Anti-Comparative Advantage: A Puzzle in US-China Bilateral Trade

Jiandong Ju, Qing Liu, Hong Ma, Yingyi Qian, and Ziru Wei[1]

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Abstract

The US-China bilateral trade has grown fast in the past three decades, while their trade imbalance also enlarges dramatically, especially after China's WTO accession in 2001. Significant structural adjustments are taking places in both countries. In particular, Obama administration has pledged to double US exports in 5 years, which may help US economy to grow and to reduce trade deficits. The importance of the structure in US-China bilateral trade is obvious in practice, yet studies in it have been very few in existing literature. This paper, therefore serves to fill this gap. Interestingly, this paper reveals a puzzle in the trade structures between China and the United States. That is: the US exports less to China in sectors it has greater comparative advantage, and the more US's productivity exceeds China in a sector, the less it exports to China than to the rest of the world; both facts get more significant after China's WTO accession. This seems to be inconsistent with the prediction of comparative advantage in standard trade theory. In contrast, the comparative advantage theory works well on China's exports to the US. Such a data pattern, named as "Anti-Comparative Advantage Puzzle", might be potentially due to the US's export control towards China or other factors affecting bilateral trade structures. We first provide some policy and data evidences; then employ an econometric analysis to control the impacts of other economic variables. Our results show that after controlling for production capacity, transportation costs, tariffs and factor intensity etc., the "Anti-Comparative Advantage Puzzle" still exists, and survives comprehensive robustness checks.

[1] Authors are all from the School of Economics and Management, Tsinghua University, Beijng, China. Ju is a Professor of Economics and the Director of the Center for International Economics Research, e-mail: jujd@sem.tsinghua.edu.cn; Liu is an Assistant Professor of Economics, e-mail: liuqing@sem.tsinghua.edu.cn; Ma is an Assistant Professor of Economics, e-mail: mahong@sem.tsinghua.edu.cn; Qian is a Professor of Economics and the Dean of the School of Economics and Management, e-mail: qianyy@sem.tsinghua.edu.cn; Wei is a PhD Candidate, e-mail: weizr04@gmail.com. We thank China Center for International Economics Exchanges (CCIEE) for financial support, and are grateful to Xinli Zheng, Jianguo Wei, Xianlei Wang, Jun Wang, Yongjun Zhang, Shaojun Zeng and Xiangdong Liu, all of whom are from CCIEE, for their helpful comments. We have benefited a lot from discussions with Shangjin Wei. We have also received useful comments from Yiping Huang, Kunwang Li, guijun Lin, Justin Yifu Lin, Yide Qiao, Yan Shen, Yi Wen, Yang Yao, Jinping Yu, Miaojie Yu, Yongding Yu, Lin Zhou, and Jianghuai Zheng as well as participants of the workshops and seminars at CCER at Beijing University, Business School of Nanjing University, Antai Economics and Management School at Shanghai Jiaotong University, Forum on World and Chinese Economy 2010 and The 9th Annual Meetings of International Trade Economics Association in Chinese Universities. However, we are responsible for all errors.

1. INTRODUCTION

The volume of trade between China and the US has grown dramatically in the past three decades. The two countries resumed diplomatic relations, signed bilateral trade agreements and gave each other the Most-Favored Nation status in 1979. Since then, according to the statistics of US International Trade Commission, US-China total trade volume (imports plus exports) has grown from $5 billion in 1980 to $409 billion in 2008, i.e., the trade volume increased 80 times in less than 30 years. Moreover, in recent 20 years, their bilateral trade volumes are growing at a surprisingly high rate of 20% annually on average. According to the statistics by the Chinese Customs, the exported goods from China to the US valued $252.3 billion in 2008, which account for 17.7% of the total Chinese export, while the imported goods from the US to China valued $81.4 billion, about 7.2% of the total imports in China. Despite the inconsistencies in two countries' statistical coverage, there is no doubt that China has now become US's second largest trading partner, and they are one of each other's very top export markets and import sources.

Along with the tremendous trade volume between China and the US is the huge trade imbalances observed in the bilateral trade, which is growing even faster in recent years. As demonstrated in Figure 1, the trade surplus (exports minus imports) of China towards the US is averaged at approximately $6.45 billion per annum between 1989 and 2000; while after the year of 2001 when China obtained its WTO accession, the annual average of their trade imbalance increases sharply; till 2008, China's trade surplus, or in symmetric term, US's trade deficit has amounted to as high as 170.9 billion US dollars. Such a huge trade imbalance has become a major political and economic issue between the two countries, and it also initiated a series of policy debates as well as academic controversies.

[Insert Figure 1 here]

The rapid increase in China's export volume generated an extensive concern in the United States and other developed countries, which also promoted a large number of studies on the causes of the US-China trade imbalance.[2] There are also studies focusing on the structure and features of China's

[2] One explanation for the trade imbalance focuses on the different statistical approach in China and the US when accounting for the bilateral trade; for example, Feenstra et al. (1998) claims that China's entrepot trade from Hong Kong might be an important source for the statistical difference; similar results can be found in Fung and Lau (1998, 2001, 2003). Other literatures such as Xu et al. (2010) suggest that it is the non-US foreign direct investment in China that leads to the US trade deficit. There are also extensive researches exploring the effect of RMB exchange rate on the trade imbalance, such as Blanchard and Giavazzi (2006), McKinnon and Schnabl (2005), which are beyond the scope of this paper.

export and its impacts on developed countries, especially the US.[3] Most of the studies, however, concentrate on China's export itself, but not the US-China bilateral trade. We have not found studies in structures of US's exports to China in existing literature. Our paper, therefore, serves to fill the gap in the literature in studying structures of the US-China bilateral trade, in particular, the structures of US's exports to China.

We find an interesting pattern in the US-China bilateral trade structures. That is, the US exports less to China in sectors it has greater comparative advantage (measured by relative productivity between US and China, or "revealed comparative advantage"); the greater comparative advantage in a sector in the US, the less it would export to China than to the rest of the world; both facts become more significant after 2001 when China entered into the WTO, with the coincidence in the time of the beginning of the rising US-China trade imbalances. Such a data pattern in US's exports to China is named as "Anti-Comparative Advantage Puzzle". In contrast, we find that the comparative advantage theory works quite well on China's exports to the US.

Our paper is not the first to document that the US exports may not be consistent with the theory of comparative advantage. A recent paper by Berger et al. (2010) exploited the declassified CIA documents to examine whether there is the evidence of US power being used to influence countries' trade decisions during the Cold War. After controlling for the effects of bilateral trade costs, political ideology, and supply of US loans and grants, they found there was an increase in foreign-country's imports from the US following CIA interventions. Further, the increase in US exports was concentrated in industries where the US had a comparative disadvantage in production, rather than a comparative advantage. Investigations in what causes "Anti-Comparative Advantage Puzzle" in US exports to China is beyond the scope of this paper. However, the finding by Berger et al. (2010) indicates that policy interventions, the US's export control policy in particular, should be on top of the list for further examinations.

