Domestic Content in China's Exports and its Distribution by Firm Ownership*

Discussion paper

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Abstract

Processing trade and foreign-invested enterprises (FIEs) account for a large share of total Chinese exports. In producing exports, they also use imported inputs disproportionately, which complicates the measurement of domestic content embedded in exports and the distribution of income generated from exports. In this paper, we extend the method developed by Koopman, Wang, and Wei (2012) to further distinguish between Chinese exports by FIEs and Chinese-owned enterprises (COEs), in addition to processing and normal exports. We propose an accounting framework and a detailed estimation procedure that separately account for the production and trade activities of FIEs and COEs. First, we decompose gross exports into domestic and foreign content by firm types. Then, we estimate factor ownership by firm types based on enterprise surveys. Finally, we compute the distribution of domestic content by factor ownership. Empirical estimation is based on China's 2007 benchmark input-output tables, supplemented by detailed trade and production statistics. Firm heterogeneity within each industry is identified by linking the NBS enterprises survey and the Customs' firm-level trade data. The empirical results from 2007 indicate the following: (1) domestic content accounted for around 59% of total exports; (2) FIEs operating in China created nearly 45% of the domestic content in Chinese exports, whereas processing COEs only contributed by less than 5%; (3) in terms of income distribution, about 52.6% of the value of Chinese exports was captured by foreign factor owners.

* The views in the paper are solely the author's own opinion. It is not meant to represent in anyway the views of the U.S. International Trade Commission or any of its individual Commissioners.

I Introduction

Globalization has made production increasingly fragmented across countries, with roughly two-thirds of world trade accounted by trade in intermediate inputs (Johnson and Noguera, 2012). In particular, outsourcing and foreign direct investment (FDI) to developing countries accelerate the "slicing-up" of the global value chain across national borders, thus widening the gap between the value of gross exports and the actual value added that is created in the exporting country. [1] Hence, the policies that focus on aggregate trade flow may be very misleading.

In this paper, we propose a new estimation strategy for the domestic content in China's exports by firm types. We focus on China because of its high export/GDP ratio compared to other large economies, while foreign invested enterprises (FIEs) and processing trade has an essential role in explaining the rapid growth in its exports. As shown in our estimation results, it is important to take into account the differences in production technology among firms with different ownership types and trade regimes.

Production for processing exports use imported intermediates more intensively than for normal exports and domestic use. Similarly, FIEs (including both wholly foreign-owned firms and joint ventures) have different patterns compared to Chinese-owned enterprises (COEs), which include state-owned, collective, and private firms, in using imported inputs. Such difference in using imported inputs exists within processing exporters as well.[2] Processing FIEs use imported intermediates more intensively than processing COEs.

Figure 1 shows that since the early 1990s, the share of exports by the FIEs increased to more than 50% and remained at that level, whereas the share of processing exports remained at around 50% and has started to decline since 2004. In addition, although the majority of the processing firms are foreign-owned, more than 15 percent of processing exports are conducted by local producers.

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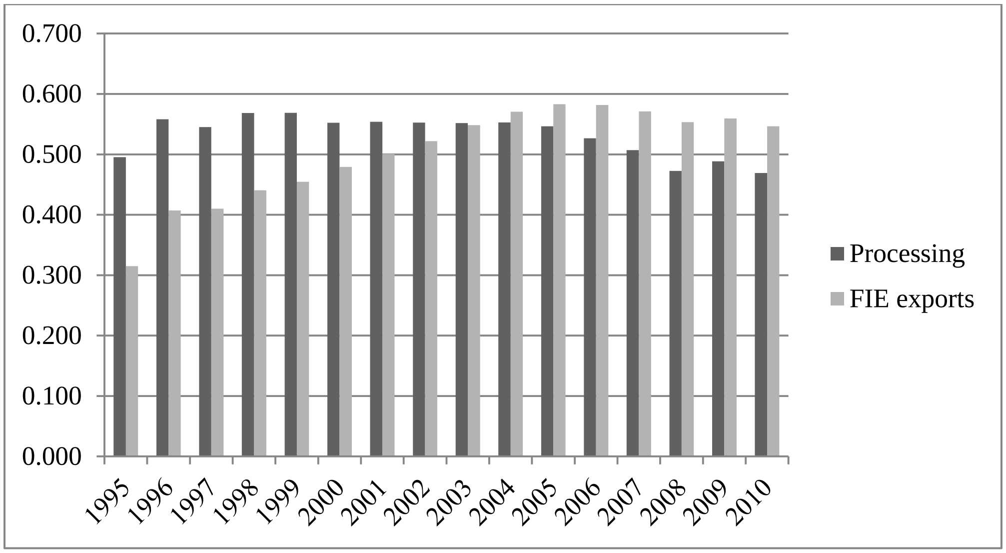
[1] Exports and GDP are measured by different accounting standards: GDP is measured in value added—a net concept, whereas export is measured in gross term containing intermediate inputs, which may cross borders many times before they become final products.

[2] This may indicate that multinational firms have better access to foreign components, or are more committed to import from their foreign parent firm or other affiliates within the same multinational group. We thank a referee for pointing this out.

Figure 1: Processing exports and FIEs exports in China (1995-2010)



Note: this figure gives the share of processing exports (in dark bar) and FIEs exports (in light grey bar) relative to the total value of Chinese exports, from 1995-2010. *Source*: The General Administration of Customs of China

Therefore, ignoring the differences in production technology may bias the estimates of the domestic content share in gross exports, and more so for firms that use more imported inputs. Consider, for example, the iPad, a device that is designed and owned by Apple. This device is assembled in China, and then exported to the US and other countries. In trade statistics, each iPad sold in the US adds $275 to their trade deficit with China. However, the value added contributed by China is merely $10, given that most parts are produced outside of China.[3] Hence, although iPads accounted for $4 billion of America's reported trade deficit with China in 2011, the *Chinese content* in the deficit was estimated to be only $150 million.[4] After accounting for foreign content, Johnson and Noguera (2012) showed that the controversial US-China imbalance is about 40% smaller than what was reported in official trade statistics. A precise measure of the domestic content is essential in understanding China's growing role in global trade. As discussed above, such a measure must acknowledge the pervasiveness of FIEs and processing trade.

The contributions of our paper are threefold. First, we decompose gross exports into domestic and foreign content by ownership (domestic-owned versus foreign-owned) and trade mode (processing exports versus normal exports), which results in four types of firms in each

[3] Those numbers are based on a study by the Personal Computing Industry Center at University of California-Irvine, and cited by *The Economist* (2012).

[4] Such discrepancy in trade statistics has also been reported by case studies such as Dedrick et al. (2009) for iPod, and by Xing and Detert (2011) for iPhone. Branstetter and Lardy (2008) estimate that Chinese domestic value-added accounts only for 15% of the value of exported electronic and information technology products.

sector. Separating processing firms from normal exporters to estimate the value added of Chinese exports has been investigated in literature. However, little attention has been given to the potential difference in the contribution to value added between multinational firms and local producers within processing and normal exporters. Based on the decomposition, we extend the official I/O table to incorporate the input usage difference across trade mode and ownership.[5]

Second, we developed a constrained optimization strategy to estimate these I/O coefficients as they are not readily available. Departing from existing literature which uses industry-level input-output (I/O) table, we rely on firm-level data from both industrial surveys and trade statistics to account for the heterogeneity in imported input intensity across different firm types. Thus, domestic content share in Chinese export by firm types, at both aggregate- and sector-level, are estimated. Based on the data from 2007, our results indicate that the domestic content accounted for approximately 59% of gross exports, and the rest is foreign-imported content. Furthermore, normal exports by COEs account for approximately 50% of domestic content in Chinese exports, whereas processing COEs only contributed 4.8%. Normal exports by FIEs account for approximately 17.8%, whereas processing FIEs contribute nearly 27.5%. We further break down the domestic content of exports at the industry level. We find that industries that are more sophisticated and have more foreign stakes or larger share of processing exports have lower domestic content share. Furthermore, at the sector level, the domestic content share of COEs and FIEs often diverge, even within the same trade mode. Therefore, splitting the I/O table by ownership is a necessary improvement on existing studies.

Finally, we calculate the share of domestic value-added that goes to foreign factor owners using information on the ownership structure, and further measure the distribution of income from export between foreign and domestic factor owners. Domestic value added is defined as value added that is generated within China, including value added generated by various types of enterprises operating in China. Thus, it is consistent with the GDP but is different from how the value added is distributed to different type of factor owners, which includes labor compensation and profits. The value added generated from production is converted into the income of various factor owners, which contributes to the gross national income (GNI). Based on the extended I/O structure with firm heterogeneity in each industry, we estimate that approximately 52.6% of the

[5] We group normal exporter and non-exporter together because of their similarity in using imported inputs.

value of Chinese exports was captured by foreign factor owners (including factors owned by Taiwan, Hong Kong, and Macau).

Our study is built on a growing literature that emphasizes the vertical structure of a global value chain. Notably, Koopman, Wang, and Wei (2012, henceforth KWW) propose a formula to compute domestic and foreign contents which takes the differences in using imported inputs by processing exporters versus normal exporters into consideration. Their results are in sharp contrast to those of Hummels et al. (2001, henceforth HIY), for the latter does not recognize the role of processing trade. KWW show that the share of domestic content in Chinese manufacturing exports was about 50% before China's accession to the WTO, and has risen to more than 60% since then.

KWW's approach still depends on industry-level statistics and may have measurement bias as long as different firms within an industry have different imported input intensities. Recent studies attempt to obtain direct measures of the I/O coefficients for processing exports. For example, De La Cruz et al. (2012) show that domestic value added accounts for only 34% of Mexico's manufacturing exports on average.

