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Comparative Study on the Technical Complexity of Agricultural Machinery Products Exported by China, Japan and Korea

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Abstract— *As a long-established farming country, China, Japan and Korea are also major exporters of agricultural machinery. With the continuous enhancement of China's comprehensive national strength, agricultural machinery manufacturing technology is also constantly developing, and the gap with Japan and South Korea has gradually narrowed. Based on the analysis of the export scale of agricultural machinery products and the structure of export commodities in China, Japan and Korea, this paper uses the export complexity index constructed by Hausmann to introduce the trade data of 7 types of agricultural machinery products from 35 countries in 2006-2016. The export technology complexity index, from the perspective of the overall and classification, compares and analyzes the changes in the technical complexity of the export of agricultural products from China, Japan and Korea. The study found that: overall, the technical complexity of China's agricultural machinery products has steadily increased in 2006-2016, and is basically in sync with Japan and South Korea, and individual years are even stronger than Japan and South Korea. In terms of classification, China's agricultural machinery product export structure is more rationalized. China, Japan and Korea each have a competitive advantage in HS8433, HS8438 and HS8432, indicating that there is a certain complementarity between China and Japan in the structure of agricultural machinery products.*

Keywords— *Agricultural machinery; export technology complexity; China, Japan and Korea.*

I. INTRODUCTION

Japan's agricultural machinery industry developed in the early 1960s. After decades of technological precipitation, it quickly transformed from a technology importer to a technology exporter, and basically realized agricultural modernization in 1986. South Korea is the second country in Asia to implement agricultural mechanization after Japan. In order to develop agricultural mechanization, South Korea has established many agricultural machinery research and promotion institutions and actively introduced advanced machinery manufacturing technology[1]. China's agricultural machinery industry started late. In 1985, the total power of agricultural machinery in the country was only 208 million kw. With the reform and opening up and the tilt of national policies, the total power of national agricultural machinery has increased to 1.144 billion kw in 2016, an increase of 5.5 in 30 years. Times. The export value of Chinese agricultural machinery products also increased from US $ 415 million in 2003 to US $ 4 billion in 2016. In 2003, the export value of agricultural machinery products exceeded Japan for the first time. China's "Agricultural Machinery Equipment Development Action Plan (2016-2025)" proposes that by 2020, the agricultural machinery equipment category will be basically complete, and the self-sufficiency rate of key parts and components will reach about 50%; the reliability of key agricultural machinery products such as tractors and combine harvesters is more than "ten The second five-year plan will increase by more than 50%; the market share of high-end products shall reach 30%.

II. LITERATURE REVIEW

Technical complexity was first proposed by Hausman[2] in 2003 to measure the technological content of an industry in a

country. The index uses per capita income and R & D inputs at the level of export substitution technology and industry to measure technical indicators of products and industries in exporting countries To reflect the level of technological development in the country.

Overall, Chinese scholars' research on the complexity of export technology has focused on the following two aspects. On the one hand is the problem of factors affecting the complexity of export technology. Such as FDI (Xi Yujie[3], 2018; Mao Haiou, Liu Haiyun[4], 2018), technology market development (Dai Kuizao[5], 2018), exchange rate changes (Dai Xiang, Zheng Lan[6], 2016), and population age structure (Indy, Chen Zhaofeng[7] , 2016; Gao Yue, Li Ronglin[8], 2018) and so on.

On the other hand, use the export technology complexity index to conduct empirical research on the export competitiveness of different industries in China, such as agricultural products (Yin Zongcheng, Tian Tian[9], 2018), service trade (Dai Xiang[10], 2012), textile and apparel industry, and machinery Transportation equipment industry (Duan Xiaomei[11], 2017) and high-tech industry (Tang Bi[12], 2012), etc.

With the development of Chinese agricultural machinery technology and the increasing export trade, domestic scholars have also done a lot of research on the export competitiveness of Chinese agricultural machinery products. Lian Xiaolu and Tian Zhihong[13] (2004) used the explicit comparative advantage index, industrial trade index and international market share index to measure the export competitiveness of China's agricultural machinery products from 1992 to 2002, and found that the overall product competitiveness is steadily increasing, but with export The product type of competitive advantage is relatively single. Lian Xiaolu, Tian Zhihong[14], etc. (2007) analyzed the export value changes of Chinese agricultural machinery products from 1993 to 2003 using the import-export price ratio, terms of trade index and quality index, and found that the growth of Chinese agricultural machinery product exports was mainly due to the increase in export volume, not Increase in value. Wang Ju and Liu Xue[15] (2007) used the comparative advantage index and trade competitiveness index to find that the overall export competitiveness of China's agricultural machinery products from 1992 to 2005 was not high, but it was generally on the rise. Zhang Meng and Xie Jianguo[16] (2016) applied the complexity of export technology to Chinese agricultural machinery products and found that Chinese agricultural machinery products as a whole are at a moderately high level, but their relative export competitiveness is declining. In terms of classification, China’s agricultural machinery products have different export competitiveness differences huge.

