A Study on the Development of Regional Marine Industry in China

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Approval Sheet

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중국 지역 해양산업의 발전에 관한 연구

姜巧彦

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요약

21 세기는 해양의 시대로 해양산업은 사회경제 발전에 중요한 역할을 수행하고 있다. 중국은 풍부한 해양자원을 갖고 있으며, 이는 대부분 11 개의 연해 도에 분포해 있다. 중국의 해양산업정책은 해양의 개발, 이용, 보존과 관련되어 있다. 그리고 해양산업은 해양 제 1 차산업, 해양 제 2 차산업과 해양 제 3 차산업으로 구분되 있다. 지역의 해양산업 발전은 지역 경제 성장에 매우 중요하므로, 지역 해양산업 발전현황과 요인의 연구는 해양 경제와 지역 경제 발전의 추진하는데 있어서 중요한 의의를 지니고 있다.

본 논문은 해양산업과 해양산업 경쟁력의 정의를 토대로 중국의 지역 해양산업 발전 현황에 대한 분석을 수행하였다. 그리고 해양산업 경쟁력을 측정하여 지역 해양산업의 발전 정도를 비교분석하였다. 본 논문은 엔트로피 방법을 통해 해양산업 경쟁력에 대한 측정을 한 결과, 지역 해양산업 발전에

차이가 존재하고 지역 해양산업 발전 상황이 서로 상이함을 발견하였다. 본 논문은 지역 해양산업 발전에 영향을 끼치는 요인들에 대하여 연구를 진행하였다. 기존의 관련 연구를 근거로 패널자료모형을 구축하여 중국 11 개의 연해 지역 해양산업 발전에 영향을 끼치는 요인들에 대해 분석하였다. 연구모형에서 지역 해양산업 생산 총액을 종속변수로 노동력, 자본, 기술과 환경 요인을 독립 변수로 설정하였다. 본 논문은 이러한 요인들을 해양 1,2,3 차 산업별로 해양 국제 경쟁력에 끼치는 영향들에 대해 비교분석하였다.

본 논문의 연구결과는 다음과 같다. 첫째, 지역 해양산업 경쟁력에 대한 비교 분석을 통해 중국의 지역 해양산업 발전정도가 서로 상이함을 알수 있었다. 즉, 광둥성, 산둥성과 상하이는 비교적 해양산업 경쟁력이 우수하였으나, 광시, 허베이와 하이난은 경쟁력에서 약세를 띄고 있었다. 둘째, 노동력, 기술, 자본과 환경이 지역 해양산업의 발전에 영향을 미치고 있음을 발견하였다. 노동력 , 해양기술, 해양 과학연구 자금과 해양환경의 오염에 대한 관리는 지역 해양산업 발전에 긍정적인 영향을 미치고 있었다. 결론적으로 본 논문은 중국 지역 해양산업 발전에 관한 실증 분석 결과를 통해 중국 지역 해양산업 발전을 위한 적절한 제안을 제시하였다.

키워드: 해양경제, 중국 지역 해양산업, 지역 해양 생산 총액, 엔트로피, 해양산업의 경쟁과 발전

A Study on the Development of Regional Marine Industry in China

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Abstract

The 21st century is a century belonging to the oceans, and the ocean plays a vital role in economic and social development. China is rich in marine resources, mainly distributed among eleven marine coastal provinces and cities. With the constant development of the ocean, the marine industries grow rapidly. In China, the “marine industry” refers to the production of developing, utilizing and protecting the ocean, which is also divided into a primary marine industry, a secondary marine industry, and a tertiary marine industry (China Marine Statistical Yearbook, 2017). To study the development of regional marine industries will drive the growth of the regional land economy. As there is a strong correlation between the development of the marine industry and the creation of shore-based organization, it is of great significance to analyze the current status

of the regional marine industry in China, which has profound effect to theory and practice for exploring the future development of the regional marine industry.

Against this background, this study firstly defines and analyzes the meaning of the marine industry and marine industrial competitiveness by combing the previous literature, and analyzing the overview of regional marine industry and the development of the three marine industries in China. Secondly, this study compares the development of regional marine industry from the perspective of competitiveness and establishes the evaluation index system which includes six first-class targets and sixteen second-class targets. Through MATLAB software, the entropy method is applied to evaluate the competitiveness of regional marine industries. Then, disparities found in regional marine industrial development are analyzed for their reasons. Thirdly, this study establishes the panel data model to analyze the factors influencing the development of regional marine industries in China. Regional gross ocean products (GROP) represent the dependent variable whilst the labor factor, capital factor, technological factor, and environmental factor represent the independent variables. This study also compares these factors, deemed as key influencing elements for the regional development of the three marine industries and the international competency.

In general, this study gives the conclusions from two perspectives. On the one hand, there are development disparities in the regional marine industry in China which are seen by comparing the regional marine industrial competitiveness. It is shown that Guangdong, Shandong, and Shanghai have stronger competitive advantages. On the other hand, Guangxi, Hebei and Hainan lack competitive advantages. In addition, marine economic capacity, marine human resources, and

marine technology occupy major shares in the evaluation of regional marine industrial competitiveness. Additionally, this study finds that labor, technology, capital, and environment have an impact on the development of the regional marine industries. Labor (that is the ocean-related employed), technology, research funds (one of the capital factors), and marine pollution treatments (one of the environmental factors) have a significant positive influence on development of regional marine industry. At the same time, these selected factors each affect the regional development of China's three marine industries and international competency to a different extent. Combining the actual development of regional marine industries in China with the results of empirical analyses, this study puts forward suggestions to enhance the development of the regional marine industries in China.

Keywords: Marine economy, Chinese regional marine industry, Regional Gross Ocean Product (GROP), Entropy method, Competitiveness and development of marine industry

Chapter 1 Introduction

1.1 Background of Research

The ocean is a critical part of the human living environment which makes up more than 70% of the earth's surface. With the development of the society and accretion of population, the living space and natural resources on land are limited to meet the needs and demands of human survival and economic development. Marine exploitation is going to be a significant factor in all areas in society, and major marine countries in the world have taken part in marine development. The Canadian government (2017) had the Oceans Strategy which aimed at understanding and preserving the marine environment; supporting sustainable development and creating the international leadership. South Korea (2003) published the "Ocean Korea 21 and Marine Environment", which indicated that a leading industry for national development was the ocean industry. The European Union (2006) promulgated a comprehensive marine policy.

China is rich in marine resources with more than 18,000 kilometers of coastlines, and its jurisdiction sea is about 3 million square kilometers which equal to one-third of the mainland. From 2010 to 2017, the gross national ocean product (GOP) of China was growing at an annual rate of 7.8%, and the national GOP in 2017 amounted to 7761.1 billion (CNY) increasing by 6.9% in comparison to the previous year. With its rapid development, the marine economy plays a significant role in national development. Having transformed into the high-quality development stage from the rapid growth stage, China's marine economy is now in the period of tackling key problems to transform the mode of economic development, optimize economic structure, and promote sustainable marine economic use. How is the Chinese marine industry developing? This study answers from a regional perspective. What would promote further development of regional marine industry in China? This study finds the reasons to answer this question.

1.2 Purposes of Research

Considering the significance of the marine industry, there are eleven coastal provinces and cities in China which play a crucial role in the development of the marine economy. However, different coastal areas each have a unique situation for marine economic development, which may be influenced by their natural resources, local economic situations, or other factors. What are their competitive marine advantages that will boost their development? In addition, what are the factors influencing the development of the marine industry in China as a whole? The two questions should be answered in this study.

Therefore, this paper intends to study the development of the regional marine industry from two perspectives. One is to compare the development of the regional marine industry in China by analyzing the competitiveness of coastal provinces and cities. Up to now, little attention has been given to the study of the competitiveness of the regional marine industries. It is beneficial to understand the advantages and disadvantages of the marine industry in regions. Another is the reasons for the development of regional marine industries in China. According to the differences in the development of regional marine industries, it is critical to find the factors influencing the development of regional marine industry which can propose the appropriate suggestions to promote further development of the marine economy. As to the classical economic factors influencing the development of the national economy, the three basic factors are labor, capital, and technology. With the particularity of the marine industry, this paper takes the environmental factors into consideration to fill the gap of previous studies.

Finally, through this research, exploring the development of regional marine industry from the competitive perspective and the factors influencing the development of regional marine industry, this study is in the hope of providing a reference for policymakers to develop the Chinese regional marine industry.

1.3 Methodology

The literature review method made full use of the library and Internet in this study, related literature on marine industrial competitiveness and the development of regional marine industries were extensively and comprehensively reviewed.

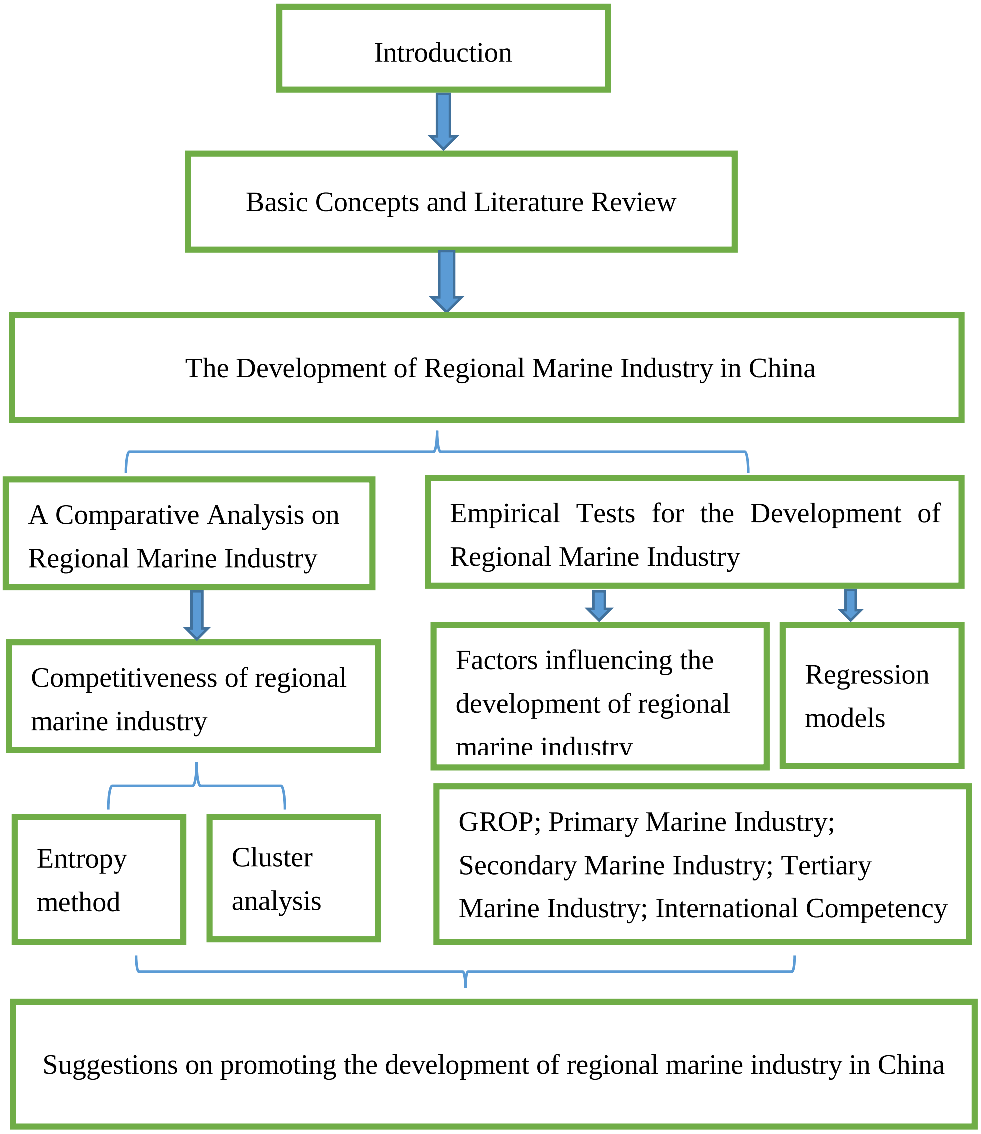
Using comparative analysis of concepts in marine industries in China and other countries, this study seeks to give a better understanding of those industries. Comparing the development of the marine industry in regions, this study aims to find advantages and disadvantages of regional marine industry.

A combination of quantitative and qualitative mathematical analysis was employed in the data analyses. A Location Entropy is employed in Chapter 3 to analyze the distribution of marine industries in regions; the Entropy method is applied in Chapter 4 to compare the development of regional marine industry in China and the cluster analysis is used to make classifications, then a regression analysis is used to analyze the factors influencing the regional marine industry development in China.

1.4 Outline of Research

To accomplish the above-mentioned purpose, the dissertation is structured as follows.

Chapter 1 introduces the background and the purpose of this study, the methodology, and the outline of the study (the structural organization of the dissertation). Following this introductory chapter, Chapter 2 reviews the basic concepts and relevant literature. The concepts of marine industry are clarified. Then, the literature review focuses on the competitiveness of the marine industry and the development of regional marine industry in this chapter. Chapter 3 describes the overview of marine industrial development in China, detailing the development of the three marine industries. Chapter 4 presents the comparison of the development of regional marine industries by analyzing the competitiveness. Firstly, the factors are to be submitted and the evaluation index system is established. Next, this chapter provides analyses of the regional marine industrial competitiveness of China by the entropy method and cluster analysis. Finding the differences in the development of regional marine industries, Chapter 5 answers the question as to what factors may foster these differences by regression estimation. Finally, Chapter 6 proposes conclusions and implications for the development of regional marine industries in China. Considering the limitations of this study, expectations for future research are proposed. The technical route of this study is presented in <Figure 1>.



<Figure 1> Research flowchart

Chapter 2 Basic Concepts and Literature Review

2.1 Basic Concepts

2.1.1 Marine industry

"Marine industry" is the base of the marine economy, and is a prerequisite for the development and existence of a marine economy. A marine economy, of the United States for example, is the portion of the economy relying on the ocean as an input for the production process. It also means the economic activities are directly associated with using ocean resources, which are considerably smaller than the coastal economy (Charles, 2003). In addition, the marine economy of New Zealand is defined as the economic activity that happened in or used the ocean or that produced the goods or services, which contributed to the national economy directly (Statistics New Zealand, 2007). Ireland defines the marine economy is an economic activity that directly or indirectly uses the ocean as input or uses the output from the sea. Therefore, marine industry is a reflection of the marine economy, and the marine economy includes the sum total activities of the marine industries.

The concept of marine industries in China just emerged at the beginning of the 1980s and became popular in the 1990s, which was defined in both a narrow sense, and a broad sense. In a narrow sense, "marine industry" refers to the production of service activities for developing, utilizing and protecting the ocean, which includes the major marine industries, scientific research, education, and management. The marine industry also includes the narrow definition of ocean-related industries, for instance, marine equipment manufacturing, ocean-related building, and installation, etc. (China Marine Statistical Yearbook, 2017).

Colgan (2003) classified the US marine industries into seven categories, which were marine engineering architecture, marine biological resources, ocean mining, marine recreation and tourism, marine transportation, shipbuilding, and other marine industry activities. There were four categories of the Canadian marine industries that were marine related industries, shipbuilding, marine resource exploitation and transportation, and marine public services (Kenneth, 2001). In China, according to GB/T 20794-2006, the marine industries can be subdivided into the marine industries and ocean-related industries including 20 main classes, 106 minor classes, and 390 subclasses. In addition, according to three industrial classifications in economics, the marine industry in China can be classified into a primary marine industry, a secondary marine industry, and a tertiary marine industry. Based on the time sequence, the marine industry can be defined into a traditional marine industry (before 1960s), an emerging marine industry (from 1960s to early 21st century), and a future marine industry (21st century) (China Marine Statistical Yearbook, 2017).

In short, the definition and classification of the marine industry is different between China and other countries. In this study, we analyze the development of the regional marine industries in China, therefore, we take the definition of the Chinese marine industry and its classification into consideration.

2.1.2 Industrial competitiveness

Industrial competitiveness plays a critical role in a country's or a region's economic development. Professor Michael Porter (2001) suggested that the key to the formation of a competitive advantage was the dominant industry, getting more profits than competitors by exploiting more markets on certain trade conditions. There was a famous model carried out by Michael Porter called the "Diamond Model", and included four elements of industrial competitiveness. Rui, M.J. (2006), a professor from Fudan University, optimized the Porter's Diamond Model and added a core of knowledge absorption and innovation to that model. The author regarded knowledge absorption and innovation as the key factor of industrial competitiveness. Jin B. (1997) proposed that if some industries in some regions provided more effective products or services than the same industry in other regions or countries, they were more competitive.

Above all, industrial competitiveness refers to a particular industry's competitiveness in a country or region in terms of its production efficiency, market demand, and continuous profits compared with the same industry in other countries or regions. This study focuses on the development of regional marine industries in China. The scope of industrial competitiveness in this study is related to the marine industries of different regions in China.

Yin, K.D. and Wang, X.L. (2010) defined marine industry competitiveness from the perspective of inputs and markets that it was able to use to create more wealth compared with competitors on the basis of production factors and resources in the efficient allocation and conversion. Guo, X. W. (2012) proposed that marine industrial competitiveness is the marine industry of one country or region compared with other countries or regions. It was more competitive in terms of the human resources, capitals, international level, scientific and technological level, production efficiency and other aspects. Wang, S. and Zhang, Y.G. (2011) divided marine industrial competitiveness into apparent competitive capacity and connotative competitive capacity. They measured them by the average rate of the industry. Li, X. G. (2012) gave a definition on city marine industrial competitiveness that coastal cities, with their comprehensive comparative advantages in resources, location, economic and social systems, and policies, could attract and utilize various marine resources to make their marine industry stronger and more sustainable than other cities. These definitions of marine industrial competitiveness are more representative in previous researches.

On the basis of integrating concepts of marine industrial competitiveness defined by many scholars, this paper combines the connotation of industrial competitiveness and the characteristics of the marine industry. It is proposed that marine industrial competitiveness should involve two basic questions: one is the content of comparison and the other is the scope of comparison. Specifically, the content of comparison means the competitive advantage of the marine industry which will reflect in a product or market. This paper analyzes the marine industrial competitiveness of regions in China. Therefore, the scope of the comparison in this paper is regionally in the same country. It should not only consider the basis of the industrial competitiveness but also should take the scope, and characteristics of marine issues into consideration.

2.1.3 Industrial cluster

A cluster represents an ecological concept, and a biological cluster in the environment refers to a structural unit in which various biological species are regularly combined with each other in a certain region or environment. The industrial cluster is built on the concept of clusters in the ecology, which appeared with the development of the social division of labor and specialization in the middle and late 18^{th} century. Industrial clusters, as an industrial district, has had a continuous division of labor and rapid increase in production capacity. Lasting and extensive links between the region and external economic space can be established to promote the development. Porter (1990) considered that industrial clusters referred to enterprises, specialized suppliers, service providers, financial institutions, related industries, and other related companies that had competition and cooperation in specific regions and were geographically concentrated and interactive. Porter (1990) also believed that the competitiveness of a region was derived from the competitiveness of industries. If an industry was well-established, it would increase its competitiveness and thus drive the development of the entire region.

When analyzing the development of the regional marine industry in China, this paper applies the Location entropy method to measure the whole spatial distribution of the marine industry and the distribution of its three regional marine industries.

2.2 Literature Review

2.2.1 Literature review on the competitiveness of marine industry

(1) Literature reviews on the industrial competitiveness

Studies on industrial competitiveness originating from Europe and America could be traced back to the early 20th century, which then entered a stage of rapid development in the late 1970s and early 1980s. In 1985, the American Commission on Industrial Competitiveness began to study the definition, calculation method, and the current situation of American competitiveness (Huang, X.R., 1997). American Professor Michael Porter (2012) established the "Diamond Model", and pointed out some elements such as factor conditions, demand conditions, related and supporting industries, firm strategy, structure, rivalry, government and chance. These elements played a vital role in industrial competitiveness.

Chinese scholars started late on industrial competitiveness in the 1990s. Di, A. Z. (1992) edited and published a book, International Competitiveness, on industrial competitiveness and international competitiveness in China. This was the first Chinese book about industrial competitiveness. Jin, B. (1997) suggested that without trade barriers, a certain industry in a country could provide more products to meet consumers' demands with higher production capacity than other countries, and would be able to make profits continuously for a long time. This was called the international competitiveness of the industry. The author (2003) also built a theoretical model of industrial competitiveness and evaluated international competitiveness of Chinese industries from the perspective of products, and constructed a framework for the competitiveness evaluation index system. Finally, the author proposed the competitiveness analysis method. Dr. Pei. (1998) proposed that industrial competitiveness was a concept of inter-regional comparison at first, which was the sum of absolute competitive advantage and comparative competitive advantage in the general market of a specific industry in a certain region. Wang, L. (2002) put forward a relatively perfect industrial competitiveness evaluation index system. This evaluation index could be divided basically into two categories. One was revealed competitive indicator, which could be found through the calculation by a mathematical formula. Another one was the analytical competitive indicator, which included direct factors and indirect factors. The analytical competitive indicator was used to reveal the origin of industrial competitiveness. The methods of industrial competitiveness had been divided into five categories by Zhu, X.J. (2004). These methods were the index comprehensive evaluation method, competition result evaluation method, factor analysis, total factor productivity model, and benchmarking. The author applied the benchmark to evaluate the international competitiveness of the auto industry and the oil and gas industry in China. Zhan, Y.P. (2007) established a regional industrial competitiveness evaluation index system based on comparative advantage and competitive advantage, who took Liaoning Province as an example to examine the competitive power of industries in Liaoning by principal component analysis.

(2) Literature review on the marine industrial competitiveness

After 2000, with the deepening of research and the progress of research methods, scholars began to use statistical and econometric methods to conduct a quantitative analysis of marine industries.

Foreign studies on marine industrial competitiveness are relatively few, and most of them focus on the impact of the marine industries on the national economy, the sustainable development of the marine industry, or the competitiveness of the marine industry clusters. Early in 1976, Professor Niels Rorholm (1967) utilized the output-input analysis made by Wassily W. Leontief to research the influence of thirteen marine industries on the economy of New England and to design some parameters to measure the influence of the marine industry to the economy. Professor Wlkinson and Pontecorvo (1972) from Columbia University in America analyzed the position of the marine industry in the national economy through analyzing national revenue, measuring the contribution of the marine economy to its gross national product. This study raised the standard of the marine industry and enlightened this research area. Colgan (1991) studied the contribution and impact of some certain marine industries to the regional economy by using the output evaluation model. The Allen Consulting Group (2004) assessed the contribution of marine industries to the national economy, such as the marine fishery, aquaculture, and marine tourism and so on. Kwah, Seung-Jun (2005) analyzed the impact of the marine industry from 1975 to 1998 on marine economic development of South Korea. And O' Connor (2005) analyzed the marine economy status of Ireland and studied the knowledge, technology, and innovation which might influence the marine economy developing in Ireland.

At present, foreign research on marine industrial competitiveness mainly focus on two parts. (i) Analysis of the impact of marine industry development on the marine economy in some regions or on the national economy. (ii) Quantitative evaluation and analysis of international competitiveness of the marine industry.