Alternatively, we may rely on firm-level information to mitigate the measurement bias. This method was first attempted by Feenstra and Jensen (2012) for the US, followed by Ahmad et al. (2012) for Turkey, and Kee and Tang (2012) for Chinese processing exporters. Using a carefully cleaned sample of processing firms that merges firms' export, import, and production information from 2000 to 2006, Kee and Tang (2012) study the input choices of processing firms without resorting to the standard input–output data. They find that the average share of domestic value added in China's processing exports has risen from 35% in 2000 to 49% in 2006. This trend is very similar to that reported by KWW, which use industry level data. Similarly, Upward et al. (2012) obtain consistent results with a more general sample of Chinese firms with trade and production information from 2003 to 2006.

However, although firm-level data provide rich information, it may not be applicable to cases with less suitable data. Furthermore, relying solely on firm-level information may result in the loss of generality and prevent us from understanding the economy as a whole. Thus, our paper chooses to group firms based on their characteristics and integrate the information of firm heterogeneity with industry-level data (I/O tables) to minimize the aggregation bias in official I/O statistics. We draw information from firm-level data to make the grouping appropriate.

To sum, we developed a framework and an estimation procedure that separately accounts for the production and trade activities of FIEs and COEs. Although our empirical investigation is based on Chinese data, our method is also applicable to other emerging economies that engage in massive processing trade or have significant FDI inflows, such as Mexico and Vietnam. In a general sense, correctly accounting for domestic contents in trade is essential for a precise understanding of world trade and global imbalance, as well as the distribution of gains across nations, considering that two-thirds of world trade is trade in intermediate inputs.

The rest of the paper is organized as follows: Section II provides a conceptual framework to estimate the shares of domestic value added in a country's exports. Section III presents the data and our estimation strategy. Section IV provides the results of the estimation. Section V concludes.

II. Theoretical Framework

A non-competitive I/O table as shown in Table 1 for an *n*-sector economy, is needed to estimate the domestic and foreign content of a country's exports.[6] Z^D and Z^M are nxn input matrices, where superscripts denote the sources of inputs, namely, D for domestic and M for imported. Clearly imported and domestic intermediate inputs are accounted separately, capturing the poor substitutability between domestic and foreign inputs (therefore called "non-competitive").[7] Similarly, Y^D and Y^M are nx1 vectors for final use. X, E, and M denote output, export, and import vectors (nx1), respectively. Finally, V is a 1xn vector for direct domestic value added (i.e., primary inputs including labor and capital).

[6] "Domestic value added exports" is often used interchangeably in literature with "domestic content" in exports. However, the two measures are not always equal except for some special cases. As emphasized in Koopman et al. (2014), domestic content includes value added exports, as well as domestic value-added that was first exported in intermediate goods and then embodied in imports and returned home. Likewise, domestic content includes pure double counting terms, considering that intermediate goods cross borders multiple times. This is a shortcoming for all single-country I/O models, given that in such a framework, imports are assumed to be completely sourced from foreign countries. This problem may be very important for a country that exports a large amount of inputs for offshoring production, such as the US. However, this is much less of a concern for China, given that only a tiny share of China's value-added embodied in its exports returns home after further processing abroad..

[7] Chen et al. (2004) first develop a "non-competitive" type I/O model for China. However, this model does not provide a systematic method to estimate separate input–output coefficients for producing processing exports versus those for other final demands.

Table 1: the Non-Competitive I/O table

Output / Input			Intermediate Uses	Final Use (C+I+G)	Exports	Total Output or Imports
		DIM	1, 2, …, n	1	1	1
Intermediate Inputs	Domestic	1 . . n	Z^D	Y^D	E	X
	Imports	1 . . n	Z^M	Y^M	0	M
Value Added		1	V			
Total Inputs		1	X^T			

Note: Table 1 gives a typical non-competitive I/O table which distinguishes domestic inputs and imported inputs. The superscripts *D and M* denote domestic and imported source, respectively. Z^D and Z^M denote domestic and imported intermediate inputs, respectively; Y^D and Y^M denotes final demand vectors for domestic products and imported ones, respectively; *X*, *E*, M, and *V* denote outputs, exports, imports and primary inputs vector, respectively.

z_{ij}^D (z_{ij}^M), an element in Z^D (Z^M), denotes the domestic (imported) inputs of sector *i* used by production in sector *j*. Similarly, x_j denotes the output of sector *j*. Furthermore, denote $A^D = [a_{ij}^D] = [z_{ij}^D / x_j]$ and $A^M = [a_{ij}^M] = [z_{ij}^M / x_j]$. By the market clearing condition, we obtain

$$X = A^D X + (Y^D + E) \tag{1}$$

$$M = A^M X + Y^M \tag{2}$$

We can express the output vector X, the total domestic content share (DVS) in final demand, and the total foreign content share (FVS) in final demand as follows.

Rearranging Equation (1), the output can be written as

$$X = (I - A^D)^{-1}(Y^D + E) = B^D(Y^D + E), \tag{3}$$

where $B^D = (I - A^D)^{-1}$ is the "Leontief inverse", which reflects both the direct and indirect usage of output in producing the final goods.

Denote $A_v = [a_{vj}] = [v_j / x_j]$ as the 1 x *n* vector of *direct domestic value added* to output ratio. Similarly, denote uA^M as the 1 x *n* vector of *imported inputs* to output ratio, where *u* is a 1 x *n* unit vector. In matrix notation, the DVS and FVS in the final demand including exports can be expressed as,

$$DVS = A_v(I - A^D)^{-1} = A_v B^D \tag{4}$$

$$FVS = uA^M (I - A^D)^{-1} = uA^M B^D \tag{5}$$

Thus, we can show that DVS + FVS = u because output equals total domestic content plus total foreign content for each sector.[8] Moreover, FVS is conceptually similar to the vertical specialization share defined in HIY (2001).[9]

In a standard model, export production uses the same technology as that for domestic sales. Thus, DVS also provides the share of domestic content in exports. However, as noted by KWW (2012) and Chen et al. (2012), processing exports utilize imported inputs more intensively than do domestic sales and normal exports. Thus, relying on the standard I/O table may be biased, since it implicit assumes proportionality in using imported input. Furthermore, FIEs have played a significant role in China's economic growth, accounting for about 20% of the total output and around 50% of total export.[10]

Based on the observations about FIEs versus COEs as described above, we have to account for the heterogeneity of firms with different trade mode and ownership to correctly estimate domestic content. Specifically, we split firms into four groups, namely, processing exports by COEs (CP), processing exports by FIEs (FP), normal exports and domestic sales by COEs (CN), and normal exports and domestic sales by FIEs (FN).[11] In Section 3, we describe the comparison of import pattern across these four groups and rationalize our current way of splitting firms.

We extend the standard I/O table to incorporate such splits, as shown in Table 2.

For input-output matrices Z, the first letter in the superscript denotes the ownership of the input supplier; the second letter denotes the ownership of the user; and the last letter denotes the export mode. C denotes COEs, F denotes FIEs, M denotes imports, P denotes processing, and N denotes normal exports and domestic sales. For example, an element in Z^{CFP}, namely z_{ij}^{CFP}, denotes the intermediate inputs produced by COEs in sector i and used by FIEs in sector j for processing exports. For the other vectors, the first letter in the superscript denotes ownership and the second denotes export mode. For example, E^{FN} denotes the normal exports of FIEs. If we

[8] $DVS + FVS = (A_v + uA^M)(I - A^D)^{-1} = (u - uA^D)(I - A^D)^{-1} = u$.

[9] HIY (2001) define the measure of vertical specialization as the imported goods that are used as inputs to produce a country's export goods, assuming the use intensity of imported inputs in the same between production for exports and production for domestic sales.

[10] A large proportion of processing trade is conducted by FIEs. However, although the share of processing exports remained steady at more than 50% during the last decade, FIE's share in China's total exports increases steadily from 31% in 1995 to 58% in 2006, and slightly decreases afterwards (see Figure 1).

[11] We assume that normal exports employ inputs in the same proportion as production for domestic sales, following KWW (2012). We have conducted further statistical tests based on detailed firm-level data to determine the best split of firm types at sector level to minimize aggregation errors caused by firm heterogeneity. A detailed discussion of the split and the comparison of key variables between groups are provided in the succeeding section.

ignore the difference in input usage between foreign and domestic firms within a trade mode (i.e., processing versus normal), Table 2 collapses to the I/O table proposed by KWW. It can be shown that HIY's results are a special case by KWW, in which no difference is found between the use of imported inputs in processing and normal exports.

Table 2: I/O table by ownership and trade mode

Input \ Output		Intermediate use by COEs		Intermediate use by FIEs		Final use	Exports	Gross Output or Imports
		N	P	N	P			
Domestic Intermediate input of COEs	N	Z^{CCN}	Z^{CCP}	Z^{CFN}	Z^{CFP}	Y^{C}	E^{CN}	X^{CN}
	P	0	0	0	0	0	E^{CP}	X^{CP}
Domestic Intermediate input of FIEs	N	Z^{FCN}	Z^{FCP}	Z^{FFN}	Z^{FFP}	Y^{F}	E^{FN}	X^{FN}
	P	0	0	0	0	0	E^{FP}	X^{FP}
Imports		Z^{MCN}	Z^{MCP}	Z^{MFN}	Z^{MFP}	Y^{M}	0	M
Value added		V^{CN}	V^{CP}	V^{FN}	V^{FP}			
Gross Input		$(X^{CN})^T$	$(X^{CP})^T$	$(X^{FN})^T$	$(X^{FP})^T$			
Foreign income		G^{CN}	G^{CP}	G^{FN}	G^{FP}			

Note: Table 2 gives the expanded I/O table that distinguishes domestic inputs by ownership and input usages by ownership and trade mode. Superscript *C* and *F* represent COEs and FIEs, respectively; M denotes imports; *P* and *N* represent processing exports, domestic sales and normal exports, respectively. *X* is gross output, E is exports, *M* is imports, *Z* denotes intermediate input matrices, *Y* is total final demand except for exports, *V* is value added, and *G* is foreign income. Superscript T represents transpose.

