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Research Article

Efficiency Measurement and Determinant Factors of Marine Economy in China: Based on the Belt and Road Perspective

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Analyzing the evolution characteristics and influencing factors of marine economic efficiency is the foundation to improve the quality of marine economic development. A super-efficiency Slacks-Based Measure (SBM) model is applied to measure the marine economic efficiency of 11 coastal provinces between 2006 and 2017 in China. Time series and standard deviation ellipse methods are used to analyze its temporal and spatial characteristics. The influencing factors of efficiency are analyzed using the Bayesian model averaging (BMA) method based on the indicator system constructed on the relationship between the *Belt and Road* and marine economic efficiency. The research found that (1) the average change of marine economic efficiency is not large, and the efficiency values among most provinces are relatively stable. (2) The center of gravity of marine economic efficiency gradually shifts from the northeast to the southwest; the spatial scope continues to shrink, the level of flatness indicates increase at first followed by decrease, and the direction angle shows a fluctuating trend. (3) The compliance rate of industrial wastewater discharge and the diversification of the marine industry structure have strong explanatory capacity in marine economic efficiency in the coastal areas. This research proposed the specific path to improve the efficiency of marine economy and facilitate quality development under the "Belt and Road" initiative from the aspects of the optimization of the marine industry structure, the integrated construction of transportation, the development of opening to the outside world, the progress of marine science and technology, and the improvement of the marine ecological environment.

1. Introduction

The eastern coast of China carries 40% of the population with 13% of the land area and creates more than 65% of the GDP. However, the gross marine economic output accounts for only 9% of GDP, which shows a significant gap compared with 15% of GDP, the highest marine economy among the world marine powers.

In response to changes in the global situation, taking into account the strategic direction of land and sea and coordinating the overall international and domestic situation, China proposed *the Belt and Road Initiative* in 2013. In 2017, the national policy emphasized on focusing on the construction of *the Belt and Road*, insisting on both importing and exporting, forming an open pattern of land-sea domestic and foreign linkages and east-west mutual assistance, and setting the new requirements and a higher starting point for the development of the marine economy in coastal areas. In 2019, China proposed at *the Second Belt and Road International Cooperation Summit Forum* that the promotion of *the Belt and Road Initiative* is inseparable from the construction of a global connectivity partnership. It can be seen that *the Belt and Road Initiative* has brought China the dual opportunities of a large international land channel as well as a large maritime transportation channel, which provided China with strong support for accelerating the development of the marine economy in coastal areas. As a "great bridge" for the Chinese economy to the world, the marine economy is an important part of the coastal economy, and its position in national development strategy has steadily improved. It is becoming a new growth point for Chinese economic development.

However, the rapid development of the marine economy has inevitably increased people's intervention in the ocean, and marine resources, environment, and ecology have been severely damaged. Under the background of the new normal of the marine economy, there is a need for scientific and quantitative research on the efficiency of the marine economy, exploring the ineffective links of its marine efficiency and seeking effective ways to improve the quality of marine economic development, in order to strengthen the Chinese marine economy and maritime power construction.

Therefore, in the context of the significant imbalance between the input and output of marine production factors, starting from the role of the *Belt and Road Initiative* on the marine economy, there is a need to accurately grasp the key influencing factors of the changes in marine economic efficiency and analyze the direction and extent of their influence. It is of great significance for improving the quality of marine economic development, speeding up achieving the strategic goal of maritime power, and ensuring the smooth implementation of the *Belt and Road Initiative*.

This study intends to select a super-efficiency Slacks-Based Measure (SBM) model to measure marine economic efficiency and analyze its temporal and spatial pattern evolution characteristics. Based on the influence mechanism of the *Belt and Road* on marine economic efficiency, a marine economic efficiency impact index system is established to analyze the factors influencing efficiency and contributing causes by application of the Bayesian model averaging (BMA) approach. It aims to provide a theoretical basis to identify the influencing factors of marine economic efficiency, improve the construction of the *Belt and Road*, and realize the high-quality development of the marine economy.

2. Literature Review

2.1. The Belt and Road and the Marine Economy. Since the *Belt and Road* was put forward, it has had a significant impact on the Chinese national economy from many aspects. Studies have found that the political connection of leaders can affect the infrastructure investment, industrial structure changes, and economic growth of the source or related regions through the implementation of fiscal, monetary, financial, and foreign trade policies [1, 2]. The improvement of transportation infrastructure and traffic density along the *New Silk Road* economic belt will help play a positive role in promoting trade and boost the integrated development of the regional economy [3]. The strong cooperation with the infrastructure construction of the countries along the *Belt and Road* can effectively promote the reconstruction of the global value chain [4].

The smooth implementation of the *Belt and Road Initiative* will not only promote the overall balance of the Chinese eastern, central, and western regions of the economy but also provide a diversified medium of cooperation for facilitating and liberalizing the world economy and trade [5]. It can strengthen appropriate trade policy communication with countries along the route and enhance the stability of bilateral trade settlement. The initiative will help China and the countries along the route to jointly construct a mutually beneficial and win-win trade growth pattern and effectively promote economic cooperation among the countries along the route [6]. From the current point of view, the intensive marginal expansion has shown a significant promotion effect on the investment of the *Belt and Road Initiative* [7]. The leading role of finance in the *Belt and Road Initiative* must be fully exerted. Attention must be paid to improving the efficiency and quality of finance in countries along the route and deepening the financial cooperation between China and countries along the route [8]. It can be seen that *the Belt and Road* construction has laid a solid foundation for regional economic development to shift from quantity growth to quality improvement.

With the development of research, scholars have introduced relevant theories about the impact of the *Belt and Road Initiative* on economic development in the marine field and researched the impact of the *Belt and Road Initiative* on the marine economy. It was pointed out that the *Belt and Road*, as China caters to the deepening of reform and opening-up, advocated the reconstruction of ocean awareness and encourages people to actively develop and utilize the ocean and breakthrough geographical barriers to walk into the world economic network [9].

It was emphasized that the implementation of the *Belt and Road Initiative* was a manifestation of the arrival of the land-sea economy era and provides an essential platform for China and countries along the route to carry out blue economic cooperation and construct "blue partnership" [10]. Some other scholars pointed out that the *Belt and Road* is intended to adhere to land-sea coordination and mutual benefit, and the key to its smooth implementation lies in the promotion of the status and role of the marine economy [11]. The *Belt and Road* is applied to develop the marine economy and achieve land-sea overall planning which is the core means of Chinese progressive geostrategic [12]. By analyzing the economic development of coastal node cities and the coordinated development of port and city, it is found that, after removing the influence of common trends and impacts, the net effect of the policy of the *Belt and Road* is negative [13]. The expansion of development levels, transportation infrastructure construction, and optimization and upgrading of the marine industry structure are the main aspects of marine economy development under the *Belt and Road* [14]. It can be seen that the continuous advancement of the *Belt and Road* initiative is conducive to the maritime economic cooperation between China and countries or regions along the route. The continuous strengthening of maritime economic cooperation between countries has also pointed out the direction for China to better plan the construction of the *Belt and Road* and then attract more maritime countries to participate.

2.2. Marine Economic Efficiency. The intensity of marine resource consumption and the pressure on the marine ecological environment continue to increase, which has seriously affected the output benefits of marine production factors [15]. Theories of economic efficiency are gradually introduced into the marine field. Evaluation methods mainly include DEA, SFA, SBM, and Malmquist. The research content mainly focuses on the efficiency of single marine industry and the overall efficiency of the marine economy.

At the efficiency level of the single marine industry, it was found that the growth rate of comprehensive technical efficiency of the fishery industry was significantly lower than that of fishery GDP and was mainly contributed by scale efficiency [16, 17]. Through methods such as the transformation of production and output constraints, it can effectively improve scale efficiency and increase the output efficiency of marine fisheries. Some scholars have gradually extended the efficiency theory to industries such as marine transportation, marine shipping, and coastal tourism. Talley [18] and Pablo et al. [19] analyzed the economic efficiency of ports and found that there is a negative relationship between port scale and economic efficiency. Pang [20] and Sun and Xiao [21] further found that the key to reducing port scale efficiency was caused by redundant input and low output efficiency. Yu and Pan [22] and Zhou and Guan [23] analyzed the efficiency values of the marine transportation industry, marine shipping industry, and coastal tourism and found that pure technical inefficiency was a reduction in overall technical efficiency, which is the direct cause that leads to regional differences.

