Evaluation on Growth Efficiency of International Competitiveness in the Shipbuilding Industry

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Abstract—**The shipbuilding industry is the international industry. Its international competitiveness attracts so much attention not only from shipyard's managers but also scholars and policymakers. On the basis of analyzing the factors affecting international competitiveness of the shipbuilding industry, the evaluation index system on international competitiveness of the shipbuilding industry is established in this paper. The growth efficiency evaluation model on the international competitiveness of the shipbuilding industry is designed as a two-stage relative evaluation model. Then an example is given to illustrate how the evaluation model works and how the results show the changes of international competitiveness in the shipbuilding industry and the implementation effect of the relative policies.**

Keywords-growth efficiency; international competitiveness; shipbuilding industry; two-stage relative evaluation model

I. INTRODUCTION

Since the 1990's, Japan, Korea, Western Europe, and China have been the top-four producers in the world shipbuilding industry. In 1993, Korean ship completions was 21.8% of the total in the world market, much lower than those in Japan, which was the largest shipbuilding nation and accounted for 43% of the total. Through the decade's development, ship completions, new orders, and orderbook in Korea increased. At the beginning of 21st century, Korea became the biggest shipbuilding country in the world.

In the meantime, the growth of Chinese economy has become an important factor that gears up the development of the global shipbuilding industry. The center of the world shipbuilding market moved to the Asia-Pacific Region, which resulted in unprecedented development of shipbuilding industry in China. The China's market share increased from 4.6% in 1999 to 14% in 2004. This exceeded the European Union in all three main indexes, ship completions, new orders, and orderbook. China became the third biggest shipbuilding country in the world. In 2007, the China's market share increased to 23%.

Though the international competitiveness of China's shipbuilding industry has increased a lot, international competitiveness of the other nations is also ascending. Therefore, the evaluation of growth efficiency in international competitiveness of the shipbuilding industry is essential for the nation to identify its position accurately and to find out the shortage in efficiency, which shows significance in the strategic development of the shipbuilding industry and decision-making to improve international competitiveness.

II. LITERATURE REVIEW

Although the concept of international competitiveness was first put forward by B.Belassa in 1964 [1], the intensive discussion and study on it was from 1970's. The attention on the issue of the international competitiveness first came from the U.S. government. In 1983, President's Commission on Industry Competitiveness was established in the United States to study industry competitiveness. It is the first professional organization studying international competitiveness established by the government [2]. Some professional research centers and private organizations were founded later and began to study this issue. In Europe, the issue of international competitiveness was firstly put forward by the World Economic Forum and a report was published in 1985, in which there were some principles, evaluating methods, and an evaluation index system on international competitiveness [3].

Scholars study international competitiveness in various relative fields including the basic concepts of international competitiveness from different levels, evaluating methods, and presentation of international competitiveness, the influences on economic development, its affecting factors, and some empirical research. Part of the literature dealing with international competitiveness focuses on the comparison between nations. For example, some scholars compared the industrial international competitiveness between the United States and Japan in 1983. Hans-Peter Frohlich pointed out that the essence of a nation's international competitiveness was the competitiveness of the enterprises within nation, on the basis of analysis on various definitions of international competitiveness. He stated that if the enterprise can meet the demands of consumers by producing attractive products at competitive prices whether in domestic or in international market, the nation will gain competitive advantages [4].

The China's research on international competitiveness began in the 1990's. In 1995, an academic group leaded by Dr. Jin Bei analyzed The international competitiveness of the textile, the shipbuilding and the other five industries. In 2003, Dr. Jin Bei, Li Peiyu and Feng Yuming put forward the theory

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and method on how to monitor the competitiveness of enterprises [5]. They applied China Business Competitiveness Index (CBCI) to assess the competitiveness of enterprises from the electricity industry, the auto manufacture industry, the food industry, the medical industry, the financial industry, the real estate industry with a different view and got valuable results.