According to the existing literature, the current research mainly focuses on the analysis and research of China's agricultural machinery export related indexes, and there are few comparative analysis of agricultural machinery product exports between China and other countries. Therefore, this article will use 2006-2016 agricultural machinery product export data of China, Japan and South Korea and other world agricultural product producing countries (or regions), combined with China, Japan and South Korea's agricultural machinery product export status and export structure, to measure the technology of China, Japan and Korea agricultural machinery products. Complexity, and do further comparison and analysis.

III. Research Methods and Data Sources

a) Scope and Classification of Agricultural Machinery Products

Agricultural machinery refers to various machinery used in the production process of planting, animal husbandry, fishery and forestry and other industries, as well as in the processing and processing of its products. According to the classification of agricultural machinery by the Ministry of Agriculture of China, there are a total of 15 categories, but under the trade caliber statistics, agricultural machinery products have 118 tax items at the level of 8 items. The classification results of the two are quite different. In order to achieve a unified accounting caliber, this paper refers to the classification method of Guo Ruimin[17] (2016). The specific classification criteria are shown in Table 1.

TABLE 1. Classification of agricultural machinery

Product Code	Product Name
HS8432	Land preparation or farming machinery for agriculture and gardening; lawn and sports field rollers
HS8433	Harvesters, threshers, lawn mowers; or cleaning, sorting, and sorting machines for agricultural products
HS8434	Milking machines and dairy processing machines
HS8435	Presses and crushers for wine or beverages
HS8436	Animal husbandry or other agricultural and forestry machinery
HS8437	Seed, grain cleaning, sorting or grading machines; grain processing machines, except agricultural machines
HS8438	Production or processing machinery for other food and beverage industries

b) Research Methods

This paper mainly draws on the method used by Hausmann et al. (2007) to calculate the technical complexity of a country's manufactured product exports, and calculates the technical complexity of agricultural machinery product exports in China and Japan in two steps.

The first step is to first measure the technical complexity index (Technological Sophistication Index, TSI) of a class of products in the 7 categories of agricultural machinery product export classification. Calculated as follows:

$$TSI_i = \sum_j \frac{x_{ji} / X_j}{\sum_j (x_{ji} / X_j)} Y_j$$

TSI_i is the technical complexity index of type i agricultural machinery products, x_{ji} is the export value of type i agricultural machinery products exported by country j; X_j is the total export of agricultural machinery products of country j, and Y_j is the per capita GDP of country j based on purchasing power parity . The TSI value can be regarded as the world output level of various agricultural machinery products after excluding production distortion caused by income levels. This indicator reflects the technical complexity of various agricultural machinery products.

The second step is to calculate the Export Sophistication (ES) of agricultural machinery products in country j by the following formula:

$$ES_j = \sum_i \frac{x_{ji}}{x_j} TSI_j$$

It can be concluded that the ES index is the weighted average of various agricultural machinery products in country j agricultural machinery industry. The index reflects the impact of the export complexity of a country's agricultural machinery products on the level of domestic production and the overall economy. It can analyze the export technology content and competitiveness of agricultural machinery industries in various countries.

c) Data sources

Since the calculation of the export technology complexity of each type of agricultural machinery products requires the export data of agricultural machinery products from various countries in the world, but because the data calculation is too complicated and some data are available, this article does not include all countries in the calculation, but chooses The top 36 countries or regions of agricultural machinery products exported in 2015 were used as samples to calculate the technical complexity of exports. The agricultural machinery exports of these countries accounted for more than 90% of the world's total exports, which is highly representative and can meet the needs of this article. These countries are China, Japan, Korea, Norway, Philippines, Poland, Australia, Austria, Belgium, Brazil, Belarus, Canada, Czech Republic, Denmark, Finland, Hungary, Indonesia, Portugal,

France, Germany, Romania, Russia, India , Slovakia, Italy, Mexico, Netherlands, Slovenia, South Africa, Thailand, Turkey, Spain, Sweden, Switzerland, United Kingdom, and the United States.

The export data of various agricultural machinery products of the above countries or regions during the sample period come from the United Nations Commodity Trade Statistics Database (UNCOMTRADE), and the export trade value is denominated in US dollars. Per capita GDP data comes from the World Bank's statistical database and is measured by purchasing power parity (PPP) (constant prices in 2005, the unit is international yuan).