The research results on the overall efficiency of the marine economy are mostly domestic. Scholars mainly combined their research themes and used models such as data envelopment analysis (DEA) and SBM to select marine employees, marine capital stock, port cargo throughput, etc., as input variables, and the added value of the marine economy as output variables. The efficiency is measured and calculated to obtain the changing rules of efficiency accurately. Marine industrial structure, resource environment, science and technology, and regional openness are the key to the formation of marine economic efficiency [24–26]. Due to the in-depth research, some scholars classified environmental factors into the evaluation system of marine economic efficiency. The green efficiency and ecological efficiency of the marine economy became research hotspots [27, 28].

By sorting out the existing literature, it is found that the research on the development of the marine economy by the *Belt and Road* is also relatively wealthy, but further improvement is needed in the following two aspects. On the one hand, the research on the impact of the *Belt and Road Initiative* on marine economic efficiency is blank. On the other hand, the efficiency-influencing factors selected by different scholars are different, and the conclusions drawn by different analytical frameworks are quite biased and lack specific theoretical support.

The review of existing literature found that scholars are relatively mature in the research on the influencing factors of marine economic efficiency and affirmed the important impact of the *Belt and Road* on the development of the marine economy, and the research on the development of the marine economy in the context of the *Belt and Road* is relatively rich. But it was mainly concentrated on the impact of the *Belt and Road* on the regional economy and marine economic efficiency. There were few studies on the impact of the *Belt and Road Initiative* on the efficiency of the marine economy.

Given this, this study applies the super-efficiency SBM model to measure the marine economic efficiency of coastal provinces and uses time series and standard deviation ellipses to analyze the characteristics of temporal and spatial patterns. A marine economy efficiency impact index system is constructed based on the relationship between the *Belt and Road* and marine economic efficiency. The research not only provides a theoretical basis for choosing a suitable coastal area marine economic development model, formulating macroeconomic policies for the marine economy, and promoting the construction of the marine economy but also pointing out the direction for coastal areas to use the *Belt and Road Initiative* to achieve high-quality marine economic development goals.

3. Research Method

3.1. Theoretical Framework. The construction of the *Belt and Road* will promote the all-round development strategy of countries along the route, promote the free flow and optimal allocation of production factors such as talents, technology, and capital, improve the output efficiency of factors, and improve the quality of economic development. Marine economic efficiency is a measure of the ability of marine labor and capital to transform into the gross marine product and an essential manifestation of the output benefits of production factors. The *Belt and Road Initiative* brings significant opportunities to the eastern region. It is necessary for coastal areas to establish the relationship between the *Belt and Road* construction and marine economic efficiency from multiple perspectives such as industry, transportation, trade, technology, and environment to seek a double-win cooperation path. The specific relationship is shown in Figure 1. The detailed description is as follows.

(1) With the continuous advancement of the *Belt and Road* construction, the "One Road" regional development platform will be completed, and the regional integrated development pattern of the coastal marine economy will gradually be shaped [11]. The advantages of the marine industry foundation, labor force, and market in the eastern region will be highlighted. They promote the upgrading and transformation of the marine industry structure, thereby realizing reasonable allocation of marine production factors and improving the output efficiency of the marine economy.

(2) The key to constructing *the Belt and Road* lies in constructing infrastructure such as aviation, high-speed rail, and ports [13]. It is necessary to build a comprehensive transportation network as a guide,

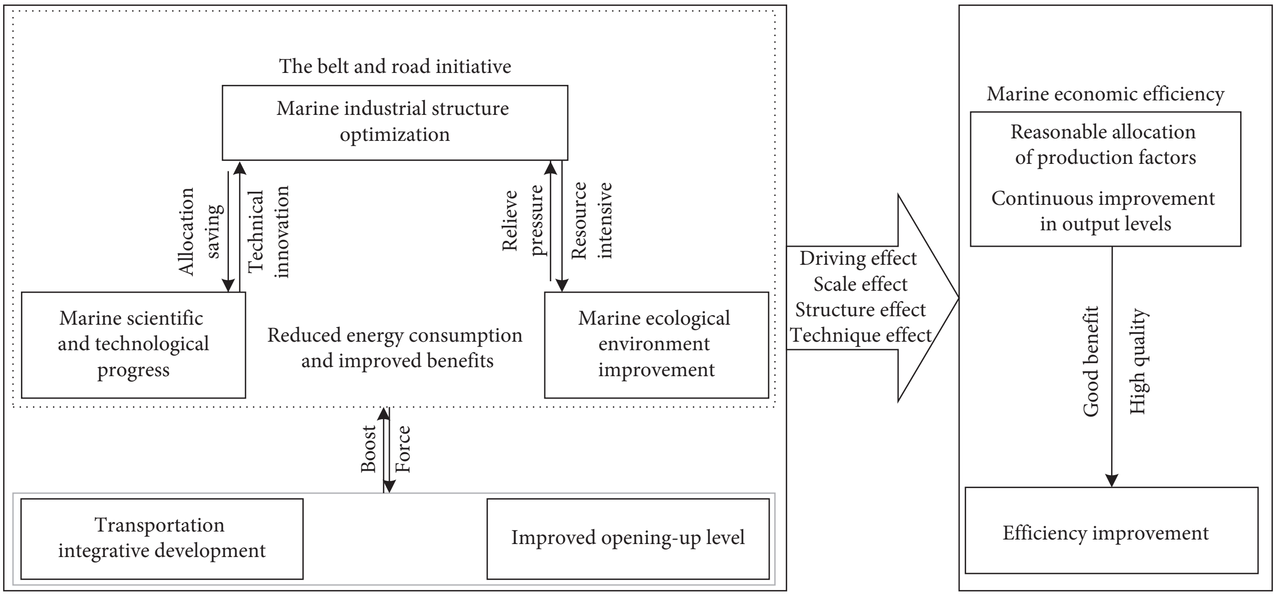

Figure 1: The mechanism of the *Belt and Road Initiative* on marine economic efficiency.

plan the interconnection layout of the countries along the route, and form a diversified, multilevel international cooperation channel. The network will deepen international cooperation in transportation, promote the facilitation of investment and trade, and maximize the social welfare of humankind.

(3) Trade opening-up and investment opening-up are the two main aspects of opening to the outside world. The promotion of the *Belt and Road* strategy will not only help open up the logistics, trade, and investment channels between the eastern region and southeast Asia but also accelerate the exploration of open economic development. The pace of system reform also laid the foundation for Chinese participation in the future development model of economic globalization and international division of labor [7].

(4) Relying on the major strategic opportunities of the *Belt and Road*, China will actively cooperate with countries along the route to build marine science and technology parks and jointly cultivate high-tech marine science and technology talents, gradually establishing a stable long-term partnership [9]. China would take advantage of the favorable conditions for international exchange and cooperation of marine science and technology and give full play to marine science and technology to the marine economy.

(5) The intensity of marine environmental protection and marine pollution control and the rational use of marine resources are the prerequisites for transforming the marine economy to quality and efficiency. The concept of the 21st Century Maritime Silk Road emphasizes the green development path and promotes organic integration with the construction of marine ecological civilization [10]. The Chinese government proposes to participate in the global marine ecological environment governance system actively and jointly implement marine ecological environmental protection actions with countries along the route. It will provide high-quality marine ecological services, ensure the ecological safety of global oceans, and reduce the marine economy's undesired output through strong ecological constraints.