Furthermore, we can express the input coefficients as n x n matrices:

$$A^{olk} = [a_{ij}^{olk}] = [z_{ij}^{olk} / x_j^{lk}] \qquad \text{where } o = C, F, M; \quad l = C, F; \quad k = N, P,$$

The direct value added coefficients as 1 x n vectors can be expressed as

$$A_v^{lk} = [a_{vj}^{lk}] = [v_j^{lk} / x_j^{lk}]$$

Similar to the derivation of Equation (3), we can write the extended Leontief inverse as[12]

[12] A complete expression for Equation (6) is shown in the online Appendix A. The whole appendix could be downloaded from http://mahong.weebly.com/uploads/2/7/0/9/27093249/201312_online_appendix_resubmission.pdf.

$$\overline{B} \equiv \begin{bmatrix} B^{CCN} & B^{CCP} & B^{CFN} & B^{CFP} \\ 0 & I & 0 & 0 \\ B^{FCN} & B^{FCP} & B^{FFN} & B^{FFP} \\ 0 & 0 & 0 & I \end{bmatrix} = (I - \overline{A^D})^{-1} = \begin{bmatrix} I - A^{CCN} & -A^{CCP} & -A^{CFN} & -A^{CFP} \\ 0 & I & 0 & 0 \\ -A^{FCN} & -A^{FCP} & I - A^{FFN} & -A^{FFP} \\ 0 & 0 & 0 & I \end{bmatrix}^{-1} \quad (6)$$

Analogous to Equation (4), the total domestic content share is,

$$\overline{DVS} \equiv \left(DVS^{CN} \quad DVS^{CP} \quad DVS^{FN} \quad DVS^{FP} \right) = \overline{A_v}\,\overline{B}, \quad (7)$$

where $\overline{A_v} = \left(A_v^{CN} \quad A_v^{CP} \quad A_v^{FN} \quad A_v^{FP} \right)$ and $\overline{B}$ is given in (6). Thus for each sector, we will obtain domestic content share for firms belonging to each of the four types. The weighted sum gives the sector-level total DVS as

$$TDVS = \sum_l \sum_k DVS^{lk} \hat{s}^{lk} \qquad \text{where} \quad l = C, F; \quad k = N, P \quad (8)$$

where each $\hat{s}$ is an *n* x *n* diagonal matrix, with the export share of each type firm as the diagonal term.

Similar to Equation (5), the total foreign contents share is

$$\overline{FVS} \equiv \left(FVS^{CN} \quad FVS^{CP} \quad FVS^{FN} \quad FVS^{FP} \right) = u\overline{A^M}\,\overline{B} \quad (9)$$

where $\overline{A^M} = \left(A^{MCN} \quad A^{MCP} \quad A^{MFN} \quad A^{MFP} \right)$. The total FVS is

$$TFVS = \sum_l \sum_k FVS^{lk} \hat{s}^{lk} = u - TDVS \quad (10)$$

Furthermore, we augment the extended I/O table with a row that represents the income that goes to foreign factor owners, and we define foreign income share (FIS) as

$$A_G^{lk} = [a_{Gj}^{lk}] = [g_j^{lk} / x_j^{lk}], \quad (11)$$

where g_j^{lk} denotes foreign income for type *lk* firms. FIS differs from foreign content share for two reasons: first, a proportion of the profits of FIEs may go to its foreign investor; second, wage compensation to foreign workers working in FIEs and COEs. FIS in domestic content can be computed as:

$$\overline{FIS} \equiv \left(FIS^{CN} \quad FIS^{CP} \quad FIS^{FN} \quad FIS^{FP} \right) = \overline{A_G}\,\overline{B} \quad (12)$$

where $\overline{A_G} = \left(A_G^{CN} \quad A_G^{CP} \quad A_G^{FN} \quad A_G^{FP} \right)$. As constructed, FIS represents the domestic content that serves as the income earned by foreign factor owners. Thus, the total domestic national income share in gross exports can be expressed as a weighted sum of the domestic content after eliminating the portion of the content that belongs to foreign factor owner:

$$TDNIS = \sum_l \sum_k (DVS^{lk} - FIS^{lk})\hat{s}^{lk} \quad \text{where} \quad l = C, F; \quad k = N, P \tag{13}$$

Correspondingly, the total foreign income share of gross exports is

$$TFNIS = \sum_l \sum_k (FVS^{lk} + FIS^{lk})\hat{s}^{lk} \tag{14}$$

III. Data and Estimation Strategy

III.A: Data construction

Our data come from several sources. First, we obtain the official I/O table for the benchmark year 2007 with 135 sectors (including 80 manufacturing sectors), published by the National Bureau of Statistics of China (NBSC). This is a standard I/O table with a similar structure as Table 1. However, it does *not* separately account for domestic and imported inputs, and thus, the imported inputs are used across sectors in proportion to the domestic inputs. With this I/O table, we obtain the intermediate input matrices (Z), the value added vector (V), the output vector (X), the exports vector (E), the imports vector (M), and a final demand (excluding exports) vector (Y). To further extend the table to account for how different types of firms use imported intermediate input in their production and how much they export, we need more detailed import and export data based on ownership and trade mode.

Such data come from combining two large firm-level datasets. The first is the Annual Surveys of Industrial Production (ASIP) compiled by the NBSC, which includes firm-level information on balance sheet, production, ownership, etc. It covers all state-owned enterprises (SOEs) and all non-state enterprises with total sales exceeding 5 million RMB in the industrial sector (including mining, manufacturing, and public utilities) from 1998 to 2007 (Brandt, 2012). The second dataset is the firm-level export and import data for 2007, from China's General Administration of Customs (CGAC). It provides information on firm-specific import of intermediate inputs and total export. Intermediate inputs are identified using the UN Broad Economic Classification (BEC). By matching firms from the two datasets,[13] we can categorize industrial firms based on ownership and trade mode, namely, processing exports by COEs (CP),

[13] We first eliminated observations with unreasonable values and outliers (i.e., observations with negative gross output, or negative input value, zero employment, and the top and bottom 0.5 percentiles for key variables). As a result, we obtain a sample with 301,774 firms, 92,628 of which are exporters. Not surprisingly, many exporters are also importing: 38,025 firms are exporting and importing at the same time. Furthermore, processing exporters are major contributors to Chinese exports; altogether, a total of 26,611 exporters are engaged in processing trade. More than one-fifth of the firms are foreign-owned firms or joint ventures. The details of the datasets, as well as the detailed matching procedure, are presented in the online Appendix B.

processing exports by FIEs (FP), normal exports or domestic sales by COEs (CN); normal exports or domestic sales by FIEs (FN). Most non-exporters are COEs, whereas most processing exporters are FIEs. Table 3 summarizes the mean, the variance, and different percentiles for imported input intensity, which are divided total input or total output, across four types of exporters.[14] On average, foreign owned processing exporters (FP firms) have the highest imported input intensity (0.436), whereas Chinese owned normal exporters (CN firms) have the lowest (0.003). In terms of variance, FP firms have the highest variance as well, whereas CN firms have the lowest. Within processing exporters, FP firms have higher imported input intensity than CP firms for all percentiles. CP firms have higher imported input intensity than CN and FN firms.

Table 3: Mean and percentile comparisons in input intensity among groups

Type	**Freq.**	**mean**	**variance**	**p25**	**p50**	**p75**	**p90**	**p99**
Panel A: Imported input over input								
CP	4,112	0.144	0.127	0.003	0.028	0.124	0.392	1.635
FP	22,495	0.436	0.655	0.049	0.217	0.536	0.899	4.300
CN	41,885	0.003	0.000	0.000	0.000	0.000	0.000	0.086
FN	24,136	0.037	0.015	0.000	0.000	0.002	0.089	0.687
Total		0.123	0.201	0.000	0.000	0.041	0.372	1.612
Panel B: Imported input over output								
CP	4,112	0.103	0.059	0.002	0.021	0.096	0.288	1.035
FP	22,495	0.287	0.202	0.036	0.159	0.388	0.656	2.113
CN	41,885	0.002	0.000	0.000	0.000	0.000	0.000	0.063
FN	24,136	0.027	0.009	0.000	0.000	0.001	0.063	0.494
Total		0.082	0.068	0.000	0.000	0.030	0.270	0.969

Note: Table 3 presents the mean and percentile comparisons in input intensity among groups by ownership and trade mode. The top panel provides summary statistics for the share of imported inputs over total inputs. The bottom panel provides summary statistics for the share of imported input over total output. *Source*: the merged sample of customs data and ASIP

Using the Scheffe multiple-comparison tests, Table 4 provides simple cross-table mean comparison for the imported input intensity across different groups. All group means are significantly different from each other. In particular, we stress that (1) within processing exports, FP firms, on average, use significantly more imported input over total input or output as compared with CP firms; (2) within FIEs, FN firms, on average, use a significantly less

[14] We lack information on imported input intensity for non-exporters. Non-exporters, as well as normal exporters, however, may use imported inputs indirectly by sourcing the inputs from direct importers or intermediaries. Therefore, our estimates of import intensity for normal exporters may be understated.

proportion of imported input than FP firms; (3) within COEs, CN firms, on average, use significantly less proportion of imported input than CP firms. Firms under different groups have distinct patterns of input usage. Similar patterns are found when the mean and variance of import intensity are compared across four types of firms within each manufacturing sector.[15]

Table 4: Mean differences in imported input intensity, Scheffe multiple-comparison test

Comparison of	**Imported input / input**			**Imported input / output**		
Row Mean - Column Mean	CP	FP	CN	CP	FP	CN
FP	0.291			0.184		
CN	-0.141	-0.433		-0.101	-0.285	
FN	-0.107	-0.399	0.034	-0.076	-0.259	0.025

Note: Table 4 does the analysis of variance using the Scheffe multiple-comparison test. Input intensity is defined as the value of imported input over total output. Differences defined as row mean - column mean. All are significant at 1% level. *Source*: the merged sample of customs data and ASIP

Moreover, splitting normal firms further into normal exporters versus non-exporters (i.e., firms that sell only at domestic market) may be desirable, as this may further reduce the aggregate bias. However, we lack information on imported input intensity for non-exporters. Although there are a large number of non-exporting producers in the ASIP data, no information is available on where their intermediate inputs are sourced from. More importantly, under the processing regime, firms can obtain imported intermediate inputs free of tariffs and value-added taxes (VAT).[16] Therefore, when importing inputs is necessary to fulfill its export contacts, a firm tends to import under processing regime. On the other hand, the difference between normal exporters and firms that sell only to domestic market in terms of imported input use intensity may not be as significant to justify further separation as compared with other countries without such incentives. On the basis of these two reasons, we decide not to separate normal exporters and domestic non-exporters in our current study.