IV. China, Japan and South Korea Agricultural Machinery Export Trade Status

a) *Analysis of the Global Agricultural Machinery Market*

In recent years, the global trade in agricultural products has been slightly stronger than the global trade in other goods, showing the characteristics of both increasing and decreasing. In 2006, the global agricultural machinery trade was US $ 30.2 billion, and in 2016 it was US $ 42.9 billion (as shown in Figure 1), which increased by 41% in 11 years, while the global trade volume increased by only 31.4%, indicating that the global agricultural machinery market demand is stronger Most other industries. Among them, in 2009, due to the impact of the financial crisis, the global agricultural machinery trade volume decreased by 24% from last year, and the global trade volume decreased by 22% from last year, indicating that the sluggish global demand caused by the economic crisis poses a greater threat to agricultural machinery products. In 2015, the global economy slowed down and demand was sluggish. Global overcapacity of agricultural machinery led to contraction in international trade, and the price of agricultural machinery fell steeply, resulting in a large decline in agricultural machinery exports in various countries.

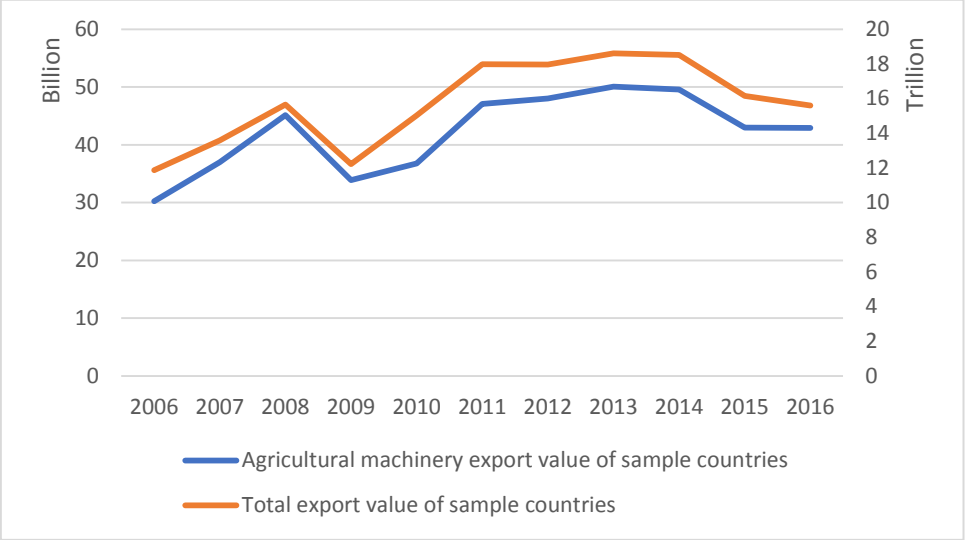

Figure 1. Total Exports of Agricultural Machinery Products in Sample Countries from 2006 to 2016

Data source: According to UN comtrade data

b) *Overview of export development of agricultural machinery products in China, Japan and South Korea*

From 2006 to 2016, China's agricultural machinery products have made great progress in both the number of exports and the growth rate, far higher than Japan and South Korea. At the same time, Japan is stronger than South Korea in the number of agricultural machinery exports, but the gap between the two has not increased. In 2006, China's agricultural machinery exports to the world totaled US $ 850 million, Japan's agricultural machinery products totaled US $ 526 million, and South Korea's agricultural machinery products totaled US $ 136 million (see Figure 2). At this time, China's export value was slightly 1.6 times that of Japan and 6.2 times that of South Korea. By 2016, China's agricultural machinery exports have reached nearly 4 billion US

dollars, an increase of 4.6 times over 10 years ago. During the same period, the export value of agricultural machinery products in Japan was US $ 790 million, and the export value of agricultural machinery products in South Korea was US $ 210 million, both of which have increased by about 1.5 times compared with 10 years ago. 18.95 times that of South Korea. Among them, the growth rates of China's agricultural machinery exports in 2007 and 2008 were 66% and 71%, respectively. Due to the financial crisis in 2009, they decreased by 17.25% compared to 2008. From 2010 to 2014, China's agricultural machinery exports maintained an increasing trend, but the growth rate gradually slowed down. Japan and South Korea are similar to China, and both fell slightly in 2009 and 2015, but Japan decreased by 7.53% in 2009 and South Korea decreased by 2.79%. The reduction is smaller than that of China, so the export value of Chinese agricultural machinery products to the international market Fluctuations in demand are more sensitive.

