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Study on Efficiency Measurement and Influencing Factors of Marine Economic Development in Jiangmen

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ABSTRACT
Marine economy is an important engine of economic development in Jiangmen city and an important guarantee for regional coordinated development. In order to evaluate the efficiency and potential of Marine economic development in Jiangmen city more accurately and objectively, and to find the optimal path, this paper combined DEA-C2R model with super-efficiency DEA model, and established an evaluation system for the efficiency of marine economic development in Jiangmen city, so as to calculate the efficiency value of marine economic development in Jiangmen city from 2011 to 2015. In order to further explore the influence of various index factors on the efficiency of marine economic development in Jiangmen city, this paper adopts the grey relational degree model and ridge regression method to construct the evaluation model of factors affecting the efficiency of marine economic development in Jiangmen city. According to the conclusions of the efficiency evaluation results and the analysis of efficiency influencing factors, four policy recommendations are proposed.
Keywords: *Marine economic development efficiency, data envelopment analysis, ridge regression, grey correlation*

1. INTRODUCTION

The 21st century is the "Marine Century", and the ocean is increasingly becoming the focus of political, economic, and social development and competition in today's world. The marine industry is a collection of sectors formed by humans using marine resources and space for production and service activities. As one of the major domestic ocean cities, Jiangmen has a unique advantage in marine resources. The coastline is 414.8 kilometers long, with about 561 islands, many harbours, abundant fishery resources, large tidal flats, and the deepest hinterland. The marine economy is an important engine for Jiangmen's economic development and an important guarantee for regional coordinated development. With the implementation and deepening of national strategies such as the “Belt and Road” and “Guangdong Marine Economic Comprehensive Experimental Zone”, Jiangmen’s marine economic development will also face greater opportunities and challenges. Therefore, this research combines the development trend of marine economy at home and abroad, evaluates the development status of Jiangmen's marine economy, explores the development direction of Jiangmen's marine economy, and proposes targeted development strategies for this purpose, which has important theoretical value and practical significance.

2. RESEARCH STATUS

In the face of the coexistence of the "rapid development" and "prominent problems" of China's marine economy, comprehensive evaluation of the development level of marine economy in coastal areas has become a hot spot for domestic scholars.

Ding Lili et al. [1] (2018) calculated the production efficiency, environmental governance efficiency and comprehensive efficiency of marine economic growth in 11 coastal areas of China. Wu shujuan et al. [2] (2015) calculated the operational efficiency of Marine economy in China's blue economic zone to find out the non-efficient links. Zhao Xin et al. [3] (2012) used the GRA-DEA mixed model to analyze and evaluate the marine economic efficiency of China's coastal areas. Du Jun et al. [4] (2016) used data envelopment analysis and the Malmquist productivity index model to evaluate the marine economic efficiency of 11 coastal provinces in China.

The above studies are mainly carried out at the provincial level in China, while the research on marine economic efficiency at the municipal level is even rarer due to the availability of data. From the level of coastal prefecture-level cities, this paper studies the efficiency of marine economic development in Jiangmen city and its influencing factors, so as to provide the decision-making basis for formulating scientific, reasonable and appropriate policies to improve the efficiency of marine economic development in Jiangmen city.

3. EFFICIENCY EVALUATION OF MARINE ECONOMIC DEVELOP-MENT IN JIANGMEN CITY

3.1. Model Selection

Data Envelopment Analysis (DEA) is suitable for solving the problem of comprehensive evaluation of the relative effectiveness of input and output [5]. This section mainly concerns the C^2R model and the super-efficient DEA model.

3.1.1. C^2R model

The A model assumes that the production process is in the stage of constant returns to scale, as shown in equation (1):

$$\begin{cases} Min\theta_o - \varepsilon(\sum_{i=1}^{m} s_i^- + \sum_{r=1}^{s} s_r^+) \\ s.t. \sum_{j=1}^{n} x_{ij}\lambda_j + s_i^- = \theta_o x_{io}, i = 1,2,\cdots,m \\ \sum_{j=1}^{n} y_{rj}\lambda_j + s_r^+ = y_{ro}, r = 1,2,\cdots,s \\ \lambda_j, s_i^-, s_r^+ \geq 0, \forall, j, r. \end{cases} \quad (1)$$

Among them, □ is called non-Archimedes infinite quantity. If the optimal solution of the above model satisfies $\theta_o^* = 1$, the relaxation variable satisfies $s_r^+ = 0$, and the remaining variable satisfies $s_i^- = 0$, it is called DEA effective; if the optimal solution of equation (1) satisfies $\theta_o^* < 1$, it is called non-DEA effective.