Since 1990's, with the rapid development of China's shipbuilding industry and the boom of research on international competitiveness, the issue of international competitiveness of the shipbuilding industry attracted more attention from scholars and the industrial administration. The authoritative research in this area was the Research on International Competitiveness of the Shipbuilding Industry in China by China Ship Industrial Economy Research Center in 2000. The data came from the shipyards subordinated to the China State Shipbuilding Corporation (CSSC). Although the research had high valuable academic significance, it did not include all the shipyards in China, especially the shipyards owned by individual companies. Therefore, enterprise system and industry development policy by the government could not be included as the important affecting factors in the research. Yang Huanzhi (2001) analyzed the international competitiveness from the view of strategy. The international competitiveness of China Shipbuilding Industry Corporation (CSIC) was analyzed from five aspects: organization, strategic environment, internal resources, strategic framework, and organization restructure in the paper [6]. As a case study, Shipbuilding Industry: An industry Developed Directly to International Markets was put forward by Dr. Jin Bei. It described the developing situation and international competitiveness of shipbuilding industry comprehensively [5]. However, because of the characteristics of case, main affecting factors, the evaluation index and other key issues were not be included in this study.

III. EVALUATION INDEX SYSTEM OF INTERNATIONAL COMPETITIVENESS OF THE SHIPBUILDING INDUSTRY

International competitiveness is a comprehensive ability with which the shipbuilding industry of the nation (or region) can receive more orders, have larger market share, and acquire higher benefits by offering better products and services than other competitors in the world market.

A. The Factors Affecting International Competitiveness of the Shipbuilding Industry

International competitiveness of the shipbuilding industry is affected by many factors, including direct and indirect factors. The direct factors reflect competitive results of an industry. For the shipbuilding industry it shows as the market share of ship products and the profit level of the shipbuilders.

Price, which is a synthetic result from shipbuilding cost and the acceptable price of products in the market, is another crucial factor affecting competitiveness. It was reported that the price of the same ship type made in Japan is usually 5%-10% higher than that made in Korea, and 7%-15% higher than in China. If the market acceptable price is 100 for Japan, it is 85-93 for China. They have the same price competitiveness if shipbuilding cost in China is also 7%-15% lower than it is in Japan. If the cost is only 5% lower than it is in Japan, the price competitiveness is weaker than it is in Japan. According to this, an index called price-cost competitiveness is introduced. It can be calculated as the ratio of difference between the market acceptable price and shipbuilding cost to shipbuilding cost [7]. The higher the number is, the stronger competitiveness shows, and vice versa.

The indirect factors include technical factors, managerial factors, manufacture factors and etc.

Since the shipbuilding industry is a technique-dense industry, the technique level and innovation ability in shipbuilding becomes the core of competitiveness. Product competitiveness relies on the ability to design various advanced ships independently instead of with lower labor cost only. Technical innovation and technical management are becoming more important factors.

Management is very crucial for competitiveness in the shipbuilding industry. The production period of ship products is about ten to twelve months on average, sometimes even longer. Moreover, the shipbuilding process is more complicated than other manufactured products such as automobiles. So the influence of management on competitiveness is profound.

Labor cost is also an important factor for international competitiveness of the shipbuilding industry. Production efficiency is one of the main indexes reflecting international competitiveness. It has direct influence on the cost and estimated time of delivery. There is a gap in production efficiency between Chinese shipyards and shipyards in Japan and Korea. If the number of production efficiency is 1 for China, then it is 3.5 for Japan and 2.6 for Korea. However, the unit labor cost in Chinese shipyards is only 1/7.3 of Japan, and 1/8.4 of Korea [8]. The unit cost in Chinese shipyards is about half of Japan's, and 1/3 of Korea's. Thus there is obvious advantage in the labor for China.

Moreover, production organization is an affecting factor for international competitiveness. The shipbuilding industry is the scale-economic industry. Without the dockyard, wharf and the derrick, steel pretreatment and other large-scale equipment, ships can not be built. The index of overall labor productivity, production concentration and average yield scale can reflect these factors.

All above mentioned factors are not independent. Supplementing each other and promoting mutually, they form an organic system. As a result, all factors should be considered carefully to evaluate international competitiveness of the shipbuilding industry.