The disputes in US-China trade imbalances can be stated as either "why does China export too much to US", or "why does US export too little to China"? Our findings in this paper reveal a structural problem in the US-China bilateral trade. The US-China trade imbalance may partially due to the fact that US exports too little to China than to the rest of the world in sectors it has greater

[3] Rodrik (2006) shows that China's export structure cannot be simply explained by its comparative advantage and free trade; the variety of the exported goods from China is much more complicated than what is suggested by its income level, and moreover, this will be a key force for China's future economic growth. This paper was followed up by further studies, such as Schott (2008), Wang and Wei (2010), Amiti and Freund (2010).

comparative advantage.

Obama administration recently pledged to revive US's economy and stimulate employment by doubling the exports in 5 years. The realization of the "export-doubling" plan relies crucially on whether the US can double its exports to China, its most important trade partner. Our finding is encouraging as it indicates that the US may be able to significantly increase its exports to China by exporting more goods to China in sectors it could and should have exported more.

The rest of the paper is organized as follows. In Section 2 we use the US-China sector-level trade data from 1989 to 2008 to reveal statistics of the trade pattern between China and the US, and the "Anti-Comparative Advantage Puzzle". In Sections 3 and 4 we introduce an econometric model to analyze other factors that affect bilateral trade volumes between the two countries, such as productivity capacity, transportation costs, tariffs, factor intensity etc., and report the empirical results. A comprehensive robustness checks follow in Section 5, and finally we conclude in Section 6.

2. STYLIZED FACTS AND POTENTIAL EXPLANATIONS

2.1 Overview of the US-China Bilateral Trade

As we've discussed in the introduction, the rapid growth of the US-China bilateral trade is associated the rising trade imbalance between the two countries. Figure 2 reports the changes of China's share in the US global trade and the US's share in China's total trade in the past 20 years (1989-08). Data show that both China's share in US's imports and US's share in China's exports grow steadily and rapidly in the past 20 years. However, to our surprise, US's share in China's imports does not increase, rather, it decreases from about 10% in 1989 to about 6% in 2008.

[Insert Figure 2 here]

We divided US-China trade products into 21 sectors, as listed in Table 1, which will act as the main industry classification in this paper. Except for Agricultural primary goods, the other 20 sectors all belong to manufacturing industry. The first two columns of Table 1 display the US's relative productivity to China (defined by "Value-added-output per labor of the US over that of China") in 1989 and 2008. Columns (3) and (4) summarize the sectoral shares of US exports to China in the same two years, compared with columns (5) and (6) reporting shares of China's sectoral exports to the US (defined in Equation (1) later). Generally speaking, Table 1 shows that sectors with the highest

US-to-China relative productivity are not usually those with largest exporting shares from the US to China.

[Insert Table 1 here]

In Figures 4 and 5, we plot the trends of the six largest US-China trading sectors from 1989 to 2008, to provide a brief description of the changes in their trade structures during the past two decades. For US's exports to China, machineries sector and transportation equipments sector are the largest two sectors, though decreasing in shares over time. In recent years, agricultural products and metallic products are catching up in their shares. For China's exports to the US, electrical equipment replaces textile and leather as the most significant contributor to the huge amount of export volume. Besides those three sectors, miscellaneous products (including electronic products) and metallic products also take significant shares in China's total exports to US.

[Insert Figure 3&4 here]

2.2 The Anti-Comparative Advantage data pattern

According to the theory of comparative advantage, a country should export more products in sectors that it has higher relative technology compared to other countries, and import more products in sectors it has lower relative technology. Following Golub and Hsieh (2000), we use relative labor productivity to represent relative technology in this paper. [4] Labor productivity is simply calculated as value-added output divided by the total employment. Then relative productivity is defined as the ratio of the exporter's labor productivity to the importer's labor productivity. A higher value of relative productivity for the exporting country in one particular sector can be interpreted as greater comparative advantage of the sector.

The prediction from the theory of comparative advantage suggests that the US is expected to export more to China in the sectors where it has higher relative productivity. Therefore, we expect a positive correlation between a country's sectoral export shares and sectoral relative productivity. The sectoral export shares are defined as follows:

$$XShare^{1}_{i,c} = \frac{\text{Country c's export to its partner in sector i}}{\text{Country c's total exports to its partner}} \quad \text{(c=China, US)} \tag{1}$$

[4] However, Golub and Hsieh (2000) use labor compensation data to generate unit labor cost, which includes wage and non-wage benefit.

$$XShare^{2}_{i,c} = \frac{\text{Country c's export to its partner in sector i}}{\text{Country c's total exports to the world in sector i}} \quad \text{(c=China, US)} \tag{2}$$

where country c can either be China, with US as the trade partner, or the United States, with China as the trade partner. We define the sectoral export shares in two ways. Definition (1) measures the share of exports within the bilateral trade framework. The problem of definition (1) is that the low share of country c's exports to its partner in sector i may just reflects that country c exports very little in sector i to the rest of the world. Definition (2), therefore, partially corrects the problem by measuring sectoral trade share in the scope of a country's worldwide sectoral trade.

[Insert Table 2 here]

Column (3) in Table 2 shows positive correlations between sectoral export shares (defined by equation (1)) from China to the US and the relative productivity between China and the US, which is consistent with the prediction from standard theory of comparative advantage. The positive correlation becomes more prominent in recent years. Column (2), however, strikes us that the opposite is true in US side: the US exports relatively less to China in sectors it has higher relative productivity. The negative correlation becomes even more significant in Column (2) after 2001. To control the fact that US may just export very little in some sectors than other sectors, we use definition (2) to export shares. The same patterns are observed. Column (4) shows that the higher US's productivity relative to China, the less it exports to China than to the rest of the world. Column (5) shows the opposite that China exports more to the US than the rest of the world in its relatively more productive sectors.

Due to the unavailability of labor productivity data from China at more disaggregate level, our analysis is restricted to the Chinese industrial classification which has 21 sectors. The trade data, however, may provide some insights at more disaggregated level. Using 8-digit Harmonized System Code (HS8), we can break the US-China commodity trade down to more than 6,000 products, and calculate the export shares for China and the US in each HS8 products according to Equations (1) and (2). Table 3 lists the 10 largest products for US-China bilateral trade in 2006, sorted by $Xshare^1$. The top 10 products exporting from the US to China contain some high-tech and capital intensive manufacturing (chips and airplane parts etc.), agricultural and textile primary goods, and a large share of metal scraps (copper, aluminum and steel wastes). If it is sorted by $Xshare^2$, steel wastes, copper wastes and aluminum wastes are the top 3, which the US exports more than half of its total exports to Chinese market. The 10 largest products exported from China to the US are mostly labor-intensive manufacture goods

[Insert Table 3 here]

The “Anti-Comparative Advantage puzzle” data pattern may be driven either by restricted supplies from US side or sluggish demands from China side. While comprehensive investigations in either supply side or demand side are beyond the scope of this paper, we briefly discuss next on US export control (from supply side), and compare US exports to China with India to examine if there is a lack of demand for US high-tech products in emerging markets

2.3 The History of US Export Control

The US has a long history of export restrictions towards China, which can be dated back to the Cold War. In 1948, the US proposed to establish Committee Controlling East-West Trade (COCOM) in order to implement military embargo against the socialist countries. Then in 1952, by the impact of the Korean War, COCOM set up the “China Commission”, implementing stricter embargo policies on China than the Soviet Union and Eastern European; the ban list for China included 500 more items than the international ban list. Eventually, with China's economic development and the progress of US-China diplomatic relation, the strength of US export control towards China had been weakened gradually. However in 1989 the United States again suspended its cooperation with China on military-technical projects, and all other COCOM members announced the termination of their previous relax on high-tech exports to China. In 1995, the US developed an export priority system based on the exporting products and their technology content, dividing countries in the world into 8 categories. China was drawn in the sixth category “Outsiders” together with India and Singapore, which is below the category of “Comrades” where Russia, Ukraine, Bulgaria and Romania belonged to, and over “The States of Concern” with members like Iraq, Iran, North Korea and Libya etc.

