

The Empirical Analysis of High-tech Trade Imbalance Between China and the US

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Abstract-The United States, as a leader in technology industry, has been in a deficit position for a long time in the high-tech trade between China and the United States, which has been increasing year by year. This is obviously contrary to traditional international trade theory and the comparative advantages of the two countries. Based on the US policy restrictions on China's high-tech product exports, the enhancement of China's independent innovation capabilities, and international direct investment in China, this article conducts an empirical analysis to explore the reasons for the China-US high-tech trade imbalance and then gives corresponding policy recommendations.

1 Introduction

The United States and China, as the first and second largest economies in the world, have close relation on trade. However, the trade between the two countries is in a state of imbalance for long time, especially in the high-tech field. According to Chinese statistics, the United States began to have a trade deficit in 1993 in Sino-US trade with a number of 6.3 billion dollars, which rose to \$ 58.6 billion in 2003, 8 times larger than that of 1993.

According to the US Bureau of Economic Analysis, China and the United States had an overall deficit of 283.6 billion US dollars in 2008 and 380.8 billion US dollars in 2018. The deficit increased more than 100 billion US dollars in the ten years. According to US Census Bureau statistics, the gap between China and the US in high-tech trade in 2006 reached 54.982 billion U.S. dollars, which increased to 115.691 billion U.S. dollars in 2016, more than doubling in ten years. This imbalance runs counter to the theory of comparative advantage and it is of great significance to explore the causes of this interesting phenomenon.

2 Literature review

Adam Smith is the first one who put forward the theory of absolute cost in his book *Research on the Nature and Causes of National Wealth* in 1776. In this book, he pointed that the reason for international trade is the difference in absolute costs between countries. Ricardo developed this theory and proposed the principle of comparative advantage in his book *Principles of Political Economy and Taxation* in 1817. He believed that the international trade was based on relative differences in production technology rather than absolute differences.

Swedish economist Heckscher (1919) put aside the differences in production technology between the two countries in his article *The Impact of Foreign Trade on Income Distribution* and studied the impact of resource endowment differences on international trade. Ohlin (1935) explained this theory further in his book *International Trade*. People combined the two sights and called it H-O theory. The theory holds that a country tends to export products that use its abundant production factors intensively and imports products that use its scarce production factors intensively. However, Leontief (1953) analyzed the US import and export data in 1947 in the report *Domestic Production and Foreign Trade: The American Capital Position Re-Examined* and found that the capital-labor ratio of US exports was lower than the capital-labor of imported substitute ratio, which challenged the H-O theory. Vanek (1968) established the H-O-V model based on the H-O theory and proposed a linear function of the volume of international trade and the endowment of a country's factors. He believed that international trade was essentially the international exchange of factors rather than commodities. Later Leamer (1980) pointed out the problem of the mystery of Leontief in *The Leontief Paradox, Reconsidered*. He believed that the capital-labor ratio of net exports should be compared with the capital-labor ratio of domestic consumption; Trefler (1993) introduced technical differences and domestic preferences in his article *International Factor Price Differences*, Leontief was right! and improved the theory. Although theories above are expressed differently, they essentially believe that the reason for international trade is the difference in product prices.

Factor endowments have become diversified as the theory of comparative advantage developed. Non-traditional factors such as technology, human capital,

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population growth and regional systems have gradually been added. Balassa (1987) proposed the comparative advantage stage theory in Comparative Advantage. He believed that a country's factor endowment would change with the continuous development of the country's economy and the comparative advantage of imported and exported goods will change accordingly. Then, Oniki & Uzawa (1965) proposed in the Patterns of Trade and Investment in a Dynamic Model of International Trade that the accumulation of endogenous capital and population growth would change the comparative advantage between countries, and then change their respective trade model. Grossman & Helpman (1990) in Trade; Innovation; And Growth believed that the reason for the dynamic evolution of comparative advantage was the investment in research and development (R & D) and technological advancement in a country. In addition to the diversification of endowments and endogenous and exogenous development, the areas of application of comparative advantages are also expanding, from the initial explanation of international trade to domestic economic development such as domestic regional trade and industrial structure upgrading.

