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Assessing Foreign and Domestic Value-Added in Gross Exports

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Abstract

As China's juggernaut export machine employs many imported inputs, there are many policy questions for which it will be crucial to know the extent of domestic value added (DVA) in its exports. The best known approach is the concept of "vertical specialization" proposed by Hummels, Ishii and Yi (2001) (HIY for short). This approach is not appropriate for countries that engage in a lot of processing exports such as China, Mexico, and Vietnam. We develop a general formula for computing domestic and foreign contents when processing exports are pervasive. Because the new formula requires some input-output coefficients not typically available from a conventional input-output table, we propose a mathematical programming procedure to estimate these coefficients by combining information from detailed trade statistics with input-output tables. By our estimation, the share of foreign content in China's exports is at about 50%, almost twice as high as the estimate from the HIY formula. There are also interesting variations across sectors and firm ownership. Those sectors that are likely labeled as relatively sophisticated such as electronic devices have particularly high foreign content (about 80%). Foreign-invested firms also tend to have higher foreign content in their exports than domestic firms.

Key words: domestic content, foreign content, processing exports

JEL Classification Numbers: F1, C67, C82

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1. Introduction

The People's Republic of China is the archetype of a national economy that is well integrated into a global production chain. It imports raw material, equipment, and other intermediate inputs, and then exports a big fraction of its output (on the order of 37% of GDP in 2006) to the world market. China's export/GDP ratio is extraordinarily high for a large economy, when compared with 8% for the United States and 13% for India in the same year. With a reputation as a "world factory," China is a top supplier of manufacturing outsourcing for many global companies.

Imported inputs used in the production for exports reduce the share of value added generated by domestic producers in a nation's exports. Consider the example of iPod, which China assembles for Apple and exports to the United States and other countries. In trade statistics, the Chinese export value for a unit of a 30GB video model in 2006 was about \$150. However, the best estimate of the value added attributable to producers in China was only \$4, with the remaining value added coming from the United States, Japan, and other countries (Linden, Kraemer, and Dedrick, 2007; and Varian, 2007).

For many policy issues, it is important to assess the extent of domestic content in exports. For example, what is the effect of a currency appreciation on a country's exports? The answer depends crucially on the share of domestic content in the country's exports. Other things equal, a given exchange rate appreciation would have a smaller effect on trade volume, the lower the share of domestic content in the exports. As another example, what is the effect of trading with China on US income inequality? The answer depends in part on whether China simply exports products that are intensive in low-skilled labor or whether China's exports are more sophisticated. Rodrik (2006) notes that the per capita income typically associated with the kind of goods bundle that China exports is much higher than China's actual income. He interprets this as evidence that the skill content of China's exports is likely to be much higher than its endowment may imply. Schott (2008) documents an apparent fast increase in the similarity between the Chinese export structure and that of high-income countries, and interprets it as evidence of a rise in the

level of sophistication embedded in Chinese exports. 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 imports from China may still generate a large downward pressure on the wage of the low-skilled Americans after all (as pointed out by Krugman, 2008).

How would one assess foreign versus domestic content in a country's exports? Hummels, Ishii, and Yi (2001) (HIY for short in subsequent discussion) propose a concept 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," and provide a formula to compute VS share based exclusively on a country's input-output table. For a sample of 14 countries (not including China), they calculate that the average share of foreign value added in exports was about 21% in 1990. Yi (2003) shows that a dramatic increase in vertical specialization after the Second World War is likely to be responsible for a faster growth of world trade relative to world GDP over the last five decades. Other recent applications of the vertical specialization concept include Goh and Olivier (2004), Chinn (2005), U.S. National Research Council (2006), and Dean, Fung, and Wang (2007).

A key assumption needed for the HIY formula to work is that the intensity in the use of imported inputs is the same between production for exports and production for domestic sales. This assumption is violated in the Chinese case due to pervasive processing exports. Processing exports are characterized by imports for exports with favorable tariff treatment: firms import parts and other intermediate materials from abroad, with tariff exemptions on the imported inputs and other tax preferences from local or central governments, and, after processing or assembling, export the finished products to the international market. The policy preferences for processing exports usually lead to a significant difference in the intensity of imported intermediate inputs in the production for processing exports and in other productions (for domestic final sales and normal exports). Since processing exports have accounted for more than 50% of Chinese exports every year at least since 1996 (see Column 1 of Table 1 for detail), the HIY formula is likely to lead to a significant under-estimation of the share of foreign

value added in its exports. In fact, most economies offer tariff reductions or exemptions on imported intermediate inputs used in production for exports. Ignoring processing exports is likely to lead to estimation errors, especially for economies that engage in a massive amount of tariff/tax-favored processing trade, such as Mexico and Vietnam.

Table 1: Processing Manufacturing Exports (excluding HS Chapters 1-27), 1996-2006

<i>Year</i>	<i>Share of processing exports in total exports (100*PE/TE)</i>	<i>Share of Processing & assembling</i>	<i>Share of Processing with imported materials</i>	<i>Share of processing imports in total imports</i>	<i>Ratio of processing imports to processing exports(100*PM/PE)</i>	<i>Processing trade surplus as share of processing exports (100*[PE-PM]/PE)</i>
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: Authors computed from China Customs Trade statistics, General Customs Administration of China.

In this paper, we aim to make three contributions. First, we develop a formula for computing shares of foreign and domestic value added in a country's exports when processing exports are pervasive. The HIY formula is a special case of this general formula. Second, because some of the input-output coefficients called for by the new formula are not generally available from conventional input-output tables, we propose a mathematical programming method to estimate these coefficients by combining information from trade statistics (which separate processing and normal trade) with standard input-output (I/O) tables. Third, we apply our methodology to the Chinese data in 1997, 2002, and 2006¹. We estimate that the share of foreign value added in Chinese manufactured exports is at about 50%, almost twice as high as that implied by the HIY formula. There are also interesting variations across sectors and firm ownership. Those sectors that are likely labeled as relatively sophisticated such as computers, telecommunication equipments, and electronic devices have particularly high foreign

¹ Note that the 2002 Input-Output Table is the latest such table available; the next table—the 2007 benchmark IO table—is scheduled to be released in 2010. Our 2006 estimates make use of the 2006 trade statistics but of the 2002 I/O table.

content (about 80%). Foreign-invested firms also tend to have higher foreign content in their exports than do Chinese domestic firms.

Besides the papers on vertical specialization in the international trade literature, this paper is also related to the I/O literature. In particular, Chen et al. (2004) and Lau et al (2007) are the first to develop a “non-competitive” type I/O model for China (i.e., one in which imported and domestically produced inputs are accounted for separately) and to incorporate processing exports explicitly. However, these papers do not describe a systematic way to infer separate input-output coefficients for production of processing exports versus those for other final demands. It is therefore difficult for others to replicate their estimates or apply their methodology to other countries. In addition, they use an aggregated version of China’s 1995 and 2002 input-output tables, respectively, to perform their analysis, with 20 some goods producing industries. We provide a more up-to-date and more disaggregated assessment of foreign and domestic values added in Chinese exports with 83 goods producing industries. Finally, they impose an assumption in estimating the import use matrix from the competitive type I/O table published by China’s National Statistical Bureau: within each industry, the mix of the imported and domestic inputs is the same in capital formation, intermediate inputs, and final consumption. We relax this assumption by refining a method proposed in Dean, Fung, and Wang (2007) that combines China’s processing imports statistics with United Nations Broad Economic Categories (UNBEC) classification.

The rest of the paper is organized as follows. Section 2 presents a conceptual framework for estimating shares of domestic and foreign value added in a country’s exports when processing exports are pervasive. It also describes a mathematic programming procedure to systematically infer a set of I/O coefficients called for by the new formula but not typically available from a conventional I/O table. Section 3 presents the estimation results for Chinese exports. Finally, Section 4 offers concluding remarks.

2. Conceptual Framework and Estimation Method

2.1 When special features of processing exports are not taken into account

We first discuss how domestic and foreign contents in a country's exports can be computed when it does not engage in any processing trade. The discussion follows the input-output literature, and is the approach adopted (implicitly) by Hummels, Ishii, and Yi (2001) and Yi (2003). Along the way, we will point out a clear connection between the domestic content concept and the concept of vertical specialization².

When imported and domestically produced intermediate inputs are accounted separately, an input-output model can be specified as follows³:

$$A^D X + Y^D = X \quad (1)$$

$$A^M X + Y^M = M \quad (2)$$

$$(A^D + A^M)' X + \hat{A}_v X = X \quad (3)$$

$$uA^D + uA^M + A_v = u \quad (4)$$

Where $A^D = [a^D_{ij}]$ is an $n \times n$ matrix of direct input coefficients of domestic products; $A^M = [a^M_{ij}]$ is an $n \times n$ matrix of direct inputs of imported goods; Y^D is an $n \times 1$ vector of final demands for domestically produced products, including usage in gross capital formation, private and public final consumption, and gross exports; Y^M is an $n \times 1$ vector of final demands for imported products, including usages in gross capital formation, private and public final consumption; X is a $n \times 1$ vector of gross output; M is a $n \times 1$ vector of imports; $A_v = [a^v_j]$ is a $1 \times n$ vector of each sector j 's ratio of value added to gross output; \hat{A}_v is an $n \times n$ diagonal matrix with a^v_j as its diagonal elements; finally, u is a $1 \times n$ unity vector. Subscripts i and j indicate sectors, and superscripts D and M represent domestically produced and imported products, respectively.