Modern Chinese marine industry developed later than other countries. Ma, R.F. et al. (2012) used data of the marine industry in the Yangtze River Delta from 2008 to 2012 to evaluate the marine industrial competitiveness of this area, single factor comparative analysis and total factor analysis were used in this paper, which gave a conclusion on the advantages and disadvantages of the marine industrial competitiveness of the Yangtze River Delta. By using Becton Matrix, Xu, C.C. et al. (2011) did a comprehensive analysis of the status quo and development of Guangdong's marine industry in recent years, and evaluated the marine industrial competitiveness of Guangdong Province. Chang, Y.M. and Cai, B.L. (2012) promoted questions on how to build the marine industry competitiveness of Jiangsu Province and utilized the principal component analysis and TOPSIS to evaluate the advantages of Jiangsu's marine industrial competitiveness. The dynamic deviate share analysis model was exercised by Zhou, J.N. and Bai, F.C. (2015) to analyze the structural changes and economic growth of the Guangdong marine industry from 2006 to 2012. It found that the industrial sector with competitive advantages either accounted for a low proportion of the industrial structure or had a bottleneck effect. These studies were the evaluation of the marine industry competitiveness of a single region.

Some studies of competitiveness of the marine industry are about an individual industry sector in the marine industry. Based on Porter's Diamond Model, Zheng, L.Y. (2007) combined the competitiveness of the coastal tourism industry in Zhoushan with government policy and industrial development opportunities, she put forward some suggestions and measures to improve the competitiveness of the marine tourism industry in Zhoushan city. Jiang, P.P and Wang, X.Y. (2008) also established the evaluation index system to analyze the marine tourism industry and provided empirical analyses. Ding, J. and Wang, Y.Y. (2010) used the grey system model to find the direct factors and indirect factors that had an impact on the competitiveness of the marine fishery industry of Shandong Province. The marine fishery industry belonged to the primary industry, which played an important role in the marine economy. They predicted the quantity of the marine fishery industry in the future.

Some scholars did a comprehensive evaluation of the marine industrial competitiveness of China. Sun, Z. C. et al. (2014) combined the comparative and competitive advantages of the marine industry and used AHP and NRCA to evaluate the marine industrial competitiveness of eleven provinces in China. Yu, L.P. et al. (2012) analyzed the situation of China's marine industry at first, then collected the related index to evaluate the marine industrial competitiveness of China by using TOPSIS. The shift-share method was utilized by Sun, L.L. et al. (2013) to analyze the structure and competitiveness of China's marine industry. It indicated that the marine industry had the advantages of structural growth, while the contribution of the marine industry to economic growth varied differently among regions. Yin, K. D. and Wang, X.L. (2010) constructed a four-dimensional joint decision theory, including entropy analysis, grey relation analysis, principal component analysis, and AHP, to analyze China's marine industrial competitiveness, and utilized the Kendall method to perform a consistency check. The key factors and inner relations of regional marine industry competitiveness had been discussed in this paper.

In general, Chinese research on competitiveness of the marine industry can be divided into three groups. Firstly, the evaluation of marine industrial competitiveness of a single region. Secondly, competitiveness in the individual industry sector of the marine industry. Lastly, comprehensive evaluations of the marine industrial competitiveness of China.

Above all, the research on marine industrial competitiveness characteristics are as follows: (i) Most of the studies are about one industry in the marine economy, only takes internal factors into consideration, and lacks the analysis of external factors. (ii) The studies are mostly from the perspective of one region or the whole country. It lacks the regional opinion and neglects the interrelation between objects in the regions. Compared with the previous studies, this paper analyzes the marine industrial competitiveness of eleven coastal provinces and cities in China, taking the interrelation between the objects into consideration. On the other side, the evaluation index system of marine industrial competitiveness is established in this paper. The entropy method and cluster analysis are applied to do empirical analyses and compare the development of the regional marine industries in China.

2.2.2 Literature review on the development of marine industry

The development of the marine industry, and the growth of the marine economy are part of the national economy. Therefore, analyzing the factors influencing the development of the marine industry, it is critical to discuss the factors affecting the development of the national economy. Some researchers propose the economic growth depends on the increase of real GDP or GDP per capita so that the marine economic growth could be the increase of real GOP or GOP per capita.

From the perspective of economic growth, it is said that economic growth is influenced by human resources, natural resources, and the increase in capital employed or technological advancement. Florin and Liliana (2015) analyzed the principal determinants affecting economic growth, showed that there were four major determinants of economic growth that were human resources, natural resources, capital formation, and technology. Obradovic, Sasa and his colleagues (2016) discussed the influence of economic growth on regional disparities with the panel sample of the OECD countries from 2000 to 2011, who found that there was a long-term relationship between the variables that the economic growth and regional disparities. GDP was a very strong measure to gauge the fiscal health of a country, which could reflect the sum total of the production of a country (Jain Dhiraj et al., 2015). <Table 1> shows the factors affecting the economic growth of previous research.

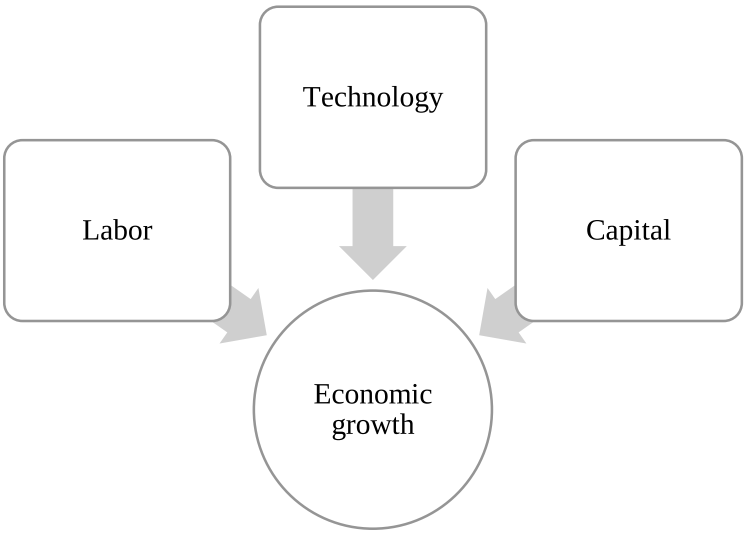
<Table 1> Literature review on the factors affecting the economic growth

Author	Subject and main content
S. Morteza Afghah (1998)	Economic and Non-economic Factors in Economic Development: The Concepts and Their Difference
	In the economic factors in economic development, the author mentioned that the land, labor, and capital had been the main economic growth, while the rapid progress in technology had been considered as a major factor in economic growth.
G. Andrew Bernat (1999)	Economic Growth Theory, Clustering, and the Rise of the South
	The author discussed the regional growth from two views. One was neoclassical growth theory, which was modeled as the function of growth in capital, labor, and technology. Another one was endogenous growth theory which refers to the innovation.
Li, Y.H. (2008)	The factors and empirical study of the differences of regional economic development of Jiangsu Province.
	The author used regression analysis to get the factors influencing the regional economic development of Jiangsu to provide some suggestions for the further development.
	Y: GDP per capita X: location difference; industrial structure; labor; education investment
Charles, I. Jones (2015)	The Factors of Economic Growth
	The author raised a question that why are some countries so much richer than others? It is said that the answer was the field of economic growth. Then the author indicated that the fact of the growth was the stability of the shares of GDP paid to capital and labor. Human capital is a major neoclassical input in production.
Florin et al. (2015)	The main determinants affecting economic growth
	Economic determinants: capital, technology, labor Non-economic determinants: government efficiency, institutions, political and administrative systems, cultural and social factors

Upreti, Parash (2015)	Factors Affecting Economic Growth in Developing Countries
	The author aimed to identify the factors affecting economic growth in developing countries. Collecting the cross-country data for 76 countries, it was found that exports, plentiful natural resources, life expectancy, and higher investment rates had positive impacts on the growth of per capita gross domestic product in developing countries.
Ms. Chimene D. Djapou Fouthe (2017)	Analyzing factors affecting economic growth with CEMAC countries
	The author highlighted the recent trends of economic growth of CEMAC countries and finally the determinants of economic performance of a country. The determinants of economic performance included the investment, human capital, innovation and research and development, and openness of a country.

Source: collected by the author.

In general, the basic factors influencing the economic growth can be concluded as follows.



Source: made by the author.

<Figure 2> Factors influencing the economic growth

From the perspective of the marine economy, the ocean is likely to become an economic force, so that the marine economy plays a vital role in the national economy. It is the reason why we need marine economic growth. And what are the major factors that foster marine economic growth? Various kinds of researches tried to answer these questions. For instance, a Chinese scholar, Ma, W.Y. (2008), proposed that developing the marine industry needed natural resources, extra labor, and capital. In addition, the author mentioned that natural resources and labor could fuel economic growth. Besides, Pan, S.L. (2011) indicated that science and technology could influence the future of the marine economy, and the development of the marine industry relied on the progress of science and technology. Moreover, Lin, X.B. (2011) applied the factor analysis to conclude that marine industrial scale, marine environment, and marine science and technology were the key factors of the marine economic development. By using the GRE-DEA model, Zhao, X. and her colleagues (2012) evaluated the efficiency of the marine economy from human resources, science and technology, and marine contribution rate. The current studies also mentioned the environment. The quality of the marine environment was the basic condition for developing the marine industry, and a good environment could promote the efficient development of the marine economy. The author also explored the factors of ocean economic development in Shandong by the multiple regression model. In this study, the industrial factors, technology, and labor force were taken into account. Ireland government (2017) figured out that investment in research for Ireland's marine sector had been essential in shaping the strategic development of their blue economic development. World Bank Group (2016) indicated that there were four key entry points for creating a comprehensive change in marine economic development, these were investments in governance, technology, markets, and finance. By summarizing the factors affecting the development of the marine industry, and is shown in <Table 2>.

<Table 2> Literature review on the factors affecting the marine industry

Author	Subject, content, and selected variables
Ma, W.Y. (2008)	The analysis of factors that put ocean economy forward
	The author made the qualitative analysis of factors supporting ocean economy forward. It included the capital and labor factor, the factor of science and technology, financial factor, and management factor.
Chang, Y.M. (2011)	A case study on China's coastal province's panel data: factors of oceanic economic development
	The author indicated that the oceanic economic development largely depends on oceanic industrial sizes, ports and policies, industrial structures and scientific aspects.
	Y: GOP X: resource (the number of ports) the scale of marine industry (regional GOP/ regional GDP) the structure of marine industry (secondary & tertiary marine industry/ GOP) technology (the number of professionals on marine industry) support (the number of marine research projects)
Yin, K.D. (2012)	The measurement of ocean scientific and technological progress contribution in China
	Based on C-D production function and Solow residual method to analyze the contribution rate of marine scientific and technology progress.
	Exploration on factors of ocean economy development in Shandong

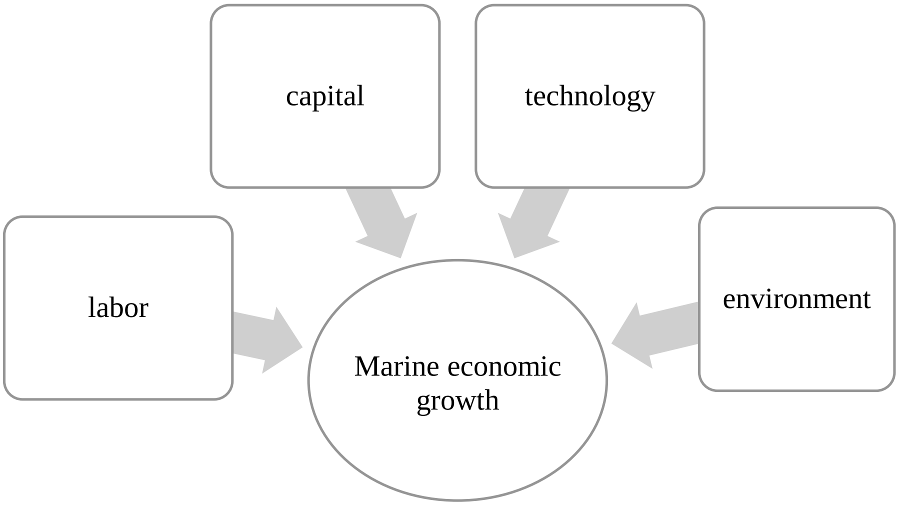
Zhao, X. et al. (2012)	The author used multiple regression model to study the contribution degree of industrial factor, technology and labor force to the development of ocean economy in Shandong.
	Y: GOP of Shandong X: the scale of marine industry (GOP of Shandong/ GDP of Shandong) the structure of marine industry(secondary & tertiary marine industry/ GOP) technology (the number of professionals in marine science and technology) labor(the number of ocean-related employed of Shandong)
Li, W. (2014)	An empirical analysis of the influencing factors of the marine economy development in the Beibu Gulf Economic Zone
	The author analyzed the complex factors that affect the marine economic development of the Beibu Gulf Economic Zone, such as the marine production, industrial structure, technology, and policy support.
	Y: GOP X: the structure of marine industry (secondary marine industry/ GOP) science and technology (the number of professionals on marine industry) policy support (the number of marine research projects)
Cao, W. et al. (2015)	A study on factors influencing oceanic economic development based on panel model
	The author summarized the factors, which were labor, resources, industry, science and technology, and environment, affecting the development of marine economy.
	Y: GOP (gross ocean products) X: labor (the number of ocean-related employed) cargo (the number of cargo throughput) the scale of marine industry (regional GOP/ regional GDP) the structure of marine industry (secondary & tertiary marine industry/ GOP) marine technology (the number of research projects)

	marine environment (the number of pollution treatments projects)
Feng, D. (2015)	The regional difference and influencing factors analysis of marine strategic emerging industry in China
	The author applied panel data model to test the influencing factors, concluding the degree of influencing factors of the development of coastal provinces.
	Y: GOP of marine strategic emerging industry X: investment (the number of investment in the fixed assets) labor (the number of ocean-related employed) technology (the funds of marine R&D) the structure of marine industry (secondary & tertiary marine industry/ GOP)
Peng, Y.F. et al. (2017)	The differences in marine economy development of China and influencing factors
	The author analyzed the factors influencing marine economy and showed that marine economy development had the significant relation with marine industrial structure, the scale of marine industry, labor, and technology, and there was positive relation between marine economy development and government support and environment.
	Y: GOP X: regional economic development (regional GDP with one year lagged) the structure of marine industry (tertiary marine industry/ GOP) the scale of marine industry (regional GOP/ regional GDP) labor (the number of ocean-related employed) technology (the number of professionals on marine industry) government support (the number of marine research projects) environment (the number of pollution treatments projects)
Wang, Z.Y. et al. (2017)	Influence factors and evolution of China's marine economic spatial pattern
	The author illustrated that the opening degree of the coastal region can promote the evolution of marine economic spatial patter, however, the utilization of marine resources, marine science and technology, the absorptive

	capacity of employment in marine industry, the benefit of marine ecology and the construction of infrastructure have less effects on the marine economic spatial pattern.
	Y: GOP X: the structure of marine industry ($\frac{\text{"i" } industry}{GOP}$) utilization capacity (GOP/ marine area) science and technology (the proportion of marine professionals) environment (the marine-type nature reserves) openness (the number of exports) infrastructure (the number of berths used for production)

Source: collected by the author.

According to the current studies on the factors influencing the development of the marine industry or the marine economy shown in <Table 2>, the researchers not only considered the basic factors of economic growth, but they also took the environment into consideration which may have been caused by the specific condition of the marine industry. The model of factors influencing the development of the marine industry is concluded in <Figure 3>.



Source: made by the author.

<Figure 3> Factors affecting the marine economic growth

Due to the particularity of the marine industry, the marine environment plays an indispensable role in the development of the marine economy. The basic element of marine life to survive and develop is a good marine environment. Besides, some marine industries depend on the marine environment to develop such as the coastal tourism industry. This is the reason why we consider environmental factors to analyze the development of the regional marine industries.

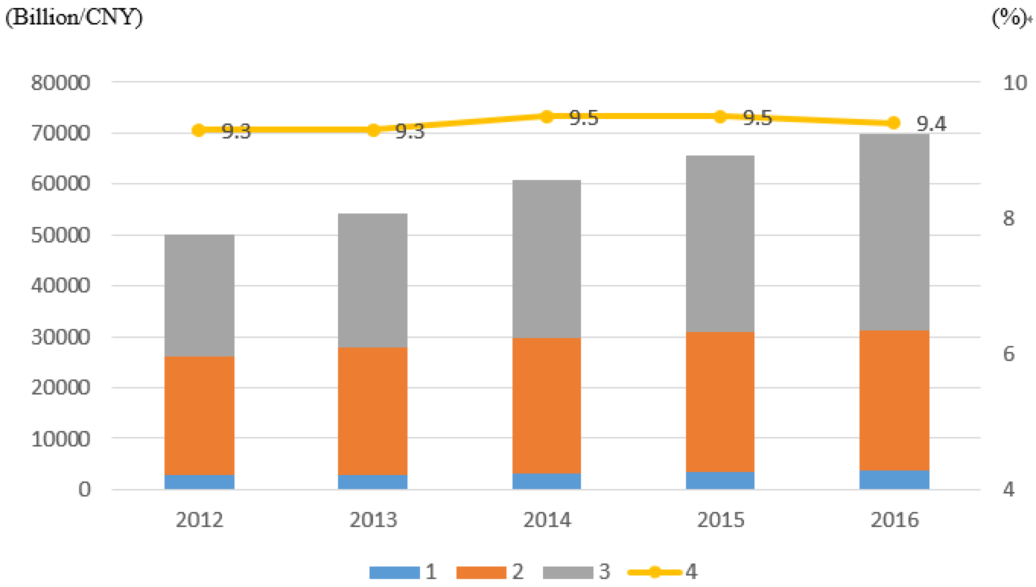
However, some variables in previous studies are not adopted in this study. For instance, the structure and scale of the marine industry have a direct relation with the growth of GOP, which is eliminated in this study.

Chapter 3 The Development of Chinese Marine Industry

There are more than 18,000 kilometers of coastline in China, and a jurisdiction of the sea is approximate three million square kilometers, equivalent to one-third of China's land area. China is a huge ocean country with huge ocean areas and abundant marine resources. Therefore, it is of great significance to formulate the development of the marine industry and actively develop marine resources with a view of marine regions.

3.1 The Current Situation of Chinese Marine Industry System

In recent years, the development and utilization of marine resources in China have been accelerating, and the marine economy has become a new growth point on the national economy. Based on a preliminary calculation (China Marine Statistical Yearbook, 2017), in 2016, the national GOP was 6969.3 billion yuan (CNY), 6.8% up from in 2015, accounting for 9.4% of the GDP. Three marine industries had realized an added value. The primary marine industry was 357.1 billion yuan (CNY), the secondary marine industry was 2766.6 billion yuan (CNY) and the tertiary marine industry was 3845.6 billion yuan (CNY). There are continuous and stable upgrades being made to the marine economy.

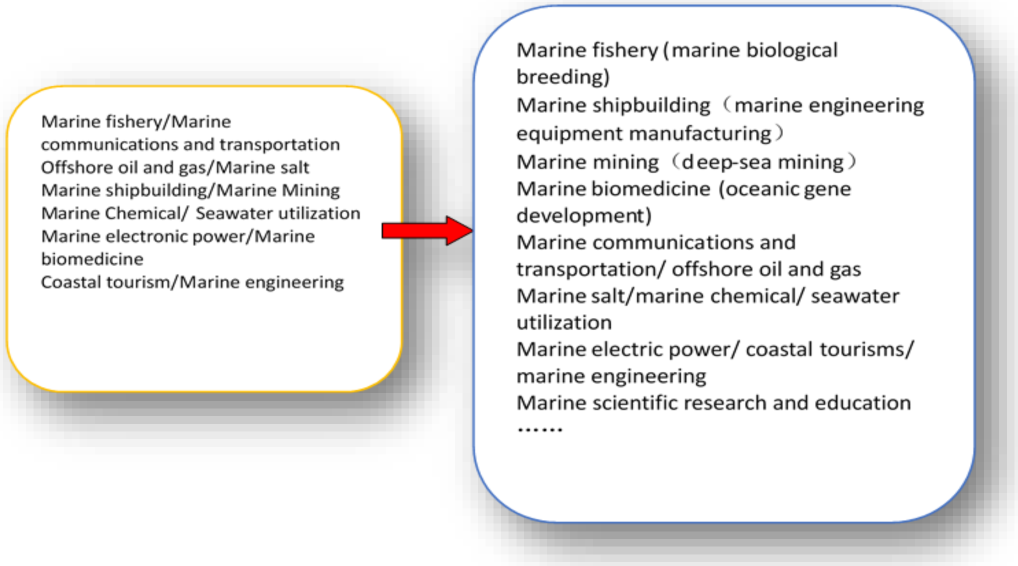


Note: "1" is primary marine industry; "2" is secondary marine industry; "3" tertiary marine industry; "4" the proportion of GOP in GDP.

Source: collected by the author according to China Marine Statistical Yearbook, 2017.

<Figure 4> National Gross Ocean Product from 2012 to 2016

The basic characteristics of China's marine industrial systems were initially in the following two aspects. (1) China has established basically a dynamic marine industry system. Initially, only six marine industries were included in the statistics and one more marine industry was added until 1990. Nowadays, there are twelve major marine industries, which means the framework of China's marine industry system dramatically improved and the development of marine economy is keeping growing. Changes in China's marine industry are shown in <Figure 5>. (2) The structure of China's marine industry continues to optimize. With the development of the marine economy, the proportion of the three marine industries has changed from "primary, tertiary and secondary" to "tertiary, secondary and primary".



Source: State Oceanic Administration of China, *China Marine Statistical Yearbook*, 2017.

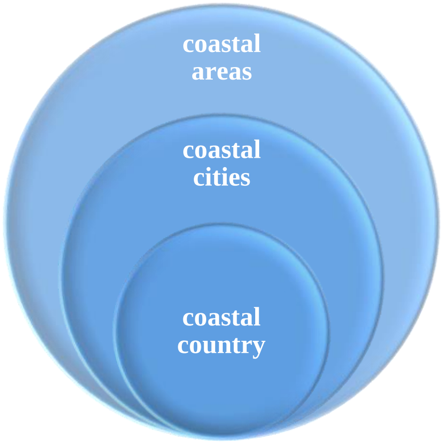
<Figure 5> Changes of China's marine industry

3.2 The Development of Chinese Regional Marine Industries

3.2.1The division of Chinese marine regions

A region is a spatial extent divided by a certain indicator. The concept of a regional or economic region can generally be divided into three levels. The first one is the value of the national economic region. The second level is the world economic region consisting of several countries or regions beyond the national or regional boundaries. The last one refers to economic regions formed by parts of several countries. In most cases, the concept of an economic zone indicates the division of different economic zones within a country, which can be adopted for the concept of marine economic regions.

According to the division of the adjacent land economic zone, China's coastal areas are divided into the northern marine economic circle, the eastern marine economic circle and the southern marine economic circle in the "Twelfth Five-Year Plan for National Marine Economic Development". In addition, China's coastal areas include Liaoning, Hebei, Tianjin, Shandong, Jiangsu, Shanghai, Zhejiang, Fujian, Guangdong, Guangxi and Hainan, all administrative regions and jurisdictional seas and islands under the jurisdiction of the eleven provinces. The division of marine regions can be divided into <Figure 6>.



