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

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Abstract

This paper proposes a theoretical framework and empirical methodologies to assess domestic value added (DVA) of exporters using firm-level and transactions-level data. We find that from 2000 to 2006 the domestic value added ratio (DVAR) of China's processing exports has risen from 35% to 49%, accounting for most of the increase in the DVA in the country's exports. This upward trend is largely driven by within-firm substitution of imported materials with domestic materials, instead of changes in the composition of firms or industries. Such substitution of materials is supported by an increasing variety of inputs available in the domestic economy. Our results suggest that Chinese exporters have been expanding along the global production chain beyond 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 \$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 the global supply chain 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.

The objective of this paper is to provide a theoretical framework to study domestic value added (DVA) of a firm and to propose an empirical methodology to measure firm-level DVA directly using customs transaction data. Broadly defined, DVA is the difference between the values of final output and imported materials. It may encompass domestic materials that are not produced directly by the firm. By adding up firm DVA, we further compute the DVA in aggregate trade by industry and export destination. The recent growing literature on value added trade (e.g., Hummels, Ishii and Yi, 2001; Koopman, Zhi and Wei, 2012; Johnson and Noguera, 2012) mainly relies on industry input-output tables to infer DVA in exports. While industry input-output tables are informative, computing sector- or country-level DVA requires strong proportionality assumptions that all firms within the same industry 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. This would render biases when firms are heterogeneous in terms of production technology and sourcing behavior, particularly when dealing with processing exports. In fact, 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 that we use firm-level customs transaction information instead of industry input-output tables to infer DVA of a firm, an industry, and a destination country. The focus is on processing exports but with additional assumptions, we extend our methodology to measure the DVA in non-processing (ordinary) exports as well so that we can infer the DVA in overall Chinese exports.

We first provide a simple theoretical model showing how DVA is optimally determined by a 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 price of domestic materials relative to the price of imported materials. Factors that affect the relative price of domestic materials, such as the exchange rate and foreign direct

[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.

investment (FDI) inflows are potentially important determinants of firm $DVAR$. Contrary to the popular press, our model shows that once the share of materials in total sales is controlled for, labor costs will not affect firm $DVAR$ over time.

We then use micro-level data to examine the time-series trend, the cross-sectional pattern, and the firm-level determinants of the $DVAR$ in Chinese exports. Specifically, our ground-up approach uses transactions-level (firm-country-product-year) import and export data of all exporters in China from 2000 to 2006, a period that the country experienced significant industrial transformation and FDI inflow, in part due to its WTO accession in December 2001. We find that the $DVAR$ in Chinese processing exports has risen from 35 percent in 2000 to 49 percent in 2006, confirming existing evidence in the literature. Furthermore, based on firm-level panel regressions, we show that this rising trend in $DVAR$ is happening within firm and it is not due to changes in the composition of firms within an industry. The rising firm $DVAR$ is accompanied by a declining share of imported materials in total materials, declining import variety, and increasing export variety. These patterns suggest that firms are substituting imported materials with domestic materials without compromising export sales. We further provide evidence showing that the increase in firm $DVAR$ is related to an increase in domestic variety produced in the upstream sectors, which is in part caused by the influx of FDI into the downstream sectors. Exchange rate fluctuation, on the other hand, does not seem to affect firm $DVAR$**.**

There are several advantages of using the micro-level approach. First, as is mentioned 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 would be classified when industry input-output tables are constructed, particularly when markups and logistic costs may be added to such transactions. By merging the transactions-level trade data with the firm census 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, the firm-level approach permits us to disentangle the sources behind the rising industry $DVAR$. In particular, we can separate within-firm changes in $DVAR$ due to firms' changing their input sources from the between-firm changes due to entry and exit of firms with different $DVAR$.

Despite these advantages, our approach has limitations. First, 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 (groups of HS2 categories). For processing firms that operate in multiple industries, we use the weighted average of $DVAR$, with weights equal to the firm's export share in the respective industry. We use the same approach to calculate the $DVAR$ in exports to each destination country.

Second, our measure could be subject to potential measurement errors due to 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 minimize the measurement errors due to indirect importing, we use two rules to identify those firms that generate "leakage". To limit the upward bias, we use a firm's material-to-sales ratio reported as an upper bound of the firm's import-to-export ratio. By definition, a processing exporter that has sales equal to exports should have its material-to-sales ratio weakly greater than its 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. The rationale of using this rule is based on the fact that processing firms in China are exempted from import tariffs, while ordinary (non-processing) exporters have to pay import tariffs and thus have stronger incentives to purchase more intermediate inputs locally and thus have a higher average $DVAR$.[2]

Finally, if production of some domestic materials uses imported materials, our estimates will be biased upward. To address this bias, we rely on the existing studies in the literature, which report 5 to 10 percent foreign content in Chinese domestic materials. We take the conservative benchmark and subtract all estimated firm $DVAR$ by 10 percent to yield an aggregate that is consistent with the existing findings.

Despite its 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

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

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 making a proportionality assumption that firms' export and domestic products use the same share of imported materials in production. By using this method, we find that the average $DVAR$ in non-processing exports in China stabilized around 0.8 during the sample period, implying that most of the rise in the $DVAR$ in Chinese aggregate exports is driven by the changes within the processing export sector.

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 for 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. Section 4 presents our results and Section 5 concludes.

[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.

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 US consistently ranked as the top destination, accounting for about 25 percent of Chinese total processing exports. Following the US 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 of processing exports in each top-10 destinations for 2000 and 2006. The share of 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 exports is a major part of China's overall exports, as well as of its exports to destinations such as the US. Given the high foreign content and the prevalence of processing trade, any analysis based on gross trade flows can therefore be highly misleading.

We present in Figure 2 the share of processing exports in 2006 by industry section, 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" section (HS2 = 6 -14) and as high as 80 percent for the "Machinery, mechanical, and electrical equipment" section (HS2 = 84-85).

[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.

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 is 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 A3 presents the industry's median materials-to-sales ratio, the variable that we use as an upper bound for the import-to-export ratio for processing firms. By definition, these ratios are always larger than the firms' $DVAR$.

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,

[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.

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

3.1 Determinants of Domestic Value Added

For each year t, consider firm i with productivity, ϕ_{it}, 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:

$$\begin{aligned} Y_{it} &= \phi_{it} K_{it}^{\alpha_K} L_{it}^{\alpha_L} M_{it}^{\alpha_M}, & (3) \\ M_{it} &= \left(M_{it}^{D\frac{\sigma-1}{\sigma}} + M_{it}^{I\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}}, & (4) \\ \alpha_K + \alpha_L + \alpha_M &= 1 \text{ and } \sigma > 1. & (5) \end{aligned}$$

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:

$$C_{it}\left(r_t, w_t, P_t^D, P_t^I, Y_{it}\right) = \frac{Y_{it}}{\phi_{it}}\left(\frac{r_t}{\alpha_K}\right)^{\alpha_K}\left(\frac{w_t}{\alpha_L}\right)^{\alpha_L}\left(\frac{P_t^M}{\alpha_M}\right)^{\alpha_M}, \text{ with} \tag{6}$$

$$\frac{P_t^M M_{it}}{C_{it}} = \alpha_M. \tag{7}$$

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

$$\frac{\partial C_{it}}{\partial Y_{it}} = \frac{1}{\phi_{it}}\left(\frac{r_t}{\alpha_K}\right)^{\alpha_K}\left(\frac{w_t}{\alpha_L}\right)^{\alpha_L}\left(\frac{P_t^M}{\alpha_M}\right)^{\alpha_M}. \tag{8}$$

A profit-maximizing firm will set the price of output as a constant markup, $\mu > 1$, over its marginal cost as

$$P_{it} = \frac{\mu}{\phi_{it}}\left(\frac{r_t}{\alpha_K}\right)^{\alpha_K}\left(\frac{w_t}{\alpha_L}\right)^{\alpha_L}\left(\frac{P_t^M}{\alpha_M}\right)^{\alpha_M}.$$

