Domestic Value Added in Chinese Exports: Firm-level Evidence*

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Abstract

This paper has three goals. First, it proposes empirical methods to assess domestic value added (DVA) of exporters using firm-level and transaction-level data. Second, it uses the methods to document the trend and patterns of DVA in Chinese exports. We find that the domestic value added ratio ($DVAR$) of China's processing exports increased from 49% to 58% from 2000 to 2006, which accounted for most of the increase in the country's DVA in aggregate exports. This upward trend is largely driven by firms' substitution of imported materials with domestic materials, instead of changes in the composition of firms or industries. Third, we examine the determinants of the within-firm increase in DVA. We find that a continuous increase in domestic input varieties, in part due to decreasing input tariffs facing the upstream industries and increasing FDI in the downstream industries, has a positive and quantitatively important impact on firms' $DVAR$. Our results provide a coherent analysis of how Chinese exporters have expanded their activities along global production chains away from the final assembly stages.

Key Words: Domestic value added; Value added trade; China

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"The last two decades have witnessed a rapid growth in global trade. Technology and new players, in particular emerging countries, have changed the pattern of international trade. Production processes are more and more fragmented across firms and countries ... The nature of trade has changed, but our trade data have not ... Many goods are assembled in China, but their commercial value comes from the numerous countries that precede its assembly ... We want to know the value added by each country in the production process of final goods."

– Pascal Lamy, Director-General of World Trade Organization, on "Made in the World" Initiative, 2011

1 Introduction

In 2010, the total value of US imports from China was $383 billion, while the total value of US exports to China was $284 billion. These result in an almost $100 billion trade deficit with China. In 1995, the values of US bilateral imports, exports, and deficit with China were merely $48.5 billion, $24.7 billion and $23.8 billion, respectively. This drastic increase in Chinese exports and the resulting trade deficits have attracted tremendous attention from the academics, policy makers, and mass media. The most heated issue is probably the impact of Chinese imports on the US labor market. In a recent study, Autor, Dorn, and Hanson (2012) find that Chinese imports significantly lower job creation, wages, and labor market participation in the US. Scott (2011) further exclaims that the "growing US trade deficit with China costs 2.8 million jobs between 2001 and 2010."

However, with China being dubbed the "factory of the world," a large part of the boom in its exports is due to its participation in global supply chains particularly toward the final stages of production. Many products that were labelled as "made in China" embody inputs from all around the world. The most-referred-to example is Apple's iPod, for which only US$4 out of a total retail value of US$150 can be attributed to labor in China, with the rest being paid to suppliers around the globe for parts and to Apple as profits (Dedrick, Kraemer and Linden, 2009; 2011). In fact, the iPod example is far from exceptional. As Figure 1 shows, processing exports, which involve firms importing materials for assembling and pure exporting, persistently contributed over 50 percent of Chinese exports from 2000 to 2006. Figure 3 further shows that over 60 percent of US imports from China during the same period belong to processing trade. With this prevalence of processing trade that presumably has low domestic content, any policy analysis based on aggregate statistics of gross trade flows could be misleading.

This paper provides a theoretical framework to study domestic value added (DVA) of a firm and propose empirical methods to measure firm-level DVA directly using customs transaction data. Broadly defined, an exporter's DVA is the difference between the values of exports and imported materials, which may encompass both domestic materials that are produced by the firm itself or by other firms in the domestic economy. Once we come up with an accurate way to compute firm $DVA's$, we can then aggregate them up to the industry and destination country levels and conduct similar analyses done by the literature. While the growing literature on value added trade (e.g., Hummels, Ishii and Yi, 2001; Johnson and Noguera, 2012; Koopman, Zhi, and Wei, 2012, 2013) has already provided useful and comprehensive information about the pattern and the trend of DVA in exports for China and other countries, the standard approach uses industry input-output tables, which requires strong proportionality assumptions. In particular, all firms within the same industry are often assumed to use the same proportion of imported materials, and that a foreign country's share in an industry's imported input use is assumed to be equal to the country's share in aggregate imports. These assumptions may render biases when firms are heterogeneous in terms of production technology and sourcing behavior, particularly when processing exports are pervasive (Koopman, Zhi, and Wei, 2012). Of note, a recent paper by Hummels, Jorgensen, Munch and Xiang (2011) decisively shows how the proportionality assumption is grossly violated in the Danish data even at the finely disaggregated industry level.[1] The main point of departure of this paper is its use of firm-level and customs transaction data instead of industry input-output tables to infer DVA of a firm, an industry, and to a destination country. We examine the determinants of how and why firms increase their DVA in exports. To enhance the accuracy of our firm measures, we focus on the sample of processing exporters that do not sell final output in the domestic market, but with additional assumptions, we extend our methodology to measure DVA in non-processing (ordinary) exports and thus overall Chinese exports.

We first provide a simple theoretical model to show how DVA is optimally determined by a

[1] By using a more detailed IO table that breaks down imports into input use and final use for select Asian countries, Puzzello (2012) shows that the standard proportionality assumptions tend to overstate the domestic content of exports.

profit-maximizing firm. With some standard assumptions, we show that the ratio of domestic value added to exports ($DVAR$) depends only on the share of materials in total sales, markup of the firm, and the industry price index of domestic materials relative to the price index of imported materials. Factors that affect these price indices, such as input tariffs facing the suppliers, foreign direct investment (FDI) in the same industry, and the exchange rate are potential determinants of a firm's $DVAR$. Contrary to the popular press, our model shows that once the share of materials in total sales is controlled for, firm $DVAR$ is independent of labor costs.

Our ground-up approach relies on the use of transaction-level (firm-country-product-year) import and export data for all exporters in China from 2000 to 2006, a period that the country experienced significant industrial transformation and FDI inflow, facilitated by its WTO accession in December 2001. There are several advantages of using the ground-up approach. First, as we discussed above, we are able to sidestep the proportionality assumptions tied to the standard approach. Second, we can better weed out transactions between firms in the domestic economy that may affect the $DVAR$ calculation. For example, firms may buy or sell imported materials in the domestic economy and it is not clear how such transactions are recorded in input-output tables, particularly when dealing with markups and logistic costs. By merging the transaction-level trade data with the manufacturing firm survey data, we identify firms that engage in such activities and then exclude them from our sample to circumvent the biases in measuring industry $DVAR$. Finally, our approach permits a detailed analysis of the drivers of the rising aggregate $DVAR$. In particular, we can assess the relative contributions of the within-firm upgrading and the between-firm allocation of resources to the aggregate upward trend. We can also examine the determinants of the within-firm upgrading, such as firms' substitution between domestic materials and imported materials and rising production costs.

Despite these advantages, our approach has limitations for which we use firm-level data to tackle. Our measures could be subject to potential measurement errors due to some transactions between importers and exporters in the domestic economy. In particular, if a processing firm imports more materials than its need and sells some of the imports to other processing firms, its computed $DVAR$ is biased downward and in the extreme case can be negative. On the other hand, if a processing firm buys imported materials from other processing firms, the computed $DVAR$ can be biased upward towards 1. To limit the upward bias, we use a firm's material-to-sales ratio as an upper bound of the firm's import-to-export ratio. Exporters that import materials purely for production purposes should have sales equal to exports and the material-to-sales ratio weakly greater than the import-to-export ratio. On the other hand, to limit the downward bias, we use the 25th percentile of the foreign content share (i.e., $1 - DVAR$) in non-processing exports in the same industry as the lower bound of all processing firms' foreign content share. This criteria is based on the fact that ordinary (non-processing) exporters in China, unlike processing firms, have to pay import tariffs and thus have stronger incentives to purchase intermediate inputs locally and have a higher average $DVAR$.[2]

Moreover, the production of some domestic materials uses foreign materials. If the embedded foreign content in domestic materials are not accounted for, our $DVAR$ estimates will be biased upward. To address this bias, we use the estimates of foreign content in domestic materials by industry from Koopman, Wang, and Wei (2012) for 2007, and impute the estimates backward for each industry-year, using the weighted average growth rate of the number of ordinary importers across upstream sectors. Finally, to better assure that all imports are being used exclusively for the production of exported goods, we focus on processing exporters that operate within a single industry (aggregates of HS2 categories). This is essential for our industry-level analysis but for our firm-level and aggregate-level analyses, we extend our sample to include multi-industry firms and confirm that the results remain robust and quantitatively similar.

After providing empirical methods to measure DVA at the firm level, the second part of the paper examines the time-series trend, the cross-sectional pattern, and the determinants of exporters' $DVAR$. We find that the $DVAR$ in Chinese processing exports has risen from 49 percent in 2000 to 58 percent in 2006, confirming existing evidence in the literature. We verify that the aggregate upward trend is due to within-industry increase rather than the allocation of resources from low-value added industries to high value added industries. By running firm-level panel regressions, we further show that DVA is increasing not only within industries but also within firms. This within-firm increase is accompanied by a declining share of imported materials in total materials, declining import varieties, and increasing export varieties. The entry and exit of exporters are not the main reason for the rise in the aggregate $DVAR$ and if anything, contributes negatively to the aggregate trend.

[2] This point has been shown by Koopman, Wang, and Wei (2012).

These patterns suggest that firms are substituting imported materials with domestic materials without compromising export sales. We further provide evidence showing that the within-firm increase in the $DVAR$ in exports is associated with the continuous decline in domestic material prices relative to foreign material prices. To deal with potential endogeneity, we use sector-specific exchange rate indices as instruments for the relative prices of imported materials. Similar to Goldberg, Khandelwal, Pavcnik, and Topalova (2010), we find that continuously decreasing input tariffs in China induce the supply of domestic product varieties by non-processing firms. We show that this tariff-induced increase in domestic material varieties from the upstream sectors contributes significantly to the decline in the prices of domestic materials, which in turn drives up processing exporters' $DVAR$.

Despite the paper's focus on processing exports, it should be noted that our methodology has a wider appeal. It can be directly applied to measuring the $DVAR$ of pure exporters. This type of firms is prevalent in many export-oriented industries throughout the world, such as the garment industry in Bangladesh, Cambodia, Dominican Republic, and Mauritius, as well as the electronics industry in Malaysia, Thailand, and Vietnam. Our methodology is also applicable for economies with a small domestic market, such as Singapore where exporters are mainly pure exporters who do not serve the domestic market. Even for exporters that sell in the domestic market, our methodology can be extended to infer their $DVAR$ by assuming a constant share of imported materials in exports and domestic sales. With this proportionality assumption at the firm level, we find that the average $DVAR$ in non-processing exports in China is quite stable during the sample period, implying that most of the rise in the $DVAR$ in Chinese aggregate exports is driven by the increases within the processing export sector, much of it is within processing firms.

This paper relates to the growing literature on domestic value-added trade (e.g., Hummels, Ishii and Yi, 2001; Koopman, Powers, Wang, and Wei, 2012; and Johnson and Noguera, 2012a, 2012b; among others). In particular, it is closely related to Chen, Chang, Fung, and Lau (2001) and Koopman, Wang, and Wei (2012) who gauge and examine the trend of the domestic content in Chinese exports. Using data on trade and input-output tables at the industry level, Koopman, Wang, and Wei (2012) introduce a novel method to estimate DVA separately for processing exports and non-processing exports of China. They show that while DVA rose tremendously from 1997 to 2004 for both types of exports, DVA for processing exports is significantly lower than that of non-processing exports. Importantly, they show that failing to account for the pervasive processing trade in some developing countries can result in a significant upward bias in estimating DVA using the traditional method.[3] Our paper complements Koopman, Wang, and Wei (2012) by providing direct measures of DVA in processing exports using transactions-level data. Consistent with their findings, we also find that DVA in Chinese exports was rising significantly over the same period and is mainly due to the rise in DVA in processing exports but not non-processing exports.

The rest of this paper is organized as follows. Section 2 describes the data source and presents the basic data pattern. Section 3 discusses our methodology and caveats. Section 4 presents the firm-level patterns. Section 5 explores the determinants of the rising DVAR. The last section concludes.

2 Data

The main data set we use covers the universe of Chinese import and export transactions in each month between 2000 and 2006.[4] It reports values (in US dollars) of a firm's exports (and imports) at the HS 8-digit level (over 7000 products)[5] to each destination (from each source) country. This level of disaggregation is the finest for empirical studies in international trade – i.e., transactions at the firm-product-country-month level.

Processing trade has been playing a significant role in driving China's export growth. Figure 1 shows the share of processing exports in aggregate exports in China over 2000-2006. While both processing and ordinary exports have been increasing, the share of processing exports has been consistently around 55 percent of total exports. Table 1 breaks down processing trade by China's major export market, including the US, the EU, Japan, and other East Asian countries. While processing trade increased by over four folds from 100 billions USD to 450 billions, the U.S. consistently ranked as the top destination, accounting for about 25 percent of Chinese total processing exports. Following the U.S. is Hong Kong, which accounted for slightly over 20 percent of the total. Japan has been the third largest market for Chinese processing exports, but its prominence has declined from 18 percent in 2000 to 10 percent in 2006. Figure 3 shows the share

[3] Johnson and Noguera (2012a) adopt the same approach proposed by Koopman, Wang, and Wei (2012) and find that after taking processing trade into account, estimated DVA for both China and Mexico decline significantly.

[4] The same data set has been used by Manova and Zhang (2010) and Ahn, Khandelwal and Wei (2010).

[5] Example of a product: 611241 - Women's or girls'swimwear of synthetic fibres, knitted or crocheted.

of processing exports in each top 10 destinations for 2000 and 2006. Processing exports accounted for 63 percent of Chinese exports to the US in 2006. It was 74 percent for Hong Kong, the highest among the top 10 destinations, and was 28 percent for Italy, the lowest among the top 10 (see Table A1 for details). In sum, processing trade is a major type of exports for China. As pointed out by Koopman et al. (2012), given the high foreign content in processing trade, any analysis based on gross trade flows for China can be highly misleading.

We present in Figure 2 the share of processing exports in 2006 by industry sector, according to the United Nations groupings of HS2 categories. There exists a substantial heterogeneity in the prevalence of processing exports across industries. The share is close to zero for the "Vegetables" sector (HS2 = 6 -14) and as high as 80 percent for the "Machinery, mechanical, and electrical equipment" sector (HS2 = 84-85).

The advantage of focusing on processing exporters is that we need not worry about imports for final consumption. By definition, all imports in processing trade have to be used as intermediate inputs. However, not all processing exporters import for their own use. Some of them import for other processing firms, which also implies that some processing firms export more than what their imported materials can support. As discussed in the introduction, we develop systematic rules to identify processing firms that potentially import from and export for other firms. To this end, we use data from the Annual Surveys of Industrial Firms conducted by China's National Bureau of Statistics (NBS hereafter). The surveys cover all state-owned enterprises (SOEs) and non-state-owned firms that have sales above 5 million yuan in a given year.[6] The NBS data contain detailed information for most of the standard balanced-sheet information, such as firm ownership, output, value added, industry code (480 categories), exports, employment, original value of fixed asset, and intermediate inputs. Table A5-6 present the industry's 25th percentile and median materials-to-sales ratios, the variables that we use to bound the $DVAR$ of processing firms. By definition, the ratio should be always larger than a firm's $DVAR$.

[6] The industry section in the official statistical yearbooks of China is constructed based on the same data source. The unit of analysis is a firm, and not the plant, but other information in the survey suggests that more than 95% of all observations in our sample are single-plant firms. 5 million yuan is roughly exchanged to 600,000 US dollars during the sample period.

