Input-Output Analysis on the Industry Relevance of China's Shipbuilding Industry

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Abstract — China's shipbuilding industry depends on manufacturing with incomplete industry chain, small industry relevance and insufficient complementary equipment. It's very important for improving international competitiveness of China's shipbuilding industry to take opportunities in the industry chain integration process, increase the relevance between different industries and add service element into the industry. This paper analyzes the relevance of China's shipbuilding industry by using the rate of intermediate inputs, the coefficient of complete consumption and the coefficient of complete partition. It shows that individual link of China's shipbuilding industry is underdeveloped and the overall relevance isn't strong. This article also gives suggestions.

Keywords - Input-output analysis; China; Shipbuilding industry; Industry relevance; Industry chain

I. INTRODUCTION

The industry relevance of shipbuilding industry is correlated with the level of manufacturing. Generally speaking, the higher the relevance, the more it can promote overall economic activities. As a typical integrated processing and assembly industry, shipbuilding industry is one of the most integrated industries. Shipbuilding industry has direct consumption from 97 industries out of all 116 industries of national economy, and the share is about 84% [1, 2]. With the development of one country's economy, shipbuilding industry can enhance its technical and economic relationship with service sector, to provide not only a single product, but also a series of services, such as financial and insurance service and R&D and so on. In the 21st century, China's shipbuilding industry has gained rapid growth and the overall production has quadrupled [3]. For the first time, China's shipbuilding industry ranks the first all over the world in terms of three indexes (Ship completion, new orders, hand-held orders) in 2010. However, China's shipbuilding industry's rapid development has not contributed much to national economy. This article focuses on the current situation of industry relevance of China's shipbuilding industry and investigates its impact on the national economy. There is no previous studies on whether China should develop the shipbuilding industry as a pillar industry, and this paper fills this gap [4].

Some literature focuses on the relevance of shipbuilding industry. Komiya (1984), and Goff et al. (2010) investigate the industry relevance of Japanese shipbuilding industry, and point out the complementary equipment, human resource and data analysis as well as executive capability are the key factors for the success of the industry. Surer Dived, Pepin Mafiosi and Erich (2004) study the Korean shipbuilding industry and point out that the development of the shipbuilding industry cannot succeed without restructuring and government funding support, as well as good steel reserve management [5, 6]. Research on the China's shipbuilding industry of scholars mainly focuses on the promotion of competitiveness and the cluster development of shipbuilding industry, while the study of the industry relevance of shipbuilding almost does not exist [7]. Zhi (2011), Ma (2012), Cai (2013) and other papers use the input-output table to analyze the industrial relevance of China's automobile industry and manufacturing industry, which can be insights for us to study the shipbuilding industry's relevance [8, 9, 10].

This paper uses input-output analysis to calculate China's shipbuilding industry's intermediate investment rate, complete consumption coefficient and the total distribution coefficient. It shows the economic and technological connections of China's shipbuilding industry in the industrial chain with its upstream and downstream industries, and puts forward the corresponding countermeasures for improvement.

II. THE STRUCTURE OF SHIPBUILDING INDUSTRY CHAIN AND CURRENT SITUATIONS OF INDUSTRY RELEVANCE OF CHINA'S SHIPBUILDING INDUSTRY

A. The Structure of Shipbuilding Industry

The shipbuilding is characterized by its long industry chain, high industry relevance and its phenomenal driving effects on the development of the upstream and downstream industries. In most cases, building a ship has much to do with hundreds of supporting enterprises, there is a saying that "once a ship is being launched, numerous industries related would be beneficial". There are many upstream industries which are closely related with shipbuilding industry, such as iron and steel, mechanics, chemical, petroleum and natural gas exploration, electronics and communication, as well as many service industries, such as shipping, marine development, warehousing, wholesale and retail, catering accommodation, finance and insurance, scientific research, etc., altogether more than 360 industries

[11].

Shipbuilding has the feature of customized manufacturing, so the shipbuilding industry has a long upstream whereas short downstream chain. The shipyard builds the ship according to the customer's requirement. Firstly, the shipyard would purchase the raw materials, facilities and outfitting from upstream accessory factories. After manufacturing and assembling step by step, the ship would be undergoing a trial trip and needs to pass it. Only after these procedures can the ship be delivered to the ship owner in the end. From the above factors that forming the industrial chain we can come to know that, generally, the manufacturers consist of suppliers, producers and distributors. But actually the shipbuilding industry doesn't need distributors at all for it is a kind of ordering production [12]. In this paper, all the nonproductive institutions are classified as services, e.g., the intermediaries, research and development institutions and regulation institutions. Accordingly, the shipbuilding industrial chain is comprised of four parts: the suppliers, producers, services and customers.