Hence the total revenue and the share of imported materials in total revenue are

$$P_{it}Y_{it} = \mu\frac{Y_{it}}{\phi_{it}}\left(\frac{r_t}{\alpha_K}\right)^{\alpha_K}\left(\frac{w_t}{\alpha_L}\right)^{\alpha_L}\left(\frac{P_t^M}{\alpha_M}\right)^{\alpha_M} = \mu C_{it}, \text{ and}$$

$$\frac{P_t^I M_{it}^I}{P_{it}Y_{it}} = \frac{P_t^I M_{it}^I}{\mu C_{it}} = \frac{P_t^M M_{it}}{\mu C_{it}}\frac{P_t^I M_{it}^I}{P_t^M M_{it}} = \frac{\alpha_M}{\mu}\frac{P_t^I M_{it}^I}{P_t^M M_{it}}.$$

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

$$\min P_t^I M_{it}^I + P_t^D M_{it}^D$$

$$s.t.\ M_{it} = \left({M_{it}^D}^{\frac{\sigma-1}{\sigma}} + {M_{it}^I}^{\frac{\sigma-1}{\sigma}}\right)^{\frac{\sigma}{\sigma-1}},$$

which gives us the following expression:

$$\frac{P_t^I M_{it}^I}{P_t^M M_{it}} = \frac{1}{1 + \left(\frac{P_t^I}{P_t^D}\right)^{\sigma-1}}. \tag{9}$$

Thus, according to (2), $DVAR$ of firm i in period t is

$$DVAR_{it} = 1 - \frac{\alpha_M}{\mu} \frac{1}{1 + \left(\frac{P_{it}^I}{P_{it}^D}\right)^{\sigma-1}}. \tag{10}$$

Equation (10) shows that, given μ and α_M, which are parameters of the demand and production functions, factors that affect the price of imported materials relative to that of domestic materials will have a direct impact on a firm's DVA. It is worth emphasizing that factors that do not affect the relative price of materials, such as the firm's wages (w) or productivity (ϕ_i), do not directly affect $DVAR_{it}$.[7]

What are the factors that may influence the relative price of imported materials? One obvious factor is the exchange rate. Let us define the yuan exchange rate E_t as the foreign-currency price of a yuan. The price of imported materials in Chinese 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 domestic-currency price of imported materials, resulting in a higher $DVAR_{it}$ according to (10) .

Another factor that will affect the relative price of materials could be the presence of foreign direct investment (FDI) in the downstream industry, for which we allow imported and domestic materials to consist of different material varieties. For simplicity, consider M_{it}^D and M_{it}^I as the CES aggregates of different varieties of domestic and imported materials:

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

where V_t^D and V_t^I are the numbers of domestic variety and foreign variety available to the firm. Assume that the elasticity of substitution between any two varieties of imported materials, as well as between any two varieties of domestic materials, is λ. Thus, the average price of imported and

[7] 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 $DVAR$.

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. Notice that

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

as is emphasized in the literature about the welfare and productivity impacts of an increase in variety (e.g., Broda and Weinstein, 2006 and Feenstra and Kee, 2008). Rodriguez-Clare (1996) and Kee (2012) show that the presence of FDI in a downstream industry can increase the demand for domestic materials, leading to an increased supply of domestic material variety, V_t^D, in the upstream industry, which implies

$$\frac{\partial V_t^D}{\partial \left(FDI_t\right)} > 0 \Rightarrow \frac{\partial \left(P_t^I/P_t^D\right)}{\partial V_t^D} > 0 \Rightarrow \frac{\partial DVAR_{it}}{\partial \left(FDI_t\right)} > 0. \tag{12}$$

This will in turn lower the price of domestic materials, given $\lambda > 1$ and according to our model, increase $DVAR$ for all firms in the related industries. We will empirically verify the predictions regarding the exchange-rate effects and the FDI effects in the empirical section below.

3.2 Caveats

3.2.1 About Foreign Content in Domestic Materials

Before we use micro-level data to empirically examine the theoretical predictions, let us make a few key remarks about the measurement of firm $DVAR$. The accounting identity (2) relies on two important assumptions. First, we assume zero imported content in domestic materials. In other words, we assume that $P^D M^D$ embodies purely domestic content. Second, we assume that imported materials have no Chinese content, such that IMP is completely foreign-made. 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 for us to assess the direction of the bias at this stage. The existing estimates by Hummels, Ishii, and Yi (2001) and Koopman, Wang, and Wei (2012) show that for Chinese processing trade, the foreign content in domestic materials is around 5 to 10 percent. We will take the conservative estimate and discount all measures of firm $DVAR$ by 10 percentage points in all industries.

3.2.2 About Indirect Importing

Another caveat relates to processing firms' indirect importing. 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. Such transactions are not confined within the same industry or geographic location.[8] 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 are widespread according to the data.

While it is not clear how common the practice of indirect importing is, it 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 (2) may underestimate their $DVAR$ and in the extreme case result in a negative $DVAR$ (issue (i)).[9] 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 (issue (ii)).

One way to get around this is to rely on industry input-output tables. However, by construction, input-output tables assume proportionality in the construction that all firms within the same industry are assumed to be completely homogeneous in terms of products and technology. This is not the case from what we observe in the Chinese customs data. Even within a narrowly defined industry, the products and technology of firms vary widely. 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 domestic transaction costs, such as markups, transportation and distribution costs involved in domestic trade. All these

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

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

issues have been sidestepped in the approach that relies on industry input-output tables. Here we adopt a completely ground-up approach by only relying on firm-level information and focus on those firms that can give us reliable $DVAR$ estimates.

To address the complication due to indirect importing, we use firm-level data to first identify the excessive importers and exporters. We use data from the Annual Surveys of Industrial Firms conducted by China's National Bureau of Statistics (NBS) for 2000-2006, which we refer 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. To this end, we first merge the transaction-level trade data with the NBS data.[10] Not all firms from the two data sets can be merged. Tables 2 and 3 present the size of the merged sample relative to the full sample.[11] 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 weed out 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

$$\frac{P^D M^D + P^I M^I}{PY} \geqslant \frac{P^I M^I}{PY} = \frac{IMP}{EXP}. \tag{13}$$

We weed out the excessive importers that violate this inequality.

On the other side of the same token, there are processing firms that appear to import too little as they purchase materials from other processing firms locally. To identify these excessive exporters, we use the 25th percentile of $DVAR$ of the single-industry non-processing firms that export within the same industry section. We first identify all registered non-processing (ordinary)

[10] Since there is no common firm identifier that exists in both data sets, 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.

[11] 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.

exporters that only export in one industry section. Unlike processing firms, these exporters are not obliged to export all products that use imported materials. They also need to pay tariffs on imports and can use the imported materials to produce for both domestic and foreign sales. Their incentives to use imported materials are thus lower than processing traders. In addition, they are not restricted by customs regulations whom to sell in the domestic economy. Thus, the $DVAR$ of non-processing exporters should be higher than processing firms in the same industry.[12] In sum, we focus on single-industry processing exporters that have their import-to-export ratios bounded between the two cutoffs as follows:

$$\frac{P^D M^D + P^I M^I}{PY} \geqslant \frac{IMP}{EXP} \geqslant \left(\frac{IMP}{EXP}\right)^{OT}_{(25)}, \text{ where} \tag{14}$$

$DVAR^{OT}_{(25)} = 1 - \left(\frac{IMP}{EXP}\right)^{OT}_{(25)}$ is the 25 percentile of the $DVAR$ of ordinary exporters in the same industry.[13] Using this filtered set of firms with excessive importers and exporters removed, we obtain the DVA of each industry by subtracting total imports from total exports.

3.2.3 About Multi-industry Firms

We can compute $DVAR$ based on (2) for all firms, regardless of how many products they produce. However, if our goal is 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 section (19 of them), according to the United Nations industry classification.[14] Examples of an industry section include Chemical Products (HS2 = 28-38), Textiles (HS2 = 50-63),

[12] In unreported results, we verify that the median of $DVAR$ in processing exports is always higher than the 25th percentile of $DVAR$ in non-processing exports across industry sections.

