

# The Coupling evaluation model of Marine Industrial Structure and Scientific and Technological Innovation in Shandong Province

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**Abstract.** The relationships between marine industrial structure and technological innovation are mutual influence and interdependence. Their coordinated development plays an important role in the transformation of China's marine economy. By constructing a comprehensive index evaluation system of marine industrial structure and technological innovation, the coupled coordination model is applied to the marine industrial structure and technological innovation of Shandong Province. This paper measures the coupled development status of these, quantitatively evaluate the current status of their collaborative development, and propose corresponding countermeasures.

## 1 Introduction

In recent years, driven by the strategy of marine power, China's marine economic output has grown rapidly, marine scientific research has also achieved breakthroughs in a number of marine industries, and key technologies have achieved independent innovation. However, due to the late start of China's marine industry, there are still some problems in industrial structure, such as uneven development, more prominent isomorphism. From the analysis of these, it can be concluded that marine scientific and technological innovation plays a huge guiding role in the industrial level, and the optimization of marine industrial structure can further effectively exert the ability of scientific and technological innovation. Improving the coupling and coordination between marine industrial structure and marine scientific and technological innovation is of great significance to the implementation of the road of scientific and technological innovation of marine industry with Chinese characteristics.

## 2 Journals reviewed

There are few researches on industrial structure and marine scientific and technological innovation at home and abroad, mainly focusing on the impact of marine scientific and technological innovation on the optimization of industrial structure. Xu Sheng makes a grey correlation analysis on the relevant data of marine industry and innovation drive in 11 coastal provinces and cities in China, and finally concludes that innovation drive is very important for the transformation and development of marine industry 1. Through quantitative analysis, Zhang Meichen and Bu Wei found that there are many problems in China's marine industrial structure, such as isomorphism and unbalanced development. They believe

that the backwardness of marine science and technology is one of the main factors restricting the structure of marine industry. We should improve the efficiency of marine technology innovation and exert the role of marine technology in promoting the upgrading of marine industries 2.

Some scholars have also studied the impact of marine industrial structure on marine scientific and technological innovation. Gao Tianyi and Chang Fei evaluated the scientific and technological innovation efficiency of Qingdao marine economy through data Envelopment Analysis, and found that the low level of industrial structure is the main reason that affects the efficiency of marine scientific and technological innovation. Then he proposed that the efficiency of marine scientific and technological innovation should be improved through the adjustment of industrial structure 3. Kui Bo and others believe that it is necessary to improve China's overall marine scientific and technological innovation capability by changing the mode of marine economic growth, expanding the proportion of secondary and tertiary industries, and developing marine high-tech industries 4. Shen believes that the development of marine emerging industries not only promotes the innovation of marine high and new technology, but also promotes the development of marine economy 5.

The existing achievements generally emphasize the one-way promoting effect of scientific and technological innovation on the optimization of industrial structure, while ignoring the research on the coupling relationship between the development of scientific and technological innovation and the optimization of industrial structure. Based on this, this paper starts from the coupling development of marine scientific and technological innovation and industrial structure, and explores the coupling mechanism and coordinated development degree of the two, which is of great significance to promote the

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industrial transformation and development of coastal areas.

### 3 Index system and data sources

#### 3.1 Construction of index system

First of all, we construct a comprehensive evaluation index system of scientific and technological innovation and industrial structure. Xi Jinping proposed to promote the development of key areas of marine science and technology in the following five aspects: technology and equipment for deep-sea and ocean investigation and exploration, ship technology and far-reaching sea transportation and engineering equipment, new marine materials, biological resources on the polar high seas, and marine science and technology personnel. Based on this, this paper selects 12 representative indicators to construct a comprehensive evaluation system of marine scientific and technological innovation. In terms of the development of marine industrial structure, its optimization and upgrading path should be changed from "primary industrial structure dominated by traditional fishery, low processing industry and low value-added industry" to "secondary industry, tertiary industry, higher processing industry and higher value-added industry"<sup>6</sup>. Based on this, this paper selects the corresponding indicators to construct a comprehensive evaluation system of marine industrial structure from the upgrading and diversification of industrial structure.

The study area is set in Shandong Province. Shandong Province is an important part of national marine development strategy and regional coordinated development strategy. Due to the diversity and richness of marine resources, especially the difficulty of obtaining marine resources, the relationship between marine industry and scientific and technological innovation is getting closer and closer. Therefore, it is of great significance to carry out the research on the coordinated development of industrial structure optimization and scientific and technological innovation in Shandong Province.

Because the dimensions of each evaluation index are different, this paper first uses the range standardization method to deal with the index, and then uses the entropy weighting method to determine the weight of each index. The specific steps will not be repeated in this article, and the weight assignment results are shown in Table 1. Then calculate the comprehensive evaluation index of scientific and technological innovation ((TI)) and the comprehensive evaluation index of industrial structure ((IS)) in Shandong Province from 2006 to 2016.  $TI = \sum_{j=1}^m W_j \times X'_{ij}$  ,  $IS = \sum_{j=1}^m W_j \times Y'_{ij}$  , ( $0 \leq SI \leq 1$ ,  $0 \leq TI \leq 1$ ).  $X'_{ij}$  is the value of the j index of the I year after standardization,  $W_j$  is the weight of the j index.

