Evaluation of Shipbuilding Universities' Technological Innovation Comprehensive Strength Based on Entropy Weight TOPSIS Model

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Abstract—To realize the transformation from the "largest shipbuilding country" to the "first top shipbuilding nation", development of marine science and technology innovation should be the first driving force. Shipbuilding universities are an important part of the collaborative innovation consortium of modern shipbuilding & offshore manufacturing industry, and also an important source of development of science and technology innovation. We collect patent data in the field of shipbuilding & offshore manufacturing technology from shipbuilding universities, analyzed and evaluated the comprehensive strength of technology innovation based on entropy weight TOPSIS model. Finally, we put forward reasonable suggestions to solve the problems.

Keywords- Shipbuilding universities; technology innovation of shipbuilding & offshore; entropy weight TOPSIS model

1. Introduction

Universities are not only the place of cultivating innovative talents in China, but also an important source of scientific and technological innovation. Universities which set major of shipping and ocean engineering are only more than 30 in our country, and there are less than 10 universities with relatively complete subject setting and application advantages. Shipbuilding universities are an important force to promote the innovation and development of technol-

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ogy innovation of shipbuilding & offshore. Due to a small number of subjects and strong specialty characteristics, the research on technology innovation of shipbuilding & offshore manufacturing from shipbuilding universities has received less attention from scholars in the field.

Existing studies on shipbuilding universities mainly focus on the aspects of characteristic disciplinary construction, curriculum design, talent cultivation, etc. There are few studies on the comparison of the level of shipbuilding & offshore technology innovation. However, there are abundant researches on the scientific and technological innovation ability of universities by using patent data, which can be used for reference. For example, Wang et al. analyzed the number of patents, the types of patents, the number of grants and other indicators applied by Fujian Agriculture and Forestry University, and found out the advantages of its technology innovation[1]; Sun et al. analyzed the trend of patents application, patent legal status, patent maintenance years and other aspects, and discovered the patent development characteristics of China Pharmaceutical University to provide theoretical basis for the establishment of intellectual property strategy and the planning and adjustment of discipline development in the process of "double first-class" construction[2]; Liu et al. selected 31 provinces, autonomous regions and municipalities as samples to evaluate the scientific and technological innovation capability of universities in each province [3]; Liu et al. analyzed and evaluate the comprehensive ocean strength and its dynamic variation law based on China's marine economy and relevant statistical data, by using the entropy weight TOPSIS model [4]. It can be seen that patents, as one of the most direct forms of scientific and technological achievements output in universities, can reflect the level of innovation ability to a certain extent.

Therefore, this paper attempts to explore the technological innovation and development of shipbuilding universities from the perspective of patent data analysis, and make scientific evaluation of the level of shipbuilding & offshore technology innovation by using the entropy weight TOPSIS model, in order to provide certain support for the development of characteristic disciplines in shipbuilding universities.

2. Data Collection

2.1 Selection of Shipbuilding Universities In China

There are 37 universities offering shipbuilding and ocean engineering majors in China, among which Liaoning, Jiangsu, Zhejiang and Shandong have a large number. Marine engineering is a secondary subject of shipbuilding and ocean engineering, and is closely related to shipbuilding industry. Therefore, we choose 17 universities for comparison including Shanghai Jiao Tong University, Harbin Engineering University, etc., which offered both two majors above.

2.2 Patent Data Retrieval and Processing

There are large differences in comprehensive strength, school scale and resources among the universities selected. In order to make the evaluation results more targeted, the patent data retrieval strategy adopts IPC technology classification and the relation table (2018) of international patent classification and national economy industry classification to retrieve the patent data applied by the universities in the field of shipbuilding & offshore technology.

3. Entropy weight TOPSIS model and evaluation index system

3.1 Entropy Weight TOPSIS Model

Entropy is a concept in informatics used to measure uncertainty. The greater the uncertainty, the greater the entropy, and the more information it contains. According to the characteristics of entropy, the entropy value is used to measure the randomness and disorder of a certain phenomenon. In addition, entropy can also measure the variation of an index. The greater the variation, the greater the weight of comprehensive evaluation. Entropy weight method is an objective weighting evaluation method based on the measurement of entropy value, which is only related to the discreteness of the data itself, and does not depend on subjective factors.

TOPSIS method is a commonly used method in the field of multi-objective decision analysis, also known as the superior distance method. By measuring the distance between the evaluation index and the optimal solution and the worst solution, the ranking is carried out. When the evaluation index is close to the optimal solution but far away from the worst solution, the evaluation index is the relatively optimal solution. When the evaluation index is close to the worst solution but far away from the optimal solution, the opposite is true. By combining entropy weight method and TOPSIS method to build entropy weight TOPSIS model, the subjective defects can be better overcome, and the information and dynamic change rules of the data in the evaluation index can be comprehensively reflected, thus improving the utility of the information of the evaluation index. Based on this, we intends to use the entropy weight TOPSIS model to conduct the research. The calculation is as follows.