In 1996, the United States and other 32 western countries signed the "Wassenaar Agreement” (WA), deciding to implement the new control list and information exchange rules since November 1, 1996; China was still one of the banned countries. WA included two control lists: one is a list of dual-use goods and technologies; the other is the military list.

The most recent adjustment of US export control policy occurred on June 19, 2007, when the Bureau of Industry Security in the US Department of Commerce officially announced the “Revisions and Clarification of Export and Re-export Controls for the People’s Republic of China (PRC); New Authorization Validated End-User; Revision of Import Certificate and PRC End-User Statement

Requirements". This policy prohibited the exporting of 9 categories of products (See Table A1 in Appendix A) to China, all of which are classified as with technologies likely to "enhance China's military strength". Besides, the US "Validated End-User" plan regulates that only "Trusted clients" can import restricted goods without special authorization. By the end of 2009, only five companies in China had received such VEU status, but none of which is local owned enterprise.

2.4 China-India Comparison

It will be more convincing to compare US high-tech exports to China with a similar country, such as India. China and India are both the world's largest developing countries with similar income level, similar location and similar demand for high-tech products. Here we use US skill intensity as a measure for technology (We did not use skill-intensity previously because the Chinese skill intensity data are unavailable). The definition of skill intensity is skilled labor income divided by total income for a certain industry. Higher skill intensity usually corresponds to higher labor productivity and technology level. The China and India comparison is extended under 4-digit Standard Industry Classification (SIC4), which provides a more disaggregate industry level (more than 400). The data we use are taken from the NBER-CES database.

Table 4 displays the 15 most technology intensive industries in the US and their export shares to China and India respectively, where Xshare^1 is still the measure defined by Equation (1) (with c=US), and $\text{Xshare}^2_{\text{std}}$ is calculated as Xshare^2 divided by China's (or India's) share in US total exports, as shown in Equation (3).

$$\text{Xshare}^2_{std} = \frac{\text{Xshare}^2}{\text{US's exports to China or India/US's total exports to the world}} \tag{3}$$

$\text{Xshare}^2_{\text{std}}$ is a standardization of Xshare^2 and fully comparable between different countries. Table 4 clearly shows that both shares for India are larger than those of China in top 15 high-tech industries.

[Insert Table 4 here]

3. ECONOMETRIC MODEL

In this part, we use an econometric model to formally test the effect of relative productivity (comparative advantage) on US-China bilateral trade structures. We apply the standard gravity model to multi-sector bilateral trade for a certain time span. In addition to relative productivity, the effects of sector-level production capacity, tariffs, transportation costs, and factor intensity on trade are all investigated.

Gravity Equation is commonly used to analyze multi-national or inter-regional trade flows. But when applied to the case of bilateral trade, we have to note that the geographic distance between any two countries is fixed and not changing over time. Also, specific bilateral variables such as whether sharing a common border or in the same Trade Union remain unchanged for a long time. Furthermore, the other main variables in Gravity Equation, such as country's GDP and population are invariant across sectors. To investigate the US-China inter-sector trade pattern, we develop a modified multi-sector Gravity Equation as follows:

$$EX_{i,t}^{us} = \beta_0 + \beta_1 GDP_{i,t}^{us} + \beta_2 GDP_{i,t}^{cn} + \beta_3 ED_t + \beta_4 T_{i,t}^{cn} + \beta_5 RP_{i,t}^{us/cn} + \beta_6 KI_{i,t} + Inter_{\mathrm{i,t}} + \delta_{\mathrm{i}} + \varepsilon_{\mathrm{t,i}} \qquad (4)$$

$$EX_{i,t}^{cn} = \beta_0 + \beta_1 GDP_{i,t}^{us} + \beta_2 GDP_{i,t}^{cn} + \beta_3 ED_t + \beta_4 T_{i,t}^{us} + \beta_5 RP_{i,t}^{cn/us} + \beta_6 KI_{i,t} + Inter_{\mathrm{i,t}} + \delta_{\mathrm{i}} + \varepsilon_{\mathrm{t,i}} \qquad (5)$$

where i denotes sector, t denotes year. EX^{us} and EX^{cn} are logarithm of the US and China's sectoral export volumes, respectively. Similarly, GDP^{us} and GDP^{cn} are the log of sectoral output in both countries. T^{cn} and T^{us} are the import-weighted tariff rate charged by China and the US. $RP^{us/cn}$ and $RP^{cn/us}$ are the relative productivities of both countries, with numerator in the superscript denoting the exporting country and denominator denoting importing country. *KI* is the capital intensity of each sector, defined by sectoral capital labor ratio. Due to the lack of Chinese data, we assume that China has the same sectoral capital intensity as the US. *Inter* is a vector of interaction terms that will be specified later. δ is sector fixed effect, which captures the specific impacts of each sector.

"Economic Distance" (ED) is a modified distance variable. Although the geographic distance between China and the US are constant overtime, their transport capacities are reinforced year by year. In a sense, the increase of either country's transport capacity is equivalent to shortening their geographic distance. Therefore we use the term "Economic distance", which is negatively correlated with both countries' overall transport capacity, to reflect their real geographic barrier of trade. The construction of this variable is discussed in Appendix B1.

4. EMPIRICAL RESULTS

Using the US-China trade data for 21 sectors from 1989 to 2008, we apply above econometric model to an empirical test. Sectoral GDP and labor productivity data for the US are from the BEA database; Chinese data is from the National Bureau of Statistics of China. Economic distance is calculated using data from the World Development Indicators. Tariff data is from WITS database. Capital intensity data is from the NBER-CES database.

We first run benchmark regressions without considering the interaction terms in Equations (4) and (5). Columns (1) and (3) in Table 5 report the benchmark results for US and China's bilateral exports. The results are summarized as follows: a). Sectoral GDP in both countries play positive roles in determining the sectoral trade volumes, while the US exports to China seem to be driven more notably by China's sectoral outputs. b). Economic distance significantly blocks the bilateral trade volumes, just like the role of geographic distance. c). The higher China-to-US relative productivity, the more China exports to the US, which is consistent with the prediction of comparative advantage theory. Those coefficients are all showing their expected signs. The US-to-China relative productivity, however, has a negligible (insignificant) impact on US exports to China.

[Insert Table 5 here]

With a data sample covering a time span of twenty years, the benchmark results capture only the average effects of explanatory variables. However, according to Table 2, the negative correlation between US-to-China relative productivity and US export shares become more prominent over years. Then it is possible that the factors that have significant effect on the exports in our model, especially the relative productivity, may have different effects on US-China bilateral trade over time, especially after the year of China's WTO accession.