Although the theory of comparative advantage is of great significance for the analysis of international trade, the current reasons for the imbalance of high-tech trade between China and the United States cannot be explained by this theory. Liu Wei (2009) proposed that the trade deficit in the communication products between China and the United States in the high-tech trade deficit is much larger than that in other high-tech products. Chen Peng and Xiong Pinsan (2013) further pointed out that the United States has transferred some of the manufacturing and processing links of high-tech product that have entered the recession to countries with lower labor costs, such as China, to reduce the expense. After the production of the product is completed, it is exported abroad. This transfer of high-tech industries has promoted the growth of foreign-invested enterprises' investment in China, including the United States, which has also promoted the export of high-tech products by domestic and foreign-funded enterprises. However, its substitution effect on China's imported high-tech products is limited, resulting in a growing trade deficit between China and the United States in high-tech products. Shen Guobing (2006) proposed that the United States imposed trade sanctions and technology embargoes on China after 1989, and strengthened the export control of high-tech products in China, resulting in distortion of China's imports of high-tech products from the United States, leading to a high-tech trade deficit between China and the United States. Du Li (2006) further proposed that the United States has always been "warning" to China and has always restricted the export of high-tech products related to safety issues, such as nuclear power plants, satellites, supercomputers, and CNC machine tools. This has led to the expansion of the Sino-US high-tech trade deficit. Chen Peng and Xiong Pinsan (2013) pointed out that since China's accession to the WTO, investment in independent innovation has been increasing, and the number of patents granted has also increased significantly. From 2001 to 2009, China's R & D investment in high-tech industries increased by nearly

7.4 billion yuan, and the number of three patents granted increased by nearly 470,000. The increasing level of China's independent innovation has reduced China's imports of high-tech products, and to some extent has led to an increase in the trade deficit between China and the US in high-tech products. Kang Meiling (2006) pointed out that the inconsistent statistical caliber of China and the United States exaggerated the imbalance in trade between the two countries. Fung & Lau (1998, 2001, 2003a) and Feinstra et al. (1998, 1999, 2002) estimated the data on China-US trade imbalance, respectively, and concluded that the statistical calibers between China and the US were not consistent and exaggerated the trade imbalance between the two countries. US used FAS and China used FOB, which is 1% higher than the former. The US export value to China should be adjusted upward by 1%.

3 The Situation Analysis

According to the theory of comparative advantage, the two parties in international trade should each export products with comparative advantages to each other, and import products without comparative advantages. For example, in the Sino-US trade, the United States has a comparative advantage in high technology. According to this theory, the US should be the US surplus with China in high-tech products trade, but the actual situation is quite different. The following is an analysis of the current status of Sino-US high-tech trade.

3.1 The definition of high technology

Here we define high-tech to analyze the Sino-US trade structure from the perspective of comparative advantage. Therefore, the "high-tech" in this article is the relative technology between the two countries, that is, the United States has a comparative advantage over China. Here we mainly refer to two standards: one is the ten major areas mentioned in the "Made in China 2025" issued by the State Council, including new-generation information technology products, high-end CNC machine tools and robots, aerospace equipment, marine engineering equipment and high technology Ships, advanced rail transportation equipment, energy-saving and new energy vehicles, power equipment, agricultural machinery equipment, new materials, biomedicine and high-performance medical equipment. These ten major areas are proposed in the context of a new generation of information technology revolution, in order to seize the commanding heights of technology with countries around the world and driven by domestic demand. They both reflect the development direction of today's cutting-edge technology and the deficiencies of China's manufacturing industry, which are in line with our definition of high technology. In addition, the U.S. Federal Bureau of Statistics lists information and communication products, optoelectronics, weapons, flexible manufacturing, aerospace, electronics, life sciences and other fields under high technology. Accurate data is available for analysis, so this article will use this as a high-tech definition and analysis standard.

