Prediction of Marine Economy based on Grey Relational Degree

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Abstract: The prediction of the Marine economy has important significance for the development of Marine industry, and a convenient prediction method is necessary for planning to marine economy. This article calculated the grey relational degree between Marine economy and Marine science and technology by the data for the year of 2006-2016, and finds that Marine economy and Marine science and technology are closely related, and we took the main influencing factors as the independent variables and the gross ocean product as the dependent variables, the Marine economy is predicted according to the linear regression equation. The prediction results of this article showed that the average relative error of the test results of the prediction equation filtered by indicators is reduced to less than 10%, and the prediction results after indictors filtering are better than the results of indictors are unfiltered.

1. Introduction

In recent years, more attention has been paid to the development of marine economy. As we all know, the practice of economic and social development shows that there is a strong interaction between technological innovation and economic development, as well as between marine science and technology and marine economy. With the increasing strategic position of the ocean in the sustainable development of national economy, prediction of marine economy is a necessary thing for discussing. Also, a reliable and stable prediction model plays an important role in planning to the development of marine economy.

About the Research on the correlation of economy, scholars have carried out in-depth discussion on it. In recent years, scholars have studied and discussed the correlation from different perspectives，such as the industrial Development, policy analysis, natural resources, research and development productivity and so on [1,2,3]. For the correlation analysis of marine science and technology and marine economy, some scholars have studied and analyzed the relationship between them from the marine academic production, knowledge transfers and academic spillovers, perspectives of marine industry development, marine sustainable development, resource consumption and so on [4,5,6]. Most of the scholars have analyzed the relationship between marine science and technology and marine economy from a static point of view by building the index system, using principal component analysis, comprehensive index, analytic hierarchy process and other methods [7]. According to the economic growth theory, some scholars use the VAR model, Spatial Durbin model and other econometric models for the dynamic analysis from the perspective of time and space [8]. About the prediction of economic development, in recent years, scholars at home and abroad mainly use the combination of economic growth theory and linear regression equation, grey system theory, neural network and other methods. They also combined the big data and artificial intelligence, through weight optimization to get a better result, the method of multi-model combination on prediction has attracted more and more attention in those years [9, 10, 11]. The stability of the combined forecasting model is better than the single model and the prediction error is smaller.

For the prediction of marine economy, some scholars used a single model, and some scholars used the combined model for prediction, but it is too complicated. This article tries to find a simple

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and convenient prediction method by combining grey relational degree with multiple linear regression. Based on the grey relational model, this article analyses the correlation between the marine science and technology and marine economy in various regions, and finds out the main influencing factors according to the grey relational degree, then forecasts the marine economy through the multiple regression equation.

2. Grey Relational Analysis

Grey theory was put forward by Chinese Professor Deng Julong. Grey relational analysis is not only an important part of grey system theory, but also the cornerstone of grey system analysis, prediction and decision-making. Grey relation analysis is often used to measure the similarity of the trend of development for each system elements. If the similarity of the trend is high, the grey relation degree of the two elements is high. In this article, the gray correlation analysis is used, mainly considering the complex relationship between the two systems of marine science and technology and marine economy. Through the Grey relational analysis, the overall development trend of the system is analyzed. There is no need for too much samples, and the highly practical value, which is suitable for the study of this article.

2.1. Evaluation Indicator System

The evaluation indicator system of marine science and technology mainly selects the indicator from science and technology investment and output. Investment indicators for science and technology include the number of scientific research institutions, the number of scientific research practitioners, the income of scientific research funds and other indicators. The output of science and technology is mainly analyzed from the number of research subjects, published papers and patents. Also, in the article, we used the gross ocean production as the development level of marine economy.

Table 1. The indicator system of marine science and technology.

The investment in science and technology	The number of scientific research institutions X_1
	The participants' number of science and technology activities X_2
	Participants with the senior title in science and technology activities X_3
	The ratio of participants with senior titles in science and technology activities X_4
	Total funds for scientific research institutions X_5
	Per capita of research total funds for scientific research institutions X_6
The output in science and technology	The number of research subjects in scientific research institutions X_7
	The number of research subjects for application X_8
	The ratio of research subjects for application to total subjects X_9
	The number of the published papers X_{10}
	The number of scientific and technological works X_{11}
	The number of applications accepted for patent X_{12}

2.2. Computational procedure of Grey relational degree

In this article, the data in the evaluation indictor system of marine science and technology is taken as the comparison sequence x_0, and the gross ocean product of the past years is taken as the reference sequence x_i. Then to do the standardized, data standardized processing to eliminate the influence of dimension on the model. Then we should calculate absolute difference between x_0 and x_i with the formula (1). Then to calculate the correlation coefficient of each indicator at different time with formula (2). And next we can1get the grey relational degree with formula (3).

$$\Delta_i(k) = \left\{ \left| x_0(k) - x_i(k) \right| (i = 1, 2, ..., m; k = 1, 2, ..., n) \right\} \tag{1}$$

$$\delta_i(k) = \frac{\min_i \min_k |x_0(k) - x_i(k)| + \beta \max_i \max_k |x_0(k) - x_i(k)|}{|x_0(k) - x_i(k)| + \beta \max_i \max_k |x_0(k) - x_i(k)|} \tag{2}$$

$$r_i = \frac{1}{n} \sum_{i=1}^{n} \delta(k) \tag{3}$$

In the formula (2), $\delta_i(k)$ is the Difference between comparison sequence and reference sequence in the moment of k. β is the resolution coefficient, and based on the experience, we think β=0.5 in this article[12]. In the formula (3), r_i is the grey relational degree for indictor i, n is the number of samples.

