Dynamic Comparative Advantage and Technology Innovation of China's Shipbuilding Industry

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Abstract: Since 1990s, production and international trade of China's shipbuilding industry has soared shapely. Three indicators in the shipbuilding industry of China surpassed those of Korea completely in 2010, which means that China has become the world's largest shipbuilding country. Meanwhile, China exports 28364 million dollars, ranked second in the world. Under this background, this paper first analyzes revealed comparative advantage of Chinese export ships. Then give an empirical research of dynamic comparative advantage of China's shipbuilding through Markov random process. Finally, present concrete proposals for improvement of comparative advantage of China's shipbuilding.
Key words: Shipbuilding industry; Dynamic comparative advantage; Technology innovation; RCAS indexes

1 Introduction

Various research methods are used in special analysis of Chinese dynamic comparative advantage by scholars in the world. However, there are few studies about dynamic comparative advantage and interests of China's shipbuilding. Mostly, those studies focus on the development of technology of shipbuilding industry.

China's shipbuilding industry can gain constantly dynamic comparative advantage through strengthening technical innovation in order to get technical advantage. The strength of driving technical innovation is made up of talents and institutional environment that is beneficial to the development of shipbuilding. Introduction of talents devotes energy to nurturing technical innovation of shipbuilding industry. There are two meanings of talents' introduction. First, strengthen the introduction of foreign shipbuilding talents while cultivating professional staffs by domestic colleges and universities and institutes of ship. Until 2008, there are 21 colleges and universities which establish an undergraduate major in shipping and marine project. Those colleges and universities are divided into two groups by their enrolment scale of each year. One group enrolls more than 100 students per year, the other group is just the opposite. Foreign talents can be attracted by China during academic activities, like, exchanges of scholars and specialists, sponsoring symposiums and sending abroad students mutually, which are supposed to enhance scientific and technical communication between Chinese colleges and universities and institutes and those of other countries. Second, no matter foreign marine engineers or native professional talents, Chinese shipbuilding enterprises should recruit talents who are calculated for their conditions. In order to make sure of demands of market, market research could be done before recruiting able people. According to the result of the research, recruiting talents meets the special needs of able people of the enterprises effectively.

Institutional environment is beneficial to technical innovation and introduction of talents. In take-off stage of shipbuilding, system of planning shipbuilding is launched by Government of South Korea. The Ship-owners, whose under construction ships are numbered among shipbuilding of native plan, can acquire shipbuilding loans on favorable terms. In growing stage, government not only follows parts of support policies used in take-off stage, actually, even enhancing the efforts of implementation, but also pluses some new support polices that aim at developing shipbuilding industry fast and catering for the situation of international markets. Enlarging shipbuilding scale and technology show that shipbuilding industry of China is in growing stage. In order to improve shipbuilding industry and terms of ship export, more and more means of financing and law should be adopted, especially those included in WTO Rules and international shipbuilding agreement[2].

2 The Analysis of Revealed Comparative Advantage of China Shipbuilding Industry

Symmetry of revealed comparative advantage index is used to measure the comparative advantage of Chinese export ships in this essay. The calculation formula is RCASij=(RCAij-1)/(RCAij+1),RCAS $\in$[-1,1],RCASij$\leq$0 represents that in country i product j doesn't have a revealed comparative advantage.

On the contrary, RCASij≥0 means that in country i product j do have a revealed comparative advantage.

Data, which used in the essay, are from Uncomtrade and WTO Statistics Database. Analyze the trend of China's shipbuilding comparative advantage by static and comparative static methods. Table1 shows the RCAS indexes of Chinese export ships, which are classified by SITC, between 2002 and 2009. Then analyze the trend of Chinese export ships comparative advantage by comparative static method. According to the size of RCAS indexes of Chinese export ships in 2009 figure1 is figured out.