Furthermore, we are interested in knowing the income transfer from domestic value-added to foreign factor owners as well. Such information by sector is available from the balance of payment (BOP) table compiled by the People's Bank of China (PBC). This includes

[15] The results are presented in online Appendix C (Table C1).

[16] VAT ranges from 13-17 percent. In addition, being recognized as "processing importer" reduces the procedures for tax "collection" and then "rebate", since value-added tax is not collected for imported intermediate goods used to produce exports.

investment income and employee compensation at the sector level.[17] To split factor income for each type of firms within a sector, we use the combined dataset described above, which also provides information for all four types of industrial firms on foreign share in total paid-in capital, and detail income decomposition in value added, including labor compensation and capital income (i.e., operation surplus plus depreciation). Thus, we can pin down the foreign share in domestic value-added for industrial sectors. We use foreign share in registered capital as reported in the 2008 China Statistical Yearbook for primary and tertiary sectors to obtain the initial value of the foreign capital income share for FP and FN firms. Assuming that a foreign employee only works for foreign firms, we split compensation to foreign employees in the sector level income into the FP and FN's foreign employee compensation based on the proportion of total employee compensation for FP and FN.

III.B. Estimation Strategy

To extend the official I/O table to account for different input usage across ownership and trade mode, we augmented the official I/O table with information from other available data sources presented above. Likewise, we split the official I/O table from NBSC into blocks by ownership and trade mode. This process ensures that all the aggregate numbers and the balance conditions in the official I/O table are met by the estimated new I/O table with firm heterogeneity.

The key variables in our estimation model are listed as follows, including both variables to be estimated and those that we have obtained from the data through construction.

Variables (o, *l=C,F, k =N,P*)	**Definition**	# unknowns
	variables to be estimated	
z_{ij}^{olk}	Intermediate good *i* produced by type *o* firms and used by type *l* firms and trade mode *k* in sector *j*	$8n^2$
z_{ij}^{mlk}	Intermediate good *i* imported to be used by firms of type *l* in sector j for trade mode *k*	$4n^2$
v_j^{lk}	Value added by *l type* firms in sector *j* for trade mode *k*	$4n$
y_j^l	Final goods used domestically produced by *l* type firms in sector *j*	$2n$
	variables with available data	
x_j , v_j , y_j , e_j , m_j	Output, value added, final demand, and export and imported intermediates by sector, from the official I/O table	

[17] More specifically, we use the sector-level income table (expenditure side) in BOP. Foreign investment income accounts for nearly 95% of the total foreign factor income.

z_{ij}	Goods *i* used as intermediate inputs in sector *j*, without distinguishing ownership and trade mode, from the official I/O table	
x_j^l , v_j^l	Output and value added by *type l* firms in sector *j,* known from the ASIP data the official I/O table, and China Statistical Yearbook.	
y_j^m	Imported final goods of sector *j*, known from trade statistics and the official I/O table.	
m_j^{lk}	Normal and processing imported intermediate inputs of sector *j* by FIEs and COEs respectively, known from the combined dataset and the official I/O table	
e_j^{lk}	Normal and processing exports of sector *j* by FIEs and COEs respectively, known from the combined dataset and the official I/O table	

We now obtain the data for output, export, value added, imports for final demand, and imported intermediate inputs, by type and sector. These data will be used as controls for our estimations. To be more specific, sector-level gross output and direct value added by each firm type are obtained from the ASIP data and the China Statistical Yearbook.[18] For example, x_j can be divided into total output of COEs (x_j^c) and FIEs (x_j^f). $x_j^{cp} = e_j^{cp}$ denotes the processing exports of COEs. $x_j^{fp} = e_j^{fp}$ denotes processing exports of FIEs. The output of COEs for normal exports and domestic use, x_j^{cn} , denotes the difference between output and processing exports ($x_j^c - e_j^{cp}$). Similarly, the output of FIEs for normal exports and domestic use x_j^{fn} is $x_j^f - e_j^{fp}$. Using the same approach, we can also separate value added v_j into v_j^c, v_j^f .

Our estimation procedure is performed using a quadratic programming model. As indicated above, our method involves estimating eight inter-industry-between-firm-type domestic input transaction matrix Z^{olk} , four inter-industry-between-firm-type imported input transaction matrix Z^{mlk} , four sector-level value added vectors V^{lk} , and two domestic final demand vectors Y^o . Assuming there are *n* sectors, our estimation will involve 12n^2 unknowns for intermediate inputs, *4n* unknowns for value added, and *2n* unknowns for the final demand. First, we make conjectures about their values based on the trade statistics, the ASIP, and the official benchmark I/O table. These conjectured values are then used in our estimation as initial values.

For domestic final demand, we set the initial value $y0_i^o$ as residual:

$$y0_i^o = \left[(x_i^o - e_i^o)/(x_i - e_i)\right] (y_i - y_i^m) , \tag{15}$$

[18] ASIP dataset only includes industrial firms. For other industries, such as construction and transportation, we can obtain the sector-level value-added data from the Statistical Yearbooks. The shares of FIEs are estimated based on total sales of FIEs or total registered capital by FIEs.

where $(x_i^o - e_i^o)/(x_i - e_i)$ indicates the fraction of domestic use (exclusive of export) by *o* type firms out of total domestic use in sector *i*.

The initial values of value added, $v0_j^{lk}$, are from decomposing v_j^c, v_j^f based on the combined data from the ASIP and the Customs statistics.

The initial values of intermediate imports use coefficients that are generated by allocating sector *i*'s imported intermediates m_i^{lk} in proportion to input *i*'s usage in sector *j*

$$z0_{ij}^{mlk} = \left[z_{ij} \Big/ \sum_{j=1}^{n} z_{ij}\right] m_i^{lk}, \tag{16}$$

where m_i^{lk} can be estimated from detailed trade statistics, whereas z_{ij} are from the official I/O table. The fraction in brackets denotes the proportion of input in sector *i* that are used in sector *j*.

The initial values for domestically produced intermediates are generated through two steps. First, we compute for the total domestic product *i* used as intermediate inputs in sector *j* as a residual of the total intermediate inputs and imported intermediate inputs:

$$z_{ij}^d = z_{ij} - \sum_l \sum_k z0_{ij}^{mlk} \tag{17}$$

Second, we assume a proportional usage of z_{ij}^d:

$$z0_{ij}^{olk} = \left[(x_i^o - e_i^o)/(x_i - e_i)\right] \left[x_j^{lk} / x_j\right] z_{ij}^d \tag{18}$$

where $\left[x_j^{lk} / x_j\right]$ denotes the fraction of output of type *lk* firms in sector j, with *o*,*l*=*C*,*F*, *k*=*N*,*P*.

Nevertheless, these initial conjectures are not guaranteed to satisfy various economic and statistical restrictions. Therefore, we cast the estimation problem as a constrained optimization procedure. In particular, the optimization program is specified to minimize the following objective function:

$$\begin{aligned}
\text{Min}\, S = &\sum_{i=1}^{n}\sum_{j=1}^{n}\sum_{o}\sum_{l}\sum_{k}\left[(z_{ij}^{olk} - z0_{ij}^{olk})^2 / z0_{ij}^{olk}\right] \\
&+ \sum_{i=1}^{n}\sum_{j=1}^{n}\sum_{l}\sum_{k}\left[(z_{ij}^{mlk} - z0_{ij}^{mlk})^2 / z0_{ij}^{mlk}\right] \\
&+ \sum_{j=1}^{n}\sum_{l}\sum_{k}\left[(v_j^{lk} - v0_j^{lk})^2 / v0_j^{lk}\right] \\
&+ \sum_{i=1}^{n}\sum_{o}\left[(y_i^o - y0_i^o)^2 / y0_i^o\right]
\end{aligned} \tag{19}$$

where z's, v's and y's are the variables to be estimated, whereas $z0$'s, $v0$'s and y0's are the initial values that have been specified above. Equation (19) minimizes the sum of the differences of the estimated values from their initial values. Furthermore, the results of this minimization problem should satisfy the balance conditions of both the official I/O table and the extended table, in addition to other regularities that we specify below.

