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How much of Chinese exports is really made in China? Assessing foreign and domestic value-added in gross exports

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Abstract

China is the archetypical example of a national economy actively integrated into a global production chain. As China's juggernaut export machine employs many imported inputs, there are a variety of policy questions for which it will be useful, even crucial, to assess accurately the extent of domestic value added (DVA) in its exports. To that end, we aim to make three contributions. While we use China for illustration, the methodological contributions of the paper are applicable to Mexico, South East Asia, Central and Eastern Europe, and other countries that engage in tariff-favored processing trade. First, we demonstrate analytically that the measure of vertical specialization (VS) in the international trade literature (Hummels, Ishii and Yi 2001) is identical to the share of foreign value added (FVA) in a country's final demand of domestic products in the input-output literature. However, the specific definition proposed by HIY is generally not the same as the share of FVA in a country's total exports with the presence of processing trade. Second, in order to estimate the share of DVA in a country's total exports, we recommend combining trade statistics from customs authorities which separate processing trade from normal trade and standard input-output tables. This allows for a separation of the production for processing trade from that for normal trade and domestic sales. A mathematical programming based procedure is proposed to estimate the shares of domestic and foreign values added in gross exports. Third, we apply the procedure to decompose China's gross exports in 83 goods-producing industries based on the country's 1997 and 2002 benchmark IO tables and trade data. Our estimates of domestic value added tend to be lower than those implied by the HIY's VS measure. There is also a trend increase in the DVA component of the exports (the opposite of what one would have estimated using the HIY measure). For Chinese manufacturing exports as a whole, DVA (as a share of the total value of exports) rose from 47.1% in 1997 to 51.3% in 2002.

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I. Introduction

World production has become more fragmented in recent years. The global supply chains of many products have stretched across ever more countries. Large quantities of imported intermediates are used to produce exports, and intermediate goods may cross international borders many times before they become final products. A dramatic increase in vertical specialization has been suggested as the most important factor for explaining why world trade has been growing faster than global GDP over last three decades (Yi 2003). In the unfolding drama of cross-border vertical specialization, China has emerged as a central player in using imported inputs for exports. This practice, also known as processing exports, accounts for more than half its manufacturing exports in last decade (detail in Table 1) .

Processing exports are characterized by imports for exports: firms import parts and other intermediate materials from abroad, often with custom duty and tax preferences from local or central governments, and, after processing or assembling, the finished products are re-exported to the international market. A mixture of processing and normal exports complicates an accurate measurement of the domestic content of exports. The intensity of imports used as intermediate inputs in producing these two types of exports is usually significantly different. Ignoring such a difference in production structures would result in overestimating the degree of domestic value-added in gross exports for economies that participate heavily in a global supply chain and in processing trade such as that carried out in China and Mexico.

For a variety of issues, it is important to be able to accurately assess the true extent of domestic content in exports. Let us discuss three examples. First, what is the effect of a currency appreciation on a country's exports? The answer depends on the extent of domestic content in the country's exports. If the domestic content is low (i.e., the value of exports reflect mostly the value of imported inputs), then the exchange rate appreciation would have relatively little effect on exports. This is because the higher foreign currency price of the exports is partly offset by the lower domestic-currency price of the imported

inputs. To the extent that the domestic content varies by industries, a given exchange rate appreciation should be expected to have different effects in different industries. The role of the Chinese exchange rate system in China's trade surplus has received much attention lately. An accurate assessment of the effect of an RMB appreciation requires an accurate assessment of the domestic content in China's exports.

Second, what is the effect of trading with China on US income inequality? On the surface, China appears to export products much more sophisticated or skill-intensive than its low per capita income would have suggested (Schott, 2006; Rodrik, 2006). This would imply that trading with China should have a smaller effect on skill premium in the United States than China's endowment would suggest (Lawrence, 2008). However, if the domestic content in China's exports is low, especially in sectors that would have been considered sophisticated or high-skilled in the United States, then a given amount of imports from China would have a larger effect on US skill premium (as pointed out by Krugman, 2008).

Third, does it make sense for governments to provide policy incentives to especially encourage sectors that have relatively high domestic content? Many policy makers and academics in developing countries including in China, appear to believe that a country does not benefit much from exporting low domestic content products as these sectors would not create as much total value added or employment. As a result, they often propose to have government-provided incentives to promote high domestic content exports. This view could be wrong if low domestic content sectors, on average, grow no slower than high domestic content sectors. However, the appropriateness of this influential view has never been systematically examined because of the difficulties associated with measuring domestic –content in a country's gross exports. An accurate assessment of the degree of domestic content at the sector level will provide a necessary input into a formal investigation of the validity of this view.

In assessing domestic content in a country's exports, the recent literature has taken two separate routes. One set of studies has focused on measuring the foreign content of exports. Hummels, Ishii, and Yi (2001) (HIY) propose a measure of the degree of vertical specialization (VS) in a country's trade, defined as "the *imported input content* of

exports, or equivalently, *foreign value added* embodied in exports" (HIY 2001: 79, italics added) and provide a general formula to compute VS as a share for a country's total exports based on the import use matrix and the Leontief inverse. As described by HIY, their VS share measures "the value of imported inputs embodied in goods that are exported," where "imported inputs are allowed to circulate through several stages of the domestic economy before 'exiting' as an export." Therefore, the imported intermediates in the HIY definition include all direct and indirect imported inputs embodied in a country's exports (HIY 2001: 80). [2] Recent applications of the vertical specialization concept include Yi (2003), Goh and Olivier (2004), Chinn (2005), and Dean, Fung, and Wang (2007).

Table 1 Imports for Exports: China's processing trade in manufacture (excluding HS Chapter 1-27), 1995-2006

Year	*Share of processing exports in total exports (100*PE/TE)*	*Among the share: Type I Process & assembling*	*Type II Process with imported materials*	*Share of processing imports in total imports (100*PM/TM)*	*Value of processing imports as share as value of processing exports (100*PM/PE)*	*Processing trade surplus as share of processing exports (100*[PE-PM]/PE)*
1995	55.3	15.5	39.8	46.5	75.7	24.3
1996	62.1	18.0	44.1	47.6	71.1	28.9
1997	**60.2**	**17.9**	**42.3**	**53.1**	**67.0**	**33.0**
1998	62.0	18.3	43.7	52.0	63.3	36.7
1999	61.2	19.9	41.3	47.9	64.7	35.3
2000	59.6	17.9	41.7	46.6	65.9	34.1
2001	59.7	17.2	42.5	43.0	62.7	37.3
2002	**58.8**	**15.6**	**43.2**	**45.6**	**67.4**	**32.6**
2003	58.5	13.2	45.4	44.0	66.7	33.3
2004	58.0	12.0	46.0	45.3	66.6	33.4
2005	57.0	11.3	45.7	48.3	64.6	35.4
2006	54.5	9.9	44.6	47.9	61.7	38.3

Source: China Customs Trade statistics, General Customs Administration of China.

[2] Note that the HIY measure refers to the value of imported intermediate goods embodied in the home country's exports, rather than to the returns to foreign labor or foreign capital working in the home country.

A recent report from the U.S. National Research Council (USNRC) recognized problems of double counting in current measures of gross exports and noted that "it is impractical to directly measure the foreign content of U.S. exports" (2006: 20). The USNRC concluded that HIY's approach could be used to estimate the foreign content of U.S. exports, excluding services. However, because the HIY measure assumes that the production of goods for exports and that for domestic final sales have the same input-output structure, it is not suited for an exporting country that engages heavily in processing trade. In addition, neither HIY nor USNRC discuss the impact of processing trade on the measurement of imported content in exports.

A second set of studies has focused on measuring the domestic content of Chinese exports. Chen et al. (2004) were the first to focus on the concept of domestic value added of exports in a non-competitive type input-output model framework for China, and developed a method to compute its share when processing exports are presented. However, the paper does not relate the measure of domestic value added to the VS measure proposed by HIY, nor does it describe how the underlying IO account data was compiled. Therefore, it is difficult for others to replicate their estimates of DVA share in China's exports. In addition, they rely on a symmetry assumption (USNRC 2006: 21) to construct their import use matrix from the competitive-type IO table published by NBS of China: within each industry of the IO table, the mix of imported and domestic products is assumed to be the same in capital formation, intermediate inputs, and final consumption. This assumption is common in the IO literature because of a lack of reliable information on the use of imports.

Dean, Fung, and Wang (DFW, 2007) extend the first set of studies by taking advantage of Chinese Customs data which explicitly identifies processing trade, and the United Nation Broad Economic Categories (BEC)[3] classification, to determine the proportion of imports used as intermediate inputs in production. This improves the accuracy of VS share estimation based on the HIY approach. The authors then use the improved data to

[3] The BEC classification categorizes products as capital goods, intermediate goods, or consumer goods based on their use.

calculate VS share in Chinese trade for the 1997 and 2002 benchmark years by sector, source, and destination. DFW find that VS share in Chinese exports, measured by the HIY definition, has been growing over time. However, DFW did not discuss the domestic value added in gross exports. In addition, because the production of goods for exports and for domestic final sales is assumed to have the same input-output structure, the computed foreign content is not accurate.

In this paper, we aim to make three contributions. First, we explore conceptual connections between two previously disconnected literatures on input-output tables and international trade. We demonstrate that the concept of foreign value added in a country's final demand of domestic products, developed in the input-output literature, and the VS share measure, developed in the international trade literature, are identical. Second, we describe a mathematical programming approach to separate the production of processing and normal exports by combining a standard IO table with information from published trade statistics, and show how domestic and foreign value-added shares in exports should be computed in such an extended IO account. This simplifies and "standardizes" a procedure proposed in Lau et al. (2007). Finally, we apply our procedure to decompose China's gross exports in 83 goods producing industries (excluding services) based on its 1997 and 2002 benchmark IO tables and on related trade statistics that distinguish processing and normal trade, using an intermediate inputs identification method refined from DFW (2008). We compare our estimates with the estimates derived by the HIY procedure. Note that the 2002 IO table is the latest such table available; the next table—the 2007 benchmark IO table— is scheduled to be released in 2010.

The rest of the paper is organized as follows. Section II lays out the conceptual framework, section III outlines the empirical estimation procedure, and preliminary estimation results are presented in section IV. Section V concludes with a discussion on the limitations of the methods developed in this paper, and on avenues for future research.

II. The Conceptual Framework

In this section, we build up from HIY (2001) and Chen et al. (2004) to illustrate how a country's domestically produced final demand, including its gross exports, can be decomposed into a *domestic content* or *domestic value-added* share and an *imported content* or *foreign value-added share*. We show that HIY's VS share measure is identical to the share of foreign value added in a country's final demand of domestic products. However, in general, the VS share is equal to the foreign value-added share in exports only under some additional assumption.

The non-competitive type IO model can be specified as follows[4]:

$$A^D X + Y^D = X \tag{2.1}$$

$$A^M X + Y^M = M \tag{2.2}$$

$$(A^D + A^M)' X + \hat{A}_v X = X \tag{2.3}$$

$$uA^D + uA^M + A_v = u \tag{2.4}$$

Equations (2.1) and (2.2) define the horizontal balance conditions, equation (2.3) gives the vertical balance conditions, and equation (2.4) is the input-output coefficient additive condition (that the column sum of IO coefficients should equal unity). Where:

$A^D = [a^D_{ij}]$ is an $n_x n$ matrix of direct input coefficients of domestic products;

$A^M = [a^M_{ij}]$ is an $n_x n$ matrix of direct inputs of imported goods;

Y^D is an $n_x 1$ vector of final demands for domestic products, which includes domestic products used in gross capital formation (K^D), private and public final consumption (G^D and C^D), and gross exports (E);

[4] The IO model we use is standard in the IO literature. Chen et al. (2004) specify the first two equations without Equations 2.3 and 2.4, while HIY (2001) specify the related Leontief inverse directly without going through even Equations 2.1 and 2.2. A fully specified non-competitive IO model helps to facilitate an understanding of why the VS share measure is identical to the share of foreign value-added in a country's final demand of domestic products, and produces the mathematical relationship that DVA share in a country's gross exports equals one minus the VS share.

