

# Analysis of Export Technology Complexity Structure of High-tech Manufacturing Industry in China and the US

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**Abstract.** High-tech manufacturing has become the pillar industry of the world's major countries. To a certain extent, the development of high-tech manufacturing determines the status of a country's global value chain. China and the United States are both big high-tech exporting countries. Based on the description of the export scale of high-tech manufacturing industries in the two countries, the paper builds the PRODY and EXPY indexes to analyze the export technical characteristics and development trends of the high-tech industries in China and the United States. The conclusions are as follows: Technical complexity of China's high-tech manufacturing exports has increased slower in recent years, which led to an unsatisfactory improvement in the technological content of China's high-tech manufacturing; overall technical level of the US high-tech industry is higher than that of China, and the industrial structure is more mature. The increasing complexity of the export of high-tech industries in China and the United States has promoted the development of the industry.

**Keywords:** High-tech Manufacturing; Export Technology Complexity; Structure.

## 1. Introduction

High-tech manufacturing has become one of the most important industries in the world. At the period of development from the mid-to-late industrialization stage to the post-industrialization stage, China is going to usher in a golden era of new economy represented by high-tech, advanced, high-end equipment and equipment manufacturing. The report of the 19th National Congress of the Communist Party of China clearly stated that it is necessary to speed up the construction of a manufacturing power, accelerate the development of advanced manufacturing, and promote the development of China's industry to the high end of global value chains. All that said, there are still also many challenges to go alongside opportunities for high-tech industry. Now the international trade pattern is increasingly complicated. US government attempts to curb the good development of China's high-tech industries by launching the new round trade war, adopting harsh means like restricting Chinese companies' investment and financing activities in the US etc.

China's current export of high-tech exports has been catching up and surpassing the United States since 2006 (Fig 1), while the export volume of high-tech manufacturing in the US remained relatively invariant in recent years, and the growth rate separately appear negative situation. However, we cannot simply judge the good or bad of an industry only based on its scale. What we need to do is to compare the export structure of high-tech manufacturing between the two countries, which is crucial to further clarify the current development gap between China and the US in the development of high-tech industries and their future development potentials.

Therefore, there are three main incentives to create this paper: First, based on the PRODY index, the technical complexity of the high-tech manufacturing exports is redistricted. Through the weighted estimates of EXPY index we can predict the overall technical level of high-tech industries both in China and the United States; Second, the time span of this paper from 2000 to 2016, is a dynamic time series analysis, not just a static model, which can better reflect the changes in the development of high-tech manufacturing in the two countries; Third, an important reason behind the US launch of the trade war is to suppress China's high-tech industries. Under the special background of this industry and equipment manufacturing industry, this paper draws conclusions to provide suggestions for China's high-tech industry to cope with the impact.

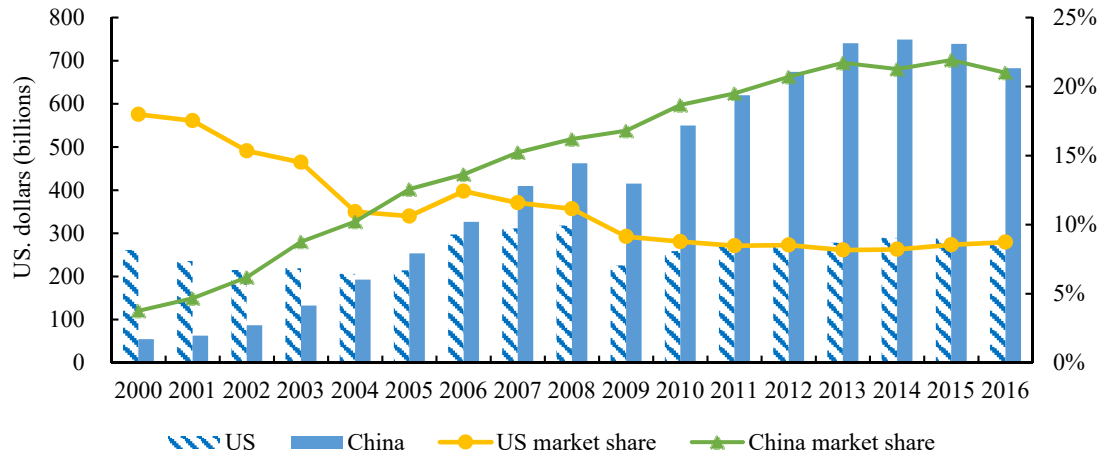


Fig 1. High-tech manufacturing exports and market share in China and the US  
Data source: UN COMTRADE