Table 1 The RCAS Indexes of China' s Shipbuilding Between 2002 and 2009

Export ships	2002	2003	2004	2005	2006	2007	2008	2009
890110	-0.763760	-0.881574	-0.879023	-0.714509	-0.765671	-0.778353	-0.788226	-0.748371
890120	-0.090822	0.079924	-0.034134	-0.057510	0.125883	0.176459	0.220683	0.322541
890130	-1.000000	-0.820546	-0.839940	-1.000000	-0.849327	-0.851966	-0.900190	-0.955055
890190	0.202370	0.296872	0.204761	0.227549	0.285348	0.353553	0.441109	0.512152
890200	-0.287520	-0.246460	-0.604195	-0.233090	-0.585916	-0.505102	-0.614477	-0.202524
890310	0.070277	0.118686	0.042506	0.102874	0.175151	0.244010	0.335728	0.374820
890391	-0.960142	-0.987708	-0.974889	-0.962593	-0.982893	-0.978672	-0.956268	-0.938835
890392	-0.981309	-0.983943	-0.977497	-0.973889	-0.990680	-0.990553	-0.974630	-0.988681
890399	-0.786576	-0.545124	-0.649807	-0.659783	-0.574396	-0.408079	-0.366897	-0.267509
890400	0.689105	0.335863	0.314944	0.349189	0.333605	0.257517	0.291193	0.418119
890510	-0.943506	-0.995086	-0.841032	-0.849141	-0.417256	0.373728	0.530043	0.106173
890520	-0.601939	-0.740729	-0.913633	-0.726935	-0.610023	-0.465392	-0.406949	0.378843
890590	-0.025620	0.230576	-0.783879	-0.060418	0.005031	-0.038128	-0.197205	0.037277
890600	-0.531223	0.316077	0.212164	0.372660	0.338435	0.266739	0.311747	0.500463
890710	-0.266033	-0.419268	-0.165711	-0.062435	-0.111850	-0.030197	0.185355	0.150577
890790 \	-0.869358	-0.802802	-0.618369	-0.796918	-0.774582	-0.526849	-0.464091	0.120793
890800	-1.000000	-1.000000	-1.000000	-1.000000	0.582954	-0.635451	-0.539508	-0.985365

South Korea's shipbuilding has risen abruptly since 1990th. Although three indicators in the shipbuilding industry of South Korea had been surpassed completely by China in 2010, South Korea, as a shipbuilding power, still monopolizes LNG and LPG in the world, which are high technology ships. To some extent, it can reflect the status of China's shipbuilding in international market by comparing RCAS indexes of China's shipbuilding with those of South Korea. Figure2 represents the RCAS indexes of South Korea's shipbuilding in 2009 under the arrangement of figure1.

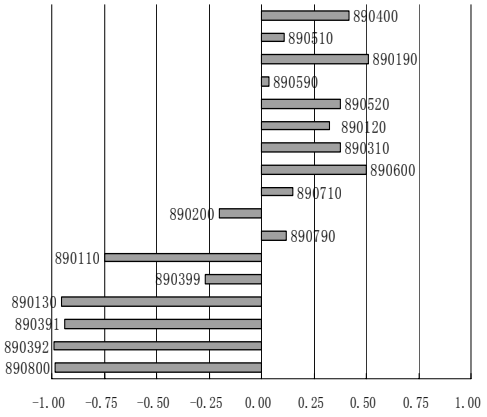

Figure 1 The RCAS Indexes of China' s Shipbuilding in 2009

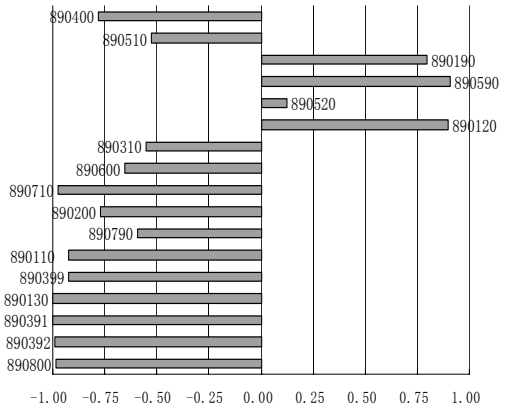

Figure 2 The RCAS Indexes of South Korea's Shipbuilding in 2009

From 2002 to 2009, China had strong comparative advantage to tugs and pusher craft, cargo vessels other than tanker or refrigerated and warships, lifeboats, hospital ships, vessels nes. In decade, RCAS indexes of those ships shows trend of growth. On the contrary, refrigerated vessels other than tankers, sail boats, with or without auxiliary motor, motorboats other than outboard motorboats and vessels and other floating structures for breaking up show strong comparative disadvantage. The RCAS indexes of those ships always has been less than -0.539508. There is and will be no great change in that comparative disadvantage. The comparative advantage of tanks, dredgers, floating docks, special

function vessels nes and floating submersible drilling or production platform are volatile. The RCAS indexes of South Korean export ships, which show comparative advantages, are high and stable. However, the RCAS indexes of China, which show comparative advantage, are just about 0.3.

3 The Empirical Research of Dynamic Comparative Advantage of China's Shipbuilding

In this part, Markov property, which means comparative advantage of shipbuilding in a following period doesn't matter what status it was in prior periods and is only decided by the status in the previous period, is used for analyzing dynamic transfer of comparative advantage of China's shipbuilding industry.

