Evaluation of innovation driven capability and diagnosis of obstacle factors based on comprehensive index method -- a case study of Qingdao Marine Industry

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Abstract. China is a big ocean country, and marine economy plays an important role in the national economic system. It is urgent to develop marine resources scientifically, protect marine ecological environment, and improve the quality and efficiency of marine economic development. As the main force of marine economic growth has changed from relying on resources to technological innovation, the evaluation of innovation driven capacity has become an indispensable and important link. Taking the marine industry of Qingdao as the research object, this paper uses the comprehensive index method to construct the evaluation index system of innovation driven ability from three aspects: the basic level of scientific and technological innovation, the input and output of scientific and technological innovation of marine industry, and analyzes the driving capacity and obstacle factors of the current marine industry in Qingdao. The results show that the innovation driven development ability of Qingdao is outstanding, and the innovation driven development ability is closely related to innovation investment, scientific research and innovation environment and other factors. According to the research results, the paper puts forward some measures to further enhance the innovation driven ability.

1. Introduction

Innovation driven research has increasingly become a hot topic in global industrial economy research. China has clearly proposed that the implementation of innovation driven development strategy should rely on scientific and technological innovation to drive China's economic development [1-2]. The most important driving force of innovation is scientific and technological innovation, and scientific and technological progress is an important manifestation of scientific and technological innovation. With the development of economy and society, more and more attention has been paid to the progress of science and technology. Scientific and technological progress has become an important indicator to measure regional economic development. Taking Qingdao as the background, it is of great significance to scientifically monitor and analyze the innovation driving capacity of Qingdao's marine industry.

The comprehensive index method is based on the determination of a set of reasonable evaluation index system, weighted average the individual index of each index, and calculate the comprehensive index value for comprehensive evaluation. Wang [3] established an evaluation model for the coordinated development of marine environment economy system, and applied the comprehensive index method to analyze the index. Fan [4] established the index of technological innovation ability and applied the comprehensive index method to quantitatively analyze the input capacity and output index of...
technological innovation in Chongqing, Sichuan and Shaanxi provinces. These research results have achieved certain positive significance.

In terms of innovation driven capacity, Chen Yuzhen [5] compared the ITIf & Kauffman innovation policy index, WEF Global Competitiveness Index and INSEAD global innovation index evaluation index system, and constructed an innovation driven ability evaluation index system from four aspects: enterprise and market, talent and education, intellectual property and patent, government system and infrastructure construction. Taking marine fishery as an example, Shen Jinsheng et al. [6] constructed an innovation driven capacity measurement model based on knowledge production function.

As mentioned above, experts have made a useful analysis on the innovation driven development[7-9]. Therefore, the topic of this paper is devoted to the quantitative evaluation of Marine industry. This research illustrates the innovation-driven ability from three aspects: the basic level, the input and the output of scientific innovation in Marine industry. This research provides technical support for building a modern Marine industry system and ensuring the sustainable development of China's Marine industry.

2. Measurement of innovation driven development capability of marine industry

Marine industry is the main body and foundation of marine economy, which refers to all kinds of production and service activities carried out by human beings using marine resources and space[10]. The concept of innovation driven development capability originates from innovation driven. The ultimate path and goal of both are to promote social and economic development through innovation. Innovation driven is to rely on scientific and technological innovation to drive economic development. Knowledge, technology, creation and other elements replace the traditional capital, labor, natural resources and other natural factors as the driving force, and promote the improvement of original innovation ability by adjusting the input and allocation of elements. The concept of innovation driven emphasizes the driving factors of economic development, while "innovation driven development capability" emphasizes the effect of innovation output, which refers to the ability to realize innovation output in the process of innovation driven. In the ability of innovation driven development, "innovation" represents the input of innovation elements, "drive" refers to the process of promoting social and economic development, "development" refers to the development of social economy, and "capability" represents the effect of innovation input to achieve innovation output. Therefore, its connotation is the ability to realize innovation output after putting innovation elements into economic activities [11].

2.1. Construction of evaluation system

Based on the analysis of marine industry innovation driving capacity and obstacle factors diagnosis of many research results, this paper analyzes the basic level of scientific and technological innovation of marine industry, input and output of scientific and technological innovation, and six secondary indicators. The specific index system and measurement method are shown in Table 1.

