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Analysis and Selection of Marine Engineering Equipment Manufacturing Industry Developing Strategy Based on Diamond Model - Take Guangdong Province as an Example

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Abstract

With the over-exploitation of global resources and the increasing cost of developing land resources, marine resources have become the new choice for coastal countries to address resource problems. The development and utilization of marine resources encourages the growing of marine engineering equipment manufacturing industry. In this paper, we take Guangdong Province as the studied area, which has a natural advantage for the development of shipping and marine equipment industry, applying the mainstream industry competitive advantage theory – "diamond model" to build evaluation index system. And we calculate combining weights by AHP and variation coefficient method, as well as giving a comprehensive evaluation from the perspective of quantitative analysis for development of marine engineering equipment manufacturing industry in Guangdong Province. The results show that although Guangdong marine engineering equipment manufacturing industry achieves rapid development in recent years, the total scale amount of industry is small, shipbuilding industry development is slow, and professional technical personnel is inadequate. For these problems, this paper provides some suggestions for marine equipment manufacturing industry in Guangdong Province.

Keywords: marine engineering equipment industry, Diamond Model, AHP, coefficient of variation method, combining weights

1. Introduction

1.1 Introduce the Problem

With the gradual depletion of the world's land resources, the development and utilization of marine resources continues to accelerate, and marine engineering equipment industry is attracting worldwide attention with its huge development potential and attractive market prospects. Internationally, the western countries and Japan, South Korea, Singapore, etc. from Asian Pacific have also set marine engineering and equipment manufacturing as a focus of national marine economic strategy, and constantly improve the technological level and the international market share of the national marine equipment manufacturing industry. In China, the development of marine engineering equipment manufacturing industry has gained more and more attention. The State Department lists it as a strategic emerging industry. In 2012, the national Industrialization and Information Ministry issued "Marine Engineering Equipment Manufacturing and Long-Term Development Plan (2011-2020)" proposed that by 2020, China's marine engineering equipment manufacturing industry would have reached the output of 40 billion yuan, accounting for more than 35% share of the international market (MIIT, NDRC, & Ministry of Science and Technology, 2012). Nowadays, Chin's marine engineering equipment industry is in the third camp, and there is a great difference compared to the world's advanced level of Europe, America, Japan, Korea, Singapore, and other countries.

Guangdong Province is one of the three shipbuilding bases of the national planning and construction. At present, Guangdong Province has achieved the initial result of gaining the abilities to construct VLCC, LNG, LPG carriers, large Ro/Ro ships and other high-tech and high-value-added shipping products, as well as offshore drilling platforms, mobile multi-function workover platforms, large-scale engineering vessels, FPSO vessels and other marine engineering equipment. So far, the marine engineering equipment and shipbuilding industry of Guangdong Province has made some achievements, but there are still some problems restricting the industrial development: on the one hand, small and medium enterprises make up the majority, and only a handful of shipbuilding units can handle more than million tons; on the other hand, it faces with the dilemma that the development of shipbuilding industry lags behind, seriously restricting the level of nationalization of Guangdong shipbuilding supporting products. In addition, the lack of professional and technical personnel results in an overall weak design capacity and poor product development capability. The low intelligent construction level, coupled with the increasing cost of human resources, greatly restricts the industrial development. Overall, there is a big gap between the Pearl River Delta and the Bohai Shipbuilding Base as well as the Yangtze River Delta shipbuilding base. In accordance with the requirements of Guangdong “12th five-year” Plan, at present, Guangdong Province has been actively guiding shipping companies to develop in the east and west wings, relying on ship repair projects of port construction, and paying further attention to the development of marine engineering equipment manufacturing. Guangdong mainly develop key projects of shipbuilding and marine engineering equipment in Guangzhou, Zhuhai and Zhongshan, forming the base for the Pearl River Delta “Shipbuilding” and “marine engineering equipment manufacturing”, promoting the cluster development of marine engineering equipment in Guangdong province (Wang, Xu, Zhao, & Peng, 2015).