Constraint set 1: row sum identities required by the I/O table

$$\sum_{j=1}^{n}\sum_{l}\sum_{k} z_{ij}^{olk} + y_i^o = x_i^o - e_i^o \tag{20}$$

$$\sum_{j=1}^{n}\sum_{l}\sum_{k} z_{ij}^{mlk} + y_i^m = m_i \tag{21}$$

Constraint set 2: column sum identities required by the I/O table

$$\sum_{i=1}^{n}\sum_{o}(z_{ij}^{olk} + z_{ij}^{mlk}) + v_j^{lk} = x_j^{lk} \tag{22}$$

Constraint set 3: adding up conditions for intermediate inputs

$$\sum_{o}\sum_{l}\sum_{k} z_{ij}^{olk} + \sum_{l}\sum_{k} z_{ij}^{mlk} = z_{ij} \tag{23}$$

Constraint set 4: adding up conditions for import intermediate inputs

$$\sum_{j=1}^{n} z_{ij}^{mlk} = m_i^{lk} \tag{24}$$

Constraint set 5: adding up conditions for value added and final use

$$\sum_{l}\sum_{k} v_j^{lk} = v_j \tag{25}$$

$$\sum_{o} y_i^o + y_i^m = y_i \tag{26}$$

Constraint set 6: non-negativity constraints

$$z_{ij}^{olk},\quad z_{ij}^{mlk},\quad v_j^{lk},\quad y^m \geq 0 \tag{27}$$

The economic meanings of the six sets of constraints are straightforward. Equations (20)-(21) pertain to the row sum identities for the expanded I/O account, which is also the market clearing condition. These equations state that the total gross output of sector i should be equal to the sum of final demand and exports, plus domestic use as intermediates by all four firm types across all sectors. Similarly, the total imports should be equal to the imported intermediate inputs used across firm types and sectors, plus imports delivered to final users. Equation (22) provides the column sum identities, maintaining that the total gross inputs of sector j should be equal the intermediated inputs supplied by four firm types across sectors and imported intermediate inputs, plus primary inputs. Equations (23) to (26) are a set of adding-up constraints that ensure the consistency of the solution from the model with official statistics on sector-level trade and transactions within the industry. Finally, Equation (27) indicates the non-negativity condition.[19]

IV. Results

Using the estimation method described in the previous section, we estimated an extended non-competitive I/O table with separate production accounts by firm ownership and trade mode.[20] The results of domestic and foreign content share of exports by the four type firms in each industry are estimated based on this estimated I/O table.

IV. A. Share of domestic and foreign content

Table 5 presents our estimation results for the DVS and FVS shares in China's processing and normal exports by COEs and FIEs from 2007. These data were calculated using Equations (7) to (10). Columns (1) to (4) report the direct DVS, total DVS, direct FVS, and total FVS, respectively. The direct DVS and FVS are the direct value added incurred in each sector as income to primary inputs, whereas the total DVS and FVS account for the iterated usage of inputs from other sectors. Several observations have to be stressed, particularly regarding the DVS in columns (1) and (2). First, comparing rows (1) and (4), although the direct DVS for COEs is very close to that for FIEs (20.92 versus 18.12), the COEs' total DVS is larger (75.07 versus 47.13). Second, within each ownership type, the difference between normal and processing exports in total DVS is larger than the difference in direct DVS. As expected, normal exports have a higher domestic content share as compared with processing exports, regardless of the ownership type. Furthermore, COEs have slightly higher total DVS than FIEs for normal exports, whereas they have slightly lower total DVS than FIEs for processing exports. Third, the total DVS of COEs within the same trade mode is very close to that of FIEs. For example, if we compare rows (2) and (5) with processing exporters, the total DVS for COEs is 35.46, whereas that for FIEs is 37.3. Thus, one may conclude that the difference of total DVS between COEs

[19] The partition among the five parts of imports (m_i^{cp}, m_i^{cn}, m_i^{fp}, m_i^{fn} and y_i^m) based on Custom import statistics and UN BEC classification allows for the slight adjustment only to the extent that a feasible solution from model could be obtained. This reconciliation procedure is implemented in GAMS (Brooke et al, 2005). Related computer programs and data files will be available at the USITC website for download.

[20] In the online Appendix C, we provide all trade share parameters that we use in estimation (Table C2).

and FIEs is mainly driven by the ratio of processing to non-processing exports. However, DVS differs substantially across ownership in certain sectors, as shown in Table 6.

Table 5: The domestic and foreign content share of China's exports (%), 2007

Total Merchandise		Direct DVS [1]	Total DVS [2]	Total FVS [3]
[1] *Total exports by COEs*		*20.92*	*75.07*	*24.92*
[2]	Processing exports by COEs	15.58	35.46	64.52
[3]	Normal exports by COEs	22.14	84.11	15.89
[4] *Total exports by FIEs*		*18.12*	*47.13*	*52.86*
[5]	Processing exports by FIEs	16.64	37.3	62.7
[6]	Normal exports by FIEs	23	79.53	20.46
[7] Total gross exports		**19.33**	**59.17**	**40.82**

Note: Table 5 presents our estimation results for the share of domestic (DVS) and foreign (FVS) content in China's processing and normal exports by COEs and FIEs in 2007.

Overall, about 59.2% of Chinese exports are domestic content, whereas 40.8% are foreign content, as shown in row (7) of Table 5. In 2007, the gross value of Chinese exports is 1.22 trillion US dollars (USD), and thus the gross domestic content in export is 720 billion USD. Table 6 shows the composition of the gross exports and gross domestic content in exports by firm type. Almost half of the domestic content is attributed to COEs' normal exports, and 4.8% of domestic content is attributed to the processing exports of COEs, and thus COEs contribute nearly 55% of gross domestic content in exports. The rest of the content can be attributed to the FIEs; in particular normal FIEs exports account for about 17.8%, whereas processing FIEs contribute nearly 27.5%.

Table 6: Distribution of Domestic Content by Firm Type (%), 2007

	COEs exports			FIEs exports		
	normal	processing	*total*	normal	processing	*total*
% share in gross exports	35.09	8.00	*43.09*	13.25	43.66	*56.91*
% share in total domestic content of exports	49.87	4.80	*54.67*	17.82	27.52	*45.34*

Note: Table 6 shows the decomposition of gross exports and gross domestic content in exports, by firm ownership and trade mode. *Source*: China trade statistics and authors' own calculation

IV. B. Domestic and foreign content share by sectors

Our findings on the heterogeneity in domestic content share across firm types are consistent with those of KWW (2012) and Chen et al. (2012).[21] In particular, KWW estimate the total DVS is 83.9% for normal exports, and 38.7% for processing exports. Overall, they find that the total DVS for Chinese exports is 60.6%. In aggregate and by trade mode, our DVS estimates are very close to theirs. However, we demonstrate that across sectors, the difference in DVS by trade mode varies within ownership, which was not captured by their studies.

In Table 7, we present the DVS by firm types for manufacturing sectors.[22] Columns (1) and (2) show the DVS for COEs and FIES of processing exports, respectively, whereas columns (3) to (4) show those for two types of normal exports. Column (5) lists the total DVS for the total exports, which is a weighted average of the DVS of four types. Sorted by total DVS in an ascending order, 11 sectors have domestic content share over 80 percent. These sectors with relatively high share of domestic content include some labor-intensive sectors, such as textile, porcelain, cement, and plaster sectors, as well as some capital- and resource-intensive sectors, such as steelmaking and coking. These sectors usually have very low processing share [column (9)]. By contrast, most high-tech or sophisticated industries have a low share of domestic content. In addition, 10 sectors have domestic content share less than 50 percent, including electronic components, telecommunication equipment, and computers. Likewise, those sectors have high share of processing exports and high share of FIEs.

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[21] All three studies present much lower DVS than HIY (2001), which assume that the intensity in the use of imported inputs is the same between production for exports and production for domestic sales. This finding indicates that ignoring the heterogeneity across types of firms in their production technology will overestimate domestic content share.

[22] To facilitate comparison, we focus on our sample of 57 manufacturing sectors, which were also reported in KWW.

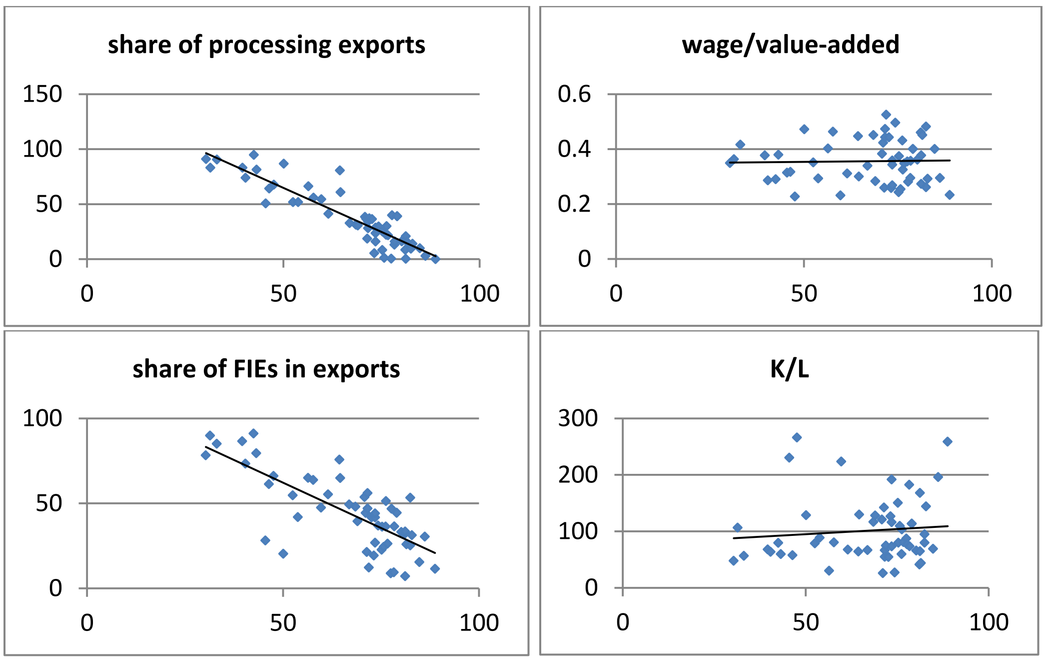
Table 7: Decomposition of Domestic Content by Sectors (%), 2007

