Foreign Value-added in China's Manufactured Exports: Implications for China's Trade Imbalance

*Jun Zhang, Dongbo Tang, Yubo Zhan**

Abstract

Economists have recently become interested in weighting how much domestic value-added is actually included in China's exports. Formally, the proportion of foreign and domestic contents could be identified by calculating the vertical specialization share using non-competitive input-output tables. Applying such a method to the Chinese case, however, would result in a big measurement bias because China has a large share of processing exports, which utilize a disproportionately high percentage of imported intermediates. This paper, by directly employing 2008 trade data for which imported intermediates in both processing and non-processing trade could be identified by means of various trade patterns, provides a simplified way to estimate the share of foreign/domestic value-added included in industry-level manufactured exports. This paper finds that the vertical specialization share of China's processing exports was about 56 percent in 2008, compared to about 10 percent for ordinary exports. It also finds that the sectors that experienced fast expansion of processing exports have a much higher share of foreign contents. Since processing exports account for about half of Chinese exports, the prevailing trade statistics, which focus on gross values rather than the value-added of exports and imports, has obviously overstated the bilateral trade imbalances, especially between China and the USA.

Key words: processing trade, trade imbalance, value-added, vertical specialization
JEL codes: F10, F14, O10

I. Introduction

There has been heated debate by both economists and politicians over the past 5 years on

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the issue of bilateral and regional trade imbalances shown in global trade statistics. Such implied imbalances have resulted in intensified trade friction between the USA and China, and US suspicion of China manipulating RMB exchange rates. In this regard, rebalancing the Chinese economy has increasingly been raised as a solution to bilateral and global trade imbalances.

However, economists' views differ regarding how best to address the issue of the growing global trade imbalances, and Sino–American trade disputes in particular. The significance of bilateral trade imbalances hinges on which approach we adopt to observe global trade patterns. Adopting either the gross value approach or the value-added approach would create very different images of bilateral trade status. Pascal Lamy, Director-General of the WTO, said on 6 June 2011 that "by focusing on gross values of exports and imports, traditional trade statistics give us a distorted picture of trade imbalances between countries," and "the picture would be different if we took account of how much domestic value-added is embedded in these flows."[1]

Indeed, identifying the *country of origin* for manufactured export goods today has become more challenging as the various operations, from the design of the product to the manufacture of the components, assembly and marketing, have spread across the world, a phenomenon referred to as *global production* or *made in the world*. With deepening globalization and the redistribution of the global production chain (GPC) among countries, traditional trade theory and policy based on the cross-border distribution of the gross export value no longer hold water; instead, the global distribution of value-added embedded in exports and the participation of countries in the global division of labor are of great importance. Today's trade, to a great extent, is no longer trade in goods, but trade in value added (IDE-JETRO and WTO, 2011).

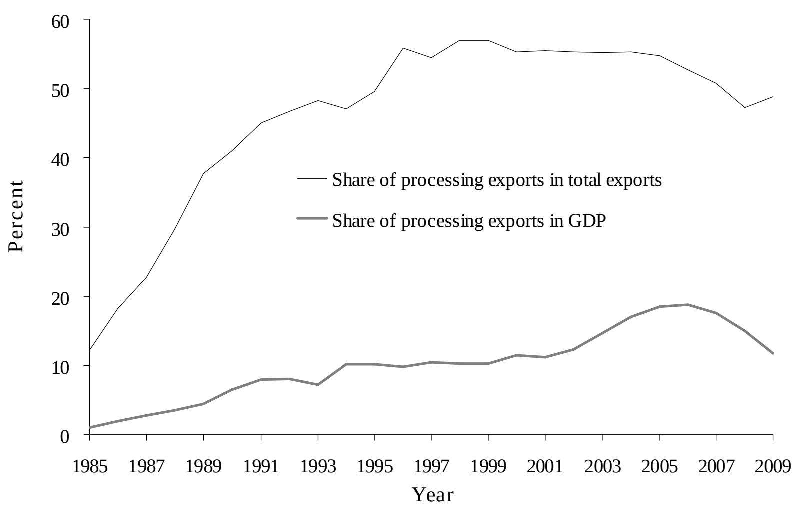
The deepening globalization has changed global trade patterns, making it possible to fragment and distribute production process globally. This is the main reason why the concept of value-added embedded in exports has drawn great attention in relation to current international trade. Each country participates in international trade by taking a position on the GPC. Vertical specialization (VS) leads to redistribution of value-added embedded in exports among the participants of international trade. Therefore, as far as a country is concerned, if we are able to exclude the value of imported intermediates from the final value of the exports, we can then observe the relative value share contributed by local producers to the GPC. The related literature, in most cases, conforms to this way of thinking in the estimation of the domestic value-added share embedded in exports.

[1] See http://www.wto.org/english/news_e/news11_e/miwi_06jun11_e.htm.

Participation by an industry or a country in the GPC can be better conceptualized by intra-industry trade or VS across the world. Therefore, the method of measuring VS share, originating from input–output (I/O) tables in Hummels *et al*. (2001), has been widely applied in the estimates of the foreign or domestic value-added embedded in exports. In Hummels *et al*. (2001), VS share is defined as the ratio of imported intermediates included in the exports to the gross export value. According to this definition, the domestic value-added share embedded in exports equals 1 minus VS share (1 – VSS).

Indeed, the concept of VS generally describes the global trade pattern emerging from the process of fragmentation and distribution of GPC among countries. The rapid growth in world trade over the past 30 years can be attributed to the deepening of vertical specialization (Feenstra, 1998; Yi, 2003; Grossman and Helpman, 2002, 2005). In China, 30 years of economic reform and opening up have enabled the expansion of trade flow and distinctive changes in the trade pattern through continuous engagement in the global production network. In 1981, for instance, processing exports accounted for only 4.82 percent of total exports, but this share had increased to 56.88 percent by 1999, with the share still at over half of total Chinese export in 2009, as shown in Figure 1. Processing trade follows a specific trade pattern in line with intra-industry trade. Therefore, the present paper used the method of measuring VS share to estimate the share of domestic value-added embedded in China's exports.