One way to reveal the time effect is to introduce year dummies and have them interacted with relative productivity as well as other factors. There are 20 years in our sample, so we can introduce 19 year dummies. Doing so may capture the time effect but at the same time it will reduce the regression's degree of freedom significantly. Instead, we use only 2 period-dummy "S1" and "S2", with S1=1 denoting for 1998-00, and =0 otherwise; S2=1 denoting for years after 2000, and =0 otherwise. By doing so, we divide the sample period into three stages, one before the 1998 Asian

Financial Crisis, one after China's accession into WTO in 2001, and one lies in between. The empirical results after introducing the interaction terms are reported in Columns (2) and (4) in Table 5. To make the table clean and easy to read, we only report the time effect of relative productivity, reflected by the sign and significance of its interaction terms with S1 and S2. The time effects of other variables are briefly summarized in the note of Table 5.

In the extended model, the regression coefficients do not change significantly for most explanatory variables. Interestingly, however, the US-to-China relative productivity shows a significantly (at 10%) negative impact on US exports to China from 1998 to 2000, and becomes more negatively significant (with a significant level of 5%) after 2001. This is consistent with the data patterns shown in Table 2. The results suggest that the US exported less to China in sectors with higher relative productivity since 1998. On the other hand, the positive effect of China-to-US relative productivity on China's exports to the US has become more prominent since 2001, which suggests that the export patterns from China to US fit the comparative advantage theory more strongly after China's WTO accession.

Note that China's sectoral GDP seems to promote trade volumes more than US's sectoral GDP. Sectoral GDP can be interpreted as a country's production capacity in a particular sector. Then, the data suggest that the increase in China's production ability (both as the supplier or demander on the international market) is a more important driving force for the expansion of the US-China bilateral trade.

5. ROBUSTNESS TESTS

5.1 Reverse Causality

The first issue we need to address is the relationship between trade volume and exporting countries' sectoral GDP. There might exist reverse causality in the data pattern we uncovered in previous sections: High production capacity may lead to high trade volume, but high trade volume might also help to achieve high output. To control such an endogeneity problem, in Tables 6 we use lagged sectoral GDP for both countries instead of using variables in the current period. In Columns (1) and (3) of Table 6, sectoral GDP is lagged for one period, and for three period in Columns (2) and (4). We get similar results as those in previous section. In particular, the negative effects of US-to-China relative productivity on US exports to China after 1998 remain.

[Insert Table 6 here]

5.2 Sectoral Transportation Costs

Due to data limitation, economic distance is not sector-specific. To resolve this problem, we follow Hansen and Xiang (2005) to construct a sector level transportation cost variable. This is to capture the characteristic that transportation costs will affect sectors asymmetrically. The construction details are displayed in Appendix B2.

New results with sectoral transportation costs are reported in Columns (1) and (4) in Table 7. Transportation costs are negatively significant on US exports to China but not significant on China exports to the US. Other than that, we obtain almost the same results as before, especially on the interaction term of S1 and S2 with the relative productivity.

5.3 Sector Scope

As Figure 3 shows, agricultural primary goods have always been one of the largest exporting sectors from the US to China (accounting for about 10% -20%). However this might be largely due to the abundant land resources of the US, which can be well explained by Heckscher-Ohlin's (HO) factor endowment theory. In addition, the data in Table 3 show that China is the most important market for scrap metal products of the US. One possible explanation is that as a mature post-industrial country, the United States has abundant endowment in scrap metal, while a developing country like China is relatively scarce in such resources, which can be explained by the endowment theory as well. Therefore, we drop the agricultural products and metal & metallic products one after the other for US exports to China, and redo the extended regressions, as reported in Columns (2) and (3) of Table 7. Results show that all independent variables have maintained their original signs and significance.

[Insert Table 7 here]

5.4 Sector Disaggregation I: Approximation for Chinese Labor Productivity

One concern to the level of aggregation is that the US specializes in high-tech products within a low-tech sector, while China does the reverse. In other words, labor productivities across industries are quite diversified; if the sector classification used to measure international trade is "too" aggregate, it will mistakenly place goods that are essentially different into the same category. To solve this issue, we need to investigate at more disaggregated levels of sectors. In the above empirical test, we have employed an industrial classification of 21 sectors, because Chinese labor productivity data in more disaggregated level are not available. In this and the following subsections, we use two different methods to improve our results on this issue.

First, following the study of Amiti and Freund (2010), we use Indonesia's labor productivity as an approximation for China's, for the similarities of their development level and industrial structure. The data is taken from UNIDO (2008) with a classification of ISIC rev3. Combining with other existing data, now we can obtain a segmentation of 97 manufacturing industries in 1998-05. Since the data of Chinese industrial GDP are not available, we omit some industry-level explanatory variables but instead employ industry fixed effects to control industry-specific factors. The model to be estimated is given in Equation (6) for US exports to China. Since the time span is shorter (1998-05), only one period dummy "WTO" (WTO=1 for the year 2001-05, WTO=0 otherwise) is introduced and interacted with the relative productivity.

$$EX_{i,t}^{us} = \beta_0 + \beta_1 GDP_{i,t}^{us} + \beta_2 T_{i,t}^{cn} + \beta_3 RP_{i,t}^{us/cn} + \beta_4 KI_{i,t} + Inter_{\mathrm{i,t}} + \delta_{\mathrm{i}} + \varepsilon_{\mathrm{t,i}} \tag{6}$$

Table 8 summarizes the empirical results for all 97 manufacturing industries with China's labor productivity replaced by Indonesia's. Note that for the first two columns (Column (1) without and Column (2) with fixed effects), the US-to-China relative productivity shows insignificant negative effect. However after introducing interaction terms with WTO, as shown in Column (3), the US-to-China relative productivity begins to show a significantly negative effect on US export to China, even though only after China's WTO accession.

[Insert Table 8 here]

5.5 Sector Disaggregation II: Revealed Comparative Advantage

Another approach for sector disaggregation is to use "Revealed Comparative Advantage (RCA)" as a measurement for technological comparative advantage instead of relative labor productivity. Revealed Comparative advantage measures the degree of specialization for a specific industry of a country, reflecting the country's relative competitiveness in the industry. RCA can be calculated directly using international trade data according to Equation (7) from Balassa (1965). $RAC_i^c > 1$ implies that for country c, industry i's share of global trade is larger than the country's average global share, indicating that country c has a comparative advantage in industry i.

$$RCA_i^c = \frac{\text{Country c's export in industry i/world total export in industry i}}{\text{Country c's total export/world total expot}} \quad (7)$$

We can re-test whether the US exports to China is consistent with its comparative advantage revealed by trade patterns. Similar to the previous part, the US-to-China Relative RCA (RRCA) is defined as Equation (8).

$$RRCA_{i,t}^{us/cn} = RCA_{us,i,t} / RCA_{cn,i,t} \quad (8)$$

To match the existing data, we employ Standard Industry Classification (SIC, containing more than 400 industries), which allows a more detailed analysis on US export structure to China. Table A2 in Appendix A lists the Top 30 manufacturing industries which has the largest US-to-China RRCA in 2008. The econometric model is the same as Equation (6), with US-to-China relative productivity replaced by US-to-China RRCA. Regression results are reported in Columns (1) and (2) in Table 9. Note that RRCA is a ratio, and can be extremely high in industries where China has few exports. To remove the effects of extreme values, we drop industries with RRCA>100,000 and RRCA>1,000 respectively and re-run the regressions for US-China trade from 1992 to 2008, with results summarized in Columns (3)-(5) in Table 9.