1.2 Describe Relevant Scholarship

In China, the literature of marine engineering equipment manufacturing industry is scarcely seen. Among them, Liu, Huang, and Wang (2011) analyze the development of the world’s marine engineering equipment manufacturing industry, and introduce the basic status of China’s marine engineering equipment industry, through the comparison of the development of domestic and international marine engineering equipment manufacturing industry, pointing out the problems of China’s Marine engineering and equipment manufacturing. Tao and Chen (2010) places SWOT analysis as the basis, makes it a principle to make use of advantages, overcome disadvantages, take advantage of opportunities and avoid threats, and puts forward the strategy of developing China’s marine engineering equipment manufacturing industry. Wu, Huang, and Zhao (2015) construct a system of questions about the development of marine engineering equipment industry, use integrated DEMATEL/ISM method to analyze the industrial development issue, and propose industry development strategies from the corporate and government levels. Wu and Huang (2013) use the diamond model to construct the indicator system of factors related to marine engineering equipment industry, apply the gray correlation analysis method to analyze the correlation factors of marine engineering equipment industry, and find out the law and problems of industrial development, as well as the solutions.

Foreign research on marine engineering equipment is common in the industrial development report of prominent marine equipment manufacturing countries. For example, Korea Marine Equipment Research Institute (2009), by reviewing the development process of the country’s marine engineering equipment industry, analyzed systematically and researched for the production of the relevant aspects. Malaysian Maritime Bureau (2010) also described the importance of the development of marine engineering equipment manufacturing industry through a report, and emphasized their current development of marine engineering equipment manufacturing industry and analyzed the existing development bottleneck, and made future development planning. Du (2012) gave a comprehensive analysis of the world’s marine engineering equipment market demand in its “Marine Equipment Manufacturing Industry Research Report”, and took the development of marine engineering equipment of several large companies for the study, analyzed their development path, and proposed deep-water equipment as the future trend.

Sorting the existing relevant marine equipment industry literature, we find that the current domestic and foreign academic exploration of marine engineering equipment manufacturing industry is still in the early stage, and the research has focused on industrial development background, current situation and the significance and importance of developing marine engineering equipment manufacturing industry. At the same time, for a particular area of industrial development, the specific research is little, and the main research method is qualitative analysis, while the study of quantitative analysis is hardly seen.

In order to overcome the defect of the above studies, we take Guangdong Province as the studied area, which has a natural advantage for the development of shipping and marine equipment industry, applying the mainstream industry competitive advantage theory – “diamond model” to build evaluation index system. And we calculate combining weights by AHP and variation coefficient method, give a comprehensive evaluation from the perspective of quantitative analysis for development of marine engineering equipment manufacturing industry in Guangdong Province, and propose solution suggestions for developing marine engineering equipment manufacturing industry.

2. Model

2.1 "Diamond Model" Theory

The "Diamond Model" theory (Porter, 1990; Porter, 1998) proposed by Professor Michael. E. Porter is the mainstream theory of industrial competitiveness analysis. It considers a country's domestic economic environment for industries to create their own competitive advantages has a great impact. The four factors which play a decisive role in international competition are: element conditions, demand conditions, related and supporting industries and corporate strategy, business structure and competitiveness of enterprises. Among them, government and opportunities are considered to generate secondary effects.

If a specific industry of a country expects to obtain international competitive advantage, the core is shown as the above four basic elements as well as two other key elements, which can play as a dynamic integration. The four basic elements are the basis for forming competitive advantage, serving as the determinant of the competitiveness of the formation. Government's support for the industry is the key factor in competitive play. Although the opportunity is unpredictable element, the formation of competitive advantage relying on the basic elements can seize the opportunity to expand the competitive advantage and even surpass the others.

The diamond model is composed of these interrelated elements, as shown in Figure 1:

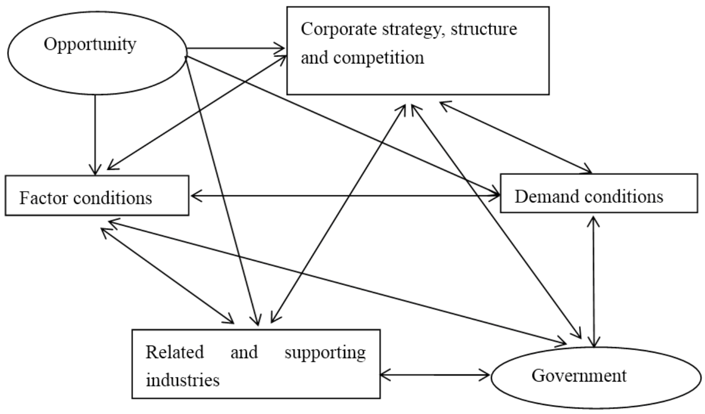

Figure 1. Diamond model of Michael. E. Porter

2.2 Indicators of Marine Engineering Equipment Industry Based on Diamond Model

Based on Diamond Model, we consider the characteristics of China's marine engineering equipment industry, as well as the indicator design principles of availability, reliability, comprehensive systematic property and comparability, then we refer to the existing literature (Wu, Huang, & Zhao, 2015; Wu & Huang, 2013; Wu & Zhao, 2014) to establish an index system of marine engineering equipment industry, as shown in Table 1.