B. Establishment of the Evaluation Index System

With the consideration of factors affecting international competitiveness of the shipbuilding industry, the evaluation index system of international competitiveness of the shipbuilding industry is established as shown in Table Ⅰ.

TABLE I. EVALUATION INDEX SYSTEM ON INTERNATIONAL COMPETITIVENESS OF THE SHIPBUILDING INDUSTRY

Factors type	First-level index	Second-level index
Direct factors	Market share	Ship completions New order Orderbook
	Profit level	Ratio of total assets to industrial output value Assets liability ratio Ratio of profits to industrial cost
	Price factors	Price-cost competition index
Indirect factors	Technical factors	R&D technician input R&D fund input
	Managerial factors	Average shipbuilding cycle Ratio of domestic marine equipment
	Manufacture factors	Labor productivity Average yield scale Production concentration

IV. EVALUATION MODEL ON GROWTH EFFICIENCY OF INTERNATIONAL COMPETITIVENESS IN THE SHIPBUILDING INDUSTRY

Since the development history of the shipbuilding industry and the characteristics of the shipbuilding industry vary in different countries, the fundamental conditions of the shipbuilding industry show great differences among nations. For example, ship completions in Japan as 435 units in 2004, while 114 units were completed in Netherlands, and 3 units in Canada [9]. Therefore, the comparison on the basis of different fundamental conditions can not show the changes and the growth efficiency on the international competitiveness of the shipbuilding industry accurately.

The two-stage relative evaluation model is chosen here, which can show the changes of competitiveness in a dynamic state and reflect efficiency in measurements for improving the competitiveness by different governments, with the consideration of differences on fundamental situation of various countries.

There are two steps in the procedure, (1) the traditional methods such as Analytic Hierarchy Process (AHP) is applied to make static evaluation on international competitiveness with data in the previous period. The results can be used as a kind of measurement on the objective fundamental condition of international competitiveness is called the reference index. Then the current circumstance of international competitiveness is estimated by the same way with the present data. The result reflects the current performance of the international competitiveness of the shipbuilding industry is called the current index. The array composed of the reference index and the current index is named the index state [10].

Supposed there are n countries to be estimated, X_j is the reference index of country j, Y_j is the current index of country j, the array (X_j, Y_j) is the index state of country j.

$$T = \{(X,Y) | \sum_{j=0}^{n} \lambda_j X_j \le X, \sum_{j=0}^{n} \lambda_j Y_j \ge Y, \sum_{j=0}^{n} \lambda_j = 1, \lambda_j \ge 0, j = 0,1,2,\cdots,n\} \quad (1)$$

T is the index state possible set, while $(X_0, Y_0) = (0,0)$. And (2) on the base of the previous results, Data Envelopment Analysis (DEA) model is applied for further estimation. Taking the reference index as input, the current index as output, the boundary of index state possible set can be calculated, which is named its frontier shown as Fig.1. The subjective valid effort in improving competitiveness of the shipbuilding industry and the contribution can be judged by the deviation to the frontier. The shadow part in the Fig. 1 shows the index state possible set.

The projection of current index Y on the frontier is marked as $\overline{Y}$, which can be used as a kind of measurement of valid effort. $\eta = Y / \overline{Y} \times 100\%$ is called the two-stage relative evaluation value.

The DEA model for the two-stage relative evaluation shows as following.

$$\begin{aligned} &\max Z \\ &s.t. \quad \sum_{j=0}^{n} \lambda_j X_j \le X_{j_0} \\ &\sum_{j=0}^{n} \lambda_j Y_j \ge Z Y_{j_0} \\ &\sum_{j=0}^{n} \lambda_j = 1, \ \forall \lambda_j \ge 0 \\ &j = 0,1,2,\cdots,n \end{aligned} \quad (2)$$

While X_j is the reference index of country j, Y_j is the current index of country j, $j = 0,1,2\cdots,n$, $X_0 = Y_0 = 0$。