Figure1. Rising Importance of Processing Exports in China (1985–2009)



Sources: NBS (2009, 2010) and CEIC database.

However, if we directly employ Chinese I/O tables and follow the method of Hummels *et al*. (2001), the VS share in China's exports will be underestimated and, therefore, the domestic value-added share will be overestimated. This is because the estimation of VS share in Hummels *et al*. (2001) requires I/O tables that are non-competitive in the sense that the domestically sourced intermediates and imported intermediates can be distinguished in these tables.[2] In fact, Chinese I/O tables should be classified as competitive. They also failed to capture the fact that the disproportionately higher share of imported intermediates is embedded in Chinese processing exports. This problem will be discussed in detail in the following section. To avoid such shortcomings of Chinese I/O tables, we split the I/O tables and directly use the Harmonized System (HS) codified imports and exports data provided by China Customs in 2008 to estimate the VS share or domestic value-added included in exports. Limited by data availability, our VS share estimates are only carried out for 3-digit manufacturing industries in the year 2008.

The paper proceeds as follows. In Section II, we review some of the recent works on VS share estimates for Chinese exports. In Section III, data compilation and estimation methods are discussed, and the estimated results are presented. In Section IV, the implications of estimated results for rebalancing the Chinese economy are discussed. Section V concludes.

II. Literature Review

Hummels *et al*. (2001) come up with a simple method to calculate VS share. The core of their method is to identify from the I/O tables the imported intermediates used for exports. By adopting this approach, they measure the VS share of 10 OECD member countries and of Ireland, Korea, Taiwan of China and Mexico. They find that the VS share of these combined 14 economies rose from 16.5 percent in 1970 to 21 percent in 1990.

Because the method of Hummels *et al*. (2001) does not differentiate processing trade and non-processing trade, simply applying the method of Hummels *et al*. (2001)

[2] The I/O tables can be divided into the following two categories: competitive I/O tables and non-competitive I/O tables. The former does not distinguish the domestically supplied intermediates from the imported intermediates and assumes that these two kinds of intermediates can be completely substituted. As a result, the competitive I/O tables do reflect the relationship between the production and the imported inputs. Instead, the non-competitive I/O tables divide the intermediates into those produced domestically and those imported, reflecting the incomplete substitution between domestically sourced and imported intermediates. In view of this shortcoming of the competitive I/O tables, Hummels *et al*. (2001) adopt the non-competitive I/O tables to measure the yearly VS share.

to the case of China without differentiating the trade patterns will obviously underestimate the VS share and, therefore, overestimate the domestic value-added share embedded in Chinese exports, because processing trade dominates in China, and the imported intermediates are used more intensively for processing exports than for non-processing exports. Needless to say, China's preferential policies for the imported intermediates for exports, which are often exempt from tariffs, give impetus to this trajectory as well.

To consider the larger share of processing exports in China's trade sector, and using data provided by China Customs, the National Bureau of Statistics of China, the Hong Kong Customs and Excise Department, the US Census Bureau and the United States Bureau of Economic Analysis, Lau *et al*. (2007) compile non-competitive IO tables for China's processing trade for 1995, 2000 and 2002. They also compile non-competitive input–occupancy–output tables for 2002 based on Table U (use table) and Table V (make table) released by the United States Bureau of Economic Analysis. Their estimates show that for every US$1000 in Chinese exports to the USA in 2002, the direct and indirect domestic value added was US$177 and US$191, respectively, totaling US$368. Similarly, for every US$1000 in US exports to China in 2002, the direct and indirect domestic value-added was US$418 and US$447, respectively, totaling US$865. These figures reveal that the contribution to the domestic value-added (thus, GDP) of one unit US exports to China is twice that of Chinese exports to the USA.

Compiling new Chinese I/O tables so that ordinary exports and processing exports can be seperated would be useful.[3] Following this idea, Dean *et al*. (2007) attempt to make Chinese I/O tables more informative by incorporating various trade patterns into the tables. For this purpose, they use trade data and information on various patterns of trade provided by China Customs. For processing trade, they regard all the imports as the intermediates used in exports, and then, under the ordinary trade pattern, they identify the imported intermediates from all imports according to the Classification by Broad Economic Categories (BEC) formulated by the United Nations. They further assume that the proportion of imported intermediates in each industry was in line with the coefficient in the I/O tables so that the identified imported intermediates can be included into the I/O tables of China in 1997 and 2002. Based on such work, they use the method of Hummels

[3] It should be pointed out that the I/O tables released by the National Bureau of Statistics of China are all competitive I/O tables. Their biggest weakness is that they do not distinguish the domestically procured intermediates from the imported intermediates. On top of that, processing trade patterns and ordinary trade patterns are not distinguished.

et al. (2001) to estimate that the VS share of Chinese exports in 1997 and 2002 were 17.9 and 25.4 percent, respectively.

As mentioned above, unlike the production for domestic sales and exports for ordinary trade, processing exports usually use a much higher proportion of imported intermediates in production. To highlight this feature of processing trade, Koopman *et al*. (2008) split the standard I/O tables into two parts to distinguish processing trade and non-processing trade patterns, and then correct the estimate bias of the VS share of Chinese exports measured using the method of Hummels *et al.* (2001). However, the coefficients shown in I/O tables, such as the coefficients of the imported intermediates for exports, for domestic sales and for ordinary trade, cannot be directly obtained from I/O tables. Therefore, Koopman *et al*. (2008) attempt to estimate those unknown I/O coefficient matrices by developing a set of mathematic programs based on the I/O data. Using these programs, they process the data for processing and ordinary trade in 1997, 2002 and 2006, which are released by China Customs, and estimate the VS share of Chinese exports, coupled with the benchmark I/O tables for 1997 and 2002. The VS share of Chinese exports they estimate is approximately 50 percent, nearly twice the result measured without differentiating processing exports and non-processing exports. They also find that the VS share of foreign invested enterprises is higher than that of local enterprises with no foreign investment.