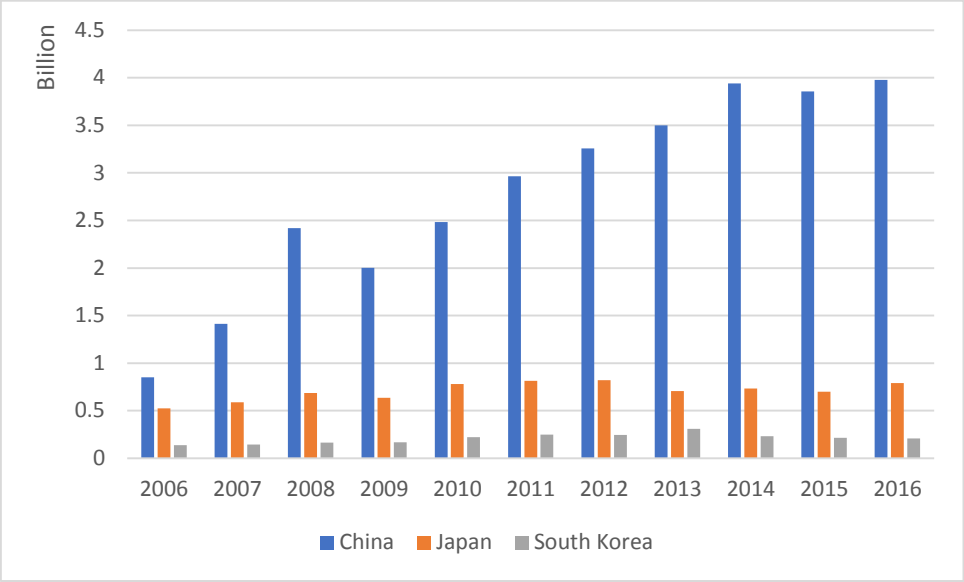

Figure 2. China-Japan- South Korea Agricultural Machinery Export Development in 2006-2016

Data source: According to UN comtrade data

c) Analysis of Export Structure of Agricultural Machinery Products in China, Japan and South Korea

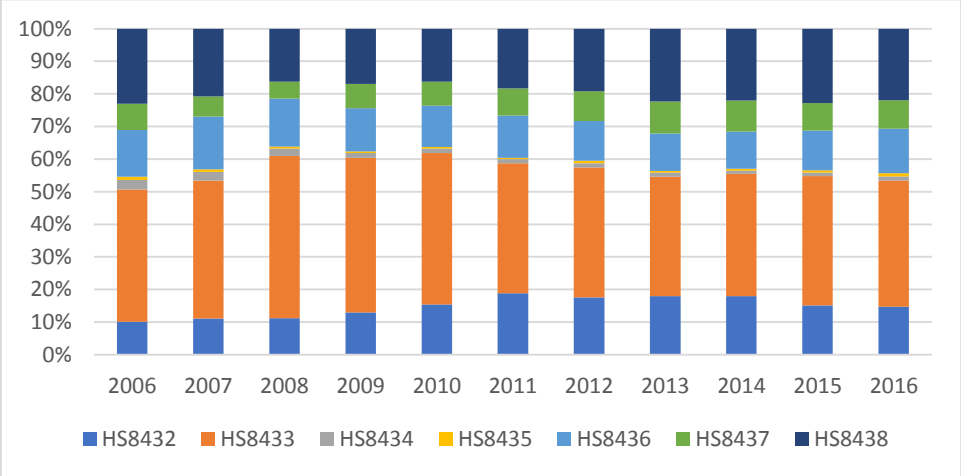

Figure 3. Export structure of agricultural machinery products in China from 2006 to 2016

Data source: According to UN comtrade data

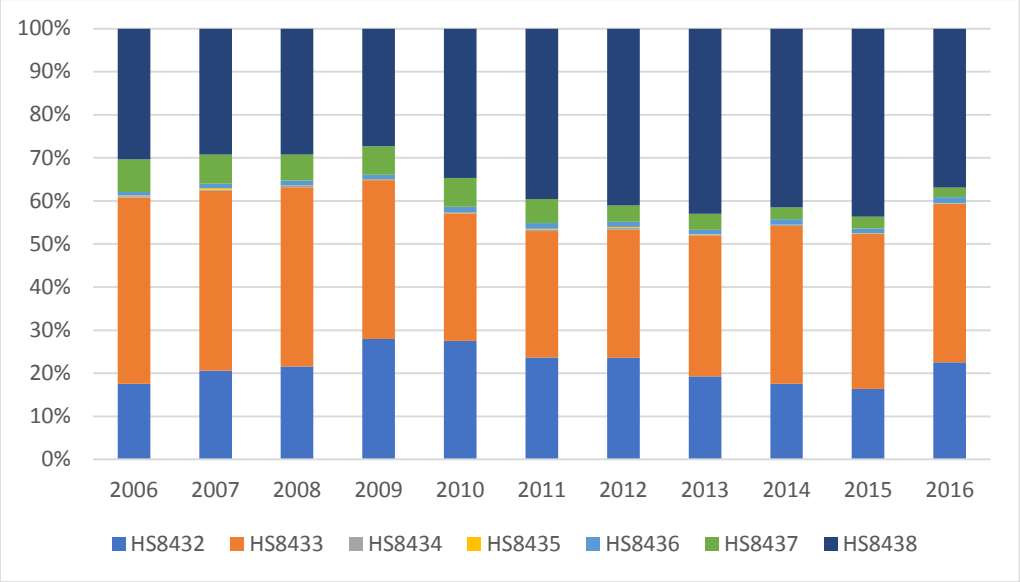

Figure 4. Export structure of agricultural machinery products in Japan from 2006 to 2016