3 Methodology

We now define the main variable of interest – domestic value added ratio ($DVAR$), starting from the accounting identity of a firm's total revenue. A firm's total revenue (PY), by definition, consists of the following components: profits, (π), wages (wL), cost of capital (rK), cost of domestic materials $\left(P^D M^D\right)$, and cost of imported materials $\left(P^I M^I\right)$.

$$PY = \pi + wL + rK + P^D M^D + P^I M^I$$

In theory, processing exporters sell all their output abroad and have revenue equal exports (EXP), and have all their processing imports (IMP) equal their cost of imported materials $\left(P^I M^I\right)$. Thus, exports can be expressed as

$$EXP = wL + rK + P^D M^D + IMP + \pi.$$

The domestic value added (DVA) of a processing firm is then equal to exports minus imports as

$$DVA = EXP - IMP = wL + rK + P^D M^D + \pi, \tag{1}$$

which includes wages, cost of capital, cost of domestic materials, and profits. Notice that a firm's DVA contains domestic materials produced by other firms and thus larger than its own value added by definition.[7] In the analysis below, we focus on the ratio of DVA to a firm's gross exports, which is referred to as $DVAR$:

$$DVAR = \frac{DVA}{EXP} = 1 - \frac{P^I M^I}{PY}. \tag{2}$$

Notice that a firm's $DVAR$ depends only on the share of imported materials in total revenue $(\frac{P^I M^I}{PY})$. This is an accounting identity, which is independent of the use of any production function. It highlights that in order to understand a firm's $DVAR$, we should focus on the determinants of the share of imported materials in total sales. To properly study these determinants, we need

[7] Firms' choice between domestic sourcing and in-house production is an important question. We abstract away from this margin of adjustment so that we can aggregate firm values up to the industry and country levels and compare our numbers directly with the existing estimates based on I/O tables. Notice that our approach does not double count DVA as long as we exclude indirect trade between processing firms and focus on mesauring DVA of the processing trade regime. We need additional assumptions to deal with the double counting issue when we measure DVA for non-processing and aggregate exports in the last section of the paper.

to introduce more structure by assuming a specific production function, which is what we will do next.

3.1 Determinants of Firms' Domestic Value Added

For each year t, consider firm i with productivity, ϕ_i, which uses both domestic $\left(M_{it}^D\right)$ and imported materials $\left(M_{it}^I\right)$, alongside capital (K_{it}) and labor (L_{it}) to produce output Y_i, according to the following production production:

$$\begin{aligned} Y_{it} &= \phi_i K_{it}^{\alpha_K} L_{it}^{\alpha_L} M_{it}^{\alpha_M}, && (3) \\ M_{it} &= \left(M_{it}^{D\frac{\sigma-1}{\sigma}} + M_{it}^{I\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}}, && (4) \\ \alpha_K + \alpha_L + \alpha_M &= 1 \text{ and } \sigma > 1. \end{aligned}$$

Each firm faces input prices $\left(r_t, w_t, P_t^D, P_t^I\right)$ for capital, labor, domestic materials, and imported materials. Given (4) it can be shown that the price index of total materials is a constant-elasticity-of-substitution (CES) function over P_t^D and P_t^I :

$$P_t^M = \left(\left(P_t^D\right)^{1-\sigma} + \left(P_t^I\right)^{1-\sigma} \right)^{\frac{1}{1-\sigma}}$$

Firms' cost minimization implies the following total cost of producing Y_{it} units of output:

$$\begin{aligned} C_{it}\left(r_t, w_t, P_t^D, P_t^I, Y_{it}\right) &= \frac{Y_{it}}{\phi_i} \left(\frac{r_t}{\alpha_K}\right)^{\alpha_K} \left(\frac{w_t}{\alpha_L}\right)^{\alpha_L} \left(\frac{P_t^M}{\alpha_M}\right)^{\alpha_M}, \text{ with} && (5) \\ \frac{P_t^M M_{it}}{C_{it}} &= \alpha_M. \end{aligned}$$

Thus, the marginal cost (c_{it}) of producing Y_{it} units of final goods is

$$c_{it} = \frac{\partial C_{it}}{\partial Y_{it}} = \frac{1}{\phi_i} \left(\frac{r_t}{\alpha_K}\right)^{\alpha_K} \left(\frac{w_t}{\alpha_L}\right)^{\alpha_L} \left(\frac{P_t^M}{\alpha_M}\right)^{\alpha_M}, \qquad (6)$$

which is constant over output. Note that while input prices and input elasticities are common across all firms within an industry-year, firms have different productivity, ϕ_i, which results in different marginal cost, c_{it}, across firms. Then we can express the share of imported materials in total revenue as:

$$\begin{aligned}\frac{P_t^I M_{it}^I}{P_{it}Y_{it}} &= \frac{P_t^I M_{it}^I}{P_t^M M_{it}}\frac{P_t^M M_{it}}{C_{it}}\frac{C_{it}}{P_{it}Y_{it}}\\ &= \frac{P_t^I M_{it}^I}{P_t^M M_{it}}\alpha_M\frac{c_{it}}{P_{it}}\\ &= \alpha_M\left(1-\chi_{it}\right)\frac{P_t^I M_{it}^I}{P_t^M M_{it}},\end{aligned}$$

where $\chi_i = \frac{P_{it}-c_{it}}{P_{it}} \in [0,1]$ is the price-cost margin of the firm.[8]

Finally, the share of imported materials in total cost of materials can be obtained by the following minimization problem:

$$\begin{aligned}&\min P_t^I M_{it}^I + P_t^D M_{it}^D\\ s.t.\ M_{it} &= \left(M_{it}^{D\frac{\sigma-1}{\sigma}} + M_{it}^{I\frac{\sigma-1}{\sigma}}\right)^{\frac{\sigma}{\sigma-1}}.\end{aligned}$$

Solving it gives the following ratio of imported material cost to total material cost:

$$\frac{P_t^I M_{it}^I}{P_t^M M_{it}} = \frac{1}{1+\left(\frac{P_t^I}{P_t^D}\right)^{\sigma-1}}. \tag{7}$$

We can then express firm i's $DVAR$ in period t, based on (2), as

$$DVAR_{it} = 1-\alpha_M\left(1-\chi_{it}\right)\frac{1}{1+\left(\frac{P_t^I}{P_t^D}\right)^{\sigma-1}}. \tag{8}$$

According to eq. (8), the determinants of a firm's $DVAR$ can be analyzed as follows:

1. Cross-sectional distribution of $DVAR$ within an industry-year

Given input prices and elasticities, the cross sectional distribution of $DVAR$ within an industry-year depends on the distribution of firm's price-cost margin, χ_i, given that $DVAR$ is an affine

[8] Note that price-cost margin, χ_i is closely related to firm's markup, which is usually defined as

$$\mu_i = \frac{P_{it}}{c_{it}} = \frac{1}{1-\chi_i}.$$

If price equals marginal cost, as it is in the case of perfect competition, χ_i equals 0 and $\mu_i = 1$. When $\mu_i > 1$, then $\chi_i > 0$.

transformation of χ_i. Thus, within an industry-year, a firm with a higher χ_i will have a higher $DVAR$. Factors that affect the price-cost margin will therefore affect firm $DVAR$.

- Perfect Competition

If the industry is perfectly competitive, $\chi_{it} = 0$, $\forall i, t$, the cross-sectional distribution of $DVAR$ degenerates to the following constant that does not vary across firms:

$$DVAR_{it} = 1 - \alpha_M \frac{1}{1 + \left(\frac{P_t^I}{P_t^D}\right)^{\sigma-1}}, \ \forall i, t.$$

- Monopolistic Competition with CES preferences

Under monopolistic competition with CES preferences, $\chi_{it} = \chi, \forall i$, since markup is constant across all firms, the cross-sectional distribution of $DVAR$ degenerates to the following constant that also does not vary across firms within the same industry:

$$DVAR_{it} = 1 - \alpha_M (1 - \chi) \frac{1}{1 + \left(\frac{P_t^I}{P_t^D}\right)^{\sigma-1}}, \ \forall i, t.$$

Note that the cross-sectional distribution of $DVAR$ does not depend on the distribution of firm productivity under CES preferences, as long as markup is constant across firms. Empirically, if we observe varying $DVAR$ across firms within the same industry-year, it indicates that the CES preference assumption is not supported and that the industry is likely not perfectly competitive.

2. Time-series movement of $DVAR$ within firms

Eq. (8) shows that the time-series movement of $DVAR$ is determined by the price of imported inputs to domestic inputs, $\frac{P_t^I}{P_t^D}$, which is common across firms within the same industry-year. Factors that affect $\frac{P_t^I}{P_t^D}$ will affect a firm's $DVAR$ over time. It is worth emphasizing that factors that do not affect $\frac{P_t^I}{P_t^D}$ directly, such as the firm's wages (w) or productivity (ϕ_i), do not directly affect the time-series movement of $DVAR$ within firms.[9]

What are the factors that may influence the relative price of imported materials? One obvious factor is the exchange rate. Let us define the exchange rate, E_t, as the foreign-currency price of a

[9] Domestic wages can still indirectly affect firm $DVAR$ through affecting the price of domestic materials. In the regression analysis below, controlling for the relative price of materials, we should expect no impact on firm $DVAR$.

yuan. The price of imported materials in yuan is then equal to the world price of foreign materials $\left(P_t^{I*}\right)$ divided by E_t:

$$P_t^I = \frac{P_t^{I*}}{E_t}.$$

A depreciation of the yuan (a lower E_t) increases the yuan price of imported materials, resulting in a higher $DVAR_{it}$ according to (8).

Another factor that will affect the relative price of materials could be due to changing supply of input varieties. The CES aggregates of different varieties of domestic and imported inputs are

$$M_{it}^D = \left[\sum_{v=1}^{V_t^D} m_{v_i}^{D\frac{\lambda-1}{\lambda}}\right]^{\frac{\lambda}{\lambda-1}}, M_{it}^I = \left[\sum_{v_i=1}^{V_t^I} m_{v_i}^{I\frac{\lambda-1}{\lambda}}\right]^{\frac{\lambda}{\lambda-1}}, \lambda > 1,$$

where V_t^D and V_t^I are the numbers of domestic varieties and foreign varieties available to the firm. Assume a constant elasticity of substitution, λ, between any two varieties of imported materials, as well as between any two varieties of domestic materials. The average price of imported and domestic materials can be expressed respectively as

$$P_t^D = \left[\sum_{v=1}^{V_t^D} \left(P_{vt}^D\right)^{1-\lambda}\right]^{\frac{1}{1-\lambda}}, \; P_t^I = \left[\sum_{v=1}^{V_t^I} \left(P_{vt}^I\right)^{1-\lambda}\right]^{\frac{1}{1-\lambda}},$$

where P_{vt}^D and P_{vt}^I represent the price of a domestic and a foreign input variety, respectively. An increase in domestic material varieties will increase the relative price of materials and therefore increase firm $DVAR$. On the contrary, an increase in imported material varieties will lower the relative price of materials and lower firm $DVAR$:

$$\begin{aligned} \frac{\partial P_t^D}{\partial V_t^D} &< 0 \Rightarrow \frac{\partial\left(P_t^I/P_t^D\right)}{\partial V_t^D} > 0 \Rightarrow \frac{\partial DVAR_{it}}{\partial V_t^D} > 0; \\ \frac{\partial P_t^I}{\partial V_t^I} &< 0 \Rightarrow \frac{\partial\left(P_t^I/P_t^D\right)}{\partial V_t^I} < 0 \Rightarrow \frac{\partial DVAR_{it}}{\partial V_t^D} < 0. \end{aligned} \tag{9}$$

The logic is the same as the positive effects of an increase in imported varieties on aggregate productivity and welfare (e.g., Broda and Weinstein, 2006 and Feenstra and Kee, 2008).

What cause an increase in domestic and imported material varieties? We explore two previously explored factors. The first factor is related to the increasing foreign direct investment (FDI) in China. Rodriguez-Clare (1996) and Kee (2012) show that an increased presence of FDI in a downstream industry can raise the demand for domestic materials, leading to an increased supply and quality of domestic material varieties, V_t^D, from the upstream industries. Given $\lambda > 1$ in our model, an increase in FDI in the downstream sectors will lower the price of domestic materials, which in turn increase $DVAR$ for all firms in the related industries. More formally, we have

$$\frac{\partial V_t^D}{\partial (FDI_t)} > 0 \Rightarrow \frac{\partial \left(P_t^I/P_t^D\right)}{\partial V_t^D} > 0 \Rightarrow \frac{\partial DVAR_{it}}{\partial (FDI_t)} > 0. \tag{10}$$

The second factor is related to the continuous trade liberalization in China. Goldberg et al. (2010) show that in India, input tariff liberalization results in domestic firms' expansion of product scope. The key reason is that after trade liberalization, domestic firms have cheaper access to existing imported input varieties and access to new input varieties. Over our sample period (2000-2006), China experienced a continuous decline in import tariffs and other trade restrictions, which accelerated after the country's accession to the WTO in 2002. While such liberalizations do not directly affect processing firms, which are always exempted from tariffs on imported materials, tariff reduction could have a significant impact on ordinary (non-processing) exporters, which provide materials to the downstream processing exporters.[10] With cheaper and new access to imported materials after tariff liberalization, ordinary firms experience lower production costs and may produce more varieties. Downstream processing exporters can now purchase these varieties domestically, substituting previously imported input varieties. This substitution at the extensive margin, as we will show in the empirical section, contributes to a higher $DVAR$ for the downstream processing firms. More formally, let's τ_t denote the (average) input tariff of the upstream sectors. Tariff liberalization may increase domestic input varieties, increase the relative price of imported materials, and thus increase the $DVAR$ of downstream exporters:

$$\frac{\partial V_t^D}{\partial (\tau_t)} < 0 \Rightarrow \frac{\partial \left(P_t^I/P_t^D\right)}{\partial V_t^D} > 0 \Rightarrow \frac{\partial DVAR_{it}}{\partial (\tau_t)} < 0. \tag{11}$$

The empirical section below will focus on exploring the relationship between the within-firm

[10] As long as the imported materials stay inside the processing regime, domestic transactions are still exempted from tariffs.

movement of $DVAR$, changes in the exchange rate, input tariffs in the upstream industries, and the value of FDI in the same industry.

3.2 Caveats

3.2.1 About Foreign Content in Domestic Materials

Before using micro-level data to empirically examine the theoretical predictions, let us mention a few caveats about the way we measure firm $DVAR$. The first caveat is about the foreign content in domestic materials and the Chinese content in imported materials. If we compute firm $DVAR$ by strictly following accounting identity (2), we are implicitly assuming zero foreign content in domestic materials and zero Chinese content in imported materials (IMP). If the first assumption is violated (i.e., $P^D M^D$ embodies foreign content), DVA will be over-estimated based on (1). On the other hand, if the second assumption is violated (i.e., IMP embodies domestic content), DVA will be under-estimated. The net bias will depend on the extent each assumption is violated, but there is little information in our data for us to assess the direction of the bias. The existing estimates by Koopman et al. (2012) suggest that for Chinese processing trade, the foreign content in domestic materials is between 5 to 10 percent depending on the sector. We use estimated foreign content in domestic materials by industry for 2007 from their paper and impute the estimates for each industry-year, using the growth rate of the number of ordinary importers in the upstream sectors. The rationale is that the net entry of ordinary importers, stimulated by China's continuous trade liberalization (more below), increases the supply of intermediate inputs that embed foreign content. We use the growth rate at the extensive margin rather than at the intensive margin, based on our findings that the share of imports in total materials of non-processing firms has not been increasing significantly even after China's accession to the WTO in late 2001.[11] See Table A4 for the estimates by industry-year.

3.2.2 About Indirect Importing

Another caveat relates to processing exporters' importing indirectly through other firms. Under the current customs regulations in China, processing firms can legally sell imported materials to other firms and benefited from tariff exemption, as long as the buyer is also a registered processing firm.

[11] Brandt et al. (2012) document similar findings.

Such transactions are not confined within the same industry or geographic location.[12] For example, a shoes processing exporter may import leather and sell it to a handbag processing exporter. The transactions of unused imported materials between two processing firms appear to be widespread according to our data.

This practice of indirect importing certainly impacts the way we construct firm-level $DVAR$ based on (2). In particular, for firms that import more than their needs, which we call "excessive importers", using eq. (2) may underestimate their $DVAR$ and in the extreme case result in a negative $DVAR$.[13] On the other hand, for firms that buy imported materials from other processing firms, which we call "excessive exporters", using (2) may overestimate their $DVAR$, and in the extreme case bias $DVAR$ towards 1.

One way to get around this is to use information from industry input-output tables. However, using input-output tables requires assumptions that all firms within the same industry are homogeneous in terms of products and technology; and that firms allocate imported materials to the production of goods for domestic and foreign sales, proportional to the corresponding shares in total sales. This is not the case from what we observe in the data. Even within a narrowly defined industry, firms can have drastically different product choices and technology. Moreover, some processing firms may consider purchases of imported materials from other processing firms as domestic purchases, while others may consider them as imported materials. On top of this there are markups and domestic transaction costs, such as transportation and distribution costs, involved in domestic trade. All these issues have been sidestepped in the approach that relies on information from industry input-output tables. In this paper, we adopt a completely ground-up approach by relying on firm-level information. Due to indirect exporting, we restrict ourselves to focus on firms that can give us reliable $DVAR$ estimates.