2.2. Calculation of composite index

The comprehensive index method is a comprehensive evaluation and prediction method based on the basic level of scientific and technological innovation of marine industry, input and output of scientific and technological innovation to determine the influence degree of Qingdao's marine industry innovation driving capacity, and determine the influence weight of various factors on this basis. The comprehensive index of impact grade assessment $W_i$ is expressed by:

$$W_i = \frac{\sum_{j=1}^{n} W_{ij}}{\sum_{j=1}^{n} W_{i,\text{max}}},$$

(1)
| Primary indicators                                                                 | Secondary indicators                                                                 | Data processing and calculation method                                                   | The current level of Qingdao in 2018.                                               | Definition of innovation driven capability                                                   | Index |
|----------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------|------|
| Basic level of scientific and technological innovation in marine industry       | High end research and development platform involving marine industry W₁               | Establishment of research institutes, universities and research and development platforms | Qingdao has 18 scientific research institutes related to marine industry, 8 universities with ocean colleges or marine majors, and 34 high-end research and development platforms involving sea at ministerial level or above | No increase in the current year is 0; cumulative increase of 1-2 companies is 2; 2-4 companies are 2; more than 4 companies are 3 | 3    |
|                                                                                  | High end research and development talents involved in marine industry W₂               | Training and introduction of academicians and senior talents                            | There are 18 academicians involved in the marine industry in Qingdao, and about 2500 scientific researchers with senior titles or above | For every additional academician or 100 senior talents in the year, the index is taken as 1, and the highest is 3. | 3    |
| Scientific and technological innovation investment in marine industry           | Value added of marine emerging industries W₃                                           | Growth of added value of marine emerging industries                                    | The added value of marine emerging industries reached 36.6 billion, an increase of 8.6%. | The proportion of scientific and technological funds of marine industry in the total marine output value increased by 0 when the growth rate was less than 5%; 1 was taken as 5% - 10%; 2 was taken as 10% - 15%; 3 was taken as > 15%. | 1    |
|                                                                                  | Transaction amount of technology contracts involving marine industry W₄                 | Increase in transaction volume of technology contracts involving marine industry        | In 2018, the turnover of Qingdao's marine industry technology contracts reached 1.82 billion, an increase of 21.2%. | If the proportion is less than 10%, take 0; 10% - 20% is taken as 1; 2 for 20% - 40%; >40% is taken as 3 | 2    |
|                                                                                  | Investment in scientific and technological innovation W₅                              | Increase of investment in scientific research funds                                    | In 2017, Shandong Province invested 25.580 billion in research and development and 30.71 | If the proportion is less than 10%, take 0; Take 1 for10% - 20%; Take 2 for 20% - 40%; >40% take 3 | 2    |
In 2017, Qingdao’s marine GDP reached 290.9 billion yuan, and the annual total marine product in 2018 was 332.7 billion, with an added value of 41.8 billion, an increase of 14.4%.

If the proportion is less than 5%, take 0; Take 1 for 5% - 10%; Take 2 for 10% - 20%; >20% take 3

Where: \( W_i \) is the actual index of the \( i \) influencing factor; \( W_{i\max} \) is the largest impact risk index of the \( i \) influencing factor; \( n \) is the number of influencing factors. The comprehensive index method avoids the interference of human subjective factors to a certain extent, and ensures the objectivity of the results to the greatest extent. The larger the index is, the better the innovation driven development ability is, and the smaller the index is, the weaker the innovation driven development ability is.

### 2.3. Calculation of obstacle factors

The obstacle factor diagnosis model is a mathematical model which comprehensively excavates the obstacle factors that affect the development of things on the basis of quantitative evaluation model. Referring to previous studies, this paper makes a quantitative diagnosis on the innovation driven development ability of marine industry, and the calculation formula is as follows:

\[
M_j = \frac{P_j R_j}{\sum_{j=1}^{n} P_j R_j}
\]

Where: \( M_j \) is the obstacle degree of each single index to innovation driven development ability. \( P_j \) represents the gap between the single factor and the goal of innovation driven development capability, reflects the impoverishment of single factor of soil nutrients, \( P_j = 1 - R_j \); and \( R_j \) represents the weight of this factor.

### 3. Analysis of innovation driven development ability of marine industry

Through the evaluation index of innovation driven development ability of marine industry, this paper analyzes the situation of innovation driven development of marine industry in Qingdao in 2018, studies the obstacle factors of innovation driven development ability of marine industry, and analyzes the influence of obstacle factors on innovation driven development ability of marine industry.

#### 3.1. Analysis of innovation driven development capability

Based on the evaluation index of innovation driven development, the final measured value of Qingdao comprehensive index is 0.722, and the level of innovation driven development is in a high stage.

The basic level of scientific and technological innovation of marine industry in Qingdao is at the leading level in China. The support of innovation driven basic level of marine industry to technological innovation of marine industry has obviously promoted the economic growth of marine industry.

The contribution of scientific and technological innovation investment in Qingdao marine industry to innovation driven economic development is low. The investment in scientific and technological innovation promotes the innovation driven development of marine industry to a certain extent, but the contribution of the overall investment to the scientific and technological innovation industry is small. The industrialization degree of universities and scientific research institutes is low, and the input of traditional marine industry is strong, but the output is low.
The scientific and technological innovation output of marine industry still has room for improvement in promoting innovation driven economic development. However, compared with other provinces, the output of marine industry driven by scientific and technological innovation is slightly insufficient.