Y^M is an n_{x1} vector of final demands for imported goods, which includes imported products used in gross capital formation (K^M), private and public final consumption (G^M and C^M);

X is a n_{x1} vector of gross output;

M is a n_{x1} vector of imports;

$A_v = [a^v_j]$ is a $1_{x}n$ vector of each sector j's ratio of value-added to gross output;

$\hat{A}_v$ is an $n_{x}n$ diagonal matrix with A_v as its diagonal elements;

u is a $1_{x}n$ unity vector;

Subscripts i and j indicate sectors, and superscripts D and M represent domestic and imported products, respectively.

From equation (2.1) we have

$$X = (I - A^D)^{-1} Y^D \tag{2.5}$$

Substituting equation (2.5) into equation (2.2) for X yields:

$$M - Y^M = A^M (I - A^D)^{-1} Y^D \tag{2.6}$$

Obviously, the left of the equation is total imports used as intermediate inputs, and $A^M (I - A^D)^{-1}$ is the total intermediate import requirement coefficient matrix. Define $VSS = \{vss_j\}$, a $1_{x}n$ vector as the VS share in per unit of final demand of domestic products, including exports. Then, based on HIY's equation 3 (2001: 80) we have,

$$VSS = uA^M (I - A^D)^{-1}$$

(2.7)

This means that HIY's VS share for each IO industry is the column sum of the total intermediate import requirement coefficient matrix and HIY's VS share of a country's total exports is the sum of *VSS* weighted by the country's export structure. As HIY described, the Leontief inverse, $(I - A^D)^{-1}$ "is the term that captures allowing the imported input to be embodied in a domestic output at [the] 2nd, 3rd, 4th,… stage before it becomes embodied in the good that is exported" (2001: 81). Because investment and final consumption are also components of Y^D, this implies that *VSS* also measures imported products embodied in per unit investment and consumption goods from the same domestic producing industry and should be broadly understood as the dependence of a

country's production of domestic final demand on foreign products (imports). As we will show later, this broader interpretation makes a qualitative difference in understanding the trend of domestic value added in China's exports.

Suppose that there is an incremental increase in final demand of domestic products ΔY^D. According to equation (2.5) the incremental increase in gross output induced by this change is given by

$$\Delta X = (I - A^D)^{-1} \Delta Y^D \tag{2.8}$$

Define the incremental increase in value-added induced by a change in gross output as:

$$\Delta V = \hat{A}_v \Delta X \tag{2.9}$$

Then, substituting equation (2.8) for ΔX, the incremental increase in value-added induced by this increase in the final demand of domestic products is given by

$$\Delta V = \hat{A}_v \Delta X = \hat{A}_v (I - A^D)^{-1} \Delta Y^D \tag{2.10}$$

where $V = \{v_j\}$ is an n_{x1} vector of sector value added (Chen et al. 2004).

Define $DVS = \{dvs_j\}$, a $1_{x}n$ vector, as the "domestic value added" generated by one unit of final demand of domestic products ($\Delta Y^D = u'$). Based on (2.10) we have $DVS = \Delta V = A_v (I - A^D)^{-1}$. The intuition behind *DVS* is as follows: when one unit of final demand of domestic products ($\Delta Y^D = (\Delta E, \Delta K^D, \Delta C^D, \Delta G^D)$) is produced, a first round of value added is generated. This is the *direct* domestic value added induced by domestic final demand. In order to produce that domestic final demand, however, intermediate inputs must be used. The production of these intermediate inputs creates the second round of value added. This is (part of) the *indirect* domestic value added induced by domestic final demand. Clearly, this process of creating indirect value added can be traced throughout the economy, as intermediate inputs are used to produce other intermediate inputs, etc. Therefore, the *total* domestic value added induced by one unit of final demand of domestic products is equal to the sum of direct domestic value added and all indirect domestic value-added (Chen et al. 2004). Expressing this process mathematically, using the terms defined above, we have:

$$DVS = A_v + A_v A^D + A_v A^D A^D + A_v A^D A^D A^D + ... \\ = A_v (I + A^D + A^{D^2} + A^{D^3} + ...) \quad (2.11)$$

It can be shown that the power series of matrix A^D is convergent and that the inverse matrix $(I - A^D)^{-1}$ exists (Miller and Jones 1985). Thus, we have:

$$DVS = A_v (I - A^D)^{-1} \ , \quad (2.12)$$

where $(I - A^D)^{-1}$ is the total domestic intermediate product requirement coefficient matrix and equation (2.12) implies that the domestic content (or value-added share) for an IO industry is the corresponding column sum of the total domestic intermediate goods requirement coefficient matrix, weighted by the direct value-added coefficient of each industry.

What is the relationship between VSS and DVS? It is easy to show that this two vectors sum to a unit vector.[5] From equations (2.7) and (2.12) we have:

$$DVS + VSS = A_v (I - A^D)^{-1} + uA^M (I - A^D)^{-1} = (uA^M + A_v)(I - A^D)^{-1} \quad (2.13)$$

Substituting equation (2.4), the IO coefficients additive condition $uA^M + A_v = u - uA^D$ into (2.13) we have:

$$DVS + VSS = (u - uA^D)(I - A^D)^{-1} = u(I - A^D)(I - A^D)^{-1} = u \quad (2.14)$$

This verifies that a country's gross exports (like its final demand of domestically produced products in general) can be decomposed into domestic and foreign value added at both the industry and national aggregate levels, and that *DVS*, the domestic value-added embodied in a unit of final demand of domestic products, equals one minus the share of foreign value added. Note however that the VS share indicator proposed by HIY measures DVA share in total exports (as opposed to final demand for domestic products) only under one additional assumption, namely that exports and other parts of final demand of domestic products have the same input-output structure A^D. This assumption

[5] A different proof was given in Chen et al. (2004: Appendix 1). Their coefficient of total imports is mathematically equivalent to HIY's VS share. However, they were not aware of HIY's work and did not realize that their domestic value-added measure actually equals one minus HIY's VS share under some conditions. Based on the suggestion from one of the authors from this paper, the linkages between the two literatures were discussed in Lau et al. (2007).

is implicitly made when one conducts a thought experiment of a change in exports as the only change in the final demand of domestic products, i.e., $\Delta Y^D = \Delta E$, and $(\Delta K^D, \Delta C^D, \Delta G^D) = 0$. Similarly, the definition of the DVA share in exports in Chen et al. (2004) is valid only under the same assumption. If this assumption doesn't hold, both measures would need to be redefined. We will return to this point in Section 3.2.

III. Estimation Methods

As we mentioned earlier, it is important to distinguish between processing and normal exports in IO accounts because otherwise the domestic value-added share in gross exports, for economies with extensive processing trade, will be overestimated. As we will show later, the trend in domestic value added may also be miscalculated if processing and normal exports are not distinguished in IO accounts. To empirically decompose foreign and domestic value added in gross exports in the presence of extensive processing trade, a non-competitive input-output table with a separate account for processing exports must first be estimated based on available statistics. Then the VS share definition and computation method proposed in HIY has to be modified to accommodate the changed structure of such an estimated input-output account. As we discussed earlier, while Chen et al. (2004) and Lau et al. (2007) used a non-competitive input-output model with separate accounts for both normal and processing exports, and a method to compute domestic value added in China's gross exports based on their IO model, they did not discuss how such an IO table could be constructed from existing statistics. Therefore, there is no way for others to duplicate their domestic value-added share estimates. In addition, their first paper built a processing exports account largely based on data of China's type I processing exports (processing and assembling: P&A), while their second paper assumes that there is a significant difference of intensity in the use of imported intermediate inputs between the production of normal exports and that of products sold inside China (for every producing industry) in their IO model. This assumption makes the derivation of their procedure quite complicated, but also may be unnecessary as the

Chinese economy becomes increasingly market oriented[6]. Therefore, in this section we develop a simplified IO model with a separate processing export production account that includes both types of processing exports, and we construct a mathematical programming model to empirically estimate such IO tables based on publicly available statistics. The estimation and computation process is transparent, and can be duplicated by other researchers.

3.1 Separating processing exports from domestic sale and normal exports

To separate intermediate input usage of imports in processing exports from domestic sales and normal exports, a quadratic programming model is developed to reconcile input-output data published by National Bureau of Statistics (NBS) of China with annual trade statistics published by the China General Customs Administration. The model assumes that:

(1) Normal exports are similar to domestic consumption (private and government) and gross capital formation as part of the nation's final demand of domestic products, and are produced by the same technology (have a similar intensity in the use of imported inputs);

(2) Processing exports can only be sold in the foreign market (no domestic sales are permitted) and are produced by different technology than normal exports and domestic sales (intensities in the use of imported inputs are significantly different);

(3) It is feasible to identify total imports by each IO sector into three portions based on trade statistics: (a) final demand for goods (for consumption or investment),

[6] In the planning years and earlier years of economic reform, Chinese firms, especially SOEs, often used imported materials to produce exports and domestic materials to produce for domestic sales, with the intent to remain competitive in quality and earn foreign exchange. Such a practice is no longer followed today. Firms decide where to buy their intermediate inputs and where to sell their products based on market signals. Because the existing policy incentives for processing trade are so great compared to those for normal trade, it is hard to imagine any firm not choosing to classify their exports as processing trade if they have imported inputs. Therefore, we make the imperfect assumption that this is relatively closer to China's reality today. Because Type I processing trade (P&A or "*liai liao jia gong*") is declining in importance, Type II processing trade has become dominant (See Table 1).

(b) intermediate inputs for processing exports, and (c) intermediate inputs for domestic sales and normal exports.