Dean *et al*. (2008) modify their 2007 results by adopting the method put forward by Koopman *et al*. (2008). They split the I/O tables in 1997 and 2002 to highlight the popularity of Chinese processing trade. The VS share they estimate is 47.7 and 46.1 percent in 1997 and 2002, respectively. The VS share of processing and ordinary exports are also measured in their paper, with values of 81.9 and 5.3 percent in 1997, and 74.3 and 10.8 percent in 2002, respectively. In addition, in terms of the destination of the exports, the VS share of China’s exports to the USA, Japan, Europe, Hong Kong SDR and other developed regions is universally higher than that of exports to other regions in the world.

The method of Koopman *et al.* (2008) is based on a series of key assumptions; however, having assumptions that are too strict, more often than not, will hinder research findings. For example, if the imported intermediates included in the exports are higher than those in goods for domestic sales, then one of the assumptions made in Koopman *et al*. (2008) does not hold. Moreover, the VS share measured by Koopman *et al*. (2008) might have been the weighted average of the domestic sales, the ordinary exports and the processing exports instead of the weighted average of both ordinary exports and processing exports only; otherwise, the previous splitting method will underestimate the true VS share. There are other problems associated with estimating the unknown flows in I/O tables, and these problems are discussed by Zhang (2011).

To assess how much domestic/foreign value-added is included in Chinese exports, it is essential to separate processing exports from non-processing exports. However, unlike the previous work that relies on edited I/O tables, we directly utilize the trade data of China Customs, which provides information about various trade patterns, and convert HS code trade data into sectoral data, using the HS-GB/T Concordance Table. Although this idea partially comes from Dean *et al*. (2007), they still worked on Chinese I/O tables by incorporating information about various patterns of trade using the trade data. Upward *et al.* (2010) is perhaps the first work to use the HS code trade data to estimate the VS share without relying on Chinese I/O tables. Following the same scenario, but not like Upward *et al.* (2010), whose focus is on GB/T2 and purely on Chinese exporting firms, the present paper concentrates on all industries codified by GB/T3.

Because the import and export data from China Customs itself provides detailed information about different trade patterns, our task is to identify the intermediates from the imports under the pattern of ordinary trade. Having done that, it becomes easier to modify the standard Hummels *et al.* (2001) method to estimate the VS share or the domestic value-added share included in Chinese exports.

One possible disadvantage of this approach is that, without using I/O tables, the value of the imported contents embodied in domestically sourced intermediates cannot be traced and identified, which might lead to the underestimation of the VS share of Chinese exports. However, the majority of imported intermediates are in processing exports and/or in the products of foreign invested enterprises (Xu and Zhang, 2008), and the pattern of processing exports has only limited spillover and access to other Chinese firms (Chen and Liu, 2011).[4] Therefore, for economies like China where the export mix is dominated by processing exports, this approach will not give rise to a big bias.[5] In fact, the inter-industry input–output linkage is very complicated. For some economies, even the imported intermediates are likely to include the value of its exports. The solution to this systematic problem relies

[4] The data in the *China Foreign Economy and Trade White Paper* of 2003 shows that the proportion of foreign invested enterprises in the gross value of processing imports and exports rose from 64.5 percent in 1996 to 75.7 percent in 2002, while the proportion of state-owned enterprises was down from 34.1 to 21 percent and the private enterprises up from 1.4 to 3.3 percent, respectively (CAITEC, 2003). Another source shows that in the first half of 2007, the foreign invested enterprises, the state-owned enterprises and the private enterprises accounted for 84, 10 and 6 percent, respectively, in the total value of processing trade. Therefore, the overwhelming majority of processing trade is carried out by foreign invested enterprises.

[5] Koopman *et al.* (2008) and Dean *et al.* (2008) also mention this point.

on the compilation of cross-country I/O tables.[6]

III. Measuring Vertical Specialization Share in Chinese Exports: Method and Data

1. Methodological Issue

The method of quantifying VS developed by Hummels *et al.* (2001) is simple, as the following formula indicates:

$$S = (X / Y)M^{I},$$

where M^{I} is the value of the imported intermediates, Y is the corresponding output value and X is the value of the exports. By multiplying imported intermediates with the export–output ratio, this formula states that the extent to which an exporter (or a country) participates in the global production chain can be roughly measured by the proportion of imported intermediates that are included in processing exports. Note that VS share equals VS divided by exports.

It is easy, however, to see that this formula has an implicit assumption: the imported intermediates for both processing and non-processing exports are evenly distributed, because this formula explicitly assumes that the amount of imported intermediates embedded in exports is proportional to the share of exports in outputs. As mentioned above, the difference between processing and ordinary trade is that the former uses much more foreign content than the latter and, therefore, all the imported intermediates are embedded in the processing exports, whereas only a portion of imported intermediates are used to produce exports under the pattern of ordinary exports. If this difference is ignored in measuring VS share, then the proportion of the foreign value-added embedded in China's exports will be underestimated and that of the domestic value-added will be overestimated.

To examine the difference between processing and ordinary exports in estimating VS, it is important to acquire information about imported intermediates for both processing and ordinary trade, and to treat them separately. Therefore, the formula for measuring VS in such conditions might be modified as follows:

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[6] IDE-JETRO of Japan has compiled cross-border I/O tables covering 9 economies in Asia. Based on these tables, researchers can estimate the domestic value-added share included in the exports of each economy. However, these tables have not yet been used to distinguish processing exports from ordinary exports. The GTAP database commonly used in research provides unofficial cross-border I/O tables covering less than 30 countries. It is not easy to compile cross-border I/O tables due to inconsistent classification of industries and methods in the collection of data. Many compromises and adjustments are necessary to produce a standard format, which makes the compilation of these tables a huge inter-governmental project.

$$VS' = M_p^I + a \cdot M_o^I .$$

In this formula, M_p^I is the value of imported intermediates used for processing exports under the pattern of processing trade, M_o^I is the value of imported intermediates used in ordinary exports, a is the coefficient that splits the imported intermediates between those for producing exports and those for non-exports under ordinary trade. For such an estimate to be feasible, a must be known. Here, we follow the assumption in Hummels *et al.* (2001), and also assume that the imported intermediates that are used to produce the exports are proportional to the export to output ratio. In this case, $a = X_o / Y_o$ under the pattern of ordinary trade. Because $Y_o = Y - X_p$, the new formula is:

$$VS' = M_p^I + \left(\frac{X_o}{Y - X_p} \right) \cdot M_o^I ,$$

where $X_o/Y - X_p$ is the ratio of ordinary exports to total output, excluding processing exports. Therefore, the second term on the right-hand side of the formula measures the proportion of imported intermediates that are used to produce exports under the pattern of ordinary trade.