Table 1. Marine engineering equipment industry evaluation index system

Goal A	Criteria B	Indicators C
Index system of marine engineering equipment industry A	Scale of market B_1	Market share of platform products X_1
	Factors of production B_2	The number of professional colleges and universities with majors of marine equipment X_2
		The number of undergraduates or graduates major in marine equipment X_3
		The number of employees in shipbuilding industry X_4
	Related industries and supporting industries B_3	Steel production of ships and marine engineering X_5
		The market scale of shipping equipment industry X_6
		The market scale of shipbuilding industry X_7
		The output value of financial GDP X_8
	Corporate structure, strategy, competition B_4	The length of the industrial chain and degree of industrial clusters X_9
		The number of development projects about marine equipment technology X_{10}
		Orders received by international enterprises X_{11}
		Orders received by the subsidiaries of the three prominent groups X_{12}
		The number of shipping industrial enterprises X_{13}
	Government B_5	Government industrial planning and political support intensity X_{14}

According to Diamond Model, this paper takes the follows as a criterion level: “Scale of market”, “Factors of production”, “Related industries and supporting industries”, “Corporate structure, strategy, competition” and “Government”.

Currently, the development of marine resources with the representative as deep-sea offshore oil and gas exploration and marine wind power development boosts the marine engineering equipment needs; while the development of natural gas hydrate, wave energy, tidal energy, deep sea mineral resources and marine spatial utilization is still in its initial stage, with a strong potential demand. Marine engineering equipment products are mainly offshore oil drilling platform equipment, production platform equipment, offshore support vessels and work boats for marine resources exploration and development, as well as offshore wind power equipment construction vessels, where platform products have a large scale, complex structure, and high difficulty in designing and production, which can serve as the best representative of marine engineering equipment industry performance and market competitiveness. Therefore, we choose “Market share of platform products” as an index of measuring the market scale of marine engineering equipment industry.

Modern western economics believes that the factors of production includes labor, technology, entrepreneurship, etc. (Li, Chen, & Chen, 2004). With the limited data, this paper chooses “The number of professional colleges and universities with majors of marine equipment”, “The number of undergraduates or graduates major in marine equipment” and “The number of employees in shipbuilding industry” into the scheme layer of “Factor of production”. The number of employees in shipbuilding industry can measure the labor level of marine engineering equipment industry. The number of professional colleges and universities with majors of marine equipment and the number of undergraduates or graduates major in marine equipment can be used to evaluate the level of technology and entrepreneurship of the marine engineering equipment industry.

Related industries and support industries of marine engineering equipment industry include the steel industry, marine equipment industry, ship manufacturing and finance, of which the finance provides financial support for marine engineering equipment industry. Therefore, we choose “Steel production of ships and marine engineering”, “The market scale of shipping equipment industry”, “The market scale of shipbuilding industry” and “The output value of financial GDP” into the scheme layer of “Related industries and support industries”.

Industry chain is a dynamic system formed when enterprises cooperate with one another through the exchange and sharing of information, and elements of resources support one another (Chen, Feng, & Zhang, 2008). Industrial cluster means that a group of the same, similar and related industries gather somewhere, then attract relevant institutions to enter the region for their services (He, 2009). The length of the industrial chain and the degree of industrial clusters reflect the enterprise structure. Therefore, this paper chooses “The length of the industrial chain and degree of industrial clusters” as an evaluation index of corporate structure. Project management plays an important role in corporate strategic management, so we choose “The number of development projects about marine equipment technology” as an evaluation index of corporate strategy. “Orders received by international enterprises”, “Orders received by the subsidiaries of the three prominent groups” and “The number of shipping industrial enterprises” reflect the intensity of competition of the enterprises in marine engineering equipment industry. Thus, we classify them as indicators for evaluating the competition.

Government can develop quantitative evaluation with the indicator “Government industrial planning and political support intensity”.

2.3 AHP- Variation Coefficient Model to Determine Index Weights

The key to reasonably and impartially evaluate marine engineering equipment manufacturing industry in Guangdong Province is to determine a set of scientific and effective weights for the index system. In this paper, we the combine the weight obtained by AHP and that by coefficient of variation weight. The specific process is as follows.