The notation used to specify the model is as follows:

Variables:

z_{ij}^{dn} = Domestically produced intermediate good *i* used by sector *j* for domestic sales and normal exports;

z_{ij}^{dp} = Domestically produced intermediate good *i* used by sector *j* for processing exports;

z_{ij}^{mn} = Imported intermediate good *i* used by sector *j* for domestic sales and normal exports;

z_{ij}^{mp} = Imported intermediate good *i* used by sector *j* for processing exports;

v_j^n = Value added by domestic and normal export production in industry *j*

v_j^p = Value added by processing export production in industry *j*

Parameters and their data sources:

x_i = Gross output of sector *i*; (from IO table)

z_{ij} = Goods *i* used as intermediate inputs in sector *j*; (from IO table)

v_j = Value-added in sector *j*; (from IO table)

e_i^n = Normal exports of sector *i*; (from IO table and trade statistics)

e_i^p = Processing exports of sector *i*; (from IO table and trade statistics)

m_i = Total imports of sector *i* goods; (from IO table)

m_i^p = Imports of sector *i* goods used as intermediate inputs to produce processing exports; (share from trade statistics)

m_i^n = Imports of sector *i* goods used as intermediate inputs for domestic production and normal exports; (share from trade statistics)

y_i = Total final demand of goods *i*; (includes consumption and investment, from IO table)

y_i^m = Final demand of goods *i* from imports (residuals of m_i - m_i^p - m_i^n)

y_i^d = Final demand of goods *i* provided by domestic production (residual of y_i - y_i^m);

Where *i* and *j* are indices of sectors from 1 to K, *d* and *m* denote domestic sales and imports, and *p* and *n* refer to processing and non-processing transactions. We wish to infer an IO matrix for the processing exports based on observed data while minimizing squared errors in doing so. Using the notations defined above, our model is specified by the following objective function and by nine constraints:

$$\begin{aligned}\text{Min } S = &\sum_{i=1}^{K}\sum_{j=1}^{K}\frac{(z_{ij}^{dn}-z0_{ij}^{dn})^2}{z0_{ij}^{dn}}+\sum_{i=1}^{K}\sum_{j=1}^{K}\frac{(z_{ij}^{dp}-z0_{ij}^{dp})^2}{z0_{ij}^{dp}}+\sum_{i=1}^{K}\sum_{j=1}^{K}\frac{(z_{ij}^{mn}-z0_{ij}^{mn})}{z_{ij}^{mn}}\\ &+\sum_{i=1}^{K}\sum_{i=1}^{K}\frac{(z_{ij}^{mp}-z0_{ij}^{mp})^2}{z0_{ij}^{mp}}+\sum_{j=1}^{K}\frac{(v_j^n-v0_j^n)^2}{v0_j^n}+\sum_{j=1}^{K}\frac{(v_j^p-v0_j^p)}{v0_j^p}\end{aligned} \tag{3.1}$$

Where variables followed by a 0 denote initial values for each**.**

$$\sum_{j=1}^{K}(z_{ij}^{dn}+z_{ij}^{dp})+y_i^d+e_i^n=x_i-e_i^p \tag{3.2}$$

$$\sum_{j=1}^{K}(z_{ij}^{mn}+z_{ij}^{mp})+y_i^m=m_i \tag{3.3}$$

$$\sum_{j=1}^{K}(z_{ij}^{dn}+z_{ij}^{mn})+v_j^n=x_j-e_j^p \tag{3.4}$$

$$\sum_{i=1}^{K}(z_{ij}^{dp}+z_{ij}^{mp})+v_j^p=e_j^p \tag{3.5}$$

$$\sum_{j=1}^{K}z_{ij}^{mn}=m_i^n \tag{3.6}$$

$$\sum_{j=1}^{K}z_{ij}^{mp}=m_i^p \tag{3.7}$$

$$\sum_{j=1}^{K}(z_{ij}^{dn}+z_{ij}^{dp})=\sum_{j=1}^{K}z_{ij}-(m_i^n+m_i^p) \tag{3.8}$$

$$z_{ij}^{dn}+z_{ij}^{dp}+z_{ij}^{mn}+z_{ij}^{mp}=z_{ij} \tag{3.9}$$

$$v_j^n+v_j^p=v_j \tag{3.10}$$

The economic meanings of the nine constraints are straightforward. Equations (3.2) and (3.3) are row sum constraints for the split IO account. They state that total gross output of sector *i* has to equal to the sum of domestic intermediates, final demand and export to the world market (both processing and normal exports). Similarly, total imports have to equal imported intermediate inputs plus imports delivered to final users. Equations (3.4) and (3.5) are column sum constraints for the split IO account. They define the value of processing exports in sector *j* as the sum of domestic and imported intermediate inputs as well as primary factors used in producing processing exports; Equations (3.6) to (3.10) are additive constraints to ensure that the sum of domestic and imported intermediates is consistent with known sector imports and inter-industry transaction information.

In short, the reconciliation problem we intend to solve is to minimize squared errors in separating the processing exports' input-output structure from a given national input-output account with equation (3.1) as the objective function and equations (3.2) - (3.10) as constraints.

Preliminary inter-industry transaction and value-added data are from China's 1997 and 2002 benchmark IO tables. We then use detailed trade data from the China General Customs administration to help differentiate the processing and normal trade in each IO sector. The China Customs trade statistics are first aggregated from 8-digit HS to China's IO industry classification, then used to compute processing export share for each IO industry and to partition imports of each industry into three parts based on the distinction of processing and normal imports in Chinese trade statistics and the UN BEC classification scheme[7]:

[7] This is a refinement of the method first developed in Dean, Fung and Wang (2007).

1. Imported intermediate inputs used in producing processing exports;
2. Imported intermediate inputs used in producing goods for domestic sale and normal exports;
3. Imports used in gross capital formation and final consumption.

A summary of these trade statistics as a percentage of China's total imports for both 1997 and 2002 is presented in Appendix tables A-C. Initial values for variables in the model were derived from IO industry level information according to following methods:

Intermediate imports used in producing processing exports and domestic sales and normal exports are generated by allocating m_i^n and m_i^p across each row of the original IO account by proportion. Mathematically:

$$z0_{ij}^{mp} = \frac{z_{ij}}{\sum_j^K z_{ij}} m_i^p \qquad z0_{ij}^{mn} = \frac{z_{ij}}{\sum_j^K z_{ij}} m_i^n \tag{3.11}$$

Domestically produced intermediates used in producing processing exports, domestic sales, and normal exports are generated by two steps: first we estimate total domestic product *i* used as intermediate inputs in sector *j* as a residual of total intermediate inputs and imported intermediate inputs:

$$z_{ij}^d = z_{ij} - (z_{ij}^{mn} + z_{ij}^{mp}) = z_{ij}^{dn} + z_{ij}^{dp} \tag{3.12}$$

then we assume domestically produced intermediates are used in producing processing exports, domestic sales, and normal exports in the following similar proportions:

$$z0_{ij}^{dn} = (z_{ij}^d / x_j)(x_j - e_j^p) \tag{3.13}$$

$$z0_{ij}^{dp} = (z_{ij}^d / x_j) e_j^p \tag{3.14}$$

Value-added generated by processing exports ($v0_j^p$) can be derived from equation (3.5) as a residual. However, due to the inconsistency between the trade statistics and China's input-output account, this residual was negative in more than half of China's IO industries for both the 1997 and 2002 tables. Because we do not have direct data on value added in processing exports in those industries, we use the same ratios of value added for processing and normal exports to initialize the corresponding variables, the balance of

industry outputs and their costs are achieved as a model solution. The proportion of processing to non-processing exports in each industry is obtained from the Customs export statistics. The partition of imports is based on a combination of Custom import statistics and UN BEC classification. To check the robustness, an alternative way to assign initial values is to use a three-year average import partition and the share of processing . This reconciliation procedure is implemented in GAMS (Brooke et al. 2005).

3.2. Computing the share of foreign and domestic value added in gross exports

To compute the domestic and foreign valued-added shares in China's gross exports from the IO account data estimated in the previous section, equations (2.7) and (2.12) have to be modified to accommodate the structural adjustments we have made to the standard IO model. This modification is the focus of the present sub-section. The structure of the IO table with a split account for processing exports, estimated by the model described in the previous sub-section, can be summarized as in Figure 1.

Figure 1: Input-output table with separate production account for processing trade

			Intermediate use		Final use		
			Production for domestic use & normal exports	Production of processing exports	Final use (C+I+G)	Exports	Gross Output or Imports
		DIM	1,2,…, N	1,2,…, N	1	1	**1**
Domestic Intermediate Inputs	Production for domestic use & normal exports (D)	1 . . . N	Z^{DD}	Z^{DP}	Y^{D}	E^{N}	$X-E^{P}$
	Processing Exports (P)	1 . . . N	0	0	0	E^{P}	E^{P}
Intermediate Inputs from Imports		1 . . . N	Z^{MD}	Z^{MP}	Y^{M}	0	M

Value-added	1	V^D	V^P	
Gross output	1	$X - E^P$	E^P	

Where superscript P and D and N represent processing exports, domestic sales, and normal exports, respectively. The direct input coefficients based on this estimated IO table can be written as:

$$A^{DD} = [a_{ij}^{dd}] = [\frac{z_{ij}^{dd}}{x_j - e_j^p}],\ A^{MD} = [a_{ij}^{md}] = [\frac{z_{ij}^{md}}{x_j - e_j^p}],\ A_v^D = [a_j^{vd}] = [\frac{v_j^d}{x_j - e_j^p}]$$

$$A^{DP} = [a_{ij}^{dp}] = [\frac{z_{ij}^{dp}}{e_j^p}], A^{MP} = [a_{ij}^{mp}] = [\frac{z_{ij}^{mp}}{e_j^p}], A_v^P = [a_j^{vp}] = [\frac{v_j^p}{e_j^p}]$$

Where *i* represents rows and *j* represents columns. The IO coefficients additive condition holds both for processing exports and for other final demand accounts.

$$uA^{Dk} + uA^{Mk} + A_v^k = u \qquad k = D, P \tag{3.15}$$

The horizontal balance conditions of the split IO model can be written as the following three equations in matrix algebra:

$$(I - A^{DD})(X - E^p) - A^{DP}E^P = Y^D + E^N \tag{3.16}$$

$$E^P = E^p \tag{3.17}$$

$$M = A^{MD}(X - E^p) + A^{MP}E^P + Y^M \tag{3.18}$$

In block matrix notation, equations (3.16) and (3.17) can be written in the following compact form:

$$\begin{bmatrix} I - A^{DD} & -A^{DP} \\ 0 & I \end{bmatrix} \begin{bmatrix} X - E^P \\ E^P \end{bmatrix} = \begin{bmatrix} Y^D + E^N \\ E^P \end{bmatrix} \tag{3.19}$$

The analytical solution of the system is

$$\begin{bmatrix} X - E^P \\ E^P \end{bmatrix} = \begin{bmatrix} I - A^{DD} & -A^{DP} \\ 0 & I \end{bmatrix}^{-1} \begin{bmatrix} Y^D + E^N \\ E^P \end{bmatrix} \tag{3.20}$$

$$B = \begin{bmatrix} I - A^{DD} & -A^{DP} \\ 0 & I \end{bmatrix}^{-1} = \begin{bmatrix} B^{DD} & B^{DP} \\ B^{PD} & B^{PP} \end{bmatrix} = \begin{bmatrix} (I - A^{DD})^{-1} & (I - A^{DD})^{-1} A^{DP} \\ 0 & I \end{bmatrix} \tag{3.21}$$

where B is the Leontief inverse of this extended IO model with a separate production account for processing trade. It can be computed according to equation (3.21). Substituting equation (3.21) into equation (3.20) we have:

$$X - E^P = (I - A^{DD})^{-1}(Y^D + E^N) + (1 - A^{DD})^{-1} A^{DP} E^p \tag{3.22}$$

Substituting equation (3.22) into equation (3.18) we have it that the demand for total imported intermediate inputs is:

$$M - Y^M = A^{MD}(I - A^{DD})^{-1}(Y^D + E^N) + A^{MD}(1 - A^{DD})^{-1} A^{DP} E^P + A^{MP} E^p \tag{3.23}$$

This has three additive components: the first is the total imported content or foreign value-added share in normal exports, and the second and the third are indirect and direct imported content or foreign value-added share in processing exports, respectively. The equation to compute VS or foreign value-added share in a unit of exports (equation 2.7) becomes:

$$\overline{VSS} = \begin{vmatrix} VSS^D \\ VSS^P \end{vmatrix}^T = \begin{vmatrix} uA^{MD}(I - A^{DD})^{-1} \\ uA^{MD}(1 - A^{DD})^{-1} A^{DP} + uA^{MP} \end{vmatrix}^T \tag{3.24}$$

and the foreign value-added share in a country's total exports can be computed as:

$$TVSS = uA^{MD}(I - A^{DD})^{-1} \frac{E^N}{te} + u(A^{MD}(1 - A^{DD})^{-1} A^{DP} + A^{MP}) \frac{E^P}{te} \tag{3.25}$$