² We use the terms “domestic value added” and “domestic content” interchangeably. Similarly, we use the terms “foreign value added,” “foreign content,” and “vertical specialization,” to mean the same thing.

³ Such a model is called a “non-competitive” model in the I/O literature. HIY (2001) do not specify this system explicitly but go straight to the implied Leontief inverse while Chen et al. (2004) specify only the first two equations. A fully specified model facilitates a better understanding of the connection between vertical specialization and domestic content, and a comparison with the model in the next sub-section that features processing exports.

Equations (1) and (2) define two horizontal balance conditions for domestically produced and imported products respectively. A typical row k in Equation (1) specifies that total domestic production of product k should be equal to the sum of the sales of product k to all users in the economy (to be used as intermediate inputs or for final sales to these users), the final sales include domestic consumption and capital formation, plus exports of product k . A typical row h in Equation (2) specifies that the total imports of product h should be equal to the sum of the sales of product h to all users in the economy, including intermediate inputs for all sectors, plus final domestic consumption and capital formation. Equation (3) is a vertical balance conditions, and Equation (4) describes an adding-up constraint for the input-output coefficients. Collectively, they imply that the total output (X) in any sector k has to be equal to the sum of direct value added in sector k , and the cost of intermediate inputs from all domestically produced and imported products.

From equation (1) we have

$$X = (I - A^D)^{-1} Y^D \quad (5)$$

$(I - A^D)^{-1}$ is the well-known Leontief Inverse, a matrix of coefficients for the total domestic intermediate product requirement. Define a vector of share of domestic content, or domestic value added, in a unit of domestically produced products, $DVS = \{dvs_j\}$, a $1 \times n$ vector, as the additional domestic value added generated by one additional unit of final demand of domestic products ($\Delta Y^D = u$).

$$DVS = \hat{A}_v \Delta X / \Delta Y^D = \hat{A}_v (I - A^D)^{-1} \quad (6)$$

Equation (6) indicates that the domestic content for an I/O industry is the corresponding column sum of the coefficient matrix for total domestic intermediate goods requirement, weighted by the direct value-added coefficient of each industry.

Under the condition that all exports and domestic sale have the same input-output coefficients, the share of domestic content in final demand and the share of domestic content in total exports should be the same. So Equation (6) is also the formula for the share of domestic content in total exports for each industry. As Chen et al (2004) points out, there is a good intuition behind the DVS formula. When one extra unit of product for final demand is produced at home, both direct and indirect values added are generated. The indirect value added comes from the domestic value added embedded in all the

domestically produced intermediate inputs. Each of them is produced with direct and indirect value added involved. Therefore, the *total* domestic value added induced by one extra unit of domestic product is equal to the sum of direct domestic value added and multiple rounds of indirect domestic value added. Expressing this process mathematically, we have:

$$\begin{aligned} DVS &= A_v + A_v A^D + A_v A^D A^D + A_v A^D A^D A^D + \dots \\ &= A_v (I - A^D)^{-1} \end{aligned} \quad (7)$$

The last step invokes the formula for the convergence of matrix power series of A^D .

Define a vector of share of foreign content (or foreign value added) in final demand for domestically produced products by $FVS = u - DVS$. By making use of Equation (4), it can be verified that

$$FVS = u - A_v (I - A^D)^{-1} = u A^M (I - A^D)^{-1} \quad (8)$$

For each industry, this is the column sum of the coefficient matrix for total intermediate import requirement. This turns out to be the exact same formula used to compute vertical specialization by HIY (2001). In other words, the concepts of vertical specialization and of foreign content are identical.

2.2 Domestic Content in Exports When Processing Trade is Prevalent

We now turn to the case in which tariff-favored processing exports are prevalent, which have a different intensity in the use of imported inputs than do domestic final sales (and normal exports). Conceptually, we wish to keep separate track of the I/O coefficients of the processing exports from those of domestic final sales and normal exports. For now, we ignore the fact that these I/O coefficients may not be directly available, and will discuss a formal approach to estimate them in the next subsection.

The expanded I/O table with a separate account for processing exports is represented by Figure 1.

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

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

We use superscript P and D, respectively, to represent processing exports, and domestic sales & normal exports. Define z_{ij}^{dd} = 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}^{md} = 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^d = Value added by domestic and normal export production in industry j ; v_j^p = Value added by processing export production in industry j . Then direct I/O coefficients for this expanded I/O model can be written as:

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

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

Where i represent a row and j represents a column. This expanded I/O model can be formally described by the following system of equations:

$$\begin{bmatrix} I - A^{DD} & -A^{DP} \\ 0 & I \end{bmatrix} \begin{bmatrix} X - E^P \\ E^P \end{bmatrix} = \begin{bmatrix} Y^D \\ E^P \end{bmatrix} \quad (9)$$

$$A^{MD}(X - E^P) + A^{MP}E^P + Y^M = M \quad (10)$$

$$(A^{DD} + A^{MD})'(X - E^P) + \hat{A}_v^D(X - E^P) = X - E^P \quad (11)$$

$$(A^{DP} + A^{MP})'E^P + \hat{A}_v^M E^P = E^P \quad (12)$$

$$uA^{Dk} + uA^{Mk} + A_v^k = u \quad k = D, P \quad (13)$$

This is a generalization of the model discussed in the previous subsection. Equations (9)-(10) are a generalization of Equations (1)-(2), and Equations (11)-(12) are a generalization of Equation of (3), with a separate account for processing exports. In a slight abuse of notation, we now re-define Y^D to be final domestic sales plus normal exports while excluding processing exports. Equation (13) is the new adding up constraint for the I/O coefficients.

The analytical solution of the system is

$$\begin{bmatrix} X - E^P \\ E^P \end{bmatrix} = \begin{bmatrix} I - A^{DD} & -A^{DP} \\ 0 & I \end{bmatrix}^{-1} \begin{bmatrix} Y^D \\ E^P \end{bmatrix} \quad (14)$$

The generalized Leontief inverse for this expanded model can be computed as follows:

$$B = \begin{bmatrix} I - A^{DD} & -A^{DP} \\ 0 & I \end{bmatrix}^{-1} = \begin{bmatrix} B^{DD} & B^{DP} \\ B^{PD} & B^{PP} \end{bmatrix} = \begin{bmatrix} (I - A^{DD})^{-1} & (I - A^{DD})^{-1} A^{DP} \\ 0 & I \end{bmatrix} \quad (15)$$

Substituting equation (15) into equation (14), we have:

$$X - E^P = (I - A^{DD})^{-1} Y^D + (I - A^{DD})^{-1} A^{DP} E^P \quad (16)$$

Substituting equation (16) into equation (10), the total demand for imported intermediate inputs is:

$$M - Y^M = A^{MD} (I - A^{DD})^{-1} Y^D + A^{MD} (1 - A^{DD})^{-1} A^{DP} E^P + A^{MP} E^P \quad (17)$$

It has three components: the first term is total imported content in final domestic sale and normal exports, and the second and the third terms are indirect and direct imported content in processing exports, respectively.

We can compute vertical specialization (VS) or foreign content share in processing and normal exports in each industry separately:

$$\begin{vmatrix} VSS^D \\ VSS^P \end{vmatrix}^T = \begin{vmatrix} uA^{MD} (I - A^{DD})^{-1} \\ uA^{MD} (1 - A^{DD})^{-1} A^{DP} + uA^{MP} \end{vmatrix}^T \quad (18)$$

The total foreign content share in a particular industry is the sum of the two weighted by the share of processing and non-processing exports s^P and $u-s^P$:

$$\overline{VSS} = (u - s^P, s^P) \begin{vmatrix} VSS^D \\ VSS^P \end{vmatrix} \quad (19)$$

The foreign content (or foreign value-added) share in a country's total exports is:

$$TVSS = uA^{MD} (I - A^{DD})^{-1} \frac{E - E^P}{te} + u(A^{MD} (1 - A^{DD})^{-1} A^{DP} + A^{MP}) \frac{E^P}{te} \quad (20)$$

Where te is a scalar, the country's total exports. Equation (19) is a generalization of Equation (8), the formula to compute industry-level share of vertical specialization. Equation (20) is a generalization of the formula for country-level share of vertical specialization proposed by HIY (2001, page 80). In particular, either when $A^{DD} = A^{DP}$ and $A^{MD} = A^{MP}$, or when $E^P/te = 0$, Equation (20) reduces to the HIY formula for VS.

Similarly, the domestic content share for processing and normal exports at the industry level can be computed separately:

$$\begin{aligned} \begin{vmatrix} DVSS^D \\ DVSS^P \end{vmatrix}^T &= \bar{A}_v B = (A_v^D \quad A_v^P) \begin{bmatrix} (I - A^{DD})^{-1} & (I - A^{DD})^{-1} A^{DP} \\ 0 & I \end{bmatrix} \\ &= \begin{vmatrix} A_v^D (I - A^{DD})^{-1} \\ A_v^D (I - A^{DD})^{-1} A^{DP} + A_v^P \end{vmatrix}^T \end{aligned} \quad (21)$$

The total domestic content share in a particular industry is a weighted sum of the two:

$$\overline{DVS} = (u - s^P, s^P) \begin{vmatrix} DVS^D \\ DVS^P \end{vmatrix} \quad (22)$$

The domestic content share in a country's total exports is:

$$TDVS = A_V^D (I - A^{DD})^{-1} \frac{E - E^P}{te} + (A_V^D (1 - A^{DD})^{-1} A^{DP} + A_V^P) \frac{E^P}{te} \quad (23)$$

Either when $A^{DD} = A^{DP}$ and $A_V^D = A_V^P$, or when $E^P/te = 0$, Equation (22) reduces to Equation (6). Note we can easily verify that for both processing and normal exports, the sum of domestic and foreign content shares is unity (see Appendix for details).