3.2. Model Development

3.2.1. Super Efficiency SBM Model. The DEA model is a commonly used method for efficiency estimation. Its basic idea is to obtain more output with minimal input. It is mainly measured from radial and angular perspectives. There is no need for the preset production function. It can effectively avoid the bias of function form setting. Due to insufficient consideration of the slackness of input and output, the accuracy of the measured efficiency value is insufficient. Tone proposed the SBM model in 2001, which effectively solved the traditional DEA model [29]. The model made the efficiency value conform to the strictly monotonous decreasing law by changing the level of relaxation. Besides, the traditional DEA model analysis method will cause multiple decision-making units to be useful simultaneously, and the resulting efficiency values are not greater than 1, while the effective decision-making units on the frontier are all at 1. It is difficult to distinguish further and the problem of sorting. Andersen and Petersen proposed a super-efficiency DEA model in 1993 [30]. The core idea is to remove the evaluated decision-making unit from the reference set. The efficiency value of the invalid decision-making unit remains unchanged, and the efficiency value of the effective decision-making unit refers to other decision-making units. The efficiency of the composition is obtained along the surface, which effectively solves the problem of sorting the efficiency values of the traditional DEA model. Tone combined the SBM model and super-efficiency DEA model to construct a super-efficiency SBM model [31], distinguishing effective decision-making units based on slack variables.

3.2.2. Bayesian Model Averaging Method. In 1978, the Bayesian model averaging (BMA) method was an effective method to solve model uncertainty [32]. An average model is obtained mainly by setting prior information and probability of explanatory variables, and it calculates the posterior inclusion probability of potential explanatory variables with the assistance of relevant information of the dataset to judge the relative importance of each explanatory variable. The details are as follows.

Consider the general multiple linear regression model $y = \alpha + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_k x_k + \varepsilon$. In the model, y is the marine economic efficiency, x is the explanatory variable set that affects marine economic efficiency, k is the number of explanatory variables, α is the constant, β is the coefficient, and ε is the error term $\varepsilon \sim N(0, \sigma^2)$. If $M = \{M_1, M_2, \ldots, M_N\}$ is a model space that is arbitrarily constructed by k explanatory variables, there are models of $N = 2^k$. The BMA method is employed to estimate each model to obtain the posterior probability and statistical coefficient indicators of each explanatory variable and mark M_j as one model in M, and the prior probability of M_j is $P(M_j)$, and based on Bayesian theory, calculate the posterior probability of the model M_j:

$$P\left(M_j | y, X\right) = \frac{P\left(y | M_j, X\right) P\left(M_j\right)}{P(y|X)} = \frac{P\left(y | M_j, X\right) P\left(M_j\right)}{\sum_{i=1}^{2^k} P\left(y | M_i, X\right) P\left(M_i\right)}. \quad (1)$$

In the above formula, X is a matrix of explanatory variables of k, and $j = 1, 2, \ldots, N$. It can be seen that the weighted average of the prior probability of the model is the posterior probability of the model. So the relevant statistical indicators of regression coefficients of each explanatory variable can be obtained [33], including posterior inclusion probability (PIP), posterior mean (PM), and posterior variance (PV). Among them, the value of PIP indicates the relative importance of each explanatory variable, the sign of the PM value reflects the direction of action of the explanatory variable, and the absolute number of the ratio of PM to posterior standard deviation reflects the explanatory ability of the explanatory variable. Besides, it should be emphasized that different models, prior parameter probabilities, and model space sampling methods will all affect the final result of BMA estimation.

3.3. Data Source and Variable Description. The research takes the panel data from 11 provinces along the coast of China between 2006 and 2017 as the research object. The data involved are drawn from the Chinese Marine Statistical Yearbook, Chinese Statistical Yearbook, and Statistical Yearbooks of coastal areas.

3.3.1. Selection of Variables for Ocean Economic Efficiency Measurement.

(1) Input variables: comprehensively, considering the availability and scalability of the data and referring to the research by Wang and Zhai [24] and Zhao et al. [26], maritime-related employees and marine capital stock are regarded as labor and quantitative capital indicators, which are used as super-efficiency SBM model input variables. Regarding the data on maritime-related employees, since the statistics in the Marine Statistical Yearbook have been the number of maritime-related employees in coastal areas since 2006, it can be obtained directly from the Yearbook. The marine economic capital stock draws on the method proposed by He et al. [34], which uses the ratio of GOP to GDP in coastal areas to convert the capital stock in coastal areas. As for the capital stock of coastal areas, the method proposed by Zhang et al. [35] is applied. Based on the perpetual inventory method, the current capital stock of coastal provinces in 2005 is calculated with a depreciation rate of 10.96%. Then, it is combined with the total fixed asset in each region to calculate in turn the current capital stock between 2006 and 2017. Finally, the fixed asset price index is applied to convert the capital stock of each period into a comparable capital stock with the year of 2006 as the base period.

(2) Output variables: corresponding to the Gross Domestic Product (GDP), the Marine Economic Gross Ocean Product (GOP) is a total indicator that reflects the level of regional marine economic development. Referring to the practice of Ji and Wang [36], the added value of marine economy in coastal provinces is applied as the output variable in the super-efficiency SBM model, and the constant price in 2006 is adopted to deflate it to remove the effect of price factors.

3.3.2. Selection of Influencing Factors for Marine Economic Efficiency. Based on the analysis of the mechanism of the *Belt and Road Initiative* on the efficiency of the marine economy, the influencing factors of the marine economy under the *Belt and Road Initiative* are selected in line with the principles of scientificity, operability, and comparability of the evaluation indicators (see Table 1).

(1) Marine industry structure: based on the research by [37, 38], the rationalization, diversification, and advancement of the marine industrial structure are selected to reflect the optimization of the industrial structure. Among them, rationalization is obtained by quantifying the proportion of each industry as an entropy coefficient, diversification is obtained by the weighted average of the proportions of the tertiary industry, and advancement is obtained by the ratio of the added value of marine tertiary and secondary industries.

Table 1: Drivers of marine economic efficiency under the *Belt and Road Initiative*.

Variable category	Variable name	Variable code
Marine industrial structure	Marine Industrial Structure	*MISI*
	Marine Industrial Structure Diversification	*MISD*
	Marine Industrial Structure Upgrading	*MISU*
Transportation integration	Transport Network Density	*TND*
	Transportation Investment Scale	*TIS*
Level of opening-up	Import and Export Trade Proportion	*IETP*
	Outward Foreign Direct Investment Proportion	*OFDIP*
	Foreign Direct Investment Proportion	*FDIP*
Marine science and technology	Marine Scientific and Technological Achievements Conversion Rate	*MSTACR*
	Marine High-level Talents Reserve	*MHTR*
	Marine Research Institutions Density	*MRID*
	Marine Scientific and Technological Innovation Level	*MSTIL*
Marine ecological environment	Industrial Wastewater Discharge Control Rate	*IWDCR*
	Industrial Solid Waste Comprehensive Utilization Rate	*ISWCUR*

(2) Transportation integration: combined with the research of [3, 4], the density of transportation network and investment are selected to determine the space-time cost of transportation and the utilization of regional industrial advantages, reflecting the development of integrated transportation. Among them, the density of the transportation network is obtained by the weighted average of the density of roads, railways, inland rivers, and aviation, and the scale of transportation investment is measured by the proportion of transportation expenditures in public financial expenditures.

(3) The level of opening-up: based on the research by Pei [39], trade opening and investment development are selected to reflect the level of opening-up. Trade opening is measured by the proportion of total import and export trade in GDP. Investment opening selects foreign direct investment as a percentage of GDP. The proportion is measured.

(4) Marine science and technology: based on the research of [40, 41], indicators such as the conversion rate of marine scientific and technological achievements, the reserve of high-level talents, the density of scientific research institutions, and the level of scientific and technological innovation are selected to reflect the development of marine science and technology. The innovation level of marine science and technology here is calculated by the weighted average of the number of topics, patents, and articles undertaken by marine science and technology institutions, and the reserve of marine high-level talents is measured by the proportion of marine postgraduates in school.