Where *te* is a scalar, the country's total exports. Equation (3.25) is a modified version of equation (3) in HIY. Similarly, the modified domestic value-added share in per unit gross exports (from equation 2.12) becomes:

$$\begin{aligned} \overline{DVS} = \begin{vmatrix} DVS^D \\ DVS^P \end{vmatrix}^T &= \bar{A}_v B = (A_v^D \quad A_v^p) \begin{bmatrix} (I - A^{DD})^{-1} & (I - A^{DD})^{-1} A^{DP} \\ 0 & I \end{bmatrix} \\ &= \begin{vmatrix} A_v^D (I - A^{DD})^{-1} \\ A_v^D (I - A^{DD})^{-1} A^{DP} + A_v^P \end{vmatrix}^T \end{aligned} \tag{3.26}$$

and domestic value-added share in a country's total exports can be computed as:

$$TDVS = A_V^D (I - A^{DD})^{-1} \frac{E^N}{te} + (A_V^D (1 - A^{DD})^{-1} A^{DP} + A_V^P) \frac{E^P}{te} \tag{3.27}$$

Based on the IO coefficients' additive condition (equation 3.15) we can easily show that the domestic and foreign value-added shares in both normal and processing exports sum to unity. That is, both types of exports can be decomposed completely into domestic and foreign value-added.[8]

$$\begin{aligned} DVS^P + VSS^P &= A_v^D (I - A^{DD})^{-1} A^{DP} + A_v^P + uA^{MD}(1 - A^{DD})^{-1} A^{DP} + uA^{MP} \\ &= (uA^{MD} + A_v^D)(1 - A^{DD})^{-1} A^{DP} + uA^{MP} + A_v^P \\ &= u(1 - A^{DD})(1 - A^{DD})^{-1} A^{DP} + uA^{MP} + A_v^P = u \end{aligned} \tag{3.28}$$

IV. Results

4.1 Decomposition of total gross exports

The decomposition results for foreign and domestic value-added shares in 1997 and 2002 are shown in Table 2. For comparison, the results for the same years given by HIY's original method are also reported. The aggregate domestic value-added share in China's gross merchandise exports was 51.7% in 1997, and 53.9% in 2002. For manufacturing products, these shares are slightly lower at 47.1% and 51.3% respectively, indicating that China used more imported contents to produce manufacturing goods than to produce its exports as a whole. In general, the direct domestic value-added shares are less than half of the total domestic value-added shares, but they show a decreasing trend between 1997 and 2002. However, the indirect foreign value-added share was relatively small; most of the foreign content comes from the directly imported foreign inputs.

Relative to the numbers from HIY's method, our procedure produces much higher shares of foreign value added in Chinese gross exports (approximately doubled) and shows a very different trend. To be more precise, estimates from the HIY method show that the foreign content share (total VS share) increased between 1997 and 2002 from 17.9% to 25.4% for all merchandise exports, and from 19.2% to 26.8% for manufactures only. In contrast, our estimates reveal a downward trend in foreign content: that the foreign value-added share in China's gross exports actually declined during this period (from 48.3% to 46.1% for all merchandise exports, and from 52.9% to 48.7% for manufactures only). In

[8] This proof that $DVS^D + VSS^D = u$ is similar to that given in equation (2.14).

other words, the domestic value added in China’s exports is likely to have increased in recent years.

Table 2 Decomposing of Chinese gross exports – total, in percent

	HIY Method		Split Method	
	1997	2002	1997	2002
Total Merchandise				
Direct foreign value-added	9.0	15.0	47.0	42.8
Direct domestic value-added	29.4	26.0	24.2	19.9
Total Foreign value-added	17.9	25.4	48.3	46.1
Total Domestic Value-added	82.1	74.6	51.7	53.9
Manufacture only				
Direct foreign value-added	9.9	15.9	51.7	45.4
Direct domestic value-added	27.5	24.6	21.9	18.4
Total Foreign value-added	19.2	26.8	52.9	48.7
Total Domestic Value-added	80.8	73.3	47.1	51.3

Source: Authors' estimates.

What accounts for the difference between our and HIY approaches? The HIY indicator measures average foreign content in all domestic production not just exports. Only under the special assumption that all exports and other domestic demand have the same intensity of imported inputs would the HIY's VS share be a proper measure of imported content share in exports. However, since processing exports tend to use substantially more imported inputs, and processing exports account for a major share of China's total exports, the HIY indicator is likely to substantially underestimate the true foreign content in exports. This explains why the level of domestic content by our measure is much lower than the HIY indicator. On the other hand, as exports firms (both those producing for normal exports and those for processing exports) gradually increase their input sourcing from Chinese firms, the extent of domestic content in exports rose during our sample period.

Table 3 Decomposing Chinese gross exports, in percent

	No processing		Processing	
	1997	2002	1997	2002
Total Merchandise				
Direct foreign value-added	1.7	3.8	83.5	73.9
Direct domestic value-added	34.2	31.5	16.2	10.7

Total Foreign value-added	4.7	9.3	83.5	75.4
Total Domestic Value-added	95.3	90.7	16.5	24.6
Manufacture only				
Direct foreign value-added	1.9	4.1	83.5	74.6
Direct domestic value-added	30.6	29.1	16.4	10.8
Total Foreign value-added	5.1	9.9	83.5	75.9
Total Domestic Value-added	94.9	90.1	16.5	24.1

Source: Authors' estimates.

Our interpretation is confirmed by the decomposition of processing exports and non-processing exports (and also of domestic consumption and capital formation) into domestic and foreign value added, shown in Table 3. The change in patterns of value-added shares in the final demand of domestic products including normal exports is similar with the change in indicators computed by HIY procedure listed in Table 2. There is a roughly five percentage point increase in the total foreign value-added share, and a similarly-sized reduction in the total domestic value-added share, indicating that more imported intermediate inputs were used in China's domestic production. However, in processing exports we see that more domestic-produced inputs were used in 2002 than in 1997, with a reduction of imported contents by about eight percentage points. In addition, processing exports make up more than half of China's gross exports (56 percent of exports in total merchandise and 59 percent of exports in manufactures), thereby resulting in an overall increase of the domestic value-added share of China's total exports. To summarize, the HIY indicator measures the average foreign content in a country's total demand, which could deviate substantially from the degree of foreign content in total exports for a country that engages in a lot of processing trade.

4.2 Domestic value-added share in Chinese exports of manufactured products

Table 4 reports our estimates of domestic value-added shares embodied in Chinese gross exports of manufactures by industries (excluding food manufactures) and of each industry's exports as shares of China's total manufacturing exports. We have sorted industries by increasing total domestic value-added shares in the exports of each. Among the 61 goods-producing industries in the table, 13 have a domestic value-added share less than 50 percent, and together account for 43.7 percent of China's total manufacturing

exports in 2002. Most of these low-DVA industries produce consumer electronics such as computers and accessories; telecommunications equipment; household appliances; leather, fur, down, and related products. A common feature of these industries is that more than two-thirds of their exports are processing exports. The low domestic value-added and high processing export shares mean the value of Chinese exports from those industries embodies a significant portion of imported intermediate goods or parts shipped to China from other countries for final processing and assembling.

The next 15 industries in Table 4 had domestic value-added shares of in the range of 51 to 65 percent, and accounted for more than 20 percent of China's total manufacturing exports in 2002. Note that several of China's large labor-intensive exporting sectors are among this group, including toys and sports related products, and arts and crafts products.

The remaining 34 industries have a domestic value-added share of over two-thirds of their gross export value, but only produced about one third of China's manufacturing exports in 2002 (their share has likely continued its decline in recent years). Apparel, China's largest labor intensive exporting industry, is at the top of this group with about a 68 percent domestic value-added share. Apparel exports alone accounted for 7.5 percent of China's total manufacturing exports in 2002. The 20 industries at the bottom of Table 4 have more than 75 percent domestic value-added shares, which is the average of world exports according to HIY (2001: 87). However, these industries produced only about 11 percent of China's manufacture exports in 2002.

Table 4 Domestic Value-added Share in Chinese Gross Manufacture Exports to the World by IO Industries, in percent, 2002

		Non processing		Processing		Weighted		
IO Industry description	Share of processing exports in industry total exports	Direct domestic value-added	Total Domestic Value-added	Direct domestic value-added	Total Domestic Value-added	Direct domestic value-added	Total Domestic Value-added	Share in China's total exports to the World
Electronic computer	99.1	14	81.2	7.5	7.5	7.6	8.2	1.3
Telecommunication equipment	91.2	27.5	83.5	7.7	10.1	9.4	16.6	3.4
Electronic element and device	89.7	33.9	89.1	7.7	10.2	10.4	18.3	3.6
Cultural and office equipment	93.4	7.5	79.6	12.6	15	12.3	19.2	4.6
Other computer peripheral equipment	99.2	30.8	80.1	14.6	21.9	14.7	22.4	6.2
Household electric appliances	79.1	27	89.7	9.3	21.8	13	36	2.1
Printing, reproduction of recording media	83	42.8	91.7	7.8	25.1	13.8	36.5	0.3
Radio, television and communication equipment and apparatus	90.6	31.2	78.7	11.2	32.2	13.1	36.5	5.6
Plastic products	64.5	26.4	84.6	7.6	10.3	14.2	36.6	2.6
Generators	76.8	26.7	88.6	7.9	21.5	12.3	37.1	1
Instruments, meters and other measuring equipment	68.6	43.9	90.8	7.7	14.2	19.1	38.3	2
Other electric machinery and equipment	66.8	27.4	89.7	14.1	25.2	18.5	46.6	6.1
Leather, fur, down and related products	54.3	24.4	93.5	7.7	11.3	15.3	48.8	4.9
Man-made chemical products	58.3	22	80.9	7.9	29.5	13.8	50.9	0.3
Toys, sporting and athletic and recreation products	72.9	45	90.3	17.8	37.5	25.2	51.8	3.3
Arts and crafts products	53.8	30.5	91.6	7.8	18.9	18.3	52.5	1.3
Ship building	95.8	27.2	85.7	12	51.5	12.7	52.9	0.7
Special chemical products	46.9	24.4	83.5	7.7	22.2	16.6	54.7	0.9
Petroleum and nuclear processing	32.1	15.4	79.1	7.6	10.6	12.9	57.1	0.9
Other general industrial machinery	43.7	28.8	91.4	7.6	13	19.6	57.1	3.7
Metal products	43.2	25	90.5	7.7	13.8	17.5	57.4	4.8
Paper and paper products	50.7	29.9	90.1	7.9	28.4	18.8	58.8	0.6
Other transport equipment	41.2	26.4	85	7.9	23	18.8	59.5	1.3
Rubber products	53.1	30.6	91.5	8.2	31.7	18.7	59.7	1.7
Nonferrous metal smelting	45	22.5	88.9	7.9	25.3	15.9	60.3	0.9
Other manufacturing products	48.8	30.6	91.9	7.9	28.8	19.5	61.1	0.6
Other special industrial equipment	39.9	28.1	90.7	7.7	17.5	19.9	61.5	1.4
Steel-smelting	58.8	25.6	90.9	8	45.3	15.2	64.1	0
Nonferrous metal pressing	46.9	17.2	85.9	7.8	45.6	12.8	67	0.4
Apparel	45.1	30.2	92.7	13.4	38.2	22.6	68.1	7.5
Other electronic and communication equipment	84.9	45.3	88.2	22.1	65	25.6	68.5	2
Cotton textiles	28.7	24.6	91.7	7.6	12.1	19.7	68.8	3.5
Parts and accessories for motor vehicles and their engines	34.3	27.3	89.9	7.9	29.4	20.6	69.2	0.7