[Insert Table 9 here]

The results show: with other explanatory variables have their significant impacts as expected, when removing the extreme values of RRCA>100,000, the US-China RRCA shows a significantly negative impact on US exports to China after 2001; when removing the extreme values of RRCA>1,000, the US-China RRCA has a significantly negative impact for the entire time periods. All these results indicate that at the level of finer sector disaggregation, the "Anti-Comparative Advantage Puzzle" still survives.

6. CONCLUSION

With China's WTO accession in 2001, the US-China trade imbalance has been further enlarged, and it has become a major economic and political issue between the two countries. Instead of focusing on the exchange rate, which seems to be a major concern for the trade imbalance, this paper explores the trade structure between the two countries and provides some new insights to the huge bilateral trade imbalance between China and the US.

We evidence a puzzle in the trade structure between China and the US by investigating the bilateral trade pattern of the two countries: The US exports less to China in the sectors it has greater comparative advantage; and the more its productivity exceeds China, the less it would export to China than to the rest of the world. These facts get more significant after China's WTO accession, which is coincident with the time that the US-China trade imbalance begins to deteriorate. The data pattern seems to be inconsistent with the prediction of comparative advantage theory. Thus we label it as "Anti-Comparative Advantage Puzzle".

The puzzle might be potentially due to the US export control policy towards China or other factors that affect bilateral trade structures. A policy flashback of US export control and a brief comparison between US exports to China and India in the paper demonstrate that China may be treated differently. The Anti-Comparative Advantage data pattern is then tested using the US-China bilateral trade data for 21 sectors from 1989 to 2008. The results show that after controlling for production capacity, transportation costs, tariffs and factor intensity etc., the "Anti-Comparative Advantage Puzzle" still exists. With comprehensive robustness checks, the puzzle remains.

Therefore our findings suggest the following twofold policy implications. First, to solve the US-China trade imbalance, increasing US's exports to China could be mutually beneficial. In particular, increasing US's exports to China in sectors US has greater comparative advantages should be a good starting point. To correct the structural abnormality of US's exports to China, not Renminbi undervaluation, but the US's export control policy is more likely to be a concern. Second, the U.S. president Barack Obama, recently called for reviving the economy and stimulating employment by expanding exports. However, though ranked second in terms of export value, China only accounted for 5.5 percent of US exports in 2008. Therefore, our findings indicate that there are indeed a lot of potentials, particularly in sectors which US has grater comparative advantages, that US may expand its exports to China significantly if the right policy is taken. Thus, the plan of "doubling US's exports in 5 years" raised by Obama administration could be possibly realized at least in China, if two countries could find and resolve the problem "why does US export too little to China in sectors that it could and should have exported more?"

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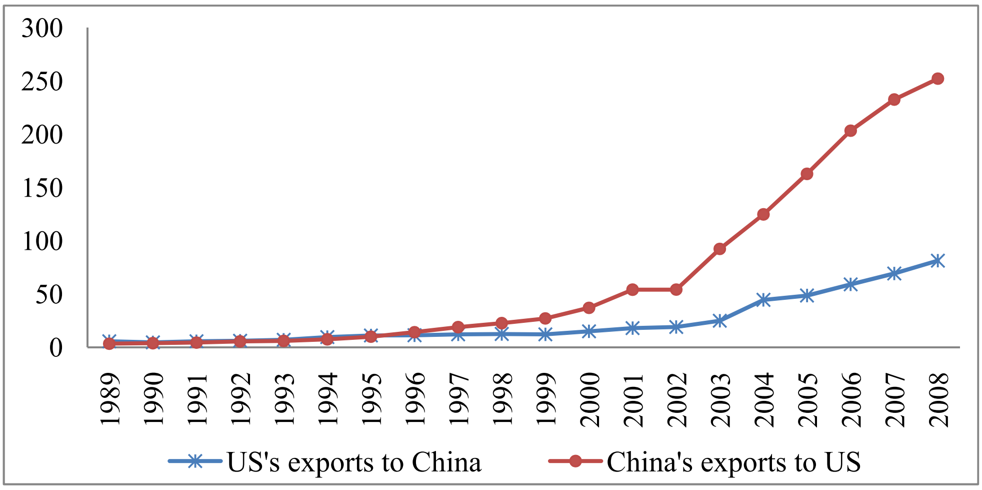