## 2. Model and Results

### 2.1 Two Important Indexes

On the basis of traded goods are associated with higher productivity levels than others, Hausmann and Hwang (2005) construct a measure by taking a weighted average of the per-capita GDPs of the countries exporting a product, where the weights reflect the revealed comparative advantage of each country in that product. The biggest advantage of the measurement is that it can use trade data to replace the hard-to-obtain product level R&D data to analyze the export technology structure of a country or region. In our paper, to calculate the technical complexity of high-tech manufacturing exports, we try to use Hausmann's method to construct an associated productivity level index (which we call PRODY). The formula is as follows:

$$PRODY_j = \sum_i \frac{\frac{x_{ij}}{X_i}}{\sum_j \frac{x_{ij}}{X_i}} Y_i \quad (1)$$

In the formula,  $X_{ij}$  is the export value of export  $j$  in country  $i$ , and  $X_i$  is the total export value of country  $i$ , and  $Y_i$  is the per capita income level, which are usually substituted by per-capita GDP.

Next, we calculate the total export technological complexity of a country through the EXPY:

$$EXPY_i = \sum_j \frac{x_{ij}}{\sum_j x_{ij}} PRODY_j \quad (2)$$

EXPY index is weighted average of all high-tech manufacturing exports' PRODY in country  $i$ . More generally, we find that EXPY is a strong and robust predictor which can reflect the overall export technological content and industry competitiveness of a country's high-tech manufacture.

### 2.2 Data and Results

We select the SITC (Rev3) 3-digit high-tech manufacturing exports data of countries in the world from 2007 to 2016. Various countries export data are from UN COMTRADE database. As for  $Y_i$ , we use the metadata for PPP (purchasing power parity) GDP in 2011 international dollars which are taken from the World Bank open database.

#### 2.2.1 Classification of High-tech Manufacturing Exports

According to the above algorithm, the PRODY of 18 types of high-tech manufacturing exports from 2000 to 2016 around the world is then obtained. Then we can get a classification of high-tech

manufacturing exports of 4 complexity levels: high-tech complexity, upper-middle-tech complexity, lower-middle-tech complexity and low-tech complexity. The technical complexity classification of high-tech manufacturing export products is shown in Table 1. Among that, the specific industry of the exports is matched by the latest *National Economic Industry Classification* (GB/T 4754-2017).