2.3 Estimation Issues

Equations (21-23) allows us to compute the shares of domestic content in processing and normal exports for each industry as well as in a country's total exports. However, statistical agencies typically only report a traditional I/O matrix, A^D , and sometimes A^M , but not A^{DP} , A^{DD} , A^{MP} and A^{MD} separately. Therefore, we have to develop a method to estimate A^{DP} , A^{DD} , A^{MP} and A^{MD} based on available information. Or, equivalently, we have to estimate $[z_{ij}^{dd}]$, $[z_{ij}^{dp}]$, $[z_{ij}^{md}]$, and $[z_{ij}^{md}]$, respectively, instead of $[a_{ij}^{dd}]$, $[a_{ij}^{dp}]$, $[a_{ij}^{md}]$, and $[a_{ij}^{mp}]$. In this sub-section, we propose to do this via a quadratic programming model by combining information from trade statistics and conventional I/O tables.

The following data are observable from a standard I/O table and enter our programming model as constants: x_i = Gross output of sector i ; z_{ij} = Goods i used as intermediate inputs in sector j ; v_j = Value-added in sector j ; and m_i = Total imports of sector i goods; and y_i = Total final demand except for exports of goods i . We combine information from a standard I/O table and trade statistics to determine the values for m_i^p = Imports of sector i good used as intermediate inputs to produce processing exports (with the share estimated from trade statistics); m_i^d = Imports of sector i goods used as intermediate inputs for domestic production and normal exports (with the share also estimated from trade statistics); e_i^n = Normal exports of sector i and e_i^p = Processing exports of sector i (with the share obtained from trade statistics). To be precise, we use

information from an I/O table to determine sector-level total imports/exports, and information from trade statistics to determine the relative proportion of processing and normal exports within a sector. Using the data from I/O table to determine sector-level total imports/exports helps to ensure that the balance conditions in official I/O account are always satisfied and the I/O table with separate processing exports account estimated from our model always sum to the published official table. Other parameters of the model can be inferred from the variables already discussed: y_i^m = Final demand of goods i from imports (residuals of $m_i - m_i^p - m_i^d$); y_i^d = Final demand of goods i provided by domestic production (residual of $y_i - y_i^m$). i and j are indices of sectors from 1 to K .

We wish to estimate within-industry transactions $[z_{ij}^{dd}]$, $[z_{ij}^{dp}]$, $[z_{ij}^{md}]$, and $[z_{ij}^{mp}]$, as well as sector-level value added $[v_j^d]$, and $[v_j^p]$. We can make initial guesses about their values based on trade statistics and coefficients from a conventional I/O table. These guesses are referred to as “initial values” below. However, these guesses are not guaranteed to satisfy various economic and statistical restrictions on the data. Therefore, we cast the estimation problem as a constrained optimization. Using the notations previously defined, our programming model is specified by the following objective function subject to ten constraints:

$$\begin{aligned} \text{Min } S = & \sum_{i=1}^K \sum_{j=1}^K \frac{(z_{ij}^{dd} - z0_{ij}^{dd})^2}{z0_{ij}^{dd}} + \sum_{i=1}^K \sum_{j=1}^K \frac{(z_{ij}^{dp} - z0_{ij}^{dp})^2}{z0_{ij}^{dp}} + \sum_{i=1}^K \sum_{j=1}^K \frac{(z_{ij}^{md} - z0_{ij}^{md})^2}{z_{ij}^{md}} \\ & + \sum_{i=1}^K \sum_{j=1}^K \frac{(z_{ij}^{mp} - z0_{ij}^{mp})^2}{z0_{ij}^{mp}} + \sum_{j=1}^K \frac{(v_j^d - v0_j^d)^2}{v0_j^d} + \sum_{j=1}^K \frac{(v_j^p - v0_j^p)^2}{v0_j^p} \end{aligned} \quad (24)$$

Where z 's and v 's are variables to be estimated, those variables with a 0 in the suffix denote initial values.

$$\sum_{j=1}^K (z_{ij}^{dd} + z_{ij}^{dp}) + y_i^d + e_i^n = x_i - e_i^p \quad (25)$$

$$\sum_{j=1}^K (z_{ij}^{md} + z_{ij}^{mp}) + y_i^m = m_i \quad (26)$$

$$\sum_{j=1}^K (z_{ij}^{dd} + z_{ij}^{md}) + v_j^d = x_j - e_j^p \quad (27)$$

$$\sum_{i=1}^K (z_{ij}^{dp} + z_{ij}^{mp}) + v_j^p = e_j^p \quad (28)$$

$$\sum_{j=1}^K z_{ij}^{md} = m_i^d \quad (29)$$

$$\sum_{j=1}^K z_{ij}^{mp} = m_i^p \quad (30)$$

$$\sum_{j=1}^K (z_{ij}^{dd} + z_{ij}^{dp}) = \sum_{j=1}^K z_{ij} - (m_i^d + m_i^p) \quad (31)$$

$$z_{ij}^{dd} + z_{ij}^{dp} + z_{ij}^{md} + z_{ij}^{mp} = z_{ij} \quad (32)$$

$$v_j^d + v_j^p = v_j \quad (33)$$

$$y_i^d + y_i^m = y_i \quad (34)$$

The economic meanings of these ten constraints are straightforward. Equations (25) and (26) are row sum constraints for the expanded I/O account. They state that total gross output of sector i has to equal to the sum of domestic intermediaries, final demand and exports (both processing and normal exports) in that sector. Similarly, total imports have to equal imported intermediate inputs plus imports delivered to final users. Equations (27) and (28) are column sum constraints for the expanded I/O 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; these four groups of constraints correspond to equations (9)-(12) in the extended I/O model respectively. Equations (29) to (34) are a set of adding up constraints to ensure that the solution from the model is consistent with official statistics on sector-level trade and within-industry transactions.

The initial values for the variables are derived from the I/O industry level information. In particular, those for intermediate imports are generated by allocating m_i^d and m_i^p in proportion to input i 's usage in sector j :

$$z0_{ij}^{mp} = \frac{z_{ij}}{\sum_j^K z_{ij}} m_i^p \quad z0_{ij}^{md} = \frac{z_{ij}}{\sum_j^K z_{ij}} m_i^d \quad (35)$$

The initial values for domestically produced intermediates are generated in 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:

$$z_{ij}^d = z_{ij} - (z_{ij}^{md} + z_{ij}^{mp}) = z_{ij}^{dd} + z_{ij}^{dp} \quad (36)$$

Second, we assume a proportional usage:

$$z0_{ij}^{dd} = z_{ij}^d \frac{(x_j - e_j^p)}{x_j} \quad (37)$$

$$z0_{ij}^{dp} = z_{ij}^d \frac{e_j^p}{x_j} \quad (38)$$

The initial values for direct value added in the production for processing exports in sector j ($v0_j^p$), are generally set to be the residuals implied by Equation (28). However, we set a minimum value at the sum of labor compensation and depreciation in a sector multiplied by the share of processing exports in that sector's total output. In other words, the initial value $v0_j^p$ is set to equal the greater of the residuals from Equation (28) or the minimum value. The initial value for direct value added in the production for domestic sales and normal exports ($v0_j^d$) is set as the difference between v_j (from the I/O table) and $v0_j^p$. 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. In the application to Chinese data, we also conduct some sensitivity checks to using alternative initial values. It turns out that these alternative initial values do not materially alter our basic conclusions. We implement this quadratic programming model in GAMS(Brooke *et al*, 2005), related computer programs and data files will be available at The USITC website for downloading.

3. Estimation Results

After describing the data sources, we report and discuss the estimation results for shares of domestic and foreign content in Chinese exports at the aggregate level, and by sector and by firm ownership.

3.1 Data

Inter-industry transaction and (direct) value-added data are from China's 1997 and 2002 benchmark I/O tables published by the National Bureau of Statistics of China (NBS). We use detailed exports and imports data from 1997, 2002, and 2006 from the General Customs Administration of China to help differentiate the processing and normal trade in each sector. The trade statistics are first aggregated from the 8-digit HS level to China's I/O industry level, and then used to compute the share of processing exports in each I/O industry. Modifying a method from Dean, Fung and Wang (2007), we partition all imports in a given industry into three parts based on the distinction between processing and normal imports in the trade statistics, and on the UN BEC classification scheme: (a) intermediate inputs in producing processing exports; (b) intermediate inputs for normal exports and other domestic final sales; and (c) those used in gross capital formation and final consumption. A summary of these trade statistics as a percentage of China's total imports during 1996-2006 is reported in Table 2, which shows a downward trend for the use of imported inputs in producing processing exports, but a moderately upward trend in their use in producing normal trade and domestic final sales. Detailed trade statistics as a percentage of China's total imports for each I/O industry in both 1997 and 2002 is listed in Appendix tables A-C.