3.1.2. Super efficiency DEA model

In order to rank multiple effective decision-making units, Andersen proposed to exclude the tested unit from the reference set to achieve the purpose of distinguishing effective decision-making units, which is the concept of super-efficiency. The super-efficient DEA model is shown in equation (2).

$$\begin{cases} s.t. \ \sum_{j=1}^{n} X_{ij}\lambda_j + S_i^- = \theta X_{ij0} \ \ i = 1,2,\cdots,m \\ \sum_{j=1}^{n} y_{rj}\lambda_j - S_r^+ = y_{rj0} \ \ r = 1,2,\cdots,s \\ \lambda_j, S_i^-, S_r^+ \geq 0, \ \ j = 1,2,\cdots,j_0 - 1, j_0 + 1,\cdots,n \end{cases} \quad (2)$$

3.2. Indicator Description

In this paper, port cargo throughput (10000 tons), fixed asset investment (10000 yuan), industrial wastewater discharge directly into the sea(10,000 tons), coastal passenger throughput(10000 passengers), marine social practitioners(person) were selected as the input indicators, and the total output value of marine industry(100 million yuan) as the output indicators. The data are from the statistical system of marine economic operation of Jiangmen and the statistical yearbook of marine economic data of China over the years. The time span is from 2011 to 2015, and the specific data are shown in Table 1.

3.3. Analysis of Empirical Results

Matlab software was used to realize DEA-C2R model and super-efficiency DEA model, and the efficiency values in different years were calculated and compared and analyzed respectively. The results are shown in Table 2.

It can be seen from Table 2 that the comprehensive efficiency value of marine economic development in Jiangmen City in 2011 was 0.601, with the lowest efficiency value.

For years with an efficiency value of 1, the C2R model cannot further distinguish its size, but the super-efficiency DEA model can. According to the calculation results of super efficiency, the decision-making units of each year were sorted. The results are shown in Table 2. In 2015, the super efficiency value of Marine economic development of jiangmen ranked first, with the efficiency value of 1.769. In 2014, the super efficiency value ranked the second, with the efficiency value of 1.0395. In 2012, the super efficiency value ranked the third, with the efficiency value of 1.0258. The efficiency values in 2012 and 2014 are not much different, but compared with the efficiency values in 2011, 2012 is a new starting point for the development of the marine economy in Jiangmen City, and there was a qualitative leap in 2015.

Table 1 Evaluation index data of marine economic development efficiency of Jiangmen city

DMU	**Input indicators**					**Output indicators**
Year	Port cargo throughput	Fixed asset investment	Industrial wastewater directly discharged into the sea	Coastal passenger throughput	Marine social practitioners	Total output value of marine industry
2011	5914	7419441	68.99	20.04	25868	353.02
2012	6211	8504108	68.17	16.63	27086	673.29
2013	6737	10008408	91.64	17.04	27694	759
2014	7352	11116497	71.4	15	27461	857.95
2015	7525	13078743	44.6	14.812	26879	948.03

Such remarkable achievements in the development of the marine economy in Jiangmen City are inseparable from the introduction and implementation of the following measures.
The twelfth five-year plan period is a key period for Jiangmen city to accelerate the development of marine economy. As the 2011 "Guangdong Marine Economy Comprehensive Experimental Zone Development Plan" and "Guangdong Marine Economic Development Pilot Work Plan Implementation", Jiangmen" edge "coastal development strategy is put forward, using the long coastline, abundant port resources, foreign economic relations and convenient advantage, according to drive big industry chain formed by industry leading idea, promote the great development and new breakthroughs in the marine economy.
The results of Jiangmen 's marine economic development efficiency evaluation prove that the efficiency value in 2012 is about twice that of 2011. It can be seen that the above measures of Jiangmen have come into effect and produced a significant effect. The relevant policies have a significant effect on supporting the development of the marine economy. It is worth further experimentation and promotion.