Data source: According to UN comtrade data

The export structure of agricultural machinery products in China, Japan and South Korea all fluctuated to some extent from 2006 to 2016. HS8433 is the most important part of China's agricultural machinery exports. China's exports of such products accounted for the largest proportion of total exports in 2008, accounting for 50%. Since then, due to the impact of the financial crisis, the proportion of such products has been declining year by year until 2014 Rise slowly (see Figure 3). HS8438 is the most important part of the export of agricultural machinery products in Japan and South Korea. The export value of such products in Japan accounts for about 36% of the total export value (Figure 4), and it is increasing year by year except for 2009 and 2016.

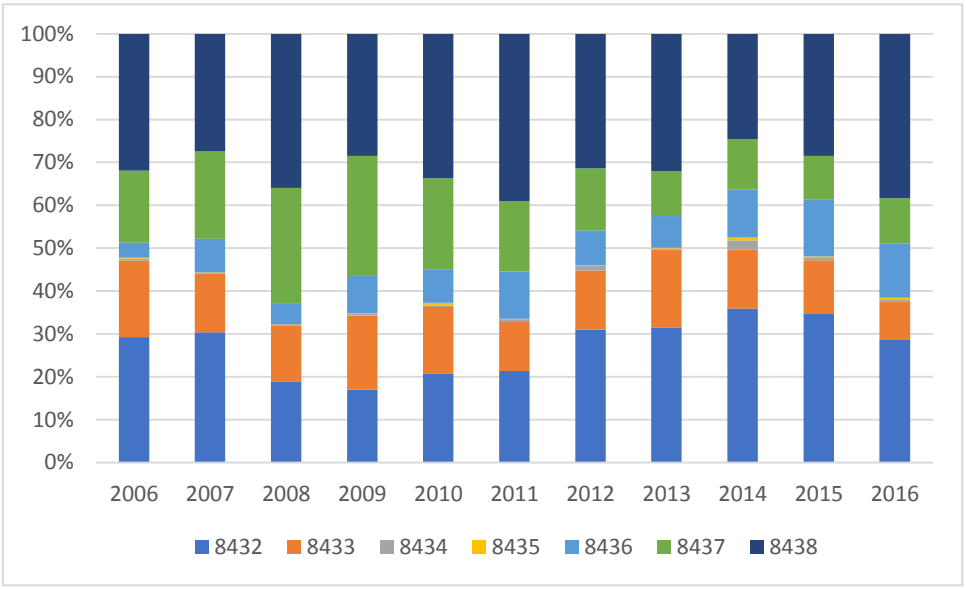

Figure 5 Export structure of agricultural machinery products in South Korea from 2006 to 2016

Data source: According to UN comtrade data

South Korea's exports of such products accounted for about 32% of the total export value (see Figure 5), but they fluctuated several times between 2006 and 2016 and were relatively unstable. Japan's HS8432, HS8433, and HS8438 account for 94% of the

total export value, indicating that Japan's agricultural machinery industry has a very high dependence on these three types of products. HS8433 is the largest agricultural machinery product exported by China, accounting for 42%. The three types of products HS8432, HS8436, and HS8438 account for 14.81%, 13.21%, and 19.98% respectively. Compared with Japan, China 's agricultural machinery exports to HS8433 Too much dependence. The export structure of South Korea is similar to that of Japan. The annual average export ratios of HS8432 and HS8438 are 27% and 32%, and the average annual export ratios of HS8433 and HS8437 are 14% and 17%. These four types of agricultural machinery products The sum of the annual average export value accounts for 90% of the total export value, which indicates that these four types of products are the leading products of the Korean agricultural machinery industry and their structure is more reasonable.