(5) Marine ecological environment: more than 80% of total marine pollution in China comes from the land. Industrial wastewater that does not meet the set standards or industrial solid waste that has not been effectively treated is the source of sea pollution. Concerning the practices of [27, 42], the rate of compliance of industrial wastewater discharge and the rate of comprehensive utilization of solid waste were selected to measure marine ecological environmental protection.

4. Result and Discussion

4.1. Time Characteristics of Marine Economic Efficiency. With the assistance of MaxDEA software, a variable return to scale, nonoriented super-efficiency SBM model is selected to calculate the marine economic efficiency values of 11 coastal provinces in China between 2006 and 2017, and the change trends of efficiency across the country and provinces are plotted, as shown in Figure 2.

It is easy to see that the national average of marine economic efficiency has not changed much between 2006 and 2017, and they are all on an effective frontier. From the perspective of the changes in the marine economic efficiency of the province, Tianjin and Jiangsu have become highly efficient in 2008 and 2009, respectively, after the low efficiency in the initial years. The efficiency value of Fujian Province has shown high efficiency since 2014. Zhejiang Province has always been in a state of low efficiency, and the efficiency values of other regions have always been on an effective frontier. The reason is that, from 2006 to 2008, China actively advocated the construction of a "resource-saving and environment-friendly" society, and the eastern coastal areas successively introduced relevant measures for energy saving and emission reduction. However, the export-oriented marine economy was hit by a financial crisis that suffered strong impact, by which the intensive effect of marine economic development has been hindered.

From 2009 to 2012, China was transitioning from the "Eleventh Five-Year" period to the "Twelfth Five-Year" period. The "National Science and Technology Support Plan," "863," and "973" plans were launched one after another. The scale effect and supporting the capacity of marine science and technology have been releasing continuously. "Transformation and structural adjustment" has become the focus of marine economic growth. However, the foam effect caused by mandatory investment in the marine industry, while accelerating the optimization and upgrading of the marine industry, harms marine resources and ecological environment, which hindered the development of the

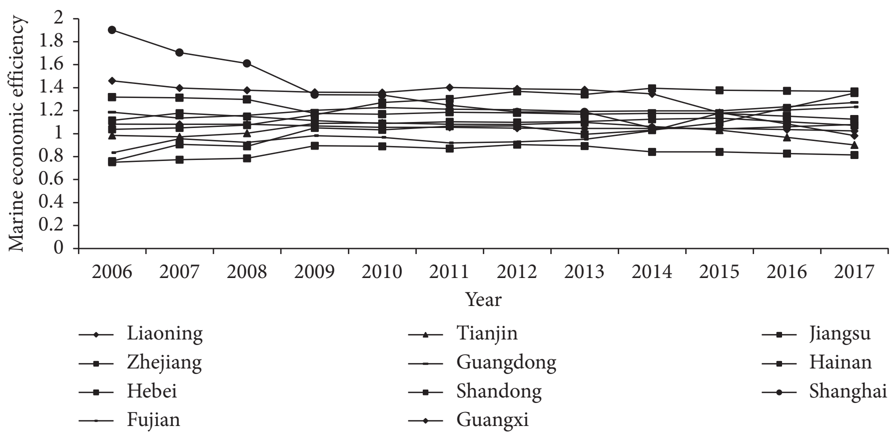

Figure 2: The changing trend of marine economic efficiency in coastal provinces between 2006 and 2017.

marine economy. Thus, the efficiency of the marine economy experienced several slight fluctuations during the period between 2006 and 2012. Between 2013 and 2017, the efficiency value showed a slightly negative growth trend, mainly due to the continuous advancement of maritime power strategy and the *Belt and Road Initiative*. Coastal areas have regarded the marine economy as the focus of regional development, and three major marine economic circles have gradually formed. The radiation-influencing effect of the economy on coastal and hinterland has become increasingly prominent. It should be noted that the previous "reclamation of sea and land" project has caused severe damage to marine resources and the ecological environment and has a certain negative effect on marine economic efficiency during this period.

4.2. Spatial Features. ArcGIS 10.5 software is used to calculate the basic parameters of the standard deviation ellipse of marine economic efficiency in coastal provinces from 2006 to 2017. The spatial pattern characteristics of marine economic efficiency are analyzed in terms of center of gravity, scope, shape, and direction.

From the changes in the center of gravity in Figures 3 and 4, from 2006 to 2017, except for a few years, the overall marine economic efficiency gradually moved from northeast to southwest with overall movement of 142.6 km. It showed an east-west movement of 83.9 km and a north-south movement of 97.34 km. Among them, during 2006–2010 and 2013-2014, it mainly moved to the southwest. During 2014–2017, it moved south, indicating that the output efficiency of marine production factors in the Yangtze River Delta and Pan-Pearl River Delta has been steadily improving. From the perspective of the range and shape changes in Figure 5(a), the overall spatial range of marine economic efficiency shows a shrinking trend. Compared with 2006, the range of efficiency distribution in 2017 decreased by about 4.07%, indicating that the growth rate of regional marine economic efficiency in the interior ellipse is significantly faster than that of the outer ellipse. The shape change is characterized by the degree of flatness, showing a changing trend of "increasing first and then decreasing." Among them, the flatness index dropped from 0.332 in 2006 to 0.318 in 2009. It then quickly increased to 0.349 in 2017, which shows that the efficiency value growth rate of the area distributed in the long axis direction of the ellipse is higher than that of the short axis direction. The higher efficiency growth rate in the Pan-Pearl River Delta region drives the efficiency standard deviation ellipse to expand southward. From the perspective of the change in the direction in Figure 5(b), the spatial direction angle of marine economic efficiency in China during the observation period increased from 23.04° in 2006 to 23.18° in 2017, showing overall fluctuating characteristics.

The abovementioned spatial pattern changes are strongly related to geographic location, marine industrial structure, and policy environment. For example, Liaoning Province in Bohai Rim is relatively backward in terms of environmental protection and resource optimization, and its comprehensive utilization rate of industrial solid waste is only 38%. Hebei Province, dominated by mineral resources and steel industry, suffers severe marine resources and environmental problems. Shandong Province, where the fishery is the leading industry, consumes lots of marine biological resources, which has severely affected the marine economic efficiency of the Bohai Rim. The Yangtze River Delta region has benefited from better geographical location advantages and land economic foundation. With the continuous advancement of national strategies such as the *Belt and Road* and the *Yangtze River Economic Belt*, the development of the green marine economy has been significantly accelerated. The efficiency of the marine economy has been significantly improved. Fujian Province in the Pan-Pearl River Delta region has always had preferential policies given by the state and has an excellent marine economic foundation. During *the* Eleventh Five-Year Plan and Twelfth Five-Year Plan period, it pays more attention to the development of marine emerging industries and has good marine resources and environmental benefits. Hainan Province has abundant marine resources and is dominated by the "high-yield, low-polluting" marine tertiary industry. However, due to the impact of marine disasters and disputes of rights, efficiency improvement is slow. The improvement of marine economic efficiency in other regions