For our purpose, if we assume there are N industries in economy k, and M_i^I stands for the imported intermediates in industry i, X_i the export value of industry i, and X_k the gross export value of the economy, then the VS share (*VSS*) of the whole economy k is obtained by averaging VS share of each industry weighted by its own share in the total exports:

$$VSS_k = \sum_i \frac{X_i}{X_k} \cdot \frac{VS_i}{X_i} .$$

Because VS share measures the foreign contents included in exports, the share of domestic value-added embedded in exports is obtained by 1 minus VS share (1 – *VSS*).

2. Data Development

In this paper, to avoid the problems introduced by splitting the I/O tables to derive the data for processing trade, we directly utilize the commodity trade data from China Customs and develop the dataset to estimate VS share at the industry level.

To fulfill this goal, it is essential that we find a way to identify from the trade data the value of the imported intermediates embedded in Chinese exports. In the China Customs database, each recorded trade (import and export) is classified as 1 of the 18 trade patterns among which the ordinary pattern and the processing pattern account for the greatest proportion. On this premise, the omission of the other 16 trade patterns does not matter, and we only need consider the 2 trade patterns mentioned above in order to simplify the measurement process.

First, under the pattern of processing trade, all the imported materials are clearly registered under the category of imports for processing exports, and should be used exclusively in the production of exports. It is required that when the imported materials are processed into semi-final or final goods, all these goods should be exported and registered by China Customs under the pattern of processing exports. Therefore, the value of imported intermediates can be easily identified by detecting the trade patterns when it comes to processing exports.

Under the pattern of ordinary trade, it is difficult to identify intermediates from all imports, but the BEC formulated by the UN (UNSD, 2003) provide a guideline. According to BEC classification, all the imports with HS codes are divided into three categories: capital goods, intermediate goods and consumption goods. The details for the BEC codes and definitions are shown in Table 1. Using the classification of intermediates in BEC, we can detect and identify the intermediates one by one from the data for imports with HS codes, and finally obtain the value of imported intermediates under the pattern of ordinary exports.

Having identified imported intermediates from the trade data of China Customs and the data of both processing and ordinary trade using HS codes, the next step is to match HS code trade data with GB/T coded sectoral data. We use the GB/T-HS Concordance Table to complete such a conversion.[7] The matching process is illustrated in Figure 2.

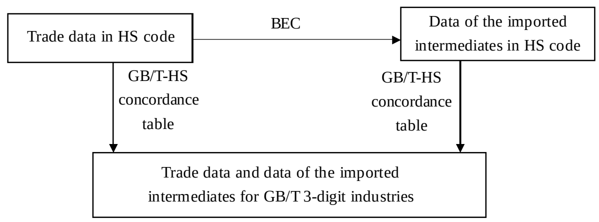
Table 1. Broad Economic Categories Definition of Intermediates

BEC code of intermediates	Definition
111	Food and beverages, primary, mainly for industry
121	Food and beverages, processed, mainly for industry
21	Industrial supplies not elsewhere specified, primary
22	Industrial supplies not elsewhere specified, processed
31	Fuels and lubricants, primary
322	Fuels and lubricants, processed (other than motor spirit)
42	Parts and accessories of capital goods (except transport equipment)
53	Parts and accessories of transport equipment

Source: UNSD (2003). BEC, Broad Economic Categories.

[7] We are grateful to Zheng Wang from the University of Nottingham for providing this concordance table. The concordance table details the matching process between HS8 and GB/T4. Constrained by our data, we have to make a change to this table and come up with a matching process between HS2 and GB/T3 by tailoring the digits. Because HS2 covers 98 chapters and GB/T3 has 164 industries, there might be cases where 1 chapter under HS2 corresponds to several GB/T3 industries. When this occurs, we use the following rule to guide the matching process: split the trade data of the chapter in question under HS2 and fit them into the respective GB/T3 industry using the number of this chapter's show-ups in these industries as weight. For example, if the commodity coded #11 under HS2 shows up 21 counts in industry #131, 4 counts in industry #137, 7 counts in industry #139 and 2 counts in industry #152 under GB/T3, then we use 21/34, 4/34, 7/34 and 2/34, respectively, as weights for each to allocate the trade data into the four industries.

Figure 2. The Roadmap of Concordance



Considering China's exports are dominated by manufactured goods, the present paper mainly estimates the VS share of all 3-digit manufacturing industries of China. The GB/T code for 3-digit industries included in this paper ranges from 130 to 450, covering 164 industries.

Having identified the imported intermediates and matched the HS code trade data with GB/T code industry data, the last step is to set the proportion of the imported intermediates that are used for producing exports. For processing trade, we assume all the imported intermediates should be used for processing exports. However, for the ordinary trade, we still need to determine what quantity of the imported intermediates is going to be used to produce final goods sold domestically and what quantitiy is to be used to produce exports. In this regard, we follow Hummels *et al*. (2001) and use the ordinary export to domestic sales ratio as a proxy.

Although the latest yearly trade data for 2009 is available, the latest 3-digit industries dataset is 2008, which is made available by national economic census. Therefore, we have to confine our estimates to the year 2008.

