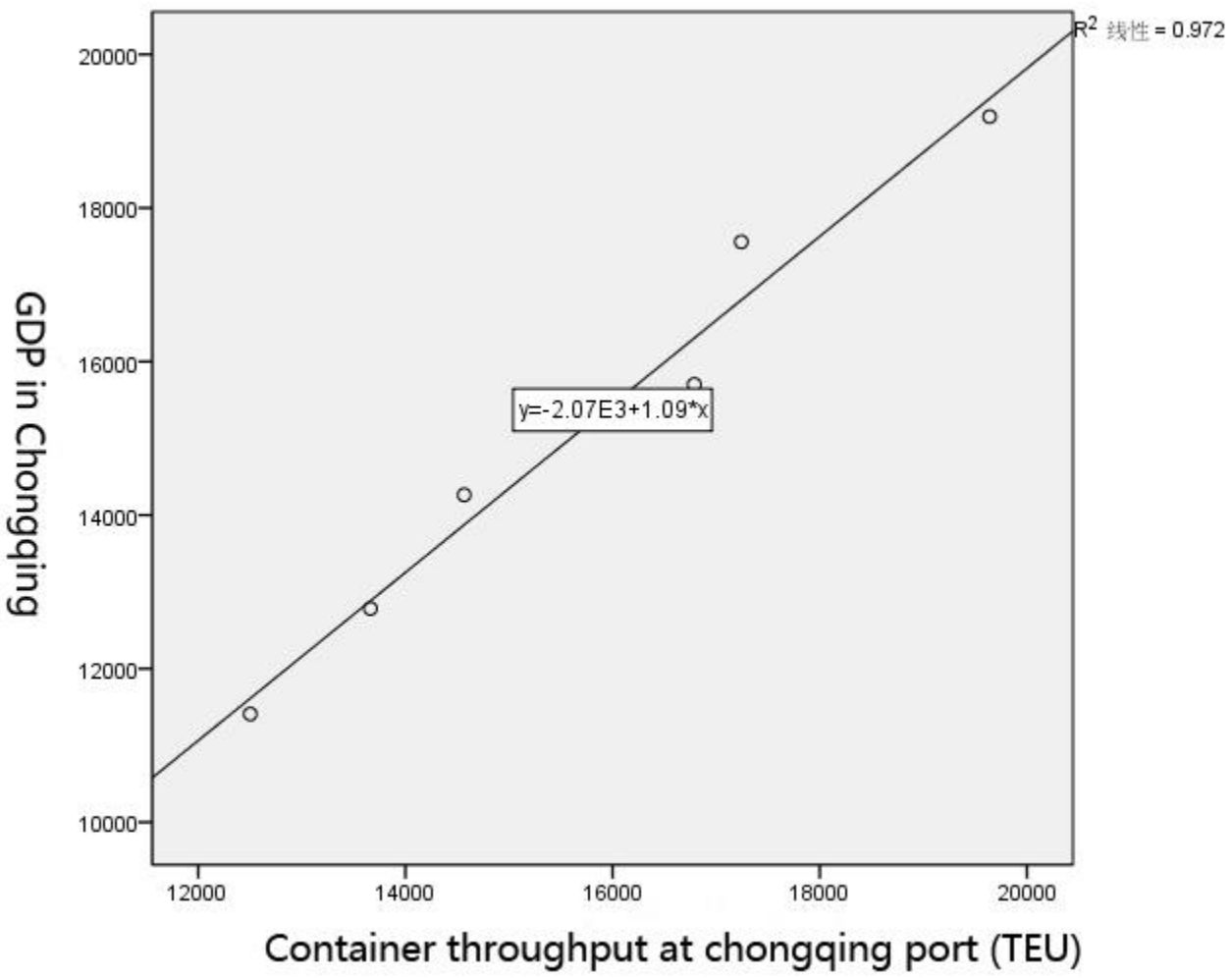

Figure 3.1 Analysis results of linear regression model

3.1.2 Evaluation of DEA Method at Macro Level

(1)Relevant Data of Evaluation Indicators

For ports, the development level of hinterland economy, the scale of tertiary industry, transportation system and population density of the region will directly affect the development of port logistics. Therefore, in macro-level analysis of port logistics efficiency, we use GDP of Chongqing, tertiary

industry GDP of Chongqing, highway mileage of Chongqing and railway mileage of Chongqing as input indicators of DEA model. The cargo throughput of Chongqing Port and container throughput of Chongqing Port are selected as the output indicators of DEA model. Specific evaluation data are shown in Table 3.2.