3.2 Status and Trend of Sino-US "High-Tech" product trade

In the circumstances of the overall US-China trade deficit, the United States should have a surplus with China in high-tech areas that the former one holds comparative advantages. However, data from the U.S. Federal Bureau of Statistics shows that in the field of high-tech products, the US trade with China is in an overall deficit, which reached as high as US \$ 123.743 billion in 2014 and even continued to expand as shown in Figure 1. Moreover, the proportion of hi-tech products exported to China accounts for less than 0.1% of the world's hi-tech products. Against the background of such a large volume of total trade volume between China and the United States, the ratio of US exports to China's hi-tech sector is significantly too small (See Figure 2).

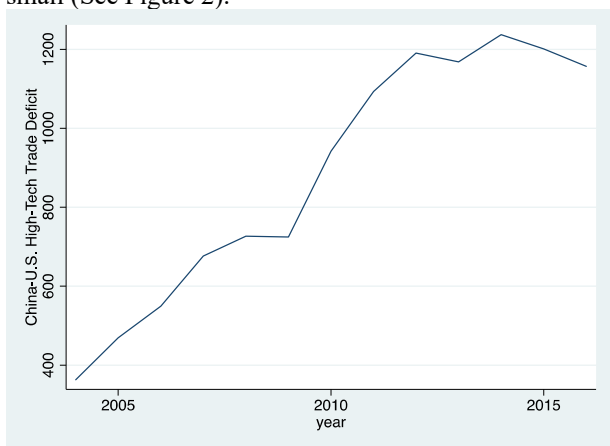


Figure 1. China-U.S. High-Tech Trade Deficit from 2004 to 2016

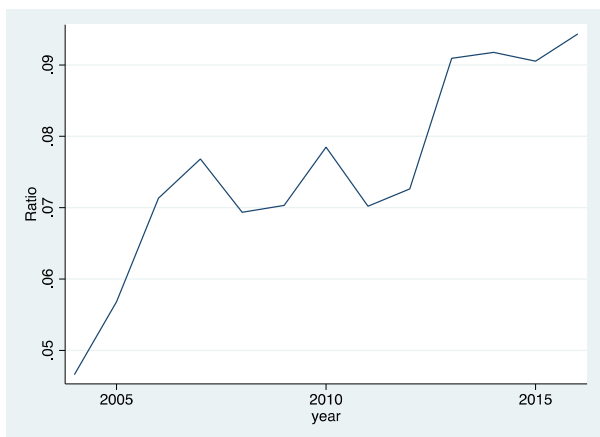


Figure 2. Ratio of U.S. exports of high-tech products to China and U.S. exports to world

Specifically, the United States has a deficit with China in the fields of information and communication, optoelectronics, and weapons, especially information technology products (See Figure 3).

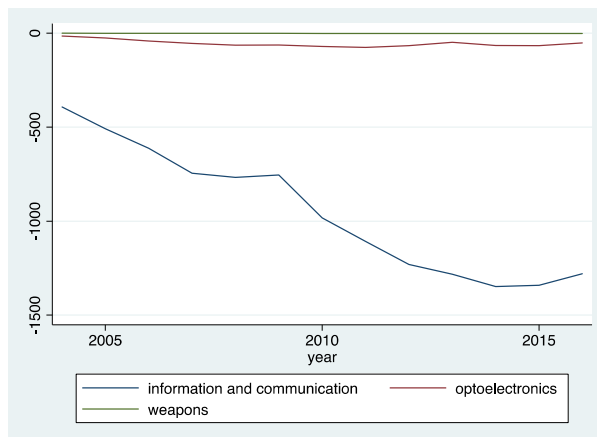


Figure 3. U.S.-China high-tech deficit products from 2004 to 2016

The U.S. surplus of high-tech products to China was only in flexible manufacturing, aerospace, electronics and life sciences. Besides the large surplus in the aerospace field, the gap in other fields was not large, and it has been significantly reduced since 2010 (see Figure 4).