V. Comparison of Technical Complexity of Agricultural Machinery Export between China, Japan and South Korea

a) Overall Technical Level of Agricultural Machinery Products in China, Japan and South Korea

TABLE 2. Complexity of China-Japan-Korea Agricultural Machinery Products from 2006 to 2016

Unit: International Yuan

	China	Japan	South Korea
2006	26481.45	26017.69	26757.17
2007	28022.92	27594.91	27841.89
2008	29183.81	28982.05	29298.09
2009	28596.22	28732.73	28528.85
2010	29954.9	29859.75	30006.86
2011	31636.72	31127.44	31781.36
2012	32360.19	32203.25	32823.96
2013	33625.99	33460.25	33845.14
2014	34346.12	34120.17	34741.05
2015	34653.5	36185.62	34081.63
2016	36208.68	36445.96	36426.88

Data source: According to UN comtrade data

From 2006 to 2016, the technical complexity of the export of agricultural machinery products in China, Japan, and South Korea all showed an increasing trend, indicating that while the agricultural machinery products of the three countries have expanded in scale, their export competitiveness has also been continuously enhanced. Among them, the export technical complexity index of Chinese agricultural machinery products in 2016 increased by 9,727 international dollars compared with 2006, Japan increased by 10,428 international dollars, and South Korea increased by 9,669 international dollars. It shows that in these years, China's level of technological improvement is slightly worse than that of Japan, which is comparable to that of South Korea. In 2006-2008 and 2010-2014, the export technical complexity index of Chinese agricultural machinery products was higher than that of Japan, but it was lower than that of Japan in 2009, 2015, and 2016, and the agricultural machinery market in all three years experienced a certain depression. The total export volume of the sample countries decreased by 25%, 13%, and 0.07% respectively compared with the previous year. That is to say, in the years when the market demand is performing well, Chinese agricultural machinery products rely on low-cost price advantages, and the export technology complexity index is stronger than that in Japan. However, in the years when the agricultural machinery market is stagnant, the index is significantly weaker than Japan. In 2015, it was even lower than Japan's 1532 international dollars. This should be due to the low technological content of Chinese agricultural machinery products, and the elasticity of foreign buyers' demand for Chinese agricultural machinery products is relatively high. The export technical complexity index of agricultural machinery products between China and South Korea was

from 2006 to 2016. South Korea was better than China in 8 years, and China was better than South Korea in 3 years. In 2009 and 2015, when the market price of agricultural machinery fluctuated sharply, China was even stronger. In South Korea, it shows that the technical level of Chinese agricultural machinery products has not changed much from South Korea, and the ability to resist risks is even better. Japan and South Korea are similar to China and Japan. In the years when the market is performing better, South Korea's export technical complexity index is stronger than Japan's, and in the poor 2009, 2015 and 2016, South Korea is significantly weaker than Japan. This shows to some extent that China and South Korea are more competitive than high-priced Japanese products in the years when the market is better because of their price and cost advantages. In the year when the market is not good, Japan is more competitive than China and South Korea because of its technical irreplaceability.

b) China, Japan and South Korea Breakdown of Agricultural Machinery Export Technical Complexity

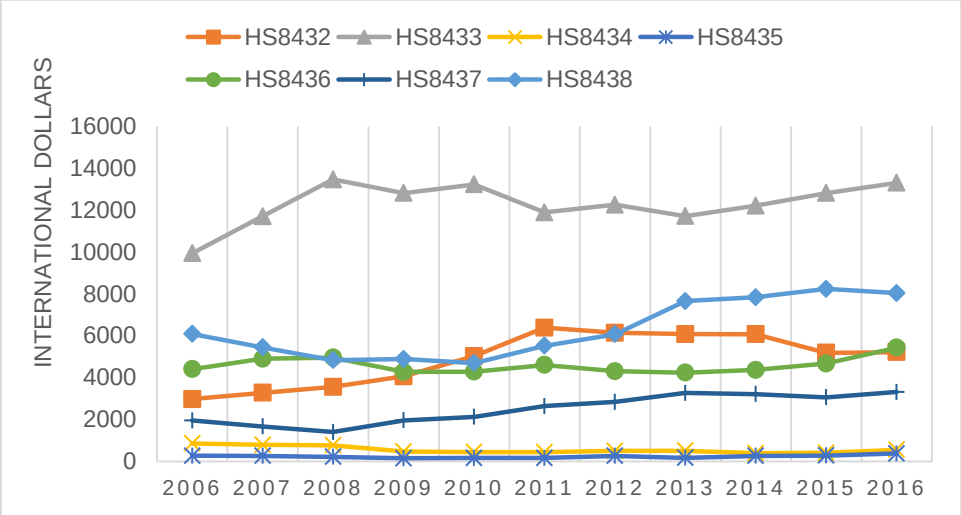

Figure 6 Technical Complexity Index of China's Seven Categories of Agricultural Machinery Products Export, 2006-2016