To address the complication due to indirect importing, we first identify both excessive importers and exporters. To this end, we use data from the Annual Surveys of Industrial Firms conducted by China's National Bureau of Statistics (NBS) for 2000-2006, which is referred to as NBS data from now on. In particular, we use a firm's material-to-sales ratio as an upper bound of the firm's import-to-export ratio. Since there is no common firm identifier shared by the two data sets, not all

[12] See Ministry of Commerce of China "*Regulations Concerning Customs Supervision and Control over the Inward Processing and Assembling Operation*":

[13] In the raw data about 10 percent of the single-industry section firms have negative net exports.

firms from the two data sets can be merged.[14] Tables 2 and 3 present the size of the merged sample relative to the full sample.[15] In terms of the number of firms, about 16% of the single-industry processing exporters from the customs were merged with the NBS data and survive our filters that remove excessive importers. In terms of export value, our final sample covers about *32%* of the original customs sample. Importantly, all manufacturing industry sections were covered in almost all years.

Total material costs presumably consist of costs of domestic and imported materials. For these export processing firms, the value of total sales is very close to that of total exports reported in the customs data. Hence, we can use the ratio of total material costs to total sales as an upper bound for a firm's import-to-export ratio as

$$\frac{P^D M^D + P^I M^I}{PY} \geqslant \frac{P^I M^I}{PY} = \frac{IMP}{EXP}. \tag{12}$$

Firms that violate this inequality are identified as excessive importers and are dropped from our sample.

On the other side of the same token, there are processing firms that appear to import too little as they purchase imported materials from other processing firms locally. To identify these excessive exporters, we rely on the $DVAR$ estimates of non-processing (ordinary) exporters within the same industry. We first identify all registered ordinary exporters that only export in a single industry. Unlike processing firms, ordinary exporters are not required by customs regulations to sell all output abroad. They can use imported materials to produce for both domestic and foreign sales. Unlike processing firms, they need to pay import tariffs and thus should have less incentive to import materials. The $DVAR$ of non-processing exporters should be on average higher than that of processing firms in the same industry. To identify the excessive processing exporters (those that have abnormally higher $DVAR$), we use the 25th percentile of $DVAR$ of ordinary exporters as an upper bound for processing firms' $DVAR$. Our regression results are robust to using the

[14] Without a common firm identifier, we use firm names to do the merge. For rare cases that have duplicate firm names, we use the firm's address to improve the merge. Depending on the year, 37-48% of export value in the trade data set is successfully merged to the NBS firm data set. On average, 70% of export value reported in NBS is covered. See Ma, Tang, and Zhang (2012) for details.

[15] There are at least two reasons why the merge is far from perfect. First, the NBS data set contains only manufacturing firms while the customs data contain a significant fraction of trade intermediaries that are considered as service firms by the NBS. Second, the NBS has a minimal threshold of 5 million yuan (approximately 600,000 USD during our sample period). The small processing exporters are not included in the NBS sample.

median of $DVAR$ as the upper bound instead.

In sum, we focus a subset of single-industry processing exporters that have their $\frac{IMP}{EXP}$ bounded between the two cutoffs as follows:

$$\frac{P^D M^D + P^I M^I}{PY} \geqslant \frac{IMP}{EXP} \geqslant \left(\frac{IMP}{EXP}\right)^{OT}_{(25)}, \text{ where} \tag{13}$$

$DVAR^{OT}_{(25)} = 1 - \left(\frac{IMP}{EXP}\right)^{OT}_{(25)}$ is the 25 percentile of the $DVAR$ of ordinary exporters in the same industry.[16] Using this filtered set of firms with excessive importers and exporters removed, we compute the DVA of each industry, using eq. (2).

3.2.3 About Capital Imports

The third caveat is about firms' imports of capital. If a firm imports equipment and machinery as capital for production, the value of these imports should not be counted as imported materials in the same year. The standard adjustment is to use the list of capital goods from the UN BEC website and subtract all capital imports from imported materials.[17] However, this treatment may not be appropriate for some sectors. For instance, an electronic processing firm may import a lot of electronic components as materials for final assembly, while a garment producer may import them as pure capital goods. To flexibly deal with capital imports, we first identify all capital goods at the HS6 level using the UN BEC guideline. To tackle the inter-industry differences in the use of capital, we assume that all capital imports to be materials if the corresponding imports are intra-industry. For example, capital imported by the "Electrical, Machinery, Equipment and Parts" sector (HS = 84) that belong to the same HS2 are considered as imported materials, while all inter-industry imports of capital are considered as capital and are excluded from the calculation of imported materials.

[16] Sometimes, particularly for those industries that use a lot of commodities based materials such as iron, copper and crude oil, firms have incentive to stock up imported materials when the international prices of such commodities are low in order to hedge again rising prices in the future. Thus, for this reason, imports may not be fully used to produce goods for immediate exports. For these firms, the calculation of DVA based on (1) may not be accurate.

There is no easy way to get around the issue of inventory management. As it will be shown in the next section, almost all the negative DVA HS 2 observations are no longer negative once we use (13) to select firms to construct industry DVA. This suggests that while inventory management could be important, it may not affect our results, except for those industries that heavily rely on commodities that have volatile international prices.

[17] Koopman et al. (2012) assume a 10% depreciation of capital across all industries. However, this method may underestimate the value of imported materials if capital in fact are used as materials. Our estimation and empirical results are insensitive to applying their rule to allocating capital services to the value of imported materials.

3.2.4 About Multi-industry Firms

The fourth caveat is about multi-industry exporters. In theory, we can compute $DVAR$ based on eq. (2) for all firms, regardless of how many industries they have businesses in. However, if we need to calculate the DVA in Chinese exports at the industry level, information from multi-industry firms is not too useful. The reason is that for a multi-industry firm, the allocation of imported materials to the production of output in different industries is generally unobservable in the data. Thus, we focus on the subset of export-processing firms that only operate in a single industry sector (15 of them), according to the industry classification by the United Nations.[18] Examples of an industry sector include Chemical Products (HS2 = 28-38), Textiles (HS2 = 50-63), Footwear and Headgear, etc. (HS2 = 64-67), and Machinery, Mechanical, Electrical Equipment (HS2 = 84-85). For these sets of single-industry processing firms, while we do not know the breakdown of its imports into each HS2 or HS6 category, we know that all imports into an industry are used in production of exported products within the same industry (subject to the potential "leakage" problem as discussed above). Using the sample of single-industry exporters, we are able to estimate the average DVA for each industry. In the firm-level regressions, we will also include multi-industry firms to check the robustness of our results.

Let us reiterate the procedures of constructing the firm-level data set. We keep export-processing firms in the transaction-level data set who export in a single industry. We then merge the customs data with the NBS manufacturing production data and apply the rule as specified in (13) to remove the "excessive" importers and exporters. We then use the cleaned sample to conduct sector-level, country-level, and firm-level analyses.

4 Results

4.1 Aggregate Patterns

The cleaned data set is an unbalanced panel of 12,548 observations for 6,270 single-industry processing exporters over 7 years (2000-2006).[19] It covers over 52% of total export value and 20% of the

[18] See http://unstats.un.org/unsd/tradekb/Knowledgebase/HS-Classification-by-Section.
There are originally 20 sectors in the UN list. Sectors 1-3, which are agricultural sectors, are excluded since we cannot match most of the transactions to the manufacturing survey data. Sector 5, a mining sector, and Sector 19 - Arms and Ammunition, are excluded for the same reason.

[19] The number of unique estabishments increases from 1550 in 2000 to 2265 in 2005.

number of single-industry processing exporters as reported in the customs data (see Table 3). We also repeat our firm-level regression analysis using a balanced sample of firms to make sure that all our results are not driven by firm entry and exit. The results remain quantitatively similar.

Our sample covers all 15 industry sectors throughout the sample period. Figure 4 presents the overall results. The (weighted) average $DVAR$ across all industry sectors in Chinese processing exports ($DVAR$) has been rising. It was 49 percent in 2000, and by 2006, it reached 58 percent. Figure 6 shows the distributions of the $DVAR$ across industries for 2000, 2003 and 2006. It is clear that across the board, the share of domestic content in Chinese processing exports is increasing over time. As is also shown in Table A3, the industry sectors that have the highest $DVAR$ in 2006 are Beverages & Spirit (HS2 = 16-24; $DVAR = 0.764$), Vehicles and Aircraft (HS2 = 86-89; $DVAR = 0.690$), and Footwear & Headgear (HS2 = 64-67; $DVAR = 0.687$). In 2000, Beverages & Spirit ($DVAR = 0.640$) and Footwear & Headgear (HS2 = 64-67; $DVAR = 0.598$) remain in the top 3, with Vehicles and Aircraft replaced by Misc. Manufacturing (HS2 = 94-96; $DVAR = 0.651$). Importantly, all values for the top 3 industries' DVAR are lower in 2000. The three industries with lowest $DVAR$ in 2006 are Plastics and Rubber (HS = 39-40; 0.380), Wood and Articles (HS = 44-46; 0.436), and Precious Metals (HS = 71; 0.436). Figure 7 normalizes $DVAR$ of the industry in the first year (usually 2000) to zero and shows the percentage increase in $DVAR$ relative to the first year. As is shown, almost all industry sections exhibit an upward trend in $DVAR$. Out of 15 sector, only 1 sector, Precious Metal (HS2 = 72-83) has lower $DVAR$ in 2006 than that in 2000. Figure 8 further shows that the increase in the aggregate $DVAR$ is mostly driven by within-industry increases in the $DVAR$ rather than between-industry allocation of resources from the low-$DVAR$ industries to the high-$DVAR$ industries.

Across export destinations, $DVAR$ tends to be positively correlated with destination countries' capital abundance and skill abundance (see Figure 9 and Figure 10). Regardless, the rise in the $DVAR$ in Chinese processing exports to most destination countries is across the board.

4.2 Firm-level Analysis

What cause the industry-level $DVAR$ to increase over time? It could be due to firm entry and exit as intense import competition may favor firms with a high $DVAR$. Another reason can be due to within-firm changes in response to the changing economic environment, such as rising production costs or increasing availability of materials in the domestic market. While existing research has documented the rising $DVAR$ in Chinese exports, our approach permits us to run firm-level regressions to disentangle the within-firm changes from the between-firm adjustments.

Specifically, according to accounting identity (2), higher prices of domestic materials will push $DVAR$ up, unless it is offset by a reduction in the firm's profit margin. Alternatively, the rise in the $DVAR$ could be due to processing firms substituting imported materials with domestic materials, an outcome of the expanding domestic segment of global production chains in China. If the second reason is the main culprit behind the rising $DVAR$ in Chinese exports, the potential effects of Chinese exports on the labor market markets in other countries, such as the US, will increase over time even when the volume of gross exports from China stays constant.

In this section, we examine the dynamics of the $DVAR$ and the underlying mechanism by running reduced-form regressions at the firm level, loosely following (8). A more formal analysis of the determinants of firm $DVAR$ will be presented in the next section. For now, we estimate the following regression using the merged data (transaction-level data and firm data):

$$DVAR_{it} = \beta_i + \beta_t + \beta_M \left(\frac{P^D M^D + P^I M^I}{PY} \right)_{it} + \beta_X X_{it} + \epsilon_{it}, \tag{14}$$

where i stands for firm, t represents year, and ϵ_{it} is the regression residual. β_i and β_t are the firm and year fixed effects, respectively. A within-firm increase in $DVAR$ over time will be captured by the increasing year fixed effects:

$$\beta_t > \beta_{t-1}.$$

Based on (8), we include the firm's material-to-sales ratio, $\alpha_M = \frac{P^D M^D + P^I M^I}{PY}$, as a control. We also control for the firm's labor cost share (X_{it}) to verify the usual claim that rising labor costs contribute to the rising DVA in Chinese exports. As (8) shows, a firm's $DVAR$ is independent of its labor costs once α_M is controlled for, so β_X is expected to be insignificant, while β_M is expected to be negative and significant. Controlling for α_M, if β_X is still positive and significant, while $\beta_t' s$ are either not rising or insignificant, then the increasing labor cost is the primary reason for the rising firm $DVAR$. Conversely, if β_X is not positive and not significant, while $\beta_t' s$ are rising and significant, then the results will suggest that some imported materials are being substituted with domestic materials, when the share of material costs in total sales remains unchanged (since α_M is already controlled for). By omitting the dummy for year 2000 in the regression, β_{2001} ... β_{2006} are interpreted as the within-firm increase in $DVAR$ in each year relative to that in 2000.

Table 4 presents our baseline results. Column (1) shows that all year fixed effects are positive, significant and increasing over time, which suggest that firm $DVAR$ is rising during the sample period. Notice that since firm fixed effects are always controlled for, the rise is within firms and is not due to a changing composition of firms. In particular, firm $DVAR$ increases on average by 13 percentage points from 2000 to 2006, which is larger than the aggregate trend of 9 percentage points (see Figure 4). This suggests that exiting firms have a higher $DVAR$ than new entrants on average. In other words, the aggregate upward trend of the $DVAR$ in Chinese exports is entirely driven by firms' increasing DVA in exports. The extensive margin due to firm entry and exit actually slows down the upward trend. Furthermore, since the firm's cost share of materials is always controlled for, the rising $DVAR$ is due to firms' substituting imported materials with domestic materials. These regression results shed light on the pattern of the rising $DVAR$ in Chinese exports, which could not be done using aggregate data.

In columns (2), we add the firm's ratio of wages to sales to examine the conventional view that the rising $DVAR$ is driven by rising labor costs. According to (8), wages should not matter for $DVAR$. The insignificant coefficient on the wage variable supports this prediction. Columns (3) to (4) show the same upward trend in both domestic or foreign firm samples. In column (5), we include firms that operate in multiple industries to ensure that our results are not specific to single-industry firms. Given that we consider broad industry categories, the sample size increases only to 18633. The year dummies remain positive, significant, and increasing over time. The magnitude of each dummy is slightly lower. In summary, our results suggest that the within-firm increase in $DVAR$ is broad based and wide reaching and it is not driven by certain firms or industries.

To further examine whether the within-firm increase in $DVAR$ arises from exporters substituting more imported materials with domestic materials over time, we estimate the following specification according to (7):

$$\left(\frac{IMP}{Material}\right)_{it} = \delta_i + \delta_t + \delta_X X_{it} + \nu_{it}, \tag{15}$$

where $\left(\frac{IMP}{Material}\right)_{it}$ is the share of imported materials in total material cost for firm i in year t, δ_i and δ_t are firm and year fixed effects, respectively. Firm-level controls (X_{it}) include the wage-sales ratio $\left(\frac{wL}{PY}\right)_{it}$ and the (log) capital-labor ratio $\ln\left(\frac{K}{L}\right)_{it}$. If firms are using more domestic materials in place of imported materials, the year fixed effects are expected to be declining, negative and significant:

$$\delta_t < \delta_{t-1}.$$

Table 5 presents results that are in line with this prediction. Similar to Table 4, the year fixed effect for 2000 is excluded and the coefficient on each year dummy is interpreted as the within-firm change in $\left(\frac{IMP}{Material}\right)_{it}$ for that year relative to 2000. Column (1) shows that all year fixed effects are negative, significant, and declining, suggesting that $\left(\frac{IMP}{Material}\right)_{it}$ is indeed declining within firms during the sample period. In particular, a firm's $\left(\frac{IMP}{Material}\right)_{it}$ dropped by about 15 percentage points on average in 2006 compared to 2000. This result supports our previous finding that Chinese processing exporters are substituting more imported materials with domestic materials over time. A firm's wage-sales ratio and capital-labor ratio do not appear to affect its $DVAR$. When we split the sample into the domestic private and foreign firm samples (columns (2)-(3)) or include multi-industry firms (column (4)), we continue to obtain consistent results.