Table 3.2 Data required for DEA evaluation at macro level

year	Chongqing GDP (RMB 100 million)	Chongqing ter-tiary industry GDP (RMB 100 million)	Highway mileage (km) in Chongqing area	Railway mileage (km) in Chongqing	Cargo through-put of Chongqing Port (10,000 tons)	Container throughput of Chongqing Port (10,000 TEU)
2013	11410	4981	1900	1380	12603	87
2014	12783	5256	2312	1700	13676	98
2015	14263	6673	2326	1800	14665	110
2016	15700	7498	2451	1929	15750	112
2017	17558	8500	2743	2231	17372	115
2018	19191	11060	3800	2371	19836	129

(2) Evaluation of logistics efficiency of Chongqing Port by DEA method at macro level

This paper selects DEA special data analysis software DEAP2.1 to evaluate the logistics efficiency of Chongqing Port. The data analysis was carried out by inputting 6 sets of data of input index and output index into DEAP2.1, and the results are shown in Table 3.3. The technical efficiency in the table represents the maximum output energy reached under stable input conditions; pure technical efficiency is the ability to make full use of inputs to maximize output, and if it is 1, it means full use of inputs to maximize output; scale Efficiency is the result of measuring whether the input and output ratios are appropriate. If it is 1, it means that the input and output ratios are just right, that is, the input amount just meets the output.

Table 3.3 Analysis results of DEA model at macro level

Decision making unit	Technical efficciency (Crste)	pure technical efficiency(Vrste)	Scale efficiency (Scale)	Scale crewar-d	DEA validity
2013	1.000	1.000	1.000	Remuneration to scalere-mains unchanged	DEA effective
2014	1.000	1.000	1.000	Remuneration to scale re-mains unchanged	DEA effective
2015	0.993	1.000	0.993	Decreasing returns to sc-ale(drs)	Weak DEA effective

2016	0.986	1.000	0.986	Decreasing returns to sc-ale(drs)	Weak DEA effective
2017	0.955	1.000	0.955	Decreasing returns to sc-ale(drs)	Weak DEA effective
2018	0.936	1.000	0.936	Decreasing returns to sc-ale(drs)	Weak DEA effective

3.1.3 Evaluating the Logistics Efficiency of Chongqing Port at Micro Level

(1) Relevant data of evaluation indicators

At the micro level, this paper chooses the length of production wharf, berth number and effective area of Chongqing yard as input indexes of DEA model. Because port throughput is an important index to study port logistics efficiency. Therefore, this paper chooses the cargo throughput of Chongqing Port and container throughput of Chongqing Port as the output indicators of DEA model. The specific indicators are shown in Table 3.4.

Table 3.4 Analysis data for DEA method

year	Length of production wharf (m)	Number of berths for production	Effective area of yard(10,000 square meters)	Cargo throughput of Chongqing Port (10,000 tons)	Container throughput of Ch-ongqing Port (10,000 TEU)
2013	73632	877	35	12603	87
2014	73204	869	35	13676	98
2015	70501	824	34	14665	110
2016	69984	812	33	15750	112
2017	70837	813	35	17372	115
2018	73102	821	36	19836	129

(2) Evaluating the logistics efficiency of Chongqing Port by DEA method at micro level

Data analysis was carried out by inputting the collected input and output data into DEAP2.1. The results are shown in Table 3.5.