Matlab software is used for classifying RCAS indexes, which are calculated from data of export ships in UN comtrade database between 1992 and 2009 which are divided into 17 sorts of products by SITC. Those RCAS indexes are assorted into 4 subspaces in the order of their sizes. Each subspace represents one of the states of comparative advantage. And the number of samples, each subspace contains, approximately equal. An one-step transition probability matrix (table 2) is calculated by the method of probability of frequency estimation, which is on the basis of the calculation formula $p_{ji}(m)=P\{X(m+1)=j|X(m)=i\},i,j\in I$ and frequency that enters or exits one state in one period. After obtaining one-step transition probability matrix, we can get a n-step transition probability matrix that shows the trend of dynamic comparative advantage of products after n periods by calculating the nth power of the one-step transition probability. Table3, which represents the probability of transition of Chinese export ships in 5years, is made of the 5th power of the one-step transition probability in table2.
Table2 includes 4 states of comparative advantage, strong comparative advantage, weak comparative advantage, weak comparative disadvantage and strong comparative disadvantage. After a year of development, the probability of the export ships of the third state of weak comparative advantage (-0.29289,0.170665] upgrading the forth state of strong comparative advantage(0.170665,1] is 0.179104. And the probability of the export ships of the third state dropping to the second state of weak comparative disadvantage is 0.19403. So do other data.

According to the definition of transition probability matrix, elements, which are on the diagonal of the matrix, reflect the information of comparative advantages. The larger those elements value are, the smaller the possibility that dynamic changes happen to comparative advantage becomes. In table2, every element that is on the diagonal of the matrix is greater than 0.5. It means for every product the possibility that remains in the original state is greater than the possibility that transfers to other states after a year. The first state of strong comparative advantage most likely remains in the original state. On the contrary, the second state of weak comparative disadvantage most likely transfers to other states.

For every product, after a five-year of development, table3 shows the possibility that transfers to other states is greater than the possibility that remains in the original state. The first state of strong comparative advantage most likely remains in the original state. However, this probability is far lower than the one-step transition probability matrix of 74.026%.

Table 2 Markov One-Step Transition Probability Matrix of China' S Shipbuilding

States	Ⅰ	Ⅱ	Ⅲ	Ⅳ
Ⅰ	0.74026	0.181818	0.025974	0.051948
Ⅱ	0.184211	0.552632	0.184211	0.078947
Ⅲ	0.044776	0.19403	0.58209	0.179104
Ⅳ	0.028986	0.072464	0.217391	0.681159

Table 3 Markov Five-Step Transition Probability Matrix of China' s Shipbuilding

States	Ⅰ	Ⅱ	Ⅲ	Ⅳ
Ⅰ	0.368723	0.265859	0.188090	0.177328
Ⅱ	0.269798	0.266386	0.244914	0.218904
Ⅲ	0.197547	0.248747	0.287081	0.266625
Ⅳ	0.160755	0.223458	0.295763	0.320024

As well as China, every element that is on the diagonal of the South Korean matrix is also greater than 0.5. After a five-year development, the first state of strong comparative advantage most likely

remains in the original state. The probability is 1.66 times that of China.

Conclusions from above:

(1)In study period, comparative advantage of Chinese export ships focus on low valued products. Comparative disadvantage of China focus on high valued products and ship supporting products. The distributed structure of comparative advantage of Chinese export ships accords with the structure of Chinese factor endowments. Comparing with China, comparative advantage of South Korean export ships focus on both low valued products and high valued products. Comparative disadvantage of South Korea focus on motorboats other than outboard motorboats and rowing boats, canoes, pleasure boats except sail/powe.

At the beginning of shipbuilding, a country needs technology as well as labor and capital. Since the implementation of reform and opening policy, China have accumulated a huge mass of capital through resource intensive products and labor intensive in international trade. Meanwhile, China has been introducing foreign qualified people. The implementation of the strategy of invigorating China through science and education and technology innovation system creates a good environment for scientific research. Under this environment, domestic enterprises actively digest advanced technology introduced from other countries. Traditional advantage of labor and accumulation advantage of capital and technology enable China's shipbuilding to take the absolutely advantage position in the manufacturing and exporting the world's three major ship forms. However, there is a gap between shipbuilding of China and shipbuilding of other countries that are first class in the world, especially in high valued technology ship.

(2)Both comparative advantage and comparative disadvantage of Chinese export ships are likely to remain in the original states after a year. They are easy to accumulate by themselves. The possibility that products in the state of weak comparative advantage drop to the state of weak comparative disadvantage is greater than the possibility that it transfer to the state of strong comparative advantage. In study period, comparative advantage of South Korean ships face similar situation.

4 Experience of Shipbuilding Industry of South Korea

The development and production of South Korea cater to demand of market and persist in the strategy of high technology and high valued ships. As a result of continuous optimization and innovation of ship form, the RCAS indexes of South Korean tankers were higher than 0.86 for a long time. Especially LNG, which is viewed as models for high technology and high valued in the world, is ahead of the competition.