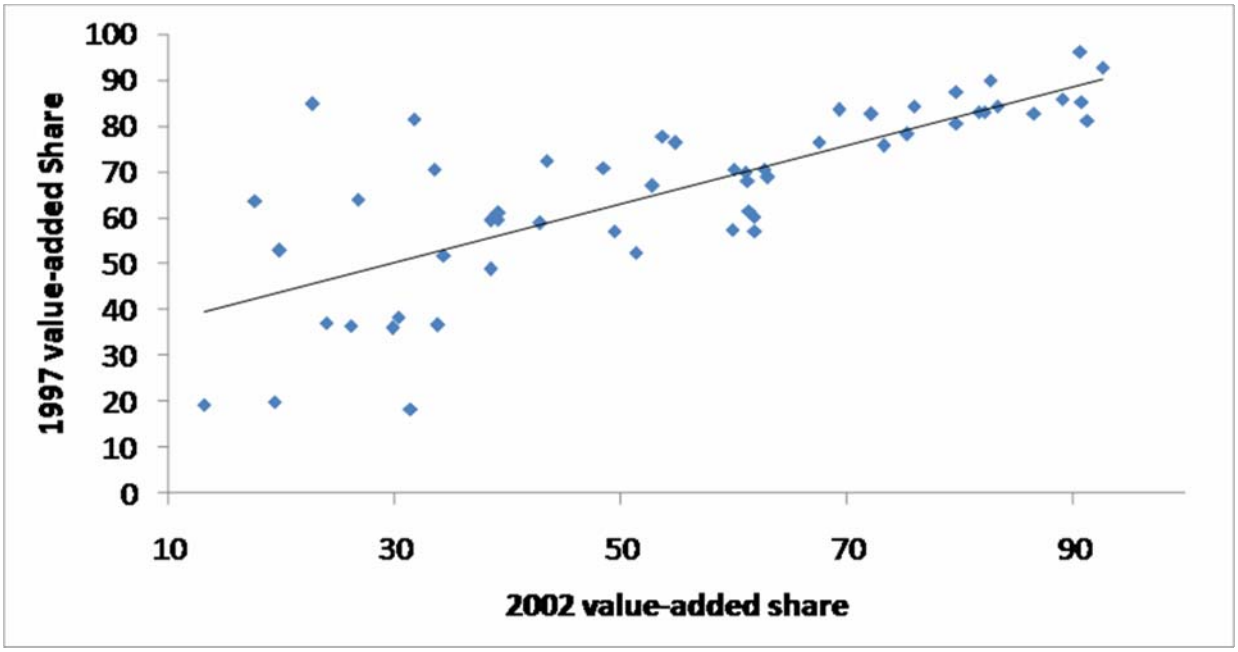
		Non processing		Processing		Weighted		
IO Industry description	Share of processing exports in industry total exports	Direct domestic value-added	Total Domestic Value-added	Direct domestic value-added	Total Domestic Value-added	Direct domestic value-added	Total Domestic Value-added	Share in China's total exports to the World
Glass and glass products	33	36.3	88.9	8	33	26.9	70.5	0.6
Chemical products for daily use	36.3	32.8	88.2	8.1	39.5	23.8	70.5	0.4
Chemical fibers	20.5	21.6	82.4	7.7	25.1	18.8	70.7	0
Stationary and related products	39.4	28.5	88.3	8	44.3	20.4	71	0.2
Knitted and crocheted fabrics and articles	31.6	33.9	92.1	7.8	28.6	25.7	72	6.3
Woolen textiles	37.7	24.2	93	8.2	38.8	18.2	72.5	0.4
Motor vehicles	37.8	26.4	89.8	8.1	44.5	19.5	72.7	0.2
paints, varnishes and similar coatings, printing ink and mastics	29.1	23.1	85.6	8.1	41.4	18.8	72.7	0.5
Textiles productions	24	27.9	91.5	7.8	23.7	23.1	75.2	1.6
Alloy iron smelting	40.8	28.2	88.2	9.1	59.2	20.4	76.4	0.3
Boiler, engines and turbine	26.6	30.6	87.4	8.2	46.4	24.6	76.5	0.4
Furniture	47.2	29.2	89.8	9.7	62.5	20	76.9	1.8
Products of wood, bamboo, cane, palm, straw	19.6	28.1	88.9	7.9	30.3	24.2	77.4	1.1
Railroad transport equipment	19.9	28.6	87.7	7.9	37.8	24.4	77.8	0.1
Chemical pesticides	6.2	25.8	80.1	8.1	50	24.7	78.2	0.2
Basic chemicals	11.7	29.4	88.3	7.8	26.7	26.9	81.1	2.1
Iron-smelting	23.7	23.3	89.1	8.3	56.8	19.7	81.5	0.1
Agriculture, forestry, animal husbandry and fishing machinery	17.8	28.9	88.9	8.2	54	25.2	82.7	0.1
Medical and pharmaceutical products	16.9	39	92.8	7.9	36	33.8	83.2	0.8
Hemp textiles	19.5	23.8	91.6	8.4	50.5	20.8	83.6	0.3
Metalworking machinery	13.3	32.4	89.9	8.1	48.5	29.1	84.4	0.2
Pottery, china and earthenware	11.4	33	90.9	7.9	34.5	30.1	84.4	0.7
Steel pressing	16	26.6	91.4	8.1	50.4	23.6	84.9	0.4
Chemical fertilizers	4.5	23.5	88.1	7.7	24.7	22.8	85.3	0.1
Fireproof materials	19.1	41.5	93.3	8.1	54.5	35.2	85.9	0.1
Cement, lime and plaster	7	27.9	92.7	7.6	13.4	26.5	87.1	0.1
Other non-metallic mineral products	14	34.1	93	8.2	52.7	30.5	87.4	0.4
Coking	2.6	34.3	93.9	8.2	54.3	33.7	92.8	0.3
Total manufactures	**58.7**	**29.1**	**90.1**	**10.8**	**24.1**	**18.4**	**51.3**	**100**

Source: Authors' estimates.

How stable is the sector rank of DVA share estimates over time? The correlation between 1997 and 2002 total domestic value-added share is plotted in Figure 2. It appears that estimates from the two benchmark years are highly correlated, especially for those

industries with higher domestic value-added shares. In other words, while TDVA shares have declined over time, the ranking across sectors is fairly stable.

Figure 2 Correlation between 1997 and 2002 DVA Shares in China's Exports



TDV02 = 31.3 + 0.63TDV02 Adj. R^2=0.58 Obs. = 54
t-statistics (7.1) (8.6)

[4.3 DVA shares in Chinese exports by trading partners

By assuming that domestic and foreign value-added shares in per unit gross exports are the same for all destination countries in each IO industry and export regime, we can further estimate the share of domestic value-added in China's exports to each of its major trading partners. The decomposition results for China's total merchandise exports to each of its major trading partners are reported in Table 5 in increasing order of the estimated domestic value-added share. Note that the variation by destination in this method is caused solely by China's structure of exports to each of its trading partners (exports to each individual country or region vary by sector and by trade regime structures) and not by the direct input intensities of imported intermediates in producing such exports.

Hong Kong, the United States, Singapore, and Taiwan are at the top of the table, with less than 50 percent of China's domestic value added embodied in its exports to these four destinations. Since a large portion of Chinese exports to Hong Kong are re-exported to the United States, the U.S. accounted for more than one third of China's export market in 2002. The lower domestic value-added share in its exports to the U.S. may partially explain why Chinese exports continued their rapid expansion in the U.S. market despite gradual appreciation in the RMB since July 2005. China's exports to the U.S. have started to slow down since late 2007, likely because of a slower US demand and other Chinese policy measures adopted during the year 2007.[9]

Another interesting feature shown by Table 5 is that China's exports to developing countries embody much higher domestic value added than do its exports to OECD countries, but exports with higher domestic valueadded (more than two-thirds of the gross value of its exports) constituted less than 18 percent of its total exports of goods in 2002. Nearly 75 percent of its exports that year had an average DVA of less than 55 percent and over 40 percent of its exports had an average DVA of less than half. These results further confirm that China has recently become a processing and assembling center in many global supply chains.

[9] Since the end of 2006, China has taken a series of policy measures to reduce VAT rebates to exports and reduce favorable treatment of foreign invested enterprises.

Table 5 Domestic Value-added Share in Chinese Gross Merchandise Exports to its Major Trading Partners, in percent, 2002

		Non processing		Processing		Weighted		
Region description	Share of processing exports in total exports to destination	Direct domestic value-added	Total Domestic Value-added	Direct domestic value-added	Total Domestic Value-added	Direct domestic value-added	Total Domestic Value-added	Share in total exports to the World
Hong Kong	74.6	31.0	90.7	10.4	23.1	15.8	40.6	17.5
United States	67.4	30.0	90.4	10.8	23.7	17.1	45.6	21.6
Singapore	63.5	29.7	89.3	10.5	21.2	17.7	46.6	2.1
Taiwan	60.9	33.9	90.5	10.7	22.2	20.1	49.8	2.0
Japan	58.5	33.7	91.9	10.9	27.9	20.2	54.0	15.0
EU15	54.7	30.2	90.6	11.2	24.7	19.8	54.5	14.9
Canada	47.9	30.5	91.0	10.3	25.7	20.8	59.6	1.3
Korea Rep	45.2	35.5	91.6	10.6	26.0	24.2	61.8	4.8
Australia/NZ	41.7	30.7	90.5	10.2	25.1	22.1	63.3	1.6
Mexico	41.7	31.0	90.8	12.7	28.8	23.3	64.7	0.9
Rest of Europe	42.5	30.4	91.2	10.2	29.6	21.7	64.7	0.4
Rest of Southeast Asia	37.9	33.2	89.7	10.6	23.0	24.9	65.3	5.1
Rest of World	52.3	29.8	90.5	11.2	45.2	20.0	66.6	0.0
EU25 (excl EU15)	40.4	30.6	91.5	12.2	30.6	23.3	67.4	1.3
Brazil	34.5	33.4	90.4	11.8	29.2	25.8	69.0	0.5
Rest of East Asia	36.6	36.8	91.5	9.5	29.2	27.1	69.4	0.5
India	23.4	33.9	90.5	10.1	22.1	28.2	74.1	0.8
Eastern Europe/Central Asia	20.4	30.7	90.5	10.2	24.8	26.5	77.1	0.6
Rest of Latin Amer/Caribbean	20.4	30.0	90.1	10.0	27.2	26.0	77.4	1.6
Middle East/North Africa	19.4	30.0	90.3	9.9	26.5	26.1	77.9	3.6
Sub-Saharan Africa	15.7	30.3	90.4	9.6	24.4	27.1	80.2	1.4
Rest of South Asia	14.0	29.8	89.6	8.8	24.2	26.9	80.6	0.8
Former Soviet Union	15.0	30.6	91.6	10.9	26.4	27.6	81.7	1.6

V. Concluding Remarks

This paper has made three contributions in assessing the extent of domestic value added embodied in a country's gross exports. First, we demonstrate analytically that the concept of vertical specialization in the international trade literature is identical to the share of foreign value added in a country's total domestic final demand and gross exports, as other parts of domestic final demand can completely be decomposed into domestic and foreign

value-added shares. We also show that the specific measure proposed by HIY is not the same as the share of foreign value added in a country's gross exports, when it applied to countries engaging heavily in processing trade.