Table 2: Final Use of Chinese Imports (in percent of total imports), 1997-2006

Year	Share of Intermediates		Share of Capital goods		Share of final Consumption
	for processing exports	for normal use	for processing exports	for normal use	
1996	46.2	26.8	8.1	16.7	2.2
1997	51.2	28.2	12.1	7.3	1.2
1998	50.8	28.2	10.0	9.8	1.3
1999	43.7	34.9	11.2	8.3	1.9
2000	39.4	41.2	9.1	8.5	1.7
2001	36.6	41.2	11.6	8.7	1.8
2002	38.3	38.5	10.3	11.1	1.8
2003	35.4	41.2	11.0	10.8	1.6
2004	35.1	42.3	9.1	12.0	1.5
2005	36.6	42.9	8.2	10.8	1.5
2006	35.7	43.5	10.0	9.1	1.7

Source: Authors' calculations based on the United Nation Broad Economic Categories (UNBEC) classification scheme, and Chinese trade statistics on normal and processing imports.

Note: "Normal use" refers to "normal exports and domestic sales." The UNBEC scheme classifies each HS 6-digit product into one of three categories: "intermediate inputs," "capital goods," and "final consumption." For the first two categories, we further decompose the imports into two subcategories: "processing imports" by customs declaration are classified as for processing exports, and the remaining imports are classified as for normal use. Capital goods are part of the final demand in a conventional I/O model. However, this classification may under-estimate the import content of exports. We therefore also experiment with classifying a fraction of the capital goods as inputs used in current year of production. This is discussed in Section 3.2.

3.2 Domestic and foreign contents in total exports

Table 3 shows decomposition results for foreign and domestic value-added shares in 1997 and 2002. Preliminary estimates for 2006 are also included⁴. For comparison, the results from the HIY method that ignore processing trade are also reported. The aggregate domestic value added share in China's merchandise exports was 52.3% in 1997, and 50.7% in 2006. For manufacturing products, these shares are slightly lower in levels but trending upward moderately at 47.6% in 1997 and 49.4% in 2006, respectively, indicating that China uses more imported intermediate inputs to produce manufacturing

⁴ We consider the estimates preliminary because the calculation relies on the trade statistics from 2006 but the I/O table from 2002. The 2002 I/O table is the most recent benchmark table currently available. The next benchmark table - the 2007 table - is scheduled to be released in 2010. Therefore, 2006 estimates are not directly comparable to 1997 and 2002 estimates.

goods than other exports. In general, the direct domestic value-added shares are less than half of the total domestic value-added shares. However, the indirect foreign value-added share was relatively small; most of the foreign content comes from directly imported foreign inputs.

Table 3 Shares of domestic and foreign value added in total exports (%)

	The HIY Method			The KWW Method		
	1997	2002	2006*	1997	2002	2006*
All Merchandise						
Total Foreign value-added	17.6	25.1	26.3	47.7	46.1	49.3
<i>Direct foreign value-added</i>	8.9	14.7	15.7	46.1	42.4	45.7
Total Domestic Value-added	82.4	74.9	73.7	52.3	53.9	50.7
<i>Direct domestic value-added</i>	29.4	26.0	25.3	23.7	20.1	19.2
Manufacturing Goods Only						
Total Foreign value-added	19.0	26.4	27.1	52.4	48.7	50.6
<i>Direct foreign value-added</i>	9.7	15.6	16.3	50.9	45.0	47.0
Total Domestic Value-added	81.1	73.6	72.9	47.6	51.3	49.4
<i>Direct domestic value-added</i>	27.5	24.6	24.6	21.2	18.5	18.4

Source: Authors' estimates.

Note: The HIY method refers to estimates from using the approach in Hummels, Ishii, and Yi (2001). The KWW method refers to estimates from using the approach developed in this paper that takes into account special features of processing exports. The estimates for 2006 are preliminary as they use the trade statistics in 2006 but the I/O table in 2002, which is the latest available. The next one (the 2007 benchmark table) is scheduled to be released in 2010.

Relative to the numbers from the HIY's method, our procedure produces a much higher share of foreign value added in Chinese gross exports (approximately double) and shows a different trend over time. To be more precise, estimates from the HIY method show that the foreign content share (total VS share) increased steadily from 17.6% in 1997 to 26.3% in 2006 for all merchandise exports, and from 19.0% to 27.1% for manufacturing only during the same period. In contrast, our estimates reveal no clear trend for foreign content (with the share of foreign value added in all merchandise exports falling from 47.7% in 1997 to 46.2% in 2002, and bouncing back to 49.3% in 2006, and a similar fluctuation for the share in manufacturing exports, it fell from 52.4% in 1997 to 48.7% in 2002 but bounced back to 50.6 in 2006 , Overall, the HIY method appears to incorrectly estimate both the level and the trend in domestic versus foreign content in Chinese exports.

What accounts for the difference between ours and HIY approaches? There are at least three factors drive the change of foreign content of the country's total exports: (1) the relative proportions of its total imports used as intermediate inputs in producing processing exports and domestic sales & normal exports; (2) the share of processing exports in its total exports; and (3) the sector composition of its exports. Because 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 for foreign content in China's exports. This explains the level of domestic content by our measure is much lower than that of the HIY indicator. On the other hand, as exporting firms (both those producing for normal exports and those for processing exports) gradually increase their intermediate inputs sourcing from firms within China or multinationals move their upstream production to be near their downstream production, the extent of domestic content in exports rose over time. However, because exports from industries with relatively lower domestic content often grow faster due to dramatic inflow of foreign direct investment, the composition of a countries total exports may play as an offsetting factor to reduce the share of domestic value-added in the country's total exports, as the case of China after its WTO entry. As Chinese government start to reduce the policy incentives for both FIE and processing exports at the end of 2006, we may see a trend of increasing domestic contents in Chinese exports again in the years to come.

Our interpretation is confirmed by a separate calculation of DVA shares for processing and normal exports (Table 4). There is a roughly six percentage point increase in the total foreign value-added share for domestic sales and normal exports between 1997 and 2006, which is consistent with the trend indicated by HIY measure. 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 seven percentage points, but it bounded back to the 1997 level in 2006 because the share of wholly foreign owned enterprises (whose exports has the lowest DVA share) in Chinese exports dramatically increased from 29.4% to 39.3%, (table 6) from 2002 to 2006.

Table 4: Domestic and Foreign Values Added: Processing vs. Normal Exports
(in percent of total exports)

	Normal Exports			Processing Exports		
	1997	2002	2006*	1997	2002	2006*
All Merchandise						
Total Foreign value-added	5.3	10.8	11.3	81.9	74.3	81.9
<i>Direct foreign value-added</i>	1.9	4.5	4.6	81.7	72.5	80.9
Total Domestic Value-added	94.7	89.2	88.7	18.1	25.7	18.1
<i>Direct domestic value-added</i>	34.4	31.0	29.3	15.0	11.4	10.5
Manufacturing Goods Only						
Total Foreign value-added	5.7	11.6	11.7	82.3	74.9	82.3
<i>Direct foreign value-added</i>	2.1	4.9	4.8	82.2	73.0	81.4
Total Domestic Value-added	94.3	88.4	88.3	17.7	25.1	17.7
<i>Direct domestic value-added</i>	30.9	28.5	28.3	15.0	9.5	10.4

Source: Authors' estimates.

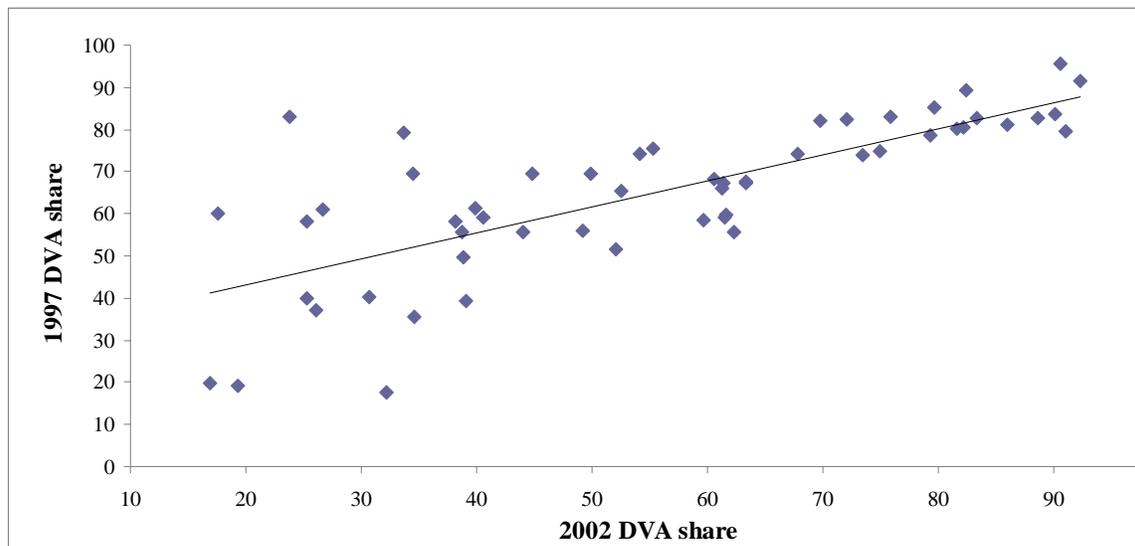
Note: The estimates for 2006 are preliminary as they use the trade statistics in 2006 but the I/O table in 2002, which is the latest available. The next benchmark I/O table - the 2007 table - is scheduled to be released in 2010.