4. ANALYSIS OF FACTORS INFLUENCING THE DEVELOPMENT OF MARINE ECONOMY IN JIANGMEN CITY

As there are many factors that affect the efficiency of the development of the marine economy, various factors are intertwined with each other, creating an intricate relationship, making it difficult to assess the efficiency of the development of the marine economy in Jiangmen. In order to explore the correlation and influence of various factors on the economic development efficiency of Jiangmen, this section takes input indicators as independent variables and super-efficiency values as dependent variables, and uses grey correlation and ridge regression methods to construct the development efficiency of Jiangmen's marine economy influencing factors assessment model, identifying key influencing factors, and effectively digging out the driving force of Jiangmen 's marine economic development efficiency, thus providing a basis for formulating further efficiency improvement policies.

4.1. Grey Correlation Analysis

Using grey correlation analysis method, the super-efficiency value is used as the reference sequence, expressed by Y, and the input index data is used as the comparison sequence, and expressed by $Xi(i = 1,2,\cdots,5)$, which measures the input index and the efficiency of Jiangmen 's marine economic development. The correlation coefficient and degree of correlation are shown in Table 3.
It can be seen from Table 3 that the correlation degree is ranked as follows: fixed asset investment > port cargo throughput> industrial wastewater directly discharged into the sea> Marine social practitioners > coastal passenger throughput. This shows that the fixed asset investment amount is most closely related to super-efficiency, and the degree of closeness of the remaining index factors and super-efficiency decreases in turn.

4.2. Ridge Regression Analysis

Taking 5 input indicators as independent variables and super-efficiency as the dependent variable for ridge regression analysis, the value is 0.01, and the model R^2 value is 0.846, which means that the 5 input indicators can explain the 84.6% change in super-efficiency. When the model is tested, it is found that the model passes the F test($F = 2.835, p = 0.039 < 0.05$), which means that at least one of the five input indicators will affect the super efficiency.
The final ridge regression model equation obtained according to Table 4 is:
$$Y = 1.047X1 + 1.544X2 - 0.814X3 + 0.445X4 + 0.796X5$$
The amount of industrial wastewater discharged directly into the sea will have a significant negative impact on super efficiency. The remaining variables have a positive influence on the super efficiency of the dependent variable.

Table 2 Evaluation of marine economic development efficiency of Jiangmen city

DMU	Comprehensive efficiency	Technical efficiency	Scale efficiency	Super efficiency	Rank
2011	0.601	1	0.601	0.601	5
2012	1	1	1	1.0258	3
2013	0.978	0.987	0.991	0.9783	4
2014	1	1	1	1.0395	2
2015	1	1	1	1.769	1

Table 3 Correlation degree results

Evaluation item	Correlation	Rank
Port cargo throughput	0.69	2
Fixed asset investment	0.76	1
Industrial wastewater directly discharged into the sea	0.673	3
Coastal passenger throughput	0.609	5
Marine social practitioners	0.663	4

Table 4 Ridge regression analysis

Variable	Regression coefficients
constant	0
Port cargo throughput	1.047
Fixed asset investment	1.544
Industrial wastewater directly discharged into the sea	-0.814
Coastal passenger throughput	0.445
Marine social practitioners	0.796
R2	0.846
F	F=2.835，p=0.039
Dependent variable: Super efficiency Y	
* p<0.05 ** p<0.01	

5. POLICY RECOMMENDATIONS

According to the measurement results of Jiangmen 's marine economic development efficiency and analysis of its influencing factors, policy recommendations are proposed from the following four aspects. One is to increase the investment in fixed assets related to the ocean and speed up the construction of marine infrastructure; the second is to accelerate the introduction of marine scientific research and teaching institutions and train high-level marine practitioners; the third is to solidly promote the management of water ecological protection and attach great importance to water pollution prevention ; the fourth is to highlight the cultural characteristics of overseas Chinese hometowns, build marine brands, and develop marine tourism.

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