Second, we develop a mathematical programming model that separates the production of processing trade account from a standard IO table by incorporating information from published trade statistics. We provide a procedure to compute the domestic and foreign valued added shares in gross exports in such an extended IO account, which makes the estimation process transparent and enables other researchers to check and duplicate our estimates.

Third, we apply our procedure to decompose China's gross exports in 83 goods-producing industries, based on the country's published 1997 and 2002 benchmark IO tables and on related trade statistics that distinguish processing and normal trade. We further compare our estimates of domestic value added with results computed by the HIY procedure, and reconcile the two sets of estimates based on our new interpretation of HIY's VS share measure.

Our estimates suggest that the DVA share embodied in Chinese exports has been increasing in recent years (in contrast to a declining trend that one would have estimated by the HIY approach). In aggregate, for every $100 dollars of Chinese exports of manufactures, $47.1 is Chinese domestic value added and $52.9 is foreign value added in 1997; the shares flip to $51.3 and $48.7, respectively, in 2002.

Our empirical results also show clearly that how one treats processing trade will make a significant difference in estimating domestic value added or the VS share embodied in gross exports, especially for countries heavily engaged in processing exports, such as China and Mexico. Our procedure produces much higher but potentially more realistic estimates of foreign value added embodied in Chinese exports than those from the HIY procedure. Our estimates are nearly double those of HIY. Our estimation results indicate that industries with a higher domestic value-added share in their exports generally

experienced slower output and export growth. Therefore, using government policies to promote exports with higher domestic value-added shares may not necessarily be a good thing to do for China's economic growth.

There are limitations to the estimates in this paper. Because we rely on an input-output model, we implicitly assume that all IO coefficients are constants once they are computed, thereby ignoring the effects of price changes on the choice of inputs by firms.[10] In addition, we assign initial values of the direct domestic content for processing exports based on information in the IO tables. If we obtain more direct measures of domestic content (e.g., wages and rental cost of capital) for firms that produce for processing exports, we can further improve the accuracy of our estimates.

[10] This process is represented by $A^M(I-A^D)^{-1}$ or $\hat{A}_v(I-A^D)^{-1}$ in the IO framework (USNRC 2006: 40).

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Appendix Table A Final Use of Total Imports by China's IO Industries, in percent, 2002

IO Industry description	Share of Intermediates for processing exports	Share of Intermediates for normal use	Share of Capital goods for normal use	Share of Capital goods for Processing exports	Share of final Consumption
Agriculture	11.7	76.1			12.2
Forestry	66.0	34.0			0.0
Logging and transport of timber and bamboo	4.0	96.0			
Animal Husbandry	22.6	74.2	3.1		0.0
Fishery	6.0	0.5			93.5
Technical services for agriculture, forestry, livestock and fishing	52.4				47.6
Mining and Washing of Coal	0.9	99.1			
Extraction of Petroleum and Natural Gas	6.8	93.2			
Ferrous metal ore mining	5.9	94.1			
Non-ferrous metal ore mining	12.6	87.4			
Salt mining	9.8	90.2			
Non-metal minerals and other mining	57.0	43.0			
Grain mill products	71.0	24.7			4.3
Forage	1.9	95.4			2.7
vegetable oil refining	4.0	91.4			4.6
Sugar manufacturing	32.1	66.7			1.2
Slaughtering and meat processing	9.2	25.4			65.4
Fish and fish productions	53.8	31.5			14.7
All other food manufacturing	15.5	27.1			57.4
Wines, spirits and liquors	1.8	2.2			96.1
Soft drink and other beverage	5.5	26.5			68.0
Tobacco products	0.5	0.1			99.4
Cotton textiles	84.6	15.4			0.0
Woolen textiles	83.5	16.4			0.1
Hemp textiles	98.0	1.9			0.0
Textiles productions	89.5	9.7			0.8
Knitted and crocheted fabrics and articles	95.5	1.3			3.3
Wearing apparel	87.2	0.0			12.8
Leather, fur, down and related products	89.8	8.3			1.8
Products of wood, bamboo, cane, palm, straw	59.1	40.9			
Furniture	28.0	42.7	7.3	1.8	20.3
Paper and paper products	36.9	62.8			0.3
Printing, reproduction of recording media	59.4	12.5			28.1
Stationary and related products	31.1	60.9			8.0
Toys, sporting and athletic and recreation products	71.7	1.8	0.4	10.1	16.0
Petroleum and nuclear processing	2.4	97.2	0.5	0.0	
Coking	3.7	96.3			
Basic chemicals	15.8	84.2			
Chemical fertilizers	0.1	99.9			
Chemical pesticides	5.2				94.8
paints, varnishes and similar coatings, printing ink and mastics	50.4	49.6			0.0
Man-made chemical products	61.7	38.3			
Special chemical products	53.0	45.4	0.0	0.0	1.5
Chemical products for daily use	33.9	53.1			12.9
Medical and pharmaceutical products	5.8	40.1			54.1
Chemical fibers	28.3	71.7			
Rubber products	42.5	54.2			3.3
Plastic products	70.6	25.3			4.1
Cement, lime and plaster	14.0	86.0			

IO Industry description	Share of Intermediates for processing exports	Share of Intermediates for normal use	Share of Capital goods for normal use	Share of Capital goods for Processing exports	Share of final Consumption
Glass and glass products	59.0	39.9			1.0
Pottery, china and earthenware	39.8	55.4			4.8
Fireproof materials	33.6	66.4			
Other non-metallic mineral products	42.9	56.3			0.8
Iron-smelting	5.4	94.6			
Steel-smelting	36.2	63.8			
Steel pressing	40.3	59.7			
Alloy iron smelting	7.7	92.3			
Nonferrous metal smelting	30.1	69.9			
Nonferrous metal pressing	68.4	31.6			
Metal products	38.8	37.8	6.8	16.0	0.5
Boiler, engines and turbine	8.8	64.2	21.7	5.2	0.1
Metalworking machinery	3.7	9.5	28.1	58.8	
Other general industrial machinery	15.5	26.3	27.1	30.4	0.6
Agriculture, forestry, animal husbandry and fishing machinery	2.3	10.7	62.4	17.2	7.4
Other special industrial equipment	4.0	8.5	37.0	50.0	0.5
Railroad transport equipment	0.3	31.9	67.8	0.0	
Motor vehicles	0.6	2.1	87.7	9.3	0.3
Parts and accessories for motor vehicles and their engines	2.1	97.9			
Ship building	8.0	40.3	45.7	5.3	0.7
Other transport equipment	5.4	27.4	67.2		0.1
Generators	22.9	12.5	28.3	36.2	
Household electric appliances	63.6	23.5	1.0	0.5	11.3
Other electric machinery and equipment	37.2	24.8	12.0	25.7	0.3
Telecommunication equipment	4.2	17.4	74.6	3.8	0.0
Electronic computer			91.8	8.2	
Other computer peripheral equipment	54.4	12.4	20.4	12.9	
Electronic element and device	80.6	17.7	0.2	1.5	
Radio, television and communication equipment and apparatus	76.3	4.3	8.2	6.9	4.4
Other electronic and communication equipment	45.0	50.9	3.5	0.6	
Instruments, meters and other measuring equipment	16.3	5.1	26.5	50.7	1.4
Cultural and office equipment	54.1	11.2	18.6	14.5	1.6
Arts and crafts products	93.3	1.4			5.3
Other manufacturing products	91.4	5.4	0.2	0.0	3.0
Scrap and waste	8.3	91.7			
Total Merchandise	38.2	38.8	11.1	10.2	1.7

Source: Author's aggregation. UN BEC classification and processing trade information from China custom trade statistics were combined to identify the purpose of final use.

Appendix Table B Final Use of Total Imports by China's IO Industries, in percent, 1997

Description	Share of Intermediates for processing exports	Share of Intermediates for normal use	Share of Capital goods for normal use	Share of Capital goods for Processing exports	Share of final Consumption
Crop cultivation	43.7	51.7			4.7
Forestry	45.9	26.2			27.8
Livestock and livestock products	69.9	29.3	0.7		0.1
Fishery	16.7	0			83.3
Other agricultural products	77.8	10.6			11.5
Coal mining and processing	36	64			
Crude petroleum products	22.2	77.8			
Natural gas products		100			
Ferrous ore mining	53.4	46.6			
Non-ferrous ore mining	57.2	42.8			
Salt mining	43.9	56.1			
Non-metal minerals and other mining	84.7	15.3			
Logging and transport of timber and bamboo	27.5	72.5			
Grain mill products, vegetable oil and forage	23.6	76			0.4
Sugar refining	51.1	48.4			0.5
Slaughtering , meat processing, eggs and dairy products	71.6	22.8			5.6
Prepared fish and seafood	93.3	1.7			5
Other food products	43.3	21.8			34.9
Wines, spirits and liquors	5.8	3.9			90.3
Non-alcoholic beverage	69.3	2.5			28.1
Tobacco products	1.4	0.1			98.5
Cotton textiles	98.7	1.3			0
Woolen textiles	93.7	6.2			0
Hemp textiles	95.4	4.6			0
Silk textiles	96.2	3.8			0
Knitted mills	98	1.1			0.9
Other textiles	98.6	1.4			0
Wearing apparel	97.4	0			2.5
Leather, furs, down and related products	98.3	1			0.7
Sawmills and fibreboard	72.3	27.7			
Furniture and products of wood, bamboo, cane, palm, straw, etc.	57.7	16.1	6	4	16.3
Paper and products	54.1	45.7			0.1
Printing and record medium reproduction	76.2	22.6			1.1
Cultural goods	16	83.3			0.6
Toys, sporting and athletic and recreation products	64.8	0.4	4.2	23.4	7.2
Petroleum refining	8.9	91.1			
Coking	13.9	86.1			
Raw chemical materials	53.1	46.9			
Chemical fertilizers	0.3	99.7			
Chemical pesticides	6.9	0.8			92.3
Organic chemical products	50.7	49.3			0
Chemical products for daily use	64.2	20.8			15
Other chemical products	78.6	21.3	0	0	0.2