Data source: According to UN comtrade data

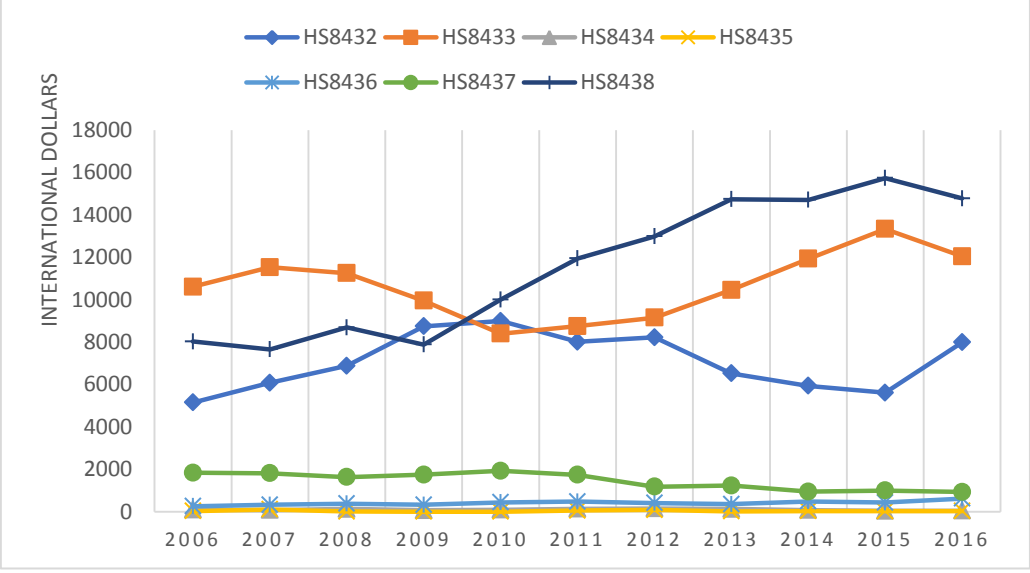

Figure 7 Technical Complexity Index of Japan's Seven Categories of Agricultural Machinery Products Export, 2006-2016

Data source: According to UN comtrade data

There are obvious differences in the technical complexity of the export of various agricultural machinery products in China, but the overall structure remains basically stable. It can be seen from Figure 7 that HS8433 is the most technologically advanced

agricultural machinery product exported by China. It has a strong export competitiveness (average annual value is more than 10,000 international dollars). It increased by 2360 international dollars from 2006 to 2016, and it is on the rise. The export technical complexity index of HS8432, HS8436, HS8437, and HS8438 are in the middle (average annual is greater than 1000 and less than 10,000 international dollars). And HS8434, HS8435 export technology complexity index is low (average annual less than 1000 international dollars).

There is a certain degree of polarization in the technical complexity indicators of agricultural machinery products exported from Japan. As can be seen from Figure 8, the technical complexity of HS8433, HS8438 and HS8432 is relatively high. The average annual technical complexity index of HS8433 and HS8438 is greater than 10,000 international dollars, and HS8432 also reaches 7108 international dollars. HS8438 During the period of 2006-2016, the export technical complexity index increased by 3534 international dollars, which is the category of agricultural machinery products with the largest increase among agricultural products in Japan, China, Japan and South Korea. HS8437, HS8434, HS8435, and HS8436 are products with a general technical level for agricultural machinery exports in Japan, especially the export technical complexity index of HS8434, HS8435, and HS8436 was less than 1,000 international dollars between 2006 and 2016, and lower than China and South Korea.

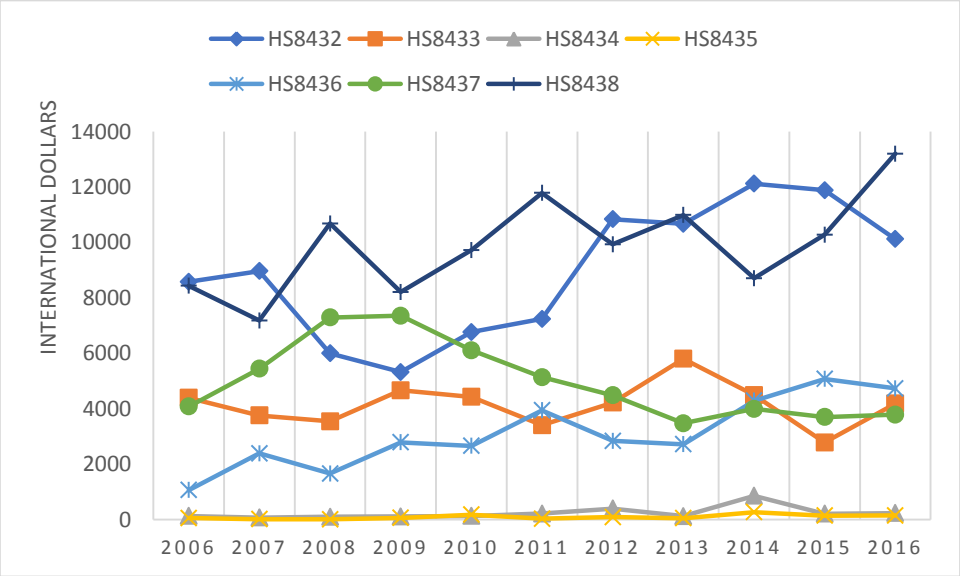

Figure 8 Technical Complexity Index of South Korea's Seven Categories of Agricultural Machinery Products Export, 2006-2016