Source: collected by the author according to *Marine Economic Statistics*, 2017.

<Figure 6> The division of marine regions in China

3.2.2 The marine industry distribution in regions

Location Quotient (LQ), also known as specialization rate, is proposed by P. Haggett to be applied to location analysis. It is a meaningful indicator to measure the spatial distribution of factors in a specified region and to reflect the degree of specialization of an industrial sector. The economic meaning of the location entropy generally refers to the ratio of the specific regional economic index value of a certain region to the proportion of the industrial index in the major economic regions. Moreover, the advantage of the location entropy method is reflecting the differences between the regional industrial agglomeration degree and the national average level, and facilitating the comparison of the degree of agglomeration among different regions. In this paper, this method is used to analyze the agglomeration degree of the marine industry in regions.

The equation of calculating Location Quotient is shown as followed.

$$\mathrm{LQ} = \frac{E_{ij}/E_i}{E_{kj}/E_k}$$

Where LQ represents the added value of j industry in i region. In this paper, the LQ is calculated from two perspectives. One is the agglomeration degree of the whole marine industry, and another one is the agglomeration degree of the three marine industries.

When LQ is about the agglomeration degree of the whole marine industry, E_{ij} is the regional gross ocean value of each coastal city, E_i is the regional gross national product, E_{kj} is the national gross ocean value and E_k represents the gross national product.

When LQ is about the agglomeration degree of the three marine industries,E_{ij} is the value of three marine industries of each coastal city, E_i is the regional gross national product,E_{kj} is the national gross ocean value, and E_k is the national gross product.

Generally speaking, if $\mathrm{LQ} < 1$, it means that the strength of i industry in this region is lower than other national industries. It is at a disadvantage in the scale of the industry, and it also means that the more dispersed the industry is in the region, the fewer signs of industrial agglomeration it will have. When $\mathrm{LQ} = 1$, it indicates that the strength of i industry in this region is at the average level of the other national industries. However, if $\mathrm{LQ} > 1$, it means i industry has more strength in this region than other national industries, which has an advantage in the scale of the industry. It is obvious that the industrial agglomeration in the region appears, that is, an industrial cluster has been formed or is forming. The larger the location entropy is, the higher level of industrial specialization will be, and there will be a more obvious comparative advantage.

The data are collected from China Marine Statistical Yearbook (2013—2017) and China Statistical Yearbook (2013—2017). These data are of national gross ocean product, regional gross ocean product, national gross product, and regional gross product. According to the formula, the results of the agglomeration degree of coastal provinces are shown in the followed tables.

<Table 3> Agglomeration degree of whole marine industry in China

City \ Year	2012	2013	2014	2015	2016
Tianjin	3.3411	3.2904	3.4475	3.3947	3.1302
Hebei	0.6355	0.6574	0.6695	0.7398	0.7506
Liaoning	1.4454	1.3423	1.4220	1.4495	1.6680
Shandong	1.9001	1.9321	1.9098	2.0152	2.0731
Shanghai	3.1421	3.1733	3.1440	2.8131	2.8290
Jiangsu	0.9297	0.9410	0.8959	0.9112	0.9150
Zhejiang	1.5069	1.5371	1.5149	1.4360	1.4751
Fujian	2.6189	2.4506	2.5011	2.6374	2.8636
Guangdong	1.8543	1.9829	1.9647	2.0699	2.0856
Guangxi	0.5622	0.6288	0.6771	0.6913	0.7072
Hainan	2.7809	2.8397	3.0247	2.7339	2.8529

According to the results in <Table 4>, LQ of eight cities are larger than 1, including Tianjin, Liaoning, Shandong, Shanghai, Zhejiang, Fujian, Guangdong, and Hainan. It indicates that the overall agglomeration of the marine industry in these eight coastal cities is ideal and the marine industry is developing towards a high level of clustering. Moreover, LQ of Tianjin, Shanghai, Fujian, and Hainan is larger than 2, which means these four coastal cities have a relatively higher degree of clustering. Liaoning, Shandong, Fujian, and Guangdong had an increasing trend of marine industrial agglomeration from 2012 to 2016. In detail, Liaoning has increased from 1.445 to 1.668, however, there was a decline in 2013 reaching to 1.342, while the whole trend was upward. Shandong rose from 1.9001 to 2.0731, and LQ of 2015 is the highest, which means that the marine industrial agglomeration of Shandong was growing. LQ of Fujian increased from 2.618 to 2.8636 and that of Hainan was from 2.7809 to 2.8529. Even though Tianjin, Shanghai, and Zhejiang had an LQ that was greater than 1, the marine industrial agglomeration of them is declining, which we should draw attention.

The LQ of three provinces: Hebei, Jiangsu, and Guangxi, was less than 1. However, the marine industrial agglomeration of Hebei and Guangxi has been increasing, and Jiangsu was stable. The LQ of Hebei increased from 0.6355 to 0.7506 and that of Guangxi was from 0.5622 to 0.7072. The highest level of marine industrial agglomeration of the two provinces was in 2015, in other words, the marine industry in these cities was still improving.

Next part is the agglomeration degree of the three marine industries in the coastal cities. The three marine industries are primary marine industry, secondary marine industry, and tertiary marine industry. The results of agglomeration degree of these three marine industries are shown in the followed table.

<Table 4> Agglomeration degree of three marine industries in regions

City \ Year		2012	2013	2014	2015	2016
Tianjin	1	0.8737	0.8775	0.8754	1.3704	1.3315
	2	4.2568	4.1077	4.4307	4.2112	3.6892
	3	2.1287	2.2065	2.2489	2.4154	2.4317
Hebei	1	0.4075	0.4241	0.4220	0.4093	0.4111
	2	0.6490	0.6523	0.6493	0.6993	0.6951
	3	0.6853	0.7363	0.7867	0.8798	0.8849
Liaoning	1	4.4224	3.9521	4.0804	3.4370	3.1006
	2	1.2455	1.0555	1.0338	1.0213	0.9614
	3	1.8079	1.7377	1.8410	1.7388	1.4207
Shandong	1	2.6380	2.8877	2.8614	3.1067	2.9023
	2	1.7271	1.7671	1.7618	1.8405	1.8989
	3	2.0472	2.0286	2.0443	2.0831	2.1332
Shanghai	1	0.5895	0.6264	0.5720	0.6493	0.7329

	2	2.9011	2.9835	3.0366	2.9043	3.0910
	3	3.0933	3.1011	3.1095	2.5860	2.5279
Jiangsu	1	0.8575	1.2289	1.1732	1.6324	1.8792
	2	0.9542	0.9375	0.8792	0.9768	0.9718
	3	0.8809	0.8986	0.8990	0.7745	0.7660
Zhejiang	1	4.2899	4.2249	4.0173	4.5145	4.6107
	2	1.2788	1.3125	1.2874	1.0884	1.1132
	3	1.5391	1.5658	1.5868	1.5575	1.5828
Fujian	1	4.3444	4.4660	4.4125	4.4775	4.4277
	2	2.1541	1.8579	1.8832	1.9128	2.0374
	3	3.0151	2.9792	3.1469	3.3461	3.6333
Guangdong	1	1.6420	1.2056	1.1990	1.1909	1.3888
	2	1.7067	1.9322	1.9129	1.9862	1.9347
	3	1.9477	2.0601	2.0284	2.1090	2.1535
Guangxi	1	1.2004	1.2520	1.2460	1.3675	1.3055
	2	0.4254	0.5035	0.5775	0.5309	0.5315
	3	0.6467	0.7023	0.7480	0.7917	0.8291
Hainan	1	3.8777	4.3583	5.2938	4.6541	4.6098
	2	1.9049	1.8736	2.0676	2.1406	2.2921
	3	3.4372	3.4069	3.4620	2.8598	2.9871

Note: "1" is the marine primary industry; "2" is the marine secondary industry; "3" is the marine tertiary industry.

According to the results of the agglomeration degree of the three marine industries in coastal provinces and cities, we can see the marine industrial structure of each coastal province.

<Table 5> The structure of marine industry in regions

Marine industrial structure	Coastal provinces and cities
"1,2,3"	Jiangsu
"1,3,2"	Liaoning, Shandong, Zhejiang, Fujian, Guangdong, Hainan
"2,3,1"	Tianjin
"3,2,1"	Shanghai, Guangdong, Hebei

Note: "1", "2", and "3" represent the same in <Table 4>.

3.3 Structure of the Chinese Marine Industry

The Chinese marine industry can be divided according to the traditional three industries, including primary marine industry, secondary marine industry, and tertiary marine industry.

<Table 6> Classification of Chinese marine industry based on three industries

Classification	Specific marine industries in the classification
Primary marine industry	Marine fishery industry
Secondary marine industry	Marine mining; offshore oil and gas; marine salt; marine electric power; shipbuilding; marine chemistry; marine biomedicine; seawater utilization; marine engineering architecture.
Tertiary marine industry	Marine communications &transportation; coastal tourism; marine scientific research and education.

Source: State Oceanic Administration of China, *China Marine Statistical Yearbook*, 2017.

3.3.1 Chinese primary marine industry

The primary marine industry belongs to the traditional marine industry which generally refers to marine industry that has developed to a certain scale before the 1960s and doesn't rely entirely on modern high technology. The main part is the marine fishery industry. Marine fishery refers to mariculture, marine fishing, marine fishery service industry, and marine aquatic products processing, etc. (China Marine Statistical Yearbook, 2017). It is an essential part of modern agriculture and the marine economy, moreover, it is an important industry category for the employment of labor forces in coastal areas. In the past five years, the output of marine products in China has generally shown an increasing trend. In 2013, the marine fishery industry grew steadily and rapidly, with an added value of 387.2 billion yuan (CNY) for the whole year, accounting for 17% of the added value of the major marine industries. In 2017, the marine fishery industry achieved an annual added value of 467.7 billion yuan (CNY), however, it went down 3.3% compared with last year.

The primary marine industry plays a prominent role in China's marine economy, which has a unique natural condition with the vast territory of the ocean. In terms of scale, the marine fishery industry has been in a leading position for a long time. Therefore, China's primary marine industry has certain advantages in the world.

3.3.2 Chinese secondary marine industry

There are nine marine industries including in the secondary marine industry shown in <Table 7>.

<Table 7> China's secondary marine industry

Marine Industry		Explanation
(a)	Offshore oil and gas	It refers to the production activities of exploring, exploiting, transporting and processing crude oil and natural gas in the ocean.
(b)	Marine salt	It means producing the salt products with the sodium chlorides which is the main component by utilizing seawater.
(c)	Marine mining	It means the production activities of submarine geothermal energy, coal/deep-sea mining, extracting and dressing beach placers, etc.
(d)	Marine shipbuilding	It includes building ocean vessels, offshore fixed and floating equipment, repairing and dismantling ocean vessels.

(e)	Marine chemical	It is about chemical products of sea salt, sea algal, seawater, oceanic petroleum chemical industries.
(f)	Marine biomedicine	It means the activities of producing, processing and manufacturing marine medicines and marine healthcare products by using raw materials of marine organisms or extracting useful components.
(g)	Marine electric power	It means generating electric power in the coastal areas through using ocean energies and ocean wind energy.
(h)	Seawater utilization	It means the direct or indirect use of seawater and the seawater desalination.
(i)	Marine engineering building	It means the architectural projects construction and the preparations in the ocean, at the bottom of the ocean and coastlines which are used for marine transportation, production, protection, etc.

Source: State Oceanic Administration of China, *China Marine Statistical Yearbook*, 2017.

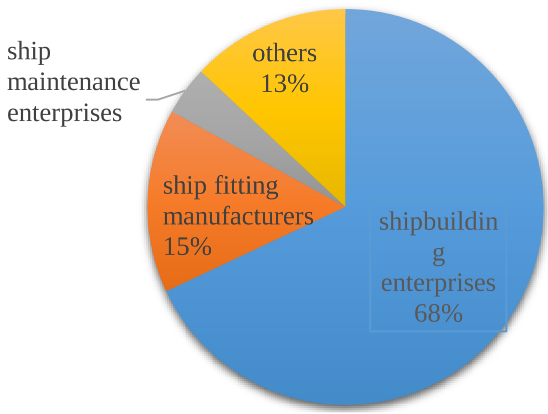
(a) Offshore oil and gas. Due to the influence of market demand and adjustment of its production structure, the output of offshore crude oil was 48.86 million tons in 2017, down by 5.3% over the previous year. And the output of offshore natural gas was 14 billion cubic meters, up by 8.3% over the previous year. The added value of the offshore oil and gas industry reached 112.6 billion yuan (CNY). With the advance of the national offshore oil and gas exploration and development, a number of advanced drilling platforms has been implemented such as “Offshore Oil 918” and “Offshore Oil 201” (the deep-water horizontal drilling rigs of China). This means that the exploration of deep-sea oil and gas is facing significant opportunities.

(b) Marine salt. Throughout the ages, China’s marine salt industry has problems such as simple product structure, low level of resource utilization, and extensive production. Especially in recent years, with the acceleration of urbanization and industrialization, the external environmental pressures faced by marine salt production are increasing. With the reduction of the salt pans, marine salt production is also declining. This industry realizes an added value of 4 billion yuan (CNY) for the entire year, down 12.7% from the previous year. Although the production and area of marine salt have declined, the technology applied in the process, energy conservation, comprehensive utilization, and equipment has made some breakthroughs. In addition, it is used for the comprehensive utilization of high-salt wastewater, and initially realizes the transfer of high-efficiency utilization of marine resources to relate to inland enterprises. It is expected to produce greater social and economic benefits.

(c) Marine mining. Generally, marine mineral resources are classified into coastal mineral resources and deep-sea mineral resources according to their distribution locations, so there are coastal mining and deep-sea mining. However, the deep-sea minerals in the world remain in the stage of technology research and mineral exploration. It is difficult to determine when it will enter the stage of large-scale industrial development. Therefore, deep-sea mining is listed as a forthcoming marine industry.

At present, China is still in the development of coastal sand mining, which includes marine gravel mining, coastal metal, and non-metallic mineral development. The main sites are situated in Zhejiang, Fujian, Guangdong, Guangxi, Shandong and other regions. In 2017, due to the strict limitation on market demand and the control of offshore resources, the marine mining industry achieved an added value of 6.6 billion yuan (CNY) with a decrease of 5.7% over the previous year. In the face of the increasing pressure of ecological protection, the transformation and upgrading of the marine mining industry are still grim.

(d) Marine shipbuilding. In 2018, national shipbuilding completed 34.58 million deadweight tons (DWT), declining by 14% year-on-year. Orders of new ships were 36.67 million DWT with an increase of 8.7%, and at the end of December the handling orders were 89.31 million DWT with an increase of 2.4%. Chinese shipbuilding enterprises had taken advantage of the small increase in the international shipping market and the opportunity of a fresh ship market. It maintained the leading position in the international market. At that time, there were 1,212 shipbuilding enterprises at the national scale achieving the core business income of 40.32 billion yuan (CNY), a decrease of 31.7% year-on-year. Among them, the shipbuilding industry was 285.36 billion yuan (CNY), which was 30.8% below its year-earlier level. Besides, the ship supporting industry and marine engineering equipment manufacturing were 17.65 billion yuan (CNY) and 36.61 billion yuan (CNY) respectively. The income ratio of the principal business of the shipbuilding industry in China is shown in <Figure 7>.



Source: China Oceanic Information Network (website).

<Figure 7> Income ratio of main business of shipbuilding industry in China

(e) Marine chemical industry. As a strong force of emerging marine industry, the marine chemical industry develops at a high speed. Overall, the value added of this industry generally shows an upward trend. In 2001, the industrial added value was 6.47 billion yuan (CNY). During that time, the crude oil price fluctuated frequently in 2008, and the added value of marine chemical industry declined, which was nearly 18% lower than that in 2007. With the national economic recovery in 2009, the marine chemical industry began to grow steadily and the added value of this industry in 2012 grew 27.9% compared with 2011 since then it maintained a steady growth. In 2017, the growth rate of marine chemical products such as caustic soda and ethylene declined which was affected by the inventory. In spite of this situation, the marine chemical industry achieved an added value of 104.4 billion yuan in the whole year.

(f) Marine biomedicine industry. This industry is upgraded and developed on the basis of traditional marine biological products. Because of its benefits, high added value, and high efficiency, it is a part of the high-tech industries.

In recent years, the scale of China's marine biomedicine industry has continued to increase. In 2001, the added value of this industry was only 570 million yuan (CNY), and the number of employees was less than 10,000. Since then, the marine biomedicine industry has been growing at high speed, and the added value and the number of employees have increased significantly. Due to the international financial crisis in 2009, China's marine biomedicine industry was affected and its added value decreased by 5.21 billion yuan (CNY). In the same year, China's government promoted the policy to accelerate the development of the biological industry which was worthwhile to resume the growth. In 2016, this industry realized an added value of 33.6 billion yuan (CNY). In 2017, the marine biomedicine industry grew rapidly and industrial clusters gradually formed, which achieved an added value of 38.5 billion yuan (CNY) in the entire year, an increase of 11.1% over the previous year.

(g) Marine electric power industry. This industry has had a rapid growth. In 2001, the added value of marine electric power was less than 200 million yuan (CNY). By 2016, the added value of marine electric power industry had reached 12.6 billion yuan (CNY). However, only offshore wind power has fully realized industrialization. The other industries are still in the testing stage such as ocean power generation and wave power generation.

(h) Seawater utilization industry. The scale of seawater utilization has continued to expand, showing a continuous growth trend. In 2001, the added value of this industry was only 110 million yuan, however, the industry realized an added value of 1.5 billion yuan in 2016. What's more, the scale of seawater desalination projects has gradually expanded, and the application of seawater desalination projects and seawater circulation cooling technology have gradually expanded. In 2017, the seawater utilization industry grew steadily and the scale of application gradually expanded. Its added value achieved 1.4 billion yuan (CNY) for the whole year.

(i) Marine engineering building industry. As a key industry in the marine economic infrastructure, marine engineering building industry maintained the rapid growth. On the one hand, the port trade in the coastal areas of China is relatively enhanced, occupying seven of the world's top ten ports, and throughput of these ports has also increased year by year. On the other hand, the state promotes regional economic policies in the free trade zone and accelerates the construction of new ports, which will promote the prosperity of marine engineering building industry. In 2017, the annual added value of this industry reached 184.1 billion yuan (RMB), an increase of 0.9% over the previous year. However, pressures on the growth of this industry has emerged, which is affected by the domestic macro-economy and the investment in offshore engineering projects.

3.3.3 Chinese tertiary marine industry

Tertiary marine industry is a department providing socialized services for the production, circulation, and life of the marine development, which includes marine communications and transportation, coastal tourism, and marine scientific research and education.

<Table 8> China's tertiary marine industry

Marine Industry		Explanation
(a)	Marine communications and transportation	This industry carries out and serves the marine transportations with vessels as main vehicles, including ocean-going passengers' transportation, coastal passengers' transportation, and so on.
(b)	Coastal tourism	This industry includes the tourist service and business depending on the coastal zone, islands as well as a variety of natural and human landscapes of the ocean.
(c)	Marine scientific research and education	This industry refers to the activities of scientific research, education and services in the process of developing, utilizing and protecting the ocean. Sometimes, it is listed as a single part of marine industry.

Source: State Oceanic Administration of China, *China Marine Statistical Yearbook*, 2017.

(a) Marine communications and transportation industry. In 2017, the Chinese and international shipping market gradually recovered, and the production of coastal ports maintained a good growth trend. It is anticipated that cargo throughput capacity will increase by 7.7%. Marine communications and transportations industry achieved an added value of 631.2 billion yuan (CNY), an increase of 9.5% over the previous year.

However, compared with developed countries, China's marine communications and transportations industry is large but not strong. What's worse, it cannot fully adapt to the needs of economic and social development even in the construction of maritime power. For instance, China's shipping service trade has been in a deficit for a long time, and the high-end service is poor. The overall share and volume of shipping are only one-quarter of the total volume of imported and exported goods, which should be improved.

(b) Coastal tourism. In the past ten years, the scale of the coastal tourism industry had continued to increase, and it has become an important pillar in the marine industry system, accounting for 30% of the added value. In 2013, coastal tourism continued to maintain a good development trend, the annual added value reached 785.1 billion yuan (CNY), an increase of 11.7% over the previous year. With the rapid development of coastal tourism, cruise ships, yachts and recreational fishery markets are growing rapidly. In 2017, the gross ocean product of coastal tourism was 1463.6 billion yuan (CNY). Taking cruises as an example, it develops from an unpopular industry to the fierce one, from the aristocratic group to the masses. With the rapid development of the economy and increasing consumption, the cruise industry has become a new force in coastal areas, such as

Royal Caribbean Cruise and Costa Cruise, who have successively opened new routes in Northeast Asia and Southeast Asia from Chinese ports.

3.3.4 Obstacles of China's three marine industries

There are three obstacles to Chinese primary marine industry.

(a) Serious pollution of the marine ecological environment. Although China's marine economy is currently in a stage of rapid development, the consciousness of marine environmental protection is poor. In order to promote the development of regional marine economies, some coastal provinces and cities have continuously started wading project construction, and large-scale land reclamation, all of which have had a grave impact on the marine ecological environment. Unlike the terrestrial ecological environment, as a unique resource carrier, the various components of the marine system are more closely related, and the marine ecological balance is more vulnerable. China Ocean Economic Environmental Quality Report pointed out that the environmental quality of coastal waters was generally poor. Most of them did not satisfy the environmental protection requirements. Nowadays, the destruction of the ecological environment has significantly restricted the sustainable development of China's marine economy. There is serious pollution in many sea areas, for instance, the ecological environment of major fisheries is degraded; the polluted seawater contains a lot of heavy metal elements.

(b) Unbalanced allocation resources of marine science and technology. The sustainable development of the marine economy requires the support of cutting-edge marine science and technology. Attracting marine scientific and technological talents is a major factor driving the rapid development of China's marine economy. However, the allocation and scientific research resources in China are extremely unbalanced. The main reason for this issue is that marine education resources are primarily concentrated in coastal areas with high economic developmental levels. In 2015, the number of marine scientific research practitioners in Beijing, Shandong, and Shanghai was 14,091, 3,922 and 3,855 respectively, which concentrated 53.97% of the country's marine scientific researchers. In addition, some marine scientific research institutions are mainly distributed in colleges and universities. Due to a lack of funds, the marine scientific research forces are idle, resulting in a waste of marine scientific research resources. It is difficult to transform scientific research results into actual products, which fails to achieve synergistic progress in production, education, and research.

(c) Short supplies of the policies of traditional marine industry. According to the 2016 China Marine Economic Statistics Bulletin, the total value of marine production reached 7.05 trillion yuan (CNY), of which added the value of marine primary, secondary and tertiary industries was 356.6 billion yuan (CNY), 2.8 trillion yuan (CNY) and 3.5 trillion yuan (CNY) respectively. Each proportion of total marine production is 5.1%, 40.4%, and 54.4% respectively. It demonstrates the disadvantages of primary marine industry. With the introduction of the strategy of maritime power, China attaches more and more importance to the development of the marine economy. However, it should be noted that as the state's support for the traditional marine industry continues to decline, the traditional marine industry cannot be developed efficiently, and the advantages of the traditional marine industry cannot be fully exerted. It means that the traditional marine shows a downward trend without supports.