[13] 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 (14) 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.

[14] See http://unstats.un.org/unsd/tradekb/Knowledgebase/HS-Classification-by-Section.

There are altogehter 20 setions but Section 19 - Arms and Ammunition is excluded because of the lack of trade data.

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 categories, 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.

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 (14) to remove the "excessive" importers and excessive 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 10,285 observations for 5,265 processing exporters over 7 years (2000-2006). It covers over 34% of total export value and 16% of the number of single-industry processing exporters as reported in the customs transactions-level 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 19 industry sections throughout the sample period. Figure 4 presents the overall results. The (weighted) average $DVAR$ across all industry sections in Chinese processing exports ($DVAR$) has been rising. It was 35 percent in 2000, and by 2006, it reached 49 percent. Figure 5 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 A2, the industry sections that have the highest $DVAR$ are Vehicles and Aircraft (HS2 = 86-89; $DVAR = 0.690$), Vegetables (HS2 = 6-14; 0.679), and Live Animals (HS = 1-5; 0.633). In 2000, the three industries with the highest $DVAR$ are Wood and Articles (HS2 = 44-46; $DVAR = 0.568$), Stone, Plaster, and Cement (HS2 = 68-70; $DVAR = 0.531$), and Beverages and Spirits (HS2 = 16-24; $DVAR = 0.473$). The three industries with lowest $DVAR$ in

2006 are Precious Metals (HS = 71; 0.315), Plastics and Rubber (HS = 39-40; 0.325), and Animal and Vegetable Oil (HS2 = 15; 0.399). Figure 6 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 19 sections, only 3 have lower $DVAR$ in 2006 compared to 2000.

Across export destinations, $DVAR$ tends to be positively correlated with destination countries' capital abundance and skill abundance (see Figure 7 and Figure 8). Regardless, there is an across-the-board rise in the $DVAR$ in Chinese processing exports to most destination countries.

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 the intense competition after China's WTO accession may favor firms with high $DVAR$. Another reason can be due to within-firm changes in response to the changing economic environment, such as rising costs of production 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 distinguish the impact due to within-firm changes from that due to firm entry and exit.

Specifically, according to the accounting identity (2), higher wages or 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 $DVAR$ could be due to processing firms substituting imported materials with domestic materials. Such substitution may be caused by the fact that a larger fraction of the global production chain is moving to China. If the second reason is the main culprit behind the rising $DVAR$ in Chinese exports, then the threat that Chinese workers are replacing workers in other countries, such as the US, will be larger.

In this section, we examine the dynamics of $DVAR$ and the underlying mechanism at the firm level by running reduced-form regressions, loosely following (10). A more formal analysis of the determinants of firm $DVAR$ will be presented in the next section. Specifically, we estimate the following regression using the merged customs-NBS data:

$$DVAR_{it} = \beta_i + \beta_t + \beta_M \left(\frac{P^D M^D + P^I M^I}{PY} \right)_{it} + \beta_X X_{it} + \epsilon_{it}, \tag{15}$$

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 (10), we include the firm's material-to-sales ratio, $\alpha_M = \frac{P^D M^D + P^I M^I}{PY}$, as a control. X_{it} includes the firm's (log) wage rate or the labor cost share, to verify the common claim that a firm's $DVAR$ can be rising due to rising labor costs. As our theoretical result in (10) shows, a firm's $DVAR$ is independent of firm's labor cost 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 our model may not be correct and the increasing labor cost is the primary reason for the firm's rising $DVAR$. Conversely, if β_X is not positive and not significant, while $\beta_t' s$ are rising and significant, then the results will be consistent with our model, which suggests that some imported materials are being substituted with domestic materials, keeping the share of material costs in total sales unchanged (given that we control for α_M). 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, suggesting that firm $DVAR$ is on average rising within firms during the sample period. In particular, firm $DVAR$ increases on average by 18 percentage points from 2000 to 2006, which is similar in magnitude to the aggregate trend of 14 percentage points (see Figure 4). Note that the aggregate trend can be driven by firms entering and exiting the market. However, since firm fixed effects are controlled for in the regression, the within-firm increase in $DVAR$ is independent of the reallocation of firms. In other words, the regression results provide stronger support for the rising $DVAR$ in Chinese exports than what the aggregate trend and existing research suggest.

In column (2) , we include the share of material costs in total revenue as a control, in addition to firm and year fixed effects. As is specified in (10), we find consistent evidence that a firm's $DVAR$ is negatively correlated with the firm's cost share of materials. In addition, the highly significant and increasing year fixed effects suggest that within a firm, $DVAR$ is rising despite keeping a constant cost share of materials – a pattern that is consistent with the hypothesis that firms substitute imported materials with domestic materials. In columns (3) and (4), we add the firm's (log) wage rate or the ratio of labor cost to sales to examine the conventional view that the rising $DVAR$ is driven by rising labor costs. According to (10), wages should not matter for $DVAR$. Given that neither the coefficients on the wage rate nor labor cost share are statistically significant, the results are consistent with our model that the within-firm increase in $DVAR$ is not driven by the firm's rising labor costs of production. Columns (5) to (6) show that the same patterns are observed in either the domestic or foreign firm sample. In column (7), we take out imports of capital good in our calculation of firm $DVAR$ to ensure that our results are not driven by the possibility that firms are using more foreign capital in production over time. 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 processing exporters substituting more imported materials with domestic materials over time, we estimate the following specification, according to (9) :

$$\left(\frac{IMP}{Material}\right)_{it} = \delta_i + \delta_t + \delta_X X_{it} + \nu_{it}, \tag{16}$$

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) includes only firm and year fixed effects. 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, the results suggest that a firm's $\left(\frac{IMP}{Material}\right)_{it}$ dropped by about 16 percentage points on average in 2006 compared to 2000. This decisively indicates that Chinese processing exporters are substituting more imported materials with domestic materials, providing a reason for our findings that $DVAR$ is increasing within firms over time. A firm's wage-sales ratio and capital-labor ratio do not appear to affect its $DVAR$ (columns (2)-(4)). When we split the sample into the domestic private and foreign firm sample (columns (5)-(6)) or exclude imports of capital goods in the calculation of firm $DVAR$ (columns (7)), we continue to obtain consistent and significant 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. Specifically, we correlate a firm's (log) number of import variety on firm fixed effect, γ_i, year fixed effects, γ_t, and the firm-level controls X_{it} as follows:

$$\ln(import\_variety_{it}) = \gamma_i + \gamma_t + \gamma_X X_{it} + \omega_{it}, \tag{17}$$

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 (15) and ω_{it} is the regression residual. Firm's import variety is measured by the number of imported HS6-country pairs at the firm level. 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 0.36 log points (about 43%) in 2006 relative to 2000.[15] Other firm-level controls are insignificant. Columns (5) and (6) show that the decline in import variety mostly happens among foreign firms but not domestic private firms. The results remain robust to the exclusion of imported capital from constructing the import variety measure (column (7)). 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 the import variety are both declining within firms over time. 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. Here we focus on the export variety of ordinary (non-processing) exporters. Unlike processing exporters, ordinary exporters consist mainly of indigenous Chinese private firms that produce for the domestic market.

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

Some of these local Chinese firms become big and may export part of their output overseas. 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.[16] Nevertheless, the following evidence is very interesting. 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 are the import demands for these products being met locally by the domestic suppliers, some of those domestic private firms are competitive enough to export such products to the world market within the short period of time. This provides direct evidence that domestic material variety is expanding to meet the demand of processing exporters.[17]

One can argue that the decline in import variety could be due to exporters specializing in their core competency, resulting in fewer export variety and thus import variety, which has nothing to do with rising $DVAR$. To rule this claim out, we estimate the following specification:

$$\ln(export\_variety_{it}) = \theta_i + \theta_t + \theta_X X_{it} + u_{it}, \tag{18}$$

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 (15). $export\_variety_{it}$ 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-level control variables are included as before.