We perform a number of robustness checks on the sensitivity of our main results to alternative ways of setting the initial values of the variables. First, we initialize $v0_j^p$ and $v0_j^d$ by apportioning the observed direct value added in a sector to processing exports and other final demands based on their respective portions in the sector's total output. Second, we initialize $v0_j^p$ either at the residuals implied by equation (28) if the residuals are positive, or by following the previous alternative if the residuals are non-positive. Third, when we partition imports into intermediate inputs used for own-sector's processing exports, and those for other purposes, we use the average of a three-year period (previous, current, and following years) rather than just one year's number. Fourth, we experiment with 0% versus 10% annual depreciation rate for capital goods. These variations produce relatively little change in the main results. For example, the estimated share of domestic value added in manufacturing exports lies in a relatively narrow range between 47.6% and 49.0% in 1997, and between 49.5% and 50.8% in 2006.

3.3 Domestic content by sector

To see if there are interesting patterns at the sector level, Table 5 reports, in ascending order, the estimated share of domestic value added in manufacturing exports in 2002 together with each sector's share in the country's total manufacturing exports. We choose to report the results from 2002 because they use the latest I/O table released. Similar results for 1997 and 2006 are omitted to save space. Note, however, that the pairwise correlation between the 1997 and 2002 estimates at the sector-level is very high (Figure 2).

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



$$\text{TDV97} = 0.86\text{TDV02} \quad \text{Adj. } R^2=0.94 \quad \text{Obs.} = 54$$

t-statistics: (29.2)

Among the 61 manufacturing industries in the table, 13 have a share of domestic value-added less than 50 percent, and collectively account for nearly 44 percent of China's manufacturing exports in 2002. Many low-DVA industries are likely to be labeled as relatively sophisticated, such as computers and accessories, telecommunications equipment, measuring instruments and electronic devices. A common feature of these industries is that processing exports account for over two-thirds of their exports and foreign invested enterprises played an overwhelming role. This

suggests that the appearance of a sophisticated export structure in China is largely a statistical mirage.

Table 5 Domestic Value-added Share in Manufacturing Exports by Sector, 2002

Industries	Processing exports in percent of industry exports	FIE exports in percent of industry exports	Non-processing		Processing		Weighted sum		Share in China's total exports to the World
			Direct domestic value-added	Total Domestic Value-added	Direct domestic value-added	Total Domestic Value-added	Direct domestic value-added	Total Domestic Value-added	
Electronic computer	99.1	99.4	14.5	80.6	3.9	3.9	4.0	4.6	1.3
Telecommunication equipment	91.2	88.4	28.1	82.8	5.4	8.4	7.4	14.9	3.4
Cultural and office equipment	93.4	71.6	6.1	70.7	12.8	15.5	12.4	19.1	4.6
Other computer peripheral equipment	99.2	87.6	40.7	81.0	8.4	19.1	8.7	19.7	6.2
Electronic element and device	89.7	87.5	31.7	86.9	12.7	14.8	14.7	22.2	3.6
Radio, television and communication equipment and apparatus	90.6	62.3	35.5	77.9	8.2	31.2	10.8	35.5	5.6
Household electric appliances	79.1	56.9	27.5	88.0	7.1	23.7	11.4	37.2	2.1
Plastic products	64.5	51.2	26.2	82.8	10.3	12.5	16.0	37.4	2.6
Generators	76.8	55.8	26.1	87.1	11.1	25.2	14.6	39.6	1.0
Instruments, meters and other measuring equipment	68.6	51.8	40.8	89.2	14.2	20.7	22.5	42.2	2.0
Printing, reproduction of recording media	83.0	62.7	42.5	90.7	19.9	33.3	23.8	43.1	0.3
Other electric machinery and equipment	66.8	60.1	28.4	88.3	10.6	25.2	16.5	46.1	6.1
Leather, fur, down and related products	54.3	50.3	24.1	92.3	8.8	12.0	15.8	48.7	4.9
Man-made chemical products	58.3	65.4	21.9	79.0	10.1	30.2	15.0	50.5	0.3
Toys, sporting and athletic and recreation products	72.9	57.3	43.5	89.0	19.4	39.7	25.9	53.0	3.3
Arts and crafts products	53.8	36.9	29.8	90.5	13.5	22.8	21.0	54.1	1.3
Special chemical products	46.9	48.4	24.2	81.9	12.3	24.1	18.6	54.8	0.9
Petroleum and nuclear processing	32.1	24.9	15.4	78.2	5.6	8.2	12.2	55.7	0.9
Ship building	95.8	21.0	26.1	84.7	15.8	55.5	16.3	56.8	0.7
Metal products	43.2	45.6	24.8	88.8	10.3	16.7	18.5	57.7	4.8
Other general industrial machinery	43.7	43.7	28.4	89.7	13.4	18.0	21.9	58.4	3.7
Paper and paper products	50.7	57.0	29.8	88.9	12.7	29.7	21.2	58.9	0.6
Nonferrous metal smelting	45.0	17.4	22.4	87.6	10.8	26.1	17.2	59.9	0.9
Other transport equipment	41.2	50.5	26.0	84.4	12.9	26.1	20.6	60.4	1.3
Rubber products	53.1	44.4	29.9	90.2	12.4	35.4	20.6	61.1	1.7
Other manufacturing products	48.8	39.1	30.1	90.7	12.8	30.2	21.7	61.2	0.6
Other special industrial equipment	39.9	44.0	27.9	89.1	12.9	21.7	21.9	62.1	1.4
Steel-smelting	58.8	86.1	25.6	89.8	13.2	43.8	18.3	62.7	0.0
Nonferrous metal pressing	46.9	48.7	17.2	84.6	7.8	43.9	12.8	65.5	0.4

Wearing apparel	45.1	39.2	30.6	91.2	11.9	37.6	22.1	67.0	7.5
Motor vehicles	37.8	28.4	26.4	88.2	8.8	33.8	19.8	67.6	0.2
Parts and accessories for motor vehicles and their engines	34.3	54.9	27.2	88.5	10.9	28.7	21.6	68.0	0.7
Chemical products for daily use	36.3	43.6	32.7	86.5	9.6	36.3	24.4	68.3	0.4
Other electronic and communication equipment	84.9	84.9	11.8	54.1	28.9	71.2	26.3	68.6	2.0
Cotton textiles	28.7	28.8	24.4	90.5	10.9	14.7	20.5	68.8	3.5
Chemical fibers	20.5	29.2	21.6	81.2	9.4	24.6	19.1	69.6	0.0
paints, varnishes and similar coatings, printing ink and mastics	29.1	44.4	23.1	83.7	8.8	36.5	18.9	70.0	0.5
Stationary and related products	39.4	42.6	28.2	86.9	12.3	44.7	21.9	70.3	0.2
Woolen textiles	37.7	42.6	24.1	91.9	9.3	35.3	18.6	70.5	0.4
Glass and glass products	33.0	48.8	35.9	87.6	16.8	37.7	29.6	71.1	0.6
Knitted and crocheted fabrics and articles	31.6	34.1	32.1	90.8	14.0	34.5	26.4	73.0	6.3
Alloy iron smelting	40.8	13.1	28.0	87.0	14.1	58.7	22.3	75.5	0.3
Chemical pesticides	6.2	14.4	25.8	78.2	11.8	34.3	24.9	75.5	0.2
Textiles productions	24.0	31.8	27.3	90.3	14.1	30.0	24.1	75.8	1.6
Boiler, engines and turbine	26.6	28.4	30.4	86.3	13.6	46.9	26.0	75.8	0.4
Railroad transport equipment	19.9	5.9	28.5	86.7	14.9	33.1	25.8	76.0	0.1
Furniture	47.2	56.8	28.7	88.5	12.9	62.3	21.2	76.1	1.8
Products of wood, bamboo, cane, palm, straw	19.6	45.6	28.1	87.8	11.6	30.4	24.9	76.5	1.1
Iron-smelting	23.7	3.0	23.2	88.1	11.6	53.9	20.5	79.9	0.1
Basic chemicals	11.7	18.8	29.3	86.8	12.9	29.5	27.3	80.1	2.1
Medical and pharmaceutical products	16.9	28.7	39.0	91.1	11.5	33.8	34.3	81.4	0.8
Agriculture, forestry, animal husbandry and fishing machinery	17.8	20.8	28.9	88.0	14.4	52.9	26.3	81.8	0.1
Hemp textiles	19.5	19.5	23.7	90.8	12.5	49.1	21.5	82.7	0.3
Pottery, china and earthenware	11.4	33.1	32.8	89.5	15.1	35.8	30.7	83.4	0.7
Metalworking machinery	13.3	27.0	32.3	88.7	16.8	49.4	30.2	83.4	0.2
Steel pressing	16.0	16.8	26.6	90.0	12.5	48.7	24.3	83.4	0.4
Chemical fertilizers	4.5	21.7	23.5	86.6	9.9	27.7	22.9	84.0	0.1
Fireproof materials	19.1	49.8	41.5	92.2	15.9	52.9	36.6	84.7	0.1
Other non-metallic mineral products	14.0	35.7	34.1	91.7	17.2	53.4	31.7	86.4	0.4
Cement, lime and plaster	7.0	77.7	27.9	91.2	20.3	22.9	27.4	86.4	0.1
Coking	2.6	5.3	34.3	92.7	13.9	52.2	33.8	91.6	0.3
Total manufacturing Goods except food	55.7	52.0	31.0	89.2	11.4	25.7	20.1	53.9	100.0

Source: Authors' estimates

The next 15 industries have their share of domestic value-added in the range of 51 to 65 percent; they collectively accounted for 22 percent of China's total manufacturing

exports in 2002. Several labor-intensive sectors are in this group, such toys and sports products, and arts and crafts products.