In Table 6, we further examine whether the decline in the share of imported materials in total material cost is in part due to a decline in the variety of imported materials. To this end, we correlate a firm's (log) number of import variety, measured by the number of imported HS6-country pairs at the firm level, on firm fixed effect, γ_i, year fixed effects, γ_t, and the firm-level controls X_{it} as follows:

$$\ln(import\_variety_{it}) = \gamma_i + \gamma_t + \gamma_X X_{it} + \omega_{it}, \tag{16}$$

where X_{it} includes $\left(\frac{wL}{PY}\right)_{it}$ and $\left(\frac{P^D M^D + P^I M^I}{PY}\right)_{it}$ as in (14) and ω_{it} is the regression residual. Consistent with the results in Table 5, all year fixed effects are negative and declining, suggesting that on average, processing firms' import variety is declining over time. At the sample mean, the number of import variety decreased by 0.31 log points in 2006 relative to 2000.[20] Other firm-level controls are insignificant. Columns (2) and (3) show that the decline in import variety mostly happens for foreign firms but not domestic private firms. The results remain robust to the inclusion of multi-industry firms (column (4)). Along with the results from the previous tables, we find that controlling for the material cost share, $DVAR$ is rising within firms over time, while the share of imported materials in total material cost as well as import variety are both declining within firms.

[20] In unreported results, we find that most of the decline is due to firms importing fewer products (HS6) instead of importing from fewer countries.

In other words, processing firms appear to substitute imported inputs with domestic inputs at both the intensive and extensive margins during the sample period.

For processing firms to substitute imported material varieties with domestic varieties, one has to observe an increasing variety of domestic materials during the sample period. Since data on domestic variety is unavailable, we use the export varieties of ordinary (non-processing) exporters. Unlike processing exporters, ordinary exporters consist mainly of indigenous Chinese private firms that also sell in the domestic market. Some of these local Chinese firms become big and start exporting. By tracking the export variety of these ordinary exporters, we are picking up the tip of the iceberg as some of the increase in domestic variety of materials may not have made it to the export market.[21] Nevertheless, the following evidence is insightful. Table 7 lists 34 products that were imported by processing exporters and were not exported by ordinary exporters in 2000. Some of them are important inputs and are used by large firms that export in almost all industries. These products accounted for US$14 million. However by 2006, not only were these products no longer imported by any processing firms, ordinary exporters have started exporting them with a total value of over US$200 million. This suggests that not only was the import demand of processing firms for these products being met by local suppliers, some of those domestic private firms are competitive enough to export such products within the short period of time.[22]

One can argue that the decline in import variety can be due to exporters specializing in their core competency, resulting in fewer export and thus import varieties. To verify this channel, we estimate the following specification:

$$\ln(export\_variety_{it}) = \theta_i + \theta_t + \theta_X X_{it} + u_{it}, \tag{17}$$

where X_{it} includes $\left(\frac{wL}{PY}\right)_{it}$ and $\left(\frac{P^D M^D + P^I M^I}{PY}\right)_{it}$ as in (14). $export\_variety_{it}$ is measured by firm i's number of exported HS6-country pairs. Firm fixed effects (θ_i), year fixed effects (θ_t), and other firm control variables are included as before.

As is shown in Table 8, despite the declining share of imported materials in total material cost

[21] Data on domestic products in China are not available. Thus, we use products produced by ordinary (non-processing) exporters to proxy for domestic variety, in the belief that a firm's export product scope is a subset of its domestic product scope. There could be export varieties that were not sold domestically or vice versa. There could also be domestic varieties produced by non-exporters that were not exported. In these regards, our proxy should be considered as a lower bound of domestic variety.

[22] We thank David Hummels for suggesting this exercise.

and import variety, a processing firm's export variety is rising over time, particularly after 2003, one year after China's accession to the WTO. This increase is particularly pronounced for the small sample of domestic private processing firms (column (3)), and reaches 72 log points in 2006 (though it is only significant at the 10% level). Together with the earlier results, we find evidence that Chinese processing firms have been expanding their product scope while reducing the imports of materials, both at the intensive and extensive margins.

In summary, our results suggest that the domestic content in Chinese processing exports is rising over time. The rise is mainly driven by firms actively substituting imported materials with domestic materials, but not rising production costs. Nevertheless, in the last sample year (2006), Chinese processing exports still embody substantial foreign content (about 40 percent), as many anecdotes and previous research have alluded to.

5 The Determinants of the Rising Firm DVAR

5.1 Two-stage Reduced-form Regressions

What drive exporters' active substitution of imported materials with domestic materials in China? To answer this question, we first present reduced-form regressions before structurally estimating (8) using firm-level data again. In particular, we examine the relationship between the average within-firm change in the $DVAR$ and the relative price index of imported materials, $\frac{P_{jt}^I}{P_{jt}^D}$, across sectors. To estimate the average within-firm change in $DVAR$ by sector, we estimate (14) by allowing year fixed effects to be industry-specific as follows:

$$DVAR_{it} = \beta_i + \beta_{jt} + \beta_M \left(\frac{P^D M^D + P^I M^I}{PY} \right)_{it} + \beta_X X_{it} + \epsilon_{it}.$$

The estimated β_{jt}, $\hat{\beta}_{jt}$, captures the average within-firm change in $DVAR$ of each industry j, relative to 2000.

We then regress $\hat{\beta}_{jt}$ on $\ln \left(\frac{P_{jt}^I}{P_{jt}^D} \right)$ using the panel of industries as

$$\hat{\beta}_{jt} = \omega_j + \omega_p \ln \left(\frac{P_{jt}^I}{P_{jt}^D} \right) + \iota_{jt},$$

where ω_j is an industry fixed effect and ι_{jt} is an error term. Table 9 reports the estimates of eq. (**??**). Since $\hat{\beta}_{jt}$ are estimated with errors, bootstrapped standard errors are used. Column (1) shows a positive and significant correlation between the relative price index of imported materials, $\frac{P^I_{jt}}{P^D_{jt}}$, and the average within-firm change in the $DVAR$ in the same sector. Specifically, we find that a 10% increase in $\frac{P^I_{jt}}{P^D_{jt}}$ is associated with 2.4 percentage-point increase in the firm $DVAR$. During the sample period, average industry $\frac{P^I_{jt}}{P^D_{jt}}$ increased by 38%, the estimated coefficient implies a 9 percentage-point increase in firms' $DVAR$ on average. From Table 4, we know that firms on average increase their $DVAR$ by 13% between 2000 and 2006, which means that the change in the relative price of imported materials on average account for 70% of the within-firm increase in $DVAR$.

Endogeneity could be a concern. For example, higher firms' $DVAR$ can induce a higher supply of domestic materials, which lower domestic material prices. To tackle potential endogeneity issues, we use the exchange rates facing processing importers in the same sector as an instrument for $\frac{P^I_{jt}}{P^D_{jt}}$. Given the price of imported materials, P^{I*}_{jt}, a RMB appreciation (higher E) is associated with a lower $\frac{P^I_{jt}}{P^D_{jt}}$. To compute exchange rates that are comparable across sectors and years, we first set all exchange rate equal to 1 in 2000. Then we use the Tornqvist method to compute the import-weighted exchange rate index for each exporting sector-year, using the shares of imports from each source country by firms operating in the same sector in consecutive years as weights (see the Appendix for details). Column (2) shows a negative coefficient on the (log) import-weighed exchange rate index in the first stage, suggesting that a stronger RMB does induce firms to switch to purchasing more materials from abroad. In 2006, the simple average of the (log) import-weighted exchange rate index across sectors is about 0.03. The coefficient of -1.56 in the first stage implies a decrease of $\frac{P^I_{jt}}{P^D_{jt}}$ by about 4.7%. Notice that all else equal, a lower $\frac{P^I_{jt}}{P^D_{jt}}$ implies a lower firm DVAR not higher as we have documented so far. In other words, exchange rate changes during the sample period do not appear to be a main factor for the rising DVAR in China, though its variation across sectors and years do make it a valid instrument for $\frac{P^I_{jt}}{P^D_{jt}}$. Importantly, by instrumenting $\frac{P^I_{jt}}{P^D_{jt}}$ by the exchange rate index, we continue to find a positive and significant effect of $\frac{P^I_{jt}}{P^D_{jt}}$ on the change in the $DVAR$.

If exchange rate fluctuation is not a main determinant of the rising firm $DVAR$, what is? According to eq. (9), an increased in the supply of domestic input varieties (relative to imported varieties) can lower $\frac{P^I_{jt}}{P^D_{jt}}$. Since data on domestic varieties are not available in our data, we use the weighted average of the number of HS6 products exported by non-processing firms in the upstream sectors as a proxy for domestic upstream varieties, in the belief that a firm's export product scope is a subset of its domestic product scope.[23] Specifically, we compute the weighted average of the number of upstream varieties by $V_{jt} = \sum_{i=1}^{I} s_{ij} V_{it}$, where s_{ij} is the share of sector $i's$ goods used in total input costs of sector j, according to the Chinese input-output table for 2002. V_{it} is the number of HS6 products exported by non-processing firms in sector i in year t.

As reported in Table A7 in the appendix, the number of varieties available to the downstream processing exporters is increasing over time for most sectors. Some sectors have systematically higher input varieties (e.g. machinery, mechanical, and electrical equipment). This industry-specific feature is already controlled for by industry fixed effects in the regressions. We measure imported input varieties by the number of HS6 products imported by processing firms in the same sector. Tables 6 and A8 show that for most sectors, the number of imported varieties decrease over time.

We then regress $\frac{P^I_{jt}}{P^D_{jt}}$ on the ratio of the number of imported input varieties to domestic upstream varieties, relative to 2000, $\ln\left(\frac{V^I_{jt}}{V^D_{jt}} / \frac{V^I_{j,00}}{V^D_{j,00}}\right)$. Column (3) shows a negative and significant relationship between $\ln\left(\frac{V^I_{jt}}{V^D_{jt}} / \frac{V^I_{j,00}}{V^D_{j,00}}\right)$ and $\ln\left(\frac{P^I_{jt}}{P^D_{jt}}\right)$, supporting our theoretical prediction that more domestic varieties are associated with lower domestic material prices. During the sample period, the mean $\frac{V^I_{jt}}{V^D_{jt}}$ decline by 28 log points (32%) from 2000 to 2006. The coefficient of -7.4 suggests that this amount of the decline in $\frac{V^I_{jt}}{V^D_{jt}}$ is associated with a 24% increase in $\frac{P^I_{jt}}{P^D_{jt}}$, which roughly account for 62% of its total decline (38%) during the sample period. The 24% increase in $\frac{P^I_{jt}}{P^D_{jt}}$ then in turn contributes about 6 percentage-point increase in the average firm DVAR (0.24*0.24 from column (1)). In the last column, we confirm that the variety channel remains robust after controlling for the import-weighted exchange rates, the one that we used in the first stage in column (2).

After confirming the importance of the variety channel, we then explore the causes of the increase (decrease) in local (imported) material varieties. One possible cause is the decreasing tariffs facing the upstream input suppliers. As discussed in Section 3.1, input tariff liberalization can result in an

[23] There could be export varieties that were not sold domestically or vice versa. There could also be domestic varieties produced by non-exporters that were not exported. In these regards, our proxy should be considered as a lower bound of the number of domestic varieties.

expansion of the product scope of domestic firms (Goldberg et al., 2010). Over our sample period, China experienced a continuous decline in input tariffs, which was accelerated by the country's accession to the WTO in 2002. It is worth highlighting again that processing firms are exempted from tariffs for imported materials, so tariff reduction will not affect their production costs directly but only indirectly through other general equilibrium effects in the domestic economy. If tariff reduction does indeed lead to an increased supply of input varieties in the domestic upstream sectors, the average price of domestic materials will decrease relative to imported materials, contributing to the rise in processing exporters' $DVAR$.

Computing a sector's upstream tariffs involves two steps. For each upstream sector, input tariffs are measured as a weighted average of tariffs facing the input suppliers to the sector. Specifically, we obtain the share of sector i's inputs in total material cost in sector j, s_{ij}, from the Chinese I/O table for 2002. Then we compute the weighted average of input tariffs for sector j as $\widetilde{\tau}_{jt} = \sum_{i=1}^{I} s_{ij}\tau_{it}$, where τ_{it} is the average tariff rate for sector i in year t and I is the total number of sectors. Finally, for each downstream sector, we use the I/O coefficients again to compute the weighted average of upstream tariffs $\widetilde{\tau}_{kt}^{U} = \sum_{j=1}^{I} s_{jk}\widetilde{\tau}_{jt}$. We then correlate $\widetilde{\tau}_{kt}^{U}$ with the (log) number of imported and domestic material varieties of downstream sector k across years. Table 10 shows that controlling for sector fixed effects, higher upstream tariffs are indeed associated with more imported varieties relative to upstream varieties. Specifically, column (1) shows that a 10% increase in the average upstream tariffs is associated with a 3.4% decline in the ratio of input varieties imported by the downstream sector (relative to the corresponding levels in 2000).

We also explore the relationship between FDI flows and the firm average $DVAR$ across sectors and years. As is proposed by Rodriguez-Clare (1996) and Kee (2012), an increased prevalence of FDI in a downstream industry can raise the demand for domestic materials, leading to an increased supply and quality of domestic material varieties to that industry. Column (2) shows a negative correlation between the change in FDI flows (relative to 2000) into the sector and the ratio of imported material varieties to domestic material varieties. However, the FDI effects become insignificant when upstream tariffs are controlled for (column (3)). These results provide a key reason for why the relative price of imported materials increases, encouraging downstream firms to substitute imported materials with domestic materials.

5.2 Quantitative Analysis

After reporting the reduced-form regression results, we quantify the effects of the changes in the relative prices of imported materials on firm $DVAR$. To this end, we need to first estimate σ, the elasticity of substitution between domestic and foreign input varieties.[24] According to our model, there are several ways to estimate σ, but the equation that requires the minimal amount of information is (7). It specifies that given firm share of imported materials in total cost of materials, $\frac{P_t^I M_{it}^I}{P_t^M M_{it}}$, and the ratio of the sector price index of imported materials to domestic materials, $\frac{P_t^I}{P_t^D}$, we can estimate σ for the whole sample and by sector. Specifically, rearranging (7) yields the following empirical specification for estimating σ:

$$\ln\left(\frac{P_t^D M_{it}^D}{P_t^I M_{it}^I}\right) = (\sigma - 1)\ln\left(\frac{P_t^I}{P_t^D}\right) + \zeta_i + \xi_{it}. \tag{18}$$

where ζ_i is the firm fixed effect and ξ_{it} is the residual. Notice that this approach does not require any information or assumption about firms' markups.

Since the dependent variables are measured with errors, we include firm fixed effects and bootstrap the standard errors. In other words, $(\sigma - 1)$ is estimated from the within-firm variation in material prices and the cost share of imported materials. Table 11 shows the estimated $\widehat{\sigma - 1}$ for the whole sample and for each sector. The estimate for the whole sample is 2.12 and is statistically significant at the 1% level. The estimates are significant for 10 of the 15 sectors. Of these 10 sectors, the implied σ's range from 2.58 for "Machinery, mechanical, and electrical equipment (HS2 = 84-85)" to 5.81 for "Textiles (HS2 = 50-63)". Even for the sectors for which the estimates are imprecise, the coefficients are positive, implying that the implied σ is larger than 1. In other words, foreign and domestic input varieties are gross substitutes for all processing sectors in China.

Depending on σ, the effect of a change in $\frac{P_{jt}^I}{P_{jt}^D}$ on firms' $DVAR$ can be very different. While eq. (11) does not let us estimate the impact on firms' $DVAR$, we can rearrange eq. (8), take log, and substitute $\alpha_M (1 - \chi_{it})$ with $P_t^M M_{it}/P_{it}Y_{it}$ to obtain

$$\ln\left(\frac{P_t^M M_{it}/P_{it}Y_{it}}{1 - DVAR_{it}} - 1\right) = \left(\widehat{\sigma - 1}\right)\ln\left(\frac{P_{jt}^I}{P_{jt}^D}\right). \tag{19}$$

[24] Notice that σ is not the elasticity of substitution between different imported varieties, as Broda and Weinstein (2006) report in their paper.