Figure1. Sino-US bilateral trade volumes, 1989 to 2008, in Billion US dollars

Source: Customs General Administration of China

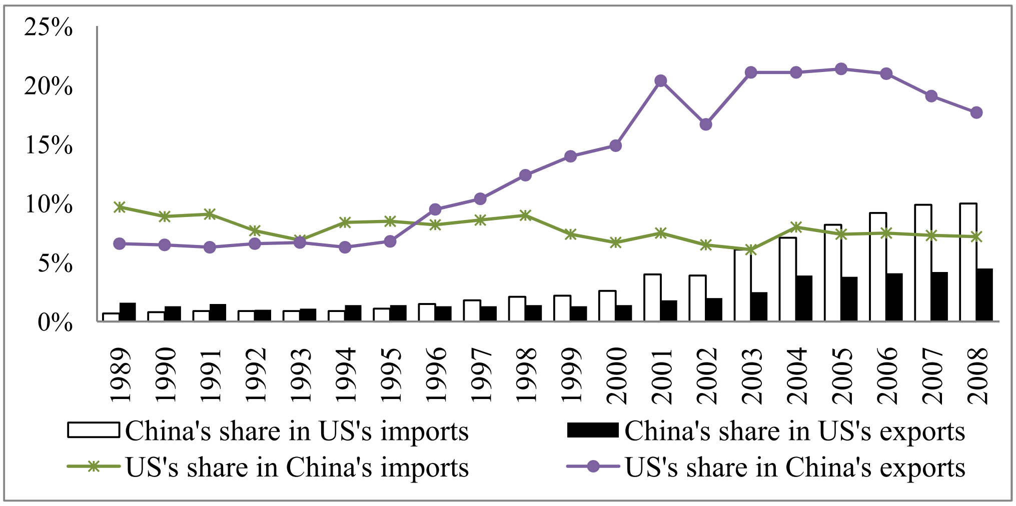

Figure 2. China’s shares in US’s trade and US’s share in China’s trade, 1989-08

Source: US Census and the Customs General Administration of China

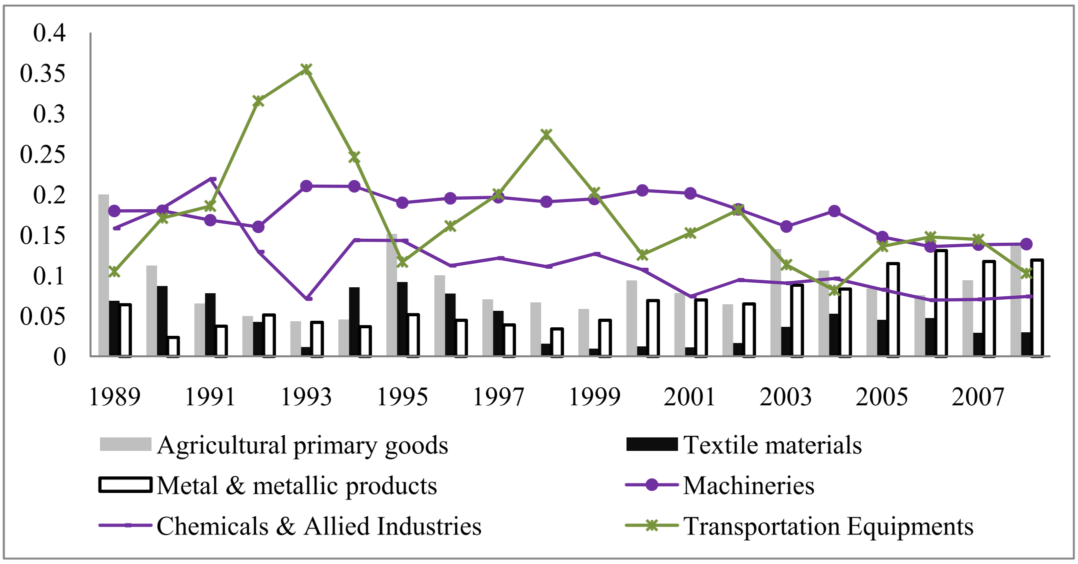

Figure 3. Trend of the 6 largest sectors in US's exports to China

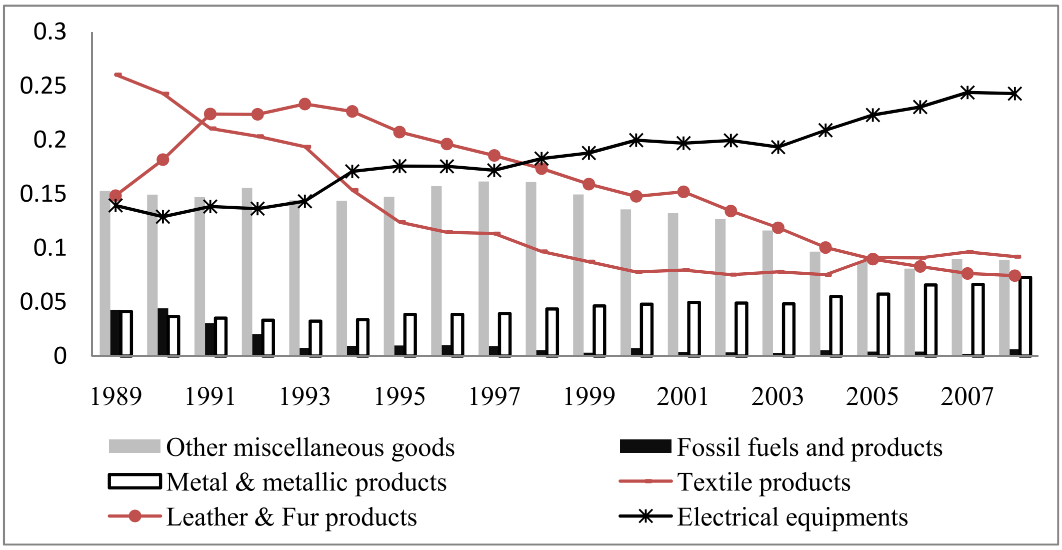

Figure 4. Trend of the 6 largest sectors in China's exports to the US

Source for Figure 2&3: US census

Table1. US-China bilateral trade structure, sectors are sorted by 2008 relative productivity

Sectors	Rank of US/China relative productivity		US export shares		China's export shares	
	(1)1989	(2)2008	(3)1989	(4)2008	(5)1989	(6)2008
Fossil fuels and products	7	1	0.30%	0.60%	4.30%	0.60%
Chemicals & allied Industries	6	2	15.80%	7.40%	2.10%	2.60%
Furniture & fixtures	2	3	0.10%	0.30%	1.40%	5.90%
Nonmetallic products	10	4	0.30%	0.60%	1.30%	1.30%
Optical & medical equipments	3	5	4.60%	5.40%	1.50%	2.20%
Paper manufacturing	1	6	3.60%	4.30%	0.50%	1.30%
Medicine & pharmaceuticals	12	7	0.10%	0.60%	0.10%	0.20%
Wood & wood products	5	8	3.20%	0.80%	1.20%	1.00%
Electrical equipments	4	9	4.20%	16.20%	13.90%	24.30%
Plastics & rubbers	9	10	4.00%	6.40%	2.20%	3.70%
Leather & fur products	11	11	0.30%	1.40%	14.90%	7.40%
Nonmetallic minerals	16	12	0.30%	1.30%	0.90%	0.20%
Textile products	13	13	0.40%	0.60%	26.00%	9.20%
Transportation Equipments	8	14	10.50%	10.30%	0.40%	2.10%
Printing & publishing	18	15	0.20%	0.50%	0.10%	0.10%
Machineries	19	16	18.00%	13.90%	2.80%	19.70%
Agricultural primary goods	20	17	20.00%	13.70%	4.00%	0.90%
Food & tobacco manufacturing	14	18	0.90%	0.80%	1.10%	0.70%
Textile raw materials	21	19	6.90%	3.00%	1.90%	0.30%
Metal & metallic products	17	20	6.40%	11.90%	4.10%	7.30%
Other miscellaneous goods	15	21	0.10%	0.20%	15.30%	8.90%

Note: Rank 1 indicates US has most productivity over China in that sector

Source: US Census and National Bureau of Statistics of China

Table2. Annual correlation coefficients of sectoral trade share and relative productivity, 1989-08

Year	**$Xshare^1_{US}$**	$Xshare^1_{Sino}$	**$Xshare^2_{US}$**	$Xshare^2_{Sino}$
1989	**-0.135**	0.01	**-0.123**	0.173
1990	**-0.067**	0.001	**-0.123**	0.123
1991	**-0.013**	0.014	**-0.052**	0.057
1992	**-0.054**	0.038	**-0.078**	0.055
1993	**-0.078**	0.056	**0.052**	0.04
1994	**-0.044**	0.054	**-0.096**	0.051
1995	**-0.095**	0.023	**-0.183**	0.054
1996	**-0.049**	0.082	**-0.153**	0.103
1997	**-0.001**	0.105	**-0.125**	0.135
1998	**-0.099**	0.264	**0.010**	0.263
1999	**-0.098**	0.263	**0.084**	0.264
2000	**-0.185**	0.242	**-0.078**	0.272
2001	**-0.255**	0.249	**-0.149**	0.248
2002	**-0.235**	0.243	**-0.140**	0.257
2003	**-0.270**	0.296	**-0.284**	0.379
2004	**-0.256**	0.262	**-0.263**	0.365
2005	**-0.302**	0.225	**-0.318**	0.327
2006	**-0.293**	0.212	**-0.318**	0.289
2007	**-0.273**	0.235	**-0.273**	0.273
2008	**-0.256**	0.207	**-0.256**	0.288

Source: Author's calculation.