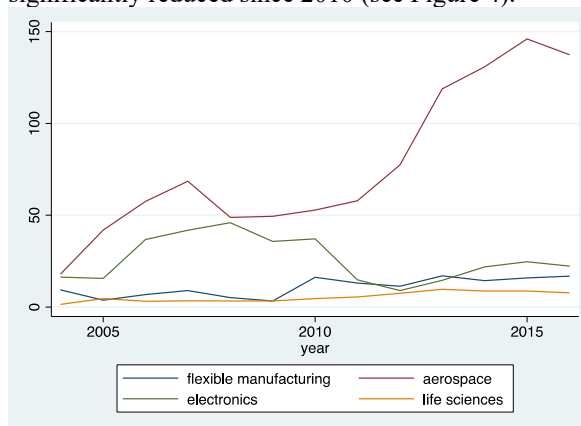


Figure 4. 2004-2016 U.S.-China surplus high-tech products

In summary, according to the theory of comparative advantage, US exports to China's high-tech fields do not conform to the actual conditions of the two countries, and even run counter to known theories. This phenomenon deserves further analysis.

4 Empirical analysis

Based on the above analysis, this article attempts to construct a dynamic model for regression estimation by using relevant data, and analyzes the estimated regression results to obtain feasible policy recommendations.

4.1 The Model and Data

This article uses a dynamic model to analyze the high-tech trade deficit between China and the United States.

$$\ln y_t = \alpha + \ln y_{t-1} + \beta x_t + \varepsilon_t \quad (1)$$

The independent variable is the logarithm of China-US high-tech trade balance, represented by $\ln y$, and the data comes from the US Census Bureau. With reference

to the research of other scholars, the explanatory variables in this article are US export restrictions on high-tech products, the level of innovation in China's high-tech industries, and foreign direct investment. This article uses the ratio of U.S. exports of high-tech products to China to U.S. exports to the world as a proxy for U.S. hi-tech product export restrictions, represented by *RATIO*. The logarithm of the number of non-resident patents is the proxy variable of innovation level, represented by *PAENT*, and the data comes from the World Bank Group public database. The proportion of FDI to GDP as the proxy variable of foreign direct investment level in China is represented by *FDIGDP*. The data sources are the same as above. The paper also uses the lagged independent variable as an explanatory variable in the model to control other unobservable factors. Table 1 gives a statistical description of the data used in this article.

TABLE I. STATISTICAL DESCRIPTION OF VARIABLES

Variables	Number of observations	Mean	Standard deviation	Minimum value	Maximum value
Year	15	2011	4.472	2004	2018
lny	13	6.715	0.408	5.894	7.120
RATIO	15	0.060	0.014	0.036	0.079
PATENT	14	11.547	0.226	11.076	11.820
FDIGDP	15	3.068	1.098	1.367	4.554

Table 2 shows the results of the stationary test. The p-value is 0.0076, which indicates that it is a stationary process. *PATENT* and *FDIGDP* are stationary after first-order difference while *RATIO* after third-order difference.

TABLE II. STATIONARITY TEST

Variables	Difference	Z Value	P Value
lny	0	-3.515	0.0076
RATIO	3	-3.400	0.0110
PATENT	1	-3.647	0.0049
FDIGDP	1	-4.703	0.0001

4.2 Regression results and analysis

$$lny = 0.77lny_{-1} - 1.24RATIO + 0.94PATENT + 0.007FDIGDP \quad (2)$$

From the regression results, we can see that the US government's policy restrictions on the export of high-tech products, China's ability to undertake foreign direct investment and China's ability to innovate independently have a effect on the China-US high-tech trade deficit. The regression coefficient of *FDIGDP* is 0.007, which indicates that the proportion of FDI to GDP changes by one unit, and *lny* changes by 0.007. So the increase in international direct investment has a positive impact on

the expansion of the China-US trade deficit. The regression coefficient of patent is 0.94, which shows that the improvement of China's independent innovation capability will promote the increase of China-US high-tech trade deficit. The regression coefficient of lagged *lny* period is 0.761, which is significant at the level of 99%, which is consistent with the results of the stationarity test in this paper.