Industry	MWZ					KWW			processing share
	CP	FP	CN	FN	Total	P	N	Total	
	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]
Household Audiovisual Apparatus	27.5	25.4	77.3	74.7	**30.3**	29.6	75.9	32.6	91.0
Electronic Component	36.8	21.9	72.8	76.7	**31.4**	23.1	77.5	32.3	83.1
Cultural and office equipment	37.7	27.6	75.2	75.5	**33.1**	33.1	74.1	36.5	90.5
Telecommunication equipment	33.3	33.2	74.7	66.8	**39.6**	35.3	75.2	43.6	83.1
Generators	31.3	27.0	80.5	71.1	**40.4**	51.2	80.3	66.6	73.9
Electronic computer	19.7	42.4	66.2	70.9	**42.5**	33.0	75.7	33.9	94.7
Measuring Instruments	41.5	34.6	81.0	71.9	**43.2**	37.8	80.0	45.8	81.3
Petroleum feline and Nuclear Fuel	15.2	37.5	68.1	69.2	**45.5**	20.1	68.7	44.4	50.6
Household electric appliances	26.8	27.2	82.3	78.2	**46.4**	35.6	82.0	51.8	64.1
Synthetic Materials	40.3	34.2	75.3	69.4	**47.6**	34.0	76.4	47.7	67.7
Ship building	39.7	65.2	84.8	74.7	**50.1**	39.1	83.9	43.8	86.7
Plastic	31.1	27.6	79.3	75.7	**52.5**	31.1	80.8	55.1	51.7
Rubber	25.2	31.1	81.5	77.5	**53.8**	27.0	81.8	53.4	51.8
Articles for Culture, Education and Sports Activities	34.3	46.4	83.2	74.4	**56.4**	45.6	83.0	58.4	66.2
Other special industrial equipment	46.9	39.1	82.9	74.6	**57.7**	43.0	82.5	65.2	55.9
Chemical Fiber	38.0	51.0	76.2	74.8	**59.7**	51.9	76.4	62.6	54.4
Other electric machinery and equipment	37.8	36.9	79.6	76.9	**61.5**	33.7	80.3	52.1	41.2
Other electronic and communication equipment	61.8	60.8	81.2	72.4	**64.4**	34.7	68.0	39.7	80.6
Paper and Paper Products	59.0	50.8	85.0	82.0	**64.6**	57.6	85.5	69.2	60.8
Metal products	39.1	30.5	85.0	82.3	**66.9**	39.7	85.1	70.1	32.7
Special Chemical Products	62.5	51.8	76.5	73.3	**68.5**	34.0	76.7	61.6	31.2
Nonferrous metal pressing	41.1	53.0	77.7	77.5	**69.0**	56.1	78.6	71.2	30.5
Glass and Its Products	63.5	51.0	84.5	78.0	**70.8**	59.0	83.3	76.7	38.4
Leather, fur, down and related products	35.3	41.1	89.3	89.1	**71.1**	40.4	90.4	69.2	36.7
Nonferrous metal smelting	49.3	57.3	76.7	63.7	**71.4**	56.4	76.2	73.3	18.6
Furniture	53.0	42.2	87.1	84.7	**71.6**	56.1	86.7	76.2	34.2
Other transport equipment	57.0	50.2	82.3	73.8	**71.6**	54.9	81.0	73.8	28.0
Railroad transport equipment	58.7	62.1	81.1	67.3	**71.9**	54.1	77.7	69.0	37.0
Other manufacturing products	39.8	53.5	86.6	84.4	**72.6**	48.1	86.5	72.3	36.3
Pesticides	59.8	60.2	73.6	75.9	**73.2**	53.6	73.9	72.9	5.4
Motor vehicles	43.0	45.3	83.4	79.6	**73.5**	47.4	84.0	75.3	23.5
Basic Chemical Raw Materials	28.6	54.3	81.5	72.4	**73.5**	42.5	80.8	74.9	16.0
Other industrial machinery	50.3	48.7	84.7	80.0	**73.5**	56.2	83.6	75.6	28.6
Wearing apparel	36.9	39.3	89.7	88.2	**74.3**	53.9	89.5	79.0	29.7
Rolling of Steel	33.9	52.8	80.4	70.2	**75.2**	52.9	80.0	77.8	8.3
Boiler, engines and turbine	59.1	63.7	82.3	71.4	**75.3**	38.7	81.6	70.6	25.0
Iron-smelting	40.5	45.5	76.8	73.9	**75.7**	50.6	75.9	75.6	1.1
Agriculture, forestry, and fishing machinery	63.9	62.3	82.6	73.0	**76.2**	57.7	80.6	75.6	22.1
Chemical Products for Daily Use	64.8	66.8	79.9	81.5	**76.3**	58.4	80.8	73.3	30.0
Cotton textiles	30.0	43.3	87.9	86.9	**76.7**	45.8	88.0	78.9	21.6
Smelting of Ferroalloy	62.4	57.1	78.2	71.5	**77.5**	53.3	75.7	75.6	0.4
Woolen textiles	61.9	64.0	90.4	79.3	**77.7**	57.9	89.4	76.9	39.8
Fertilizers	55.7	60.0	82.8	72.4	**78.3**	57.3	81.0	77.9	13.0
Metalworking machinery	63.4	61.6	82.8	78.2	**78.4**	56.8	81.2	77.3	16.0
Paints, Printing Inks, Pigments and Similar Products	63.0	68.8	86.9	85.5	**79.0**	56.8	76.5	72.6	39.0
Printing, Reproduction of Recording Media	63.0	68.8	86.9	85.5	**79.0**	61.0	86.4	76.5	39.0
Wood, Bamboo, Rattan, Palm and Straw Products	57.4	61.3	84.8	82.1	**80.2**	58.4	84.6	80.4	16.1
Pottery and Porcelain	65.0	63.8	84.3	78.2	**81.1**	58.2	83.4	82.0	8.4
Steelmaking	N/A	17.4	81.7	76.0	**81.2**	51.7	80.8	80.8	0.2
Textiles productions	45.2	60.1	88.8	86.5	**81.2**	54.9	88.4	82.4	20.7
Knitted and crocheted fabrics and articles	40.8	49.3	87.9	87.0	**81.5**	51.6	88.2	82.5	15.6
Other non-metallic mineral products	65.2	62.7	87.5	72.7	**82.5**	56.6	86.0	83.0	11.3
Fire-resistant Materials	63.1	60.1	88.2	81.3	**82.5**	55.1	86.6	84.7	9.4
Medicines	60.0	58.1	87.9	83.7	**82.9**	37.5	87.6	80.3	13.9
Hemp textiles	64.1	62.5	88.0	80.7	**84.8**	56.8	86.6	83.9	9.9
Cement, Lime and Plaster	61.2	43.0	89.8	81.7	**86.2**	52.9	89.0	88.4	2.8
Coking	N/A	N/A	90.8	73.9	**88.8**	N/A	89.6	89.6	0.0
Total Merchandise	**35.5**	**37.3**	**84.1**	**79.5**	**59.2**	**37.3**	**84.0**	**60.6**	**50.7**

Note: This table gives the decomposition of domestic content by manufacturing sectors. Columns [1]-[5] present DVS estimated in this paper, while columns [6]-[8] present DVS estimates by KWW. Column [9] gives the share of processing exports in total exports. To facilitate comparison with KWW, we focus on the sample of 57 manufacturing sectors also reported in KWW.

Furthermore, Figure 2 shows the simple relationship between sector level DVS and the processing share, the FIE share in exports, the labor compensation relative to total direct value added, and the capital labor ratio. Figure 2 confirms that sectors that have higher processing share or higher FIEs share in exports tend to have lower DVS. The correlation between DVS and wage share of value added is flat, whereas the correlation between DVS and the capital intensity of the sector is weakly positive. Thus, the more capital-intensive industries are likely to have higher DVS, a result that is probably due to industry upgrading.

Figure 2: DVS and sector level characteristics



Note: this figure shows the correlation between sector level DVS (horizontal axis) and the processing share in exports, the FIE share in exports, the labor compensation relative to total direct value added (wage/value-added), and the capital labor ratio (K/L). *Source*: share of processing exports in total Chinese exports, share of FIEs in total exports are from trade statistics, K/L ratio from the ASIP data, wage/value-added from 2007 benchmark I/O table.

Table 7 shows that within processing exports, the domestic content of FIEs often diverge from that of COEs at the sector level. For example, the DVS of processing COEs is substantially larger than that of processing FIEs in sectors such as electronic components, cultural and office equipment, measuring instruments, and metal products, among others. Conversely, the reverse relationship holds for the shipbuilding, chemical fiber, and steel rolling sectors. Meanwhile, within normal export, COEs have higher DVS in the measuring instrument, other communication equipment, and the railroad transport sectors.