B. Current Situations of Industry Relevance of China's Shipbuilding Industry

While China's shipbuilding industry is developing at a fast speed, it also faces many problems such as the extensive mode of production, the incomplete industrial chain, unbalanced economic structure, excess capacity and so on. China's shipbuilding industry is still far away from the advanced countries in terms of innovation, complementary industries and consumption of energy and resources [13].

(1) Relying mainly on the processing trade

Judging from the upstream industries, the steel plates account for more than 60% of the shipbuilding cost, which explains why the price of steel exerts a tremendous influence on the profits of shipyard. And China steel plates come mainly from imports, which means the price of steel depends on the price of iron ore in countries such as Australia, Brazil and India. This results in the high price volatility of the shipbuilding cost. As for the downstream industry, China's shipbuilding industry is seated in the bottom of "smiling curve" of the multinational companies global value chain by the processing trade. It mainly deals with manufacturing and processing assembly the hull, but not good at the high value-added sectors, e.g., design and development, order handling, market development and brand sales. And this leads to serious unequal industrial chain of profit distribution with foreign traders. This way of production gives rise to the poor persistence and instability of the shipbuilding industry. It is due to their weak bargaining power that they cannot remove the increasingly cost stress and have little to do with the decreasing profit space over time [14].

(2) Small cluster and size effect, whereas notable industrial chain fault phenomenon

There are more than 3000 shipbuilding companies in China, but the capacity is far lower than Japan and Korea. Chinese companies are difficult to realize the scale economy effect as they are scattered out. The area where the shipbuilding industry located is not large enough for the ship equipment industry to cluster. Besides, the technical capacity is too weak to satisfy the need of shipbuilding base construction. And most of the supporting equipment in the base are not open enough. They can only meet the need of several leading shipbuilding companies, and the external companies find it is hard to purchase equipment from them. It is the imperfect industrial chain that causes a loose relationship between upstream and downstream industries. On the one hand, most shipbuilding industries have to rely on the imported ship equipment with huge assemble production cost, and some companies even got the date of delivery postponed because of the untimely supply of major complementary products. On the other hand, the shipbuilding industry didn't have many cooperations with the main engine plants and the key fittings factories in technological and new products development, which imposes restrictions on the expansion of the scale of the shipbuilding industry. As the big supporting companies expand their business mainly by own funding, they have the problem of funding constraints. Gradually, they couldn't further their reformation and improve their ability of self-development and innovation. Even worse, other private supporting companies are basically left on their own.

(3) Insufficient science and technology ability and weak leading role of assembly manufacturing in supporting industries

By far, the market of low value-added ship products starts to saturate. However, China's shipbuilding industry is not adept at research and development, designing and building, and is weak in high end production. Moreover, compared with the advanced shipbuilding countries, such as Japan, Korea and Germany, China is inferior to them in the level of technology and equipment and product development capabilities. For example, China's shipbuilding industry usually finish the design work by cooperating with other foreign countries or just import it directly. Even though the ships are made by China, sometimes they have many drawbacks as well. They may have poor capabilities of designing, have longer design cycles, and the ship models are not standardized, which seriously hinder the further development of the industry. And the supporting industry is underdeveloped. The share of domestic production is relatively low. Nowadays, China's domestically made ship equipment is fewer than 40%, yet Japan reach to more than 95% to 98%. China's high, precise and top-notch ship equipment products depend heavily on import, and the small profit space is also being eroded by the expensive imported facilities. All of these contribute to weaken the shipbuilding industry's role in driving other industries such as mechanical and electrical industries.

Due to the imperfect industrial chain and weak industry relevance, China's shipbuilding industry fails to play its role in driving its supporting industries.

III. INPUT-OUTPUT ANALYSIS ON CHINA SHIPBUILDING INDUSTRY RELEVANCE

A. Index and Data

Input-output analysis is an important economic quantitative analysis method. It mainly analyzes technical economic relations between various parts of economic system and predicts the change of balanced relationship of national economy. Direct consumption coefficient, complete consuming coefficient and total demand coefficient are the three most important factors of other coefficients in the input-output analysis. In addition, it also includes the middle direct distribution coefficient, completely distributive coefficient, input rate, the intermediate demand rate, influence coefficient, induction coefficient etc.

This paper uses input-output analysis method to analyze data in 1997, 2002 and 2007 to calculate intermediate input rate, complete consumption coefficient and the total distribution coefficient. This paper reveals China's shipbuilding Industry's demand coefficient and economic technology connection degree between its upstream and downstream industry chain.