3.1.1 Data standardization

Due to the differences of measurement units and orders of magnitude of the original indicators in the index system, they cannot be directly compared with each other. In order to eliminate the dimensional influence and ensure the accuracy of the evaluation results, the original index data should be standardized first, and the normalization method is adopted.

$$x'_{ij} = \frac{x_{ij} - x_{min}}{x_{max} - x_{min}}$$

3.1.2 Weight calculation

1) Calculate the proportion p_{ij} of x_{ij}

$$p_{ij} = \frac{x'_{ij}}{\sum_{i=1}^{n} x'_{ij}} \quad (i = 1,\ 2 \ldots m;\ j = 1,\ 2 \ldots n)$$

2) Calculate the entropy value e_j of the index of column j

$$e_j = -\frac{1}{ln(m)} * \sum_{i=1}^{m} (P_{ij} * ln(P_{ij}))$$

3) Calculate the difference coefficient d_j of the index of column j

$$d_j = 1 - e_j$$

4) Calculate the weight of evaluation indicators

$$w_j = \frac{d_j}{\sum_{j=1}^{m} d_j}$$

3.1.3 Calculate the level of shipbuilding & offshore technology innovation capability

1) Calculate the weighted normalization matrix

$$Z = (Z_{ij})_{m*n} = (w_j * x_{ij})_{m*n}$$

2) Calculate the positive ideal solution and negative ideal solution of the weighted normalized matrix

$$Z_j^+ = \{maxZ_{ij} | i = 1,2,3 \dots, n\}$$
$$Z_j^- = \{minZ_{ij} | i = 1,2,3 \dots, n\}$$

3) Calculate the distance between each evaluation object and the positive and negative ideal solutions

$$D_i^+ = \sqrt{\sum_{j=1}^{n} (Z_{ij} - Z_j^+)^2}$$

$$D_i^- = \sqrt{\sum_{j=1}^{n} (Z_{ij} - Z_j^-)^2}$$

4) Calculate the proximity between the ith evaluation object and the optimal scheme

$$C_i = \frac{D_i^-}{D_i^+ + D_i^-}$$

It can be seen that $0 \leqslant C_i \leqslant 1$, and the smaller D_i^+ is, the larger C_i is, that is, the closer to the optimal scheme. In this paper, C_i is used as an index to measure the technological innovation level of each shipbuilding university.

3.2 Evaluation Index System

High quality creation and high efficiency transformation of intellectual property are the primary tasks of intellectual property work in universities. Therefore, the design of index system focuses on three aspects: the creation level, protection level and application level of technical output (patent) in universities. The selected indicators are shown in the table 1. As shown below:

Table 1 Evaluation index system

Grade 1	***Symbol***	***Grade 2***
creation level	X_1	number of patent applications
	X_2	number of invention patent applications
	X_3	average number of patent claims
	X_4	scope of patent IPC classification

Grade 1	*Symbol*	*Grade 2*
	X_5	patent maintenance time
	X_6	number of patent citations
protection level	X_7	number of valid patents
	X_8	number of valid invention patents
application level	X_9	number of patent transfers
	X_{10}	number of patent licenses

4. Empirical Results

4.1 Calculation Results

According to the index weight obtained by the entropy weight method and the standardized data, the weighted normalized matrix is obtained, and then the TOPSIS method is used to calculate the comprehensive level of shipbuilding & offshore technology innovation of each shipbuilding university, as well as the levels of each sub-index are shown in the figure 1.

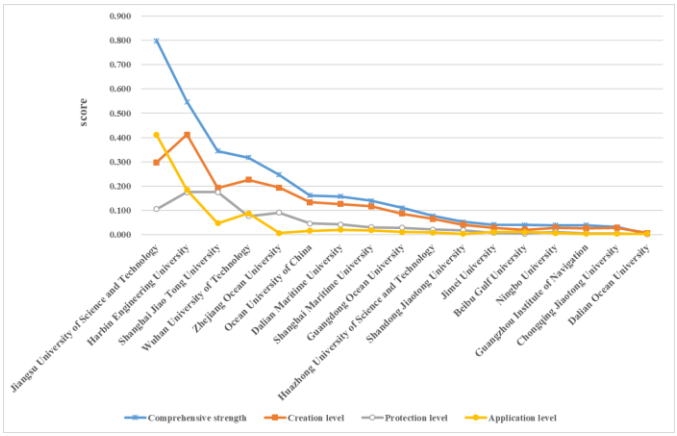

Figure 1. Results of shipbuilding & offshore technology innovation capability level of each shipbuilding university.