Thus, given three values: sector-specific σ, the firm's cost share of materials, $\frac{P_t^M M_{it}}{P_{it} Y_{it}}$ (which is independent of $\frac{P_t^I}{P_t^D}$ according to our model), and $\frac{P_t^I}{P_t^D}$, we can estimate a firm's $DVAR$ in year t relative to 2000 as

$$\widehat{DVAR}_{it} = 1 - \left(\frac{P_t^M M_{it}}{P_{it} Y_{it}}\right) \left[1 + \exp\left[\left(\widehat{\sigma - 1}\right) \ln\left(\frac{P_{jt}^I}{P_{jt}^D}\right) + \ln\left(\frac{P_{00}^M M_{i,00}/P_{i,00} Y_{i,00}}{1 - DVAR_{i,00}} - 1\right)\right]\right]^{-1}$$

Simple regressions show that these three variables can explain 42% of the variation in firm $DVAR$ in 2001 and 34% in the next 5 years (2001-2006). Intuitively, the elasticity of a firm's $DVAR$ to a change in $\frac{P_{jt}^I}{P_{jt}^D}$ is increasing in σ, but the relationship is non-linear and depends on the cost share of materials in total sales (implicitly on markups) in the current year and the base year, the level of $DVAR$ in the base year, and the relative price index of imported materials. More specifically, the semi-elasticity is as follows:

$$\frac{d\widehat{DVAR}_{it}}{d\ln\left(\frac{P_{jt}^I}{P_{jt}^D}\right)} = \left(\widehat{\sigma - 1}\right)\left(\frac{P_t^M M_{it}}{P_{it} Y_{it}}\right) \frac{\exp\left[\left(\widehat{\sigma - 1}\right) \ln\left(\frac{P_{jt}^I}{P_{jt}^D}\right) + \ln\left(\frac{P_{00}^M M_{i,00}/P_{i,00} Y_{i,00}}{1 - DVAR_{i,00}} - 1\right)\right]}{\left[1 + \exp\left[\left(\widehat{\sigma - 1}\right) \ln\left(\frac{P_{jt}^I}{P_{jt}^D}\right) + \ln\left(\frac{P_{00}^M M_{i,00}/P_{i,00} Y_{i,00}}{1 - DVAR_{i,00}} - 1\right)\right]\right]^2}.$$

6 Extension to Non-Processing and Aggregate Exports

The methodology we have developed above is suitable for pure exporters that handle importing of materials themselves, such as processing exporters in China. It is possible to extend our methodology to ordinary (non-processing) firms if we impose make one proportionality assumption at the firm level, i.e., the allocation of imported materials to the production of exported goods is proportional to the share of exports in total sales. We need this assumption because, first, unlike processing exporters, ordinary exporters can import materials for multiple purposes, including direct domestic sales, production for domestic sales, and production for exports. Using eq. (2) will likely underestimate the $DVAR$ in ordinary exports, as it ignores the first two purposes of imported material use and attributes all imports to the production for exports. To reduce the bias, the goal is to remove the portion of imported material use for the first two purposes, but information about how firms split their imported materials between domestic and export production is generally unavailable. We thus make the firm-level proportionality assumption to take out the portion of imported materials for production for domestic sales, before computing an exporter's $DVAR$. Note that our proportionality assumption will likely be non-binding if firms produce the same products for both the domestic and export markets. In addition, it is considerably less restrictive than the sector-level proportionality assumption commonly made by the existing literature, as we still allow firms to be heterogeneous in terms of their shares of exports in total sales. For a non-processing exporter, we define DVA and $DVAR$ as follows:

$$DVA^{OT} = EXP - IMP\left(\frac{EXP}{PY}\right) \tag{20}$$

$$DVAR^{OT} = \frac{DVA}{EXP} = 1 - \frac{IMP}{PY}, \tag{21}$$

where the superscript 'OT' stands for ordinary trade. Similar to processing exports, there are transactions between non-processing exporters and the rest of the economy. After the adjustment based on the proportionality assumption, we drop firms that have $\frac{IMP}{EXP} > \frac{material}{Total\_Sales}$ (i.e., drop the excessive importers that violate (12)). However, unlike what we can do for the processing exporters that export excessively, there is no corresponding filter we can use to drop the excessive ordinary exporters. Unintentionally keeping those excessive exporters will result in an overestimation of $DVAR$ in ordinary exports. This is a caveat to keep in mind. Finally, to deal with the possibility that domestic materials contain foreign content, we use the estimated foreign content based on Koopman, et al. (2012), similar to what we do when we compute processing $DVAR$.

We can measure the $DVAR$ in Chinese aggregate exports, by taking the weighted average of processing $DVAR$ and ordinary $DVAR$, with weights equal to the corresponding export shares.[25] Intuitively, given that over half of Chinese exports are from the processing regime, the $DVAR$ in Chinese total exports is largely driven by changes in processing exports. Figure 11 shows that the $DVAR$ in China's aggregate exports increased from 0.67 to 0.72 between 2000 and 2006. The main message here is that the DVA in Chinese exports has increased significantly in recent years, with almost all of it being driven by the increase in DVA in processing exports instead of ordinary exports.

[25] Here we measure the $DVAR$ for single-industry exporters only. As we have done for processing exports, we can also measure it for both single- and multiple-industry firms. The drawback is that excessive processing importers are identified as those that have import-export less the 25th percentile of the $DVAR$ of ordinary exporters in the same year, but not the same sector-year. The numbers are available upon request.

7 Conclusions

This paper proposes a ground-up approach to assess a country's domestic value added (DVA) in exports using transaction-level trade data and firm-level production data. By applying our methods to measuring Chinese processing trade, we find that the DVA ratio ($DVAR$) of Chinese processing exports increased from 49 percent in 2000 to 58 percent in 2006. This drastic increase in DVA in exports is observed across all industries. Given the prevalence of processing trade in China, such an increase accounts for most of the rise in DVA in the country's aggregate exports during the period. These findings resonate well with the existing literature that relies on input-output tables as the basis for analysis, such as Koopman, Wang, and Wei (2012).

Our firm-level approach permits an analysis of the micro patterns and dynamics behind the rising $DVAR$ at the aggregate level. The rise is a within-industry and within-firm phenomenon. Reallocation of resources across industries and entry and exit of firms both have a negative effect on the aggregate $DVAR$.

We build a simple model to analyze the determinants of a firm's $DVAR$. With reasonable assumptions, we show that the key factor that affects a firm's $DVAR$ is the relative price of imported materials to domestic materials, not labor and capital costs. Firm-level regressions confirm that the rising $DVAR$ is not driven by changes in labor costs, but an active substitution of imported materials with domestic materials. This substitution is revealed at both the intensive margin, represented by a lower cost share of imported materials, and the extensive margin, manifested by decreasing imported varieties. Behind this substitution is a continuous decline in the prices of domestic input varieties relative to imported varieties. We find that during the sample period, the continuous tariff liberalization facing the upstream industries have quantitatively significant effects on domestically produced input varieties and their prices. Exchange rates play a limited role in shaping exporters' DVA. These micro-level findings provide coherent explanations about how Chinese exporters have expanded their activities along global production chains away from the final stages of production.

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8 Data Description

8.1 Transforming Chinese I/O Tables to One Based on UN Industry Code

1. Use the concordance from China's National Bureau of Statistics to match multiple IO codes with multiple HS 6-digit codes (revision 2002).

2. Match multiple HS6 codes to multiple UN industry section codes (20 of them).

3. For each IO code, pick the UN code that has the largest number of HS6 shared. This will guarantee that all IO codes will be covered.

4. For UN codes that are matched with multiple IO codes, manually choose a unique UN code for the match. It happens in only one case.

5. Then add up the values of intermediate inputs for each pair of upstream-downstream relationship. A matrix of 20 groups by 20 groups will be built.

6. Recompute the IO coefficients based on the UN industry section classification.

8.2 Computing Sector-specific Exchange Rate Indices

We use the Tornqvist method to construct a sector-specific time-varying exchange rate. For each sector i, let I_{it} be the set of common countries firms in sector i import from in two consecutive years, t and $t-1$. Denote country c's currency price of a yuan in year t and $t-1$ by E_{ct} and E_{ct-1}; and denote country c's shares in sector $i's$ total imports in year t and $t-1$ by s_{ct} and s_{ct-1}. The firm-specific rate of yuan appreciation with respect to the countries sector i imports from in year t is defined as

$$d\ln E_{it} = \sum_{c\in I_{it}} \frac{1}{2}\left(s_{ct} + s_{c,t-1}\right)\left(\ln E_{ct} - \ln E_{c,t-1}\right).$$

Using this weighted average of appreciation rates, we define the sector-specific exchange rate for imports as

$$E_{it} = E_{i_{t-1}} \exp\left(d\ln E_{it}\right),$$

with E_{it} normalized to 1 in the base year (i.e., 2000) or any starting year for each sector.

8.3 Computing Sector-specific Domestic Input Price Indices

Computing the input price indices involve two steps. First, we use the Tornqvist method to construct a sector-specific time-varying domestic input price indices. For each sector j (15 of them), let I_{jt} be the set of common subsectors in two consecutive years, t and $t-1$. Denote subsector s's output price index in year t and $t-1$ by P_{st} and $P_{s,t-1}$; and denote the share of subsector s's sales in sector $j's$ total sales in year t and $t-1$ by ω_{st} and $\omega_{s,t-1}$. Data on output price indices at the 4-digit sector level (based on China's NBS classification) are obtained from Brandt et al. (2012).[26] The sector-specific rate of output price inflation in year t is defined as

$$d\ln \widetilde{P}_{jt} = \sum_{j\in I_{it}} \frac{1}{2}\left(\omega_{st} + \omega_{s,t-1}\right)\left(\ln P_{st} - \ln P_{s,t-1}\right).$$

Using this weighted average of inflation rates, the sector-specific output price level is defined as

$$\widetilde{P}_{jt} = \widetilde{P}_{j,t-1} \exp\left(d\ln \widetilde{P}_{jt}\right),$$

with $\widetilde{P}_{jt}$ normalized to 1 in 2000.

The second step is to compute the weighted average of $\widetilde{P}_{jt}$, with weights equal to the coefficients from the Chinese I/O table for 2002. The goal is to compute the average domestic prices facing processing firms in sector j. Specifically, for each sector j, the weighted average of input prices is $P_{jt}^{D} = \sum_{k=1}^{J} a_k \widetilde{P}_{jt}$, where a_k is the share of sector k goods in total material costs for production of a unit of sector j goods. Notice that P_{jt}^{D} varies across time purely due to the variation in $\widetilde{P}_{jt}$, since a_k is fixed throughout the sample.

8.4 Computing Sector-specific Imported Input Price Indices

Computing the imported input indices also involve two steps. First, we use the Tornqvist method to construct a sector-specific time-varying import price indices. For each sector j (15 of them), let I_{jt} be the set of common subsectors in two consecutive years, t and $t-1$. Denote product s's (at the HS 8-digit level) import prices in year t and $t-1$ by p_{st}^{I} and $p_{s,t-1}^{I}$; and denote the share of product s's imports in sector $j's$ total imports in year t and $t-1$ by ϖ_{st} and $\varpi_{s,t-1}$. Product-level import

[26] http://www.econ.kuleuven.be/public/N07057/CHINA/appendix/

prices (by processing firms only) are computed as total import value divided by total quantity of import at the HS8 level, using customs transaction-level data. Then sector-specific rate of import price inflation in year t is defined as

$$d\ln \widetilde{P}^I_{jt} = \sum_{j\in I_{it}} \frac{1}{2}\left(\varpi_{st} + \varpi_{s,t-1}\right)\left(\ln p^I_{st} - \ln p^I_{s,t-1}\right).$$

Using this weighted average of inflation rates, the sector-specific import price level is defined as

$$\widetilde{P}^I_{jt} = \widetilde{P}^I_{j,t-1}\exp\left(d\ln \widetilde{P}^I_{jt}\right),$$

with $\widetilde{P}^I_{jt}$ normalized to 1 in 2000.

The second step is to compute the weighted average of $\widetilde{P}^I_{jt}$, with weights equal to the coefficients from the Chinese I/O table for 2002. The goal is to compute the average imported input prices facing processing firms in sector j. Specifically, for each sector j, the weighted average of imported input prices is $P^I_{jt} = b_k \widetilde{P}^I_{jt}$, where b_k is the share of sector k goods in total material costs for production of a unit of sector j goods. Notice that P^I_{jt} varies across time purely due to the variation in $\widetilde{P}^I_{jt}$, since b_k is fixed throughout the sample.

9 Figures and Tables

Figure 1: Share of Chinese Processing Exports, 2000-2006

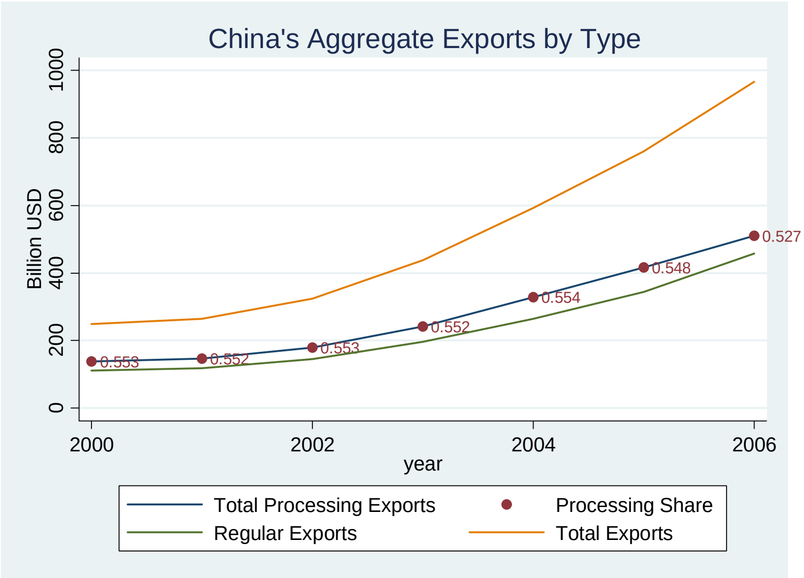

Figure 2: Shares of Processing Exports by Industry Group (2006)

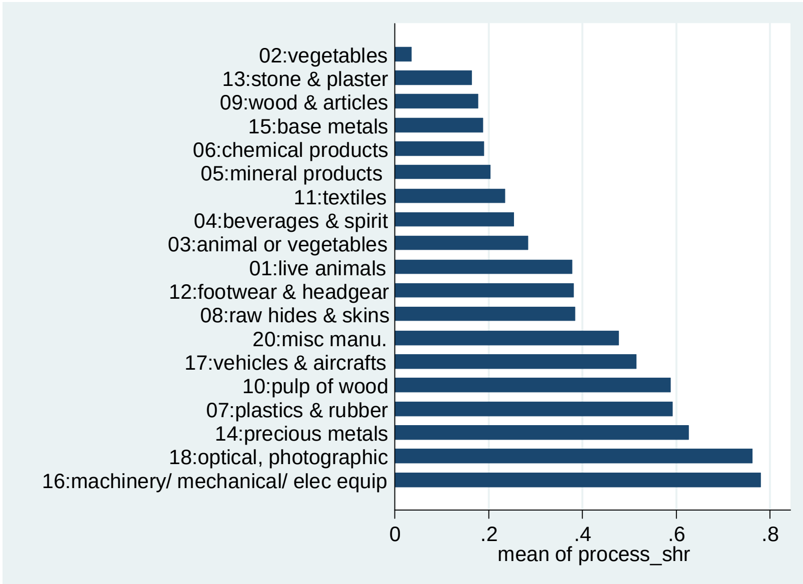

Figure 3: Shares of Processing Exports in Top Destinations (2000, 2006)