1) Dimensionless Process of Index Data

Due to the difference in dimension, economic significance and the effect to the overall goal, the evaluation indicators of the index system are not comparable, and we must eliminate the influences of dimension on data before calculating the results of the evaluation, that is the dimensionless process of data. The process is the premise of parameter evaluation.

There are several common ways to operate dimensionless process on index data. By comparing a variety of methods, this paper selects linear proportional transformation for dimensionless index data processing. The method takes into account the differences in index values. The process is shown as follows:

In the system of m indicators and *n* evaluating years, we can obtain the evaluation matrix $X=(x_{ij})_{m\times n}$ constructed by the raw data of indicators corresponding to the evaluation object as:

$$X=\begin{pmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{pmatrix}_{m\times n}$$

Given that the indicators selected in this paper are positive indicators, therefore the dimensionless equation is:

$$y_{ij}=\frac{x_{ij}}{x_j^*}\times 100\% \text{，} \quad 1\le i\le m, 1\le j\le n \tag{1}$$

$$x_j^*=\max_{1\le i\le m} x_{ij}\neq 0 \tag{2}$$

Among them, x_{ij} refers to the original value of the j-th evaluation object on index I; n refers to the number of objects to be evaluated; m refers to the number of evaluation indicators; y_{ij} refers to the scoring after the dimensionless process of the original index data.

Finally, we obtain a new evaluation matrix with an evaluation system of m indicators and n samples, as well as the dimensionless value as y_{ij} for evaluation objects, which is written as: $Y=(y_{ij})_{m\times n}$

$$Y=\begin{pmatrix} y_{11} & y_{12} & \cdots & y_{1n} \\ y_{21} & y_{22} & \cdots & y_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ y_{m1} & y_{m2} & \cdots & y_{mn} \end{pmatrix}_{m\times n}$$

Among them, y_{ij} refers to the value of the i-th indicator of the j-th sample.

2) AHP to obtain the Subjective Weight of Indicators

AHP method is a multi-objective decision analysis method for qualitative and quantitative analysis, and it is suitable to deal with decision-making problems with a complex structure and multi-criteria, which are difficult to quantify (Yuan & Xu, 2010).

Firstly, we sort out the evaluation objectives, and construct a hierarchical structure model. The top layer (also known as the target layer) is the evaluation system of Guangdong marine engineering equipment industry; the intermediate layer (also known as the criterion layer) is for 5 primary indicators including market scale, factors of production, related industries and support industries, business structure, strategy and competition; the bottom layer (also known as the scheme layer) is for 15 secondary indicators, such as the market share of platform products, the number of colleges and universities with majors of offshore engineering equipment, steel production of ships and marine engineering, and the number of large marine engineering equipment technology development projects.

After establishing the hierarchical structure, we need to develop pairwise comparisons between various factors at the same level, and build a comparative judgment matrix. Set A as the target layer, Bi (i = 1,2, ..., m) as the evaluation factors below the A layer, and B_{ij} as the relative importance value of Bi to Bj (j = 1,2, ..., m). Apply the 1-9 scale method to obtain the values of the pairwise comparison judgment matrix $B=(B_{ij})_{m\times m}$. Invite relevant experts to score the importance of the indicators in each criterion layer independently for times, and construct the judgment matrix. According to the results of pairwise comparisons, the A-B judgment matrix can be obtained as follows:

Table 3: A-B judgment matrix

A	*B1*	*B2*	…	*Bm*
B1	*b11*	*b12*	…	*b1m*
B2	*b21*	*b22*	…	*b2m*
…	…	…	…	…
Bm	*bm1*	*bm1*	…	*bmm*

Wherein $b_{ij}>0$; $b_{ij}=1/b_{ji}$ ($i\neq j$); $b_{ii}=1$ ($i, j=1, 2, \ldots, m$).

AHP weight calculation is to calculate the importance weights of the elements of one level to an element of the former layer based on the judgment matrix. It can be attributed to the problem of calculating the largest eigenvalue and eigenvector in the judgment matrix. The calculation method is as below:

1) Calculate the results M_i of elements in each row in the judgment matrix;

a) $$M_i = \prod_{j=1}^{m} b_{ij} \; ; i, j = 1, 2, 3, ..., m \tag{3}$$

2) Calculate m-th Root $\bar{W}_i$ of Mi;

a) $$\bar{W}_i = \sqrt[m]{M_i} \tag{4}$$

3) Operate normalization process on the vector $\bar{W} = [\bar{W}_1, \bar{W}_2, ..., \bar{W}_n]^T$;

$$w_i^{(a)} = \frac{\bar{W}_i}{\sum_{j=1}^{m} \bar{W}_j} \tag{5}$$

Then $w^{(a)} = [w_1^{(a)}, w_2^{(a)}, ..., w_m^{(a)}]^T$ is the feature vector we need, i.e. the weight vector.