4.2 Comparative Conclusion

From the perspective of the comprehensive level of shipbuilding & offshore technology innovation, the top three universities are Jiangsu University of Science and Technology, Harbin Engineering University and Shanghai Jiao Tong University, with the comprehensive scores of 0.798, 0.547 and 0.344 respectively. It was followed by Wuhan University of Technology, Zhejiang Ocean University and Ocean University of China. In the field of shipbuilding and offshore manufacturing, the comprehensive strength of technology innovation of established shipbuilding universities is still among the best, which not only provides important technical support for the implementation of marine power strategy, but also provides talent training

support. Universities in the middle place are Zhejiang Ocean University, Ocean University of China, Dalian Maritime University, Shanghai Maritime University, Guangzhou Ocean University and Huazhong University of Science and Technology. These universities are also institutions of higher learning with good comprehensive strength in China, but they have different disciplinary characteristics, and the comprehensive level of technological innovation in the field of shipbuilding and offshore manufacturing is relatively weaker than the top four universities.

Specifically from the aspects of creation, protection and application, Harbin Engineering University has a great advantage in the level of creation and protection, but is relatively weaker than Jiangsu University of Science and Technology in the level of application. The comparative advantage of Jiangsu University of Science and Technology among the old ship colleges lies in the high score of technological innovation application level. Thanks to the characteristic development of the integration of industry and education, Jiangsu University of Science and Technology is closely connected with the shipbuilding industry, therefore the transformation of scientific and technological innovation achievements is relatively fast. Shanghai Jiao Tong University ranked fifth in the level of creativity, first in the level of protection and fourth in the level of application. Wuhan University of Technology ranked third in the level of creation and application, and fifth in the level of protection. The level of technological innovation of Zhejiang Ocean University is relatively unbalanced, with the level of creation and protection ranking the fourth and the level of application ranking the twelfth.

5. Inspiration and suggestions

Through the above analysis and comparison, it is found that the overall application level of innovation achievements in the field of shipbuilding and offshore manufacturing in shipbuilding universities is weak, and the transfer and authorization rate is low. Only Jiangsu University of Science and Technology, Harbin Engineering University and other four universities have relatively good application levels. Based on the development paths of these universities, the following suggestions are put forward for reference.

First, explore and establish a mechanism for mutual promotion of disciplines and industries.

In order to achieve leap-forward development of shipbuilding & offshore technology innovation, it is urgent to improve the discipline system which is in line with the future development direction of the industry. Discipline construction and industrial upgrading rely on and promote each other. Shipbuilding universities should be rooted in the characteristics of the industry, pay close attention to the "pain points" and "blocking points" of the development of the industry, strive to meet the major concerns and needs of the development of the national shipbuilding and offshore manufacturing industry, scientifically plan the layout of the discipline, and complement the weak points. Strengthen the research and analysis of the development trend of industrial technology, carry out related layout to seize the commanding heights of industrial technology competition. At the same time, universities should take the initiative to conquer the core and key technologies for industrial modernization and lead the transformation of industrial paradigm, and the profits generated by the rapid industrial development will in turn feed the construction of basic research and basic disciplines, so as to form a virtuous circle.

Second, improve the quality of patent application and the mechanism of quality control.

At present, there is a misunderstanding of "quantity over quality" in the orientation of scientific and technological achievements assessment in colleges and universities. Patent application is often linked with professional title assessment, performance assessment, project conclusion, etc., which leads to many patents not for the purpose of transfer and transformation, and thus produces a large number of "sleeping patents". Therefore, to improve the quality of patent application, we should control the source. On the one hand, we should reform and optimize the existing performance evaluation system and pay more attention to the inspection of quality indicators. On the other hand, the patent quality control and management mechanism of the whole process should be established, and the evaluation system before patent application should be strictly implemented. At the same time, universities should deeply integrate into the construction of innovation consortium, take this opportunity to establish long-term and stable cooperative relations among universities in the field of common research, learn from each other's strengths, complement each other's strengths, and jointly contribute scientific research to the technological breakthroughs of enterprises in the industry.

Third, strengthen the development of platforms and human resources for the application of scientific and technological achievements.

In accordance with the rules of the market, an operation organization for transforming scientific and technological achievements with independent management rights should be set up, which can provide professional services such as intellectual property rights, legal advice, achievement evaluation and project financing for universities. Universities are encouraged to cooperate with third-party intellectual property operation service institutions, and to provide intermediary service fees to third-party professional institutions from the profits derived from the transfer and transformation of scientific and technological achievements. Universities should integrate with local economic development, and set up industry-specific intellectual property operation centers based on local industrial layout and academic advantages of universities. Compound talents should be cultivated and introduced who are not only skilled in technology and industry, but also familiar with law, management and market, so that professional people can do professional things.

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