Description	Share of Intermediates for processing exports	Share of Intermediates for normal use	Share of Capital goods for normal use	Share of Capital goods for Processing exports	Share of final Consumption
Medical and pharmaceutical products	16.9	28.6			54.4
Chemical fibers	79.8	20.2			0
Rubber products	73.7	25.8			0.5
Plastic products	88.6	9.2			2.2
Cement	12.4	87.6			
Cement and asbestos products	68.1	31.9			
Bricks, tiles, lime and light-weight building materials	52.7	47.3			0
Glass and glass products	78.6	20.4			1
Pottery, china and earthenware	66.8	29.9			3.3
Fireproof products	67	33			
Other non-metallic mineral products	83.8	15.6			0.6
Iron-smelting	78.1	21.9			
Steel-smelting	23.8	76.2			
Steel processing	62.1	37.9			
Alloy iron smelting	52.5	47.5			
Nonferrous metal smelting	45	55			
Nonferrous metal processing	83.3	16.7			
Metal products	58.9	19.7	2.5	18.3	0.6
Boiler, engines and turbine	23.9	48.4	13.4	14.2	0.2
Metalworking machinery	10.2	9.3	17.9	62.6	
Other general industrial machinery	22.8	14.1	18.6	44.2	0.2
Agriculture, forestry, animal husbandry and fishing machinery	9.9	4	37.1	46.4	2.7
Other special industrial equipment	12.9	5.6	16.7	64.7	0.1
Railroad transport equipment	11.1	28.2	59.8	0.8	
Motor vehicles	4.1	64.5	25.6	5.8	0.1
Ship building	12	4.9	25.6	56.6	0.9
Aircraft	2.7	17.1	78	1.4	0.8
Bicycle	89.6	10			0.4
Other transport machinery	17.5	81.8			0.7
Generators	29.6	5.5	19.5	45.3	
Household electric appliances	40.8	11.3	4.4	35	8.5
Other electric machinery and equipment	54.3	11.6	9.5	23.9	0.7
Electronic computer	69.2	3.9	13.4	13.5	
Electronic appliances	93.5	2.6	1.8	2	0.1
Electronic element and device	74.9	17.4	0.8	6.8	
Other electronic and communication equipment	18.5	25.4	47	3.5	5.5
Instruments, meters and other measuring equipment	37.3	5	24.5	33	0.2
Cultural and office equipment	89.5	3.2	4.6	2.4	0.3
Arts and crafts products	89.3	2.2			8.5
Other manufacturing products	96.6	2.1	0	0	1.3
Total Merchandise	51.2	28.2	7.3	12.1	1.2

Source: Author's aggregation. UN BEC classification and processing trade information from China custom trade statistics were combined to identify the purpose of final use.

Appendix Table C Final Use of Total Imports by Major Source Countries, 2002

Region Description	Share of Intermediates for processing exports	Share of Intermediates for normal use	Share of Capital goods for normal use	Share of Capital goods for Processing exports	Share of final Consumption	Share of processing exports	Share in total imports from the World
Australia/NZ	27.5	65.7	2.1	0.7	4.0	41.7	2.2
Brazil	10.1	84.2	2.4	1.0	2.4	34.5	1.1
Canada	16.7	63.8	14.5	2.5	2.5	47.9	1.3
Rest of East Asia	26.5	43.1	0.2	0.2	30.0	36.6	0.2
Eastern Europe/Central Asia	8.4	86.8	2.0	1.0	1.8	20.4	0.3
EU10	35.7	42.3	12.7	6.4	2.9	40.4	0.3
EU15	18.2	39.5	27.0	12.6	2.7	54.7	13.7
Former Soviet Union	8.9	84.1	5.8	0.1	1.0	15.0	3.9
Hong Kong	74.9	9.3	2.7	10.8	2.2	74.6	3.7
India	26.4	69.4	1.6	0.6	2.0	23.4	0.8
Japan	46.9	27.3	10.2	15.1	0.7	58.5	19.0
Korea Rep	47.4	31.9	10.6	9.8	0.4	45.2	10.5
Rest of Latin Amer/Caribbean	11.4	86.2	0.4	0.1	1.9	20.4	1.5
Middle East/North Africa	13.4	84.5	1.0	0.9	0.2	19.4	3.8
Mexico	56.9	29.5	8.4	3.4	1.9	41.7	0.4
Rest of Europe	15.9	38.1	20.8	17.9	7.2	42.5	1.0
Rest of South Asia	84.8	13.4	0.0	0.3	1.5	14.0	0.2
Rest of Southeast Asia	49.2	40.6	2.6	4.9	2.7	37.9	8.6
Singapore	43.7	37.0	8.5	9.8	1.1	63.5	2.4
Sub-Saharan Africa	16.1	83.4	0.2	0.0	0.2	15.7	1.4
Taiwan province	60.0	17.7	4.3	17.7	0.3	60.9	14.1
United States	25.5	35.3	26.2	9.2	3.8	67.4	9.5
Rest of World	26.9	54.7	0.6	0.3	17.5	52.3	0.0
World Total	38.5	38.3	11.2	10.4	1.7	55.9	100.0

Source: Author's aggregation. UN BEC classification and processing trade information from China custom trade statistics were combined to identify the purpose of final use.

Appendix Table D Domestic and foreign value-added embodied in Chinese gross merchandise exports, in percent, 2002

	Split Method				HIY Method			
IO industry description	Direct foreign value-added	Direct domestic value-added	Total Foreign value-added	Total Domestic Value-added	Direct foreign value-added	Direct domestic value-added	Total Foreign value-added	Total Domestic Value-added
Agriculture	2.5	63.9	5.3	94.7	1.9	65.4	6.2	93.8
Forestry	3.4	63.2	5.9	94.1	1.8	65.5	5.4	94.6
Logging and transport of timber and bamboo	4.0	60.7	6.4	93.6	2.8	60.7	7.0	93.0
Animal Husbandry	2.1	44.7	4.9	95.1	1.2	45.7	5.6	94.4
Fishery	1.8	54.5	5.1	94.9	1.6	55.0	6.7	93.3
Technical services for agriculture, forestry, livestock and fishing	20.1	40.7	23.0	77.0	2.3	54.8	7.3	92.7
Mining and Washing of Coal	1.6	56.9	4.7	95.3	3.3	56.9	8.6	91.4
Extraction of Petroleum and Natural Gas	3.3	69.1	5.6	94.4	2.9	71.1	6.6	93.4
Ferrous metal ore mining	5.8	46.3	9.6	90.4	5.6	46.3	11.9	88.1
Non-ferrous metal ore mining	8.2	37.7	13.7	86.3	5.0	39.9	13.8	86.2
Salt mining	2.5	63.3	5.3	94.7	2.6	63.9	7.5	92.5
Non-metal minerals and other mining	24.4	33.0	28.2	71.8	4.7	44.6	12.3	87.7
Grain mill products	41.3	13.5	43.8	56.2	3.0	20.1	8.7	91.3
Forage	19.6	16.2	23.1	76.9	5.9	18.1	12.4	87.6
vegetable oil refining	15.3	17.4	19.5	80.5	4.6	21.7	10.7	89.3
Sugar manufacturing	31.6	11.3	36.1	63.9	3.2	31.2	8.7	91.3
Slaughtering and meat processing	6.6	14.8	10.1	89.9	2.2	16.1	7.9	92.1
Fish and fish productions	14.2	19.4	17.4	82.6	2.4	24.9	8.3	91.7
All other food manufacturing	20.1	22.4	24.1	75.9	5.1	26.8	12.7	87.4
Wines, spirits and liquors	15.8	33.9	19.1	80.9	2.8	40.7	8.6	91.4
Soft drink and other beverage	11.8	28.2	16.6	83.4	4.5	31.7	13.1	86.9
Tobacco products	2.4	72.9	3.7	96.3	0.7	76.3	2.6	97.4
Cotton textiles	26.7	19.7	31.1	68.9	8.5	23.7	18.6	81.4
Woolen textiles	22.8	18.2	27.0	73.0	6.3	23.5	14.9	85.1
Hemp textiles	10.9	20.8	16.3	83.7	5.1	23.6	14.1	85.9
Textiles productions	20.3	23.1	24.9	75.1	10.7	26.0	21.3	78.7
Knitted and crocheted fabrics and articles	23.5	25.7	28.1	72.0	10.3	27.9	21.0	79.0
Wearing apparel	28.1	22.5	32.0	68.0	10.5	27.1	20.9	79.2
Leather, fur, down and related products	48.8	15.3	51.1	48.9	13.5	20.5	23.5	76.5
Products of wood, bamboo, cane, palm, straw	17.1	24.2	22.4	77.6	8.2	27.8	17.3	82.7
Furniture	17.4	19.9	23.1	76.9	7.8	26.4	18.1	81.9
Paper and paper products	36.9	18.8	40.5	59.5	7.2	29.5	15.5	84.5
Printing, reproduction of recording media	60.8	13.8	63.1	36.9	5.6	42.0	13.9	86.1
Stationary and related products	23.4	20.4	29.0	71.0	8.4	26.9	19.6	80.4
Toys, sporting and athletic and recreation products	45.3	25.1	48.3	51.7	10.9	31.8	21.4	78.6
Petroleum and nuclear processing	40.1	12.9	42.8	57.2	18.7	15.3	24.9	75.1
Coking	3.6	33.7	7.2	92.8	2.9	34.3	9.4	90.6
Basic chemicals	14.3	26.9	18.8	81.2	9.2	28.9	17.2	82.8
Chemical fertilizers	8.1	22.8	14.4	85.6	7.8	23.5	18.6	81.5
Chemical pesticides	14.8	24.7	21.8	78.2	12.7	25.7	23.3	76.7
paints, varnishes and similar coatings, printing ink and mastics	20.1	18.8	26.9	73.1	10.5	22.8	22.1	77.9
Man-made chemical products	43.1	13.8	48.6	51.4	13.5	21.6	25.9	74.1
Special chemical products	40.5	16.6	44.9	55.1	13.3	23.6	23.9	76.1
Chemical products for daily use	23.7	23.9	29.1	71.0	8.0	31.9	18.3	81.7
Medical and pharmaceutical products	12.6	33.8	16.7	83.3	5.3	38.7	12.5	87.5
Chemical fibers	19.6	18.8	27.5	72.6	13.8	21.6	26.4	73.6
Rubber products	37.0	18.7	40.4	59.7	7.3	27.7	15.6	84.4
Plastic products	59.9	14.2	63.3	36.7	14.6	25.1	27.9	72.1
Cement, lime and plaster	8.1	26.5	12.9	87.1	4.8	27.9	13.6	86.4