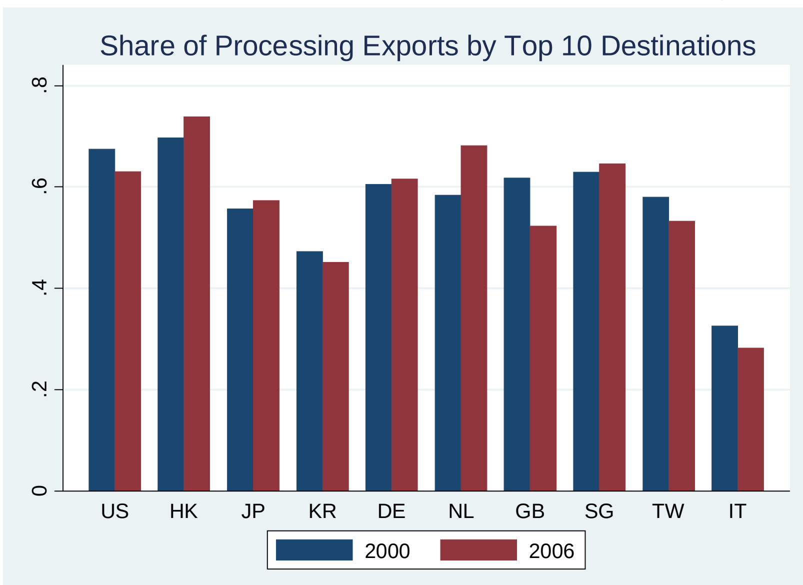

Figure 4: DVAR in Processing Exports (2000-2006)

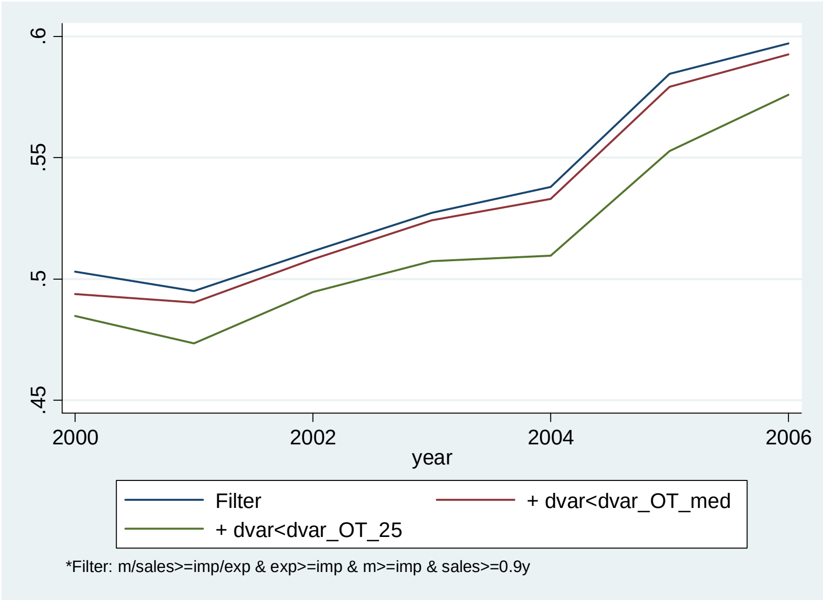

Figure 5: DVAR in Processing Exports (including multiple-industry firms)

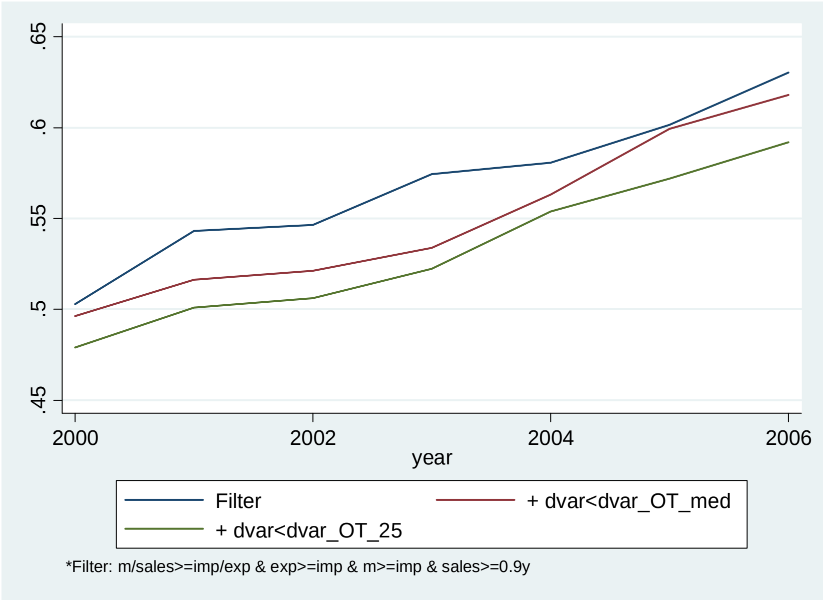

Figure 6: Distributions of DVAR across Industry Sectors (2000-2006)

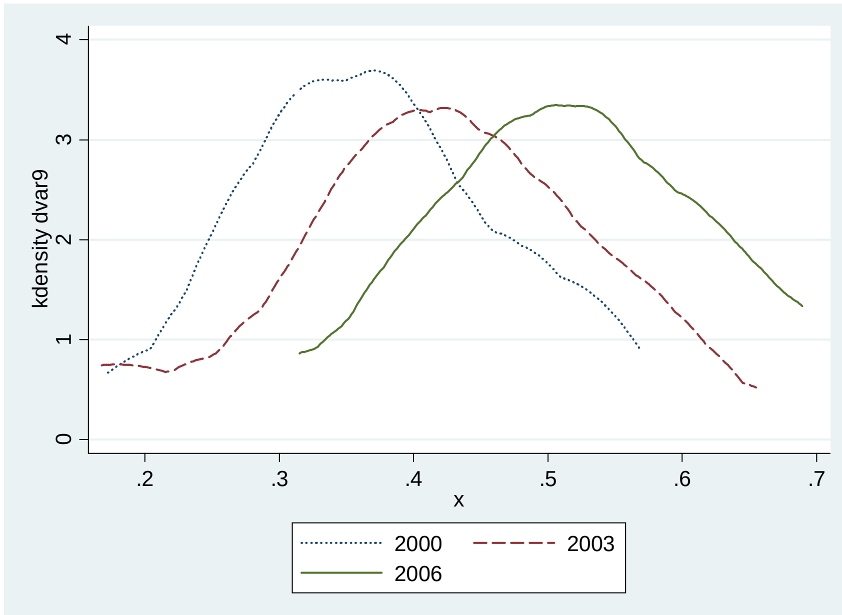

Figure 7: DVAR Trend (2000-2006) by Industry Sector

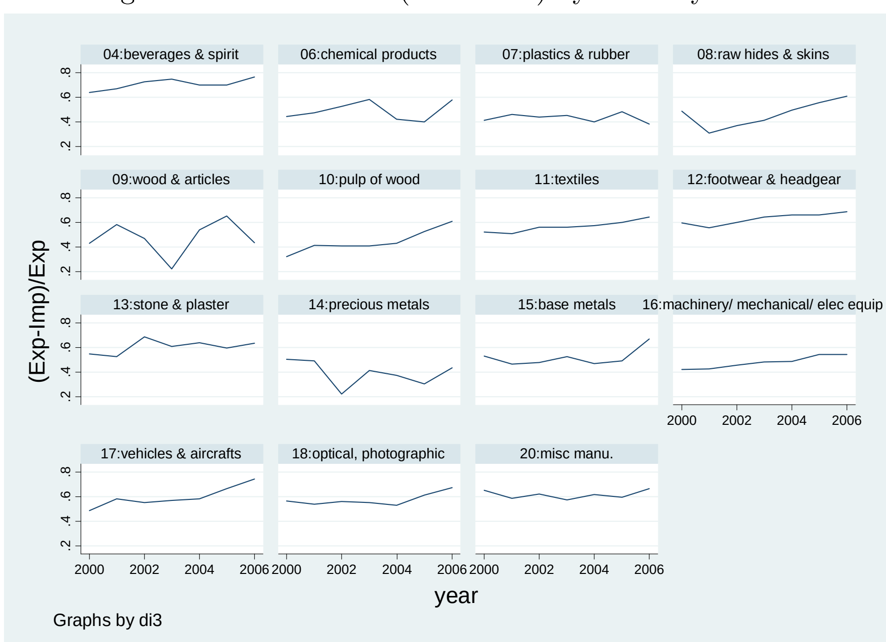

Figure 8: Decomposing the Growth in DVAR into Within-industry and Between-industry Growth

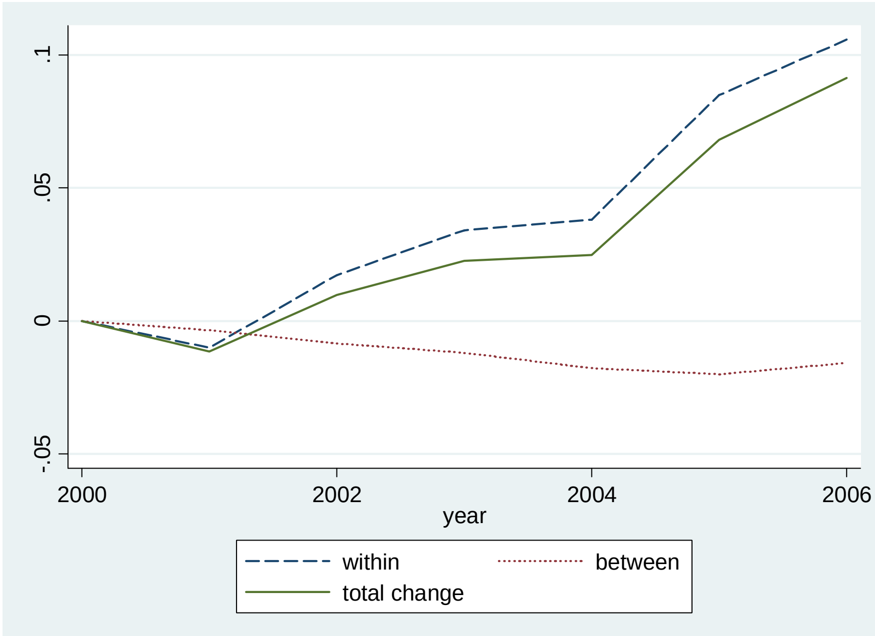

Figure 9: DVAR vs. Destinations' Capital Endowment (2006)

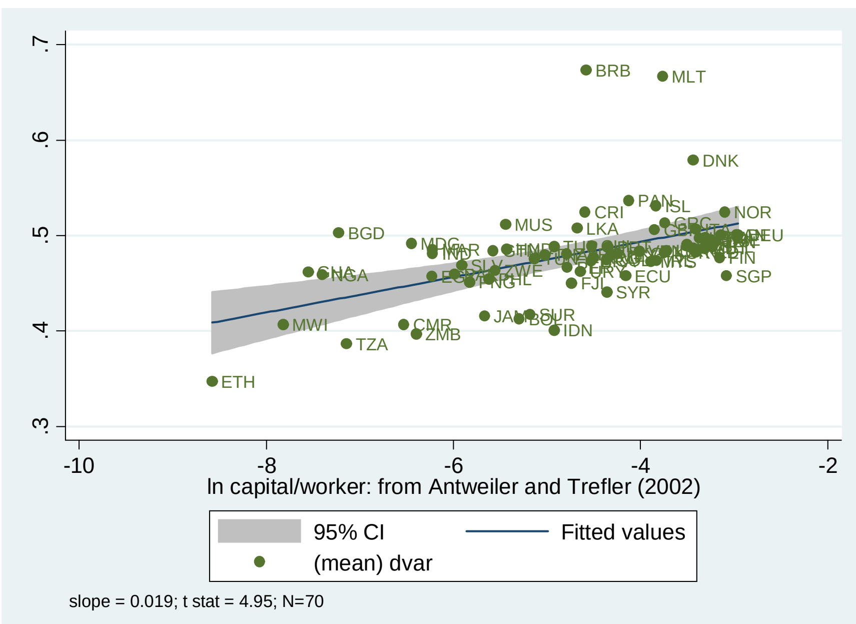

Figure 10: DVAR vs. Destinations' Human Capital Endowment (2006)

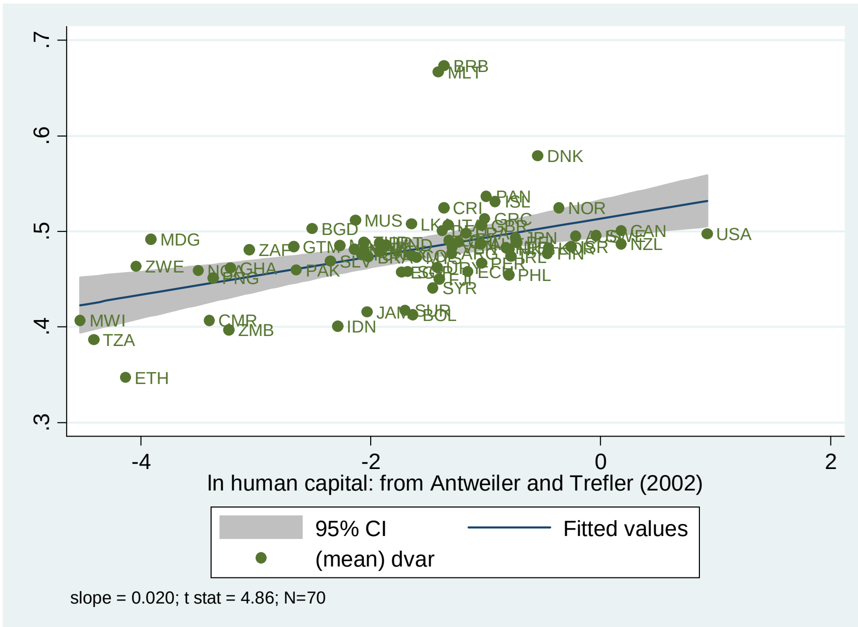

Figure 11: DVAR in Chinese Aggregate Exports (2000-2006)

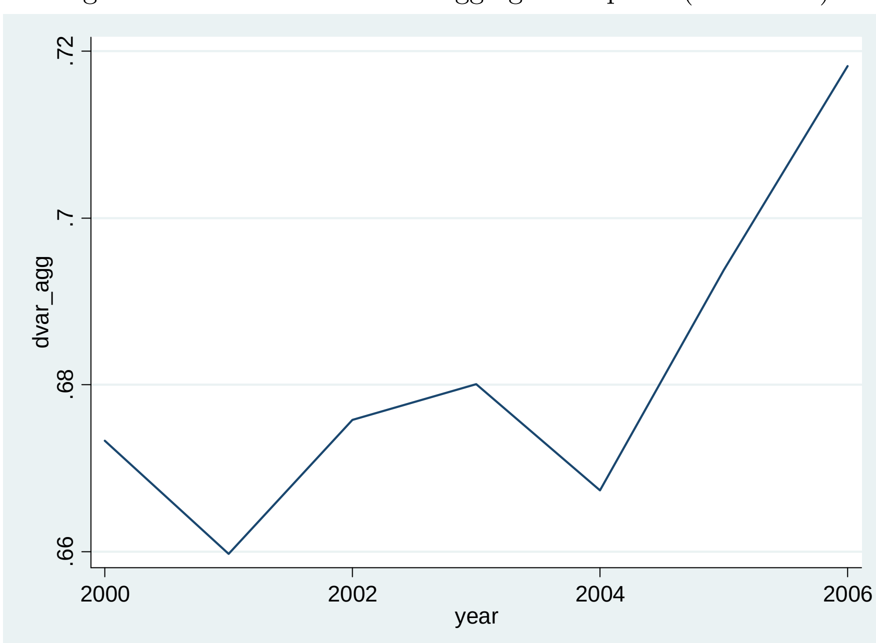

Table 1: Top 10 Destinations for China's Processing Exports

	2000			2003			2006		
Rank		Share	USD (Bil)		Share	USD (Bil)		Share	USD (Bil)
1	United States	0.25	25	United States	0.25	50.1	United States	0.25	113
2	Hong Kong	0.22	22.2	Hong Kong	0.23	44.6	Hong Kong	0.23	105
3	Japan	0.18	18.2	Japan	0.15	30.1	Japan	0.1	47.1
4	Korea, Republic of	0.04	4.17	Germany	0.04	8.65	Germany	0.05	21.3
5	Germany	0.04	3.8	Netherlands	0.04	7.85	Netherlands	0.04	18.9
6	Singapore	0.03	3.17	Korea, Republic of	0.04	7.81	Korea, Republic of	0.04	18.2
7	Netherlands	0.03	3.07	Singapore	0.02	4.92	Singapore	0.03	12.8
8	United Kingdom	0.03	2.77	United Kingdom	0.02	4.81	United Kingdom	0.02	11.1
9	Taiwan	0.02	2.06	Taiwan	0.02	4.45	Taiwan	0.02	9.89
10	France	0.02	1.59	France	0.02	3.94	Malaysia	0.02	7.17
Total			101			198			449

Table 2: Subsamples Relative to the Original Customs Sample (in terms of number of exporters in 2000-2006)

Group	Number of Firm-year Observations				
	customs	merged	% of customs	filtered	% of customs
04:beverages & spirit (16-24)	676	284	42.01%	180	26.63%
06:chemical products (28-38)	1822	717	39.35%	215	11.80%
07:plastics & rubber (39-40)	5284	1842	34.86%	703	13.30%
08:raw hides & skins (41-43)	2575	916	35.57%	495	19.22%
09:wood & articles (44-46)	457	123	26.91%	43	9.41%
10:pulp of wood (47-49)	2052	921	44.88%	215	10.48%
11:textiles (50-63)	16527	6038	36.53%	3640	22.02%
12:footwear & headgear, etc. (64-67)	3784	1625	42.94%	1117	29.52%
13:stone, plaster, cement, etc. (68-70)	814	304	37.35%	195	23.96%
14:precious metals (71)	1309	326	24.90%	115	8.79%
15:base metals (72-83)	3321	1295	38.99%	519	15.63%
16:machinery, mechanical electrical & equipmt (84-85)	16401	6349	38.71%	3176	19.36%
17:vehicles & aircraft (86-89)	900	424	47.11%	288	32.00%
18:optical, photographic, etc. (90-92)	2474	753	30.44%	574	23.20%
20:misc manufacturing (94-96)	3625	1195	32.97%	1073	29.60%
Total	62716	23319	37.18%	12548	20.01%

Source: China's Customs Trade Data and National Bureau of Statistics (NBS) Manufacturing Survey.