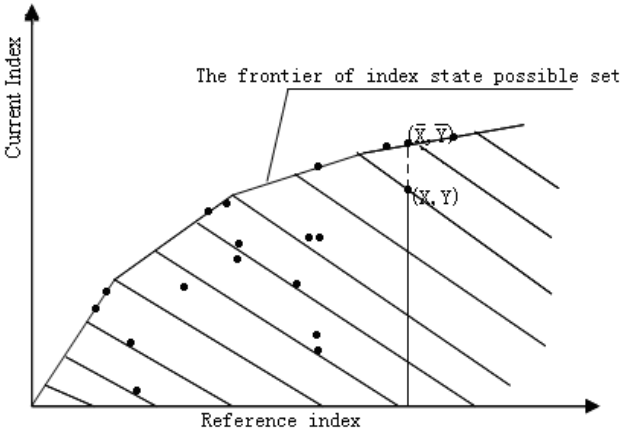

Figure 1. Index state possible set and its frontier

Suppose Z_0 is the optimal solution to linear programming (2), $\eta = Y / \overline{Y} \times 100\% = 1/ Z_0 \times 100\%$ is named the two-stage relative evaluation value of international competitiveness of the shipbuilding industry, which means the percentage of current index in what the current index can reach as high as possible under the same reference condition.

Therefore the results of the model show the change on growth efficiency of international competitiveness, which reflect the influence of valid effort to improve the competitiveness of the shipbuilding industry with the consideration of differences in objective fundamental condition.

V. AN EXAMPLE

According to procedures of the above model, the international competitiveness of the main shipbuilding countries such as Korea, Japan, and China can be evaluated. The relative data is collected and calculated first. The data on China's shipbuilding industry is mainly collected from the China Shipbuilding Statistical Yearbook 2004-2006, other statistics are compiled from the statistical data of the Organization for Economic Cooperation and Development.

The average score of results in 2003 and 2004 is taken as reference index with AHP model and the score of result in 2005 as current index. Supposed there are six countries and the scores are shown in Table Ⅱ. Taking the reference score as input, the current score as output, the growth efficiency on international competitiveness of the shipbuilding industry is calculated by the DEA model. The results are shown in Table Ⅲ.

As shown in Table Ⅱ and Table Ⅲ, the conditions in these six countries are very different. The countries with high growth efficiency have the characteristics of: a) for the countries with high reference index, if there is a little increase in current index, and even if there is a little decrease in current index as country E, the high growth efficiency appears. b) for the countries with low reference index, if there is an increase in current index, the high growth efficiency appears. c) for the countries with reference index in the effective scale range, high growth efficiency appears only when there is an rapid increase. Thus, the evaluating results depend on neither the objective fundamental condition nor the improvement of the current index. It can reflect both the difficulty and extent of improvement in industrial international competitiveness of the nation.

TABLE II. SOURCE MATERIAL OF GROWTH EFFICIENCY EVALUATION

Source material	Main shipbuilding countries					
	A	B	C	D	E	F
Reference score (year 2003-2004)	34	25	54	33	62	23
Current score (year 2005)	45	72	32	35	54	34

TABLE III. TWO-STAGE RELATIVE EVALUATING RESULTS

Country	Reference index (year 03-04)	Current index (year 05)	Frontier index	Two-stage relative evaluating results	Sequence
A	0.5484	0.6250	1.0740	0.5819	2
B	0.4032	1.0000	1.0000	1.0000	1
C	0.8710	0.4444	1.2385	0.3589	6
D	0.5323	0.4861	1.0658	0.4561	5
E	1.0000	0.7500	1.3043	0.5750	3
F	0.3710	0.4722	0.9319	0.5068	4

VI. CONCLUSION

With the rapid development of the global shipbuilding industry, the centre of the world ship market moves frequently. The international competitiveness of the different shipbuilding nations changes a lot in decades. The evaluation index system on international competitiveness of the shipbuilding industry is established. The index system includes six factors and fourteen indexes in detail. The two-stage relative evaluation model is applied to evaluate the growth efficiency of international competitiveness in the shipbuilding industry. This model can effectively eliminate the influence of objective fundamental condition, with the consideration of both difficulty and range in improvement of international competitiveness of the shipbuilding industry. The results can provide a valuable reference for evaluating changes of international competitiveness in the shipbuilding industry effectively and help identifying its position accurately from dynamic state in international competition.

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