Data source: According to UN comtrade data

TABLE 3. Comparison of export competitiveness of agricultural machinery products in China, Japan and South Korea

Data source: According to UN comtrade data

Country	China	Japan	South Korea
High technical complexity (Greater than 10,000 international dollars)	HS8433 （42%）	HS8433、HS8438 （72%）	无
Technical complexity (Greater than 1000 and less than 10,000 international dollars)	HS8432、HS8436 HS8437 、HS8438 （54%）	HS8432、HS8437 （26.6%）	HS8432、HS8433 HS8436、HS8437 HS8438（99%）
Low technical complexity (less than 1000 international dollars)	HS8434、HS8435 （3%）	HS8434、HS8435 HS8436 （1.5%）	HS8434、HS8435 （1%）

Note: The annual average value of the export value of this type of agricultural machinery products in the total export value of agricultural machinery products in parentheses

South Korea's most technologically superior agricultural machinery product category is HS8438. During 2006-2016, its export technology complexity index increased by 1487 international dollars, but its annual average export technology complexity index was 9924 international dollars, weaker than Japan and stronger than China. In addition, HS8432, HS8433, HS8436, and HS8437 are at a medium level of technical complexity. Between 2006 and 2016, HS8436 increased the most, while HS8433 decreased slightly. HS8434 and HS8435 are South Korea's least competitive agricultural machinery product categories. The export complexity index of HS8435 is even lower than 100 international dollars.

From the above, Japan 's HS8433 and HS8433 agricultural machinery products have an average annual technical complexity index of more than 10,000 international dollars, and the export value of these two types of agricultural machinery products accounts for 72% of the total agricultural machinery product exports. While China only has HS8433, South Korea has no agricultural machinery products with an average annual technical complexity of more than 10,000 international dollars. China's HS8432, HS8436, HS8437 and HS8438 are at a medium technical complexity level, with total exports accounting for 54% of total exports, Japan's HS8432 and HS8437 accounting for 26.6%, and South Korea's HS8432, HS8433, HS8436, HS8437, and HS8438 exports The amount accounts for 99%. It can be found that the export structure of Japan 's agricultural machinery products is the most reasonable. The country that exports the most is the products of high technological complexity in the country, which basically conforms to the law of higher technological complexity and greater export share. The high-tech complexity of agricultural machinery products exported by China each occupies half. The agricultural machinery products exported by South Korea are mainly the products of medium technical complexity in the country. Therefore, the export structure of agricultural machinery products of China and South Korea is inferior to that of Japan.

In addition, the technical complexity of China's HS8433 was slightly lower than that of Japan in 2006 and higher than that of Japan in 2016, and it holds certain technical advantages in HS8434, HS8435, and HS8436. The technical complexity of Japan's HS8438 is significantly higher than that of China and South Korea, while the technical complexity of South Korea's HS8432 and HS8437 is higher than that of China and Japan. Therefore, it can be considered that China, Japan, and South Korea have their own advantages and competition in the export of agricultural machinery products.

VI. CONCLUSION

Based on the current status of the export of agricultural machinery products from China, Japan, and South Korea, this paper conducts a comparative analysis of the overall and subdivided product categories of the seven types of agricultural machinery products from 2006 to 2016 in China, Japan, and Korea, and draws the following conclusions:

(1) On the whole, the technical complexity of Chinese agricultural machinery products has steadily increased from 2006 to 2016, and has basically kept pace with Japan and South Korea. Compared with Japan, there is still some gap in resistance.

(2) From the perspective of subdivided product categories, China's agricultural machinery product export structure has made steady progress. The technical complexity of China's highest export agricultural machinery product HS8433 has even surpassed Japan in 2016 and is stronger than South Korea, but in HS8432 and HS8438 still has a big gap with Japan and South Korea. China, Japan, and South Korea occupy competitive advantages in HS8433, HS8438, and HS8432, which also shows that China, Japan, and South Korea have certain complementarities in the structure of agricultural machinery products.

In view of the above conclusions, the following policy recommendations are given: First, increase the R & D expenditure of the agricultural machinery industry, improve the scientific research and innovation mechanism, increase funding support for China's agricultural machinery enterprises that have reached world advanced technology, and give them more convenient financing and management The conditions encourage such enterprises to actively "go global", compete with similar foreign companies, expand their business scale, generate technology spillovers, and drive the development of corresponding upstream and downstream enterprises. Second, in view of the agricultural machinery product categories in which China is still at a competitive disadvantage, domestic enterprises that produce such products are encouraged to actively introduce advanced foreign production technologies and increase technological research and development to form their own intellectual property rights.

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