Sections 1, 2, 3, 5, and 19 are non-manufacturing sectors and are excluded from the analysis. See Figure 2 for the listing.

Table 3: Subsamples Relative to the Original Customs Sample (in terms of export value in 2000-2006)

Group	Sales (million usd)				
	customs (mil usd)	merged	% of customs	filtered	% of customs
04:beverages & spirit (16-24)	1090	784	71.93%	587	53.85%
06:chemical products (28-38)	3110	1700	54.66%	687	22.09%
07:plastics & rubber (39-40)	9230	5960	64.57%	3280	35.54%
08:raw hides & skins (41-43)	5120	3240	63.28%	1310	25.59%
09:wood & articles (44-46)	441	256	58.05%	109	24.72%
10:pulp of wood (47-49)	1410	870	61.70%	734	52.06%
11:textiles (50-63)	29400	19600	66.67%	14900	50.68%
12:footwear & headgear, etc. (64-67)	13100	9160	69.92%	7820	59.69%
13:stone, plaster, cement, etc. (68-70)	1140	835	73.25%	610	53.51%
14:precious metals (71)	9680	7400	76.45%	717	7.41%
15:base metals (72-83)	8990	4760	52.95%	2660	29.59%
16:machinery, mechanical electrical & equipmt (84-85)	122000	74000	60.66%	68200	55.90%
17:vehicles & aircraft (86-89)	15900	12000	75.47%	10900	68.55%
18:optical, photographic, etc. (90-92)	5460	4070	74.54%	2990	54.76%
20:misc manufacturing (94-96)	6810	3960	58.15%	4570	67.11%
Total	232881	148595	63.81%	120074	51.56%

Source: China's Customs Trade Data and National Bureau of Statistics (NBS) Manufacturing Survey.

Sections 1, 2, 3, 5, and 19 are non-manufacturing sectors and are excluded from the analysis. See Figure 2 for the listing.

Table 4: Dependent variable: Domestic Value Added in Exports

	(1)	(2)	(3)	(4)	(5)
Sample	All	All	Dom private	Foreign	Multiple Ind
β_{2001}	0.0196***	0.0197***	0.0978	0.0212***	0.0205***
	(0.007)	(0.006)	(0.114)	(0.007)	(0.005)
β_{2002}	0.0361***	0.0362***	0.0720	0.0374***	0.0334***
	(0.008)	(0.007)	(0.146)	(0.007)	(0.005)
β_{2003}	0.0580***	0.0580***	0.200	0.0568***	0.0578***
	(0.007)	(0.007)	(0.150)	(0.007)	(0.005)
β_{2004}	0.0603***	0.0604***	0.157	0.0606***	0.0590***
	(0.006)	(0.007)	(0.149)	(0.007)	(0.005)
β_{2005}	0.0910***	0.0910***	0.190	0.0918***	0.0849***
	(0.006)	(0.007)	(0.153)	(0.007)	(0.005)
β_{2006}	0.126***	0.126***	0.271*	0.125***	0.115***
	(0.009)	(0.006)	(0.160)	(0.008)	(0.006)
$\left(\frac{P^D M^D + P^I M^I}{PY}\right)_{it}$	-0.0616***	-0.0616***	0.101	-0.0606***	-0.0789***
	(0.020)	(0.022)	(0.319)	(0.020)	(0.015)
$\left(\frac{wL}{PY}\right)_{it}$		-0.002	0.261	-0.002	-0.008
		(0.021)	(0.504)	(0.024)	(0.008)
N	12548	12548	506	11825	18633
R-sq	.08	.08	.11	.08	.07

Note: Firm and year fixed effects are always included. Data set: merged NBS and customs data. Columns (1)-(2) use the whole sample; columns (3) and (4) include only domestic private and foreign-invested firms, respectively. Column (5) includes firms that operate in multiple industries as well.
Bootstrapped standard errors are in parentheses. * p<0.10; ** p<0.05; *** p<0.01.

Table 5: Dependent variable: Share of imports in total materials

	(1)	(2)	(3)	(4)
Sample	All	Dom private	Foreign	Multiple Ind
δ_{2001}	-0.0209***	-0.0594	-0.0204***	-0.0226***
	(0.007)	(0.037)	(0.007)	(0.005)
δ_{2002}	-0.0232***	0.0234	-0.0250***	-0.0201***
	(0.008)	(0.076)	(0.008)	(0.006)
δ_{2003}	-0.0605***	-0.0590	-0.0620***	-0.0626***
	(0.007)	(0.078)	(0.008)	(0.006)
δ_{2004}	-0.0744***	-0.0740	-0.0766***	-0.0798***
	(0.009)	(0.078)	(0.008)	(0.007)
δ_{2005}	-0.111***	-0.136*	-0.112***	-0.112***
	(0.009)	(0.078)	(0.008)	(0.006)
δ_{2006}	-0.149***	-0.184**	-0.150***	-0.146***
	(0.008)	(0.084)	(0.009)	(0.007)
$\left(\frac{wL}{PY}\right)_{it}$	0.0141	-0.0431	0.0142	0.0243
	(0.085)	(0.416)	(0.092)	(0.020)
$\ln{(K/L)}_{it}$	-0.000896	0.0204	-0.00210	-0.000977
	(0.004)	(0.043)	(0.004)	(0.003)
N	12522	505	11802	18598
R-sq	.09	.13	.09	.09

Note: Firm and year fixed effects are always included. Data set: merged NBS and customs data. Columns (1) uses the whole sample; columns (2) and (3) include only domestic private and foreign-invested firms, respectively. Column (4) includes firms that operate in multiple industries as well.
Bootstrapped standard errors are in parentheses. * p<0.10; ** p<0.05; *** p<0.01.

Table 6: Dependent variable: ln(number of import varieties)

	(1)	(2)	(3)	(4)
Sample	All	Dom private	Foreign	Multiple Ind
γ_{2001}	-0.139***	-0.429	-0.128***	-0.145***
	(0.019)	(0.273)	(0.022)	(0.017)
γ_{2002}	-0.163***	-0.0628	-0.156***	-0.148***
	(0.023)	(0.416)	(0.023)	(0.018)
γ_{2003}	-0.273***	-0.294	-0.268***	-0.250***
	(0.023)	(0.428)	(0.022)	(0.016)
γ_{2004}	-0.342***	0.0216	-0.341***	-0.312***
	(0.025)	(0.442)	(0.023)	(0.018)
γ_{2005}	-0.442***	-0.0849	-0.439***	-0.395***
	(0.021)	(0.450)	(0.023)	(0.019)
γ_{2006}	-0.309***	-0.0815	-0.302***	-0.260***
	(0.024)	(0.535)	(0.029)	(0.020)
$\left(\frac{wL}{PY}\right)_{it}$	-0.0139	-0.788	-0.0118	-0.0191
	(0.089)	(1.860)	(0.071)	(0.056)
$\left(\frac{P^D M^D + P^I M^I}{PY}\right)_{it}$	-0.0183	0.887	-0.0105	0.00259
	(0.045)	(1.255)	(0.038)	(0.037)
N	12548	506	11825	18633
R-sq	.08	.13	.08	.07

Note: Firm and year fixed effects are always included. Data set: merged NBS and customs data. Columns (1) uses the whole sample; columns (2) and (3) include only domestic private and foreign-invested firms, respectively. Column (4) includes firms that operate in multiple industries as well.
Bootstrapped standard errors are in parentheses. * p<0.10; ** p<0.05; *** p<0.01.

Table 7: Products that used to be imported by processing exporters but not exported by ordinary exporters in 2000

Rank	HS6	Description	Imp 00 ('000 USD)	Exp 06 ('000 USD)
1	720421	Waste and scrap of alloy (stainless)	5280.88	12.74
2	720441	Other waste and scrap - turnings, shavings, etc.	2928.86	115.63
3	470411	Unbleached - Coniferous	1508.45	133.65
4	262050	Containing mainly vanadium	994.39	2162.71
5	50900	Natural sponges of animal	978.55	12.01
6	370231	Other film, without perforations	887.61	0.07
7	721041	Otherwise plated or coated w/ zinc	697.85	735.76
8	841013	Hydraulic turbines and water wheels	300.00	3073.40
9	530210	True hemp, raw or retted	168.65	206.93
10	720429	Waste and scrap of alloy (other)	148.33	7.98
11	290121	Unsaturated - Ethylene	77.03	137000.00
12	842541	Jacks; used for raising vehicles	61.49	0.71
13	20900	Pig fat, free of lean meat	45.40	90.30
14	310280	Mixtures of urea and ammonium nitrate	43.68	16.14
15	50100	Human hair, unworked	39.50	8.87
16	851931	Turntables (record-decks)	38.54	1.37
17	150300	Lard stearin, lard oil, etc.	31.81	3.94
18	370256	Other film, for color photography (polychrome)	29.56	13.38
19	20441	Other meat of sheep, frozen	29.22	5507.38
20	20319	Fresh or chilled - Other	28.44	4369.41
21	847230	Machines for sorting or folding mail	13.61	1562.01
22	261690	Other	11.89	3.21
23	151521	Maize (corn) oil and fractions	11.34	17600.00
24	160231	Poultry, turkeys	9.19	4.10
25	750300	Nickel waste and scrap	8.91	4592.15
26	843020	Snow-ploughs and snow-blowers	8.56	20600.00
27	900620	Cameras used for recording documents on microfilm	8.35	2.19
28	291212	Acyclic aldehydes - Ethanal	7.37	1.50
29	381111	Anti-knock prep. (based on lead compounds)	6.36	2568.87
30	842111	Centrifuges, incl. centrifugal dryers	5.76	11.27
31	290260	Ethylbenzene	3.94	0.01
32	290911	Acyclic ethers and their halogenated	3.83	87.73
33	845620	Operated by ultrasonic process	2.70	137.80
34	854340	Electric fence energisers	0.54	142.78
Total			14420.55	200785.98

Imp 00 is the value of imports by processing exporters in 2000.

Exp 06 is the value of exports by ordinary exporters in 2006.

Table 8: Dependent variable: ln(number of export varieties)

	(1)	(2)	(3)	(4)
Sample	All	Dom private	Foreign	Multiple Ind
θ_{2001}	-0.0379*	0.00467	-0.0269	-0.0307*
	(0.022)	(0.260)	(0.024)	(0.018)
θ_{2002}	0.0454**	0.225	0.0622**	0.0601***
	(0.022)	(0.349)	(0.025)	(0.019)
θ_{2003}	0.101***	0.301	0.110***	0.118***
	(0.020)	(0.327)	(0.028)	(0.022)
θ_{2004}	0.136***	0.507	0.138***	0.167***
	(0.022)	(0.369)	(0.027)	(0.023)
θ_{2005}	0.209***	0.591	0.212***	0.235***
	(0.024)	(0.390)	(0.028)	(0.021)
θ_{2006}	0.298***	0.723*	0.299***	0.322***
	(0.025)	(0.434)	(0.032)	(0.024)
$\left(\frac{P^D M^D + P^I M^I}{PY}\right)_{it}$	-0.0958	-0.359	-0.0880	-0.0949*
	(0.068)	(0.820)	(0.071)	(0.051)
$\left(\frac{wL}{PY}\right)_{it}$	-0.0377	-0.409	-0.0379	-0.0393
	(0.066)	(0.991)	(0.075)	(0.059)
N	12548	506	11825	18633
R-sq	.048	.12	.05	.06

Note: Firm and year fixed effects are always included. Data set: merged NBS and customs data. Columns (1) uses the whole sample; column (2) and (3) include only domestic private and foreign-invested firms, respectively. Column (4) includes firms that operate in multiple industries as well.
Bootstrapped standard errors are in parentheses. * p<0.10; ** p<0.05; *** p<0.01.

Table 9: Determinants of the Within-firm Increase in DVAR

Dep Var :	$DVAR_{jt} - DVAR_{j,00}$		$\ln(P^I/P^D)_{jt}$	
Method	OLS	2SLS	OLS	
$\ln(P^I/P^D)_{jt}$	0.244***	0.186***		
	(0.026)	(0.052)		
$\ln\left(\frac{(V^I/V^D)_{jt}}{(V^I_j/V^D_j)_{00}}\right)$			-0.735***	-0.509***
			(0.098)	(0.101)
$\ln(E)_{jt}$ (RMB appreciation)				-1.116***
				(0.242)
Industry Fixed Effects	Y	Y	Y	Y
N	90	90	90	90
R-sq	.712	.697	.483	.642
First Stage				
$\ln(E_{jt})$ (RMB appreciation)		-1.558***		
		(0.209)		
F-stat		55.69, p=0.00		

Bootstrapped standard errors are reported in parentheses. All fixed effects are included in the first stage. * p<0.10; ** p<0.05; *** p<0.01.

Table 10: Determinants of the Rising Upstream Varieties

Dep Var:	$\ln\left(V^I_{jt}/V^D_{jt}\right)$		
$\ln(\text{Upst input tariff})_{jt}$	0.340***		0.281**
	(0.087)		(0.134)
$\ln(\text{Foreign K})_{jt}$		-0.119***	-0.052
		(0.039)	(0.042)
Industry Fixed Effects	Y	Y	Y
N	90	90	90
R-sq	.638	.593	.647

Bootstrapped standard errors are reported in parentheses. Both dependent and independent variables are differenced from their 2000 values. * p<0.10; ** p<0.05; *** p<0.01.

Table 11: Estimated Sigma from Estimating the Theoretical Expression of DVAR

	$\sigma - 1$	s.e	nb. obs.
04:beverages & spirit (16-24)	3.593***	(1.135)	180
06:chemical products (28-38)	1.831***	(0.672)	215
07:plastics & rubber (39-40)	0.688	(0.476)	703
08:raw hides & skins (41-43)	4.157***	(0.965)	495
09:wood & articles (44-46)	2.744	(5.401)	43
10:pulp of wood (47-49)	1.897	(1.231)	215
11:textiles (50-63)	4.813***	(0.466)	3640
12:footwear & headgear, etc. (64-67)	2.839***	(0.414)	1117
13:stone, plaster, cement, etc. (68-70)	1.356	(0.843)	195
14:precious metals (71)	0.187	(1.340)	115
15:base metals (72-83)	2.000***	(0.673)	519
16:machinery, mechanical eletrical & equipmt (84-85)	1.579***	(0.161)	3176
17:vehicles & aircraft (86-89)	2.633***	(0.430)	288
18:optical, photographic, etc. (90-92)	1.888***	(0.425)	574
20:misc manufacturing (94-96)	2.254***	(0.398)	1073
Whole sample	2.126***	(0.145)	12548

Bootstrapped standard errors are reported in parentheses. * p<0.10; ** p<0.05; *** p<0.01.