**Table1.** INDEX SYSTEM Assessment System of Development Level of Marine S&T and Marine Industry

System	Indicators	Index analysis	weight
Scientific and technological innovation	Number of employees in scientific research institutions		0.063
	The proportion of personnel with senior professional titles in technological activities	Senior title personnel / technology activity personnel *100%	0.05
	Per capita funding for scientific research	scientific research funds / employees in scientific research institutions *100%	0.053
	The proportion of the number of achievement application projects	Achievement application project / scientific research institution project *100%	0.098
	Pelagic fishing yield		0.198
	Crude oil production		0.075
	Natural gas production		0.061
	Sea salt yield		0.068
	Chemical products		0.046
	Repair a ship		0.141
	Shipbuilding		0.095
	Freight volume		0.052
Industrial structure	Proportion of marine primary industry	Marine primary industry / GOP *100%	0.073
	Proportion of marine secondary industry	Marine secondary industry / GOP*100%	0.066
	Proportion of marine tertiary industry	Marine tertiary industry / GOP *100%	0.215
	Degree of diversification of marine industry	Entropy value of marine industrial structure	0.137
	Optimization degree of marine industrial structure	(Marine secondary industry + marine tertiary industry) / GOP	0.168
	The proportion of GOP in GDP	GOP/GDP*100%	0.22
Marine industrial structure upgrading index	(marine primary production + 2 * marine secondary production + 3 * marine tertiary production)/100	0.121	

#### 3.2 Data source

The average data in this paper come from China Marine Statistical Yearbook (2007-2017).

## 4 Construction of coupled coordination model

The coupling degree function of scientific and technological innovation and industrial structure is:  $C = \frac{2\sqrt{TI \times IS}}{TI + IS}$ ,  $C \in [0, 1]$ . It can reflect the degree of interaction between marine scientific and technological innovation and marine industrial structure. However, because the coupling degree cannot comprehensively measure whether the system is coordinated in coupling or not, the coupling coordination degree function is further introduced:  $D = \sqrt{C \times T}$ ,  $T = \alpha TI + \beta IS$ ,  $D$  is the degree of coupling coordination,  $C$  is the degree of coupling,  $T$  is the comprehensive coordination index of the system.  $\alpha$  and  $\beta$  are undetermined coefficients, and the values are taken according to the different contribution rates of the system, satisfying  $\alpha + \beta = 1$ . This paper thinks that the importance of scientific and technological innovation and industrial structure is equal, so  $\alpha = \beta = 0.5$ .

**Table2.** Assessment Criteria of Coupling Coordination Degree

type	Coupling coordination degree	Horizontal classification	$\mu=IS/TI$
Uncoordinated development	$0 < D \leq 0.3$	Severe disorder	$\mu > 1.2$
			$0.8 \leq \mu \leq 1.2$
	$0.3 < D \leq 0.5$	Mild disorder	$\mu \leq 0.8$
			$\mu > 1.2$
Transformation and development	$0.5 < D \leq 0.7$	Basic coordination	$0.8 \leq \mu \leq 1.2$
			$\mu \leq 0.8$
	$0.7 < D \leq 1$	Highly coordinated	$\mu > 1.2$
			$\mu \leq 0.8$

## 5 Results and analysis

### 5.1 Analysis of Comprehensive Development level of Subsystem

**Table3.** CALCULATION RESULT

year	TI	IS	C	P	D	$\mu=IS/TI$
2006	0.3539	0.2603	0.9883	0.3071	0.5509	0.7356
2007	0.3317	0.3477	0.9997	0.3397	0.5827	1.0483
2008	0.3306	0.3248	1.0000	0.3277	0.5724	0.9827
2009	0.2837	0.3138	0.9987	0.2988	0.5462	1.1059
2010	0.3003	0.3851	0.9923	0.3427	0.5831	1.2824
2011	0.3397	0.3720	0.9990	0.3559	0.5962	1.0950
2012	0.3461	0.3945	0.9979	0.3703	0.6079	1.1397
2013	0.3864	0.4133	0.9994	0.3998	0.6321	1.0696
2014	0.6186	0.5842	0.9996	0.6014	0.7753	0.9444
2015	0.6182	0.6757	0.9990	0.6469	0.8039	1.0931
2016	0.5299	0.7102	0.9894	0.6201	0.7833	1.3403

As shown in table 3, the comprehensive evaluation index

of marine scientific and technological innovation in Shandong Province is relatively stable from 2006 to 2013, which has been maintained at a level of about 0.35, and achieved a leap in 2014, with an increase rate of 60.1%. Among the indicators, open-water fishing has the largest weight of 0.198. Marine fishery is an important part of marine economy. There has been a general decline in offshore fisheries due to human overexploitation. The open-water fishing has very high technical requirements, and requires a variety of sophisticated equipment to master the currents, water temperature, salinity and other conditions of the operating waters to achieve precision fishing. Since the 12th five-year Plan, China has vigorously promoted the technological innovation of the open-water fishing and has made various breakthroughs. Shandong Province doubled its open-water fishing output in 2014 compared to the previous year, which was inextricably linked to relevant technological developments and innovations. Although the index fell slightly in 2016, it is still higher than the 11-year average.