(1) Index selection

Input-output model uses input-output table to reflect the mutual relations and balanced relationship of various sectors of national economy systematically, from production to final usage from the view of total amount and structure.

$$\begin{cases} \sum_{j=1}^{n} x_{ij} + y_j = x_i \\ \sum_{i=1}^{n} x_{ij} + g_j = x_j \qquad (i = 1,2,\ldots\ldots,n) \\ \sum_{i=1}^{n} x_i = \sum_{j=1}^{n} x_j \end{cases} \tag{1}$$

In the above equations, x_{ij} represents the amount of the consumption of product i in the production of j. x_i denotes the amount of total production of product i and y_i denotes the amount of product i finally used. g_j indicates that the added value of sector j. In the relative analysis of input-output tables, it also relates not only to backward direct consumption coefficient and total consumption coefficient, but also to forward direct distribution coefficient and total distribution coefficient. For the reason that total consumption coefficient and total distribution coefficient both have taken direct and indirect factors into consideration, they can reflect essential technical economic relations between different industries. Total consumption coefficient and total distribution coefficient can be expressed as:

$$\begin{aligned} b_{ij} &= a_{ij} + \sum_{i=1}^{n} b_{ik} a_{kj} \\ l_{ij} &= r_{ij} + \sum_{k=1}^{n} l_{ik} r_{kj} \end{aligned} \tag{2}$$

Among them, b_{ij} represents the total consumption coefficient of industry j to industry i; a_{ij} denotes the direct consumption coefficient of industry j to industry i; b_{ik} indicates the total consumption coefficient of other industries k to industry i; a_{kj} indicates the direct distribution coefficient of industry j to other industries k; l_{ij} indicates the direct distribution coefficient of department i to department j; l_{ik} indicates the total distribution coefficient of industry i to other industries k; r_{kj} indicates the direct distribution coefficient of industry j to other industries k.

This paper mainly uses intermediate input rate, complete consumption coefficient and the total distribution coefficient.

(2) Source of data

This paper's uses Input-output tables of 124 sectors in 1997, 123 in 2002, 135 in 2007.It mainly analyzes intermediate input rate, complete consumption coefficient and the total distribution.

B. Intermediate Input Rate and Calculation Results

(1) Intermediate input rate

Intermediate input rate indicates the proportion of transformation value of goods and services in production process. High intermediate input rate means that the consumption of the industry is high. Low intermediate input rate means that the input rate and the dependence on upstream industry is low. As we all know, added value rate plus intermediate input rate equal to 1, so if intermediate input rate of one industry is high, its added value rate would be low. Intermediate input rate is the ratio of intermediate input and total input of one industry. From another view, intermediate input rate is the sum of total direct distribution coefficients of one industry. So it can reflects the direct dependency relationship of one industry on the others. By analyzing and calculating of intermediate input rate, we can find the amount of product change of upstream products that are driven by one industry.

The calculation formula of intermediate input rate:

$$L_j = \frac{\sum_{i=1}^{n} X_{ij}}{X_j} \qquad (j = 1,2,\ldots\ldots,n) \tag{3}$$

(2) Calculation of intermediate input rate of China's shipbuilding Industry

This paper calculates and analyzes the intermediate input rate of downstream industries of China shipbuilding Industry. The result shows in Table I.

According to total inputs of downstream industries, this paper calculates the proportion of investment of other industries in shipbuilding industry. The result shows in

Table II.

TABLE I. TNTERMEDIATE INPUT RATE OF CHINA SHIPBUILDING INDUSTRY (10 THOUSAND CHINESE YUAN)

Industries	1997	2002	2007
Transportation and warehousing industry	27355	96644	266106
Wholesale and retail industry	88153	250859	814801
Catering accommodation industry	27491	18833	120795
Finance and insurance industry	39905	110518	539071
Information transmission, computer services, software industry	—	69811	39823
Education	5257	7706	19030
Scientific research undertakings	218	792	100467
Comprehensive technical service industry	9918	19011	43168
Water conservancy, environment, public facilities management industry	—	19	9355
Other services	4344	28995	51898
Total	67260	295825	2004514

TABLE II. THE PROPORTION OF INVESTMENT OF OTHER INDUSTRIES IN SHIPBUILDING INDUSTRY (%)