Table 1. Classification of high-tech manufacturing exports

Classification	Codes	Exports	Industry
High-tech Complexity Exports	541	MEDICINES, ETC.EXC.GRP542	Manufacture of Medicines
	718	OTH.POWR.GENRTNG.MACHNRY	Manufacture of Aircrafts and Space crafts and Related Equipment
	759	PARTS, FOR OFFICE MACHINS	Manufacture of Computers and Office Equipment
	774	ELECTRO-MEDCL, XRAY EQUIP	Manufacture of Medical Equipment and Measuring Instrument
	882	PHOTO. CINEMATOGRPH.SUPPL	Manufacture of Electronic Equipment and Communication Equipment
Upper-middle-tech Complexity Exports	542	MEDICAMENTS	Manufacture of Medicines
	776	TRANSISTORS, VALVES, ETC.	Manufacture of Electronic Equipment and Communication Equipment
Lower-middle-tech Complexity Exports	712	STEAM TURBINES	Manufacture of Aircrafts and Space crafts and Related Equipment
	751	OFFICE MACHINES	Manufacture of Computers and Office Equipment
	752	AUTOMATC.DATA PROC.EQUIP	Manufacture of Computers and Office Equipment
	764	TELECOMM. EQUIP.PARTS NES	Manufacture of Electronic Equipment and Communication Equipment
	771	ELECT POWER MACHNY.PARTS	Manufacture of Electronic Equipment and Communication Equipment
	778	ELECTRIC.MACH.APPART.NES	Manufacture of Electronic Equipment and Communication Equipment
	792	AIRCRAFT, ASSOCTD.EQUIPNT	Manufacture of Aircrafts and Space crafts and Related Equipment
	874	MEASURE, CONTROL INSTRMNT	Manufacture of Medical Equipment and Measuring Instrument
Low-tech Complexity Exports	716	ROTATING ELECTRIC PLANT	Manufacture of Electronic Equipment and Communication Equipment
	761	TELEVISION RECEIVERS ETC	Manufacture of Electronic Equipment and Communication Equipment
	871	OPTICAL INSTRUMENTS, NES	Manufacture of Medical Equipment and Measuring Instrument

The standard of the classification is as follows: If the average PRODY of exports is greater than 29,557, it belongs to high-tech complexity exports; if the PRODY is less than 29,557 but greater than 25,845, it belongs to medium-high-tech complexity exports; if the PRODY is less than 25,845 but greater than 23,108, it belongs to medium-low-tech complexity exports; else it belongs to low-tech complexity exports. The cut-off point is determined by the quartiles of PRODY for high-tech exports over the past decade.

According to the results shown in Table 1, there are some conclusions as follows: First, the technical content of the two exports belong to the pharmaceutical manufacturing industry is relatively high, of which medicines (541) have a mean value of PRODY of 36,958 US dollars during the past ten years and have already exceeded \$40,000 in 2016. The other medicaments (542) have a PRODY value of more than \$30,000 in 2016. Second, the high-tech complexity exports classified by this paper are involved in 5 major high-tech industries, none of which is left. The phenomenon indicates that the technical content of exports in all high-tech industries has been greatly improved in recent years, as well as maintained a balanced development, which is to say that high-tech manufacture has begun to present a good situation of “all flowers bloom together”. Third, the low-tech complexity exports in this paper totally contain 3 types: rotating electric plant (716), television receivers (761) and optical instruments (871), but the PRODY values of these 3 types still improved year by year, for example the PRODY value of Optical instruments (871) in 2016 has reached a level in excess of \$25,000. These 3 low-tech complexity exports are mainly from two industries: electronic and communication equipment manufacturing, medical equipment and measuring instrument manufacturing industries, indicating that these two industries should continue to strengthen the technological level of exports and further consolidate an important position in the high-tech industrial chain.

### 2.2.2 Export Technology Complexity Structure of High-tech Manufacturing

Generally speaking, developed countries specialize in the technical complexity of R&D design and key parts production in the production value chain, while developing countries focus on less complex technology process such as raw material supply, assembly processing and simple parts production. The complexity structure of a country's high-tech manufacturing exports can reflect the status of the country in the global value chains to some extent. The paper compares changes in the technical structure of high-tech manufacturing exports between China and the US as below.