Table 3.5 DEA analysis results

Decisionmaking unit	Technical eff iciency (Crste)	pure technical ef ficiency (Vrste)	Scale effici-en cy(Scal-e)	Scale reward	DEA validity
2013	0.694	0.950	0.730	Increasing returns to sc ale(irs)	Not DEA val-id
2014	0.781	0.956	0.817	Increasing returns to	Not DEA val-id

				scale(irs)	
2015	0.903	0.993	0.910	Increasing returns to scale (irs)	Not DEA val-id
2016	0.947	1.000	0.947	Increasing returns to scale(irs)	Weak DEA effective
2017	0.920	1.000	0.920	Increasing returns to scale(irs)	Weak DEA effective
2018	1.000	1.000	1.000	Remuneration to scale remains unchanged	DEA effectiv-e

3.2 Evaluation result

3.2.1 Assessment results at macro level

Through the linear regression analysis, it can be concluded that the fitting degree between the throughput of Chongqing Port and the linear regression equation of GDP in Chongqing area is very high, which shows that the scatter plot of the linear regression equation is very close to the linear regression equation. However, from the analysis results, we can see that the scatter points in 2013 and 2014 basically fit the unitary regression equation, while the scatter points in 2015 and 2018 deviate from the unitary regression equation. Secondly, the linear relationship between the two groups is significant and positive. From the analysis of linear regression model, it can be concluded that the logistics efficiency of Chongqing Port from 2013 to 2014 is higher, while the logistics efficiency of Chongqing Port from 2015 to 2018 is not the best.

By using the DEA method to analyze the selected data, the results of the analysis in 2013 and 2014 are both valid, indicating that the number of inputs in the past two years just meets the output quantity, making the ratio of input and output suitable. But in the recent 2015 to 2018, it was effective for weak DEA. From Figure 3.2, the pure technical efficiency of the six years from 2013 to 2018 is basically stable, and both are optimal values of 1, which means that the port makes full use of the input to maximize the output. The scale efficiency has been declining since 2015, indicating that the ratio of input to output is appropriate from 2013 to 2014, but it is not suitable from 2015 to 2018. Therefore, the logistics efficiency of Chongqing Port in 2013 is also high, and the logistics efficiency of Chongqing Port from 2015 to 2018 has not reached the optimal efficiency.

3.2.2 Analytical results at the micro level

The analysis results can be used to determine whether increasing input will lead to an increase in output or whether reducing input will lead to a decrease in the amount of output indicators. From Figure 3.3, we can see that the pure technical efficiency has been increasing in the six years from 2013 to 2018, which shows that the port is making full use of input and output capacity is increasing. Besides 2017, the scale efficiency is also increasing year by year, which shows that the ratio of input and output is becoming more and more appropriate. Through the analysis of the above data envelopment results, it can be concluded that the first three years of the analysis results are not DEA effective but weak DEA effective. Finally, the analysis results in 2018 show that the logistics efficiency of Chongqing Port has been improving continuously in the past six years at the micro-level, and reached the best efficiency in 2018.

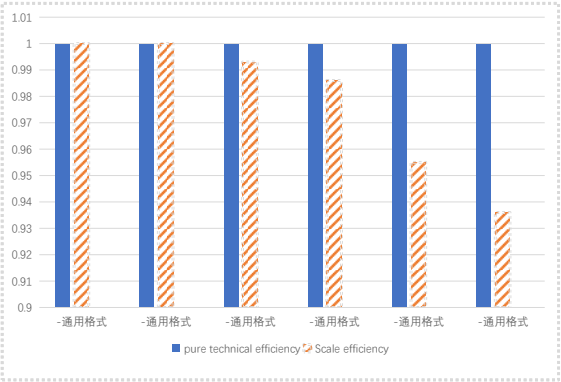

Figure 3.2 Macro-level DEA method evaluation results pure technology and scale efficiency evaluation index histogram over the years

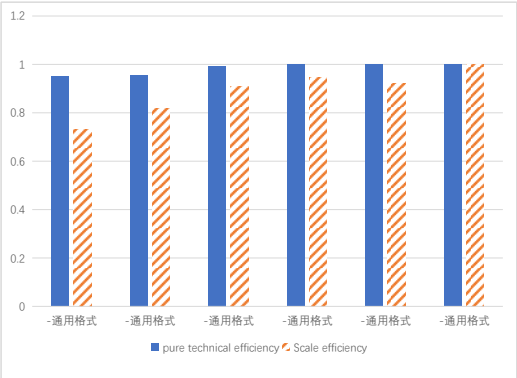

Figure 3.3 The results of DEA method at micro level are a histogram of pure technology and scale efficiency over the years.