The comprehensive evaluation indicator of the industrial structure of Shandong Province has been growing steadily, with a maximum increase of 41.4 per cent in 2014. In the indicators of the industrial structure subsystem, the proportion of marine gross domestic product in GDP and the proportion of marine tertiary industry ranks in the top two. Both of them show an increasing trend after 2013, indicating that the industrial structure of Shandong Province is developing well. With the continuous optimization of the marine industrial structure, the proportion of the marine tertiary industry should continue to rise, and the above research results are also consistent with the facts.

It can be seen from table 3 that the growth nodes of the comprehensive evaluation index of the two subsystems are the same, and both achieved a leap in 2014. In 2013, General Secretary Xi Jinping stressed the "four changes" in China's maritime power strategy. This is of great guiding significance to the improvement of the ability of marine scientific and technological innovation and the optimization of industrial structure in Shandong Province.

### 5.2 System coupling coordination time-series change analysis

According to the measured results in the table 3, the coupling degree of marine scientific and technological innovation and industrial structure of Shandong Province fluctuates smoothly and has been maintained at a level of about 1, which belongs to high coupling. It indicates a high degree of interaction and correlation between the two. From the results of the coupling coordination degree, we can see that the coupling coordination degree of Shandong Province in 2006 and 2016 shows an upward trend as a whole. It can be divided into two stages.

The first stage is the transformation and development stage from 2006 to 2013, and the degree of coupling coordination increases from 0.5509 to 0.6321. In 2006, the development of the two systems is not balanced, and it is in the basic coordination stage that the marine scientific and technological innovation is in advance and the marine

industrial structure lags behind. Since then, it has been in the running-in type of basic coordinated development until 2013. The second stage is the coordinated development stage from 2013 to 2016, and the highest value of coupling coordination degree is 0.8039. In 2014 and 2015, the two systems developed in a highly coordinated manner. In 2016, it changed to the advanced development of industrial structure, while the development of scientific and technological innovation lagged behind. Within the scope of the study, Shandong Province has not reached the ideal level of extreme coupling coordination, indicating that there is still room for development. From the perspective of time characteristics, the fluctuation range of coupling coordination degree reached the maximum in 2014, which is consistent with the growth node of the subsystem comprehensive evaluation index. It can be concluded that with the development of marine scientific and technological innovation and the continuous optimization of industrial structure in Shandong Province, the level of coordinated development of the two will be improved. In the process of future development, it is necessary to initiatives in scientific and technological innovation to accelerate the realization of the role of science and technology innovation in promoting the industrial structure.

## 6 Conclusion and suggestion

By constructing the systematic evaluation index system of marine scientific and technological innovation and industrial structure, this paper uses the model of coupling degree and coupling coordination degree. The coupling degree and coupling coordination degree of Shandong Province from 2006 to 2016 are measured. Based on the analysis of the time series characteristics of evolution, the following conclusions are drawn. (1) The marine industrial structure index fluctuated continuously from 2006 to 2016, entered a stage of rapid development in 2014, and reached the maximum in 2016. The marine science and technology innovation index is in a steady state of development, with a large increase in 2014, but declined in 2016. With the continuous growth of marine economy in recent years, the two systems are also developing. (2) The coupling correlation between marine scientific and technological innovation and marine industrial structure in Shandong Province has been in a highly coupled state since 2006, but there is still room for improvement. On the other hand, the change range of coupling coordination degree is more obvious, which achieves a qualitative leap. It has been upgraded from the running-in type of basic coordinated development to the synchronous type of highly coordinated development, but there is still the problem that the development of marine scientific and technological innovation lags behind. The improvement of regional marine innovation capability will promote the innovation behavior of marine industry, form new industrial clusters and promote the optimization and upgrading of industrial structure. At the same time, the relationship between supply and demand brought about by the optimization and upgrading of industrial structure will make more innovation elements invested, so as to further

enhance the ability of marine innovation.

Based on the above conclusions, this paper further puts forward some suggestions and countermeasures to speed up the development of marine scientific and technological innovation and the optimization of industrial structure. First, in order to accelerate the speed of marine scientific and technological innovation, promote the upgrading of marine industrial structure, and realize the sustainable development of marine economy, we must adhere to the development road led by innovation. We will optimize the environment for marine scientific and technological innovation, promote the integration of different industries, promote the reorganization and optimal allocation of resources, and create a complete chain of innovation and entrepreneurship. Second, we should build an efficient and coordinated development mechanism between marine scientific and technological innovation and industrial structure, and play a leading role in policy. For high-tech industries, the government should formulate tax and subsidy policies macroscopically, increase support and guidance, and give corresponding financial support. The government has set up a platform for industry-university-research cooperation to actively absorb and introduce innovative achievements. Local enterprises are encouraged to innovate independently and improve total factor productivity. This will enhance the competitiveness of the marine industry and rationalize the industrial structure.

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