Finally, we operate a consistency check, and the calculated value of the random consistency ratio is $CR = CI/RI$. When CR <0.10, it is considered that the A-B judgment matrix has satisfactory consistency, otherwise we need to adjust the judgment matrix, so that it can achieve a satisfactory consistency.

3) Coefficient of Variation Method to Obtain Objective Index Weight

Objective weighting methods include entropy method, fuzzy matter element method, variation coefficient method and the like. For example, Chen (2010) applies the osculating value method to evaluate China's energy reduction. This paper selects variation coefficient method to determine the objective weight of the evaluation system. The basic idea of the variation coefficient method (Chu & Chen, 2011) is: for comprehensive evaluation, if the variability of observed values of one indicator on all objects is evaluated as relatively great, it is difficult for the indicator to reach the average level when executed by an evaluated company, and it can clearly distinguish the ability of each object to evaluate in this regard, thus the indicator should be given a greater weight; on the contrary, a smaller weight should be given.

After calculating the new evaluation matrix $Y = (y_{ij})_{m \times n}$ of the dimensionless value, calculate the average value $\bar{y}_i$ and the standard deviation s_i of each indicator:

$$\bar{y}_i = \frac{1}{n} \sum_{j=1}^{n} y_{ij}, \quad i = 1, 2, \cdots, m \tag{6}$$

$$s_i = \sqrt{\frac{1}{n-1} \sum_{j=1}^{n} (y_{ij} - \bar{y}_i)^2}, \quad i = 1, 2, \cdots, m \tag{7}$$

Next, calculate the coefficient of variation v_i and the weight $w_i^{(e)}$ of each indicator:

$$v_i = \frac{s_i}{\bar{y}_i}, \quad i = 1, 2, \cdots, m \tag{8}$$

$$w_i^{(e)} = \frac{v_i}{\sum_{i=1}^{m} v_i}, \quad i = 1, 2, \cdots, m \tag{9}$$

4) Determining the Combining Weight

Based on the importance and complexity of evaluating marine engineering equipment manufacturing, we overcome the limitation of using a single weighting method in determining the index weights, and use the combination weighting method by combining the AHP method and the coefficient of variation method. We obtain the weighted average of the AHP calculation results and variation coefficient calculation results to determine the weight of each indicator of the evaluation of marine engineering equipment manufacturing. This combination weighting method ensures that the evaluation result is more consistent with the actual situation, in order to better reflect the actual situation of marine engineering equipment manufacturing industry. Combining weights are calculated as follows:

Assumptions: w_i is the final weight of the i-th index after the combination process of AHP method and the coefficient of variation method. Set w_i as the linear combination of $w_i^{(a)}$ and $w_i^{(e)}$ (i = 1,2, ..., m), then

$$w_i = \alpha w_i^{(a)} + (1-\alpha) w_i^{(e)} \tag{10}$$

In the formula, $w_i^{(a)}$ represents the AHP weight of the *i*-th indicator; α represents the subjective preference coefficient, that is, the proportion of AHP weight in combining weights, $\alpha \in [0,1]$; $w_i^{(e)}$ represents the weight of the *i*-th indicator of the coefficient of variation method; $1-\alpha$ represents the objective preference factor, that is, the proportion of the weight by coefficient of variation method in combining weights. Our target is to minimize the quadratic sum of the deviation between combining weights and AHP weights and the deviation between combining weights and coefficient of variation weights:

$$\min O = \sum_{i=1}^{m}[(w_i - w_i^{(a)})^2 + (w_i - w_i^{(e)})^2] \tag{11}$$

Calculate the first derivative of the above equation and make it zero. Obtain $\alpha = 0.5$, then:

$$w_i = 0.5w_i^{(a)} + 0.5w_i^{(e)} \tag{12}$$

This result shows that: on the assumption that the quadratic sum of the deviation is minimal, the best result of combining weights is that the subjective AHP weight and the objective variation coefficient account for 50% each, indicating that the two weights are of the same cognitive importance of indicators. Eventually, the combining weight is: $w = [w_1, w_2, \cdots, w_m]^T$.

4. Empirical Analysis

4.1 Data

By referring to the data of "China Shipbuilding Industry Almanac (2011-2015)", "China Financial Almanac (2011-2015)", relevant websites of colleges, enterprises and research institutes, marine engineering equipment website, Shipbuilding Industry Association website, and expert questionnaires, we obtain the index data of the marine engineering equipment industry in Guangdong from 2010 to 2014, as shown in Table 4.