Industries	1997	2002	2007
Transportation and warehousing industry	0.769	1.4783	0.9276
Wholesale and retail industry	2.4782	3.8373	2.84
Catering accommodation industry	0.7728	0.2881	0.421
Finance and insurance industry	1.1218	1.6906	1.8789
Information transmission, computer services, software industry	—	1.0679	0.1388
Education	1.472	0.1179	0.0663
Scientific research undertakings	0.0061	0.0121	0.3502
Comprehensive technical service industry	0.2788	0.291	0.1505
Water conservancy, environment, public facilities management industry	—	0.0003	0.0326
Other services	0.1221	0.4435	0.1809
Total	5.6967	9.2268	6.9867

We can know from table I and table II that: three are 8 industries closely related to China's shipbuilding Industry and we can divide them into two groups according to their proportions and orders of input into China's shipbuilding Industry. Wholesale and retail trade, finance and insurance, transportation and warehousing industries, together with integrated technical services, belong to the first group, for that their proportions are big and they rank high. The proportions of total input of these industries into China's shipbuilding Industry are 76.7%, 75.9%, 80.8% in 1997, 2002 and 2007. It shows that wholesale and retail trade, finance and insurance, transportation and warehousing industries and comprehensive technical service industry have high consumption on China's shipbuilding industry and that China's shipbuilding industry has high degree of dependence on these industries. Catering accommodation, computer and related industry, education and scientific research undertakings belong to the second group, for that their proportions are small and they rank low. The proportions of total input of these industries into China's shipbuilding Industry are 16.3%, 16.1%, 14% in 1997, 2002 and 2007. Catering accommodation industry, computer and related industries rank higher than education and scientific research undertakings in the second group. It shows that education and scientific research undertakings have low consumption on China's shipbuilding industry and that China's shipbuilding industry has low degree of dependence on these industries.

(3) Results Analysis

Combined Table I and Table II with Figure 1 and Figure 2 below, this paper tries to state the changes in the internal structure of China' shipbuilding industry by classifying and comparing investment growth speed of various industries and studying the orders and proportions of other industries in shipbuilding industry. The result is as follows: (1) The transportation and warehousing industry became smaller grew slowly after a fast growth. Based on the year 1997, the growth rate up to 2002 has been 253.7%.

In 2007 the growth rate became smaller and the proportion rate of China's shipbuilding industry decreased and its position was relatively stable, increasing from the fourth place in 1997 to the third place in 2002 and became stable thereafter. (2) The growth rate of wholesale and retail industry in the three years changed little. It kept the first place, but its proportion in 2007 decreased a little.(3) The finance and insurance industry grew rapidly in 2007, compared with the data of 2002 the growth rate was as high

as 387.8%. In the three years it has been in the second place, and the its proportion of investment in the shipbuilding industry increased year by year. (4) Investment of comprehensive technical service industry in China's shipbuilding industry tended to be stable. Its growth rate showed a stable trend while the ranking decreased year by year. (5) The investment of catering accommodation industry decreased in 2002 and rose slightly in 2007.

Its proportion in shipbuilding industry in 2002 started to fall, ranking from 1997 third down to seventh in 2002, and then rose to fifth in 2007. (6) Education in 2002 almost had no growth. Compared with the data of 2002, the growth rate was as high as 100% in 2007, while the proportion of investment of education in the shipbuilding industry and its position decreased year by year. It ranked 6th in 1997, 8th in 2002 and 9th in 2007. (7) Scientific industry had rapid growth in 2007, a growth rate of 12585.2%, but because of its small base, the proportion is still small. It ranked low in 1997 and 2002 and in 2007 in the fourth place. (8) The data of computer and related industries were not in statistics in 1997 and in 2002, and it invested 698.11 million yuan, but in 2007 its investment dropped to 398.23 million yuan. The data of water conservancy, environment and public facilities show no data in 1997. In 2002 it just invested 190 thousand yuan, but in 2007 the investment had increased to 93.55 million yuan.