Without introducing qualified people, South Korea can not conduct innovation in shipbuilding technology continuously. If there are no qualified people, advanced technology from foreign countries can not be applied to practice. If there are no qualified people, advanced technology can not be digested and re-innovated. Simultaneously, domestic independent technology innovation also needs qualified people. Cultivate professional and technical personnel by arranging and organizing domestic technical personnel to pursue advanced studies in Europe or Japan and participate in international academic meetings. At the same time, construct domestic education system of ship science and technology, nurturing professional talents.

Great support of South Korean government benefits technology innovation and talents recruitment. After South Korea's shipbuilding industry entering growing phase, government continues to adopt systems and policies which are used in take-off stage of developing shipbuilding industry to promote the development of shipbuilding industry, like, system of planning shipbuilding that caters to domestic ship demand, preferential financing policy provided for enlarging shipbuilding ability and conducting technical improvement, and other laws and rules. On the basis of that, government adds encouragement policy to foster the development of ship supporting industry and offer subsidy for technical innovation. That achieves good results.

South Korea's shipbuilding, which has been leading in the world within thirty years, is on the basis of combination of the shipbuilding system that is compatible with the phase of the shipbuilding development and continuous introduction of professional talents, oriented by market acquirement, and making ship technical innovations on a big scale.

Shipbuilding is an industry that needs labor, capital and technology. Shipbuilding of China takes comparative advantage of ground resource and labor, where South Korea does not have advantage. However, South Korea has factor advantage of technology that is created by-self and becomes its competitive advantage. In a long run, this competitive advantage will be increased as a result of

accumulation of knowledge while other competitive advantage gained from static factor endowment advantage will be declined. Actually, the advantage of labor of China's shipbuilding is gradually whittled according to some research, which points salaries of workers who work at domestic large shipyard is much higher than salaries' average level in southern coastal regions and is not much lower than the cost for unit labor in South Korea[1]. China's shipbuilding industry should use the experience of South Korea's shipbuilding industry to transfer comparative advantage to competitive advantage dynamically.

5 Conclusion

Both introduction of able people and formulation of institutional innovation are made for importing international advanced technology and implementing domestic independent technical innovation effectively. Technical innovation could be classified two types. One is a sort of passive innovation under the stress of objective factors. The other is initiative innovation based on exerting itself advantage.

(1)Passive technical innovation. Most shipyards of China belong to this type. Few researches of ship forms, which are on the list of new orders, have been done before orders have been taken. Usually, there are 2~3years before delivering, which make it possible for shipyards to use this kind of production and transaction mode. Domestic shipyards' technical innovation, caused by demands of international trade, could be viewed as passive technical innovation. This kind of technical innovation could be implemented by strategy of technical introduction to assimilate foreign shipbuilding technology, like, licensing, transferring of skill, capital cooperation and other informal methods. Until 2008, although China has signed a non-exclusive agreement with European shipyards, as a result of lacking necessary successive investment and technical preparation, China can only manufacture 147,000 m^3 LNG ship while South Korea can produce 200,000 m^3 LNG ship. It has to be mentioned that resistance, from other countries, could be met in the process of technical introduction by importing shipyards. That may lead to unsuccessful passive technical innovation.

However, now, passive innovation can not be abandoned as a result of lacking terms of transferring from passive innovation to initiative innovation. Except some large shipyards, others' capability of production is small and structure contradiction is obvious. The whole industry concentration has to be improved.

(2)Initiative technical innovation. Initiative technical innovation not only means creature of a totally new technology, but also accumulation of knowledge and skills from learning by doing. It does emphasize kind of technical innovation on the basis of correctly analyzing demands of domestic and international markets, not technical innovation that just aims at innovation. In order to promote initiative technical innovation, shipyards should strengthen the study on demand of market and implementation of the digestion and absorption of imported technology. Comparing with shipyards of foreign countries, which spend 1dollar in importing technology, then will take 2~3 dollars digestion and absorption, shipyards of China universally emphasize on importing and take digestion and absorption lightly. Therefore, shipyards of China should make it a rule to spend how much money in importing and how much in digestion[3]. After considering competitive situation and their own demands, South Korean shipyards import core technology wanted best, especially technology can be further developed and innovated. Shipyards of China should strengthen the combination of research and production to make sure technique innovation achievement is used for ships immediately.

Now, shipbuilding industry of China builds dynamic comparative advantage through passive technical innovation with introduction of talents and effective systems that create conditions for initiative innovation. When conditions permit, shipyards of China conduct initiative technical innovation completely with introduction of talents and effective systems to make China one of few major shipbuilding industry powers in the world.

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