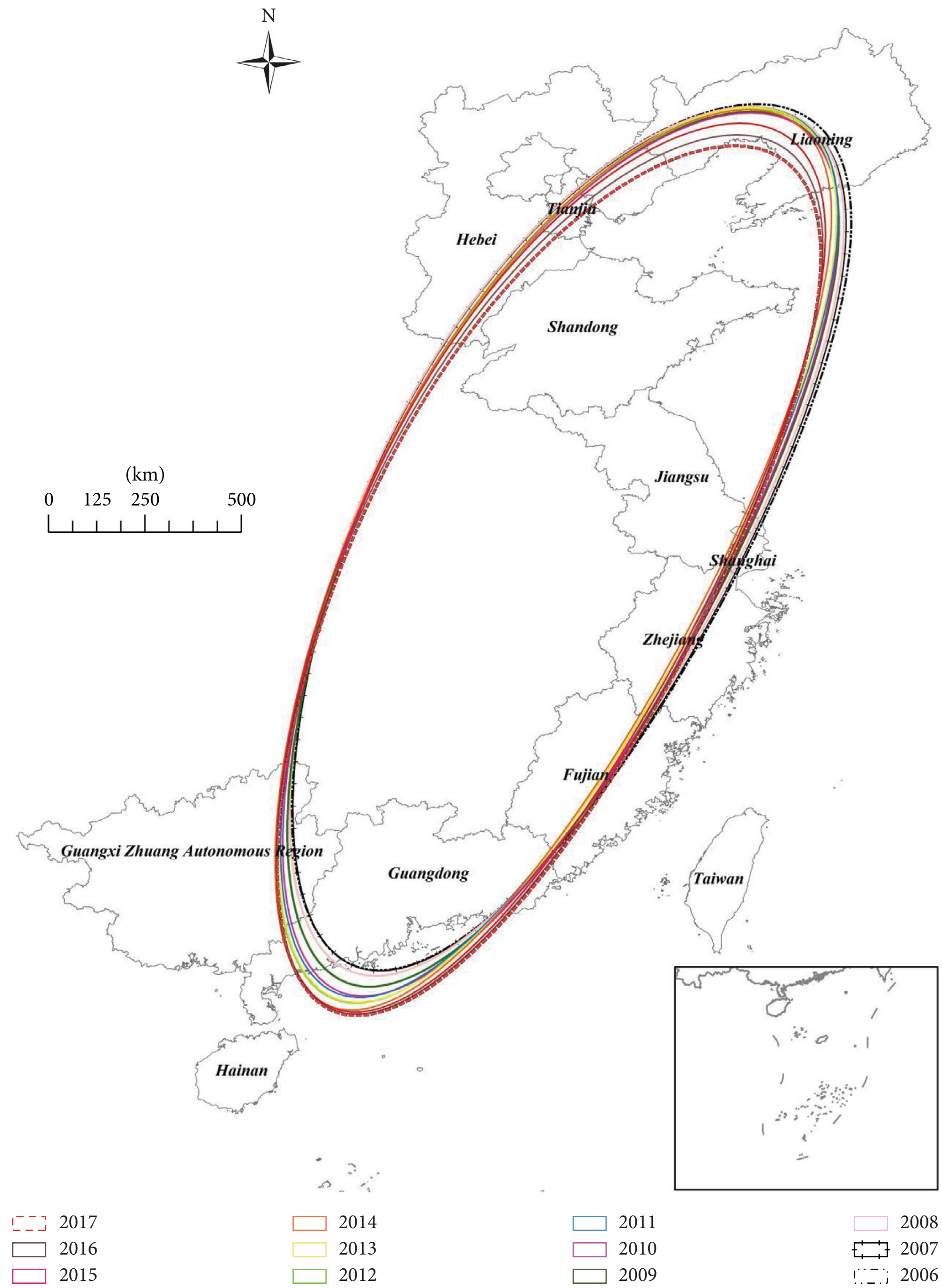

FIGURE 3: The spatial change of the center of gravity of marine economic efficiency between 2006 and 2017: ellipse distribution.

such as Zhejiang and Guangdong has benefited from the superior marine industrial structure and the scale effect and technology-induced effect brought by the input of marine production factors such as the number of sea employees and marine capital stock.

4.3. Drivers of Marine Economic Efficiency. Given the regional differences in natural resource endowments, land economic foundations, industrial development policies, and spatial interactions, the unbalanced development of the coastal marine economy is more prominent. The same explanatory variable produces a different-level impact on the efficiency of each regional marine economy. Concerning geographical locations of the South (including Fujian Province, Guangdong Province, Guangxi Zhuang Autonomous Region, and Hainan Province), Centre (including Shanghai, Jiangsu Province, and Zhejiang Province), and North (including Hebei Province, Liaoning Province, Tianjin City, and Shandong Province), the observation objects are divided into regions. From regional perspectives, the marine economy's efficiency is estimated by BMA to

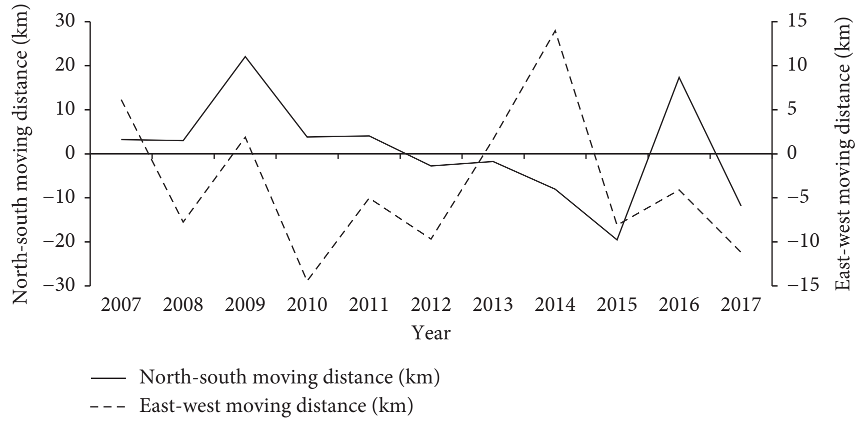

Figure 4: The offset distance of the center of gravity of marine economic efficiency between 2007 and 2017.

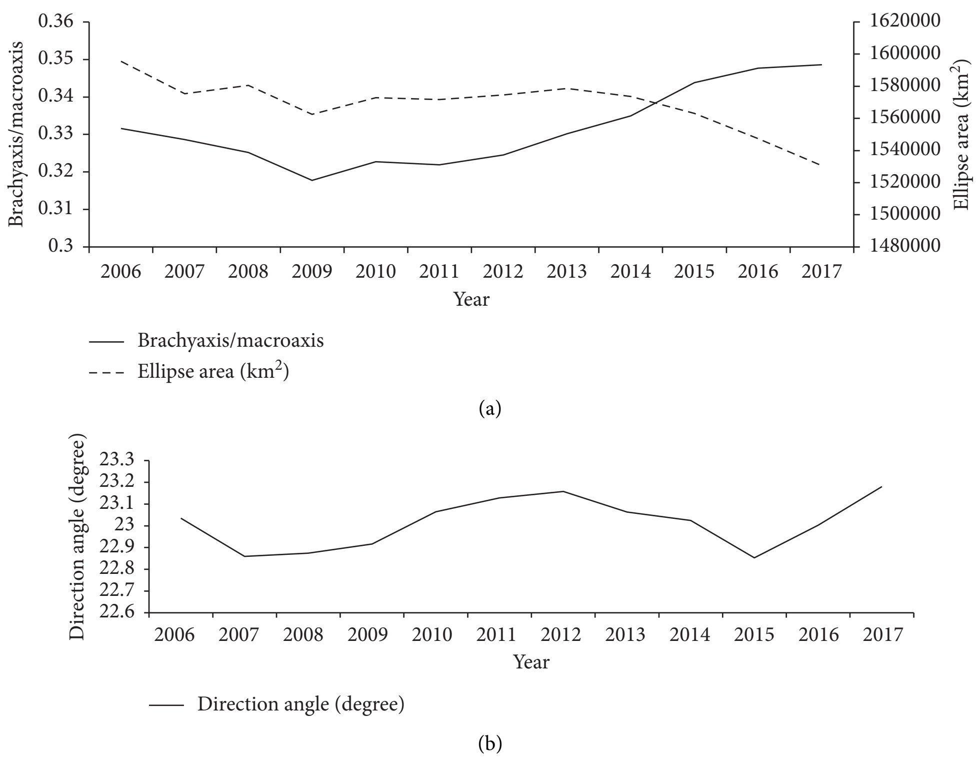

Figure 5: Change trends of marine economic efficiency between 2006 and 2017. (a) Changes in range and shape. (b) Changes in direction angle.

formulate developmental policies by local governments based on local conditions.