The remaining 33 industries have relatively high shares of domestic value-added. However, they as a group produced only about one third of China's manufacturing exports in 2002. Apparel, the country's largest labor intensive exporting industry, which by itself was responsible for 7.5 percent of the country's total manufacturing exports in 2002, is at the top of this group with a share of domestic content at 67 percent. The 20 industries at the bottom of Table 5 collectively produced only about 11 percent of China's manufacture exports in 2002.

3.4 Domestic content in exports by firm ownership

Since foreign-invested firms account for over half of China's exports, it may be interesting to compare the share of domestic content in exports between them and other Chinese firms. Because we lack information on separate input-output coefficients by firm ownership, our estimation assume that they are the same on this dimension. The variation in the share of domestic content comes from different degrees of reliance on processing exports with a sector, and differences in the sector composition of their exports.

Estimates of the domestic content shares by firm ownership are presented in Table 6. The results show that exports by wholly foreign owned enterprises exhibit the lowest share of domestic valued-added (at 33% in 2002 but declined to 28% in 2006), followed by Sino-foreign joint venture companies (about 45% in both 2002 and 2006). Exports from Chinese private enterprises embodied the highest domestic content shares (84% and 82% in 2002 and 2006, respectively), while those from the state-owned firms were in the middle (about 70% in both years). Note that these estimates represent the best guesses based on currently available information; better estimates can be derived once information on I/O coefficients by firm ownership becomes available.

Table 6: Shares of Domestic Value Added in Exports by Firm Ownership (%)

	Share of Total Domestic Value-added	Share of Direct Domestic Value-added	Share of processing exports in total exports	Share of exports by firm ownership in China's total exports
2002				
Wholly Foreign Owned	32.6	14.2	87.9	29.4
Joint Venture Firms	44.1	16.4	71.0	22.6
State Owned Firms	69.7	25.2	31.8	37.9
Collectively Owned Firms	72.3	24.5	28.1	5.8
Private Firms	83.7	28.3	8.7	4.3
All Firms	53.8	20.1	55.9	100.0
2006*				
Wholly Foreign Owned	27.8	13.3	85.3	39.3
Joint Venture Firms	44.8	17.5	63.1	18.6
State Owned Firms	70.0	24.6	27.1	19.8
Collectively Owned Firms	70.9	24.2	24.7	4.3
Private Firms	82.0	27.4	10.3	18.0
All Firms	50.9	19.3	53.6	100.0

Source: Authors' estimates.

Note: The estimates for 2006 are preliminary as they use 2006 trade statistics but the 2002 I/O table, which is the latest available. The next benchmark I/O table (the 2007 table) is scheduled to be released in 2010.

3.5 DVA shares in Chinese exports by trading partners

By assuming 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 domestic value-added share 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 7 in increasing order of the estimated domestic value-added share. Note, however, the variation by destination in this method is caused solely by China's export structure to each of its trading partners (exports to each individual country/region vary by sector and trade regime structures), not 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-exports to the United States, the U.S. accounted for more than one third of China's

exports 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 RMB gradually appreciation since July 2005. China's exports to the U.S. have started to slow down since late 2007, likely because of other economic factors and policy measures adopted by the Chinese government during last year.⁵

Table 7 Domestic Value-added Share in Chinese Gross Merchandise Exports to its Major Trading Partners, in percent, 2002

Region description	Share of processing exports in total exports to destination	<i>Non processing</i>		<i>Processing</i>		<i>Weighted-sum</i>		Share in total exports to the World
		Direct domestic value-added	Total Domestic Value-added	Direct domestic value-added	Total Domestic Value-added	Direct domestic value-added	Total Domestic Value-added	
Hong Kong	74.0	30.5	89.1	11.5	24.4	16.4	41.2	17.5
United States	67.2	29.6	88.8	11.1	24.6	17.1	45.6	21.6
Singapore	62.7	28.3	86.8	11.0	22.2	17.5	46.3	2.1
Taiwan	59.6	33.6	89.0	11.3	23.4	20.3	49.9	2.0
Japan	59.2	33.2	90.6	11.8	29.0	20.5	54.1	15.0
Old EU15	54.8	29.8	89.0	11.5	25.7	19.7	54.3	14.9
Canada	48.0	30.1	89.5	11.1	26.8	21.0	59.4	1.3
Korea Rep	45.4	35.1	90.2	12.2	27.6	24.7	61.8	4.8
Australia & New Zealand	41.6	30.2	89.1	11.0	26.2	22.2	62.9	1.6
Mexico	42.1	30.5	89.2	12.8	29.9	23.1	64.2	0.9
Rest of Southeast Asia	36.6	32.7	88.1	11.1	24.0	24.8	64.7	5.1
Rest of West Europe	42.9	29.9	89.7	12.7	32.2	22.5	65.0	0.4
New EU10	39.5	29.9	90.0	12.3	31.6	22.9	66.9	1.3
Rest of World	52.7	29.1	88.8	15.0	49.1	21.6	67.9	0.0
Brazil	35.0	32.4	88.2	12.7	30.6	25.5	68.0	0.5
Rest of East Asia	35.5	36.5	90.3	11.9	31.1	27.8	69.3	0.5
India	24.0	33.4	88.9	10.5	22.9	27.9	73.1	0.8
Eastern Europe/Central Asia	20.4	30.0	88.8	11.3	26.3	26.2	76.1	0.6
Rest of Latin Amer/Caribbean	20.3	29.6	88.6	11.4	28.8	25.9	76.5	1.6
Middle East/North Africa	19.4	29.5	88.6	11.4	28.0	26.0	76.9	3.6
Sub-Saharan Africa	15.5	30.0	88.9	11.0	25.9	27.0	79.1	1.4
Rest of South Asia	13.8	29.0	87.7	11.5	26.0	26.6	79.2	0.8
Former Soviet Union	15.2	30.1	90.2	12.8	28.2	27.5	80.7	1.6
World	55.7	31.0	89.2	11.4	25.7	20.1	53.9	100.0

Source: Authors' estimates.

⁵ China has taken a series of policy measures to change its preferences to processing trade and foreign invested enterprises since the end of 2006.

Another interesting feature in Table 7 is that China's exports to developing countries embody much higher domestic value added than its exports to OECD countries, but exports with higher domestic value-added (more than two thirds of the gross value of its exports) constituted of less than 13 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 with less than half DVA on average. These results further confirm that China has become a processing and assembling center in many global supply chains in the recent period.

4. Concluding Remarks

The use of imported inputs in the production for exports reduces domestic content in a nation's exports. By being able to receive tariff exemptions on imported inputs, processing exports are likely to have especially low domestic value added per unit of exports.

In this paper, we first present a general framework in assessing the shares of domestic and foreign value added in a country's exports when tariff-favored processing exports are pervasive. This formula nests the existing best known approach (HIY, 2001) as a special case. Because some of the I/O coefficients called for by the new formula are not readily available from conventional I/O tables, we propose an easy-to-replicate mathematical programming procedure to estimate these coefficients by combining information from detailed trade statistics (which records processing and normal exports/imports separately) with conventional input-output tables. This methodology should be applicable to Vietnam, Mexico, and many other countries that engage in a significant amount of processing exports.

By applying our methodology to Chinese data, we have found several interesting patterns. First, we estimate that the level of foreign content in Chinese exports is close to 50%, almost twice as high as what we calculate by using the HIY formula. Second, we find interesting heterogeneity across sectors: those sectors that are likely to be labeled as sophisticated or high-skilled, such as computers, electronic devices, and telecommunication equipment, tend to have especially low shares of domestic content.

Conversely, many sectors that are relatively intensive in low-skilled labor, such as apparel, are likely to exhibit a high share of domestic content in China's exports. Finally, we find that foreign invested firms (including both wholly-owned foreign firms and Sino-foreign joint venture firms) tend to have a relatively low share of domestic content in their exports.

There are several areas in which future research can improve upon the estimation in this paper. First, we assign initial values of the direct domestic value added for processing exports at the industry level based on the information in a conventional I/O table. If a firm-level survey data becomes available that tracks the direct value added for processing and normal exports separately, we can improve the accuracy of our estimates. Second, as an inherent limitation of an I/O table, the input-output coefficients are assumed to be fixed - that's the nature of a Leontief technology - rather than be allowed to respond to price changes. This could be problematic when a big change in export volume, such as what China has been experiencing, induces a change in the world market price for imported inputs, which in turn could trigger a change in the underlying production technology and in the corresponding I/O coefficients. These could be fruitful areas for future research.

Appendix

Based on the I/O coefficients' additive condition (equation 13), 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 contents.