Although Chinese secondary and tertiary marine industries are gradually being evaluated by the state, localities, and enterprises, the number and scale of marine-related enterprises are growing steadily, but there are many constraints on its development.

(a) Decentralization of marine scientific researches. The system of marine scientific research is imperfect, the conversion rate of marine scientific and technological achievements is still at a low level, and the industrialization mechanism and the competitiveness of products have yet to be further improved. Why is this happening? On the one hand, some coastal provinces and cities lack the unified planning guidance for the development of marine science and technology, resulting in a low degree of organization and lag in management. Despite the fact that the marine industry in the coastal areas is relatively developed, there are still some departments that lack the coordination of the various sectors of the marine industry. The cooperation efficiency is low and the degree of an organization needs to be strengthened. On the other hand, marine science and technology projects lack integrity and systematicity. There are not any long-term goals of marine science and technology projects, and the technology development is often limited by locally and neglects integrity. What's worse, applied research is too one-sided, which makes the cluster effect of marine science and technology projects greatly reduced.

(b) The main part of marine science and technology innovation. Due to the lack of an intermediary in the transformation of marine technology, it often creates unnecessary contradictions in the distribution of production, education, and research, and hinders the construction of cooperation mechanisms. Marine-related enterprises are not the main body of marine science and technology innovation. At present, practical technologies and key technologies that constrain the rapid growth of enterprises have attracted widespread attention to coastal companies. These companies tend to transform the previous achievements of applied technology institutions, rather than invest in the development of new technologies and new products. In addition, compared with the fundamental technologies of the promotion and innovation, enterprises pay more attention to production task which largely restricts the development of marine technology. In the field of applied research, the marine-related enterprises have insufficient research on marine technology and lack of independent innovation, which makes the development of marine science and technology seriously lag behind the development of the industry itself.

(c) Weakness in the leading role of the secondary marine industry. Primary marine industry develops much longer than secondary and tertiary marine industries, which accounts for a large proportion. Although the proportion of secondary and tertiary marine industries have increased, it cannot be exceeded for a short time. Some secondary and tertiary marine industries have great development potentials, such as marine engineering building and marine biomedicine. However, due to the weak foundation and small total volume, these industries are still in the initial stage of development. On the other hand, the level of industrialization of secondary marine industry is low, and the leading role of scientific technology in the sea is insufficient. Some coastal provinces are biased towards practical application research. They have short-sighted behaviors at the prospect of marine high-tech and have not invested enough manpower or money. This is one reason why numerous technological applications cannot be effectively promoted. In particular, key marine technologies in the emerging marine industries are still far apart from the frontier areas, and their development is relatively backward. Most of the marine scientific and technological achievements are concentrated in the low-end industries, and there are few high-end industrial achievements.

Chapter 4 A Comparative Analysis on Regional Marine Industry in China

In this chapter, we compare the development of the regional marine industry in China from the perspective of competitiveness. Firstly, we analyze the factors influencing competitiveness of the marine industrial and establish the evaluation index system. Second, we apply the Entropy method to get the weight and scores of regional marine industrial competitiveness in China by MATLAB.

4.1 Factors Influencing the Marine Industrial Competitiveness

Firstly, as an industry category, the marine industry development will be affected by common factors. Secondly, as a marine industry depending on the ocean, marine factors will also affect the development of the marine industry. Therefore, the establishment of the index system of marine industrial competitiveness considers the factors comprehensively, combining the industrial competitiveness factors with the characteristics of the marine industry.

The competitiveness and evaluation research center of Renmin University of China proposes that the degree of competitiveness is the potential for development. This potential is accompanied by labor, exports, technology, and other manifestations. The organic combination of these elements can provide sufficient power and competitiveness for the system.

Ni, P.F. (2003) constructed the Bowstring model of urban competitiveness which conducted an empirical study on the overview of China's competitiveness. The author divided the urban competitiveness into two sides. One was called "soft power" including the management capacity, openness, cultural characteristics, and other elements. Another one was "hard power" including technology, labor, capitals and other factors. Xiao, Y. et al. (2015) analyzed the marine industrial competitiveness of blue economic regions, establishing the evaluation index system including four indices which were marine comprehensive capacity, marine industrial output capacity, marine research capacity, and marine environmental protection capacity. Li, X.G. et al. (2012) conducted the analysis of marine industrial competitiveness of Shandong Province, who established the evaluation index system with nine indices which were marine industrial innovation competitiveness, marine industrial output capacity, marine industrial structure, marine industrial marketing, marine industrial potentials, marine resources and environment, marine enterprises development, marine international competitiveness and marine soft environment. The author (2010) also suggested the united decision of the measurement mode to analyze Chinese marine industrial competitiveness, taking four indices into consideration which were marine industrial human resources, marine industrial capitals, international level of the marine industry, and marine industrial science and technology. Yin, K.D. and Li, X.D. (2011) analyzed the comprehensive strength of the marine economy, including three indices in the evaluation index system which were the gross marine economy, marine industrial structure and impelling force of the marine industry. Wu, K. F. (2014) applied Principal Component Analysis and TOPSIS methods to evaluate the industrial competitiveness of the marine industry in Guangdong Province. There were five indices in the evaluation index system that were: the abundance of marine resources, marine human resources, marine technology, main activities of the marine industry and the foundation of the marine economy.

Considering the characteristics of China’s marine industry and the literature reviews above, the structure of factors influencing the competitiveness of the marine industry is divided into two parts. One part is subject factors, and another part is objective factors.

This paper takes four subjective factors into consideration. (1) Regional economic capacity. The development of marine industry needs the support of certain economic strengths. How strong the economy is has a direct impact on the marine industry. Sufficient funds cannot only guarantee marine industry to develop healthily and rapidly, but also promote the upgrading of the marine industry. In this paper, this factor mainly refers to the gross domestic product of coastal areas, regional marine gross domestic product, and other economic indicators. (2) Output capacity. This means the output value of the marine industry, considering the primary marine industry, secondary marine industry, and tertiary marine industry. (3) Human resources. Human resources play an extremely significant role in the development of China’s marine industry. In this paper, human resources refer to the people who engage in various marine production activities. As the human factor of the marine industry, it mainly includes the number and quality of laborers involved in the marine area. With the continuous development of marine industry, the number of ocean-related employees increases year by year. In 2016, the number of ocean-related jobs covered 36.225 million people, and Guangdong Province had the largest number which was 8.685 million, and Shandong Province ranked second. (4) Technology conditions. This means the science and technology innovations in the marine industry. Science and technology are the primary productive forces, and scientific research and technological innovation have become the engine for the sustainable and stable development of the marine industry. The levels of marine science and technology, as an important driving force for the rapid development of the marine industry, is the key to the formation of marine industrial competitiveness in regions. Moreover, the essential difference between the emerging marine industry and the traditional marine industry lies in the dependence level of high technology. Therefore, applying the latest achievements of science and technology to marine production can continuously improve efficiency, enhance production capacity, and thus improve the competitiveness of the marine industry. What's more, there are important indicators of marine scientific research and technological innovation, such as the number of marine scientific research institutions and personnel, research funds allocated to the marine scientific research and research achievements.

On the other hand, this paper takes three objective factors into consideration. (1) Regional natural resources. Natural resources and geographical location have a great impact on marine industrial competitiveness. The marine fishery industry and marine oil and gas industry are closely related to marine natural resources, because their production needs the raw materials which are obtained from marine natural resources. Therefore, the development of marine industries in different regions will be constrained by the abundance of natural resources. At the same time, due to the regional differences in the natural resources of coastal provinces and cities, each province and city will explore their advantaged marine industries according to their individual characteristics. (2) Environment. This includes the policy institutional environment and the ecological environment. Marine industrial policy is the sum of all policies formulated and implemented which are related to the marine industry. China aims to improve the international competitiveness of its marine industry and promote its coordinated development. In 2002, the 16th National Congress of the CPC proposed developing the ocean. The State Council issued the “National Marine Economy Development Plan” in 2013. The “Eleventh Five-Year Plan” proposed strengthening the awareness of the oceans, safeguarding maritime rights and interests, protecting marine ecology and implementing comprehensive marine management, which aimed to promote the development of the marine economy. In 2007, the 17th National Congress of the CPC moved forward to develop the marine industry and the State Council approved the “National Maritime Development Plan”. In recent years, the report from the 18th National Congress of the CPC clearly pointed out five principles that were improving the ability to develop marine resources, developing the marine economy, protecting marine ecological environment, safeguarding maritime rights and interests and building maritime power. In 2014, China’s State Oceanic Administration held a seminar on strategic planning for maritime powers. In December 2016, “Strengthening the ocean by science and technology” was issued jointly by China’s State Oceanic Administration and Ministry of Science and Technology, which aimed to promote the opening up and development of the sea through science and technology. Laws and regulations also play a crucial role in the marine industry activities. Laws and regulations can restrict marine production to ensure the standardization and good operation of marine activities within a legal and reasonable scope. The United Nations had held three conferences on the law of the ocean, the first one was held in Geneva in 1956 and the second is in 1960; the third conference, held in Jamaica in 1982, adopted the United Nations Convention on the Law of the Sea. China has promulgated laws and regulations on marine issues, such as Law on the Exclusive Economic Zone, and the Continental Shelf of the People's Republic of China and so on. Facing the status quo of resource scarcity and environmental degradation, sustainable development has become the only way to economic and social development. Developing the marine industry should also adhere to the concept of sustainable development. To some extent, environmental protection restricts the development of marine industry and will become one of the vital factors affecting the competitiveness of marine industry in the future. This is the reason why we should attach importance to resource conservation and environmental protection. It is necessary to strengthen investment in technological innovation and adopt environmental protection measures to develop the marine industry. (3) External activity, especially for exports. This refers to the capacity of exports of marine products. With the advance of economic globalization, the development of marine industry will be affected by the international economic environment. For instance, the import and export trade of marine products will be affected by the international economic environment.

4.2 The Evaluation Index System

For analyzing the influencing factors on regional marine industrial competitiveness of China, it is essential to establish a suitable index system. And why we should establish the index system and how to establish it in this paper are the issues in this section.

4.2.1 The purpose of the establishment of the index system

Although academia has conducted in-depth research on industrial competitiveness and regional industrial competitiveness, the marine industry is distinct from the land industry. Besides, many evaluation indexes which are applicable to the land industry are not suitable for the marine industry. The establishment of an evaluation index system of marine industrial competitiveness is the way from the theoretical basis for empirical analysis.

In this paper, the regional marine industrial competitiveness index system should not only include the influencing factors that are analyzed above but also facilitate the quantitative evaluation of the competitiveness level of marine industrial regions. Since there are both causes and results for the formation of marine industry competitiveness, the index system should both reflect the competitiveness of individual factors and can explore the reasons for the formation and the mutual relations among various factors. At the same time, there is a great difference between quantitative evaluation and qualitative analysis. This paper attempts to reduce the subjectivity of evaluation indicators and selects the evaluation indicators that are representative and can fully reflect marine industrial competitiveness. So it will take three aspects into consideration to design the index system. Firstly, marine industries are mostly resource-dependent industries, and these resources are mostly distributed in secondary and tertiary marine industries. The evaluation indexes should conform to the development status of marine industries. Secondly, the concept of marine industrial competitiveness is rich in connotation, and there are many influencing factors. Therefore, it is essential to distinguish the correlation between the indicators. Thirdly, this paper compares the regional marine industrial competitiveness, so indicators should be designed with regional comparability.

4.2.2 The principles of the establishment of index system

Due to the analysis of the regional marine industrial competitiveness of China, the process of interaction and influence of many factors in regions needs to be taken into account. Besides, with the complicated and dynamic characteristics of marine industrial competitiveness, when evaluating it objectively, it is necessary to follow these principles to establish the index system.

(1) Scientific and rational principle

The principle of scientificity means that the index system should have a theoretical basis for the calculation method, and the actual meaning of the object can be clearly defined. When establishing the index system of marine industrial competitiveness, it should start from the connotation of the marine industrial competitiveness, in the view of regions, and combine the research results of China and other countries. At the same time, the establishment of the index system should cover the essence of marine industrial competitiveness as much as possible to ensure the systematicness and integrity of the index system.

The principle of reasonability should consider the availability of data. It is impossible to further analyze and study the scientific index system without corresponding statistical data.

This paper is based on previous papers from home and abroad to ensure the scientificity of the index system, and this paper selects the indicators according to the data from China Marine Statistical Yearbook, China Statistical Yearbook, and Marine Economic Statistics Bulletin. Therefore, the data accords with the principle of science and rationality.

(2) Systematic and comprehensive principle

There are numerous factors influencing marine industrial competitiveness, which brings difficulties to evaluate. To establish the index system we should consider the score of each indicator systematically. Moreover, the index system of marine industrial competitiveness should reflect the content of each indicator and combine the object with indicators, which would constitute a rigorous comprehensive evaluation index system.

When selecting the indicators for evaluating regional marine industrial competitiveness, this paper should consider the internal and external factors which are discussed above. According to systematic and comprehensive principles, the indicators should be selected from multi-dimensions.

(3) Comparable and targeted principle

Currently, there is no unified standard for the research on the index system of marine industrial competitiveness in China or other countries, especially on the view of regions, which makes it difficult to make a horizontal comparison in different regions. So it is essential to select indicators based on comparable and targeted principles.

Because of the different developments of the marine industry in coastal areas and the occurrence of data loss, this paper follows the principle of comparability to select indicators with the consistent statistical caliber and relatively stable data, which could facilitate the comparison of regional marine industrial competitiveness.

(4) Objective and practical principle

This paper applies quantitative analysis, but the operability of data variables in quantitative analysis is one of the crucial problems in the empirical analysis. So on the one hand, selecting indicators should meet the objective requirements. On the other hand, selecting indicators should guarantee that the variables of corresponding indicators can be quantified. It is accurate for using quantitative indicators, therefore, this paper doesn’t consider the qualitative indicators.

In addition, there are various levels of the designed evaluation index system, so the whole evaluation process is too complex and the calculation is prone to errors and is difficult to operate. As a consequence, the selected indicators should take the possibility of data into account. If some data were therefore difficult to collect and sort out, so in this case, alternative indicators should be chosen.

(5) Dynamic and static principle

The evaluation of marine industrial competitiveness not only has the measure of a certain time point but also has the comparison of changes in a period of time. The dynamic index is the variable reflecting the process of the object, while the static index refers to the variable that reflects a certain point of the evaluation object. For instance, this paper selects the data of regional GOP and added value of the marine industry, where one is a static index and the other is a dynamic index.

Therefore, the index system should include not only static indicators that reflect the current development situation, but also dynamic indicators that reflect the changes in the past and future.

4.2.3 The establishment of the evaluation index system

In the synthesis of the above contents, this paper will follow the listed principles to select indicators and refer to the result of previous studies on marine industrial competitiveness in China and other countries.

The evaluation index system of this paper not only considers the factors of the marine industry itself but also takes other factors into account, such as the foundation of regional marine economy, marine resources, marine industrial technology, human resources, and so on. Since it is hard to obtain and quantize some data such as marine policies and regulations, the evaluation index system designed in this paper does not take these indicators into consideration. To sum up, the indicators selected in this paper are given in <Table 9>. The comprehensive index system is composed of three levels. First of all, it is to study the target layer, namely the regional marine industrial competitiveness. Secondly, the index system consists of six first-class indices which are regional marine economic capacity, regional marine output, marine science and technology, marine human resources, marine environmental protection, and marine exports.

In addition, each first-class indice has the specific indicators and there are seventeen second-level targets that will be explained one by one.

<Table 9> Evaluation index system

	First-class Indices	Second-class Indices	
Regional Marine Industrial Competitiveness of China	A_1	Average annual growth rate of regional marine industry	X_1
		Proportion of regional GOP in regional GDP	X_2
		Proportion of regional GOP in national GOP	X_3
		Proportion of regional marine industrial added value in national marine industrial added value	X_4
	A_2	Gross product of marine primary industry	X_5
		Gross product of marine secondary industry	X_6
		Gross product of marine tertiary industry	X_7
	A_3	Proportion of regional marine patents in national marine patents	X_8
		Proportion of regional marine projects in national marine projects	X_9
		Proportion of regional marine funds in national marine funds	X_{10}
	A_4	Proportion of regional ocean-related employed in all regional employed	X_{11}
		Proportion of regional ocean-related employed in national ocean-related employed	X_{12}
		Proportion of professional regional ocean-related employed in national ocean-related employed	X_{13}
	A_5	Proportion of regional pollution treatments projects in national marine pollution treatments projects	X_{14}
		Proportion of regional marine-type nature reserves in national marine-type nature reserves	X_{15}
	A_6	Proportion of regional marine exports in national marine exports	X_{16}
		Proportion of regional marine exports in regional marine added value	X_{17}

Note: $\boldsymbol{A_1}$ is the regional marine industrial economic capacity; $\boldsymbol{A_2}$ is the regional marine industrial output capacity; $\boldsymbol{A_3}$ is the regional marine industrial science and technology capacity; $\boldsymbol{A_4}$ is the regional marine industrial human resources capacity; $\boldsymbol{A_5}$ is the regional marine industrial environmental protection capacity; $\boldsymbol{A_6}$ is the regional marine industrial exports capacity.

<Table 10> First-class target of the evaluation index system

	First-class Indices	Explanation
A_1	Regional marine industrial economic capacity	This indicator reflects the strength of marine economy, to a certain extent, it also measures the economic contribution of marine industry to a region.
A_2	Regional marine industrial output capacity	This indicator reflects the production capacity of marine industry, including marine primary industry, marine secondary industry and marine tertiary industry.
A_3	Regional marine industrial science and technology capacity	This is a significant indicator of the level of marine economic development. It can reflect the ability of regional science and technology and determine the potential of marine economy.
A_4	Regional marine industrial human resources capacity	Human resources play a vital role in industrial development. This indicator reflects the number of people engaged in marine production and the number of people engaged in marine research.
A_5	Regional marine industrial environmental protection capacity	Environment play a crucial role in the development of marine industry, which belongs to the external factors. This indicator can reflect the capacity of marine ecological protection and waste treatment in a region.
A_6	Regional marine industrial exports capacity	This indicator means that marine products earn foreign exchange through exports. It reflects the ability of international competitiveness of marine industry.

<Table 11> Second-class target of the evaluation index system

A_1	Average annual growth rate of regional marine industry	It is an indicator that reflects the economic benefits of regional marine industry and the growth quality of marine industry.	X_1
		$X_1 = \frac{Added\ Value\ of\ Regional\ GOP}{Regional\ GOP} \times 100\%$	
	Proportion of regional GOP in regional GDP	This indicator reflects the economic strength of marine industry development, and shows the contribution of marine industry in a region.	X_2
		$X_2 = \frac{Regional\ GOP}{Regional\ GDP} \times 100\%$	
	Proportion of regional GOP in national GOP	This indicator reflects the scale of regional marine economy and the contribution of regional marine economy to the nation.	X_3
		$X_3 = \frac{Regional\ GOP}{National\ GOP} \times 100\%$	
	Proportion of regional marine industrial added value in national marine industrial added value	This indicator reflects the output capacity of marine industry in a region, and shows the position in national marine economy.	X_4
		$X_4 = \frac{Added\ Value\ of\ RegionalGOP}{Added\ Value\ of\ National\ GOP} \times 100\%$	
A_2	Gross product of marine primary industry	This indicator reflects the development level of marine primary industry in regions.	X_5
		X_5=*Gross product value of marine primary industry*	
	Gross product of marine secondary industry	This indicator reflects the development level of marine secondary industry in regions.	X_6
		X_6=*Gross product value of marine secondary industry*	
	Gross product of marine tertiary industry	This indicator reflects the development level of marine tertiary industry in regions.	X_7
		X_7=*Gross product value of marine tertiary industry*	
A_3	Proportion of regional marine patents in national marine patents	This indicator refers to the number of the professional patents granted to the unit by the patent administrative department in the year, it reflects the	X_8

		researching capacity and innovation ability in a region.	
		$X_8 = \frac{Regional\ Marine\ Patents}{National\ Marine\ Patents} \times 100\%$	
	Proportion of regional marine projects in national marine projects	This indicator is about the number of regional marine scientific and technological research projects, which reflects the scale of marine science and technology research.	X_9
		$X_9 = \frac{Regional\ Marine\ Research\ Projects}{National\ Marine\ Research\ Projects} \times 100\%$	
	Proportion of regional marine funds in national marine funds	This indicator is about the research funds receipts of marine scientific research institutions, which reflects the situation of the support of marine science and technology.	X_{10}
		$X_{10} = \frac{Regional\ Marine\ Science\ Funds}{National\ Mairne\ Science\ Funds} \times 100\%$	
A_4	Proportion of regional ocean-related employed in all regional employed	This indicator reflects the number of people employed in marine industry, which is the situation of human resources.	X_{11}
		$X_{11} = \frac{Regional\ Ocean-related\ Employed}{All\ Regional\ Employed} \times 100\%$	
	Proportion of regional ocean-related employed in national ocean-related employed	This indicator reflects the level of regional participation in the development of marine industry.	X_{12}
		$X_{12} = \frac{Regional\ Ocean-related\ Employed}{National\ Ocean-related\ Employed} \times 100\%$	
	Proportion of professional regional ocean-related employed in national ocean-related employed	This indicator reflects the high level of human resources in marine industry development in a region.	X_{13}
		$X_{13} = \frac{Regional\ Ocean-related\ Employed\ in\ Prof}{National\ Ocean-related\ Employed\ in\ Prof} \times 100\%$	

A_5	Proportion of regional pollution treatments projects in national marine pollution treatments projects	The pollution treatments projects include the treatment of waste water and treatment of solid wastes. This indicator reflects the pollution treatments projects of a region in China.	X_{14}
		$X_{14} = \frac{Regional\ Pollution\ Treatments\ Projects}{National\ Marine\ Pollution\ Treatments\ Porje} \times 100\%$	
	Proportion of regional marine-type nature reserves in national marine-type nature reserves	The number of nature reserves of regional marine areas reflects the environmental protection of each region in China.	X_{15}
		$X_{15} = \frac{Regional\ Marine-type\ Nature\ Reserves}{National\ Marine-type\ Nature\ Reserves} \times 100\%$	
A_6	Proportion of regional marine exports in national marine exports	This indicator reflects the market share of the regional marine industry in China.	X_{16}
		$X_{16} = \frac{Exports\ of\ Regional\ Marine\ Products}{Exports\ of\ National\ Marine\ Products} \times 100\%$	
	Proportion of regional marine exports in regional marine added value	This indicator reflects the contribution of regional marine industry to the regional development.	X_{17}
		$X_{17} = \frac{Exports\ of\ Regional\ Marine\ Products}{Added\ Value\ of\ Regional\ GOP} \times 100\%$	

4.3 Empirical Analysis

4.3.1 The selection of evaluation methods

When evaluating the industrial competitiveness, the evaluation can be structured into a distinct item and a comprehensive item. The single evolution depends on one index, getting a judgment by the comparison. This method can give a clear understanding of the state of industrial competitiveness, however, the disadvantage of this method is difficult to ensure how the industrial competitiveness forms and it is hard to establish the factors that influence industrial competitiveness. Therefore, this paper does not apply to a single evaluation. The comprehensive evaluation is based on various indexes and makes a comprehensive judgment from a variety of aspects. Firstly, we should analyze the situation of the factors that influence industrial competitiveness. Then, the index system is put in place to evaluate industrial competitiveness systematically. Besides, it measures the index system by quantitative analysis of the data and model. The comprehensive evaluation overcomes the limitation of a single evaluation that only focuses on the results of competitiveness.