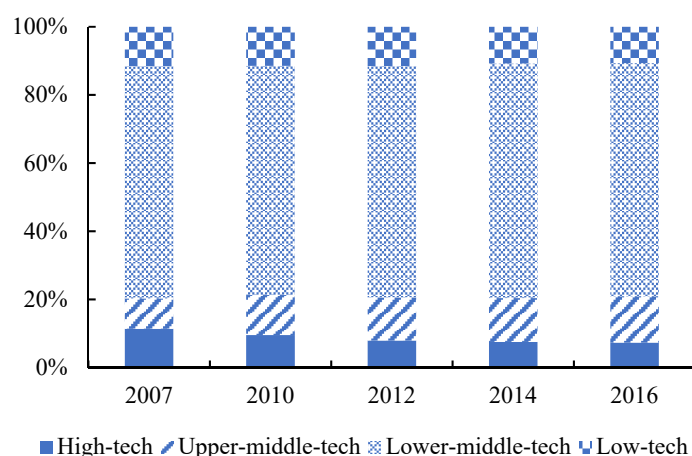


Fig. 2 China's high-tech manufacturing export technology complexity structure

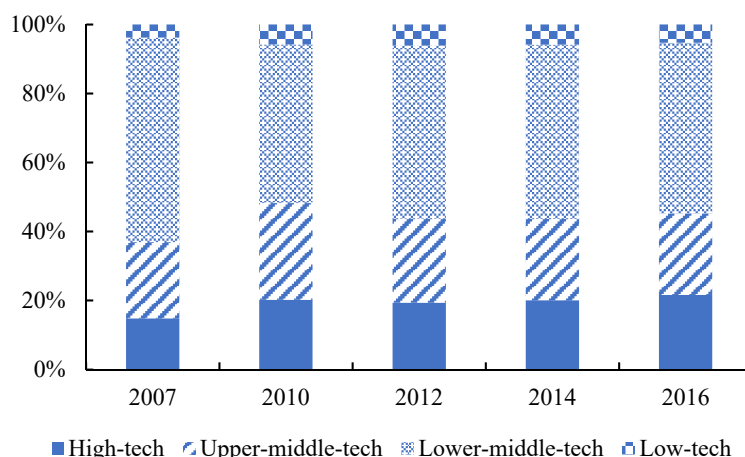


Fig. 3 America's high-tech manufacturing export technology complexity structure  
Data source: The author complies with the calculated results.

There are major differences in the technological complexity of high-tech industries between China and the United States. On the whole, although the most important high-tech manufacturing exports by China and the United States are both lower-middle-tech complexity exports currently, the proportion of exports of various technical complexity types is relatively different. China's lower-middle-tech complexity exports have maintained an absolute advantage of over 70% during the past decade, which severely squeezed other types of exports, resulting in upper-middle-tech and high-tech complexity exports ratio are very small and there has been no upward trend in recent years; However, the United States presents another scene. High-tech and upper-middle-tech complexity types are on equal with the lower-middle-tech complexity exports. Like the proportion of high-tech complexity exports have been floating at a level of 20% since 2010. Moreover, although the low-tech complexity exports of high-tech industries both in China and America account for the smallest proportion of exports compared to other types of complex products, the United States is much smaller than China and the gap is basically controlled within 5%. Then we consider the changing rules, the technical complexity structure of China's high-tech manufacturing has been relatively stable over the years. Besides there has been a slight increase in the proportion of products with upper-middle-tech complexity exports and a slight decrease in the proportion of high-tech complexity exports. In contrast, the structure of high-tech industries in the United States has been quite volatile. There is a significant downward trend of the proportion of lower-middle-tech complexity exports in 2016 compared with that of 2007, on the opposite, that the proportion of upper-middle-tech complexity type shows a slow growth year by year. It can be seen that in the overall change the United States, as a developed country, is superior to China in the export structure of high-tech manufacturing industry, which is to say the high-tech manufacturing industry in the United States exports products to the world with much more technical content and higher technical complexity compared with China.

### 2.2.3 Overall Technical Level Analysis

Next, the paper analyzes the technical level of high-tech manufacturing industry in China and the United States by measuring the EXPY index. Referring to the comparison of the average EXPY index of China, the US and the world as shown in Fig 4, the conclusions can be drawn: First, since 2007, the average EXPY level of the world high-tech industry has been above \$20,000, and by 2016 the value has approached \$30,000. This situation also indicates that the per capita output of high-tech industries is indeed much higher than other industries. Second, the average EXPY level of the three has shown a steady upward trend in the past decade (except for the 2008 financial crisis). In addition to the impact of high-tech industries in various countries, the high-tech industry EXPY value in the US is higher than China and the world average, as well as China is just slightly higher than the world average in most of the year; Third, focus on 2008-2009, this paper found that the average high-tech industry EXPY value in China and the world had declined rapidly, while the US high-tech industry's

EXPY value was basically the same, indicating that the high-tech manufacturing industry in China is less resistant to economic shocks compared with in the US. However, Fig 4 shows the technical level of overall China's high-tech industry is approaching the US year by year, and the gap between the two countries is in the process of steady shrinking. In particular, China has vigorously developed emerging high-tech industries to provide comprehensive external conditions for the development of high-tech industry in recent years. We believe that the development of China's high-tech industries will certainly catch up with the pace of the world's major developed countries in the future.