4. COUNTERMEASURE RESEARCH

4.1 Analysis on Influencing Factors of Logistics Efficiency in Chongqing Port

Based on the analysis of the evaluation results, this paper puts forward the following factors that restrict the development of Chongqing Port:

(1) The impact of hinterland economic development

From the macro level, the evaluation results show that Chongqing Port achieved the best efficiency in 2013 and 2014, while Chongqing Port did not achieve the best efficiency from 2015 to 2018. From Table 4.1, we can see that Chongqing's GDP growth rate is the highest from 2013 to 2014. There is a downward trend from 2015 to 2018. Similarly, the throughput growth rate of Chongqing Port has not changed much from 2015 to 2018. In conclusion, the logistics efficiency of the port will be affected by the economic development speed of the hinterland, that is, the faster the economic development of the hinterland, the better the economic efficiency of the port and the higher the logistics efficiency.

Table 4.1 Comparison of Chongqing Regional GDP and Chongqing Port Cargo Throughput from 2013 to 2018

year	Chongqing GDP (100 million yuan)	Compared with the sam-e period last year (%)	Cargo throughput of Chongqing Port	Compared with the same period last year (%)
2013	11410	114.1	12603	107.7
2014	12783	112.0	13676	108.5
2015	14263	111.6	14665	107.2
2016	15700	110.1	15750	107.4
2017	17558	111.8	17372	110.3
2018	19191	109.3	19836	114.2

(2) Competition near ports

The most competitive port near Chongqing Port is Luzhou Port. From Table 4.2, we can see that Luzhou Port's cargo throughput increased steadily every year from 2013 to 2018. The growth rate of its cargo throughput is greater than that of Chongqing Port except 2017. Therefore, some passenger and cargo resources in Chongqing Port are diverted by Luzhou Port with its unique advantages. Apart from Luzhou Port, the rapid development of other nearby ports of Chongqing Port also poses a certain threat to Chongqing Port.

Table 4.2 Comparison of cargo throughput between Luzhou Port and Chongqing Port from 2013 to 2018

year	Luzhou Port cargo throughput (10,000 tons)	Compared with the sa-me period last year (%)	Cargo throughput of Chongqing P-ort	Compared with the same period last year (%)
2013	2348	113.2	12603	107.7
2014	2707	115.3	13676	108.5

2015	3134	115.8	14665	107.2
2016	3567	113.8	15750	107.4
2017	4123	115.6	17372	110.3
2018	4679	113.5	19836	114.2

(3) Limited transportation of Yangtze River waterway

It is unavoidable that the Three Gorges Dam will be used for passenger and cargo transportation in the Yangtze River waterway. However, the Three Gorges Dam is a large-scale water conservancy project after all, so the passage width through which ships are released is limited. The Yangtze River's transport vessels are growing and the freight volume is also increasing. Therefore, the limited waterway often can not carry a large number of ships through the congestion, waiting and other phenomena. The restriction of Yangtze River waterway transportation will inevitably affect the logistics efficiency of Chongqing Port.