In the comprehensive evaluation, there are qualitative and quantitative analyses. In the qualitative analysis, Delphi Method and the Analytic Hierarchy Process (AHP) are often used. In two methods, the experts can choose different measurements according to their understanding. To a great extent, the evaluation process is subjective, so the results may be less reliable. It is the disadvantage of the two methods. In the quantitative analysis, the consequences would be decided by objective data by considering the statistical nature of the indicators. Here are applied quantitative methods in this paper, which are the entropy method and cluster analysis.

(1) Entropy method

The entropy method is a comprehensive evaluation method based on the concept of entropy as a measure of uncertainty in information theory. This method has been implemented in the social economy, statistics and other regions. The more information there is, the less uncertainty there will be; otherwise, the less information there is, the greater uncertainty there will be and the higher entropy there is.

Considering the significance of index weight, this paper applies entropy to judge the dispersion degree of indicators affecting the marine industrial competitiveness according to the characteristics of entropy, which reflects the influence of each indicator on the comprehensive evaluation results. Because the entropy method is used as the weight of the comprehensive evaluation index, the results are more objective. The entropy method can fully obtain the original data information and overcome the randomness of subjective index selection. Therefore, the advantage of the entropy method is avoiding the subjective arbitrariness of evaluation results, even if there is less flexibility. The entropy method makes up the deficiency of the subjective weighting method effectively.

The main principle of the entropy method is to use the entropy values to measure the effective information of the identified index data and to calculate the weight, that is, the weight of each index determined by a different degree of the evaluation object. If the dispersion degree of the index is larger, it indicates that the value of a certain index of the evaluation object is greatly different and the entropy is small which indicates that the index has a significant influence on the comprehensive evaluation. On the contrary, if the effective information provided by this index is small, it plays a small role in the whole index system, so the weight of this index is relatively small. If a specific index value of each evaluation index is completely consistent, then the entropy reaches the maximum, which means that this index can be removed from the evaluation index system.

The specific steps of applying the Entropy Method are as follows.

Step 1: Selection of the index and sample.

The first step is to select the data of marine industrial competitiveness in *n* years and *m* indicators, then $X_{ij}$is the value of j_{th} indicator in the i_{th} year of marine industry. (*i*=1,2,…, n ; *j*=1, 2,…, m)

Step 2: Index standardization.

Since the measurement units of various indicators are not uniform, they should be standardized before calculating, that is, the absolute value of indicators should be transformed into the relative value, $X_{ij} = |X_{ij}|$ this will solve the problem of homogenization of different quality index values. Moreover, due to the different meanings represented by positive index and negative values, we use different algorithms to conduct data standardization processing for high and low indexes.

Positive index: $\mathrm{x}'_{\mathrm{ij}} = \left[\frac{\mathrm{x}_{\mathrm{ij}} - \min(\mathrm{x}_{1\mathrm{j}}, \mathrm{x}_{2\mathrm{j}}, \mathrm{x}_{3\mathrm{j}}, \cdots, \mathrm{x}_{\mathrm{nj}})}{\max(\mathrm{x}_{1\mathrm{j}}, \mathrm{x}_{2\mathrm{j}}, \mathrm{x}_{3\mathrm{j}}, \cdots, \mathrm{x}_{\mathrm{nj}}) - \min(\mathrm{x}_{1\mathrm{j}}, \mathrm{x}_{2\mathrm{j}}, \mathrm{x}_{3\mathrm{j}}, \cdots, \mathrm{x}_{\mathrm{nj}})}\right] \times 100$

Negative index: $\mathrm{x}'_{\mathrm{ij}} = \left[\frac{\min(\mathrm{x}_{1\mathrm{j}}, \mathrm{x}_{2\mathrm{j}}, \mathrm{x}_{3\mathrm{j}}, \cdots, \mathrm{x}_{\mathrm{nj}}) - \mathrm{x}_{\mathrm{ij}}}{\max(\mathrm{x}_{1\mathrm{j}}, \mathrm{x}_{2\mathrm{j}}, \mathrm{x}_{3\mathrm{j}}, \cdots, \mathrm{x}_{\mathrm{nj}}) - \min(\mathrm{x}_{1\mathrm{j}}, \mathrm{x}_{2\mathrm{j}}, \mathrm{x}_{3\mathrm{j}}, \cdots, \mathrm{x}_{\mathrm{nj}})}\right] \times 100$

$\mathrm{x}'_{\mathrm{ij}}$ is the value of j_{th} indicator in the i_{th} year $(\mathrm{i} = 1,2,3 \cdots \mathrm{n}; \mathrm{j} = 1,2,3 \cdots \mathrm{m})$, as a matter of convenience, here still marks as $\mathrm{x}'_{\mathrm{ij}} = \mathrm{x}_{\mathrm{ij}}$.

Step 3: Calculating the proportion of the j_{th} indicator in the i_{th} year

$$y_{ij} = \frac{x_{ij}}{\sum_{i=1}^{n} x_{ij}} (i = 1,2,3 \cdots n; j = 1,2,3 \cdots m) \quad (4.1)$$

Step 4: Calculating the entropy of j_{th} indicator

$$e_j = -k\sum_{i=1}^{n} y_{ij} \ln(y_{ij}), \quad \text{and} - k = \frac{1}{\ln(n)}, e_j \geq 0 \quad (4.2)$$

Step 5: Calculating the difference coefficient of j_{th} indicator. For the j_{th} indicator, the greater difference of the index value is, the greater effect on the scheme evaluation will be, and the entropy will be smaller. The calculation of the different coefficient is

$$g_j = \frac{1-e_j}{m-E_e}, \quad (4.3)$$

$$E_e = \sum_{j=1}^{m} e_j, 0 \leq g_j \leq 1, \sum_{j=1}^{m} g_j = 1, \ j = 1,2, \ldots, p$$

Step 6: Calculating the weight

$$\omega_j = \frac{g_j}{\sum_{j=1}^{p} g_j} \quad (1 \leq j \leq p) \quad (4.4)$$

Step 7: Calculating the comprehensive score

$$Z_i = \sum_{j=1}^{p} \omega_j x_{ij}^{'} \quad (4.5)$$

(2) Cluster analysis

Cluster analysis is a mathematical statistical method that classifies the samples under study based on the quantitative characteristics of the variables. There is no category of the research objects in advance. Cluster analysis is based on information provided by the research objects themselves and makes the classification through statistical means, which is of certain exploratory. In this paper, we consider the measurement of similarities. When doing cluster analysis of regions, to ensure the measurement of regional similarities is the first stage. Here is used Euclidean distance.

Here Ω is sample set, distance- $d(x,y)$ is the function of $\Omega \times \Omega \rightarrow R^{+}$, and

① $d(x, y) \geq 0, x, y \in \Omega$;

② $d(x, y) = 0, x = y$;

③ $d(x, y) = d(y, x), x, y \in \Omega$;

④ $d(x, y) \leq d(x, z) + d(z, y), x, y, z \in \Omega$.

The definition of the distance should satisfy positive definiteness, symmetry and triangle inequality. In cluster analysis, the most common method is min type distance.

$$d_q(x,y) = [\sum_{k=1}^{p} | x_k - y_k |^q]^{\frac{1}{q}}, q > 0,$$

When q is equal to 2, that is Euclidean distance.

In the analysis of the marine industry, the cluster analysis method can be used to further explore the potential information and provide a framework for measuring the marine economy in each region.

In conclusion, the entropy method is used to calculate the weight and scores of each class target and comprehensive index system respectively, then the cluster analysis is used to divide the marine industry development on the view of regions according to the final competitiveness.

4.3.2 Data source

The original data for this paper are from the China Marine Statistical Yearbook, China Marine Statistical Bulletin from 2007 to 2017. According to the evaluation index system of the regional marine industrial competitiveness of China, the related data are collected to analyze the competitiveness of the marine industry in eleven coastal provinces.

4.3.3 Results

Empirical analysis by Entropy method

By means of the dimensionless model to analyze the original data, the first step is to standardize all collected data. Using MATLAB, we can get the entropy, difference coefficient and weight of the second-class target according to formula (4.2), (4.3) and (4.4). The results are presented in <Table 12>.

<Table 12> Results of the second-class targets

	X_1	X_2	X_3	X_4	X_5	X_6
e_j	0.998975	0.995564	0.995615	0.995739	0.996292	0.996685
g_j	0.001043	0.004436	0.004385	0.004261	0.003708	0.003315
w_j	0.016803	0.071496	0.003315	0.068672	0.059765	0.053417
	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}
e_j	0.997367	0.99703	0.995217	0.996055	0.996071	0.994982
g_j	0.002633	0.00297	0.004783	0.003945	0.003929	0.005018
w_j	0.042433	0.047858	0.077082	0.063572	0.063312	0.080863
	X_{13}	X_{14}	X_{15}	X_{16}	X_{17}	
e_j	0.996381	0.996652	0.996135	0.995736	0.99747	
g_j	0.003619	0.003348	0.003865	0.004264	0.00253	
w_j	0.058327	0.053955	0.062284	0.068714	0.04078	

Note: e_j is the entropy; g_j is the difference coefficient and w_j is the weight.

According to the weights of the second-class targets, the weights of the first-class targets are shown in <Table 13>.

<Table 13> Weights of the first-class targets

	A_1	A_2	A_3	A_4	A_5	A_6
w_j	0.22764	0.155615	0.188513	0.202502	0.116239	0.109491

Note: w_j is the weight. A_1,A_2, A_3 ,A_4 ,A_5 ,A_6 are the same in <Table 9>.

As can be seen the weights of the first-class targets in <Table 13>, regional marine industrial economic capacity has the greatest weight, followed by regional marine industrial human resources capacity, regional marine industrial science and technology capacity, regional marine industrial output capacity, regional marine environmental protection capacity, and regional marine industrial exports capacity. The results indicate that regional marine industrial economic capacity contributes the most to competitiveness in China with a weight of 0.22764, at the same time marine science and technology capacity and human resources capacity play a vital role in competitiveness. In comparison, the regional marine industrial exports contribute the least during the period examined, which has a weight of 0.109491.

Then according to the formula (6), we can get the comprehensive scores and scores of each first-class target of eleven coastal provinces and cities from 2007 to 2016 shown in the followed tables and figures.

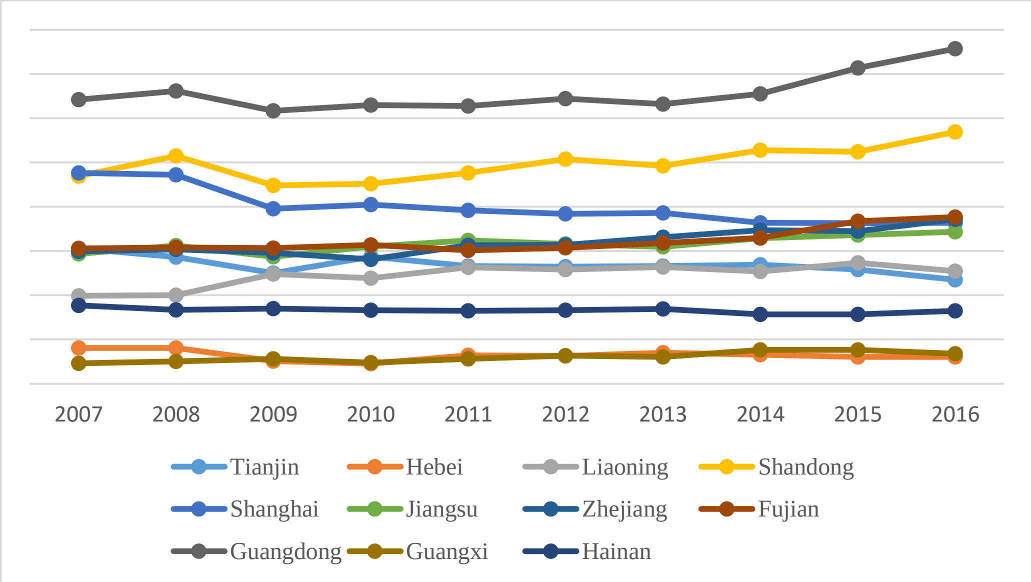
(1) Comprehensive scores of regional marine industrial competitiveness of eleven coastal provinces and cities from 2007 to 2016.

<Table 14> and <Figure 8> are the comprehensive scores of regional marine industrial competitiveness from 2007 to 2016.

<Table 14> Overall Scores of regional marine industrial competitiveness

City \ Year	2007	2008	2009	2010	2011
Tianjin	0.305780	0.286045	0.250053	0.287069	0.265591
Hebei	0.080803	0.080703	0.051330	0.045004	0.064094
Liaoning	0.198533	0.200378	0.247905	0.238521	0.262791
Shandong	0.468873	0.514994	0.448140	0.452021	0.476416
Shanghai	0.476123	0.471891	0.395738	0.405080	0.391481
Jiangsu	0.293686	0.311910	0.287125	0.309772	0.323564
Zhejiang	0.299237	0.303861	0.295861	0.281178	0.312760
Fujian	0.305357	0.307624	0.306091	0.313938	0.301630
Guangdong	0.642230	0.661723	0.616927	0.629961	0.627390
Guangxi	0.045919	0.050664	0.056164	0.047350	0.056245
Hainan	0.176670	0.167004	0.169843	0.165970	0.164309

City \ Year	2012	2013	2014	2015	2016
Tianjin	0.264276	0.266070	0.269067	0.257604	0.234788
Hebei	0.062787	0.070130	0.065756	0.060412	0.060481
Liaoning	0.257807	0.263669	0.253322	0.273065	0.25444
Shandong	0.507390	0.492538	0.527826	0.524463	0.568878
Shanghai	0.383573	0.385885	0.363901	0.362943	0.363783
Jiangsu	0.315691	0.308961	0.328927	0.336221	0.342986
Zhejiang	0.313352	0.331147	0.347186	0.344972	0.371212
Fujian	0.306856	0.318269	0.329639	0.367022	0.376774
Guangdong	0.643994	0.631668	0.655297	0.714033	0.757345
Guangxi	0.063472	0.060357	0.076731	0.076454	0.067703
Hainan	0.166108	0.169042	0.157029	0.156881	0.164612



<Figure 8> Trends of regional marine industrial competitiveness

As <Table 14> and <Figure 8> reveal, Guangdong, Shandong, and Shanghai had relatively higher scores of competitiveness and ranked at the top of the three during the period examined. In comparison, the comprehensive scores of Guangxi, Hebei, and Hainan were the lowest during the period examined.

In general, the comprehensive score of the regional marine industrial competitiveness of Guangdong Province ranked the first and had a gap in the second during the evaluation period. From 2007 to 2016, the whole trend of regional marine industrial competitiveness of Guangdong had a steady but slight increase. In 2008 and 2009, the regional marine industrial competitiveness of Guangdong declined from 0.642230 to 0.616927. Shandong and Shanghai ranked second and third respectively during the evaluation period, and their comprehensive scores were 0.468846 and 0.47123 in 2007. During ten years, Shandong had an increasing trend of regional marine industrial competitiveness, except in 2008 and 2009. However, the regional marine industrial competitiveness of Shanghai in these ten years decreased, even in 2015 and 2016 its regional marine industrial competitiveness ranked fourth and fifth. At that time, the regional marine industrial competitiveness of Jiangsu increased from 0.328927 to 0.342986 and ranked third.

In contrast, Guangxi and Hebei had the lowest scores of regional marine industrial competitiveness during the period examined, always ranking the eleventh or the tenth, with slight changes. Hainan also had a relatively low regional marine industrial competitiveness score, but higher than the formers.

Moreover, the competitiveness of the regional marine industries of Fujian, Jiangsu, Liaoning, and Zhejiang were in the middle, and their general trends appeared to increase. The comprehensive score of Fujian went up from 0.305357 to 0.376774 from 2007 to 2016, and that of Jiangsu ascended from 0.293686 to 0.342986 during the period examined. The regional marine industrial competitiveness of Liaoning had an increase from 0.198533 to 0.25444, and that of Zhejiang increased from 0.299237 to 0.371212.

In general, Guangdong had the most comprehensive score of regional marine industrial competitiveness, which means that it has a stronger marine industrial competitiveness compared to other provinces and cities. Next were Shandong and Shanghai. In contrast, Guangxi and Hebei get the lower comprehensive scores, which indicates that the two coastal provinces have weaker marine industrial competitiveness values.

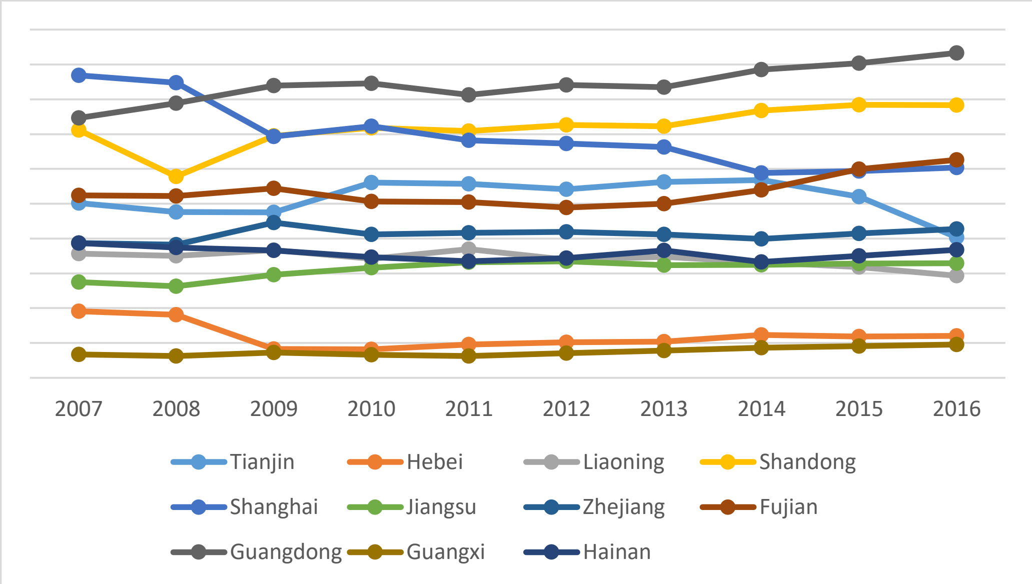
(2) Scores of regional marine industrial economic capacity

<Table 15> shows the scores of regional marine industrial economic capacity of each coastal provinces and cities. <Figure 9> shows the trend of the scores of regional marine industrial economic capacity during the period examined.

<Table 15> Scores of regional marine industrial economic capacity

City \ Year	2007	2008	2009	2010	2011
Tianjin	0.100305	0.095175	0.09505	0.112070	0.111393
Hebei	0.038279	0.036105	0.016468	0.016348	0.019118
Liaoning	0.071408	0.070032	0.073372	0.068350	0.073941
Shandong	0.142368	0.115656	0.139055	0.143548	0.141685
Shanghai	0.173775	0.169462	0.138628	0.144567	0.13646
Jiangsu	0.055011	0.052534	0.059145	0.063150	0.066436
Zhejiang	0.077340	0.076394	0.089157	0.082340	0.083358
Fujian	0.104882	0.104442	0.108834	0.101323	0.100871
Guangdong	0.149249	0.157869	0.167953	0.169159	0.162521
Guangxi	0.013350	0.012426	0.014417	0.013183	0.012464
Hainan	0.077428	0.074867	0.073223	0.069261	0.066871

City \ Year	2012	2013	2014	2015	2016
Tianjin	0.108282	0.112506	0.113600	0.104158	0.080683
Hebei	0.02044	0.020744	0.024562	0.023766	0.023981
Liaoning	0.067798	0.069419	0.066440	0.063552	0.058608
Shandong	0.145191	0.144516	0.153467	0.156927	0.156633
Shanghai	0.134586	0.132557	0.117770	0.118804	0.120857
Jiangsu	0.066889	0.064724	0.064961	0.065620	0.065791
Zhejiang	0.083752	0.082294	0.079804	0.082859	0.085470
Fujian	0.097896	0.100077	0.107998	0.119801	0.125297
Guangdong	0.168291	0.166944	0.177026	0.180700	0.186605
Guangxi	0.014163	0.015655	0.017329	0.018191	0.019067
Hainan	0.068695	0.073239	0.066597	0.069981	0.073620



Note: $\boldsymbol{A_1}$ is the regional marine industrial economic capacity.

<Figure 9> Trends of A1 of each coastal province and city

As can be seen from <Table 15> and <Figure 9>, Shanghai had the highest score of the regional marine industrial economic capacity in 2007 and 2008, which were 0.173775 and 0.169462. At that time Guangdong and Shandong ranked the second and the third respectively. After ten years, Guangdong was with gradual growth that reached 0.186605 in 2016 ranking first. This implied that Guangdong had a strong competitiveness in the regional marine industrial economic capacity. In contrast, Shanghai had a great surge from 2008 to 2009 then had a slight increase but had still declined since 2013, ranking third in 2016. Shandong declined from 2007 to 2008, but after that, it increased slightly, ranking second in 2016. Thus, Guangdong, Shandong, and Shanghai were the top three coastal provinces with a relative advantage in regional marine industrial economic capacity.

In comparison, Guangxi fell behind on regional marine industrial economic capacity ranking last during the period examined, and there was no obvious change in its regional marine industrial economic capacity during these ten years. Hebei was also with the weaker competitiveness on regional marine industrial economic capacity ranking the tenth, but had a great surge from 2008 to 2009. The score of the regional marine industrial economic capacity of Jiangsu was lower, however, it experienced an increasing trend during the evaluation period.

In addition, the regional marine industrial economic capacity of Fujian ranked fourth, and the score increased in 2015, ranking third. The next rankings were Tianjin, Zhejiang, Hainan, and Liaoning. From 2009 to 2014, the marine industrial economic capacity of these provinces developed slowly with an increasing trend, however, Tianjin had declined since 2014 from 0.1136 to 0.080683.