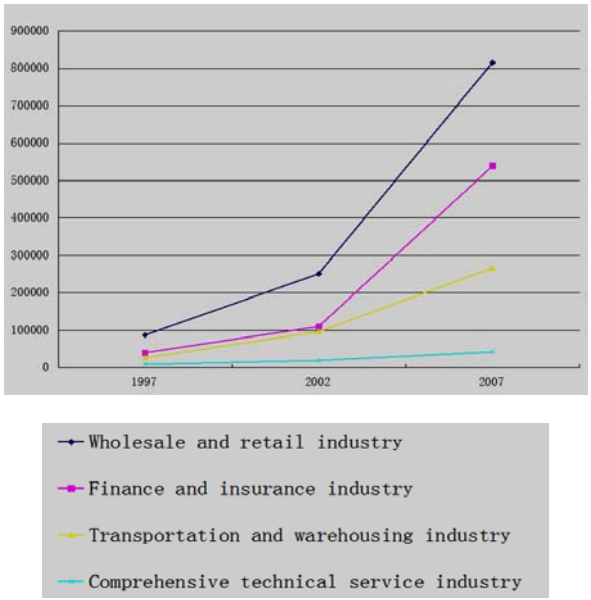

Fig.1 Line Chart of Intermediate Input of the Main Industries

In summary, we can know that: (1) Growth of all industries in 2002 was big except education and comprehensive technical service industry; growth of some traditional big industries was big in 2007, while growth of education, scientific and computer service industry was small in 2007. (2) Because of growth rates of different industrial investments are different, their proportions will also change, education proportion decreased rapidly, but the rankings of industries in shipbuilding industry remained relatively stable.

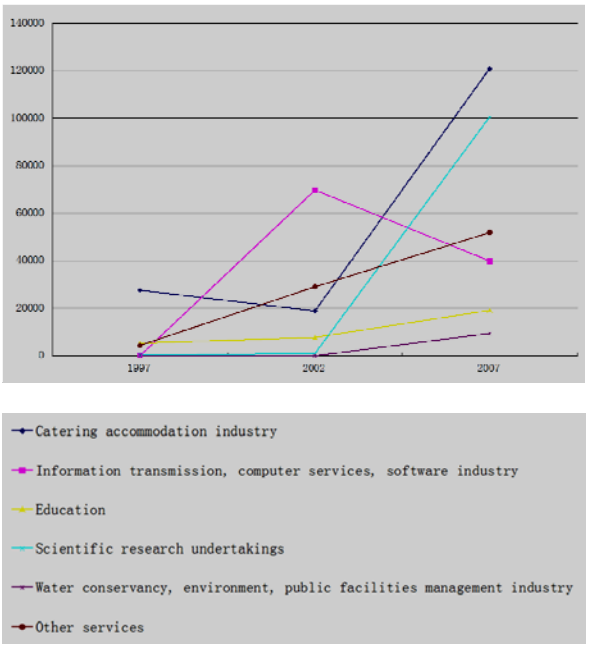

Fig..2 Line Chart of Intermediate Input of Other Industries

C. Complete Consumption Coefficient and the Calculation Results

(1) Complete consumption coefficient

Complete consumption coefficient fully reflect dependencies between industries, which includes not only the direct consumption, but also indirect consumption, which is consumed by other products in the sector of the product; indirect consumption can be further divided into primary indirect consumption and secondary indirect consumption. Direct consumption coefficient and complete consumption can be combined to analyze the dependence between a sector and other sectors. Complete consumption coefficient need to be based on direct consumption coefficient and use matrix methods. If total consumption coefficient b_{ij} is big, it means that the backward correlation between industry j and industry i is big. It also can say the development of the industry has larger role in pulling another industry.

Complete consumption coefficient calculation formula is:

$$B = A + A2 + A3 + \ldots = (I - A) - 1 - I \qquad (4)$$

Here B is complete consumption coefficient matrix, and b_{ij} is complete consumption coefficient. The meaning of b_{ij} is the complete consumption quantity of i sector's intermediate product if we want to have final product in j sector.

(2) The calculate of China's shipbuilding industry upstream industry's complete consumption coefficient

When we calculate the complete consumption coefficient, we considered the upstream and downstream of China's shipbuilding industry. The complete consumption coefficient of the upstream industry is calculated in Table III.

TABLE III. THE COMPLETE CONSUMPTION COEFFICIENT OF THE SHIPBUILDING INDUSTRY'S UPSTREAM INDUSTRIES FROM 1997 TO 2007 (SORT BY AVERAGE)

Rank	Name	1997	2002	2007	Average
1	Steel rolling processing industry	0.220438	0.243462	0.2525	0.2388
2	Other common equipment industry	0.158644	0.168685	0.1121	0.146477
3	The production and supply of electricity and heat	0.067505	0.087121	0.144498	0.099708
4	Boiler and prime mover manufacturing	0.108159	0.081862	0.084572	0.091531
5	Petroleum and nuclear fuel processing industry	0.043112	0.051385	0.067866	0.054121
6	Steel industry	0.031921	0.066108	0.061844	0.053291
7	Non-ferrous metal smelting and alloy manufacturing	0.047862	0.042057	0.068987	0.052969
8	Other electrical machinery and equipment manufacturing	0.06901	0.065085	0.017131	0.050409
9	Oil and gas industry	0.031422	0.040447	0.059975	0.043948
10	Other special equipment manufacturing	0.061619	0.052233	0.003992	0.039282
11	Paint, ink, pigment and similar products manufacturing	0.020701	0.045501	0.027926	0.031376

In the ship manufacturing industry chain, the major upstream industry which has a strong correlation with the shipbuilding includes steel rolling processing industry, other common equipment industry, the industry which product and supply electricity and heat, boiler and prime mover manufacturing, petroleum and nuclear fuel processing industry, steel industry, non-ferrous metal smelting and alloy manufacturing, other electrical machinery and equipment manufacturing, oil and gas industry, other special equipment manufacturing, paint, ink, pigment and similar products manufacturing.