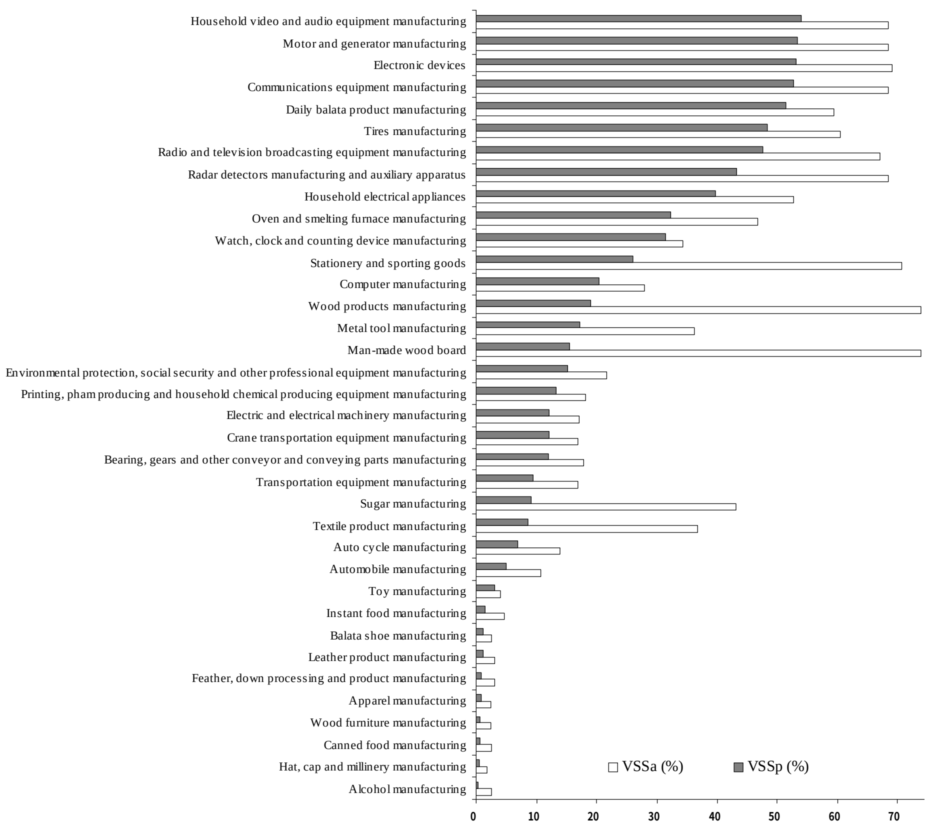
The import and export data in HS code for both processing trade and ordinary trade come from the *China Trade and External Economic Statistical Yearbook 2009* (NBS, 2009). The output data for each industry comes from the *China Economic Census Yearbook 2008* (NBS, 2008). It is noted that the output data for all enterprises covered by 3-digit industries is missing from the Census, so we chose to use their yearly operating revenue as a proxy. In fact, the aggregate operating revenues of all enterprises covered by 3-digit industries is found to be very close to the output value of the 2-digit industries. Moreover, for the 3-digit industries, the data for yearly operation revenue of all the enterprises under the industry coded as "GB/T #366" is also missing. However, because this industry belongs to the 2-digit industry coded "GB/T #360," by subtracting other 3-digit industries included in "GB/T #360," the operation revenue data of the industry coded "GB/T #366" is obtained.

IV. Results of Estimation and Implications

1. Estimated Results

The Appendix to this paper provides the estimated results, and the results for some selected industries are shown in Figure 3. In each industry, we estimated VS share for both total exports and processing exports. However, estimates included in the Appendix are only kept for 115 3-digit industries rather than 164. For quite a few industries classified into *resources and energy*, the estimated results were not meaningful for two reasons: first, the value of imported resources are highly volatile annually, and, second, in China, there have been huge volumes of resource and energy imports in recent years, which are mainly used for domestic final demand, rendering the export value of such industries substantially lower

Figure 3. The VS Share of Selected 3-digit Manufacturing Industries in 2008



Source: Authors' calculation.

Note: VSSa stands for vertical specification share for all exports, while VSSp stands for vertical specification share for processing exports.

than their import value. As a result, the assumptions made for the case of ordinary exports in the estimating method are violated.

The estimated results do reveal some interesting findings. First, the VS share of China's exports weighted by industry was 32.22 percent in 2008. For the purpose of comparison, let us refer to the WTO and IDE-JETRO estimates of VS share for 9 countries and regions (Japan, Indonesia, Korea, Taiwan of China, Thailand, the Philippines, Singapore and China) in the same year. In a joint research report by the WTO and IDE-JETRO in Japan published in 2011, based on the dataset of Asia Input–output Tables (AIO) compiled by IDE-JETRO covering 9 countries and regions, researchers estimated the country-weighted VS share of the 9 economies as 28 percent in 2008, with Singapore having a 58 percent share, Taiwan 47 percent, Korea 37 percent and Thailand 35 percent. As the AIO database does not pay special attention to the fact that processing exports dominate in China, they confess that the VS share of China in 2008 was underestimated. By incorporating the data from Chinese exporting zones to modify the results, they re-estimated the VS share for China, which was increased from 19.7 to 37 percent. In addition, this report mentioned that the VS share of the USA and Japan were very close, at approximately 15 percent in 2008 (IDE-JETRO and WTO, 2011). Therefore, compared with the developed industrial economies, the share of domestic value-added in exports is lower in the emerging market economies.

Second, this paper finds that the VS share of capital-intensive and technologically sophisticated industries is distinctively higher than that of the labor-intensive and simple technology industries. For example, household video and audio equipment manufacturing, motor and generator manufacturing, and electronic devices and communications equipment manufacturing all posted the highest VS shares, as high as 54.01, 53.26 and 53.14 percent, respectively. In other words, the capital-intensive and technologically sophisticated industries use more imported intermediates than other industries in producing exports; hence, the former has a much lower domestic value-added share. Therefore, although we observe that China's exports of technologically sophisticated goods have grown more rapidly than those of the technologically simple goods, the foreign contents included in the former are much higher than the latter, which suggests that China's increasing export of technologically sophisticated goods is largely the result of its participation in vertical division of labor and the global value chain.