3.2. Analysis of secondary index obstacle factors
The obstacle degree of each index was calculated by the obstacle factor diagnosis model. The calculation results are shown in Table 2.

| Primary indicators | Basic level of scientific and technological innovation in marine industry | Scientific and technological innovation investment in marine industry | Scientific and technological innovation output of marine industry |
|--------------------|-----------------------------------------------------------------------|------------------------------------------------------------------|------------------------------------------------------------------|
| Secondary indicators | W₁ | W₂ | W₃ | W₄ | W₅ | W₆ |
| obstacle factors    | 0.2217 | 0.2217 | 0.0837 | 0.1576 | 0.1576 | 0.1576 |

3.3. Suggestions on innovation driven development capability of marine industry
Qingdao should continue to inherit and enhance the advantages of the project, to make up for the shortcomings. At the same time, they should formulate feasible mechanism system, vigorously launch marine education, increase marine related majors in Colleges and universities, strengthen the training and introduction of marine talents, create a good scientific research environment for high-tech talents and scientific research institutions, and mobilize the innovation enthusiasm of scientific and technical workers with excellent system guarantee.

Qingdao should attach importance to the strong combination of universities, scientific research institutes and traditional advantageous marine industries, encourage scientific research institutes of colleges and universities to carry out technical cooperation with traditional advantageous industries, and establish production, teaching and research bases. To provide strong support for innovation driven development of marine industry, we should increase investment in scientific research funds of marine industry, establish and improve system guarantee, and encourage private capital to participate in base construction and scientific and technological research and development.

4. Conclusion
(1) Taking the marine industry of Qingdao as the research object, this paper uses the comprehensive index method to construct the evaluation index system of innovation driven ability of comprehensive marine industry from three aspects: the basic level of scientific and technological innovation, the input of scientific innovation and the output of scientific innovation. Based on the evaluation index of innovation driven development, the final measured value of Qingdao comprehensive index is 0.722, and the level of innovation driven development is in a high stage.

(2) Based on the analysis of the innovation driven development ability of marine industry in Qingdao, this paper comprehensively analyzes the marine industry foundation, input and output in Qingdao, and studies the obstacle factors of innovation driven development ability. The research shows that the ability of innovation driven development in Qingdao is outstanding, and the innovation driven development ability is closely related to the factors such as innovation investment and scientific research innovation environment. According to the research results, the paper proposes measures to further enhance the innovation driven ability, and the research results provide a certain reference for other coastal cities to enhance the innovation driven development ability of marine industry.

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References

[1] Xia, K., Guo, J. K., Han, Z. L., Dong, M. R., and Xu, Y. (2019). Analysis of the scientific and technological innovation efficiency and regional differences of the land–sea coordination in China's coastal areas. Ocean & Coastal Management, 172(APR.), 157-165.

[2] Zhong, S., Wang, H., Wen, H. et al. The total factor productivity index of science and technology innovations in the coastal regions of China between 2006 and 2016. Environ Sci Pollut Res (2020). https://doi.org/10.1007/s11356-020-09300-3

[3] Wang, X.L., Jiang G.Q., andWamg J.l. (2015). Evaluation of coordinated development of marine environment-economy system based on multivariate statistical methods. Marine Environmental Science, 34(5), 777-782.

[4] Fan X.R., and He B. (2008). Research on technology innovation capacity index of chongqing,sichuan and shaanxi. Journal of Northwest A&F University(Social science Edition), 8(006), 36-39.

[5] Chen Y.Z.(2014). The international evaluation index system of innovation-driven capability and its referential significance to china. Journal of Nanjing University of ence and Technology(Social ences Edition), (04), 27-33.

[6] Shen J. S., and Yu,W. (2014). Research on innovation drive of china's traditional strong marine industry—a case study of marine fishery. Journal of Ocean University of China(Social ences), 000(002), 23-28.

[7] Nazir, K., Yongtong, M., Hussain, K., Kalhoro, M. A., Kartika, S., & Mohsin, M. (2016). A study on the assessment of fisheries resources in pakistan and its potential to support marine economy. Indian Journal of Geo-Marine Sciences, 45(9), 1181-1187.

[8] Choi, Y. Y., Ha, H. K., & Park, M. (2008). Analysis of the role of maritime freight transport industry in the korean national economy. Marine Policy, 2005, 29(4): 371-383.

[9] Park, J.-U., Seo, Y.-H., Kang, B.-D., & Jeon, E.-S. (2014). A Study on the Effects of Self-Efficacy and Social Support on Career Decision level in Fisheries and Merchant Marine High School Students. Journal of Fisheries and Marine Sciences Education, 26(2), 335–344. https://doi.org/10.13000/jfms.e.2014.26.2.335.

[10] He,G.S. (2011). Development course of marine economic statistics of china. Marine Economy. Marine Economy, (01), 6-11.

[11] Hu H.P., Yuan Y., and Li Y.T. (2019). Research on Monitoring and Evaluation of Innovation Driven Development Capability in Guangdong Province. Science and Technology Management Research, 2020,40(09):68-73.