As is shown in Table 8, despite the decline in the share of imported materials in total material cost and the decline in import variety, a processing firm's export variety is in fact rising over time, particularly after 2003, one year after China's accession to the WTO. The rise is more pronounced for the small sample of domestic private processing firms (column (5)). These results show that processing firms in China have been expanding their product scope while reducing their reliance on imported materials.

[16] 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.

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

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 (40-50 percent), as many anecdotes have described.

5 Exploring the reasons for the rising firm DVAR

What cause the Chinese exporters to substitute imported materials with domestic materials? To answer this question systematically, we rearrange the model-based expression of $DVAR$ in eq. (10) and take log to obtain the following empirical specification:

$$\ln(1 - DVAR_{it}) = \ln \alpha_M - \ln\left[1 + \left(\frac{P_{it}^I}{P_{it}^D}\right)^{\sigma-1}\right] - \ln \mu \tag{19}$$

$$\Rightarrow \ln(1 - DVAR_{it}) = \kappa_M \ln \alpha_M + \kappa_Z Z_{it} + \kappa_i + \eta_{it}. \tag{20}$$

Equation (20) assumes that firm markup μ is time-invariant and is absorbed by the firm fixed effect. Controlling for the firm's material cost share, α_M, the within-firm increase in $DVAR$ can be explained by any factors that affect the relative price of imported materials, $\frac{P_{it}^I}{P_{it}^D}$. Because there is no data available on the price of domestic materials, P_{it}^D, we cannot directly control for $\frac{P_{it}^I}{P_{it}^D}$ in (20). We will introduce factors (Z_{it}) that could affect the relative price of imported materials and verify whether those factors shape the within-firm movement of $DVAR_{it}$.

In section 3.1, we already discussed two factors that affect $\frac{P_{it}^I}{P_{it}^D}$ and thus firm $DVAR$. The first factor is related to the Chinese exchange rate. When the Chinese yuan is depreciating with respect to the countries that firm i used to import from, $\frac{P_{it}^I}{P_{it}^D}$ increases as long as pass-through is imperfect. According to (19), a higher $\frac{P_{it}^I}{P_{it}^D}$ would imply a lower $(1 - DVAR_{it})$ and thus a higher firm $DVAR$ as is reported so far. To examine whether exchange rates are the reasons for the rising firm $DVAR$, we first construct a firm-specific time-varying exchange rate. For each firm i, let I_{it} be the set of common countries firm i imports from in two consecutive years, t and $t-1$. Denote country j's currency price of a yuan in year t and $t-1$ by E_{jt} and E_{jt-1}; and denote country j's shares in firm

$i's$ imports in year t and $t-1$ by s_{jt} and s_{jt-1}. The firm-specific rate of yuan appreciation with respect to the countries firm i imports from in year t is defined as

$$d\ln E_{it} = \sum_{j\in I_{it}} \frac{1}{2}\left(s_{jt} + s_{jt-1}\right)\left(\ln E_{jt} - \ln E_{jt-1}\right).$$

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

$$E_{it} = E_{i_{t-1}} \exp\left(d\ln E_{it}\right), \tag{21}$$

with E_{it} normalized to 1 in the base year (2000) or any starting year for each firm. Likewise, we construct a firm-specific time-varying exchange rate for the exports of each firm. Given that exchange rate fluctuations with respect to export markets may affect firm markups, it is not clear a priori how a change in the Chinese exchange rate may affect firm $DVAR$ (Chatterjee, Dix-Carneiro and Vichyanond, 2012). Notice that our model has no prediction about how export-weighted exchange rates should affect $DVAR$.

Table 9 reports the regression results about the exchange rate effects on firm $DVAR$, based on eq. (20). All regressions include firm fixed effects so that the coefficients should be interpreted as the within-firm effects of the variable concerned. The log material cost share, $\ln\alpha_M$, is controlled for as specified in (20). In column (1), the coefficient on the firm-specific import-weighted exchange rate takes the right sign but is statistically insignificant. Column (2) also shows no correlation between firm-specific export-weighted exchange rate and firm $DVAR$. Column (3) includes both exchange rates as regressors while column (4) uses nominal exchange rates as the basis to calculate the firm-specific Tornqvist exchange rate. The results are similar. Overall, our findings suggest that the exchange rate movement may not have been an important determinant of the rising firm $DVAR$.

Next, we examine the second factor - whether the sharp increase in foreign direct investment (FDI) into the firm's industry contributes to the rising firm $DVAR$, through its positive influence on the variety of domestic materials produced in the upstream industries. As part of the conditions for accession to the WTO, China has to relax substantially restrictions on foreign participation in its economy. This regime change resulted in a large inflow of FDI into China. In addition to raising the demand for labor, an increased presence of foreign firms in the downstream industry may cause quality upgrading and variety expansion in the upstream industries (Rodriguez-Clare, 1996; Kee, 2012). As such, all firms have access to better and more variety of domestic materials, indirectly raising exporters' $DVAR$.

To examine the specific channel that FDI increases $DVAR$ through inducing an increase in the upstream variety, we compute an upstream variety measure for each downstream industry the firm belongs to. The upstream variety measure is computed as the weighted average of the number of variety (HS6 categories) exported by non-processing exporters in the upstream sectors, with weights equal to the material cost share of each upstream industry. The idea to focus on the variety exported by non-processing firms is that these firms often also produce for domestic sales. Ideally we would want to have a measure of variety available in the domestic market but such data are not available for China. To compute the material cost shares for each downstream industry, we use the benchmark input-output tables for 2002 from the NBS, the same I/O tables used by Koopman, Wang, and Wei (2012).[18] As is reported in Appendix Table A5, upstream variety increased over time for all but one industry sections during the sample period.

Table 10 reports the results for the regressions about the "FDI and variety" effects. All specifications include firm fixed effects and (log) material cost share. Since the variables of interest (FDI stock and upstream variety) vary across industry sections and years, we cluster standard errors at the industry section level.[19] Column (1) shows that within a firm, an increase in the upstream variety at the industry level is indeed associated with a within-firm increase in firm $DVAR$ as suggested in (11). Column (2) correlates ln(foreign capital stock) in the same industry-year with firm $\ln(1 - DVAR)$. Since we always include firm fixed effects, the stock measure is automatically differenced out from the industry-section averages. We can then interpret the coefficient on the FDI stock as the effects of FDI flows. We find that ln(foreign capital stock) is significantly and negatively correlated with firm $\ln(1 - DVAR_{it})$ (i.e., positively correlated with firm $DVAR$). These results are consistent with (12) suggesting that the influx of FDI has a positive impact on firm $DVAR$ within the same industry.

To further investigate our hypothesis that the prevalence of foreign activities in the downstream sector induces the supply of local intermediates in the upstream sector,[20] we instrument the up-

[18] Using a concordance table from the same source, we concord the original I/O code (123 x 123) to the industry section level (19 x 19).

[19] Clustering standard errors at the industry-section-year level yields even more significant results.

[20] Capital stock data by ownership type are from China's National Bureau of Statistics (NBS). In unreported results,

stream variety variable with industry FDI in a 2SLS regression. For industry FDI to be a valid instrument, the exclusion restriction requires that FDI has no direct influence on firm $DVAR$ other than through the upstream input variety. To satisfy such a restriction, we remove the share of each firm foreign capital from the industry FDI measure to sever the direct link between firm's characteristic and the industry FDI. In addition, we argue that it is not clear a priori why firms would have a higher $DVAR$ on average in an industry that has a higher FDI presence if it is not through the impact of industry FDI on upstream input variety. If the presence of FDI in an industry provides positive productivity spillover to other firms within the same industry, for instance through worker turnovers (Poole, 2012), then we should expect firm $DVAR$ to be lower since existing empirical studies suggest that the more productive firms tend to import more which would imply lower $DVAR$ (e.g., Bernard et al., 2007). Thus the FDI spillover hypothesis which suggest that industry FDI may not satisfy the exclusion restriction contradicts the results in column (2). Similarly, an increased presence of foreign capital in an industry may also intensify competition, forcing firms to cut their profit margins, which according to (1) should also lower $DVAR$. The relation contradicts our findings of increasing firm $DVAR$ so far. Finally, an increased presence of FDI in an industry may increase demand for all inputs, including workers and domestic materials, driving up wages and the price of domestic materials. We have already shown that wages have no impact on firm $DVAR$ once we control for the share of materials in total sales (see Table 4). Higher prices of domestic materials will decrease rather than increasing firm $DVAR$, according to (10). Thus, more intense competition due to more FDI in an industry should decrease $DVAR$, which again contradicts the results in column (2). Overall, we are reasonably confident that industry FDI satisfies the exclusion restriction – the channel via which FDI may have positive effects on firm $DVAR$ is by raising the supply of upstream input variety, as suggested by Rodriguez-Clare (1995) and Kee (2012).