Third, as shown in Figure 3 and in the Appendix, the VS share of processing exports is universally much higher than that of ordinary exports. For example, the VS share for all exports in the manmade wood board and wood products manufacturing industry is 19 percent, but the VS share for processing exports for the same industry is as high as 74 percent. In fact, other estimates using different methods reach the same result, revealing that the domestic value-added share for China's ordinary exports is substantially higher than that for processing exports. In other words, the higher VS share facing China's manufacturing industries as a whole is mainly attributed to less domestic value-added embedded in processing exports. At the aggregate level, the VS share of processing exports weighted by industry is 55.62 percent, whereas the figure for ordinary exports is only 8.06 percent. The huge disparity between the two indicates that China has participated in the global value chain mainly through receiving an influx of foreign direct investment and encouraging the expansion of processing trade.

Finally, there are 31 industries with VS share higher than the average, accounting for 35.47 percent of China's gross export value, 13 of which post VS share over 50 percent. Most of these industries are classified into capital-intensive or technologically sophisticated industries, with the greatest pace of expansion in exports. There are 42 industries with VS shares below 10 percent, and the majority of them are technologically simple or labor-intensive industries. The export value of these 42 industries represents 32.12 percent of China's gross export value in 2008. The combined export value of the 10 industries with the lowest VS share accounts for only 4.88 percent of China's gross export value that year. These findings imply that fast expansion of trade flow mainly as a result of global VS has provided China the opportunity to reap huge gains from revealing its comparative advantages.

2. Implications

The value-added approach can not only deepen our understanding of the way that China integrates into the global economy, the stage of China's participation in the GPC and the mechanism of industrial upgrading, but also help change people's perception of the formation and nature of the Sino–American bilateral trade imbalance.

On the surface, the technological contents of Chinese exports have seen a distinctive rise over the past two decades. Rodrik (2006), for example, finds that the GDP per capita of those countries with similar mixes of exports is much higher than that of China. At the same time, the technology intensity of Chinese exports has continuously increased.[8] Similarly, by comparing the export mix of 1992 and 2005, Amiti and Freund (2010) find that the proportion of agricultural goods and apparel declined distinctively, while the proportion of

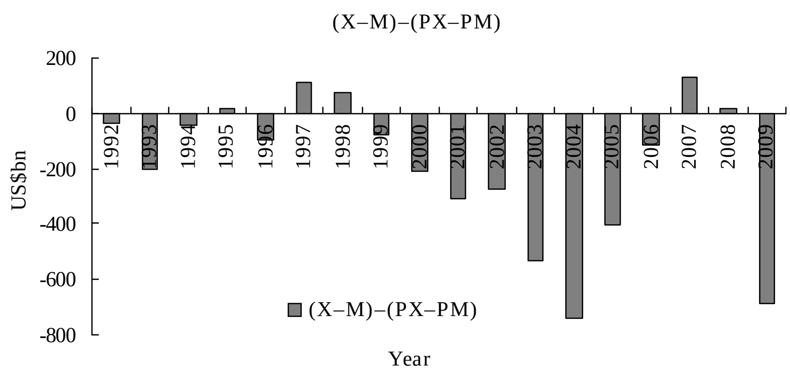
[8] By calculating the index reflecting the technology intensity of exports, Rodrik (2006) finds that the technology intensity has a positive correlation with the per capital income of a country (i.e. a country with high per capital income tends to export goods with a high degree of technological sophistication, and vice versa). Contrary to this correlation, China, with a comparatively low income per capita, has exported a great quantity of highly technology goods, which is regarded as a key factor in the rapid economic growth of China.

computer and other electronic goods rose drastically. Wang and Wei (2010), based on a comparison of the export basket of China with developed countries, find that, in the exports basket by G3, the number of goods that China does not export decreased from 101 in 1996 to 83 in 2005. Yang *et al*. (2009) also find that, since the 1980s, the technology mix of Chinese exports has greatly improved.

Although there is considerable evidence to demonstrate that the export mix and technology sophistication of Chinese exports have undergone distinctive upgrading, it cannot be concluded that the domestic value-added embedded in Chinese exports rises simultaneously because the improvement in the technology content and sophistication might also stem from the higher proportion of processing trade. As Yao (2009) and Amiti and Freund (2010) point out, the rise in the technology intensity of Chinese exports has mainly occurred in processing trade. Without being fully aware of the disproportionately higher share of imported intermediates embedded in Chinese exports, Rodrik must have overestimated the domestic value-added included in Chinese exports. Considering the popularity of processing trade in China, Lemoine and Ünal-Kesenci (2004) and Steinfeld (2004) are all disposed to think that China is still at a relatively primary stage of integration to the global economy.

By the same token, the value-added approach would create a different picture in illustrating the Sino–American trade imbalance. In fact, the Sino–American trade imbalance is a good example for demonstrating the difference between the gross export value and the value-added embedded in exports. On 15 December 2010, an article by Andrew Batson was published in the *Wall Street Journal* (Batson, 2010). Batson quotes a report by Xing and Detert (2010) titled "How the iPhone widens the United States deficit with the People's Republic of China." According to this report, the prevailing trade statistics in the globalization era are misleading; that is, the final product is exported from the place where it is finally assembled regardless of where it was designed and its core components were produced. Although China is not in charge of the design of the iPhone and the production of its core components, it is the final assembler. Therefore, when it is exported to the USA, US Customs record it as a Chinese export to the USA. However, in reality, China is only in charge of assembling all the components of the iPhone, and the core components and design are all imported from, for example, the USA, Japan, Germany and Korea. The wholesale price of an iPhone is US$178.96, for which China only accounts for 3.6 percent (approximately US$6.5) in terms of value-added. In 2009, the number of iPhones sold to the USA was 11.3 million, so China's gross export value of the iPhone to the USA was US$2.02bn. However, if calculated as value-added embedded in exports, this figure is reduced to only US$73.5m. Interestingly, because China imported the components from the USA, which made up US$121.5m of value-added in 2009, the USA had a trade surplus of $48.1m with China as far as the product of iPhone is concerned. Obviously,