(3) Calculation of China's shipbuilding industry downstream industries' complete consumption coefficient

The complete consumption coefficient of the downstream industries is calculated in Table IV.

This paper listed 10 downstream industries in shipbuilding industrial chain, including transportation and warehousing industry, wholesale and retail trade, catering accommodation industry, finance and insurance industry, information transmission, computer services and software industry, education, scientific research institutions, comprehensive technical services, water resources and environment and public facilities management industry, and service industry.

TABLE IV. THE COMPLETE CONSUMPTION COEFFICIENT OF THE SHIPBUILDING INDUSTRY'S DOWNSTREAM INDUSTRIES FROM 1997 TO 2007 (SORT BY AVERAGE)

Industries	1997	2002	2007
Transportation and warehousing industry	0.042929	0.086755	0.064178
Wholesale and retail industry	0.095144	0.11401	0.07195
Catering accommodation industry	0.020673	0.021122	0.022806
Finance and insurance industry	0.043557	0.057129	0.060677
Information transmission, computer services, software industry	—	0.033968	0.013875
Education	0.003857	0.003913	0.002566
Scientific research undertakings	0.000847	0.007148	0.011019
Comprehensive technical service industry	0.005664	0.001217	0.003536
Water conservancy, environment, public facilities management industry	—	0.001351	0.001751
Other services	0.01569	0.017287	0.011055

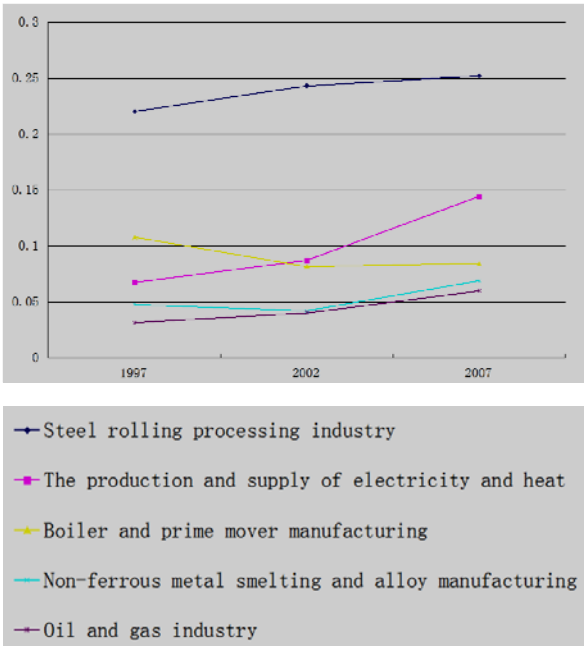

Fig.3 Line Chart of Total Consumption Coefficient of the Main Upstream Industries

(4) Results Analysis

According to table III, figure 3 and figure 4, the relevance degree of steel rolling industry with shipbuilding industry development is the largest. The average total consumption coefficient of China's steel rolling industry on shipbuilding industry is 0.23879984 from 1997 to 2007. It means that if shipbuilding industry spends 1 yuan, 0.23879984 yuan will be spent on product of steel rolling. The average total consumption coefficient of other common equipment industry on shipbuilding industry is 0.1464765, ranking second. By contrast, average total consumption coefficients of petroleum and natural gas exploitation, paint, ink, paints and similar products manufacturing are 0.04394781 and 0.03137604, which is not high. It shows that demand-driven effect of China's shipbuilding industry of the two industry is low.

Total consumption coefficients of other industries of China's shipbuilding industry rose considerably in addition to scientific research undertakings in 2002. It shows that the relation between China's shipbuilding industry and other industries strengthened. Total consumption coefficients of transportation and warehousing industry, the wholesale and retail industry, computer industry and other related services of China's shipbuilding industry decreased obviously in 2007. It shows that the economic and technical relation between China's shipbuilding industry and these industries weakened. Total consumption coefficients of water conservancy, environment, public facilities management industry, scientific research institutions, catering accommodation industry, finance and insurance industry of China's shipbuilding industry rose slowly in 2007. It shows that the economic and technical relation between China's shipbuilding industry and these industries strengthened. The total consumption coefficient of education of China's shipbuilding industry dropped slowly in 2007. It shows that the economic and technical relation between China's shipbuilding industry and education weakened relatively.