Column (3) presents the 2SLS results. The first stage result is presented in the bottom part of Column (3).[21] It is clear that industry FDI is a strong predictor of upstream variety in the first stage, with a very high Kleibergen-Paap F-statistic showing that the instrument passes the weak instrument test by a wide margin. In the second stage, the effect of upstream variety on firm $DVAR$

we also include ln(state-owned capital) in the sector as a control. We find a positive correlation betwene ln(state-owned capital) and ln(1-DVAR). More importantly, the negative correlation between ln(FDI) and ln(1-DVAR) remains robust.

[21] The first stage also includes $\ln(\alpha_M)$ as an instrument but to conserve space, the results are not reported.

becomes stronger than its OLS counterpart, suggesting that FDI influx into the downstream industry helps promote firm $DVAR$ in the same industry through its impact on upstream input variety.

In sum, our results show that more FDI explain a significant part of the rising firm $DVAR$, and it is through the stimulated increase in upstream variety that this effect is realized. The yuan depreciation against either China's import source or destination countries do not appear to be an important determinant.

6 Extension to Non-Processing Firms 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 non-processing (ordinary) firms if we impose the within-firm proportionality assumption, i.e., the allocation a firm's imported materials to the production of exported goods is proportional to the export share in the firm's total sales. The reason we need such an assumption is because, first, unlike processing exporters that import primarily for producing exported goods, non-processing exporters can import materials for multiple purposes, including direct domestic sales, production of goods for domestic sales, and production of exported goods. The $DVAR$ in non-processing exports based on eq (2) is likely to be underestimated, as the equation ignores the first two types of imported material use and attributes all imports to the production of exported goods. Removing the portion of imported material use due to (1) and (2) can reduce the bias. However, firm-level information about how imported materials are split between domestic and export production is generally unavailable. We thus use the within-firm proportionality assumption to separate out the portion of imported materials for export production from the firm's total imports. One should note that our within-firm proportionality assumption will likely be non-binding if firms produce the same products for both the domestic and export markets. In addition, the assumption is considerably less restrictive than the within-industry proportionality assumption that has been imposed in the existing literature that relies on input-output tables. Here we still allow firms to be heterogeneous as each firm may have a different share of exports in total sales. For a non-processing exporter, we define DVA and $DVAR$ as follows:

$$DVA^{OT} = EXP - IMP\left(\frac{EXP}{PY}\right) \quad (22)$$

$$DVAR^{OT} = \frac{DVA}{EXP} = 1 - \frac{IMP\left(\frac{EXP}{PY}\right)}{EXP}, \quad (23)$$

where the superscript 'OT' stands for ordinary (non-processing) 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 (13)). 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 non-processing exporters. Unintentionally keeping those excessive exporters will result in an overestimation of $DVAR$ in non-processing exports. This is a caveat to keep in mind. Finally, to deal with the possibility that domestic materials contain foreign content, we take the conservative estimate in the literature to discount the computed $DVAR$ by 10 percentage points.

Figure 9 depicts the $DVAR$ in Chinese non-processing exports between 2000 and 2006, which increases from 0.87 at the bottom in 2001 to 0.88 in 2006. The increase seems small, but our measures based on firm-level data are largely in line with both the aggregate trend and numbers reported by Koopman, Wang, and Wei (2012).

By taking the weighted average of processing exporter's $DVAR$ and ordinary exporters' $DVAR$, with weights equal to the corresponding export share, we can compute the $DVAR$ in aggregate single-industry exports from China. Intuitively, given that over half of Chinese exports are accounted for by processing exports, the $DVAR$ in Chinese total exports is largely driven by the changes in processing exports. Figure 10 shows that the $DVAR$ in China's aggregate exports increased from 0.58 to 0.67 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 $DVAR$ in processing exports instead of that in non-processing exports.

7 Conclusions

In this paper, we use a ground-up approach to assess the domestic value added (DVA) in Chinese exports based on transactions-level trade data and firm-level production data. We find that the DVA ratio ($DVAR$) of processing exports used to be around 35 percent in 2000, and has since risen to 49 percent in 2006. Such changes affect most industries in our sample and most export destinations of China. Our finding of a rising $DVAR$ resonates with the existing literature, such as Koopman, Wang, and Wei (2012), which use information from the input-output tables for China to measure the $DVAR$ in Chinese exports. Our firm-level regressions confirm that the increase is due to an overall within-firm increase in $DVAR$, but not a reallocation of firms with different $DVAR$.

We build a simple model to highlight the firm determinants of $DVAR$. With reasonable assumptions, we show that factors that affect the relative price of imported materials to domestic materials, but not labor and capital costs, affect a firm's $DVAR$. Our firm-level analysis confirms that the rising $DVAR$ in Chinese exports is not driven by rising labor costs, but a gradual substitution of foreign imported materials with domestic materials. This substitution is revealed at both the intensive margin, represented by a lower imported material cost share, and the extensive margin, represented by a decline in import variety. We further verify that this substitution is in part due to a large influx of FDI. We empirically show that an increase in FDI raises firm $DVAR$ by stimulating an increased supply of local input variety. Changes in the exchange rates do not appear to affect firm $DVAR$. Regardless of the reasons, our findings point to the fact that Chinese exports have been expanding along the global production network and are no longer only responsible for the final stages of production. Nevertheless, any policy analysis based on gross exports will most likely overestimate the impact of Chinese exports on the US economy, given that the $DVAR$ of Chinese overall exports, while rising, is still far from one.

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8 Figures and Tables

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

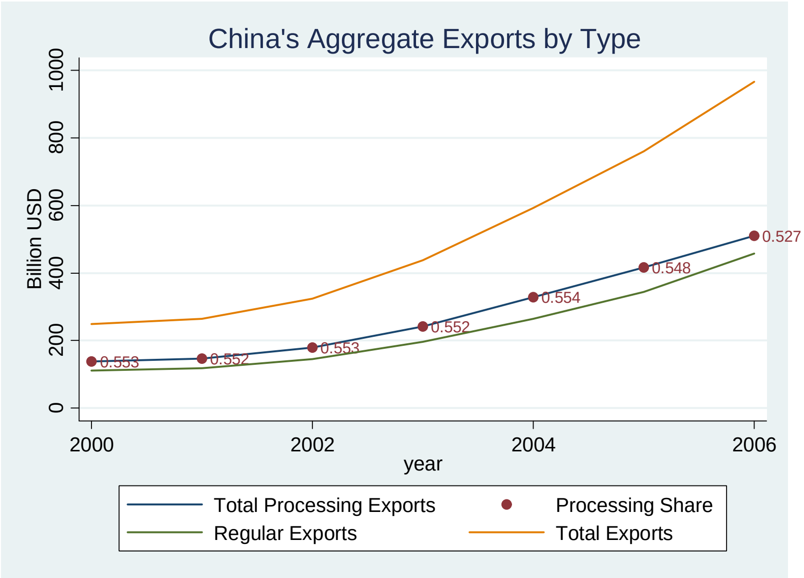

Figure 2: Shares of Processing Exports by Industry Group (2006)