Table 4. Index data of marine engineering equipment industry in Guangdong (2010-2014)

Index	2010	2011	2012	2013	2014
X_1	2	3	4	10	5
X_2	2	2	2	2	3
X_3	200	201	159	493	388
X_4	32193	59519	51719	58701	59653
X_5	77.2	84.0	79.2	89.5	91.2
X_6	7.6	11.3	10.1	9.8	11.3
X_7	395.30	174.33	271.85	568.91	354.11
X_8	2658.76	2916.13	3171.96	3817.42	4447.43
X_9	1	1	1	2	3
X_{10}	6	8	10	35	18
X_{11}	8	12	15	40	20
X_{12}	174	116	120	122	111
X_{13}	8	10	11	13	14
X_{14}	2	4	4	6	6

The length of industrial chains and the degree of industrial clusters, government industrial planning and policy support intensity are qualitative indicators. We set the comment as very strong, strong, relatively strong, medium, relatively weak, weak and very weak, and assign scores to them respectively as 6 points, 5 points, 4 points, 3 points, 2 points, 1 point and 0 points. Invite experts to evaluate each year from 2010 to 2014 in Guangdong Province, and register the most given score as the final score of the index.

4.2 Results of Weight Calculation

In this paper, we apply the AHP method and coefficient of variation method (CV) to calculate the weights of indicators separately, then use the minimum information entropy principle to combine the weights obtained by the above two methods, and calculate the combination weight. The weights of the evaluation indicators by different methods are as shown in Table 5. The index weight of the criterion layer is obtained by adding up the weights in scheme layer.

Table 5. Weights of the evaluation indicators by different methods

Criteria	Weights (combination)	Scheme	Weights		
			AHP	CV	Combination
B_1	0.14941	X_1	0.1940	0.1048	0.1494
B_2	0.22527	X_2	0.0384	0.0328	0.0356
		X_3	0.0335	0.0812	0.0574
		X_4	0.0878	0.1768	0.1323
B_3	0.26737	X_5	0.0706	0.0118	0.0412
		X_6	0.0342	0.0244	0.0293
		X_7	0.1832	0.0675	0.1253
		X_8	0.1086	0.0345	0.0715
B_4	0.27531	X_9	0.0442	0.0903	0.0673
		X_{10}	0.0142	0.1245	0.0693
		X_{11}	0.0281	0.1065	0.0673
		X_{12}	0.0181	0.0323	0.0252
		X_{13}	0.0566	0.0358	0.0462
B_5	0.08258	X_{14}	0.0884	0.0768	0.0826

4.3 Evaluation of Guangdong Marine Engineering Equipment Industry

Perform synthesized operation on the index combining weight w_i and the dimensionless index value y_{ij} of cities according to formula (13). Obtain the comprehensive evaluation value of Guangdong marine engineering equipment industry each year, and the results are shown in Table 6.

$$z_i = \sum_{i=1}^{m} w_i y_{ij}, \quad i = 1, 2, \cdots, m; \ j = 1, 2, \cdots, n \tag{13}$$

Table 6. Annual score of Guangdong marine engineering equipment industry

Year	Score
2010	0.4136
2011	0.4177
2012	0.4579
2013	0.7973
2014	0.6807

As can be seen from the annual score of Guangdong marine engineering equipment industry of five years (Table 6), Guangdong marine engineering equipment industry shows an overall positive trend, since Guangdong "12th five-year" Plan lists shipbuilding and marine engineering as a significant new emerging industry, and invests a lot of manpower and resources, especially in 2013 with prominent improvement. But in 2014, there was a slight decline, as in mid-2014 the international crude oil prices fell sharply, the global offshore engineering equipment market suffered from a downturn, a large backlog appeared in construction equipment, the new orders almost disappeared, and Guangdong marine engineering equipment industry was also affected. Oil prices may still go downward in the future. It is hard to improve the global marine market decline significantly in the short term. Marine construction companies need to further optimize the adjustments to get through the difficult times.