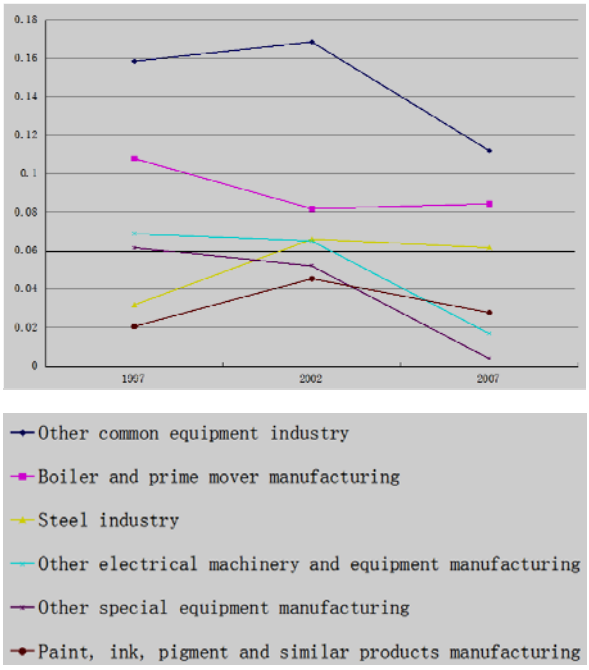

Fig.4 Line Chart of Total Consumption Coefficient of Other Upstream Industries

D Total Distributive Coefficient and the Result Analysis

(1) Total distributive coefficient

The total distributive coefficient can reflects where a product goes directly or indirectly. It means the sum of direct distributive coefficient and indirect distributive coefficient in economy. We can analyze where products of one industry goes, taking direct distributive coefficient and indirect distributive coefficient into consideration. Total distributive coefficient can be gotten from direct distributive coefficient, using matrix method. The bigger total distributive coefficient h_{ij} is, the more obvious the supply-driven effect is. The formula for complete distributive coefficient is:

$$H = R + RH \tag{5}$$

(1) Calculation of data of total distributive coefficient of downstream industries of China shipbuilding industry

This paper mainly calculates coefficients of downstream industries of China's shipbuilding industry when analyzing total distributive coefficient and the result shows in Table V.

TABLE V. TOTAL DISTRIBUTIVE COEFFICIENTS OF DOWNSTREAM INDUSTRIES OF CHINA'S SHIPBUILDING INDUSTRY FROM 1997-2007

Industries	1997	2002	2007	Average
Transportation and warehousing industry	0.112223	0.459418	0.006788	0.19281
Wholesale and retail industry	0.017498	0.039282	0.022319	0.026366
Catering accommodation industry	0.024603	0.043391	0.01796	0.028652
Finance and insurance industry	0.005623	0.007323	0.002648	0.005198
Information transmission, computer services, software industry	—	0.008997	0.002194	—
Education	0.00703	0.010751	0.003571	0.007118
Scientific research undertakings	0.000644	0.00159	0.005765	0.002666
Comprehensive technical service industry	0.001169	0.00159	0.005765	0.002841
Water conservancy, environment, public facilities management industry	—	0.003419	0.001556	—
Other services	0.004874	—	0.001805	—

(2) Results Analysis

According to Table V, average total distributive coefficients of transportation and warehousing industry, catering accommodation industry and the wholesale and retail industry were the biggest from 1997-2007, reaching 0.1928097, 0.02865158 and 0.02636621. It means that the demand of transportation of shipbuilding industry is the biggest and that the quick development of warehousing industry, catering accommodation industry and the wholesale and retail industry rely on the progress of shipbuilding industry. The pull of demand of finance and insurance industry is mainly produced by bank loans and all kinds of insurance, ship needed in the business process of shipbuilding enterprises. By contrast, we can find that the pull effect of shipbuilding industry on finance and insurance industry is obvious. The average total distributive coefficient of finance and insurance industry was 0.005198109. The average total distributive coefficients of scientific research and comprehensive technical services were the smallest, reaching 0.00266615 and 0.002841237. It shows that the driving effect of shipbuilding industry on these two industries is little and that science and technology innovation ability of shipbuilding industry is inadequate and the input of science research is low.