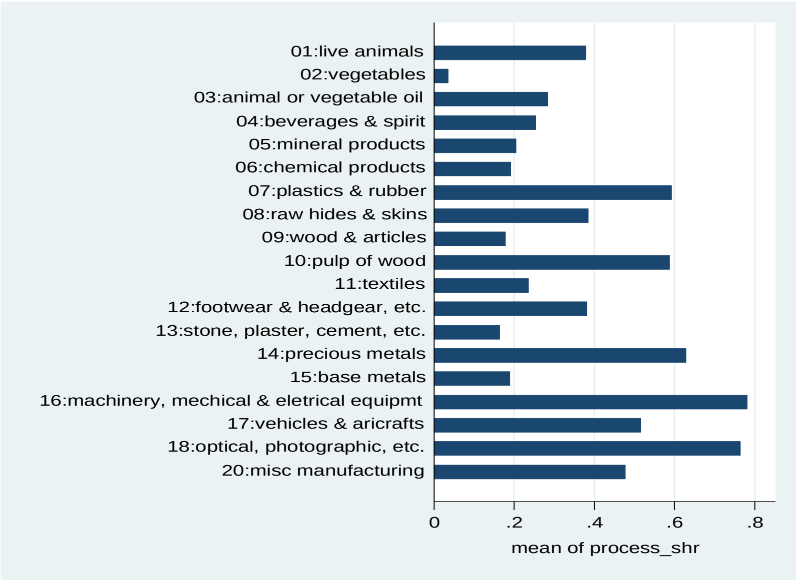

Figure 3: Shares of Processing Exports in Top Destinations (2000, 2006)

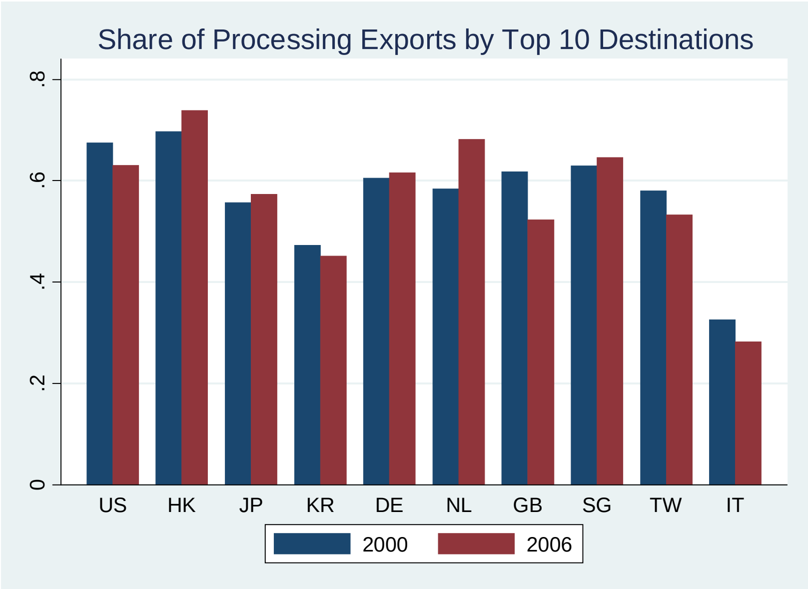

Figure 4: DVAR in Processing Exports (2000-2006)

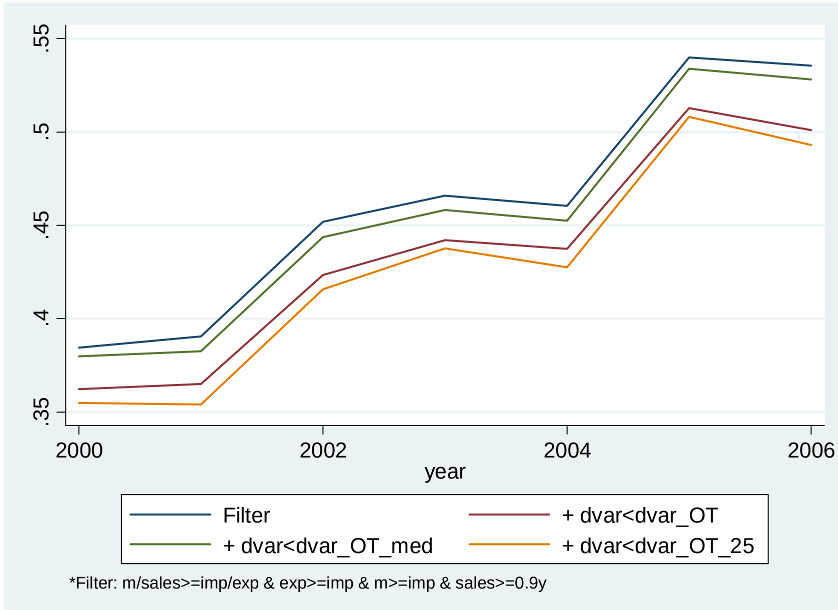

Figure 5: Distributions of DVAR across Industry Sections (2000-2006)

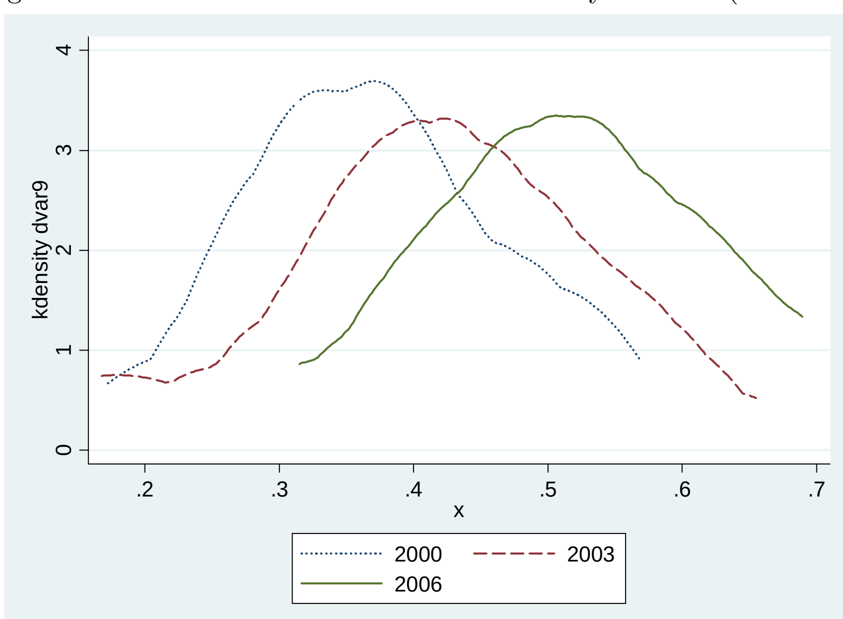

Figure 6: DVAR Trend (2000-2006) by Industry Section

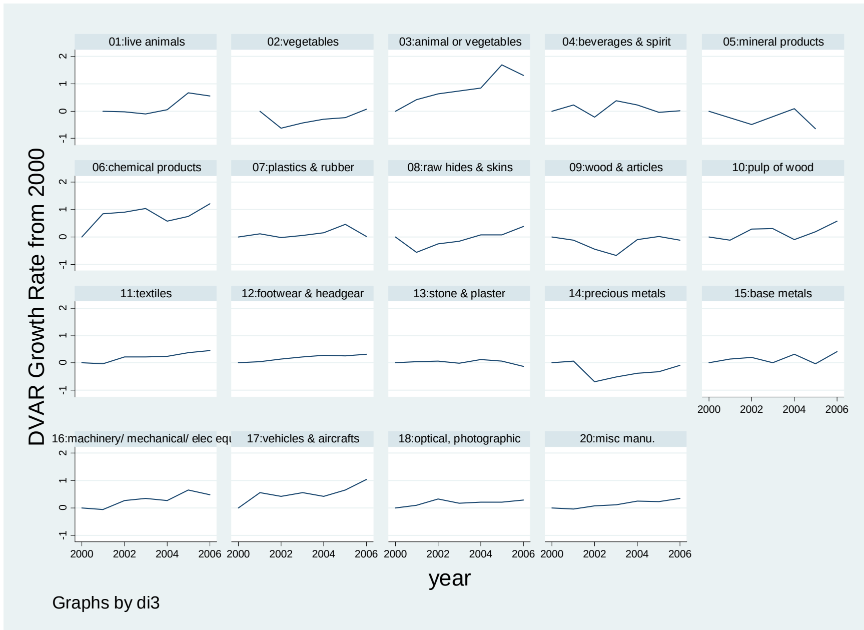

Figure 7: DVAR vs. Destinations' Capital Endowment (2006)