(3) Scores of regional marine industrial output capacity

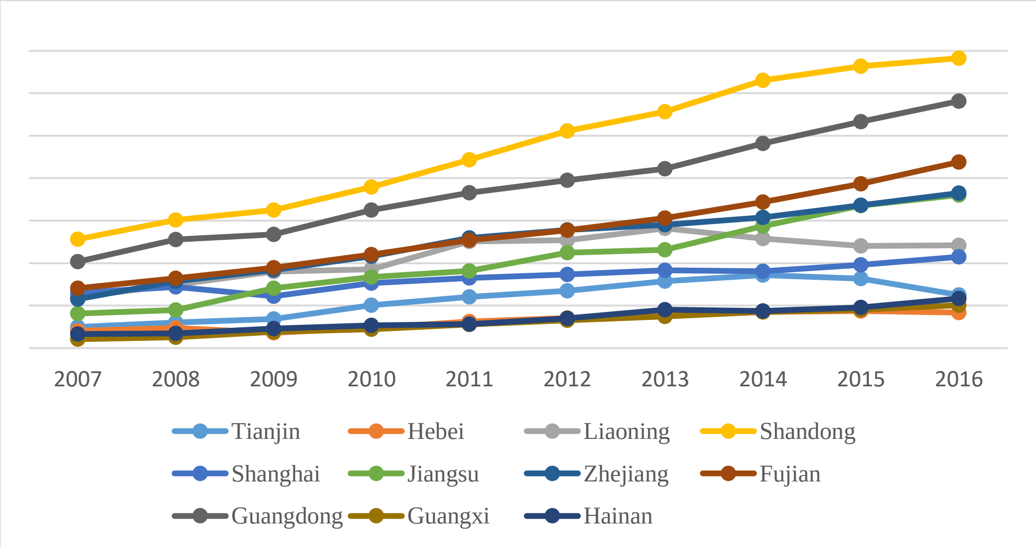
<Table 16> shows the scores of regional marine industrial output capacity of each coastal provinces and cities. <Figure10> shows the trend of the scores of regional marine industrial output capacity during the period examined.

<Table 16> Scores of regional marine industrial output capacity

Year / City	2007	2008	2009	2010	2011
Tianjin	0.009957	0.012069	0.013658	0.020142	0.02412
Hebei	0.008067	0.009389	0.007133	0.009467	0.01244
Liaoning	0.023901	0.029839	0.036064	0.037148	0.050272
Shandong	0.051287	0.060256	0.064966	0.075904	0.088739
Shanghai	0.026033	0.028841	0.024366	0.030592	0.032946
Jiangsu	0.016301	0.017864	0.028191	0.033527	0.036251

Zhejiang	0.023092	0.031429	0.036812	0.043289	0.051808
Fujian	0.028141	0.032804	0.037774	0.04396	0.050835
Guangdong	0.04062	0.051141	0.053453	0.065049	0.073122
Guangxi	0.004183	0.005039	0.007699	0.008845	0.01105
Hainan	0.00655	0.006955	0.009169	0.010603	0.011232

Year / City	2012	2013	2014	2015	2016
Tianjin	0.026922	0.031461	0.034345	0.0327	0.025028
Hebei	0.014162	0.015348	0.016962	0.017387	0.016654
Liaoning	0.050806	0.056405	0.051522	0.048035	0.048452
Shandong	0.102259	0.111244	0.126094	0.13267	0.136514
Shanghai	0.034698	0.036616	0.036234	0.03921	0.043
Jiangsu	0.044982	0.046255	0.057495	0.06715	0.072086
Zhejiang	0.055677	0.05801	0.061441	0.067174	0.07301
Fujian	0.055477	0.061229	0.068828	0.07741	0.087661
Guangdong	0.079045	0.084372	0.096418	0.106698	0.116263
Guangxi	0.013126	0.01485	0.01696	0.018095	0.020216
Hainan	0.013934	0.018082	0.017464	0.019045	0.023413



Note: A_2 is the regional marine industrial output capacity.

<Figure 10> Trends of A2 of each coastal province and city

As can be seen from <Table 16> and <Figure 10>, the regional marine industrial output capacity almost all had an increasing trend from 2007 to 2016. Shandong ranked first during the period examined and had a huge surge from 0.051287 to 0.136514. Guangdong ranked second during the evaluation period, and also had an increase from 0.04062 to 0.116263. This means that Shandong and Guangdong have strong competitiveness in the regional marine industrial output capacity. In addition, Fujian ranked third during the period examined, except in 2011 and 2012.

On the contrary, Guangxi, Hainan, and Hebei had the lowest scores of regional marine industrial output capacity during the period examined, which indicates that the three coastal provinces have weaker competitiveness on regional marine industrial output capacity. Most of the eleven coastal provinces and cities had an increasing trend, however, Liaoning declined from 0.056405 to 0.048452 between 2013 and 2016, and Tianjin had decreased since 2015.

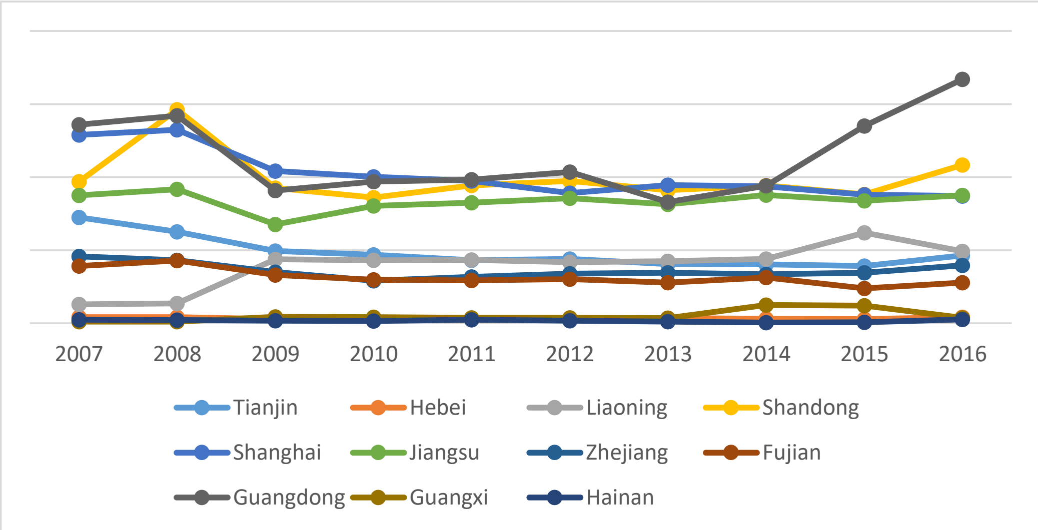
(4) Scores of regional marine science and technology capacity

<Table 17> shows the scores of regional marine industrial science and technology capacity of each coastal provinces and cities. <Figure 11> shows the trend of the scores during the period examined.

<Table 17> Scores of regional marine industrial technological capacity

Year / City	2007	2008	2009	2010	2011
Tianjin	0.072415	0.062663	0.049481	0.04699	0.043156
Hebei	0.004282	0.004294	0.002828	0.00297	0.003397
Liaoning	0.012934	0.01362	0.043756	0.043233	0.043385
Shandong	0.096949	0.14623	0.09269	0.086042	0.094348
Shanghai	0.128942	0.132393	0.104248	0.100328	0.097504
Jiangsu	0.087584	0.091632	0.067603	0.080434	0.082645
Zhejiang	0.045828	0.043192	0.03511	0.029214	0.031845
Fujian	0.039261	0.043034	0.033072	0.029914	0.029407
Guangdong	0.135965	0.142079	0.090828	0.097065	0.098301
Guangxi	0.001193	0.001216	0.004391	0.004244	0.003726
Hainan	0.0024	0.002336	0.001771	0.001719	0.002595

Year / City	2012	2013	2014	2015	2016
Tianjin	0.044096	0.040561	0.040235	0.039313	0.046493
Hebei	0.003164	0.003634	0.003176	0.002957	0.004187
Liaoning	0.041781	0.042635	0.044065	0.062095	0.049297
Shandong	0.097485	0.091066	0.094278	0.088222	0.108355
Shanghai	0.089157	0.094592	0.093609	0.088127	0.087189
Jiangsu	0.085519	0.081362	0.087775	0.083934	0.087505
Zhejiang	0.033996	0.034681	0.03345	0.034567	0.039593
Fujian	0.030271	0.027805	0.031458	0.023914	0.027958
Guangdong	0.103595	0.083035	0.094081	0.135024	0.166899
Guangxi	0.003793	0.003584	0.012568	0.012031	0.003732
Hainan	0.001873	0.001191	0.000581	0.000754	0.002791



Note: $\boldsymbol{A_3}$ is the regional marine industrial science and technology capacity.

<Figure 11> Trends of A3 of each coastal province and city

From <Table 17> and <Figure 11>, we can see that the regional marine industrial science and technology capacity of China develops slowly. Guangdong, Shandong, and Shanghai ranked at the top in the period examined, which means that the three coastal provinces have stronger competitiveness of regional marine industrial science and technology compared with other coastal provinces and cities. Guangdong and Shanghai both decreased between 2008 and 2009. Guangdong declined from 0.142079 to 0.090828 and Shanghai declined from 0.132393 to 0.104248. However, Guangdong had witnessed a surge from 0.094081 in 2014 to 0.166899 in 2016. Comparatively, Guangxi, Hainan, and Hebei had the lowest scores of regional marine industrial science and technology capacity. It means that the three coastal provinces have little competitiveness in marine industrial science and technology capacity.

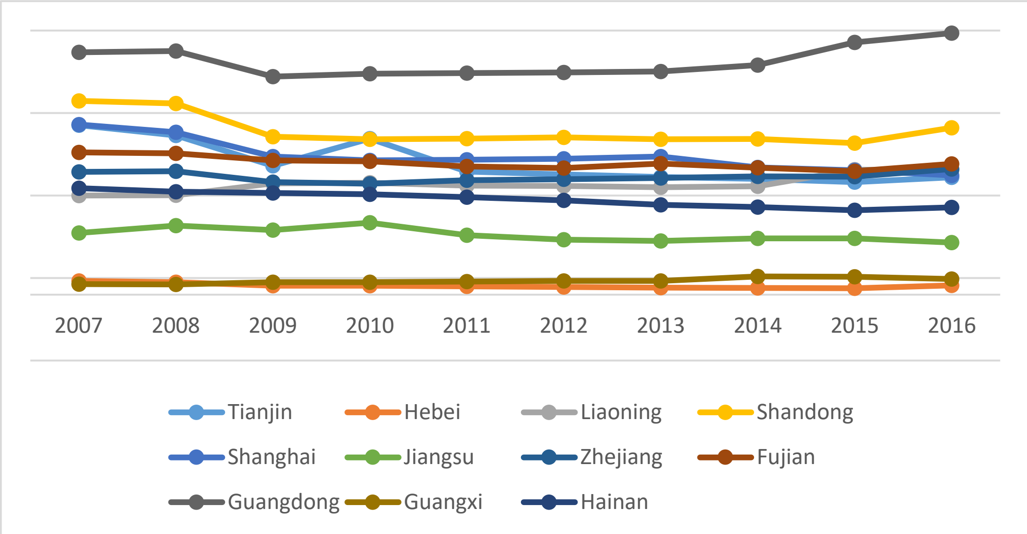
(5) Scores of regional marine human resources capacity

<Table 18> shows the scores of regional marine industrial human resources capacity of each coastal province and city. <Figure 12> shows the trend of the scores of regional marine industrial human resources capacity during the period examined.

<Table 18> Scores of regional marine industrial human resources capacity

Year / City	2007	2008	2009	2010	2011
Tianjin	0.102617	0.096468	0.078008	0.094506	0.074474
Hebei	0.008342	0.007481	0.005284	0.005357	0.004879
Liaoning	0.060029	0.060242	0.067409	0.067656	0.065934
Shandong	0.117322	0.115845	0.095552	0.094096	0.094395
Shanghai	0.103088	0.098372	0.083561	0.081375	0.081677
Jiangsu	0.037378	0.041731	0.038967	0.043551	0.035908
Zhejiang	0.074288	0.074616	0.068062	0.067119	0.069199
Fujian	0.086159	0.085584	0.081328	0.080678	0.07753
Guangdong	0.146848	0.147581	0.132069	0.133886	0.134126
Guangxi	0.006269	0.006056	0.007489	0.007445	0.007805
Hainan	0.064423	0.062319	0.061556	0.060691	0.059048

Year / City	2012	2013	2014	2015	2016
Tianjin	0.072784	0.071166	0.070086	0.068106	0.070957
Hebei	0.004576	0.00428	0.003969	0.003809	0.005568
Liaoning	0.065829	0.065104	0.065575	0.075669	0.075274
Shandong	0.095263	0.09416	0.094213	0.091667	0.101011
Shanghai	0.082192	0.083711	0.077069	0.075249	0.072173
Jiangsu	0.033262	0.032428	0.033997	0.034102	0.031545
Zhejiang	0.069811	0.070629	0.071693	0.071359	0.076129
Fujian	0.076718	0.079428	0.076829	0.074724	0.079191
Guangdong	0.134523	0.135166	0.139114	0.15276	0.158494
Guangxi	0.0082	0.008306	0.01099	0.010866	0.009373
Hainan	0.057154	0.054314	0.053108	0.051094	0.052882



Note: $\boldsymbol{A_4}$ is the regional marine industrial human resources capacity.

<Figure 12> Trends of A4 of each coastal province and city

From <Table 18> and <Figure 12>, we can see that Guangdong had the highest score of regional marine industrial human resources capacity compared with other coastal provinces and cities, which ranked first from 2007 to 2016. There was a great gap between Guangdong and other coastal provinces and cities. In 2007, Guangdong had a score of 0.146848 attended by Shandong and Shanghai whose scores were 0.117322 and 0.103088 respectively. In 2016, the score of regional marine industrial human resources capacity of Guangdong was 0.158494 followed by Shandong and Shanghai whose scores were 0.101011 and 0.072173 respectively. This means that Guangdong has the strongest competitiveness in regional marine industrial human resources capacity. Guangdong had a steady, but a slight, increase in the period examined except for a decline from 2008 to 2009, neither Shandong nor Shanghai did.

On the contrary, Guangxi, Hebei, and Jiangsu had lower scores of regional marine industrial human resources capacity in the period examined. The three coastal provinces had weaker competitiveness on marine industrial human resources, which meant that these provinces had a significant shortage of human resources on the marine industry.

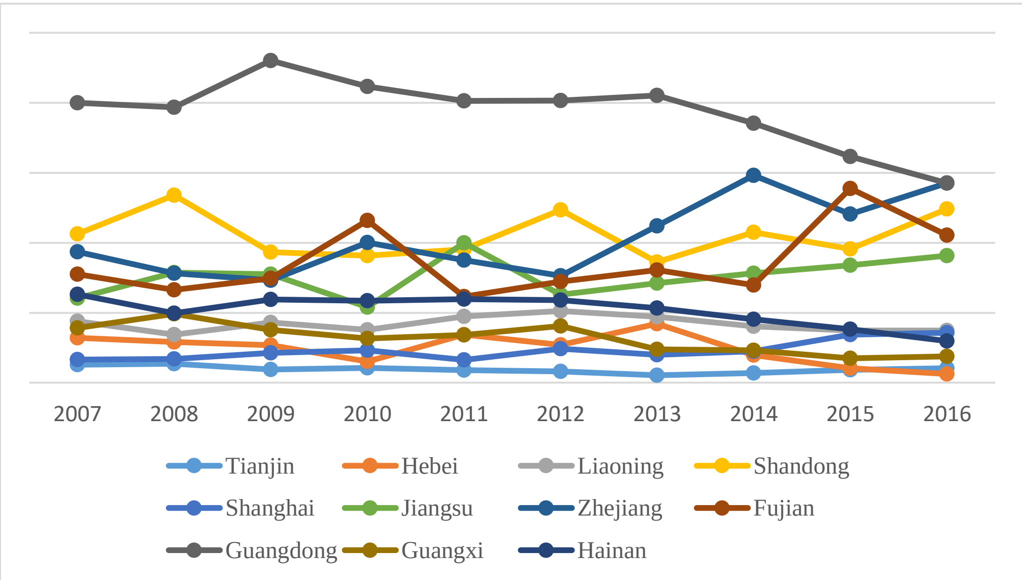
(6) Scores of regional marine industrial environmental protection capacity

<Table 19> shows the scores for regional marine industrial environmental protection capacity of each coastal province and city. <Figure 13> shows the trend of the scores of regional marine industrial environmental protection capacity during the period examined.

<Table 19> Scores of regional marine industrial environmental capacity

City \ Year	2007	2008	2009	2010	2011
Tianjin	0.005191	0.005458	0.003822	0.004247	0.003601
Hebei	0.012878	0.011657	0.010766	0.006035	0.013775
Liaoning	0.017585	0.013761	0.017208	0.015148	0.018993
Shandong	0.042553	0.053562	0.037345	0.036341	0.038185
Shanghai	0.006639	0.006834	0.008568	0.009243	0.006554
Jiangsu	0.024137	0.031445	0.031009	0.021617	0.040018
Zhejiang	0.03745	0.031341	0.029326	0.040028	0.035059
Fujian	0.030981	0.026541	0.029808	0.046387	0.024615
Guangdong	0.08004	0.078743	0.092082	0.084646	0.080561
Guangxi	0.015642	0.019665	0.015118	0.012616	0.01364
Hainan	0.025299	0.019877	0.023831	0.023465	0.023882

Year / City	2012	2013	2014	2015	2016
Tianjin	0.00322	0.002172	0.002773	0.003657	0.004118
Hebei	0.010801	0.016828	0.00787	0.004162	0.002505
Liaoning	0.020505	0.018855	0.016153	0.014943	0.014948
Shandong	0.04944	0.034462	0.042953	0.038271	0.049711
Shanghai	0.009725	0.007969	0.009006	0.013788	0.014284
Jiangsu	0.025203	0.02843	0.031301	0.033543	0.036349
Zhejiang	0.030555	0.044827	0.059288	0.04818	0.057056
Fujian	0.028901	0.032257	0.027905	0.055542	0.042219
Guangdong	0.080624	0.082143	0.074202	0.064699	0.057054
Guangxi	0.016258	0.00957	0.00926	0.006974	0.007548
Hainan	0.023651	0.021369	0.018171	0.015305	0.011906



Note: A_5 is the regional marine industrial environmental protection capacity.

<Figure 13> Trends of A5 of each coastal province and city

As showed in <Table 19> and <Figure 13>, we can see the state of regional marine industrial environmental protection capacity of eleven coastal provinces and cities. Guangdong ranked first on regional marine industrial environmental protection capacity in the period examined. It had witnessed an increase between 2008 and 2009 from 0.078743 to 0.092082, while there was a slight decrease after 2009, what's worse, it had witnessed a sharp decline between 2013 and 2016 from 0.082143 to 0.057054. Guangdong had a relative competitiveness in regional marine industrial environmental protection capacity, not only in the marine pollution treatments, but also the marine-type nature reserves, while it was losing its competitiveness in regional marine industrial environmental protection capacity in recent years. Shandong ranked second in regional marine industrial environmental protection capacity followed by Zhejiang. However, for the score in this capacity, Zhejiang was 0.057056 in 2016 which was higher than that of Shandong, whose score was 0.049711. Most of coastal provinces and cities had an unstable marine industrial environmental protection capacity from 2007 to 2016. In comparison, Tianjin, Shanghai, and Hebei had weaker competitiveness in marine industrial environmental protection capacity in the bottom of the rankings. The three coastal provinces and cities might not pay attention to the protection of the marine environment when they developed marine industries.

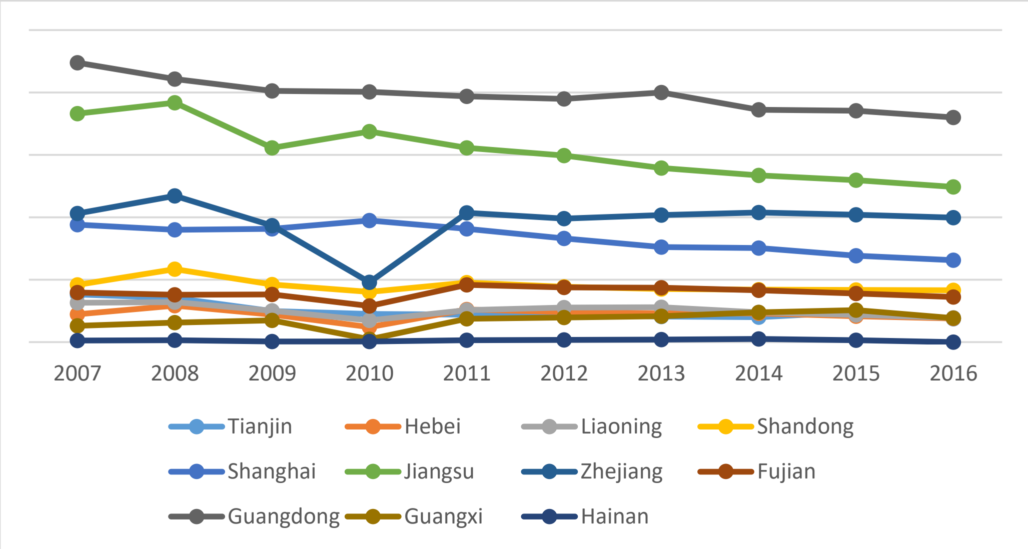
(7) Scores of regional marine industrial exports capacity

<Table 20> shows the scores of regional marine industrial export capacity of each coastal province and city. <Figure 14> shows the trend of the scores during the period examined.

<Table 20> Scores of regional marine industrial export capacity

Year / City	2007	2008	2009	2010	2011
Tianjin	0.015295	0.014211	0.010033	0.009113	0.008847
Hebei	0.008954	0.011776	0.008851	0.004827	0.010486
Liaoning	0.012676	0.012884	0.010096	0.006986	0.010266
Shandong	0.018393	0.023445	0.018532	0.01609	0.019064
Shanghai	0.037646	0.03599	0.036368	0.038975	0.03634
Jiangsu	0.073274	0.076703	0.062209	0.067493	0.062305
Zhejiang	0.041239	0.04689	0.037394	0.019188	0.041491
Fujian	0.015933	0.01522	0.015277	0.011676	0.018372
Guangdong	0.089509	0.08431	0.080542	0.080156	0.078759
Guangxi	0.005282	0.006261	0.007051	0.001016	0.007559
Hainan	0.000571	0.000649	0.000293	0.00023	0.000681

Year / City	2012	2013	2014	2015	2016
Tianjin	0.008972	0.008205	0.008028	0.00967	0.007510
Hebei	0.009644	0.009297	0.009218	0.008331	0.007586
Liaoning	0.011089	0.011251	0.009568	0.008772	0.007860
Shandong	0.017752	0.01709	0.016822	0.016706	0.016653
Shanghai	0.033214	0.03044	0.030213	0.027766	0.026280
Jiangsu	0.059836	0.055762	0.053398	0.051872	0.049710
Zhejiang	0.03956	0.040707	0.04151	0.040833	0.039953
Fujian	0.017593	0.017473	0.016621	0.015631	0.014448
Guangdong	0.077916	0.080008	0.074456	0.074153	0.072030
Guangxi	0.007933	0.008392	0.009624	0.010297	0.007767
Hainan	0.000799	0.000847	0.001108	0.000701	0



Note: A_6 is the regional marine industrial export capacity.