Table 7: Decomposition of Domestic Content by Sectors (%), 2007

Industry	MWZ					KWW			processing share
	CP	FP	CN	FN	Total	P	N	Total	
	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]
Household Audiovisual Apparatus	27.5	25.4	77.3	74.7	**30.3**	29.6	75.9	32.6	91.0
Electronic Component	36.8	21.9	72.8	76.7	**31.4**	23.1	77.5	32.3	83.1
Cultural and office equipment	37.7	27.6	75.2	75.5	**33.1**	33.1	74.1	36.5	90.5
Telecommunication equipment	33.3	33.2	74.7	66.8	**39.6**	35.3	75.2	43.6	83.1
Generators	31.3	27.0	80.5	71.1	**40.4**	51.2	80.3	66.6	73.9
Electronic computer	19.7	42.4	66.2	70.9	**42.5**	33.0	75.7	33.9	94.7
Measuring Instruments	41.5	34.6	81.0	71.9	**43.2**	37.8	80.0	45.8	81.3
Petroleum feline and Nuclear Fuel	15.2	37.5	68.1	69.2	**45.5**	20.1	68.7	44.4	50.6
Household electric appliances	26.8	27.2	82.3	78.2	**46.4**	35.6	82.0	51.8	64.1
Synthetic Materials	40.3	34.2	75.3	69.4	**47.6**	34.0	76.4	47.7	67.7
Ship building	39.7	65.2	84.8	74.7	**50.1**	39.1	83.9	43.8	86.7
Plastic	31.1	27.6	79.3	75.7	**52.5**	31.1	80.8	55.1	51.7
Rubber	25.2	31.1	81.5	77.5	**53.8**	27.0	81.8	53.4	51.8
Articles for Culture, Education and Sports Activities	34.3	46.4	83.2	74.4	**56.4**	45.6	83.0	58.4	66.2
Other special industrial equipment	46.9	39.1	82.9	74.6	**57.7**	43.0	82.5	65.2	55.9
Chemical Fiber	38.0	51.0	76.2	74.8	**59.7**	51.9	76.4	62.6	54.4
Other electric machinery and equipment	37.8	36.9	79.6	76.9	**61.5**	33.7	80.3	52.1	41.2
Other electronic and communication equipment	61.8	60.8	81.2	72.4	**64.4**	34.7	68.0	39.7	80.6
Paper and Paper Products	59.0	50.8	85.0	82.0	**64.6**	57.6	85.5	69.2	60.8
Metal products	39.1	30.5	85.0	82.3	**66.9**	39.7	85.1	70.1	32.7
Special Chemical Products	62.5	51.8	76.5	73.3	**68.5**	34.0	76.7	61.6	31.2
Nonferrous metal pressing	41.1	53.0	77.7	77.5	**69.0**	56.1	78.6	71.2	30.5
Glass and Its Products	63.5	51.0	84.5	78.0	**70.8**	59.0	83.3	76.7	38.4
Leather, fur, down and related products	35.3	41.1	89.3	89.1	**71.1**	40.4	90.4	69.2	36.7
Nonferrous metal smelting	49.3	57.3	76.7	63.7	**71.4**	56.4	76.2	73.3	18.6
Furniture	53.0	42.2	87.1	84.7	**71.6**	56.1	86.7	76.2	34.2
Other transport equipment	57.0	50.2	82.3	73.8	**71.6**	54.9	81.0	73.8	28.0
Railroad transport equipment	58.7	62.1	81.1	67.3	**71.9**	54.1	77.7	69.0	37.0
Other manufacturing products	39.8	53.5	86.6	84.4	**72.6**	48.1	86.5	72.3	36.3
Pesticides	59.8	60.2	73.6	75.9	**73.2**	53.6	73.9	72.9	5.4
Motor vehicles	43.0	45.3	83.4	79.6	**73.5**	47.4	84.0	75.3	23.5
Basic Chemical Raw Materials	28.6	54.3	81.5	72.4	**73.5**	42.5	80.8	74.9	16.0
Other industrial machinery	50.3	48.7	84.7	80.0	**73.5**	56.2	83.6	75.6	28.6
Wearing apparel	36.9	39.3	89.7	88.2	**74.3**	53.9	89.5	79.0	29.7
Rolling of Steel	33.9	52.8	80.4	70.2	**75.2**	52.9	80.0	77.8	8.3
Boiler, engines and turbine	59.1	63.7	82.3	71.4	**75.3**	38.7	81.6	70.6	25.0
Iron-smelting	40.5	45.5	76.8	73.9	**75.7**	50.6	75.9	75.6	1.1
Agriculture, forestry, and fishing machinery	63.9	62.3	82.6	73.0	**76.2**	57.7	80.6	75.6	22.1
Chemical Products for Daily Use	64.8	66.8	79.9	81.5	**76.3**	58.4	80.8	73.3	30.0
Cotton textiles	30.0	43.3	87.9	86.9	**76.7**	45.8	88.0	78.9	21.6
Smelting of Ferroalloy	62.4	57.1	78.2	71.5	**77.5**	53.3	75.7	75.6	0.4
Woolen textiles	61.9	64.0	90.4	79.3	**77.7**	57.9	89.4	76.9	39.8
Fertilizers	55.7	60.0	82.8	72.4	**78.3**	57.3	81.0	77.9	13.0
Metalworking machinery	63.4	61.6	82.8	78.2	**78.4**	56.8	81.2	77.3	16.0
Paints, Printing Inks, Pigments and Similar Products	63.0	68.8	86.9	85.5	**79.0**	56.8	76.5	72.6	39.0
Printing, Reproduction of Recording Media	63.0	68.8	86.9	85.5	**79.0**	61.0	86.4	76.5	39.0
Wood, Bamboo, Rattan, Palm and Straw Products	57.4	61.3	84.8	82.1	**80.2**	58.4	84.6	80.4	16.1
Pottery and Porcelain	65.0	63.8	84.3	78.2	**81.1**	58.2	83.4	82.0	8.4
Steelmaking	N/A	17.4	81.7	76.0	**81.2**	51.7	80.8	80.8	0.2
Textiles productions	45.2	60.1	88.8	86.5	**81.2**	54.9	88.4	82.4	20.7
Knitted and crocheted fabrics and articles	40.8	49.3	87.9	87.0	**81.5**	51.6	88.2	82.5	15.6
Other non-metallic mineral products	65.2	62.7	87.5	72.7	**82.5**	56.6	86.0	83.0	11.3
Fire-resistant Materials	63.1	60.1	88.2	81.3	**82.5**	55.1	86.6	84.7	9.4
Medicines	60.0	58.1	87.9	83.7	**82.9**	37.5	87.6	80.3	13.9
Hemp textiles	64.1	62.5	88.0	80.7	**84.8**	56.8	86.6	83.9	9.9
Cement, Lime and Plaster	61.2	43.0	89.8	81.7	**86.2**	52.9	89.0	88.4	2.8
Coking	N/A	N/A	90.8	73.9	**88.8**	N/A	89.6	89.6	0.0
Total Merchandise	**35.5**	**37.3**	**84.1**	**79.5**	**59.2**	**37.3**	**84.0**	**60.6**	**50.7**

Note: This table gives the decomposition of domestic content by manufacturing sectors. Columns [1]-[5] present DVS estimated in this paper, while columns [6]-[8] present DVS estimates by KWW. Column [9] gives the share of processing exports in total exports. To facilitate comparison with KWW, we focus on the sample of 57 manufacturing sectors also reported in KWW.

Considering that our findings are worth comparing with KWW at the sector level, we therefore list the DVS values by processing, normal, and their weighted sum in columns (6) to (9), which are shown in Table 6 of KWW. Our method is based on the optimization strategy proposed in KWW; however, we consider ownership within each trade mode. Our estimation further adds restrictions on the balance conditions for COEs and FIEs, which captures the internal difference in DVS by ownership type within each trade mode. Thus, the correlation between our sector level DVS and KWW's is over 0.9. On the other hand, the correlation between our CP's and FP's DVS and KWW's processing export DVS is only 0.65 and 0.67, respectively; the correlation between our CN's and FN's DVS and KWW's normal export DVS is 0.86 and 0.69, respectively.

IV. C. Distribution of export value to factor owners

In the previous subsections, we estimated the domestic contents share in export, for each type of firms at the aggregate and sector levels. These domestic contents, however, may likewise become foreign income because of foreign ownership. Thus, we further study the income distribution of exports across ownership types. We add a row of foreign factor income at the bottom of the expanded I/O table to capture the foreign factor inputs in each sector (i.e., Table 2). Two types of foreign factor inputs in domestic production exist, namely, capital and labor. As discussed in the data section, we utilize the merged sample to obtain the value added and foreign share in total paid-in capital for the four types of firms to estimate foreign labor and capital income share. Multiplying these shares with capital income provides the foreign capital income from domestic contents in exports. In addition, we collect sector-level investment income data from the BOP table compiled by the People's Bank of China. In each sector, we apply the labor and capital income share based on the BOP to compute for the share of foreign factor in gross exports by four types of firms. [23]

Table 8 presents our estimates on foreign income shares in processing and normal exports by either COEs or FIEs, which are based on Equations (12) to (14). For reference, we first present the total DVS and FVS in exports for each type of firms in the first two rows, followed by the foreign income share in domestic content in row (3). A small share of foreign income was

[23] The sector-level results of foreign income share are listed in the online Appendix C (Table C3).

found in the exports generated by COEs. For each 100 USD of processing exports by COEs in 2007, 35.5 USD are generated by domestic production factors, only 0.5 USD can be attributed to foreign factor income [column (1)]. Similarly, for each 100 USD of normal exports by COEs, 84 USD are generated by domestic factors, only 0.76 USD is attributed to foreign factor income [column (3)], whereas the foreign factor income share in FIEs' exports is much higher. For example, for each 100 USD processing exports by FIEs, 37 dollars are generated by domestic factors, whereas 16.3 USD can be attributed to foreign factor income [column (2)]. Similarly, for each 100 USD of normal exports by FIEs, 79.5 USD are generated by domestic factors, and a striking 32.7 USD is attributed to foreign factor income [column (4)].

To estimate the domestic GNI of exports, we can use domestic content in exports minus the part that goes to foreign factors income. Then, by using foreign content in exports[24] plus the foreign income from domestic content in exports, we can obtain the foreign GNI of Chinese exports. The results are shown in the last two rows of Table 8. The majority of processing exports in China contribute to foreign GNI, regardless of the ownership type of exporters. For example, for 100 USD processing exports by COEs, 65 USD go to foreign GNI, and 79 USD go to processing exports by FIEs. About 53.2 percent of normal exports by FIEs can be attributed to foreign GNI, whereas the foreign GNI share in normal exports by COEs is much lower, which is around 16.6 percent. Overall, there are 47.4 USD in domestic GNI and 52.6 USD in foreign GNI for each 100 USD in Chinese gross exports [column (5)].