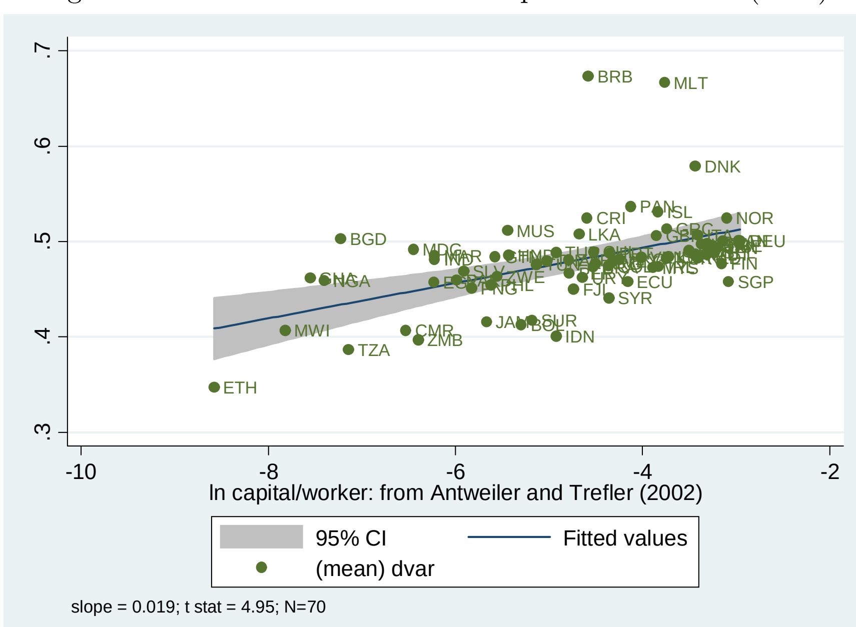

Figure 8: DVAR vs. Destinations' Human Capital Endowment (2006)

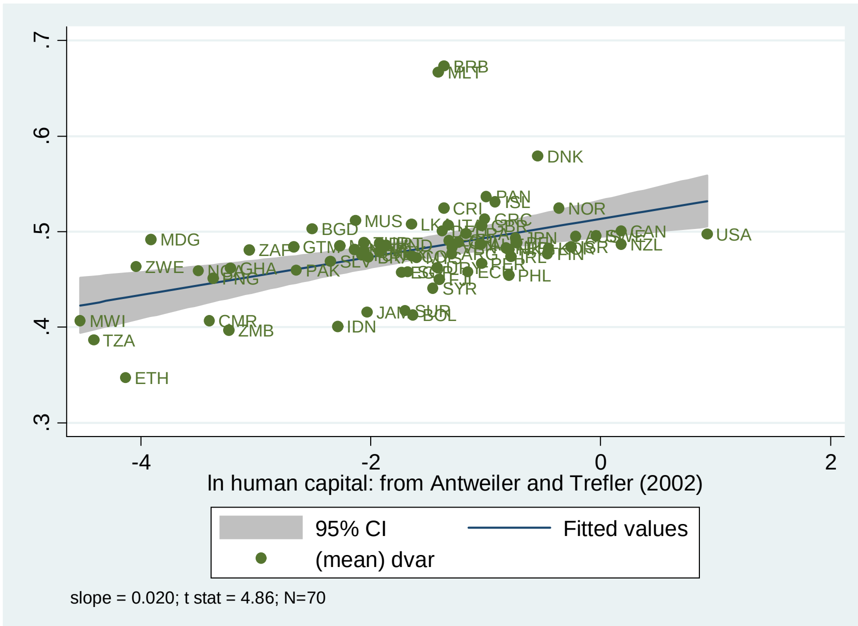

Figure 9: DVAR in Ordinary Exports (2000-2006)

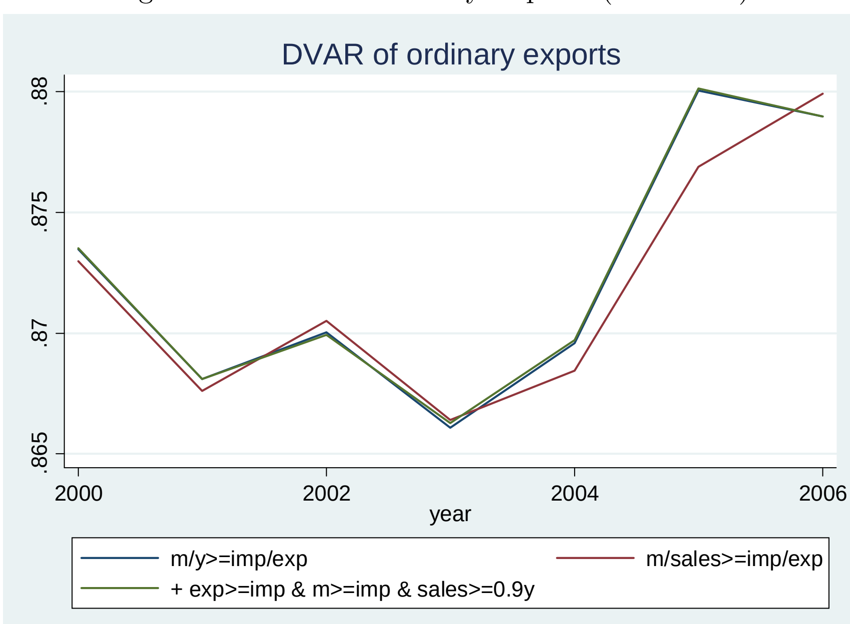

Figure 10: DVAR in Chinese Aggregate Exports (2000-2006)

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: Representativeness of Subsamples in the Original Customs Sample (in terms of number of exporters in 2006)

Group	Number				
	customs	merged	% of customs	filtered	% of customs
01:live animals (1-5)	400	101	25.25%	22	5.50%
02:vegetables (6-14)	175	46	26.29%	16	9.14%
03:animal or vegetable oil (15)	21	14	66.67%	10	47.62%
04:beverages & spirit (16-24)	676	284	42.01%	117	17.31%
05:mineral products (25-27)	69	44	63.77%	8	11.59%
06:chemical products (28-38)	1822	717	39.35%	259	14.22%
07:plastics & rubber (39-40)	5284	1842	34.86%	636	12.04%
08:raw hides & skins (41-43)	2575	916	35.57%	386	14.99%
09:wood & articles (44-46)	457	123	26.91%	44	9.63%
10:pulp of wood (47-49)	2052	921	44.88%	150	7.31%
11:textiles (50-63)	16527	6038	36.53%	2922	17.68%
12:footwear & headgear, etc. (64-67)	3784	1625	42.94%	958	25.32%
13:stone, plaster, cement, etc. (68-70)	814	304	37.35%	150	18.43%
14:precious metals (71)	1309	326	24.90%	99	7.56%
15:base metals (72-83)	3321	1295	38.99%	495	14.91%
16:machinery, mechanical electrical & equipmt (84-85)	16401	6349	38.71%	2692	16.41%
17:vehicles & aircraft (86-89)	900	424	47.11%	221	24.56%
18:optical, photographic, etc. (90-92)	2474	753	30.44%	374	15.12%
20:misc manufacturing (94-96)	3625	1195	32.97%	735	20.28%
Total	62716	23319	37.18%	10294	16.41%

Source: China's Customs Trade Data and National Bureau of Statistics (NBS) Manufacturing Survey.
Section 19 - Arms and ammunition is excluded from the analysis.