Through the analysis, China's high-tech industrial structure is not as mature as the US, and the overall technical level of the industry is slightly lower than that of the US. Therefore, what China should do first in the economy is to promote the development of high-tech manufacturing and commit to establish an independent industrial system with the highest technological level in the world. In light of the current Sino-US trade war, we need face up to the strength of the US, seeing the gap, and learn from America's high-tech manufacturing, and never let anti-American sentiment dominate our work. Back to our country itself, we should systematically plan targeted economic policies for industrial development and protection, especially for industrial technology level. If the government can take proper measurements, trade war can help accelerate the process of China's economic development and transformation into developed countries.

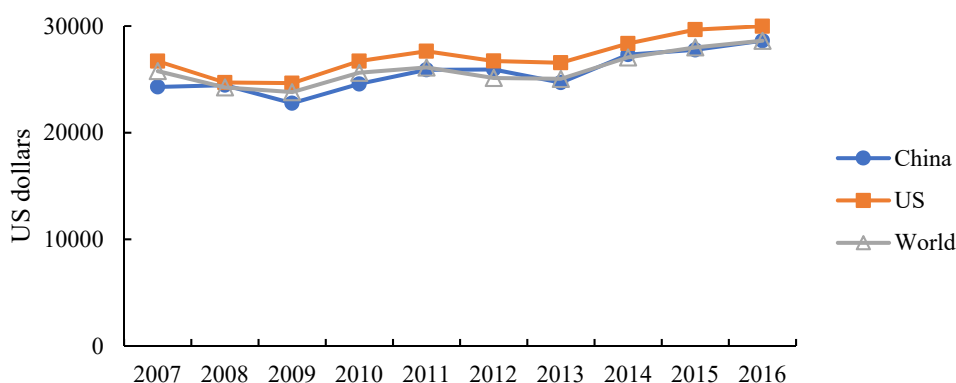


Fig.4 China, the United States, the world high-tech industry EXPY index  
Data source: The author complies with the calculated results.

### 3. Conclusion

In this section, the paper sorts out the important conclusions of the full text, aiming to provide some experience for the study of high-tech manufacturing industry in China and the United States.

Despite China's high-tech manufacturing exports are larger than the US, the export structure of high-tech manufacturing industry in China is not as mature as that of in the United States, and the overall technical level is also slightly lower than that of the United States. The technical level of the high-tech industries in both two countries is higher than the world average. Specifically, China's low-tech complexity exports in high-tech manufacturing industry account for more than 70% of the absolute advantage over the years, but the proportion of upper-middle-tech and high-tech complexity exports are very small (about 10%); lower-middle-tech complexity exports is also an essential part for high-tech manufacturing industry in the US, but the upper-middle-tech and high-tech complexity exports can be equally divided as well. As a developed country, the US's high-tech manufacturing export technology complexity structure is better than China's overall. There is still a lot of potential for the development of China's high-tech manufacturing export structure.

However, on the other hand, that the United States attempts to curb the development of China's high-tech industries through the trade war approach will not produce much effect in a short period of time. The structure of high-tech manufacturing in China and the United States has been in a relatively stable process of change. Each segment of the industry is gradually moving forward in accordance with the laws governing the development of its own industry, although a series of measures such as



the Trump government tariff policy will inevitably cause fluctuations to, but China's high-tech industry has formed certain anti-impact capabilities for many years, so it is rather difficult to form the threats which can shake the high-tech industry fundamentals in China.

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