Regarding marine economic efficiency as the explained variable, the influencing factors mentioned above act as an explanatory variable, and a total of 16,384 candidate models are formed. The R software is used to call the BMS software package that integrates the BMA method and MC^3 sampling technology. In the premise of the model obeying random prior probability and hyperparameters, the BMA estimation results of the determinant factors of regional marine economic efficiency are obtained, as shown in Table 2.

(1) From the perspective of marine industry structure variables, the efficiency of the marine economy in the southern and central regions is hugely dependent on diversification, advancement, and rationalization of the marine industry structure and a strong positive effect. The northern region is strongly dependent on the diversification of the industrial structure. The proposal of the *Belt and Road Initiative* has fully released the advantages of marine resources, geographical location, and economic foundation of core coastal cities. It has a strong effect on improving the

Table 2: BMA regression results of influencing factors of regional marine economic efficiency.

Variate	South part			Middle part			North part		
	PIP	PM	PV	PIP	PM	PV	PIP	PM	PV
ISWCUR	99.67%	−0.323 6	0.085 7	7.20%	0.000 3	0.023 8	19.96%	−0.030 4	0.081 3
MISD	100%	−2.048 4	0.229 0	94.35%	−6.52	2.741 9	79.15%	0.259 3	0.041 9
MSTIL	98.24%	0.008 0	0.086 7	12.89%	0.011 2	0.047 1	12.30%	0.002 1	0.042 3
MISI	99.91%	−1.644 2	0.363 3	93.82%	−1.397 5	0.627 9	11.69%	0.001 5	0.051
MISU	99.90%	1.051 9	0.244 0	97.46%	2.771 7	1.266 6	14.47%	−0.019 8	0.071
MHTR	97.66%	0.489 0	0.148 8	0.67%	0.000 1	0.011 4	2.52%	0.006	0.04
IETP	99.99%	−1.192 1	0.253 5	13.27%	−0.021 8	0.100 9	93.23%	−0.517 9	0.199 6
TND	71.57%	0.170 5	0.147 6	17.93%	0.080 3	0.232 2	11.11%	0.002 9	0.057 2
FDIP	58.23%	−0.118 8	0.144 8	14.71%	−0.021 8	0.079 6	93.06%	0.448 7	0.178 6
TIS	30.36%	−0.012 9	0.051 6	84.88%	−0.311	0.183 8	9.19%	0.002 7	0.034 5
IWDCR	99.90%	−0.359 9	0.082 8	77.78%	−0.150 8	0.013 4	99.36%	−0.437 8	0.150 2
OFDIP	60.14%	0.092 8	0.104 7	10.31%	0.005 7	0.044 3	66.58%	−0.140 5	0.121 3
MRID	0.61%	0.000 7	0.024 0	27.94%	−0.069 5	0.148 3	14.65%	−0.012 9	0.091
MSTACR	0.75%	0.000 6	0.011 5	16.20%	0.022 1	0.068 8	9.33%	0.006 9	0.045

Note: PIP, PM, and PV represent posterior inclusion probability, posterior mean, and posterior variance.

efficiency of the marine economy. Further analysis found that, except for Guangdong and Shandong, other neighboring provinces with close GDPs have a small gap in marine economic GDP, but the industrial structure difference is noticeable. For example, Zhejiang and Fujian have a higher level of advanced industrial structure. The industrial structure has been formed earlier, making the southern and central regions have similar effects on the efficiency of the marine industrial structure. The northern region is overly dependent on the pull of marine primary and secondary industries, and the problem of overexploitation of marine resources is serious. The level of rationalization and advancement of the industrial structure is relatively backward, and the ability to explain efficiency is unobvious.

(2) From the perspective of transportation integration variables, the density of the transportation network promotes the efficiency of the three major regions to varying levels. The southern region has the most substantial dependence on the density of transportation network; the scale of transportation investment in the central region reflects strong explanatory ability (84.88%) and adverse effect (−0.311). The reason for this is that most of the southern cities are located in Guangdong Province, where the intercity traffic correlation is relatively strong and the spatial spillover effect of the marine economy is more significant. Lianyungang and Yancheng in the middle and Cangzhou, Dandong, Binzhou, and other cities in the north have transportation infrastructure, and the level of its interconnection and interoperability is low. The regional transportation master plan still needs to be improved, resulting in a weaker influencing force for radiation from Tianjin and Shanghai. The *Belt and Road Initiative* has increased investment in transportation projects in coastal areas, especially the Yangtze River Delta and Guangdong. However, public finances cannot afford the long-term, high-investment, and high-risk transportation infrastructure construction. Private participation in the investment and financing model gradually dominates. The substantial investment competitiveness of the central region is the main reason for its strong negative effect on marine economic efficiency.

(3) From the perspective of variables such as the level of opening to the outside world, the explanatory capacity of all variables on the efficiency of the marine economy in the central region is between 10% and 20%. The explanatory capacity and adverse effects of trade opening on the efficiency of the southern and northern regions are more significant. The explanatory capacity of foreign direct investment in the northern region is relatively strong. The explanatory capacity of foreign direct investment in the southern and northern regions is between 60% and 70%. In the early stage of reform and opening-up, foreign investment in China was mostly concentrated on the southeast coast. With the development of Pudong, the policy advantages enjoyed by the Pearl River Delta gradually disappeared, and the foreign direct investment performance index in coastal areas gradually declined. The central region thoroughly enjoyed the dividends brought by Shanghai constructing an international economic, trade, financial, and shipping center. The past export experience will help increase eastern coastal area investment in countries along the *Belt and Road.* Besides, the Chinese economic structure and growth model have inherent shortcomings, making the development of the marine industry not keep pace with the level of trade and investment, leading to traditional industries dominating the foreign investment industry. The degree of integration with the world economy still needs to be improved. Thus, the positive effect of marine economic efficiency needs to be further explored.

(4) From the perspective of marine science and technology variables, the southern marine scientific and technological innovation level and high-level talent reserves have a substantial impact on marine economic efficiency. The central and northern parts are similar, and all variables have less than 30% explanatory capacity for marine economic efficiency. The reason is that the layout of Chinese marine scientific research institutions is characterized by the spatial pattern of the North being more important than the South. Since the *Belt and Road Initiative* was put forward, China has paid more attention to the growth of the total marine economy in the short term, which has led the marine industry sector to commit to scaling expansion. More than half of the institutions engaged in marine basic scientific research are different from the actual needs of the regional marine industry. Among them, the southern region is more obviously driven by the radiation of central cities such as Shanghai and Guangzhou, enjoying a higher level of marine technology and a complete platform for transforming scientific and technological achievements, and most regions have high technical efficiency. The cities such as Tangshan, Qinhuangdao, Qinhuangdao, Panjin, and Yancheng in the central and northern regions lack government support and intervention. The lack of investment in scientific research and innovation motivation weakened the marine technology spillover effect in core cities, and the overall technical efficiency level was not prominent.

(5) From the perspective of marine ecological environment variables, the industrial wastewater discharge compliance rate has a strong explanatory capacity and negative effect on the marine economic efficiency of the three major regions. The comprehensive utilization rate of industrial solid waste has a high explanatory capacity of 99.67% for the efficiency of the southern region. The northern and central regions do not exceed 20%, and both show adverse effects. The *Belt and Road* construction has promoted the rapid development of the coastal industrial economy. Although the growth rate of industrial wastewater and solid waste discharge in various regions has been declining year by year, but affected by the environmental governance model of the heavy end, light source, and weak cycle, land-source sewage is discharged into the sea. The phenomenon of excessive discharge and substandard monitoring has become severe, and nearly 40% of solid waste cannot be effectively used. For example, the discharge of industrial wastewater and solid waste per GOP in Liaoning, Hebei, Jiangsu, Guangxi, and other places has been above average. The total solid waste utilization rate in Hebei, Guangxi, Hainan, and Fujian is less than 80%. The Pearl River Delta region with better industrial bases actively introduces advanced foreign capital technology and management to promote industries with high technological content and low environmental pollution.