4.4 Scheme Layer Evaluation of Guangdong Marine Engineering Equipment Industry

Perform synthesized operation on the index combining weight w_i and the dimensionless index value y_{ij} of cities according to formula (14). Obtain the score in each scheme layer of Guangdong marine engineering equipment industry each year, and the results are shown in Table 7.

$$\eta_{ij} = w_i y_{ij}, \quad i = 1, 2, \cdots, m; \ j = 1, 2, \cdots, n \tag{14}$$

Table 7. Annual score in scheme layer of Guangdong marine engineering equipment industry

Year	2010	2011	2012	2013	2014
X_1	0.0299	0.0448	0.0598	0.6494	0.0747
X_2	0.0237	0.0237	0.0237	0.0237	0.0356
X_3	0.0233	0.0234	0.0185	0.0474	0.0551
X_4	0.0123	0.0237	0.0206	0.0234	0.0238
X_5	0.0349	0.0379	0.0358	0.0404	0.0412
X_6	0.0197	0.0293	0.0262	0.0254	0.0293
X_7	0.0871	0.0384	0.0599	0.0853	0.0780
X_8	0.0428	0.0469	0.0510	0.0614	0.0715
X_9	0.0224	0.0224	0.0224	0.0448	0.0673
X_{10}	0.0119	0.0158	0.0198	0.0693	0.0357
X_{11}	0.0135	0.0202	0.0252	0.0673	0.0337
X_{12}	0.0252	0.0168	0.0174	0.0177	0.0161
X_{13}	0.0264	0.0330	0.0363	0.0397	0.0462
X_{14}	0.0206	0.0413	0.0413	0.0619	0.0826

1) Evaluation of Market Scale

This paper selects the market share of platform products as the indicator to measure the market scale of marine engineering equipment industry. From 2010 to 2013, the market share of marine engineering equipment platform products were increasing. But in recent years, China faces the serious situation of overcapacity in shipbuilding, so the shipbuilding industry firmly puts forward the strategic transformation and upgrading, and performs control and guidance from the policy level, in order to seek solutions to the overcapacity. A series of measures have been published in "State Council's Guidance on Solving Serious Conflicting Overcapacity", "Implementation Program of Accelerating Structural Adjustment to Promote Transformation and Upgrading of Shipbuilding Industry (2013-2015)", "Opinions on Further Optimizing Market Environment for Corporate Mergers and Restructuring", "Standards and Conditions of Shipping Industry" and "Implementation Program of Early Reject and Update of Old Ships and Single-Hull Tankers". The plan supports mergers and restructuring, encourages old energy-intensive ship shipping to exit transportation, and plays a role as a guide to accelerate technological innovation and product upgrading (Lv, 2015). By elimination, digestion, integration, transfer and other methods, the market share of Guangdong platform products decreases from 10 in 2013 to 5 in 2014, obtaining remarkable achievements.

2) Evaluation of Production Factors

This paper selects technology and labor as representatives for production factors of marine engineering equipment industry. As for technology, we choose the number of professional colleges and universities with majors of marine equipment and the number of undergraduates or graduates major in marine equipment as indicators. As for labor, we choose the number of employees in shipbuilding industry as the evaluation indicator. It can be seen from Table 7 that the scores of the three indicators increase annually. It is because Guangdong "12th five-year" vigorously develops marine technology and management personnel, invests a lot of research funding to encourage shipbuilding industry to cultivate outstanding personnel. However, from the actual index data in Table 4, we can see that Guangdong shipbuilding still suffers from job vacancy crisis. Professional personal from universities and vocational schools cannot meet the needs of production and innovation, which results in weak capacity of innovation in Guangdong shipbuilding enterprises, and the lack of professional and technical personnel. It is not conducive to the sustainable development of the shipbuilding industry in Guangdong.

3) Evaluation of Relevant Industries and Supporting Industries

For relevant industries and supporting industries, this paper selects four indicators as "steel production of ships and marine engineering", "the market scale of shipping equipment industry", "the market scale of shipbuilding industry" and "the output value of financial GDP".

Guangdong, as a traditional region for shipbuilding industries, has a good foundation, and it is one of the three shipbuilding bases in China, with great strength in shipbuilding and related equipment manufacturing industry, which can be seen from the actual indicators in Table 4. But as "steel production of ships and marine engineering", "the market scale of shipbuilding industry" and "the output value of financial GDP" rise, "the market scale of shipping equipment industry" changes little, and maintains at the value between 0.02 and 0.03. We can learn that Guangdong shipping equipment industry lags behind. Moreover, the market scale of shipping equipment industry is relatively small; the local matching rate is low; the industry output value of shipping equipment industry accounts for only 3% of the country's, far behind Shanghai, Jiangsu, Zhejiang and other provinces or cities. The existing shipping equipment products are mainly supporting marine propulsion systems for river trade vessels and marine auxiliary steel and other ancillary products. Most of the products supporting the export of ocean-going vessels and other key products also need to be imported from outside the province or abroad (Zhang & Yang, 2015).