Table 8: National Income and Foreign Income Share in China's Exports, 2007 (%)

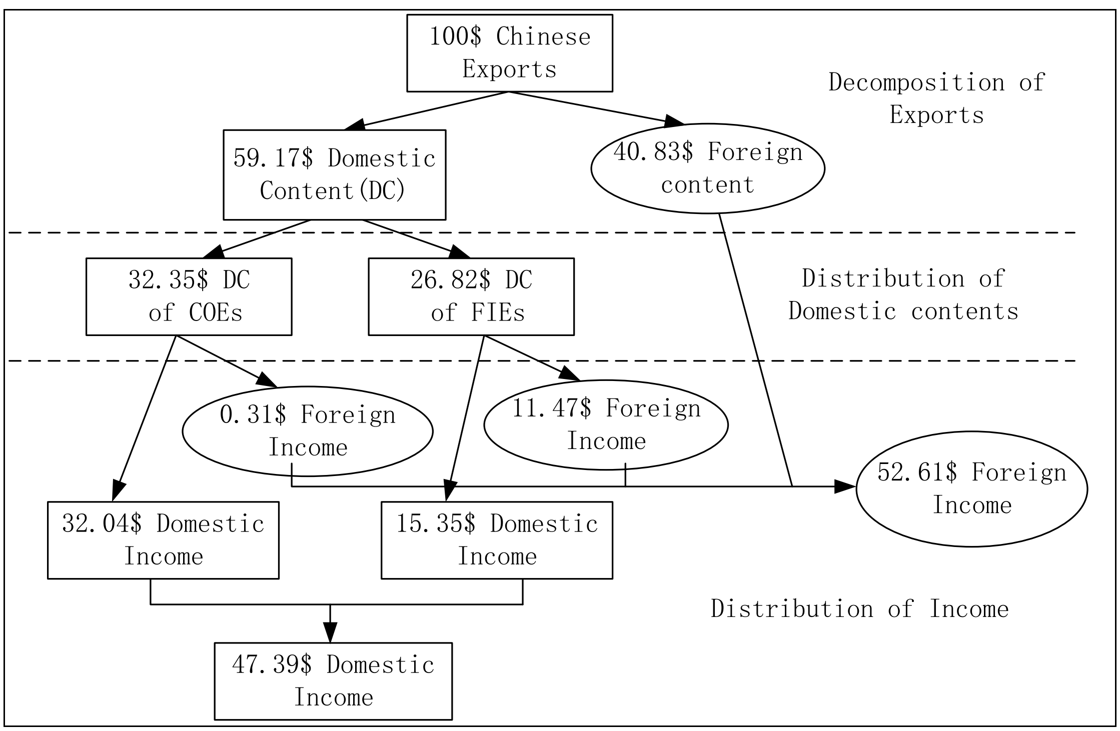
	Processing exports by		Normal exports By		Aggregate
	COEs	FIEs	COEs	FIE	
Total DVS	35.46	37.30	84.11	79.53	59.17
Total FVS	64.54	62.7	15.89	20.47	40.83
Total Foreign Income Share in Domestic Value-added (TFI)	0.50	16.34	0.76	32.74	11.78
TDNI	34.96	20.96	83.35	46.79	47.39
TFNI	65.04	79.04	16.65	53.21	52.61

Note: This table presents estimates on foreign income shares in processing and normal exports by either COEs or FIEs. TFI denotes total foreign incomes in total domestic value added, TDNI and TFNI denotes total domestic national incomes and foreign incomes of gross exports.

[24] We assume that no Chinese-owned factor income are found in these imported foreign value-added, although we admit that China's outgoing FDI has grown in recent years.

The distribution of gross export income is summarized in Figure 3. For each of the 100 USD gross exports, on average 59.17 USD goes to domestic source and 40.83 USD goes to foreign source. Domestic sourced share is higher. For the 59.17 USD of domestic content in gross exports, 32.35 USD is attributed to the COEs, and 26.82 USD is attributed to the FIEs. The foreign factor owners in COEs receive a negligible income (0.31 USD) out of the 32.35 USD of domestic sourced value by COEs, and foreign factor owners in FIEs receive 11.47 USD worth of income out of the 26.82 USD of domestic-sourced value by FIEs. Adding the 40.83 USD of foreign-sourced value, the total foreign income is 52.61 USD, and the total domestic income is 47.39 USD. Thus, in terms of income, domestic share is lower than domestic content share and lower than foreign content share as well.

Figure 3: the DVS and Income Distribution of 100$ Gross Exports.



Note: this figure describes how 100 USD gross exports from China can be decomposed into domestic and foreign content, by Chinese-owned enterprises (COEs) and foreign-owned enterprises (FIEs), and finally the distribution of gross export income into factors of different nationality.
Source: Based on authors' calculation.

IV.D. Robustness check

In our benchmark estimation, we set the initial values for inter-industry, inter-firm type transaction, final demand, and value added, $z0_j^{lk}$, $y0_j^{lk}$, and $v0_j^{lk}$, based on the available official I/O table and other available statistics. However, different sets of initial values may affect our estimated I/O table by firm types. In addition to the above-mentioned initial values, we performed three alternatives in order to test the sensitivity of our results.

For the first alternative, we adjust the initial value for the direct value added, $v0_j^{lk}$, as the residual of the total gross output minus total intermediate input:

$$v0_j^{lk} = x0_j^{lk} - \sum_o \sum_{i=1}^{K} z0_{ij}^{olk} - \sum_{i=1}^{K} z0_{ij}^{mlk} \qquad \text{where } o,l = C,F \quad \& \, k = N,P \tag{28}$$

Second, we adjust the usage of intermediate inputs by imposing proportionality assumption. Thus, the intermediate input matrix is set as follows:

$$z0_{ij}^{olk} = \left[(x_i^o - e_i^o - y0_i^o)/(x_i - e_i - y_i)\right] \left[(x0_j^{lk} - v0_j^{lk})/(x_j - v_j)\right] z_{ij} \tag{29}$$

$$z0_{ij}^{mlk} = \left[(m_i - y_i^m)/(x_i - e_i - y_i)\right] \left[(x0_j^{lk} - v0_j^{lk})/(x_j - v_j)\right] z_{ij} \tag{30}$$

where $\left[(x0_j^{lk} - v0_j^{lk})/(x_j - v_j)\right]$ is the proportion of intermediate inputs used in sector *j* by firms of type *lk*, relative to total input usage in sector *j*. $\left[(x_i^o - e_i^o - y0_i^o)/(x_i - e_i - y_i)\right]$ is the proportion of input production by firms with ownership *o* (i.e., FIEs or COEs) in sector *i* relative to the total input production in sector *i*. Likewise, $\left[(m_i - y_i^m)/(x_i - e_i - y_i)\right]$ is the imported inputs in sector *i* relative to the total input production in sector *i*.

In the final robustness check, we simultaneously adjust the initial value of value added and input matrix, according to Equations (28) to (30). Table 9 lists the results of direct domestic value added and total domestic content share using different initial values. All alternative initializations provide qualitatively and quantitatively similar patterns and magnitudes. Thus, we conclude that our benchmark estimation is robust, as long as we control for the gross output and value added for each industry by COEs and FIEs from industrial survey data, as well as intermediate imports used for each type of firm from trade statistics.[25]

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[25] Sector level results of these sensitivity tests are listed in the online Appendix C (Table C4). Except for a few cases, most sectors are still in the same range of total DVS as the benchmark. The correlation between benchmark and alternative method 1, for example, is 95%.

Table 9: Robustness Check on Direct DVS and Total DVS Using Different Initial Values.

	Scenario	Processing exports by		Normal exports By		Aggregate
		COEs	FIEs	COEs	FIEs	
Direct domestic content	benchmark	15.58	16.64	22.14	23.00	**19.33**
	alternative 1	11.43	16.32	22.30	23.22	**18.94**
	alternative 2	8.25	10.70	22.40	25.20	**16.53**
	alternative 3	8.58	15.77	22.46	23.77	**18.60**
Total domestic content	benchmark	35.46	37.30	84.11	79.53	**59.17**
	alternative 1	34.49	37.26	84.27	79.00	**59.06**
	alternative 2	34.49	36.72	84.25	79.93	**58.94**
	alternative 3	33.89	37.14	84.34	79.11	**59.00**

Note: This table reports the results of direct domestic value added and total domestic content share using different initial values. See section IV.D for details.

V. Conclusion

In most countries, statistical agencies compile an I/O table at the industry level for the entire economy. However, such I/O tables are not separately available for exporters and non-exporters. The I/O table assumes that only one single homogenous production technology exists for all of the firms (and all of the products) in the same industry category. As such, a single average production technology is regarded to produce the entire output of an industry. In reality, different firms, even those that produce the same products, often use different production technologies, and thus have different I/O coefficients and import intermediate use intensities. This paper proposes an estimation method for reducing the aggregation bias caused by firm heterogeneity in existing I/O tables by combined firm- and industry-level data, thereby making contributions to current vertical specialization and trade in value added literature. In addition, the proposed method can be potentially applied to other developed and developing countries.

To complement existing literature, we propose an extension to the approach of KWW (2012) by considering exports by both foreign invested enterprises and domestic-owned Chinese firms separately for processing exports and normal exports. Processing trade and FIEs play major roles in the fast growth of Chinese exports. However, they also use imported intermediate inputs much more intensively than normal exports by COEs. Thus, it is important to separate domestic production by trade mode and ownership to capture the processing exports and FIEs exports. By extending the theoretical framework of KWW (2012) and applying it to China's firm-level trade and production data, we obtain more detailed estimates on domestic and foreign content shares in Chinese exports. Our empirical results show that the total domestic content share in gross Chinese exports is only 59 percent. Furthermore, processing exports and exports by FIEs have much lower domestic content shares. Within the processing export regime, the domestic content share at the sector level between FIEs and COEs differ across sectors, although the weighted sum is similar. This difference at the sector level justifies our categorization according to ownership and trade mode.

We further study the distribution of GNI by factor ownership. About 52.6 percent of the total Chinese export value is obtained by foreign factors owners. This finding implies that the Chinese local income from exports in value added term may not be as large as what official trade statistics have indicated.

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