<Figure 14> Trends of A6 of each coastal province and city

As <Table 20> and <Figure 14> reveal, the regional marine industrial export capacity of Guangdong ranked first from 2007 to 2016, followed by Jiangsu and Zhejiang. Guangdong had a steady but slight decrease in marine industrial exports, especially from 2013 to 2014. Jiangsu had an increase between 2007 and 2008, but witnessed a decline between 2008 and 2009 from 0.076703 to 0.062209, then it rose by 2010. What's worse, the regional marine industrial exports of Jiangsu kept decreasing after 2010. Zhejiang had instability in regional marine industrial exports from 2007 to 2011. It had a slight increase from 2007 to 2008, then decreased dramatically from 2008 to 2009, then it increased again. After 2011, the regional marine industrial export capacity of Zhejiang was a steady, but with a slight increase.

In comparison, Hainan, Guangxi, and Hebei had weaker competitiveness in regional marine industrial export capacity in the bottom of the rankings. In general, most of coastal provinces and cities had a decline between 2008 and 2010, except for Shanghai, which might have been influenced by the economic situation.

With the analysis of comprehensive scores in regional marine industrial competitiveness and scores of each first-class target from 2007 to 2016, the conclusion is shown in <Table 21>.

<Table 21> Overall comparison of each coastal province and city

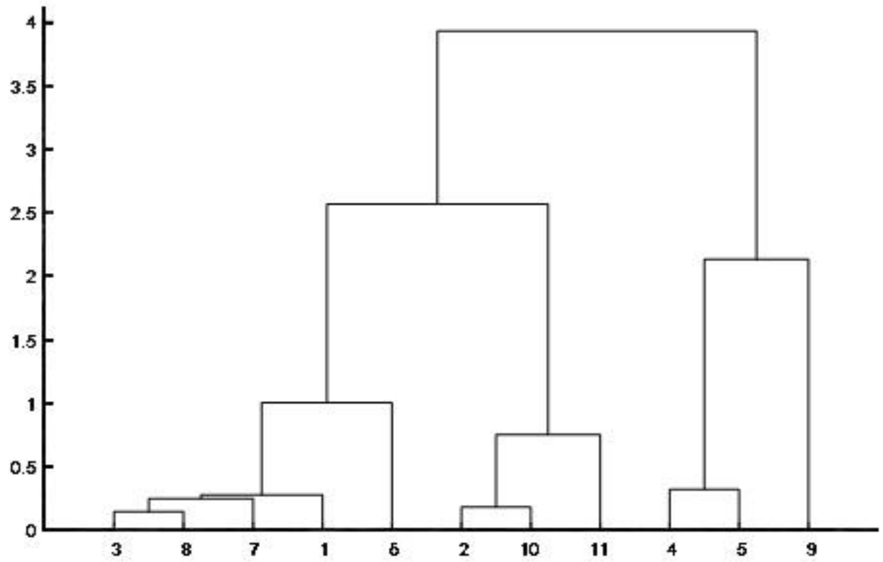
City	Comprehensive Score		A1	A2	A3	A4	A5	A6
Tianjin	7						▼	▼
Hebei	10	▼	▼	▼	▼	▼	▼	▼
Liaoning	8							
Shandong	2	●	●	●	●	●	●	
Shanghai	3	●	●		●	●	▼	
Jiangsu	6		▼			▼		●
Zhejiang	5						●	●
Fujian	4			●				
Guangdong	1	●	●	●	●	●	●	●
Guangxi	11	▼	▼	▼	▼	▼		▼
Hainan	9	▼		▼	▼			▼

Note: $\boldsymbol{A_1}, \boldsymbol{A_2}, \boldsymbol{A_3}, \boldsymbol{A_4}, \boldsymbol{A_5}, \boldsymbol{A_6}$ are explained in <Table 9>. ●means the advantage of the competitiveness; ▼means the disadvantage of the competitiveness.

As can be seen from <Table 21>, Guangdong has the strongest advantage in marine industrial competitiveness, not only on the comprehensive score but also on each first-class target. In contrast, Hebei has the weakest marine industrial competitiveness and has no advantages, neither on comprehensive score nor on each first-class indices. In comparison, Shandong and Shanghai have stronger marine industrial competitiveness. Shandong has the advantages of regional marine economic capacity, regional marine industrial output, regional marine science and technology, regional marine human resources, and regional marine environmental protection. Shanghai has the advantages of regional marine economic capacity, regional marine science and technology and regional marine human resources. However, Shanghai has a disadvantage in marine industrial competitiveness on regional marine environmental protection. In addition, Fujian has an advantage in marine industrial competitiveness on regional marine output. Zhejiang has advantages in marine industrial competitiveness on regional marine environmental protection and regional marine exports. Jiangsu also shows an advantage in marine industrial competitiveness on regional marine exports, however, it has two disadvantages on marine economic capacity and marine human resources. Comparatively, Guangxi and Hainan have weaker marine industrial competitiveness. Guangxi has disadvantages in marine industrial competitiveness on marine economic capacity, marine output, marine science and technology, marine human resources and marine exports. Hainan has disadvantages in marine industrial competitiveness on marine output, marine science and technology, and marine export capacity.

Cluster analysis

Cluster analysis is a mathematical statistical method that classifies the samples under study based on the quantitative characteristics of the variables. According to the comprehensive score of each coastal province, cluster analysis is used to give a classification to coastal provinces. The results of cluster analysis is illustrated in <Figure 15>.



Note: 3 is Liaoning, 8 is Fujian, 7 is Zhejiang, 1 is Tianjin, 6 is Jiangsu, 10 is Guangdong, 11 is Hainan, 4 is Shandong, 5 is Shanghai, 9 is Guangdong.

<Figure 15> Result of cluster analysis of marine industry in China

According to the comprehensive evaluation of marine industrial competitiveness in China, the Cluster analysis is applied in this part. Results of Cluster analysis are classified into four categories. The first-class is Guangdong, there are Shandong and Shanghai in the second-class, the third-class includes Liaoning, Fujian, Zhejiang, Tianjin, and Jiangsu, and the last class includes Hebei, Guangxi and Hainan.

In Cluster analysis, Guangdong as a separate class, has the highest comprehensive score of marine industrial competitiveness. And the score of Guangdong in each first-class indices all rank first, this indicates that Guangdong has strong competitiveness in these areas. Shandong and Shanghai are classified in one group, the marine industrial competitiveness of these two coastal provinces is comparable. The next classification includes Liaoning, Fujian, Zhejiang, Tianjin, and Jiangsu. Their competitiveness in the marine industry is at the intermediate level. There are Hebei, Guangxi, and Hainan in the last classification. Guangxi has the lowest competitiveness of marine industrial economic capacity, marine industrial output, marine science and technology, and marine human resources. The economic foundation of Guangxi is relatively weak and the marine industries of Guangxi develop slowly. Hainan has the lowest competitiveness of marine science and technology, human resources, which means Hebei has weaker competitiveness both in marine employment and marine R&D researchers. Hebei is at the lowest competitiveness of the marine industry in China. Different levels of competitiveness are related to the development of the marine industry and the promotion of its comprehensive competitiveness.

4. 4 Summary

Based on the factors and the weight of each first-class target, regional marine industrial economic capacity, regional marine industrial human resources, and regional marine science and technology account for the larger proportions, indicating these indices are relatively important. There are five indices of the first-class targets that can be considered subject factors, and environmental protection should be regarded as an object factor, as shown in <Figure 16>

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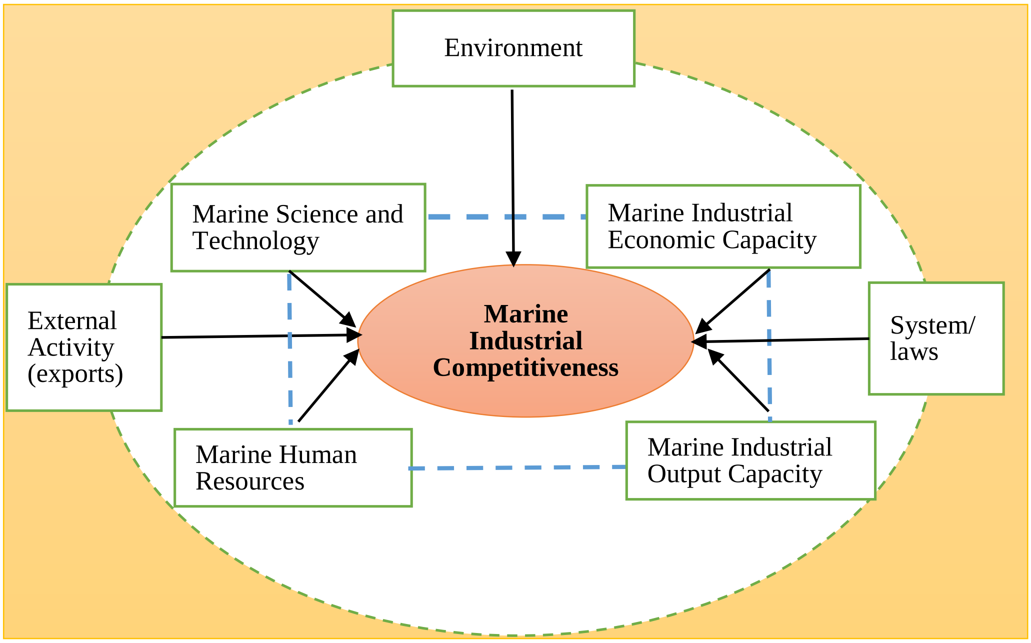

Source: made by the author.

<Figure 16> Competitiveness promotion system of marine industry in China

Guangdong, Shandong, and Shanghai have a stronger competitive advantage in the marine industry compared with other coastal provinces. Guangdong should be concentrated in marine production, marine human resources, and marine environmental protection. Shanghai and Shandong both have advantages in geographical location. Shandong is located between the political center of the Northern area and the economic center of the Southern area, and the Eastern areas of Japan and Korea. Shanghai is the economic and financial center of China. Even though both of them have relatively strong competitiveness in the marine industry, the development potential is relatively small. Shandong has abundant marine resources, but its marine industrial structure and marine exports are poor. In order to further enhance the competitiveness of the marine industry, it is essential to develop and utilize marine resources actively and accelerate the transformation of traditional marine industry. Shanghai situation is mainly due to the lack of marine resources, but its strength in marine science and technology and reasonable marine industrial structure can make up for its resource disadvantages.

However, Guangxi, Hebei, and Hainan have weaker competitiveness in the marine industry. The three provinces are all affected by their location and regional economic strength and their advantages in marine resources are small. Therefore, to improve their competitiveness in the marine industry they should focus on the development of the leading marine industries and industrial layouts. Although Hebei has a short coastline and small sea area, it links with Beijing, Tianjin and Bohai Bay which are advantages for this province. Although Guangxi has the weakest regional advantages and economic situation, its marine ecological environment is good. As a "Cleanest Sea Area" offshore in China, Guangxi should focus on the advantages of the marine ecological environment, strive to develop the marine green economy and build a demonstration zone of marine ecological civilization and develop coastal tourism vigorously. Hainan has a unique geographical location with good marine ecological resources and national support policies.

In conclusion, the development of the regional marine industries in China is different, each coastal province has its own advantages and disadvantages.

Chapter 5 Empirical Tests for the Development of Regional Marine Industries in China

With the improvement of marine industrial development, there are differences between each region. The unbalanced development of the regional marine industries in China was caused by various factors influencing the marine economy of the regions. Comparing competitiveness of the marine industry in each coastal province in Chapter 4, it is found that Guangdong, Shandong, and Shanghai have the stronger competitiveness in marine industries, which means that the three coastal provinces have a comparative advantage to develop their marine industries, however, Guangxi, Hainan, and Hebei have lower marine industrial competitiveness. The aim of comparing the marine industrial competitiveness is to understand and give full play to each of the coastal province’s advantages to narrow the gap among each region and promote the development of the marine industry. With the development of the marine economy, the national gross ocean product is 7761.1 billion yuan (CNY), 6.9% up from that in 2016. Guangdong has the most GOP with 1328.04 billion yuan followed by Shandong and Shanghai, while the development of Guangxi and Hainan lag behind. So what are the reasons that lead to such a huge gap in GOP between coastal provinces and cities? What are the principal factors that foster different situations? It is the question that we should answer in this chapter.

5.1 The Selection of Variables and Data Source

5.1.1 The selection of variables

In the analysis of economic growth, GDP is used to measure the development of the national economy, so here we take GOP as the measurement of marine economic growth. According to the literature reviews, there are four factors taken into consideration that are labor, capital, science and technology, and the environment.

Labor plays an essential role in marine economic development. As a major population country, there is a comparative advantage in China. For instance, labor plays a dominant role in the coastal tourism industry and marine fishery industry. If there were no labor, the natural resources couldn't be explored which could not contribute to the economic development. Analyzing the marine economic growth of China, labor is regarded as an important factor. Some researchers choose the absolute data of the number of ocean-related employed shown in <Table 22>. In this study, we also choose the ocean-related employed as the labor factor, which is an indicator to represent the labor situation of the marine industry fully. The ocean-related employed is not just about the professionals in the marine industry, but the people engaged in marine or related marine industry.

<Table 22> Labor as a factor in previous studies

Labor	the number of ocean-related employed	Zhao, X. et al. (2012)
	the number of ocean-related employed	Cao, W. et al. (2015)
	the number of ocean-related employed	Feng, D. (2015)
	the number of ocean-related employed	Peng ,Y.F. et al. (2017)

Source: collected by the author according to literature review in Chapter 2.

Capital refers to the support of marine economic development in this study. Most of the researchers, studying factors influencing the development of the marine industry, take the number of marine research projects as capital factor shown in <Table 23>. In general, the capital refers to the investment, due to the lack of data on this, we consider marine research projects in this study, at the same time we choose the funds of marine research. This is the support from the government, and marine research projects are the output of that capital, and the marine research funds are the input.

<Table 23> Capital as a factor in previous studies

Capital	the number of marine research projects	Chang, Y.M. (2011)
	the number of marine research projects	Li, W. (2014)
	the number of marine research projects	Peng, Y.F. et al. (2017)

Source: collected by the author according to literature review in Chapter 2.

Technology, as the tool, can drive the development of the marine industry. Due to the uniqueness of the marine economy, the exploration of the marine industry, the upgrade of the marine industry and the investigation of the marine economy all needs the support of technology. Some scholars choose the number of research projects, some select the professionals in the marine industry, and some choose the funds of marine R&D shown in <Table 24>.

<Table 24> Technology as a factor in previous studies

Technology	the number of professionals on marine industry	Chang, Y.M. (2011)
	the number of professionals in marine science and technology	Zhao, X. et al. (2012)

	the number of professionals on marine industry	Li, W. (2014)
	the number of research projects	Cao, W. et. al (2015)
	the funds of marine R&D	Feng, D. (2015)
	the number of professional on marine industry	Peng, Y.F. (2017)
	the proportion of marine professionals	Wang, Z.Y. (2017)

Source: collected by the author according to literature review in Chapter 2.

In this study, the technological factor is equal to the number of marine patents which are the results of marine science and technology. Some researchers select the professionals of the marine industry, as the technological factor. However, to avoid the multicollinearity with the labor factor, we take the number of marine patents as the technological factor.

The environment is the base condition for marine economic development. It is a disaster for a marine organism to live in a destroyed marine environment. Even to change the marine environment may lead to the changes in marine resources, which will influence the marine economic development indirectly. Some researchers propose the number of pollution treatment projects or marine-type nature reserves as an environmental factor.

<Table 25> Environment as a factor in previous studies

Environment	the number of pollution treatments projects	Cao,W. et al, (2015)
	the number of pollution treatments projects	Peng, Y.F. et al. (2017)
	the number of marine-type nature reserves	Wang, Z.Y. et al. (2017)

Source: collected by the author according to literature review in Chapter 2.

Most of the marine pollution comes from the land, especially for the industrial wastewater discharge. Therefore, we consider the regional pollution treatments projects as the factor of the environment in this study. In addition, the number of marine-type nature reserves is also taken as the environmental factor, which refers to regional marine protection.

5.1.2 Data source

This study collects ten years of data between 2007 and 2016 from the China Marine Statistical Yearbook about the eleven coastal provinces and cities in China. The pooling includes 110 observations which are in the panel data. The panel data consists of the cross-section, time, and variables. In this study, we analyze the eleven coastal provinces and cities in China in ten years with six independent variables. To build a model of the panel data we can obtain more information and deeper analyses of the relationship between dependent variables and independent variables.

Compared with the previous studies of marine economic development, most choose absolute data to do the regression estimation. However, we choose the change rate data of selected variables to do the regression estimation. Because development is a dynamic trend, analyzing the development of the regional marine industry with the change rate data can show the trend of changes which is more appropriate for this study. Therefore, the variables of this study are presented in <Table 26>.

<Table 26> Selection of variables

Type of variables	Variable	Explanation	
Dependent variable	GROP	It is the regional gross ocean products representing the development of regional marine economy. Here is the change rate data of regional GOP.	⊿GROP
	GROP of Primary Marine Industry	The change rate data of regional GOP of primary marine industry	⊿RPMI
	GROP of Secondary Marine Industry	The change rate data of regional GOP of secondary marine industry	⊿RSMI
	GROP of Tertiary Marine Industry	The change rate data of regional GOP of tertiary marine industry	⊿RTMI
	International Competency	The change rate data of regional exports	⊿REX
Independent variable	Labor	The change rate data of regional ocean-related employed	⊿EMP
	Capital	(1) The change rate data of regional marine research projects.	⊿PRO
		(2) The change rate data of regional marine research funds	⊿FUD
	Technology	The change rate data of regional marine patents	⊿PAT
	Environment	(1) The change rate data of regional marine pollution treatments projects	⊿PTP
		(2) The change rate data of regional marine-type nature reserves	⊿MRS

Source: made by the author.

Collecting original data from China Marine Statistical Yearbook, we use the change rate data and make the descriptive statistical analysis of the data set shown in <Table 27>.

<Table 27> Description statistical analysis

	Minimum	Maximum	Mean	Standard deviation
⊿GROP	-.34	.46	.1297	.1031
⊿RPMI	-.20	.98	.1359	.1803
⊿RSMI	-.34	.59	.1125	.1519
⊿RTMI	-.87	.36	.1473	.0946
⊿REX	-.02	11.66	.3706	1.6469
⊿EMP	-.02	.06	.0205	.0175
⊿PRO	-.79	3.35	.1379	.4945
⊿FUD	-.86	12.10	.5642	1.9541
⊿PAT	-1.00	37.00	.5468	3.7445
⊿PTP	-.96	24.94	.1444	2.4208
⊿MRS	-.67	3.00	.0953	.48135

5.2 Empirical Tests

5.2.1 Regression estimation of regional marine industry (GROP)

In this study, the panel data is used to analyze the factors influencing regional marine industrial development of eleven coastal provinces in China. Panel data refer to the multi-dimensional time series data obtained by continuous observation of cross section individuals at different times, which are the three-dimensional information including the cross-section, time and index. In an economic study, if using only time-series data for analysis this may neglect the relation and difference between cross-sections, while only using the cross-section data for analysis will neglect the changes in time. The panel data can avoid these problems, as Ranjit Kumar Paul (2011) gave six advantages for panel data, such as (1) The panel data hereby authorized to use the individual specific variables to consider heterogeneity explicitly. (2) There are more informative data provided in the panel data, which is variable and less collinearity. The panel data are more freedom and efficiency. (3) The effect could be better observed by panel data rather than the pure cross-section or time series data. Baltagi (2013) asked the question why we should use the panel data. The author listed seven advantages to the panel data, and also pointed out that the panel data could identify and measure effects better than in the pure cross-section or time-series data and the panel data could give more variability, less collinearity among the variables.

The panel data is usually defined as

$$Y_{it} = a_{it} + X_{it}\beta + \varepsilon_{it}, i = 1,2,\dots,N; t = 1,2,\dots,T$$

Where Y_{it} is the dependent variable, a_{it} is the cross-section, X_{it} is the independent variable, β is the variation coefficient, and ε_{it} is the error term. Here i means the different item and t stands for the time.

According to the above analyses, the model of this paper is established as follows.

$$\triangle GROP_{it} = c + \beta_1 \triangle EMP_{it} + \beta_2 \triangle PRO_{it} + \beta_3 \triangle FUD_{it} + \beta_4 \triangle PAT_{it} + \beta_5 \triangle PTP_{it} + \beta_6 \triangle MRS_{it} + \varepsilon_{it}$$

Where $\triangle GROP$ is the dependent variable representing the change rate data of regional GOP; $\triangle EMP_{it}$ is the change rate data of ocean-related employed representing the labor factor; ΔPRO_{it} is the change rate data of regional marine projects and ΔFUD_{it} is the change rate data of regional marine funds, representing the capital factor which is supported by the government; ΔPAT_{it} is the change rate data of regional marine research patents which means the science and technology; ΔPTP_{it} is the change rate data of regional pollution treatment projects and ΔMRS_{it} refers the change rate data of marine-type nature reserves, which represent the marine environmental factor.

After choosing the independent variables, it is necessary for us to check whether there is multicollinearity or not, which is shown in <Table 28> and <Table 29>.

<Table 28> Multicollinearity test

	Tolerance	VIF
⊿EMP	.986	1.014
⊿PRO	.977	1.023
⊿FUD	.983	1.018
⊿PAT	.994	1.006
⊿PTP	.991	1.009
⊿MRS	.972	1.029

If the tolerance is smaller or equal to 0.1 or the VIF is larger or equal to 10, there is the multicollinearity. From the above table, all the values of tolerance are larger than 0.1 and VIF is smaller than 10, so there is no multicollinearity.

<Table 29> Correlation test

Correlation						
	⊿EMP	⊿FUD	⊿PAT	⊿PRO	⊿PTP	⊿MRS
⊿EMP	1.0000	0.0078	0.0131	-0.0739	0.0260	-0.0298
⊿PRO	0.0078	1.0000	-0.0275	0.0338	-0.0289	-0.0941
⊿FUD	0.0131	-0.0275	1.0000	0.0018	0.0706	-0.0165
⊿PAT	-0.0739	0.0338	0.0018	1.0000	-0.0134	-0.1256
⊿PTP	0.0260	-0.0289	0.0706	-0.0134	1.0000	-0.0502
⊿MRS	-0.0298	-0.0941	-0.0165	-0.1256	-0.0502	1.0000

From <Table 28> and <Table 29> we can see that there is no multicollinearity between each variable, so we can do the regression analysis.

Step 1: Unit Root Test

Before the regression analysis, it is necessary to check the stationary of the data in the panel data model. Hence, we make the stationary test, which is a unit root test, by Eviews 9.0 getting the results in <Table 30>.

<Table 30> Results of unit root test

Variable	Breitung *t*-stat	*p* value	Pass or Not Pass the Test
⊿GOP	-3.33797	0.0004	PASS
⊿EMP	-6.13850	0.0000	PASS
⊿PRO	-2.87303	0.0020	PASS
⊿FUD	-1.07876	0.1403	NOT PASS
d⊿FUD	-1.70436	0.0442	PASS
⊿PAT	-4.50516	0.0000	PASS
⊿PTP	-5.95773	0.0000	PASS
⊿MRS	-3.43075	0.0003	PASS

As is shown in <Table 30>, all variables pass the original level of unit root test expect for FUD which needs the reduction order. Making all variables in the same order, then we make the Cointegration test.

Step 2: Cointegration test

Here we take Kao to do the Cointegration test, and *p* value is 0.0000 (*t*-statistic is -10.9110) which is smaller than 0.05. It means that all variables are in the stationary and the regression analysis is allowed.