4) Corporate Structure, Strategy and Competition Evaluation

The criterion layer selects the length of industrial chain and the degree of industrial clusters as evaluation indicators of evaluating corporate structure; the number of development projects about marine equipment technology as an evaluation indicator of corporate strategy; orders received by international enterprises, orders received by the subsidiaries of the three prominent groups and the number of shipping industrial enterprises as indicators for evaluating the competition.

From 2010 to 2013, orders received by Guangdong shipbuilding industry increased, but decreased in 2014. Related enterprises also declined in 2014, showing that the shipbuilding industry was faced with relatively serious challenges. Faced with such fierce domestic and international competition in the shipping industry, Guangdong "12th Five-Year" Plan repeatedly highlights the "development of marine engineering emerging industries", plans several key construction projects for Guangdong shipbuilding industry, makes it clear to change Guangzhou, Zhuhai and Zhongshan into three ship building and marine engineering equipment manufacturing base, and improves the related industrial chain. From the scores in Table 7, we can see that the length of industrial chain and the degree of industrial clusters continue to optimize, but experts only score between 1-3 points, within the scope of the weak. In consultation with the survey, experts explain that the industrial chain of Guangdong marine engineering equipment is short, and the industrial system is not perfect. Independent product design, raw materials, components, equipment, project contracting, engineering services, financial support, insurance, legal and technological innovation all belong to the weak link. The shipbuilding enterprises in Guangdong should give out active responds, plan their own appropriate development path, and develop in the competition.

5) Evaluation of Government

Whether it is experts' scores or the final scores, the score of the government industrial planning and policy support intensity is gradually increasing in recent years, or even close to full-mark. It can be seen that the state and Guangdong government take the marine engineering equipment industry rather seriously. In order to developing pillar industries of shipbuilding, the government issued a series of preferential policies. In October 2010, the State Council issued "On Accelerating the Development of Strategic New Industries", listing the marine engineering equipment as a strategic emerging industry. In February 2012, the Ministry of Industry, the National Development and Reform Commission, Ministry of Science, the SASAC and the State Oceanic Administration jointly published "Medium and Long Term Development Plan of Marine Engineering Equipment Manufacturing" (Lv, 2015). Guangdong "12th Five-Year" Plan pointed out that in terms of shipbuilding, we should vigorously promote cutting-edge technology of shipbuilding industries to develop high-value-added and high-tech (ultra) large-scale, special ships and marine engineering and supporting industries, focusing on the construction of Guangzhou, Zhongshan, Zhuhai, the three ships and marine engineering equipment manufacturing base. As for the marine spatial development, perform rational development and utilization of marine space of the Pearl River Delta, eastern and western region of Guangdong, promote the rational allocation of port resources, encourage the coordinated development of port clusters in the Pearl River Delta, eastern and western region of Guangdong, and improve the capacity and level of service of major ports near coasts and rivers (Li, 2011).

5. Conclusions

In 30 years of reform and opening up, Guangdong shipbuilding industry has developed rapidly. The shipbuilding industry has high correlation degree, strong leading abilities, and it is capital-intensive, technology-intensive and labor-intensive. In this sense, it is a strategic industry in need of effective development on condition that Guangdong speeds up industrial restructuring and upgrading. Guangdong has many advantages for developing shipbuilding industries, such as favorable geographical conditions, rare policy advantages and strong development momentum. But we must clearly realize that a lot of contradictions and problems have also accumulated with the rapid development of shipbuilding industry in Guangdong, mainly shown as the following three aspects: firstly, the total scale is small, and the industrial layout is not enough for optimization; secondly, the development of shipbuilding industry lags behind, and the industrial structure is irrational; thirdly, the independent innovation capability is not strong, and the professional and technical personnel is insufficient. Faced with these difficulties, Guangdong provincial government should strengthen the co-ordination of the shipbuilding industry in rational distribution, clearly regard the shipbuilding industry in Guangdong province as the major equipment manufacturing industry and export-oriented pillar industry, and effectively improve the industry status of shipbuilding industry. Guangdong shipbuilding industry should promote the restructuring and capital centralization, expand the scale of the group, and enhance international competitiveness. Major colleges and universities should establish a high-level talent development fund for cultivating the much-needed high-level talents of marine engineering and developing the key projects of marine engineering equipment. Meanwhile, the government should strengthen the political support. Not only should they provide the financial support, but also expand the financing channels of marine engineering equipment industry.

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