With the development of a country's economy, shipbuilding industry will continue to strengthen its economic and technological links with service areas. It will be a range of services, such as financial insurance, science research, rather than a single product. However, China's shipbuilding industry is still mainly based on manufacturing. To seize the opportunities the during the industry chain integration process, strengthen the related industries, and achieve the conversion from products to the complex of products and services are very important for improving international competitiveness of China's shipbuilding industry.

IV. STRATEGIES FOR CHINA'S SHIPBUILDING INDUSTRY TO STRENTHEN INDUSTRIAL RELEVANCE

A. Break From Single Point, Strengthen Industrial Relevance and Strengthen Industrial Chain

According to the analysis, there is little relation between scientific research and China's shipbuilding industry, and the features of demand-driven is weak. Therefore we should improve it from the following aspects. Firstly, we should raise the level of research and development in the process of development of China's shipbuilding industry chain. Meanwhile, it's also important to strengthen shipbuilding hardware facilities and improve shipbuilding technology. Secondly, increasing research input to the shipbuilding industry, encouraging innovation and increasing the intensity of patent protection are also necessary. Thirdly, we should take advantage of education and increase the intensity of training innovative talent. Lastly, utilize the way of incremental innovation and break through foreign technical barriers so that local production can replace imports gradually and technological catch-up can be strengthened in the key areas.

Currently, there are three severe problems in the process of development of China's shipbuilding industry chain: industry chain is imperfect, industrial fault is obvious, and industry correlation degree is not high. So shipbuilding enterprises should cooperate more with their upstream and downstream industries and increase technology investment around the restrictions to break the "short board" constraint. Meanwhile, in order to achieve a relatively balanced development in all sectors of the industry chain, it's necessary to change the single trade mode of tradition shipbuilding industry chain and set up the interactive innovation network mode of innovation and competition. In addition, shipbuilding industry also need to develop cooperatively with service industry so that they can be competitive on the basis of a system of integrated

manufacturing services from products to logistics and credit financing.

B. Improve the Level of Matching Equipment and Achieve a Breakthrough From the Spot to the Line

In the shipbuilding industry chain, matching equipment companies play an important role. However, the rate for domestic production of matching equipment in China is not high, thus industry chain fault occurs and industry relevance is decreased. Therefore, in the process of optimizing shipbuilding industry chain and strengthening industry relevance, we should push forward the development of shipbuilding matching equipment industry and shipbuilding industry by the localization of matching equipment such as the policy of tax, land and loan, to increase the appropriate allocation of shipbuilding resource and conduct regional management nationwide. Simultaneously, matching equipment companies can enhance their strength from the following aspects. On one hand, they can strengthen the cooperation with node enterprises of supply chain to realize the win-win situation; on the other hand, they can strengthen the cooperation with foreign advanced enterprises. Moreover, an after-sale service network of matching equipment companies which is based on supply chain is also needed so that a complete one-stop service system can be achieved.

Furthermore, services supporting industries should be developed and technical economy relation between shipbuilding and service industry should be taken seriously because of the low industry relevance.

C. Strengthen the Construction of Industrial Clusters and Achieve a Breakthrough From the Line to the Surface

Industrial clusters can bring shared advantages of information, knowledge and labor. Given that the scale advantage of shipbuilding industry is not obvious and industrial faults do exist, the scope of centralized management should be expanded and the degree of industry intensive should be enhanced as well. The scale advantages of large enterprises should be centralized and the development of small enterprises should be driven. In terms of government, special departments should be established to manage the shipbuilding industry uniformly. Moreover, the just-in-time centralized delivery mode is a way to reduce the storage cost and risk. Meanwhile, we should pay attention to shipbuilding infrastructure construction and form shipbuilding bases. Large enterprises need to cooperate more with their upstream and downstream industries to strengthen the industrial chain integration.

D. Extend to Higher Value-added Links and Achieve a Breakthrough From the Surface to the Net

In the trend of economic globalization, the international division of labor is increasingly apparent. Developed countries are more inclined to invest directly and form advantages of their products by the cheap labor and abundant resource of developing countries. So far, the shipbuilding industry in China manufacture low-end products mainly, which is still in the low-end links of international shipbuilding industry chain. Hence, China should integrate into the system of international division of labor. China should also try to cultivate learning ability, technology research ability and organizational management of the enterprise by the cooperation with developed countries. In this way, the shipbuilding industry in China could gradually extend to high-end links such as design and service. Ultimately, the international competitiveness can be improved along with the change of the surface to the net.

CONFLICT OF INTEREST

The authors confirm that this article content has no conflicts of interest.

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