Step 3: Regression estimation

By using Eviews 9.0, the results of regression estimation are shown in <Table 31>.

<Table 31> Results of regression estimation of GROP

Dependent Variable: ⊿GROP (regional Gross Ocean Products)				
Variable	Coefficient	Std. Error	*t*-Statistic	*p* value
c	0.0816**	0.0145	5.624	0.0000
⊿EMP	1.8900**	0.2213	8.5393	0.0000
⊿PRO	0.0071	0.0098	0.7248	0.4702
⊿FUD	0.0094**	0.0022	4.2358	0.0000
⊿PAT	0.0023**	0.0011	2.1037	0.0379
⊿PTP	0.0027**	0.0010	2.6230	0.0101
⊿MRS	0.0149	0.0115	1.2913	0.1995
R-squared	0.1548	Adjusted R-squared		0.1050

Note: ** means $p<0.05$; D.W. is 1.853023

In the regression estimation, *p* value determines the significance of the parameter. As we can see in <Table 31>, the coefficient of labor is 1.8900, signifying that as the labor of the marine industry increases by 1 unit, the GROP will increase by approximately 1.8900. It also sees significance by looking at the *p* value of the labor which is equal to 0.0000 less than the level of significance of 0.05, illustrating that the labor can be seen as a relevant variable in the model. It means the more ocean-related employed there are, the better GROP there will be.

For the capital factor in this model, the coefficient of the marine research project is 0.0071, the p value of marine research projects is equal to 0.4702 which does not satisfy the condition where *p* value should be less than the level of significance of 0.05 to be seen as a relevant variable for the model. However, the coefficient of marine research funds is 0.0094, indicating that as the marine research fund increases by 1 unit, the GROP will increase by approximately 0.0094. The *p* value of marine research fund is 0.0000 which is less than 0.05 signifying that the marine research fund is a relevant variable in this model. Marine research funds can explain the development of the regional marine industry significantly, which has a positive influence on the development of regional marine industry. Marine research projects have a positive relationship with the development of regional marine industry.

For marine patents as the technological factor, the coefficient is 0.0023 which signifies that as the marine patents increase by 1 unit, then GROP will increase by approximately 0.0023. It is also seen as significant as its *p* value which is equal to 0.0379 less than that of 0.05, indicating that the marine patents can be taken as a relevant variable in this model. The technology has a positive effect on the development of marine industry, which will improve the development of the marine economy.

Lastly, marine pollution treatments as the environmental factor, the coefficient is 0.0027 which signifies that as marine pollution treatments increase by 1 unit, the GROP will increase by approximately 0.0027. The p value of this variable is equal to 0.0101 which satisfies the condition where *p* value should be less than the level of significance of 0.05. It means the environmental factor plays a crucial role in marine economic growth. In addition, the variable of marine-type nature reserves has a positive relationship with the development of the regional marine industry. In general, the more pollution treatments there are, the better the marine environment will be. It is essential to pay attention to protecting the environment when developing the economy.

According to the regression estimation of GROP, the significant factors that affect the GROP are ocean-related employed (labor), marine research funds (capital), marine patents (technology), and marine pollution treatments (environment). Ocean-related employed (labor) has a positive and direct relationship meaning that when ocean-related employed increases it would lead to an increase in the growth of GROP. Marine research funds (capital) have a positive and direct relationship with the growth of GROP. There is no statistical significance of marine projects. In addition, the marine patents (technology) have a relatively positive relationship with the growth of GROP. Marine pollution treatments (environment) are positively related to the growth of GROP meaning that when marine pollution treatments increase it would result in an increase in the growth of GROP. Even though the marine-type nature reserves are not significant, there is a positive relation with GROP. Therefore, when developing the marine industry, it is necessary for us to protect the marine environment at the same time. The marine economy should never be at the cost of the environment.

5.2.2 Regression estimation of primary marine industry

According to the model of regional GOP, we establish the model of primary marine industry to analyze the selected factors influencing the development of primary marine industry.

$$\triangle RPMI_{it} = c + \beta_1 \triangle EMP_{it} + \beta_2 \triangle PRO_{it} + \beta_3 \triangle FUD_{it} + \beta_4 \triangle PAT_{it} + \beta_5 \triangle PTP_{it} + \beta_6 \triangle MRS_{it} + \varepsilon_{it}$$

<Table 32> Results of regression estimation of primary marine industry

Dependent Variable: ⊿RPMI (regional GOP of Primary Marine Industry)				
Variable	Coefficient	Std. Error	*t*-Statistic	*p* value
c	0.0847**	0.0132	6.4294	0.0000
⊿EMP	2.1078**	0.2298	9.1716	0.0000
⊿PRO	0.0842**	0.0162	5.2104	0.0000
⊿FUD	-0.0017	0.2298	-0.6390	0.5243
⊿PAT	0.0028*	0.0015	1.8897	0.0616
⊿PTP	-0.0129**	0.0014	-9.0947	0.0000
⊿MRS	-0.0325**	0.0113	-2.8679	0.0050
R-squared	0.1310	Adjusted R-squared		0.0799

Note: * means $p<0.1$; ** means $p<0.05$; D.W. is 2.308533

As we can see from <Table 32>, labor, capital, technology, and environment have a significant influence on the development of the primary marine industry. The coefficient of labor is 2.1078, signifying that as the labor of the marine industry increases by 1 unit, the primary marine industry will increase by approximately 2.1078. It is also seen significant by looking at the *p* value of the labor which is equal to 0.0000 less than the level of significance of 0.05, illustrating that the labor can be seen as a relevant variable in the model. Marine fishery industry, the main industry in primary marine industry, is labor-intensive. Therefore, improving labor in the primary marine industry will contribute to the development of the primary marine industry.

The coefficient of marine research projects is 0.08429, as it increases by 1 unit, the primary marine industry will increase by 0.0842 and its *p* value is 0.0000 which is less than that of 0.05 indicating this variable is significant to the development of primary marine industry. In addition, the *p* value of the patent as the technological factor is 0.0616 which is less than 0.1, indicating that the patent increases 1 unit, the primary marine industry will increase 0.0028.

However, coefficients of marine pollution treatments and marine-type nature reserves are -0.0129 and -0.0325 respectively, meaning that the variables increase 1 unit, the primary marine industry will decrease 0.0129 and 0.0325 respectively. Logically, the environment should be helpful to the development in a long time, however, in the period examined the environment has a negative relationship with the development of primary marine industry. Primary marine industry is mainly about the marine fishery industry, which needs the space for marine fishing or marine aquaculture. If there are more marine pollution treatments projects and marine-type nature reserves, there will be less space for the marine fishery industry. For instance, Sanya (Hainan) has the coral nature reserves which is only employed for coastal tourism, not for marine fishing. And Dalian (Liaoning) has the snake island which is the marine-type nature reserve for protecting the Agkistrodon halys and its ecological environment, so the adjacent area is limited for fishing or aquaculture. This can explain the reason why the environmental factor has a negative relationship with the development of primary marine industry during the period examined.

In conclusion, labor, marine research projects, and technology play a critical role in the primary marine industry, which have a positive relationship with the primary marine industry. Therefore, to develop the primary marine industry is to improve these factors. The environmental factor is also significant in the development of primary marine industry, and we should test this factor over a long time.

5.2.3 Regression estimation of secondary marine industry

According to the model of regional GOP, we establish the model of secondary marine industry to analyze the selected factors influencing the development of secondary marine industry.

$$\varDelta \mathrm{RSMI}_{it} = c + \beta_1 \varDelta EMP_{it} + \beta_2 \varDelta PRO_{it} + \beta_3 \varDelta FUD_{it} + \beta_4 \varDelta PAT_{it} + \beta_5 \varDelta PTP_{it} + \beta_6 \varDelta MRS_{it} + \varepsilon_{it}$$

<Table 33> Results of regression estimation of secondary marine industry

Dependent Variable: ⊿RSMI (regional GOP of Secondary Marine Industry)				
Variable	Coefficient	Std. Error	*t*-Statistic	*p* value
c	0.0680**	0.0248	2.7417	0.0072
⊿EMP	1.9115**	0.4243	4.5049	0.0000
⊿PRO	-0.0312*	0.0171	-1.8267	0.0706
⊿FUD	0.0115*	0.0046	2.52450	0.0131

⊿PAT	0.0022	0.0015	1.4401	0.1529
⊿PTP	0.0027**	0.0010	2.6230	0.0101
⊿MRS	0.0140	0.0172	0.8155	0.4167
R-squared	0.0946	Adjusted R-squared		0.0414

Note: * means $p<0.1$; ** means $p<0.05$; D.W. is 1.931095

As we can see in <Table 33>, the ocean-related employed as a factor has a significant influence on the growth of secondary marine industry, when the labor increases 1 unit, the growth of the secondary marine industry will increase 1.9115. However, marine research projects have a negative relation with the secondary marine industry, and the marine research funds have a positive relation with secondary marine industry. In the examined period, the funds are helpful to develop the secondary marine industry, but the research projects are less during that period. Marine pollution treatments have a significant impact on the development of secondary marine industry, whose p value is 0.0101 less than that of 0.05. Besides, marine-type nature reserves have a positive relation with the secondary marine industry.

Marine patents as the technological factor have a positive relation with secondary marine industry, but its p value is 0.1529 greater than that of 0.05. During the period examined, the Chinese government did not pay much attention to the technology in the secondary marine industry, and this factor was not helpful to the secondary marine industry, which should raise concern.

In fact, the secondary marine industry includes marine shipbuilding, seawater utilization, marine electronic, and six other marine industries. These marine industries need the support of technology, so the more the investment of funds, the better the secondary marine industry will be. However, why did the research projects have a negative relation with the secondary marine industry and marine patents have no significance? Actually, the outcomes of marine science and technology have a very low rate of transformation to productivity, which could explain the question. This problem deserves the government's attention to take measures.

R-squared of this model is 0.0946, indicating that the selected factors could not explain this model fully and there may be other factors influencing the development of the secondary marine industry.

5.2.4 Regression estimation of tertiary marine industry

According to the model of regional GOP, we establish the model of tertiary marine industry to analyze the selected factors influencing the development of tertiary marine industry.

$$\triangle \mathrm{RTMI}_{\mathrm{it}} = c + \beta_1 \triangle EMP_{it} + \beta_2 \triangle PRO_{it} + \beta_3 \triangle FUD_{it} + \beta_4 \triangle PAT_{it} + \beta_5 \triangle PTP_{it} + \beta_6 \triangle MRS_{it} + \varepsilon_{it}$$

<Table 34> Results of regression estimation of tertiary marine industry

Dependent Variable: ⊿RTMI (regional GOP of Tertiary Marine Industry)				
Variable	Coefficient	Std. Error	*t*-Statistic	*p* value
c	0.1017**	0.0110	9.2070	0.0000
⊿EMP	1.6458**	0.1806	9.1123	0.0000
⊿PRO	0.0267**	0.0076	3.5146	0.0007
⊿FUD	0.0070**	0.0017	4.1369	0.0001
⊿PAT	0.0023**	0.0009	2.5636	0.0118
⊿PTP	0.0044**	0.0009	5.0924	0.0000

⊿MRS	0.0281**	0.0118	2.3920	0.0118
R-squared	0.1639	Adjusted R-squared		0.1147

Note: ** means $p<0.05$; D.W. 1.949434

As we can see in <Table 34>, all the selected variables have a significant impact on the development of the tertiary marine industry. The coefficient of labor is 1.6458, indicating that as the labor of marine industry increases by 1 unit, the tertiary marine industry will increase by approximately 1.6458. It is also seen significant by looking at the *p* value of the labor which is equal to 0.0000 less than the level of significance of 0.05, illustrating that the labor can be seen as a relevant variable in the model. For the capital factor in this model, the coefficient of marine research projects is 0.0267, signifying that as marine research projects increase by 1 unit, the tertiary marine industry will increase by approximately 0.0267. The *p* value of marine research projects is equal to 0.0000 which satisfies the condition where *p* value should be less than the level of significance of 0.05 to be seen as a relevant variable in the model. In addition, the coefficient of marine research fund is 0.0070, indicating that as marine research fund increases by 1 unit, the tertiary marine industry will increase by approximately 0.0070. The *p* value of marine research fund is 0.0001 which is less than 0.05 signifying that the marine research fund is a relevant variable for this model. Both of the two variables can explain the development of the regional marine industry significantly, and the capital factor has a positive influence on the development of regional marine industry.

For marine patents as the technological factor, the coefficient is 0.0023 which signifies that as the marine patents increase by 1 unit, then tertiary marine industry will increase by approximately 0.0023. It is also seen as significant as its *p* value which is equal to 0.0118 less than that of 0.05, indicating that the marine patents can be taken as a relevant variable in this model. The technology has a positive effect on the development of marine industry, which will improve the development of the marine economy. Lastly, the marine pollution treatments as the environmental factor, the coefficient is 0.0044 which signifies that as marine pollution treatments increase by 1 unit, the tertiary marine industry will increase by approximately 0.0044. The *p* value of this variable is equal to 0.0000 which satisfies the condition where *p* value should be less than the level of significance of 0.05. The marine-type nature reserves as another environmental factor have a positive relation with the tertiary marine industry, whose *p* value is 0.0118 less than 0.05, indicating that the marine-type nature reserves increase 1 unit, the growth of tertiary marine industry will increase 0.0281. It means the environmental factor plays a crucial role in marine economic growth. For instance, coastal tourism is an important marine industry in tertiary marine industry, which requires a better environment to develop.

In fact, the tertiary marine industry includes marine communication and transportation, coastal tourism, and marine scientific service and education. Marine communication and transportation require labor input, coastal tourism needs labor input and good environments, and marine scientific service and education requires labor, especially professional and technical. This is the reason why six variables have a significant influence on the development of tertiary marine industry.

5.2.5 Regression estimation on international competency

According to the model of regional GOP, we establish the model of international competency to analyze the selected factors influencing the international competency. Here we take the number of regional exports as the dependent variable referring to the international competency.

$$\varDelta \mathrm{REX}_{\mathrm{it}} = c + \beta_1 \varDelta EMP_{it} + \beta_2 \varDelta PRO_{it} + \beta_3 \varDelta FUD_{it} + \beta_4 \varDelta PAT_{it} + \beta_5 \varDelta PTP_{it} + \beta_6 \varDelta MRS_{it} + \varepsilon_{it}$$

<Table 35> Results of regression estimation of international competency

Dependent Variable: ⊿REX (Regional Exports)				
Variable	Coefficient	Std. Error	*t*-Statistic	*p* value
c	0.0312	0.2018	0.1547	0.8774
⊿EMP	17.3738**	2.5774	6.7407	0.0000
⊿PRO	-0.0436	0.0913	-0.4777	0.6339
⊿FUD	-0.0342	0.0208	-1.6477	0.1025
⊿PAT	0.0471**	0.0132	3.5573	0.0006
⊿PTP	0.0129	0.0118	1.0913	0.2777
⊿MRS	-0.1279	0.1361	-0.9400	0.3495
R-squared	0.0498	Adjusted R-squared		-0.0061

Note: ** means p<0.05; D.W. is 2.009853

As is shown in <Table 35>, the ocean-related employed has a significant influence on international competency, the coefficient is 17.3738 which signifies that as labor increases by 1 unit, and the exports will grow by approximately 17.3738. The p value of this variable is equal to 0.0000 which satisfies the condition where p value should be lower than the level of significance of 0.05.

Labor plays a crucial role in the regional exports, which means that improving the labor will strengthen the international competency in the period examined. In addition, marine patents as the technological factor have a positive relationship with regional exports, when the increase of patents is 1 unit, the international competency will increase by 0.0471. In this model, marine research projects, marine research funds, and marine-type nature reserves have a negative relation with regional exports, while the pollution treatments have a positive relation.

R-squared is 0.0498 which is relatively low, indicating that there should have additional factors influencing the exports of the marine industry, such as the exchange rate and FDI which are usually used to analyze factors influencing the exports.

5.3 Summary

To attain the answer to the question stated at the beginning of this chapter, we look into the results of regression estimations.

<Table 36> Conclusions of regression estimations

	⊿EMP	⊿PRO	⊿FUD	⊿PAT	⊿PTP	⊿MRS
GROP	+**	+	+**	+**	+**	+
Primary Marine Industry	+**	+**	−	+*	−**	−**
Secondary Marine Industry	+**	−*	+*	+	+**	+
Tertiary Marine Industry	+**	+**	+**	+**	+**	+**
Intentional Competency	+**	−	−	+**	+	−

Note: * means p<0.1; ** means p<0.05

According to the results in <Table 36>, it indicates that the labor factor plays a crucial role in the development of regional marine industries, three marine industries, and regional exports. The capital factor has a different influence on them. Besides, the impact of capital factor on the secondary marine industry should hold the government's attention. The technological factor has a significant impact on these dependent variables except for the secondary marine industry. In addition, the environmental factor is under a significant influence on the development of regional marine industry and three marine industries. However, there is a negative relation between the environmental factor and primary marine industry. In the regression estimation of the exports, the variables we selected could not fully explain the export situation in the development of the marine industry. Therefore, we propose some suggestions for the development of regional marine industries according to the regression estimation.

(1) To increase the labor input and cultivate marine talents.

Labor plays a crucial role in the development of marine industries, and China's marine economy is a labor-intensive industry, which needs a great number of workers for three marine industries. On the one hand, increasing the labor input can enlarge the scale of the marine economy and offer more job opportunities on the marine industry. On the other hand, it is essential to place a high value on training professionals in the marine industries, and the need for marine technical personnel to transform the marine technologies into the actual marine productions.

(2) To strength marine science and technology.

In 2003, the State Council of China indicated that China would vigorously develop the ocean in the "Outline of the National Planning for Development of

Ocean Economy". For one thing, it is necessary to increase the input of technology to improve the level of marine technological innovation. Marine economy is unique and relies on the exploitation and utilization of marine resources, and the support of marine technology should be not only on human resources, especially on funds and policies. For another thing, it is crucial to transform science and technology into actual marine products. At present, China has a low rate of scientific and technological achievement transfers of the marine industry, which is approximate 20% lower than the world average. There are a large number of scientific and technological achievements that cannot be converted every year.

(3) To protect the marine ecological environment.

Firstly, we should pay attention to the prevention of marine pollution. Most marine pollution is from the land. To prevent environmental pollution is to test the discharge of pollutants near the estuary, and to strengthen the treatment before discharge. When discharging pollution into the ocean, we should ensure that all indicators of pollution are within the range of the discharge. Secondly, it is necessary to strengthen public awareness and education on protecting the marine environment. The government should establish environmental protection organizations to publicize the environmental protection which will provoke the environmental awareness of the public. The environmental protection organizations can encourage the public to participate in marine activities like the Quizarium Pro on marine to improve the knowledge of protecting the marine economy.

The marine resources are limited, before the development and utilization, rational planning should be carried out to improve the utilization efficiency of marine resources in the actual production and reduce the dependence on marine resources. Protecting the marine ecological environment can realize the sustainable development of the marine economy. For instance, the coastal tourism industry is highly dependent on the environment, so ecological protection is critical for the sustainable development of the marine economy.

Chapter 6 Conclusions

6.1 Research Findings

The development of the marine industry is an indispensable part of the national economy. China, as an ocean country with abundant marine resources, has paid more and more attention to the marine industry. It is widely acknowledged that a complete and reasonable marine industry development system with high competitiveness would play a crucial economic function in the marine industry, which also takes account of the special status of the marine industry in the national economy.

By analyzing the current development of China's regional marine industry, we can understand the current situation of the Chinese marine industry system, primary marine industry, secondary marine industry, and tertiary marine industry. There are eleven coastal provinces and cities in China that have different agglomeration degrees, and the clusters of the marine industry in China are generally becoming better.

By comparing the development of various regional marine industry in China, we established an evaluation index system for regional marine industrial competitiveness to compare their different developments. Marine economic capacity, marine human resources, marine technology, marine output capacity, and marine environment constitute the evaluation index system. In addition, marine economic capacity, marine human resources, and marine technology account for the larger proportions. Then eleven coastal provinces and cities are divided into four groups, Guangdong, Shandong, and Shanghai have the stronger competitive advantages of the marine industry. However, Guangxi, Hebei, and Hainan have no competitiveness in the marine industry. It is identified that there are differences in the regional marine industry development in China.

Due to the differences among the development of marine industries, we use regression analysis to estimate the factors influencing the development of marine industries. According to the results of regression analyses, it is found that labor, capital, technology, and environment have a significant effect on the development of marine industries. By analyzing the factors affecting the development of three marine industries and exports respectively, we can find that labor has a significant influence on the development of all three marine industries and international competency.

In short, marine economic capacity, marine human resources, and marine technology are the competitive advantages of regional marine industry to develop, and labor, technology, and environment have a significant impact on the development of regional marine industry. To promote the development of regional marine industry, it is essential for us to pay attention to human resources, technology, and the environment.

6.2 Implications

The findings of the study provide meaningful implications.

The academic contribution of this study is an empirical analysis of the development of regional marine industry in China. On the one hand, the author establishes the evaluation index system with six first-class targets to compare the development of regional marine industry, which provides more quantitative results with the entropy method. Compared with previous studies, this paper finds the differences in the regional marine industry from the perspective of regional marine industrial competitiveness, which provides another view in analyzing the differences of regional marine industries. On the other hand, this study establishes the panel data model to analyze the factors influencing the regional marine industry in China, which applies the econometrics into the researches of the marine industry. Most of the previous studies use the absolute data to analyze, while the change rate data are used in this study. Because the development of regional marine industry is dynamic, the change rate data can explain the trends of development, which may provide another perspective to analyze the marine industry.

The practical contribution of this study is to be helpful for policymakers to understand the competitive advantages of China's regional marine industry and factors influencing its development. For instance, technology occupies a greater proportion in the regional marine industrial competitiveness. However, no significance of technology showed in the secondary marine industry, due to the low rate of transformation of science and technology to productivity. This should draw the policymakers' attention.

In short, to analyze the development of regional marine industry in China helps to understand the current situation of China's regional marine industry, advantages of regional marine industrial development, and its influencing factors. To understand the competitive advantages and factors of regional marine industry is the basic step for making effective and efficient suggestions.

6.3 Further Study

In general, this study is beneficial to further understand the development of regional marine industries in China. The marine industrial cluster, competitiveness of marine industry, and factors influencing the development of regional marine industry in China are analyzed in this study, and this study proposes some advice from the human resources, technology, environment and other aspects, which is helpful to the development of regional marine industry in China.

However, there are some limitations of this study which should be improved in the further studies. On the one hand, we would like to better enrich the data of marine industry in China in the future. The data of the marine industry are updated quite slowly: the latest data for this study are of 2016 from China's Statistical Yearbook 2017. For further study, it is essential to update the data to compare the changes in the marine industry. On the other hand, the capital factor in this study refers to the marine research project and marine research funds instead of the general capital which is about investment, this is a restriction of this study that should be modified in the future to make the research model better. There may be other factors influencing the development of the marine industry that should be analyzed in further study. This study analyzes the marine industry in China from the regional perspective, based on this, we could do analyses of marine industries from the international perspective to compare nations.

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