From equations (18) and (21), for normal trade:

$$DVS^D + VSS^D = A_v^D (I - A^{DD})^{-1} + uA^{MD} (I - A^{DD})^{-1} = (uA^{MD} + A_v^D)(I - A^D)^{-1} \quad (A1)$$

Substituting equation (13), the I/O coefficients additive condition $uA^{MD} + A_v^D = u - uA^{DD}$ into (A1) we have:

$$DVS^D + VSS^D = (u - uA^{DD})(I - A^{DD})^{-1} = u(I - A^{DD})(I - A^{DD})^{-1} = u \quad (A2)$$

similarly, for processing trade:

$$\begin{aligned} DVS^P + VSS^P &= A_v^D (I - A^{DD})^{-1} A^{DP} + A_v^P + uA^{MD} (I - A^{DD})^{-1} A^{DP} + uA^{MP} \\ &= (uA^{MD} + A_v^D)(I - A^{DD})^{-1} A^{DP} + uA^{MP} + A_v^P \\ &= u(I - A^{DD})(I - A^{DD})^{-1} A^{DP} + uA^{MP} + A_v^P = u \end{aligned} \quad (A3)$$

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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 & New Zealand	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
New EU10	35.7	42.3	12.7	6.4	2.9	40.4	0.3
Old 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 America & 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 West 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

IO industry description	Split Method				HIY Method			
	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	2.3	64.8	5.5	94.5	1.9	65.4	6.2	93.8
Forestry	3.1	64.5	5.8	94.2	1.8	65.5	5.4	94.6
Logging and transport of timber and bamboo	3.8	60.7	6.6	93.4	2.8	60.7	7.0	93.0
Animal Husbandry	2.0	45.3	5.2	94.8	1.2	45.7	5.6	94.4
Fishery	1.8	54.8	5.6	94.4	1.6	55.0	6.7	93.3
Technical services for agriculture, forestry, livestock and fishing	18.2	47.8	21.0	79.0	2.3	54.8	7.3	92.7
Mining and Washing of Coal	2.0	56.9	5.7	94.3	3.3	56.9	8.6	91.4
Extraction of Petroleum and Natural Gas	3.7	69.5	6.2	93.8	2.9	71.1	6.6	93.4
Ferrous metal ore mining	6.2	46.3	10.6	89.4	5.6	46.3	11.9	88.1
Non-ferrous metal ore mining	8.4	38.5	14.6	85.4	5.0	39.9	13.8	86.2
Salt mining	3.0	63.6	6.2	93.8	2.6	63.9	7.5	92.5
Non-metal minerals and other mining	20.8	37.9	25.1	74.9	4.7	44.6	12.3	87.7
Grain mill products	43.5	13.4	46.2	53.8	3.0	20.1	8.7	91.3
Forage	19.7	16.4	23.7	76.3	5.9	18.1	12.4	87.6
vegetable oil refining	16.9	17.8	21.4	78.6	4.6	21.7	10.7	89.3
Sugar manufacturing	34.0	13.6	38.7	61.3	3.2	31.2	8.7	91.3
Slaughtering and meat processing	7.0	14.7	11.0	89.0	2.2	16.1	7.9	92.1
Fish and fish productions	13.6	20.4	17.3	82.7	2.4	24.9	8.3	91.7
All other food manufacturing	20.8	23.2	25.3	74.8	5.1	26.8	12.7	87.4
Wines, spirits and liquors	16.6	35.7	20.2	79.8	2.8	40.7	8.6	91.4
Soft drink and other beverage	13.4	28.5	18.9	81.1	4.5	31.7	13.1	86.9
Tobacco products	2.8	72.8	4.3	95.7	0.7	76.3	2.6	97.4
Cotton textiles	26.3	20.5	31.3	68.8	8.5	23.7	18.6	81.4
Woolen textiles	24.9	18.6	29.5	70.5	6.3	23.5	14.9	85.1
Hemp textiles	11.4	21.5	17.3	82.7	5.1	23.6	14.1	85.9
Textiles productions	18.8	24.1	24.2	75.8	10.7	26.0	21.3	78.7
Knitted and crocheted fabrics and articles	21.7	26.4	27.0	73.0	10.3	27.9	21.0	79.0
Wearing apparel	28.4	22.1	33.0	67.0	10.5	27.1	20.9	79.2
Leather, fur, down and related products	48.7	15.8	51.3	48.7	13.5	20.5	23.5	76.5
Products of wood, bamboo, cane, palm, straw	17.6	24.9	23.5	76.5	8.2	27.8	17.3	82.7
Furniture	17.5	21.2	23.9	76.1	7.8	26.4	18.1	81.9
Paper and paper products	37.2	21.2	41.1	58.9	7.2	29.5	15.5	84.5
Printing, reproduction of recording media	54.6	23.8	56.9	43.1	5.6	42.0	13.9	86.1
Stationary and related products	23.5	21.9	29.7	70.3	8.4	26.9	19.6	80.4
Toys, sporting and athletic and recreation products	43.4	25.9	47.0	53.0	10.9	31.8	21.4	78.6
Petroleum and nuclear processing	41.2	12.2	44.3	55.7	18.7	15.3	24.9	75.1
Coking	4.1	33.8	8.4	91.6	2.9	34.3	9.4	90.6
Basic chemicals	14.6	27.3	19.9	80.1	9.2	28.9	17.2	82.8
Chemical fertilizers	8.8	22.9	16.0	84.0	7.8	23.5	18.6	81.5
Chemical pesticides	16.9	24.9	24.5	75.5	12.7	25.7	23.3	76.7
paints, varnishes and similar coatings, printing ink and mastics	22.7	18.9	30.0	70.0	10.5	22.8	22.1	77.9
Man-made chemical products	43.6	15.0	49.5	50.5	13.5	21.6	25.9	74.1
Special chemical products	40.4	18.6	45.2	54.8	13.3	23.6	23.9	76.1
Chemical products for daily use	25.9	24.4	31.7	68.3	8.0	31.9	18.3	81.7
Medical and pharmaceutical products	13.9	34.3	18.6	81.4	5.3	38.7	12.5	87.5
Chemical fibers	22.0	19.1	30.4	69.6	13.8	21.6	26.4	73.6
Rubber products	35.2	20.6	38.9	61.1	7.3	27.7	15.6	84.4
Plastic products	58.9	16.0	62.6	37.4	14.6	25.1	27.9	72.1
Cement, lime and plaster	7.9	27.4	13.6	86.4	4.8	27.9	13.6	86.4

IO industry description	Split Method				HIY Method			
	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	23.9	29.6	28.9	71.1	8.4	35.2	16.8	83.2
Pottery, china and earthenware	10.7	30.7	16.6	83.4	5.9	32.2	14.9	85.2
Fireproof materials	10.5	36.6	15.3	84.7	3.8	41.4	10.9	89.1
Other non-metallic mineral products	8.3	31.7	13.7	86.4	4.0	33.9	12.0	88.0
Iron-smelting	14.8	20.5	20.1	79.9	7.0	23.2	14.2	85.8
Steel-smelting	32.7	18.3	37.3	62.7	5.2	25.6	13.0	87.0
Steel pressing	10.3	24.3	16.6	83.4	5.0	26.5	13.8	86.2
Alloy iron smelting	18.9	22.3	24.6	75.5	7.1	27.3	15.4	84.6
Nonferrous metal smelting	35.8	17.2	40.1	59.9	7.4	22.0	15.9	84.1
Nonferrous metal pressing	27.7	12.8	34.5	65.5	9.2	16.9	20.4	79.7
Metal products	37.9	18.5	42.4	57.7	7.0	23.7	17.1	82.9
Boiler, engines and turbine	18.3	26.0	24.2	75.8	9.6	30.1	19.2	80.8
Metalworking machinery	10.5	30.2	16.6	83.4	8.1	32.2	17.7	82.3
Other general industrial machinery	37.4	21.9	41.6	58.4	7.5	27.5	18.0	82.0
Agriculture, forestry, animal husbandry and fishing machinery	11.6	26.3	18.3	81.8	6.7	28.8	16.9	83.1
Other special industrial equipment	33.3	21.9	37.9	62.1	9.3	27.4	19.2	80.8
Railroad transport equipment	18.1	25.8	24.0	76.0	7.4	28.4	17.5	82.5
Motor vehicles	26.6	19.8	32.4	67.6	6.1	26.4	17.2	82.8
Parts and accessories for motor vehicles and their engines	26.4	21.6	32.0	68.0	6.6	26.9	17.4	82.6
Ship building	38.4	16.3	43.3	56.8	12.7	23.8	23.1	77.0
Other transport equipment	34.4	20.6	39.6	60.4	10.9	25.0	22.3	77.7
Generators	57.5	14.6	60.4	39.6	10.5	23.5	21.4	78.6
Household electric appliances	59.4	11.4	62.8	37.2	10.5	23.9	23.0	77.0
Other electric machinery and equipment	49.5	16.5	53.9	46.1	9.9	24.4	21.8	78.2
Telecommunication equipment	84.0	7.4	85.1	14.9	24.2	23.5	37.9	62.1
Electronic computer	95.3	4.0	95.4	4.6	35.2	13.2	51.5	48.5
Other computer peripheral equipment	78.9	8.7	80.4	19.7	35.0	20.8	46.2	53.8
Electronic element and device	76.8	14.7	77.8	22.2	23.4	26.1	33.3	66.7
Radio, television and communication equipment and apparatus	61.1	10.8	64.5	35.5	34.6	19.4	45.6	54.4
Other electronic and communication equipment	25.5	26.3	31.4	68.6	31.7	26.0	40.2	59.8
Instruments, meters and other measuring equipment	55.6	22.5	57.8	42.2	14.6	32.1	24.3	75.7
Cultural and office equipment	80.0	12.4	80.9	19.1	40.0	10.6	56.8	43.2
Arts and crafts products	42.4	21.0	46.0	54.1	7.0	27.8	16.5	83.5
Other manufacturing products	34.7	21.7	38.8	61.2	6.9	28.6	16.3	83.8
Total Merchandise	42.4	20.1	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