Original data source: US Census and National Bureau of Statistics of China

Table3. Comparison between Xshare[1] and Xshare[2] for the Top 10 trading products

US exports to China			
HS8	$Xshare^1_{US}$	$Xshare^2_{US}$	Products
88024000	10%	15%	New passenger transportations, non-military
85422180	7%	15%	Chips & wafers of silicon
12010000	5%	37%	Soybean seeds for sowing
74040000	**3%**	**61%**	**Copper waste & scrap, refined #1**
76020000	**3%**	**61%**	**Aluminum waste and scrap**
52010010	3%	49%	Cotton, not carded/combed
84733000	2%	7%	Parts & accessories for ADP machines & units
72042900	**1%**	**75%**	**Waste and scrap of other ally steel**
85422900	1%	10%	Chips, integrated circuit, except for digital
88033000	1%	4%	Other parts of civil airplanes/helicopters
China exports to the US			
HS8	$Xshare^1_{Sino}$	$Xshare^2_{Sino}$	Products
84713000	6%	45%	Portable digital ADP machine,<10kg
85252090	4%	45%	Cellular radio telephones
84716045	2%	79%	Display units
84733050	2%	53%	Parts & accessories of mach of heading of 8471
95041000	1%	95%	Video games used with TV receiver, parts & accessories
64039990	1%	70%	Footwear for women
85219000	1%	78%	Video recording or reproducing apparatus except for tape
85209000	1%	91%	Other magnetic sound recording or reproducing equipments
94036080	1%	52%	Wooden furniture
85254040	1%	47%	Digital still image video cameras
95039000	1%	90%	Toys, parts & accessories

Source: US Census

Table 4. US high-tech exports to China and India, SIC4, 2005

SIC code	Skill-intensity of US	$XShare^1$		$Xshare^2_{std}$		Products
		China	India	China	India	
3769	0.808	0.0%	0.0%	0.01	0.13	Space vehicle equipments
3826	0.801	1.3%	1.6%	1.62	2.03	Analytical instruments
3825	0.794	1.4%	1.7%	1.52	1.79	Instruments to measure electricity
3577	0.787	0.9%	1.8%	0.80	1.68	Computer peripheral equipments
3578	0.783	0.1%	0.1%	1.30	1.27	Calculating, accounting equipments
3812	0.772	0.4%	1.0%	0.66	1.74	Search and navigation equipment
3661	0.756	1.7%	3.1%	1.41	2.50	Telephone and telegraph apparatus
3844	0.754	0.6%	1.0%	1.46	2.53	X-ray apparatus and tubes
3663	0.748	0.4%	2.4%	0.47	2.82	Radio, communications equipment
3571	0.741	3.2%	3.7%	1.13	1.30	Electronic computers
2835	0.731	0.2%	0.6%	0.38	1.02	Diagnostic substances
3579	0.726	0.1%	0.1%	1.00	0.84	Office machines
3572	0.707	0.2%	0.8%	0.49	2.49	Computer storage devices
3669	0.705	0.1%	0.2%	1.01	1.96	Communications equipment
3489	0.704	0.0%	0.0%	0.01	0.05	Ordnance and accessories

Table 5. Basic empirical results, 21 sectors, 1989-08

Independent variable	US export to China		China export to the US	
	(1)	(2)	(3)	(4)
China GDP	0.566***	0.475***	0.269***	0.228***
	(0.080)	(0.088)	(0.056)	(0.062)
US GDP	0.053	0.0951	0.249***	0.257***
	(0.093)	(0.095)	(0.069)	(0.069)
Economic distance	-0.555***	-0.654***	-0.809***	-0.856***
	(0.098)	(0.106)	(0.063)	(0.068)
Tariff	-0.698**	-0.723**	-5.409**	-6.335**
	(0.305)	(0.305)	(2.592)	(2.625)
Rel. productivity:	0.007	0.00324	0.0242***	0.0262***
(Exporter/Importer)	(0.006)	(0.006)	(0.004)	(0.004)
Rel. productivity*S1		-0.0198*		0.00378
		(0.010)		(0.007)
Rel. productivity*S2		-0.0311**		0.0230**
		(0.014)		(0.010)
Capital intensity	-0.002	0.000315	-0.0140***	-0.0115***
	(0.004)	(0.004)	(0.003)	(0.003)
Constant	4.883***	3.988***	4.118***	3.827***
	(1.193)	(1.250)	(0.944)	(0.953)
Observations	420	420	420	420
R-squared	0.751	0.754	0.88	0.882

Note: We also conduct analysis on the time effect of other explanatory variables, which are not listed in the table but summarized here. a). For US exports to China, the economic distance has played a larger negative role after 2001. b). For China's exports to the United States, the impact of China's sector GDP weakened while that of the US is enhanced since 2001; the role of economic distance again weakened with time. c). Time effect of other variables are not significant.

Table 6. Robustness test: Reverse causality, 21 sectors, 1989-08

Independent variable	US export to China		China export to the US	
			(3)	(4)
China GDP (-1)	0.294***		0.275***	
	(0.100)		(0.070)	
US GDP (-1)	0.08		0.06	
	-0.11		-0.07	
China GDP (-3)		0.383***		0.0717
		(0.098)		(0.075)
US GDP (-3)		0.312***		0.0654
		(0.095)		(0.072)
Economic distance	-0.783***	-0.711***	-0.883***	-1.054***
	(0.140)	(0.126)	(0.080)	(0.087)
Tariff	-0.920**	-0.447	-6.940**	-9.776***
	(0.360)	(0.378)	(2.710)	(3.079)
Rel. productivity:	-0.0023	0.00253	0.0229***	0.0228***
(Exporter/Importer)	(0.006)	(0.006)	(0.004)	(0.004)
Rel. productivity*S1	-0.0277***	-0.0228**	0.00121	0.00881
	(0.010)	(0.010)	(0.007)	(0.008)
Rel. productivity*S1	-0.0412***	-0.0313**	0.0202**	0.0317***
	(0.010)	(0.014)	(0.010)	(0.011)
Capital intensity	0.00548	0.00408	-0.00762***	-0.00564*
	(0.004)	(0.004)	(0.003)	(0.003)
Constant	4.090***	1.596	5.119***	4.932***
	(1.300)	(1.433)	(0.810)	(1.163)
Observations	400	360	400	360
R-squared	0.742	0.753	0.883	0.877

Note: GDP (-1) denotes that GDP for lagged for one year; GDP (-3) means "lagged for three year".

Table7. Robustness test: Transport cost and Sector scope, 21 sectors, 1989-08

Independent variable	US export to China			China export to US
	(1)	(2)	(3)	(4)
China GDP	0.412***	0.470***	0.422***	0.232***
	(0.090)	(0.091)	(0.097)	(0.064)
US GDP	0.122	0.085	0.079	0.256***
	(0.094)	(0.096)	(0.098)	(0.070)
Economic distance	-0.763***	-0.645***	-0.655***	-0.850***
	(0.112)	(0.106)	(0.124)	(0.073)
Transport cost	-0.390***	-0.358***	-0.351***	0.021
	(0.133)	(0.133)	(0.123)	(0.094)
Tariff	-0.725**	-0.723**	-0.846**	-6.309**
	(0.302)	(0.305)	(0.336)	(2.631)
Rel. productivity:	0.002	0.003	0.001	0.0262***
(Exporter/Importer)	(0.006)	(0.006)	(0.006)	(0.004)
Rel. productivity*S1	-0.0177*	-0.0198*	-0.0204*	0.004
	(0.010)	(0.010)	(0.011)	(0.007)
Rel. productivity*S1	-0.0349**	-0.0311**	-0.0307**	0.0228**
	(0.014)	(0.014)	(0.015)	(0.010)
Capital intensity	0.002	0	0.002	-0.0116***
	(0.004)	(0.004)	(0.004)	(0.003)
Constant	2.897**	3.988***	4.678***	3.879***
	(1.293)	(1.250)	(1.407)	(0.983)
Observations	420	420	380	420
R-squared	0.759	0.754	0.744	0.882
Sector scope	Full sample	No agriculture	No agriculture & metals products	Full sample

Table 8. Robustness test: Sector segmentation I.