(4) Construction of transportation system in hinterland of port

The results of macro-level DEA method evaluation show that Chongqing Port achieved the best efficiency in 2013 and 2014, while Chongqing Port did not achieve the best efficiency from 2015 to 2018. This paper will make a detailed analysis of the transportation investment and construction in Chongqing. As shown in Table 4.3 below, the rapid development of Chongqing's transportation system construction in 2013 and 2014 has greatly improved the logistics efficiency of Chongqing Port, so the logistics efficiency of Chongqing Port has reached the optimum in these two years. From 2014 to 2018, the mileage of expressways and railways in Chongqing did not increase much. Even when Chongqing built the "three-ring, twelve-shooting and multi-connection" expressway network in 2018, it increased by 138.5% compared with 2017. However, because the construction of Railways in Chongqing lagged behind the speed of Expressway construction, the evaluation result is still that Chongqing Port has not reached the optimal logistics efficiency. From the above analysis, we can get that a convenient and sound transportation system can improve the efficiency of port logistics.

Table 4.3 Comparisons of Highway and Railway Mileage in Chongqing from 2013 to 2018

year	Highway mileage (km) in Chongqing area	Compared with the same period last year (%)	Railway mileage (km) in Chongqing	Compared with the same period last year (%)
2013	1900	106.3	1380	107.2
2014	2312	121.2	1700	123.1
2015	2326	100.6	1800	105.9
2016	2451	105.4	1929	107.1
2017	2743	111.9	2231	115.7
2018	3800	138.5	2371	106.3

(5) Input of port infrastructure

Although Chongqing Port has a large number of berths and a wide port area, it still has the problems of insufficient infrastructure and limited transport capacity. The results of DEA analysis at the micro level show that the input of port infrastructure has a great impact on the logistics efficiency of the port. From the evaluation results of 2013 to 2015, we can see that there are excessive investment and insufficient output in these three years. However, in the three years from 2013 to 2015, whether the length of production wharf, the number of berths for production or the effective area of the yard, the amount of input is the largest compared with the research year from 2016 to 2018. However, the evaluation results show that the port logistics efficiency in recent years is not the best logistics efficiency. In summary, a large amount of investment in infrastructure may not necessarily bring higher output, but may cause excessive investment in infrastructure and increase management and operation costs, which will reduce the efficiency of port logistics to a certain extent.

(6) Port Information Processing Technology and Intelligent Degree of Port

Information processing plays an important role in port-related operations. Port information processing includes information processing of various related documents of port operations, port cargo trade, port warehousing, port-related financial services, etc. If the information processing technology of the port is not perfect and efficient enough, the relevant technology can not be updated and perfected in time. Limited processing capacity of information technology is bound to have a negative impact on the growing volume of port passenger and cargo transactions. Fast and accurate information processing ability and intelligent facilities and equipment can accelerate the port passenger and cargo turnover capacity, and most importantly, can also improve the efficiency of port logistics. At the micro level, the DEA evaluation results show that although the investment in infrastructure is reduced, the efficiency of port logistics can still reach the best level, which indicates that a large amount of investment in infrastructure may not necessarily lead to the improvement of logistics efficiency, but if appropriate infrastructure investment is combined with efficient port information processing capacity and intelligent facilities and equipment, the efficiency of port logistics can approach the best state.

4.2 Discussion on the Measures to Improve the Logistics Efficiency of Chongqing Port

There is still much room to improve the logistics efficiency of Chongqing Port. Based on the analysis of the factors affecting the efficiency of Chongqing Port, the specific measures to improve its efficiency are as follows:

(1) Strengthening cooperation with surrounding ports

In order to improve its logistics efficiency, Chongqing Port should pay attention to strengthening close cooperation with surrounding ports and introduce advanced management and development mode. Establish strategic alliances with surrounding ports and strengthen information communication with each other in order to attract more passenger and cargo resources and reduce overall costs, so as to achieve mutual development.

(2) Harbour realizes the coordinated development with hinterland

From the above analysis, we can see that the logistics efficiency of the port will be affected by the hinterland economic development. The benign development of the hinterland economy can bring more passenger and cargo resources to the port, more development opportunities to the port, and also

can drive the development of the port logistics.Ports should actively strive for more passenger and cargo resources in the hinterland and seize the opportunities for port development in the hinterland. Actively integrate and promote the construction and development of "one belt and one road" and "Yangtze River Economic Belt". Ports can also promote the development of hinterland economy while developing their own economy. Therefore, the communication between ports and hinterland hinders the strengthening of cooperation and exchanges in order to achieve coordinated development with hinterland economy.