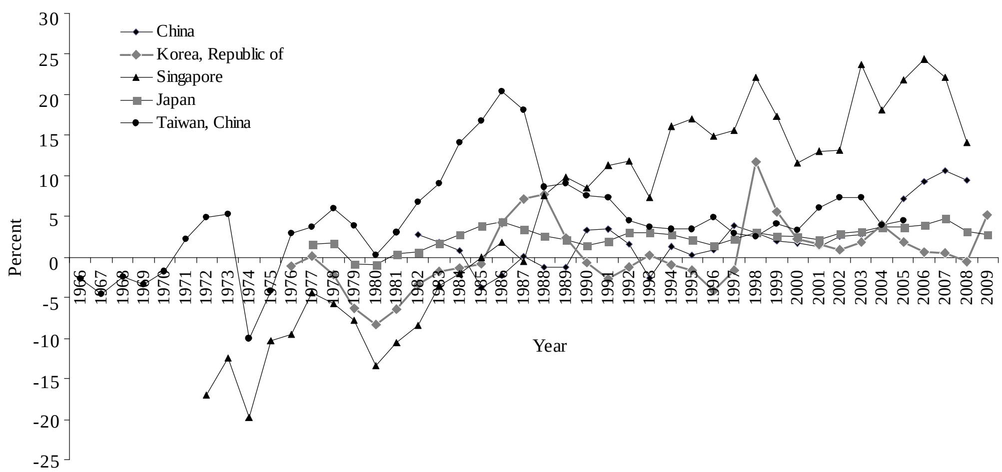
Figure 4. Balance of China's Ordinary Trade



Sources: NBS, *China Statistical Yearbook*, various years.

Note: (X–M) = total balance of trade; (PX–PM) = balance of processing trade

Figure 5. Balance of Trade as Percentage of GDP in China and East Asian Economies



Sources: Data for China, South Korea, Singapore and Japan are from World Bank (2011); data for Chinese Taiwan are from WTO (2011).

the gross export value statistics overestimate the extent to which the Sino–American trade imbalance evolves. Pascal Lamy, Director-General of the WTO, stated in October 2010: "We say 'Made in China' is assembled in China actually.... If the product reflect[s] the contributions of different countries the real value of US$226.8bn in the US trade deficit will be halved."[9]

It is also important to note that without processing exports, the trade surplus of China

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[9] See http://www.21tradenet.com/news_2010-12-20/51550.htm.

would become a trade deficit. As Figure 4 shows, China's ordinary trade, which is the residual of the total balance of trade minus that of processing trade, has been continuously generating deficit since the beginning of the 21st century. Furthermore, even though China has a huge trade surplus with the rest of the world, the surplus per unit of export value is rather low due to the lower share of domestic value-added embedded in Chinese exports. The scale of China's trade surplus should be explained by the quantity expansion of processing trade rather than its value-added per unit of export. As a result, China's trade surplus as a percentage of GDP has not been kept higher than that of East Asian economies, as Figure 5 indicates. Therefore, the persistent US call to rebalance the US–China trade imbalance through revaluation of the RMB is not well justified.

V. Conclusion

Difficulties will be faced in obtaining the appropriate datasets for any attempt to estimate the foreign/domestic value-added embedded in China' exports. In this regard, there are two problems with the Chinese I/O tables compiled by the National Bureau of Statistics of China. First, in these tables, there is no information about the value of intermediates are imported. Another problem is that there is no information to distinguish between processing exports and non-processing exports. Having faced such problems, most studies have attempted to edit the Chinese I/O tables with the information provided by China Customs trade data to estimate foreign/domestic contents embedded in Chinese exports.

This paper, by directly employing trade data for the year 2008 for which imported intermediates in both processing and non-processing trade could be identified through various trade patterns, provides a simplified way to estimate the share of foreign/domestic value-added included in industry-level manufacturing exports. The estimates in this paper are for the year 2008 due to the availability of data. Because trade patterns will not undergo distinctive and substantial changes in the short run, the estimated results for 2008 are appropriate to use in an investigation of the nature of the trade expansion of China, and the extent to which China participates in the global production chain.

Based on the estimated results for 115 3-digit manufacturing industries, this paper finds that the VS share (or the share of foreign value-added) included in China's exports weighted by industries was 32.22 percent in 2008, and that included in China's processing exports was approximately 56 percent in 2008, compared to approximately 10 percent for ordinary exports. It also finds that industries that experienced fast expansion of processing exports have much higher shares of foreign contents and, therefore, lower domestic value-added shares. Because processing exports account for approximately half of Chinese exports, the prevailing trade statistics, which focus on gross values rather than the value-added of exports and imports, have obviously overstated the bilateral trade imbalances, especially between China and the USA.

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Appendix

The VS Share and Export Share of China's 3-digit Industries in 2008

Industry	VSSp (%)	VSSa (%)	Export share (%)
Household video and audio equipment manufacturing	68.55	54.01	2.97
Motor and generator manufacturing	68.55	53.26	1.94
Electronic devices	69.07	53.14	2.37
Relay and industrial control manufacturing	68.55	52.83	3.09
Communications equipment manufacturing	68.55	52.76	3.27
Battery manufacturing	68.55	52.75	1.09
Other electronic devices	68.55	52.52	0.30
Wire, cable, optical cable and electrical appliance manufacturing	68.55	52.49	2.00
Electronic components manufacturing	68.55	52.33	1.45
Balata board, hose, belt manufacturing	61.32	51.75	0.29
Vegetable fruit and nut processing	76.21	51.68	0.48
Valued metal smelting	81.44	51.67	0.08
Daily balata product industry	59.35	51.47	0.09
Lighting apparatus manufacturing	65.26	49.52	2.61
Recording media reproducing	68.55	49.20	1.27
Liquid dairy and dairy products manufacturing	59.35	49.02	0.16
Rebirth parts product industry	59.35	48.77	0.01
Tires manufacturing	60.57	48.31	0.23
Radio and television broadcasting equipment manufacturing	66.99	47.60	3.19
Other balata product industry	67.79	47.51	0.08
Black lead and other nonmetal mineral product	76.68	47.20	0.43
Special chemical product manufacturing	87.96	47.15	1.22
Fur, leather accessories and trimmings and product processing	73.20	47.04	0.08
Daily plastic goods manufacturing	84.83	46.48	0.48
Other electrical machinery manufacturing	67.86	45.30	1.82
Plastic parts manufacturing	83.84	44.89	0.17
Radar detectors manufacturing and auxiliary apparatus	68.55	43.23	0.42
Household electrical appliances	52.71	39.78	2.64
Seafood processing	45.82	38.73	0.37
Other agricultural and side-product processing	68.88	36.97	0.13
Oven and smelting furnace manufacturing	46.71	32.24	0.75
Watch, clock and counting device manufacturing	34.26	31.46	0.23
Paper product manufacturing	50.75	27.56	0.29
Paper making	49.12	27.34	0.38
Biology product industry	77.55	26.16	0.06
Stationery and sporting goods	70.69	26.06	0.47
Glass and glass product	79.24	23.98	1.01

(To be continued on the next page.)