Table A1: Share of Processing Exports in Top Destinations

Rank	2000		2003		2006	
1	US	0.675	US	0.675	US	0.630
2	HK	0.697	HK	0.716	HK	0.738
3	JP	0.557	JP	0.591	JP	0.574
4	KR	0.473	KR	0.460	KR	0.451
5	DE	0.606	DE	0.632	DE	0.616
6	NL	0.584	NL	0.676	NL	0.682
7	GB	0.618	GB	0.562	GB	0.523
8	SG	0.630	TW	0.587	SG	0.646
9	TW	0.580	SG	0.615	TW	0.533
10	IT	0.326	FR	0.626	IT	0.283

Table A2: Domestic Value Added Ratio

Year	DVAR (filter 1)	DVAR (filter 2)	DVAR (filter 3)
2000	0.503	0.494	0.485
2001	0.495	0.490	0.473
2002	0.511	0.508	0.495
2003	0.527	0.524	0.507
2004	0.538	0.533	0.510
2005	0.585	0.579	0.553
2006	0.597	0.593	0.576

Filter 1: Include exporters that have mat/sales > imp/exp, exp >= imp, mat >= imp and sales >= 0.9y.
Filter 2: Include exporters that satisfy Filter 1 and dvar < dvar_OT_med.
Filter 3: Include exporters that satisfy Filter 1 and dvar < dvar_OT_25.

Table A3: DVAR by Industry Sector and Year

Industry Sector	Year						
	2000	2001	2002	2003	2004	2005	2006
04:beverages & spirit (16-24)	0.640	0.671	0.726	0.750	0.703	0.702	0.766
06:chemical products (28-38)	0.445	0.474	0.524	0.582	0.422	0.401	0.579
07:plastics & rubber (39-40)	0.414	0.460	0.441	0.451	0.398	0.482	0.380
08:raw hides & skins (41-43)	0.486	0.307	0.367	0.411	0.495	0.558	0.610
09:wood & articles (44-46)	0.430	0.584	0.470	0.219	0.541	0.653	0.436
10:pulp of wood (47-49)	0.319	0.412	0.407	0.408	0.430	0.525	0.610
11:textiles (50-63)	0.520	0.507	0.562	0.559	0.575	0.599	0.643
12:footwear & headgear, etc. (64-67)	0.598	0.557	0.601	0.644	0.663	0.663	0.687
13:stone, plaster, cement, etc. (68-70)	0.549	0.527	0.689	0.610	0.640	0.597	0.635
14:precious metals (71)	0.506	0.490	0.222	0.411	0.372	0.305	0.436
15:base metals (72-83)	0.529	0.464	0.476	0.526	0.470	0.490	0.669
16:machinery, mechanical electrical & equipmt (84-85)	0.423	0.424	0.457	0.482	0.488	0.544	0.544
17:vehicles & aircraft (86-89)	0.487	0.584	0.553	0.568	0.582	0.664	0.742
18:optical, photographic, etc. (90-92)	0.564	0.540	0.563	0.553	0.531	0.612	0.675
20:misc manufacturing (94-96)	0.651	0.587	0.621	0.572	0.617	0.596	0.664

Source: China's Customs Trade Data and National Bureau of Statistics Manufacturing Survey

Table A4: Foreign Content in Domestic Materials (%)

Industry Sector	Year						
	2000	2001	2002	2003	2004	2005	2006
04:beverages & spirit (16-24)	1.95	2.19	2.69	3.25	4.43	5.79	5.59
06:chemical products (28-38)	1.53	1.99	2.57	3.23	4.45	5.63	5.56
07:plastics & rubber (39-40)	1.17	1.46	1.93	2.39	3.34	4.31	4.24
08:raw hides & skins (41-43)	1.61	1.82	2.43	2.91	3.99	5.36	5.24
09:wood & articles (44-46)	2.51	2.99	3.67	4.54	5.84	7.54	7.31
10:pulp of wood (47-49)	2.25	2.61	3.43	4.27	5.39	6.74	6.27
11:textiles (50-63)	1.62	1.91	2.49	3.16	4.33	5.73	5.70
12:footwear & headgear, etc. (64-67)	1.40	1.69	2.29	2.87	3.99	5.30	5.26
13:stone, plaster, cement, etc. (68-70)	1.95	2.46	3.29	4.16	5.64	7.21	7.05
14:precious metals (71)	1.47	1.99	2.60	3.28	4.58	6.00	5.90
15:base metals (72-83)	1.57	2.09	2.72	3.46	4.75	6.13	6.08
16:machinery, mechanical electrical & equipmt (84-85)	1.41	1.80	2.48	3.17	4.30	5.47	5.48
17:vehicles & aircraft (86-89)	1.95	2.40	3.34	4.28	5.66	7.22	7.12
18:optical, photographic, etc. (90-92)	1.37	1.74	2.38	3.03	4.10	5.30	5.28
20:misc manufacturing (94-96)	1.64	2.05	2.76	3.45	4.73	6.22	6.11

Source: From Koopman, Wang, and Wei (2012) and authors' imputation based on the growth rate of the number of ordinary importers

Table A5: Median of Materials to Sales Ratio by Industry Sector and Year

Industry Sector	Year						
	2000	2001	2002	2003	2004	2005	2006
04:beverages & spirit (16-24)	0.832	0.770	0.783	0.728	0.820	0.762	0.764
06:chemical products (28-38)	0.811	0.822	0.787	0.750	0.797	0.768	0.761
07:plastics & rubber (39-40)	0.805	0.800	0.822	0.791	0.816	0.813	0.790
08:raw hides & skins (41-43)	0.807	0.810	0.784	0.785	0.767	0.791	0.750
09:wood & articles (44-46)	0.801	0.810	0.796	0.840	0.779	0.769	0.770
10:pulp of wood (47-49)	0.805	0.800	0.789	0.796	0.810	0.796	0.750
11:textiles (50-63)	0.798	0.778	0.771	0.771	0.767	0.755	0.743
12:footwear & headgear, etc. (64-67)	0.798	0.774	0.757	0.761	0.759	0.750	0.737
13:stone, plaster, cement, etc. (68-70)	0.805	0.802	0.728	0.759	0.750	0.758	0.716
14:precious metals (71)	0.751	0.752	0.714	0.726	0.706	0.682	0.720
15:base metals (72-83)	0.838	0.819	0.806	0.788	0.806	0.777	0.781
16:machinery, mechanical electrical & equipmt (84-85)	0.808	0.805	0.785	0.774	0.799	0.793	0.769
17:vehicles & aircraft (86-89)	0.815	0.836	0.851	0.823	0.829	0.819	0.799
18:optical, photographic, etc. (90-92)	0.817	0.771	0.763	0.739	0.760	0.752	0.722
20:misc manufacturing (94-96)	0.796	0.788	0.769	0.786	0.782	0.752	0.749

Source: China's National Bureau of Statistics Industrial Firm Survey

Table A6: 25th-percentile of Ordinary Exporters' DVAR by Industry Sector and Year

Industry Sector	Year						
	2000	2001	2002	2003	2004	2005	2006
04:beverages & spirit (16-24)	0.943	0.952	0.943	0.944	0.930	0.954	0.976
06:chemical products (28-38)	0.913	0.899	0.937	0.951	0.898	0.908	0.901
07:plastics & rubber (39-40)	0.847	0.806	0.831	0.761	0.801	0.853	0.848
08:raw hides & skins (41-43)	0.997	0.939	0.954	0.985	0.966	0.957	0.925
09:wood & articles (44-46)	0.676	0.830	0.721	0.835	0.893	0.928	0.928
10:pulp of wood (47-49)	0.770	0.777	0.798	0.744	0.831	0.849	0.853
11:textiles (50-63)	0.989	0.992	0.990	0.988	0.987	0.989	0.989
12:footwear & headgear, etc. (64-67)	0.987	0.995	0.998	0.993	0.988	0.994	0.994
13:stone, plaster, cement, etc. (68-70)	0.969	0.962	0.976	0.958	0.966	0.964	0.971
14:precious metals (71)	1.000	1.000	1.000	1.000	1.000	1.000	1.000
15:base metals (72-83)	0.932	0.932	0.914	0.934	0.919	0.946	0.964
16:machinery, mechanical eletrical & equipmt (84-85)	0.874	0.858	0.878	0.882	0.857	0.898	0.917
17:vehicles & aircraft (86-89)	0.946	0.953	0.944	0.896	0.921	0.978	0.984
18:optical, photographic, etc. (90-92)	0.897	0.922	0.901	0.926	0.907	0.948	0.936
20:misc manufacturing (94-96)	0.956	0.970	0.981	0.985	0.971	0.985	0.983

Source: China's Customs Trade Data and National Bureau of Statistics Manufacturing Survey

Table A7: Median of Ordinary Exporters' DVAR by Industry Sector and Year

Industry Sector	Year						
	2000	2001	2002	2003	2004	2005	2006
04:beverages & spirit (16-24)	0.988	0.989	0.991	0.989	0.988	0.993	0.997
06:chemical products (28-38)	0.988	0.981	0.989	0.991	0.986	0.983	0.988
07:plastics & rubber (39-40)	0.980	0.954	0.952	0.932	0.952	0.961	0.962
08:raw hides & skins (41-43)	0.999	0.998	0.991	0.995	0.994	0.992	0.995
09:wood & articles (44-46)	0.941	0.972	0.962	0.976	0.988	0.992	0.993
10:pulp of wood (47-49)	0.911	0.903	0.905	0.919	0.949	0.958	0.953
11:textiles (50-63)	0.999	0.999	0.999	0.999	0.999	0.998	0.999
12:footwear & headgear, etc. (64-67)	0.997	1.000	0.999	1.000	0.998	0.999	0.999
13:stone, plaster, cement, etc. (68-70)	0.994	0.995	0.993	0.995	0.993	0.996	0.996
14:precious metals (71)	1.000	1.000	1.000	1.000	1.000	1.000	1.000
15:base metals (72-83)	0.993	0.988	0.990	0.996	0.995	0.994	0.997
16:machinery, mechanical eletrical & equipmt (84-85)	0.978	0.966	0.975	0.977	0.969	0.980	0.985
17:vehicles & aircraft (86-89)	0.994	0.993	0.996	0.994	0.996	0.998	0.999
18:optical, photographic, etc. (90-92)	0.977	0.992	0.988	0.989	0.984	0.989	0.989
20:misc manufacturing (94-96)	0.996	0.997	0.998	0.997	0.998	0.997	0.998

Source: China's Customs Trade Data and National Bureau of Statistics Manufacturing Survey

Table A8: Upstream Variety Counts (HS-6 Categories)

Industry Sector	Year						
	2000	2001	2002	2003	2004	2005	2006
01:live animals (1-5)	287.93	289.97	289.77	289.28	289.51	293.08	290.31
02:vegetables (6-14)	390.79	393.97	395.26	398.13	397.76	403.85	402.68
03:animal or vegetable oil (15)	187.17	189.20	184.79	189.02	187.13	193.76	187.40
04:beverages & spirit (16-24)	346.47	348.56	348.63	347.52	348.91	351.85	349.30
05:mineral products (25-27)	347.60	350.50	352.09	354.47	356.57	359.41	361.56
06:chemical products (28-38)	394.19	396.86	399.37	401.53	403.38	406.99	409.35
07:plastics & rubber (39-40)	345.71	343.44	349.30	348.81	352.70	355.77	357.70
08:raw hides & skins (41-43)	206.30	209.12	206.33	206.47	205.21	208.70	207.62
09:wood & articles (44-46)	267.13	269.43	270.92	271.56	274.78	275.98	276.00
10:pulp of wood (47-49)	313.38	316.26	315.92	318.90	319.05	324.02	321.78
11:textiles (50-63)	659.24	662.88	669.34	669.24	673.33	678.34	680.32
12:footwear & headgear, etc. (64-67)	307.32	308.25	310.45	310.30	313.28	315.85	316.14
13:stone, plaster, cement, etc. (68-70)	332.72	335.48	336.53	338.60	340.71	343.69	345.35
14:precious metals (71)	349.05	355.49	359.25	360.48	366.79	369.88	370.66
15:base metals (72-83)	240.60	244.65	244.45	247.75	250.20	252.70	254.81
16:machinery, mechanical electrical & equipmt (84-85)	573.57	578.65	583.57	584.42	590.25	592.85	594.72
17:vehicles & aircraft (86-89)	339.21	340.20	345.25	348.50	352.29	354.25	357.19
18:optical, photographic, etc. (90-92)	511.23	514.34	519.19	518.81	524.55	527.11	529.04
20:misc manufacturing (94-96)	278.44	280.56	281.36	281.79	284.84	285.97	285.57

Source: China's Customs Trade Data and National Bureau of Statistics Manufacturing Survey

Table A9: Varieties Imported by Each Sector (HS-6 Categories)

Industry Sector	Year						
	2000	2001	2002	2003	2004	2005	2006
01:live animals (1-5)	125	78	71	111	121	89	69
02:vegetables (6-14)	99	46	64	71	24	103	49
03:animal or vegetable oil (15)	45	17	34	24	19	21	23
04:beverages & spirit (16-24)	682	470	511	468	423	450	316
05:mineral products (25-27)	154	136	103	166	152	134	219
06:chemical products (28-38)	1056	999	1112	995	1011	976	936
07:plastics & rubber (39-40)	1154	1091	1132	1150	1212	1108	1006
08:raw hides & skins (41-43)	853	846	817	739	623	615	535
09:wood & articles (44-46)	205	227	171	215	166	228	190
10:pulp of wood (47-49)	665	601	671	651	640	693	533
11:textiles (50-63)	1651	1595	1524	1512	1459	1450	1351
12:footwear & headgear, etc. (64-67)	1008	1032	1024	919	839	874	807
13:stone, plaster, cement, etc. (68-70)	633	654	572	562	462	500	382
14:precious metals (71)	458	461	492	466	484	445	344
15:base metals (72-83)	1222	1136	1305	1207	1099	1156	999
16:machinery, mechanical electrical & equipmt (84-85)	2105	2098	2167	2088	2092	2038	1948
17:vehicles & aircraft (86-89)	957	902	1023	1074	1085	1117	1158
18:optical, photographic, etc. (90-92)	1288	1254	1244	1233	1098	1148	944
20:misc manufacturing (94-96)	1510	1434	1437	1293	1269	1189	1128

Source: China's Customs Trade Data and National Bureau of Statistics Manufacturing Survey

Table A10: ln(Price Index of Imported Materials/ Price Index of Domestic Materials)

Industry Sector	Year					
	2001	2002	2003	2004	2005	2006
04:beverages & spirit (16-24)	-0.021	-0.033	0.059	0.058	0.086	0.174
06:chemical products (28-38)	-0.021	0.009	0.101	0.170	0.300	0.456
07:plastics & rubber (39-40)	-0.004	0.035	0.105	0.148	0.233	0.360
08:raw hides & skins (41-43)	0.003	0.028	0.115	0.143	0.200	0.278
09:wood & articles (44-46)	-0.034	-0.019	0.048	0.073	0.114	0.194
10:pulp of wood (47-49)	-0.004	0.035	0.112	0.160	0.219	0.307
11:textiles (50-63)	-0.006	-0.001	0.069	0.091	0.132	0.207
12:footwear & headgear, etc. (64-67)	-0.005	0.018	0.088	0.133	0.202	0.289
13:stone, plaster, cement, etc. (68-70)	-0.005	0.004	0.066	0.152	0.295	0.422
14:precious metals (71)	-0.018	-0.061	0.011	0.055	0.158	0.280
15:base metals (72-83)	-0.025	-0.024	0.015	0.077	0.203	0.342
16:machinery, mechanical eletrical & equipmt (84-85)	0.008	0.051	0.134	0.182	0.283	0.518
17:vehicles & aircraft (86-89)	0.040	0.038	0.086	0.173	0.308	0.463
18:optical, photographic, etc. (90-92)	0.009	0.077	0.157	0.223	0.314	0.505
20:misc manufacturing (94-96)	-0.006	0.001	0.074	0.134	0.229	0.349

Source: China's Customs Trade Data and National Bureau of Statistics Manufacturing Survey
Indices for year 2000 are not shown as they are all 0 by construction.