Dependent variable: Logarithm of US exports to China, ISIC rev3, only manufacturing, 1995-05

Independent variable	(1)	(2)	(3)
US GDP	0.279*	-0.182	-0.097
	(0.157)	(0.226)	(0.214)
US GDP*WTO			0.0265***
			(0.003)
Tariff	-0.0086**	-0.00886**	0.004
	(0.004)	(0.004)	(0.005)
Rel. productivity: US/China	-0.001	-0.001	0.001
	(0.001)	(0.001)	(0.001)
Rel. productivity*WTO			-0.00265**
			(0.001)
Capital intensity	0.00652	0.011	0.0110*
	(0.0068)	(0.007)	(0.007)
Constant	9.595***	20.37***	17.85***
	(3.617)	(5.198)	(4.920)
Industry Fixed Effect	N	Y	Y
R-squared	0.007	0.014	0.125

Note: WTO=1 denotes the year of 2001 to 2005, WTO=0 otherwise.

Table 9. Robustness test: Sector segmentation II

Dependent variable: Logarithm of US exports to China, ISIC rev3, only manufacturing, 1992-08

Independent varaible	All manufacturing		RRCA<100,000		RCCA<1,000
	(1)	(2)	(3)	(4)	(5)
US GDP	0.480***	0.479***	0.481***	0.485***	0.478***
	(0.089)	(0.088)	(0.089)	(0.088)	(0.088)
Tariff	-0.0224***	-0.0226***	-0.0224***	-0.0226***	-0.0224***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
RRCA	0.0e-03	0.06e-03***	-0.01e-03	0.05e-03**	-3.01e-03***
	(0.000)	(0.022)	(0.012)	(0.022)	(0.907)
RRCA*S1		0.68e-03***		0.68e-03***	
		(0.187)		(0.186)	
RRCA*S2		-0.06e-03***		-0.10e-03***	
		(0.022)		(0.025)	
Capital intensity	0.0134***	0.0136***	0.0133***	0.0135***	0.0140***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Constant	4.461***	4.473***	4.457***	4.430***	4.497***
	(0.671)	(0.668)	(0.671)	(0.667)	(0.666)
Industry FE	Y	Y	Y	Y	Y
R-squared	0.157	0.165	0.157	0.168	0.164

APPENDIX A

Table A1. Product Categories of US export control towards China

Category	Description
1	Nuclear Materials, Facilities & Equipment (and Miscellaneous Items)
2	Materials, Chemicals, Microorganisms, and Toxins
3	Electronics
4	Computers
5	Telecommunications
	Information Security
6	Sensors and Lasers
7	Navigation and Avioni Computers
8	Marine
9	Propulsion Systems, Space Vehicles and Related Equipment

Table A2. The top 30 industries for US-to-China Relative Revealed Comparative Advantage (RRCA), 2008

SIC4	Industry	US RCA	China RCA	US-to-China RRCA
2087	Flavoring extracts and flavoring syrups	2.851	0.000	47000000
1031	Lead and zinc ores	1.820	0.000	4493411
2022	Cheese, natural and processed	0.397	0.000	4272
0272	Horses, mules, asses and burros, live	2.068	0.001	1452
1011	Iron ores	0.234	0.001	205
0111	Wheat	2.755	0.025	111
2836	Biological products	3.329	0.035	96.38
0115	Corn	7.209	0.098	73.19
1021	Copper ores	0.525	0.009	57.16
0131	Cotton and cottonseed	6.218	0.135	46.20
2451	Trailers and semi-trailers for housing or camping,	5.517	0.207	26.69
2721	Periodicals	2.550	0.126	20.19
1099	Metallic ores	0.233	0.012	19.22
0116	Soybeans	5.879	0.363	16.21
2611	Pulp mill products	1.879	0.135	13.87
2951	Paving mixtures and blocks	1.648	0.179	9.22
2834	Pharmaceutical preparations	1.031	0.134	7.71
2429	Staves and hoops; tight barrelheads of softwood	1.883	0.274	6.88
2079	Shortening, table oil, margarine and other edible	0.563	0.089	6.36
2021	Creamery butter	0.573	0.103	5.54
2835	Prepared diagnostic substances	3.200	0.581	5.51
2045	Prepared flour mixes and dough	1.786	0.353	5.06
2095	Roasted coffee	0.738	0.154	4.8
2085	Distilled, rectified, and blended liquors	0.735	0.154	4.77
2631	Wet machine board	1.000	0.213	4.69
0172	Grapes	1.261	0.291	4.33
2911	Petroleum refinery products	1.853	0.440	4.21
2952	Asphalt felts and coatings	1.767	0.449	3.93
2813	Industrial gases	2.327	0.600	3.88
0214	Sheep and goats	0.129	0.035	3.74

APPENDIX B

1. The construction of "Economic Distance"

ED is the opposite number of the US-China overall transport capacity. US-China transport capacity is simply defined as the geometric mean of transport capacities of goods and information in these two countries. For capacity in goods, transportations by air, rail and by sea are all embodied, and for capacity in information, number of registered subscribers for telephone and internet are counted.

To be concrete, the *ED* is derived by the following steps: 1, take natural log of the capacity data on all modes of transport (capacity is measured by number of registered air lines, total length of rail tracks and number of container port traffics, and numbers of subscribers for telephone and internet). 2, calculate the geometric mean of the above 10 log-values (5 modes of transports in each country) as the measurements for US-China transport capacity. 3, Take the opposite number of the US-China transport capacity for each year as the measure of *ED*. All data used here is taken from World Development Indicators (WDI).

The detailed data for ED in each year is listed in Table B1.

Table B1 Data of US-China Economic Distance

Year	*ED*	Year	*ED*
1989	-13.41	1999	-14.84
1990	-13.51	2000	-15.02
1991	-13.62	2001	-15.12
1992	-13.79	2002	-15.25
1993	-13.94	2003	-15.37
1994	-14.13	2004	-15.51
1995	-14.23	2005	-15.57
1996	-14.38	2006	-15.64
1997	-14.54	2007	-15.71
1998	-14.66	2008	-15.77

2. The construction of "Transport Cost"

Follow Hansen and Xiang (2005), we constructed a sector-level transport cost variable in the following steps. a). Take the implicit US's sectoral freight rate (insurance and freight charges/import value) and regress it on log distance to the source country, where coefficients are allowed to vary across sectors. b). Use the projected sectoral freight rate from these coefficient estimates (at median distance for all export countries to the US) as the transport cost for a certain sector. Thus we obtain estimates on the year-sector specific transportation costs.

To be noted, we assume that US and China have the same transport cost in the same sector due to the data available of China. This is reasonable because transport cost only reflect heterogeneity of good in different sector, not affected by the importing countries.