2.3. Results of the Grey relational analysis

The object of study in this article is the coastal provinces in China. Based on the availability of getting data, the data for 2006-2016 used in this article are from the *China Ocean Statistics Yearbook* and the economic statistics bulletins of various cities. The result is shown in the table below.

Table 2. The result of Grey relational degree

Indictors	X_1	X_2	X_3	X_4	X_5	X_6
results	0.771	0.899	0.736	0.772	0.771	0.824
Indictors	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}
results	0.721	0.750	0.731	0.751	0.707	0.807

Table 3. Different ranks of Grey relational degree

Grey relational degree	Ranks
0-0.35	Poor
0.35-0.55	Low
0.55-0.75	Medium
0.75-0.90	Well
0.90-1	Excellent

The grey relational degree of the selected indicators and marine economy is above 0.65, it is reached the medium level or above. From the specific results, the indicator of the participants' number of science and technology activities (X2), Per capita of research total funds for scientific research institutions (X6) and the number of applications accepted for patent (X12) are more than 0.8. Scientific and technological activity personnel represent the human resources input in scientific and technological activities, scientific research funds mean capital input, and the number of patent applications represents the measurement of scientific and technological output.

3. Prediction of Marine Economy

In this article, the multiple linear regression equation is constructed to predict. According to the above calculation results of the grey relational degree, the indicators with the grey relational degree greater than 0.75 are taken as the explanatory variables to be selected, and the gross ocean product is taken as the explanatory variable. SPSS 22.0 software was used for analysis. The data from coastal provinces in China of the year of 2006-2016, we used for training, and the data from the year of 2012-2016 for China were used for predicting. According to the results of t-test and significance level, the explanatory variables in the model are reduced to four, which are the Per capita of research total funds for scientific research institutions (X_6), The number of research subjects for application (X_8), The ratio of research subjects for application (X_9) and The number of the published papers (X_{10}). According to the new model and test results, the final prediction equation is obtained. The fitting degree of the equation is 0.910. The equation is determined as follows:

$$Y = 4.508x_6 + 1.653x_8 - 11.441x_9 + 2.826x_{10} - 433.093 \quad (4)$$

Table 4. The first model for test.

model	t-test	Sig.
constant	-1.008	.315
X_1	1.179	.241
X_2	-.518	.606
X_4	-.576	.566
X_6	8.423	.000
X_8	3.748	.000
X_9	-6.668	.000
X_{10}	6.502	.000
X_{12}	1.029	.306

Table 5. The second model for test.

model	t-test	Sig.
constant	-2.078	.040
X_6	10.505	.000
X_8	6.986	.000
X_9	-8.077	.000
X_{10}	4.394	.000

According to the equation, the data in the past five years are predicted, and the results are compared with the actual values. At the same time, this article compared the result to the prediction results without filtering. The results are shown in the Table 6. According to the result in the table, the errors of the results with filtering are all below 15%, and the relative errors of the predicted values in the other four years are all below 10%, excluding the predicted values in 2012. The average of relative errors of the five-year is 7.65%, less than 10%. However, for the results of direct prediction without filtering, the relative errors of prediction results in 2012 and 2013 are all greater than 20%, and the average of relative errors are also reached 13%.

Table 6. The result of the prediction.

Year	actual values	After filtering		Without filtering	
		prediction	errors (%)	prediction	errors (%)
2012	50172.9	56472.7	12.55	63260.1	26.08
2013	54718.3	58380.3	6.69	65699.5	20.06
2014	60699.1	59698.3	1.65	68234.8	12.41
2015	65534.4	60041.3	8.38	70095.5	6.96
2016	69693.7	63453.1	8.95	70851.5	1.66

4. Conclusion

It can be concluded from the results of grey relational degree that the investment of human resources and capital have a great influence to marine economic growth. In the future, scientific and technological innovation of marine must have a closer relationship with the growth of marine economy. Therefore, we should pay more attention to the investment of science and technology, policy making for attracting researchers. And should pay attention to the quality not only the quantity for the achievements in scientific research.

From the results of prediction, we can know that results of the combination of multiple linear regression equations with selecting the indicators by grey relational degree is better than without filtering, the average of errors for the prediction results is less than 10%. It is considered that this method can better predict the marine economy. Due to the reasons of time, this article only

discusses the preliminary combination of grey relational degree and multiple linear regression. In the future research, we can combine more prediction models and methods, and also can combine the method of parameter optimization, weight optimization and others to find a combination prediction method with better fitting degree and smaller errors.

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