IO industry description	Split Method				HIY Method			
	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	3.5	64.5	5.3	94.7	2.5	65.0	6.0	94.0
Forestry	2.4	72.7	3.6	96.4	1.4	73.3	3.7	96.3
Livestock and livestock products	4.0	49.2	6.1	93.9	2.7	49.6	6.3	93.7
Fishery	6.5	58.9	8.5	91.6	2.2	60.6	6.0	94.0
Other agricultural products	7.8	54.9	9.4	90.6	1.8	57.2	5.3	94.7
Coal mining and processing	1.4	51.4	4.0	96.0	3.7	51.4	9.2	90.8
Crude petroleum products	1.0	75.2	2.5	97.5	2.5	75.2	5.4	94.6
Natural gas products	2.6	54.2	5.5	94.6	4.5	54.2	10.2	89.8
Ferrous ore mining	3.3	33.7	7.1	92.9	8.4	33.7	16.0	84.0
Non-ferrous ore mining	7.7	34.9	10.7	89.3	4.4	36.1	11.5	88.5
Salt mining	1.3	59.7	3.5	96.5	2.1	60.0	7.3	92.7
Non-metal minerals and other mining	18.8	36.3	21.4	78.6	4.9	40.1	11.9	88.1
Logging and transport of timber and bamboo	5.4	60.1	7.0	93.0	2.4	62.1	5.9	94.1
Grain mill products, vegetable oil and forage	49.0	12.7	50.6	49.4	3.7	18.7	9.1	90.9
Sugar refining	78.6	12.2	79.0	21.0	3.3	18.7	9.1	90.9
Slaughtering , meat processing, eggs and dairy products	10.6	14.4	13.6	86.4	1.8	15.3	7.6	92.4
Prepared fish and seafood	17.1	22.3	19.4	80.6	1.1	25.1	6.0	94.0
Other food products	24.1	26.9	26.4	73.6	3.8	31.3	9.7	90.3
Wines, spirits and liquors	17.5	29.0	20.0	80.0	3.1	32.9	9.0	91.0
Non-alcoholic beverage	15.5	27.0	18.4	81.6	3.7	29.7	10.5	89.5
Tobacco products	7.9	52.1	9.6	90.4	2.0	55.8	5.8	94.2
Cotton textiles	34.4	24.0	36.5	63.5	8.5	28.3	18.2	81.8
Woolen textiles	56.6	20.0	57.6	42.5	5.8	33.5	12.3	87.7
Hemp textiles	26.1	25.3	28.3	71.7	6.3	27.9	12.5	87.6
Silk textiles	5.6	24.1	8.6	91.4	2.6	24.9	10.8	89.2
Knitted mills	23.9	26.5	26.2	73.8	9.0	28.1	18.5	81.5
Other textiles	51.5	17.6	52.9	47.1	5.7	25.9	11.6	88.4
Wearing apparel	39.0	30.3	40.4	59.6	6.8	36.1	15.3	84.7
Leather, furs, down and related products	61.9	17.5	62.8	37.3	11.6	22.6	20.6	79.4
Sawmills and fibreboard	20.7	27.4	23.2	76.8	6.4	30.5	13.3	86.7
Furniture and products of wood, bamboo, cane, palm, straw, etc.	37.6	21.6	39.7	60.3	7.3	26.3	16.4	83.6
Paper and products	51.5	22.3	52.8	47.2	5.3	29.4	12.4	87.7
Printing and record medium reproduction	66.1	21.1	66.8	33.2	6.3	37.4	13.6	86.4
Cultural goods	50.7	27.4	51.9	48.1	6.4	41.1	13.7	86.3
Toys, sporting and athletic and recreation products	60.4	24.7	61.2	38.8	10.2	27.9	20.0	80.0
Petroleum refining	50.4	14.4	51.8	48.2	15.2	22.0	20.3	79.7
Coking	4.4	22.7	7.6	92.4	2.5	23.0	9.7	90.3
Raw chemical materials	5.8	31.9	9.0	91.0	3.1	32.9	10.1	89.9
Chemical fertilizers	5.6	22.1	9.7	90.3	5.2	22.4	14.7	85.3
Chemical pesticides	20.6	20.5	24.4	75.6	4.9	23.0	14.6	85.4
Organic chemical products	19.9	20.5	24.4	75.6	8.6	22.2	18.3	81.8
Chemical products for daily use	36.0	27.7	38.3	61.7	4.5	37.8	12.3	87.7
Other chemical products	35.0	21.3	37.5	62.5	8.1	25.7	15.8	84.2
Medical and pharmaceutical products	15.8	32.9	18.4	81.6	3.0	36.9	9.5	90.5
Chemical fibers	63.3	15.0	64.9	35.1	14.8	23.3	25.2	74.8
Rubber products	60.7	17.4	61.7	38.3	8.6	25.0	17.1	82.9
Plastic products	65.6	16.0	67.0	33.1	12.9	24.3	23.6	76.4
Cement	5.1	23.6	8.9	91.1	3.9	24.0	12.7	87.3
Cement and asbestos products	47.4	19.0	49.2	50.8	2.4	26.8	11.1	88.9

IO industry description	Split Method				HIY Method			
	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
Bricks, tiles, lime and light-weight building materials	9.3	37.4	12.2	87.8	3.6	39.6	10.3	89.7
Glass and glass products	35.6	25.2	37.8	62.2	4.5	30.7	12.4	87.6
Pottery, china and earthenware	13.0	35.5	16.0	84.0	3.3	37.8	10.6	89.4
Fireproof products	7.6	27.4	11.0	89.0	3.6	28.5	11.6	88.4
Other non-metallic mineral products	17.0	27.9	19.8	80.3	3.0	30.9	10.6	89.4
Iron-smelting	36.4	17.3	38.4	61.6	5.7	22.3	12.9	87.1
Steel-smelting	66.9	16.8	67.7	32.3	3.9	23.7	11.6	88.4
Steel processing	73.4	13.6	74.2	25.8	5.9	21.0	15.1	84.9
Alloy iron smelting	41.5	18.1	43.6	56.4	5.5	21.4	14.2	85.8
Nonferrous metal smelting	35.0	16.4	37.2	62.8	4.6	19.5	12.5	87.6
Nonferrous metal processing	40.4	12.2	42.9	57.1	7.2	15.4	16.7	83.3
Metal products	38.2	19.5	40.8	59.2	5.9	23.3	15.4	84.6
Boiler, engines and turbine	28.8	28.9	31.4	68.6	7.4	34.6	15.5	84.5
Metalworking machinery	20.1	28.7	23.1	76.9	5.8	31.9	14.5	85.5
Other general industrial machinery	37.2	29.0	39.2	60.8	5.3	37.7	13.3	86.8
Agriculture, forestry, animal husbandry and fishing machinery	9.4	21.0	13.8	86.2	6.5	21.8	17.2	82.8
Other special industrial equipment	36.1	25.9	38.4	61.6	7.6	32.5	16.3	83.7
Railroad transport equipment	39.8	22.5	42.1	57.9	5.5	26.3	15.2	84.8
Motor vehicles	35.7	20.0	38.6	61.4	5.2	25.7	15.3	84.7
Ship building	70.9	22.6	71.4	28.7	8.1	28.7	17.6	82.4
Aircraft	29.2	38.8	31.3	68.7	23.5	42.4	28.0	72.0
Bicycle	72.1	12.8	73.1	26.9	6.5	18.8	18.0	82.0
Other transport machinery	38.2	20.4	40.9	59.1	6.2	27.4	16.3	83.7
Generators	74.1	15.9	74.7	25.3	7.9	26.2	17.8	82.2
Household electric appliances	72.6	14.2	73.5	26.6	8.7	26.3	19.7	80.3
Other electric machinery and equipment	68.3	13.9	69.5	30.5	9.0	19.7	20.0	80.0
Electronic computer	86.3	12.2	86.4	13.6	24.5	23.4	36.7	63.3
Electronic appliances	84.7	10.9	85.0	15.0	21.5	19.8	33.5	66.5
Electronic element and device	73.9	17.1	74.4	25.6	14.6	29.7	23.6	76.4
Other electronic and communication equipment	80.0	15.4	80.4	19.6	18.3	27.3	30.0	70.0
Instruments, meters and other measuring equipment	62.3	25.8	63.0	37.0	10.6	36.3	19.1	80.9
Cultural and office equipment	82.6	16.3	82.7	17.3	15.6	19.8	26.9	73.1
Arts and crafts products	48.2	22.1	49.7	50.3	6.1	29.8	14.2	85.9
Other manufacturing products	58.9	22.9	59.9	40.1	5.5	34.3	13.7	86.3
Total Merchandise	46.1	23.7	47.7	52.3	9.0	29.4	17.9	82.1

Source: Authors' estimates.