It can be seen that, during the study period, the industrial wastewater discharge compliance rate and the PIP of the marine industrial structure diversification were both greater than 77%, and the corresponding absolute numbers of the posterior mean and standard deviation ratios were both greater than 1.1. Both have the strong explanatory capacity in marine economic efficiency. Further analysis of the variables that have a strong negative effect on the efficiency value found that the southern region needs to tap the potential of the transformation rate of marine scientific and technological achievements and the density of marine scientific research institutions. The central region needs to pay attention to the impact of the marine high-level talent pool. The northern region needs to focus on stimulating the effect of the marine tertiary industry on the marine economy.

5. Conclusions and Recommendations

This study takes the panel data of 11 coastal provinces in China as a sample between 2006 and 2017. It applies the super-efficiency SBM model to measure the marine economic efficiency and analyzes its temporal and spatial pattern evolutionary characteristics. Then, the marine economic efficiency-influencing indicator system is established based on the impact of the *Belt and Road* mechanism on marine economic efficiency. At last, it adopts the BMA method to analyze efficiency-influencing factors and causes. It provides a theoretical basis for advancing the construction of the *Belt and Road* and achieving the goal of high-quality marine economic development, also it provides advice on promoting marine economic efficiency in coastal areas, choosing appropriate development models, and formulating macroeconomic policies for the marine economy. The results show the following:

(1) The average change of the national marine economic efficiency during the observation period is not large. The efficiency values of most provinces are relatively stable. The overall efficiency center of gravity is gradually shifting from the northeast to southwest, and the spatial scope was in shrinking trends. The flatness level shows "increase at first followed by decrease," and the direction angle indicates a fluctuating trend.

(2) The compliance rate of industrial wastewater discharge and the diversification of the marine industry structure have a robust explanatory capacity in marine economic efficiency in the three major regions. The southern region needs to tap the potential of the transformation rate of marine scientific and technological achievements and the density of marine scientific research institutions. The central region needs to pay attention to the role of the marine high-level talent pool. The northern region needs to

focus on the role of the marine tertiary industry in pulling the marine economy.

In specific practice, it is necessary to start from various factors that affect the efficiency of the marine economy and combine the level of impact and the direction of action to comprehensively improve the quality of marine economic development. The specific approaches are as follows:

(1) Facilitating the optimization of the marine industry structure: based on the characteristics of rationalization, diversification, and advanced nation of the marine industrial structure of each province, appropriate marine industry development goals will be formulated. With the development trend of the world's marine fisheries, the marine aquaculture industry should be developed to reduce the contribution of traditional marine fisheries to marine economic growth. With the progressing of technology and achievement transformation of the marine industry, the marine industry would be built with strong brands and excellent technology, to improve the added value and efficiency of the marine secondary, grasp the "service" function of the marine tertiary industry, scientifically determine the development scale of the marine tertiary industry, and avoid blindly pursuing the increase in the value of the industrial proportion. For example, for Tianjin, Shanghai, and Guangdong, there is a need to break the trend of centralized development of a single marine industry; for Liaoning, Shandong, Jiangsu, Zhejiang, and Fujian, there is a need to focus on the diversified development of marine industries, and for Hebei and Guangxi, there is a need to focus on increasing marine labor productivity.

(2) Strengthening the construction of integrated transportation: based on the *Belt and Road* policy guarantee function, there is a need to fully release the advantages in the prioritized areas of facility connectivity, attach importance to the investment and construction of transportation infrastructure, accelerate the realization of international interconnection in the transportation field of coastal areas, and enhance the radiation and driving capacity of the marine industry to achieve marine production factors to effectively flow around the world. Regarding the transportation industry as the basic industry and tourism and port industry as advantageous industries, gradually build the eastern port industry cluster, resource development industry belt, and tourism industry belt to strengthen the dominant position of the marine industry. For example, for the coastal areas of Liaoning, Hebei, and Jiangsu, there is a must to continuously improve the overall transportation planning, increase investment, fully play the leading role of the surrounding areas with higher accessibility, and strive to improve the connectivity of the eastern coastal transportation infrastructure.

(3) Improving the opening-up level of the marine economy: in order to promote the construction of the *Belt and Road* as the top-level design of China's economic diplomacy and a key guideline for opening-up, we should focus on alleviating the shortage of land resources, breaking through resource bottlenecks, and expanding development space. We should also make full use of the advantages of coasts opening to the outside world and absorb optimized allocation methods for marine economic production factors and advanced ocean management concepts from other countries or regions. Under the new development pattern of "circulation," we should match the cooperation for the double win with the essential connotation of "opening," take the matching and reform of both supply and demand sides as the starting point to cater to the market demand for marine high-tech and high value-added market, and change the traditional labor-intensive, primary product marine industry supply model. Besides, we also need to optimize the structure of marine foreign trade and cultivate new momentum for marine trade, continue to enhance the status of maritime foreign trade in services, and finally achieve the purpose of enhancing the positive impact of opening-up on the growth of marine economic efficiency.

(4) Promoting the progress of marine science and technology: combined with the short-, medium-, and long-term development plan of marine science and technology, we should allocate the national marine science and technology resources scientifically, improve the unreasonable layout of marine scientific research institutions, and pay attention to the problems of obvious regional advantages and weak scientific research force. The coastal regions should be encouraged to strengthen human capital investment, improve the induction system of high-level marine talents, train high-quality marine scientific and technological personnel, enhance the cooperation between "politics, industry, university, and research" in coastal cities, which aims to change the current unitary marine technological research and developmental model, encourage enterprises and universities or scientific research institutions to jointly establish marine technology research and development centers, and share scientific and technological patent dividends employing capital or technology shares. Also, it needs to fully exert the radiative and driving function of the three major coastal city clusters, relies on the flow of talents and technology transfer, promotes the effective application of marine scientific and technological resources, improves the efficiency of the marine economy, and builds the eastern coastal zone full of modern science and technology vitality.

(5) Contributing to the improvement of the marine ecological environment: it is advocated to use the *Belt and Road* to strengthen marine cooperation with other countries in the field of marine environmental protection and restoration, marine endangered species protection, marine environmental pollution prevention, marine acidification, etc., adhere to the principle of “jointly protecting and avoiding large-scale development” to formulate a sustainable marine development strategy from the overall situation, strengthen the development of marine economic management and planning, and ensure the coordinated development of marine economy, society, and ecology with the “large-scale, paid, and orderly” marine industry. We should also need to establish a land-sea linkage pollution prevention mechanism to strictly control the increase in pollution sources and improve the ecological carrying capacity of shorelines and beaches. Besides, there is a need to participate in global marine environmental governance action actively, relying on the idea of systematic governance and multiple forces to improve the efficiency of marine ecological environment governance and force the efficient development of marine resources through ecological environmental constraints and promote the marine economy to take quality and benefit-oriented development path.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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References

[1] Z. Y. Fan, F. Peng, and C. Liu, “Political connections and economic growth: evidence from the DMSP/OLS satellite data,” *Economic Research Journal*, vol. 51, no. 1, pp. 114–126, 2016.

[2] L. Y. Song, X. B. Wang, and X. X. Xu, “Local officials induce structural change,” *China Economic Quarterly*, vol. 12, no. 1, pp. 71–92, 2013.

[3] Y. H. Liu and X. Wang, “Transportation infrastructure and regional economic integration of the “new Silk road” economic belt—an empirical analysis of gravity model,” *Journal of Xi’an Jiaotong University (Social Sciences)*, vol. 34, no. 2, pp. 43–48+80, 2014.

[4] X. Lu and Y. Liang, “Infrastructure construction under the “belt and road initiative” and global value chain reconstruction,” *China Economic Studies*, vol. 54, no. 1, pp. 11–26, 2020.

[5] Z. Q. Liu and Y. Zhang, “The belt and road initiative and the rebalancing of China’s economy to the outside world,” *Hubei Social Sciences*, vol. 10, pp. 78–84, 2017.

[6] Z. F. Liao, T. Li, and Y. J. Cheng, “Trade obstacles and potential between China and the countries along “the belt and road”, ” *Shanghai Journal of Economics*, vol. 37, no. 1, pp. 77–85, 2017.