Industry	VSSp (%)	VSSa (%)	Export share (%)
Container and metal containing vessels manufacturing	65.51	23.78	0.39
Enamel products manufacturing	56.89	22.89	0.27
Computer manufacturing	27.91	20.51	1.20
Wood products manufacturing	73.99	19.00	0.25
Other tobacco products processing	25.00	18.49	0.02
Metal processing machine manufacturing	23.52	17.54	2.54
Metal tool manufacturing	36.18	17.28	0.97
Balata parts product industry	21.97	16.90	0.07
Food, beverage, tobacco and animal feeds producing special equipment manufacturing	21.40	16.33	0.76
Non-electrical home appliance manufacturing	43.42	16.18	0.32
Saw, wood chips processing	73.98	15.96	0.12
Other metal products	53.14	15.75	0.48
Man-made wood board	73.98	15.55	0.30
Environmental protection, social security and other professional equipment manufacturing	21.64	15.16	1.22
Chemical, timber, non-metal processing equipment manufacturing	19.94	14.58	1.17
Art and craft article manufacturing	34.26	14.44	1.04
Ceramic product industry	48.23	14.30	0.77
Metallurgy, mining, construction industrial equipment manufacturing	19.35	14.03	2.93
Printing	22.69	13.68	0.29
Confectioneries, chocolate & candied fruits manufacturing	41.41	13.53	0.04
Printing, pharm producing and household chemicals producing equipment manufacturing	18.26	13.29	1.87
Other related printing activities	17.16	12.48	0.03
Fan, weighing apparatus and packing equipment manufacturing	17.16	12.48	2.87
Boiler and motor manufacturing	17.16	12.48	1.31
Pump, valve, compressor and similar machinery manufacturing	17.16	12.48	1.26
Weaving, apparel, leather equipment manufacturing	17.16	12.48	2.66
Daily chemical product manufacturing	30.20	12.45	0.26
Agriculture industry machinery manufacturing	17.01	12.40	1.15
Aviation, aerospace vehicle manufacturing	18.61	12.24	0.32
Electric and electrical machinery manufacturing	17.16	12.17	0.26
Crane transportation equipment manufacturing	17.00	12.10	1.37
Bearing, gears and other conveyor and conveying parts manufacturing	17.82	11.95	0.59
Bamboo, vine, palm and grass products	60.16	11.62	0.24
Fabricated metal product	74.19	11.57	0.27
Medical material and supplies manufacturing	33.27	11.45	0.04
Bicycle manufacturing	9.63	10.48	0.36
Cement product and asbestos cement product industry	65.56	9.85	0.19
Construction and safety metal products	37.33	9.82	0.64
Transportation equipment manufacturing	16.98	9.36	0.08

(To be continued on the next page.)

Industry	VSSp (%)	VSSa (%)	Export share (%)
Tobacco leaf processing	25.00	9.34	0.02
Sugar manufacturing	43.06	9.09	0.03
Fireproof materials products	83.28	8.86	0.28
Textile product manufacturing	36.67	8.59	2.68
Veterinary medicines manufacturing	11.61	8.24	0.03
Musical instrument and other entertaining goods	16.63	7.97	0.17
Various household supplies	20.95	7.27	0.86
Other food manufacturing	25.00	7.23	0.16
Animal slaughtering & meat processing	12.15	6.90	0.42
Motorcycle manufacturing	13.88	6.84	0.34
Chemical fertilizer manufacturing	46.66	6.07	0.42
Pharmaceutical preparations manufacturing	11.61	4.98	0.09
Automobile manufacturing	10.73	4.93	3.06
Knit fabric, knitting and product manufacturing	20.03	4.10	6.21
Tile, lime and light construction material manufacturing	47.17	3.31	0.43
Baked food manufacturing	11.47	3.29	0.05
Chinese patent drug	11.61	3.06	0.01
Toy manufacturing	4.00	2.96	0.60
Games, amusement equipments	3.79	2.76	0.64
Sporting and athletic goods	3.77	2.67	1.49
Instant food manufacturing	4.57	1.36	0.03
Textile shoes manufacturing	2.61	1.09	0.57
Balata shoe manufacturing	2.61	1.09	0.76
Drink manufacturing	8.34	1.08	0.04
Leather product manufacturing	2.98	1.05	2.08
Soft drink manufacturing	4.70	1.03	0.14
Rail transport equipment manufacturing	0.55	0.96	0.85
Feather, down processing and product manufacturing	3.04	0.84	0.26
Apparel manufacturing	2.47	0.76	3.62
Boat building	0.79	0.71	1.91
Feed processing	2.00	0.63	0.02
Bamboo, vine furniture manufacturing	2.42	0.60	0.18
Metal furniture manufacturing	2.42	0.60	0.71
Wood furniture manufacturing	2.42	0.60	0.77
Plastic furniture manufacturing	2.42	0.60	0.12
All other furniture manufacturing	2.42	0.60	0.65
Canned food manufacturing	2.57	0.58	0.40
Hat, cap and millinery manufacturing	1.75	0.42	0.12
Alcohol manufacturing	2.56	0.28	0.01

Source: Authors' calculation.

Note: The 115 3-digit industries are classified according to GB/T4754-2002.

(Edited by Xiaoming Feng)