(3) Continue to improve the hardware conditions of the port

The amount of infrastructure investment in Chongqing Port will affect the logistics efficiency of Chongqing Port, so it should be improved. For the actual passenger and cargo situation of the port, first of all, the large tonnage berth of the port is added to ensure that more large tonnage vessels can be berthed. Secondly, the technology of port information platform is upgraded to ensure that a large number of port operations related documents, port cargo trade, port warehousing, port-related financial services and other information can be processed quickly and accurately.

(4) Improving the Soft Environment of Ports

Port development should not only pay attention to infrastructure construction, information platform and other hardware conditions, but also pay attention to handling efficiency, service quality and other soft environment. Logistics industry, as a third-party service industry, aims to bring better service quality to customers. Because Chongqing Port has unique location advantages and geographical advantages, the number of customers is large and the composition is complex. Therefore, the port will expand its scope of service, improve the quality and level of service of its relevant departments, in order to achieve better service experience for customers. In this way, customer disputes and service complaints can be reduced, thus reducing additional unnecessary expenses.

(5) Further enhancing the role of collection and distribution network

Chongqing has four links and eight major railway, road and air transport networks. The arrival cargo and departure cargo of Chongqing Port must be transported by other modes of transportation besides waterways. Therefore, the efficient collection and distribution network system can ensure the efficient flow of passenger and cargo resources in the port. However, at present, the comprehensive utilization mode and efficiency of Chongqing Port for various modes of transport are lagging behind those of well-known domestic seaports. If Chongqing Port can further improve the role of the collection and distribution network, adopt more advanced and efficient management mode, strengthen the cooperation and information sharing among transportation systems, and make full use of the limited investment in transportation facilities to reach the maximum output quantity, it will be able to improve the speed of port cargo flow to improve the efficiency of port logistics.

5. CONCLUSION

The efficiency evaluation of port logistics is of great significance to the operation and development of the port. This paper evaluates and analyses the logistics efficiency of Chongqing Port by using linear regression analysis and DEA method at macro and micro levels. The concrete conclusions are as follows:

(1) At the macro level, by combining the results of linear regression analysis with DEA analysis, we can conclude that Chongqing Port achieved the best efficiency in 2012 and 2013, while Chongqing Port did not achieve the best efficiency in 2014 and 2017. Therefore, from the macro level, the logistics efficiency of Chongqing Port has room for improvement.

(2) At the micro level, we can see that although the logistics efficiency of Chongqing Port has the trend of increasing continuously, we can see that the value of pure technical efficiency and scale efficiency are not stable in the analysis of the past years. The pure technical efficiency has been improving continuously in the six years from 2012 to 2017, which shows that the port is making full use of the input output capacity is increasing. Besides 2016, the scale efficiency is also increasing year by year, which shows that the ratio of input and output is becoming more and more appropriate. In the analysis of DEA in the past six years, only one year has reached DEA validity, so the logistics efficiency of Chongqing Port still has great room for improvement.

Through the analysis of the evaluation results, it is concluded that the factors affecting the logistics efficiency of Chongqing Port are the hinterland economic development, the competition between adjacent ports, the limited Yangtze River waterway transportation, the construction of the hinterland transportation system, the input of infrastructure, the port information processing technology and the intellectualization of the port. If the port can improve the factors that affect the efficiency of port logistics, it can improve its logistics efficiency.

This paper evaluates the efficiency of port logistics through linear regression and data envelopment analysis. Although this method evaluates the efficiency of port logistics from macro and micro perspectives, it still has some shortcomings. Because this paper mainly uses quantifiable indicators for analysis, without considering some inefficient evaluation indicators. This may lead to some errors in the analysis results. Further consideration will be given to the impact of non-quantifiable evaluation indicators on port efficiency evaluation in the future.

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