[7] Y. Lyu, Y. Lu, S. B. Wu, and Y. Wang, “The effect of the belt and road initiative on firms’ OFDI: evidence from China’s greenfield investment,” *Economic Research Journal*, vol. 54, no. 9, pp. 187–202, 2019.

[8] G. Q. Ren and L. Liu, “Evaluation of financial efficiency for countries along “the belt and road”,” *Economic Geography*, vol. 38, no. 6, pp. 109–116, 2018.

[9] Z. M. Zhang and L. M. Hu, “Three-dimensional ocean awareness construction enhancement under the “belt and road” strategy,” *Study & Exploration*, vol. 38, no. 4, pp. 33–40, 2016.

[10] M. B. Chen and L. M. Han, “Driving factors, areas of cooperation and mechanisms for international cooperation in the blue economy of the 21st-century maritime Silk road,” *Strategic Study of CAE*, vol. 18, no. 2, pp. 98–104, 2016.

[11] Y. P. Zhang and L. Zhang, “Promoting the belt and road initiative with land-sea coordination,” *Pacific Journal*, vol. 27, no. 2, pp. 63–70, 2019.

[12] X. Li and J. J. Li, ““One belt and one road” and the reshaping of China’s geopolitical and geo-economic strategy,” *World Economics and Politics*, vol. 29, no. 10, pp. 30–156, 2015.

[13] B. Lu, W. Q. Qiu, J. Xing, and I. Moon, “Coordinated development strategy of China’s coastal node ports and cities base on assessment of Belt and Road,” *Systems Engineering-Theory & Practice*, vol. 40, no. 6, pp. 1627–1639, 2020.

[14] G. W. Zhang and S. G. Liu, “The 21st Century maritime Silk road: strategic connotation, jointly building mechanism and promoting path,” *Pacific Journal*, vol. 25, no. 8, pp. 73–80, 2017.

[15] W. J. North, “Biomass from marine macroscopic plants,” *Solar Energy*, vol. 25, no. 5, 1980.

[16] L. Xu, *The Research on Change of Marine Fisheries Green Total Factor Productivity and Convergence of China’s Coastal City-Based on Dynamic Malmquist Model*, Ocean University of China, Qingdao, China, 2015.

[17] T. D. T. Pham, H. W. Huang, and C.-T. Chuang, “Finding a balance between economic performance and capacity efficiency for sustainable fisheries: case of the Da Nang gillnet fishery, Vietnam,” *Marine Policy*, vol. 44, 2014.

[18] W. K. Talley, “Optimum throughput and performance evaluation of marine terminals,” *Maritime Policy & Management*, vol. 15, no. 4, 1988.

[19] C. M. Pablo, B.-P. Jose, and R.-A. Ana, “Economic efficiency in Spanish ports: some empirical evidence,” *Maritime Policy & Management*, vol. 27, no. 2, 2000.

[20] R. Z. Pang, “Dynamic evaluation of main sea ports in mainland China based on DEA model,” *Economic Research Journal*, vol. 41, no. 6, pp. 92–100, 2006.

[21] C. Z. Sun and S. Xiao, “Relative efficiency evaluation of the port economy in the coastal provinces and cities based on DEA method,” *Areal Research And Development*, vol. 28, no. 1, pp. 32–36, 2009.

[22] J. K. Yu and J. Pan, “Performance analysis on the marine communications and transportation industry in China based on the super-efficiency DEA-malmquist model,” *Marine Economy*, vol. 5, no. 5, pp. 3–12, 2015.

[23] Z. W. Zhou and H. B. Guan, "Analysis of total factor productivity and influencing factors in China's shipbuilding industry: based on industrial environment perspective," *Ocean Development and Management*, vol. 36, no. 1, pp. 114–120, 2019.

[24] Y. Y. Wang and R. X. Zhai, "Adjustment of marine industrial structure, spatial spillover and coastal economic growth—analysis based on the spatial panel data of China's coastal provinces," *Journal of Nantong University(Social Sciences Edition)*, vol. 36, no. 1, pp. 97–104, 2020.

[25] W. Zou, C. Z. Sun, and X. H. Qing, "Spatial evolution of marine economic efficiency and its influential factors in Bohai sea ring area based on bootstrap-DEA model," *Scientia Geographica Sinica*, vol. 37, no. 6, pp. 859–867, 2017.

[26] X. Zhao, Y. Peng, and L. L. Ding, "An analysis of the spatial patterns of marine economic efficiency and its influencing factors in coastal provinces of China," *Journal of Yunnan Normal University (Philosophy and Social Sciences Edition)*, vol. 48, no. 5, pp. 112–120, 2016.

[27] L. L. Ding, H. H. Zheng, and X. M. Liu, "Production efficiency, environmental governance efficiency and comprehensive efficiency of marine economy in China," *Forum on Science and Technology in China*, vol. 34, no. 3, pp. 48–57, 2018.

[28] Q. M. Yuan, W. L. Zhang, and D. Feng, "An analysis of Chinese marine economic efficiency change and productivity change under constraints of resources and environment," *Economic Survey*, vol. 33, no. 3, pp. 13–18, 2016.

[29] K. Tone, "A slacks-based measure of efficiency in data envelopment analysis," *European Journal of Operational Research*, vol. 130, no. 3, 2001.

[30] P. Andersen and N. C. Petersen, "A procedure for ranking efficient units in data envelopment analysis," *Management Science*, vol. 39, no. 10, 1993.

[31] K. Tone, "A slacks-based measure of super-efficiency in data envelopment analysis," *European Journal of Operational Research*, vol. 143, no. 1, 2002.

[32] E. Leamer, *Specification Searches: Ad Hoc Inference with Nonexperimental Data*, John Wiley and Sons Incorporated, New York, NY, USA, 1978.

[33] Z. Y. Ke, "The economic performance and influencing factors of listed firms in Chinese GEM stock market," *The Journal of Quantitative & Technical Economics*, vol. 34, no. 1, pp. 146–161, 2017.

[34] G. S. He, L. L. Ding, and W. Song, *Theory, Methods, and Practice of Marine Economic Analysis and Assessment*, Ocean Press, Beijing, China, 2014.

[35] J. Zhang, G. Y. Wu, and J. P. Zhang, "The Estimation of China's provincial capital stock: 1952–2000," *Economic Research Journal*, vol. 39, no. 10, pp. 35–44, 2004.

[36] J. Y. Ji and Q. Wang, "A study on the marine economic efficiency and its influencing factors in China based on stochastic frontier analysis model," *Journal of Ocean University of China (Social Sciences)*, vol. 25, no. 1, pp. 43–49, 2018.

[37] Z. Y. Wang, M. Y. Guo, C. Z. Sun, and Li. Bo, "The evaluation of modern marine industry development levels," *Resources Science*, vol. 37, no. 3, pp. 534–545, 2015.

[38] C. H. Gan, R. G. Zheng, and D. F. Yu, "An empirical study on the effects of industrial structure on economic growth and fluctuations in China," *Economic Research Journal*, vol. 46, no. 5, pp. 4–16+31, 2011.

[39] C. H. Pei, "The effect evaluation on Chinese expansion openness under economic new normal," *Economic Research Journal*, vol. 50, no. 4, pp. 4–20, 2015.

[40] D. H. Liu, M. Xu, C. J. Wang, and X. X. Li, "Research on the marine science and technology resource allocation in China," *Science & Technology Progress and Policy*, vol. 33, no. 21, pp. 32–39, 2016.

[41] C. Z. Sun, K. M. Guo, and W. Zou, "The coordination and response between regional marine economy and marine science and technology in China," *Resources Science*, vol. 39, no. 11, pp. 2017–2029, 2017.

[42] H. Li, Q. Gao, and F. Wu, "Ecological environment response to marine economy development and the influence factors in Bohai Bay Rim Area," *China Population, Resources and Environment*, vol. 27, no. 8, pp. 36–43, 2017.