RATIO is the ratio of US exports of high-tech products to China to US exports of high-tech products to the world, reflecting the US government's restrictions on high-tech exports to China. The regression coefficient of *RATIO* is -1.24, which indicates that the total share of high-tech products exported by the United States to China increased by one unit, and the Sino-US high-tech trade deficit will decrease by 1.24. This shows that the US government's relaxation of restrictions on the export of high-tech products to China will have a positive impact on alleviating the imbalance between China and the United States in high-tech trade. Moreover, the absolute value of the US export control variable coefficient is the largest, indicating that the US export control policy is the most significant impact on China-US high-tech product trade imbalance.

In order to further verify the impact of the US government's policy restrictions on the export of high-tech products, China's ability to undertake foreign direct investment, and China's increased capacity for independent innovation on the Sino-US high-tech trade deficit, this article conducts a Granger causality test. Table 3 shows the test results. It is obvious that the improvement of China's independent innovation capability, the actual use of foreign capital and the US export controls on China are the reasons for the growing gap between China and the United States in high-tech products, and the reverse causality does not exist.

TABLE III. GRANGER CAUSALITY TEST RESULTS

Null hypothesis	F value	P value
RATIO is the Granger cause of lny	16.77	0.003
lny is the Granger cause of RATIO	0.28	0.761
PATENT is the Granger cause of lny	57.54	0.000
lny is the Granger cause of PATENT	0.11	0.900
FDIGDP is the Granger cause of lny	53.38	0.000
lny is the Granger cause of FDIGDP	0.65	0.543

5 Conclusions

The empirical results show that the US export restrictions on China's high-tech trade is an important reason for the significant deficit in the China-US high-tech trade, like

the United States Export Administration Regulations (hereinafter referred to as the Administrative Regulations) and the United States Export Controlled Commodities List (hereinafter referred to as the List).

The Administrative Regulations expired in 1994, but the current Export Management Regulations continues to be implemented within the scope authorized by the International Emergency Economic Power Law. The Administrative Regulations contain more than 13 control reasons for prohibiting technology exports, and there are more than 11 control reasons for China's high-tech exports. In addition, the List divides the controlled commodities into 10 categories, including computers, telecommunications and information security, navigation and avionics, and spacecraft and other high-tech products. Each of these categories has items that restrict export to China, not only at the product level, but also in product-related technologies, software, materials, and even test products. On June 15, 2007, the U.S. Department of Commerce officially announced the Amendments and Interpretations of the Export and Re-Export Control Policies of the People's Republic of China; New Verified End-User System; Modification of Import Certificates and Chinese End-User Specification Requirements (Hereinafter referred to as the New Regulations) The "New Regulations" expanded the scope of merchandise for military export licenses to China and required the Chinese Ministry of Commerce to issue end-user instructions, further strengthening restrictions on high-tech exports to China. On May 16, 2019, the U.S. Department of Commerce's Industry and Security Administration (BIS) added Huawei Technologies Co., Ltd.

6 Policy recommendations

In order to control this factor as the impact of the high-tech trade deficit between China and the United States, China can import high-tech products from other high-tech countries, strengthen trade with other countries, expand imports of high-tech products from these countries, and improve its own technology. At the same time, the ability to innovate makes up for the shortage of Chinese imports of high-tech products from the United States.

To fundamentally improve the imbalance between China and the United States in the trade of high-tech products, we must work hard to improve China's technological innovation capabilities and independent research and development levels, enhance the international competitiveness of independent research and development of high-tech products, increase the technological content of export products, and increase international competitiveness Position, thereby promoting the optimization and upgrading of China's export product structure. Firstly, increase R & D funding for high-tech products, give generous policy subsidies to some companies that focus on technological innovation, and guide and encourage domestic high-tech product manufacturing enterprises to conduct independent technology research and development through policy guidance. Secondly, pay attention to the cultivation of

technical talents, the introduction of talents, and attract and retain talents through technological innovation incentives and equity dividend incentive mechanisms.

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