	Split Method				HIY Method			
IO industry description	Direct foreign value-added	Direct domestic value-added	Total Foreign value-added	Total Domestic Value-added	Direct foreign value-added	Direct domestic value-added	Total Foreign value-added	Total Domestic Value-added
Glass and glass products	24.7	26.9	29.2	70.8	8.4	35.2	16.8	83.2
Pottery, china and earthenware	10.3	30.1	15.5	84.5	5.9	32.2	14.9	85.2
Fireproof materials	9.7	35.2	14.0	86.0	3.8	41.4	10.9	89.1
Other non-metallic mineral products	7.8	30.5	12.5	87.5	4.0	33.9	12.0	88.0
Iron-smelting	13.8	19.7	18.5	81.5	7.0	23.2	14.2	85.8
Steel-smelting	31.8	15.2	36.1	63.9	5.2	25.6	13.0	87.0
Steel pressing	9.5	23.6	15.1	84.9	5.0	26.5	13.8	86.2
Alloy iron smelting	18.7	20.4	23.7	76.3	7.1	27.3	15.4	84.6
Nonferrous metal smelting	35.5	15.9	39.4	60.6	7.4	22.0	15.9	84.1
Nonferrous metal pressing	26.5	12.8	32.6	67.4	9.2	16.9	20.4	79.7
Metal products	38.7	17.5	42.5	57.5	7.0	23.7	17.1	82.9
Boiler, engines and turbine	18.0	24.6	23.3	76.7	9.6	30.1	19.2	80.8
Metalworking machinery	10.3	29.1	15.7	84.4	8.1	32.2	17.7	82.3
Other general industrial machinery	39.0	19.6	42.8	57.2	7.5	27.5	18.0	82.0
Agriculture, forestry, animal husbandry and fishing machinery	11.4	25.2	17.3	82.7	6.7	28.8	16.9	83.1
Other special industrial equipment	34.1	19.9	38.1	61.9	9.3	27.4	19.2	80.8
Railroad transport equipment	16.2	24.4	21.6	78.4	7.4	28.4	17.5	82.5
Motor vehicles	21.4	19.5	27.0	73.0	6.1	26.4	17.2	82.8
Parts and accessories for motor vehicles and their engines	25.3	20.6	30.4	69.6	6.6	26.9	17.4	82.6
Ship building	43.3	12.3	47.4	52.6	12.7	23.8	23.1	77.0
Other transport equipment	35.6	18.8	40.3	59.8	10.9	25.0	22.3	77.7
Generators	60.2	12.3	62.7	37.3	10.5	23.5	21.4	78.6
Household electric appliances	61.8	12.7	64.3	35.7	10.5	23.9	23.0	77.0
Other electric machinery and equipment	50.3	18.3	53.8	46.2	9.9	24.4	21.8	78.2
Telecommunication equipment	82.5	9.4	83.4	16.6	24.2	23.5	37.9	62.1
Electronic computer	91.7	7.6	91.8	8.2	35.2	13.2	51.5	48.5
Other computer peripheral equipment	77.1	14.6	77.9	22.1	35.0	20.8	46.2	53.8
Electronic element and device	80.7	10.4	81.6	18.4	23.4	26.1	33.3	66.7
Radio, television and communication equipment and apparatus	61.2	12.9	63.8	36.2	34.6	19.4	45.6	54.4
Other electronic and communication equipment	26.4	25.6	31.5	68.5	31.7	26.0	40.2	59.8
Instruments, meters and other measuring equipment	59.8	19.1	61.6	38.4	14.6	32.1	24.3	75.7
Cultural and office equipment	80.0	12.3	80.7	19.3	40.0	10.6	56.8	43.2
Arts and crafts products	44.1	18.3	47.3	52.7	7.0	27.8	16.5	83.5
Other manufacturing products	34.8	19.5	38.6	61.4	6.9	28.6	16.3	83.8
Total Merchandise	42.8	19.9	46.1	53.9	15.0	26.0	25.4	74.6

Source: Authors' estimates.

Appendix Table E Domestic and foreign value-added embodied in Chinese gross merchandise exports, in percent, 1997

	Split Method				HIY Method			
IO industry description	Direct foreign value-added	Direct domestic value-added	Total Foreign value-added	Total Domestic Value-added	Direct foreign value-added	Direct domestic value-added	Total Foreign value-added	Total Domestic Value-added
Crop cultivation	4.3	63.7	6.0	94.1	2.5	65.0	6.0	94.0
Forestry	3.7	71.5	4.7	95.3	1.4	73.3	3.7	96.3
Livestock and livestock products	4.9	48.2	6.8	93.2	2.7	49.6	6.3	93.7
Fishery	9.4	56.0	11.1	88.9	2.2	60.6	6.0	94.0
Other agricultural products	11.2	51.5	12.6	87.4	1.8	57.2	5.3	94.7
Coal mining and processing	1.3	51.4	3.5	96.5	3.7	51.4	9.2	90.8
Crude petroleum products	0.9	75.2	2.2	97.8	2.5	75.2	5.4	94.6
Natural gas products	1.4	54.2	4.0	96.0	4.5	54.2	10.2	89.8
Ferrous ore mining	2.7	33.7	6.0	94.0	8.4	33.7	16.0	84.0
Non-ferrous ore mining	8.5	33.8	11.2	88.8	4.4	36.1	11.5	88.5
Salt mining	1.4	59.6	3.3	96.7	2.1	60.0	7.3	92.7
Non-metal minerals and other mining	21.0	34.0	23.4	76.6	4.9	40.1	11.9	88.1
Logging and transport of timber and bamboo	6.4	58.9	7.9	92.2	2.4	62.1	5.9	94.1
Grain mill products, vegetable oil and forage	48.7	13.0	50.2	49.8	3.7	18.7	9.1	90.9
Sugar refining	82.0	8.8	82.4	17.7	3.3	18.7	9.1	90.9
Slaughtering , meat processing, eggs and dairy products	14.6	14.2	17.3	82.7	1.8	15.3	7.6	92.4
Prepared fish and seafood	26.0	21.4	27.8	72.2	1.1	25.1	6.0	94.0
Other food products	24.6	26.3	26.7	73.3	3.8	31.3	9.7	90.3
Wines, spirits and liquors	18.0	28.4	20.3	79.7	3.1	32.9	9.0	91.0
Non-alcoholic beverage	15.7	26.6	18.3	81.7	3.7	29.7	10.5	89.5
Tobacco products	7.7	52.3	9.3	90.7	2.0	55.8	5.8	94.2
Cotton textiles	35.1	23.3	37.0	63.0	8.5	28.3	18.2	81.8
Woolen textiles	55.7	20.9	56.6	43.5	5.8	33.5	12.3	87.7
Hemp textiles	28.7	23.1	30.6	69.4	6.3	27.9	12.5	87.6
Silk textiles	5.8	23.9	8.5	91.5	2.6	24.9	10.8	89.2
Knitted mills	31.0	27.0	32.7	67.3	9.0	28.1	18.5	81.5
Other textiles	51.3	17.8	52.5	47.5	5.7	25.9	11.6	88.4
Wearing apparel	37.6	34.3	38.7	61.3	6.8	36.1	15.3	84.7
Leather, furs, down and related products	60.8	18.4	61.5	38.5	11.6	22.6	20.6	79.4
Sawmills and fibreboard	21.5	26.0	23.6	76.4	6.4	30.5	13.3	86.7
Furniture and products of wood, bamboo, cane, palm, straw, etc.	38.2	20.9	40.0	60.0	7.3	26.3	16.4	83.6
Paper and products	56.0	17.9	57.1	42.9	5.3	29.4	12.4	87.7
Printing and record medium reproduction	73.2	14.0	73.8	26.2	6.3	37.4	13.6	86.4
Cultural goods	50.4	28.1	51.5	48.5	6.4	41.1	13.7	86.3
Toys, sporting and athletic and recreation products	65.1	21.8	65.7	34.4	10.2	27.9	20.0	80.0
Petroleum refining	49.3	15.4	50.6	49.4	15.2	22.0	20.3	79.7
Coking	4.6	22.5	7.3	92.7	2.5	23.0	9.7	90.3
Raw chemical materials	5.9	31.8	8.7	91.4	3.1	32.9	10.1	89.9
Chemical fertilizers	5.5	21.9	9.2	90.8	5.2	22.4	14.7	85.3
Chemical pesticides	21.2	19.9	24.6	75.4	4.9	23.0	14.6	85.4
Organic chemical products	20.2	19.9	24.3	75.7	8.6	22.2	18.3	81.8
Chemical products for daily use	35.2	28.2	37.3	62.7	4.5	37.8	12.3	87.7
Other chemical products	36.3	19.9	38.6	61.4	8.1	25.7	15.8	84.2
Medical and pharmaceutical products	15.5	33.0	17.8	82.2	3.0	36.9	9.5	90.5
Chemical fibers	65.0	13.2	66.5	33.5	14.8	23.3	25.2	74.8
Rubber products	60.0	18.0	60.9	39.1	8.6	25.0	17.1	82.9
Plastic products	65.0	16.7	66.2	33.8	12.9	24.3	23.6	76.4
Cement	5.4	23.3	8.7	91.3	3.9	24.0	12.7	87.3

	Split Method				HIY Method			
IO industry description	Direct foreign value-added	Direct domestic value-added	Total Foreign value-added	Total Domestic Value-added	Direct foreign value-added	Direct domestic value-added	Total Foreign value-added	Total Domestic Value-added
Cement and asbestos products	50.0	16.4	51.5	48.5	2.4	26.8	11.1	88.9
Bricks, tiles, lime and light-weight building materials	10.1	36.5	12.7	87.3	3.6	39.6	10.3	89.7
Glass and glass products	37.9	22.8	39.9	60.1	4.5	30.7	12.4	87.6
Pottery, china and earthenware	14.0	34.6	16.6	83.4	3.3	37.8	10.6	89.4
Fireproof products	8.0	26.9	10.9	89.1	3.6	28.5	11.6	88.4
Other non-metallic mineral products	17.8	26.9	20.3	79.7	3.0	30.9	10.6	89.4
Iron-smelting	67.8	20.7	68.2	31.8	5.7	22.3	12.9	87.1
Steel-smelting	72.5	11.1	73.2	26.8	3.9	23.7	11.6	88.4
Steel processing	76.6	10.3	77.2	22.8	5.9	21.0	15.1	84.9
Alloy iron smelting	43.3	16.4	45.1	54.9	5.5	21.4	14.2	85.8
Nonferrous metal smelting	36.3	15.0	38.2	61.8	4.6	19.5	12.5	87.6
Nonferrous metal processing	45.1	12.0	47.2	52.8	7.2	15.4	16.7	83.3
Metal products	37.9	19.4	40.1	59.9	5.9	23.3	15.4	84.6
Boiler, engines and turbine	30.2	27.4	32.4	67.6	7.4	34.6	15.5	84.5
Metalworking machinery	21.4	27.1	24.0	76.0	5.8	31.9	14.5	85.5
Other general industrial machinery	36.4	29.5	38.1	61.9	5.3	37.7	13.3	86.8
Agriculture, forestry, animal husbandry and fishing machinery	9.5	20.7	13.4	86.6	6.5	21.8	17.2	82.8
Other special industrial equipment	36.6	25.1	38.6	61.4	7.6	32.5	16.3	83.7
Railroad transport equipment	44.3	17.9	46.3	53.7	5.5	26.3	15.2	84.8
Motor vehicles	36.4	19.2	39.0	61.0	5.2	25.7	15.3	84.7
Ship building	79.9	14.1	80.2	19.8	8.1	28.7	17.6	82.4
Aircraft	29.2	35.7	31.0	69.0	23.5	42.4	28.0	72.0
Bicycle	74.5	10.5	75.2	24.8	6.5	18.8	18.0	82.0
Other transport machinery	39.2	19.4	41.5	58.5	6.2	27.4	16.3	83.7
Generators	75.5	14.5	76.0	24.0	7.9	26.2	17.8	82.2
Household electric appliances	69.4	17.2	70.2	29.8	8.7	26.3	19.7	80.3
Other electric machinery and equipment	68.1	14.0	69.1	30.9	9.0	19.7	20.0	80.0
Electronic computer	80.6	17.8	80.7	19.4	24.5	23.4	36.7	63.3
Electronic appliances	85.3	12.5	85.4	14.6	21.5	19.8	33.5	66.5
Electronic element and device	68.0	22.6	68.6	31.4	14.6	29.7	23.6	76.4
Other electronic and communication equipment	77.5	17.8	77.9	22.1	18.3	27.3	30.0	70.0
Instruments, meters and other measuring equipment	69.1	19.8	69.7	30.3	10.6	36.3	19.1	80.9
Cultural and office equipment	86.8	12.3	86.8	13.2	15.6	19.8	26.9	73.1
Arts and crafts products	47.3	22.8	48.6	51.4	6.1	29.8	14.2	85.9
Other manufacturing products	59.9	21.9	60.8	39.2	5.5	34.3	13.7	86.3
Total Merchandise	47.0	24.2	48.3	51.7	9.0	29.4	17.9	82.1

Source: Authors' estimates.