Table 3: Representativeness of Subsamples relative to the Original Customs Sample (in terms of export value in 2006)

Group	Sales (million usd)				
	customs (mil usd)	merged	% of customs	filtered	% of customs
01:live animals (1-5)	695.0	348.0	50.07%	50.2	7.22%
02:vegetables (6-14)	135.0	54.6	40.44%	23.9	17.70%
03:animal or vegetable oil (15)	78.6	68.6	87.28%	60.6	77.10%
04:beverages & spirit (16-24)	1090.0	784.0	71.93%	331.0	30.37%
05:mineral products (25-27)	6740.0	6640.0	98.52%	81.6	1.21%
06:chemical products (28-38)	3110.0	1700.0	54.66%	731.0	23.50%
07:plastics & rubber (39-40)	9230.0	5960.0	64.57%	2940.0	31.85%
08:raw hides & skins (41-43)	5120.0	3240.0	63.28%	1070.0	20.90%
09:wood & articles (44-46)	441.0	256.0	58.05%	117.0	26.53%
10:pulp of wood (47-49)	1410.0	870.0	61.70%	315.0	22.34%
11:textiles (50-63)	29400.0	19600.0	66.67%	9590.0	32.62%
12:footwear & headgear, etc. (64-67)	13100.0	9160.0	69.92%	6680.0	50.99%
13:stone, plaster, cement, etc. (68-70)	1140.0	835.0	73.25%	459.0	40.26%
14:precious metals (71)	9680.0	7400.0	76.45%	630.0	6.51%
15:base metals (72-83)	8990.0	4760.0	52.95%	2610.0	29.03%
16:machinery, mechanical electrical & equipmt (84-85)	122000.0	74000.0	60.66%	39900.0	32.70%
17:vehicles & aircraft (86-89)	15900.0	12000.0	75.47%	8650.0	54.40%
18:optical, photographic, etc. (90-92)	5460.0	4070.0	74.54%	1060.0	19.41%
20:misc manufacturing (94-96)	6810.0	3960.0	58.15%	2360.0	34.65%
Total	240539.4	155709.8	64.79%	77659.3	32.29%

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

Section 19 - Arms and ammunition is excluded from the analysis.

Table 4: Dependent variable: Firms' DVAR

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Sample	all	all	all	all	dom private	foreign	all - excl machinery/ equip imp.
β_{2001}	0.0273***	0.0264***	0.0253***	0.0264***	0.0776	0.0285***	0.0280***
	(0.007)	(0.007)	(0.007)	(0.007)	(0.080)	(0.007)	(0.007)
β_{2002}	0.0572***	0.0547***	0.0530***	0.0548***	0.0955	0.0546***	0.0597***
	(0.007)	(0.007)	(0.007)	(0.007)	(0.083)	(0.007)	(0.007)
β_{2003}	0.0901***	0.0875***	0.0868***	0.0876***	0.217**	0.0865***	0.0814***
	(0.008)	(0.008)	(0.008)	(0.008)	(0.089)	(0.008)	(0.008)
β_{2004}	0.0992***	0.0983***	0.0970***	0.0984***	0.175**	0.0982***	0.0941***
	(0.008)	(0.008)	(0.008)	(0.008)	(0.086)	(0.008)	(0.008)
β_{2005}	0.141***	0.137***	0.135***	0.137***	0.216**	0.138***	0.126***
	(0.008)	(0.008)	(0.008)	(0.008)	(0.088)	(0.008)	(0.009)
β_{2006}	0.178***	0.174***	0.171***	0.174***	0.277***	0.174***	0.167***
	(0.009)	(0.009)	(0.009)	(0.009)	(0.099)	(0.009)	(0.010)
$\left(\frac{P^D M^D + P^I M^I}{PY}\right)_{it}$		-0.0798***	-0.0802***	-0.0798***	-0.199	-0.0776***	-0.0861***
		(0.020)	(0.020)	(0.020)	(0.245)	(0.020)	(0.035)
$\left(\frac{wL}{PY}\right)_{it}$				-0.00269	0.160	-0.0031	-0.003
				(0.004)	(0.240)	(0.004)	(0.002)
$\ln(\text{wage rate})_{it}$			0.0051				
			(0.005)				
N	10285	10285	10170	10285	506	9562	7827
r2	.122	.13	.13	.13	.115	.133	.118

Note: Firm and year fixed effects are always included. Data set: merged NBS and customs data.
Columns (1)-(4) use the whole sample; columns (5) and (6) include only domestic private and foreign-invested firms, respectively.
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)	(5)	(6)	(7)
Sample	all	all	all	all	dom private	foreign	all - excl machinery/ equip imp
δ_{2001}	-0.0245***	-0.0245***	-0.0244***	-0.0246***	-0.0964*	-0.0235***	-0.0258***
	(0.008)	(0.008)	(0.008)	(0.008)	(0.056)	(0.008)	(0.008)
δ_{2002}	-0.0335***	-0.0335***	-0.0331***	-0.0339***	-0.0621	-0.0353***	-0.0396***
	(0.008)	(0.008)	(0.008)	(0.008)	(0.069)	(0.008)	(0.008)
δ_{2003}	-0.0756***	-0.0765***	-0.0772***	-0.0767***	-0.109	-0.0794***	-0.0774***
	(0.009)	(0.009)	(0.009)	(0.009)	(0.068)	(0.009)	(0.009)
δ_{2004}	-0.0839***	-0.0846***	-0.0848***	-0.0850***	-0.113	-0.0879***	-0.0828***
	(0.010)	(0.010)	(0.010)	(0.010)	(0.078)	(0.010)	(0.010)
δ_{2005}	-0.117***	-0.117***	-0.117***	-0.118***	-0.181**	-0.120***	-0.113***
	(0.010)	(0.010)	(0.010)	(0.010)	(0.081)	(0.010)	(0.010)
δ_{2006}	-0.159***	-0.160***	-0.161***	-0.161***	-0.192**	-0.164***	-0.161***
	(0.010)	(0.010)	(0.011)	(0.010)	(0.086)	(0.010)	(0.010)
$\ln(K/L)_{it}$		-0.0044	-0.0041	-0.0044	0.0088	-0.0060	-0.0057
		(0.005)	(0.005)	(0.005)	(0.038)	(0.005)	(0.005)
$\ln(\text{wage rate})_{it}$			0.0005				
			(0.006)				
$\left(\frac{wL}{PY}\right)_{it}$				0.0127	0.0621	0.0129	0.0129
				(0.012)	(0.215)	(0.012)	(0.012)
N	10285	10260	10145	10260	505	9540	7803
R-sq	.0866	.0873	.0875	.0878	.113	.0913	.0853

Note: Firm and year fixed effects are always included. Data set: merged NBS and customs data.
Columns (1)-(4) use the whole sample; columns (5) and (6) include only domestic private and foreign-invested firms, respectively.
Standard errors are in parentheses. * p<0.10; ** p<0.05; *** p<0.01.

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

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Sample	all	all	all	all	dom private	foreign	all - excl machinery/ equip imp
γ_{2001}	-0.145***	-0.146***	-0.149***	-0.146***	-0.425**	-0.137***	-0.125***
	(0.020)	(0.020)	(0.020)	(0.020)	(0.205)	(0.020)	(0.020)
γ_{2002}	-0.180***	-0.180***	-0.181***	-0.180***	-0.0223	-0.174***	-0.172***
	(0.022)	(0.022)	(0.022)	(0.022)	(0.248)	(0.022)	(0.023)
γ_{2003}	-0.336***	-0.337***	-0.341***	-0.336***	-0.425	-0.332***	-0.301***
	(0.024)	(0.024)	(0.024)	(0.024)	(0.277)	(0.024)	(0.025)
γ_{2004}	-0.403***	-0.403***	-0.409***	-0.403***	0.000307	-0.406***	-0.372***
	(0.027)	(0.027)	(0.027)	(0.027)	(0.262)	(0.028)	(0.029)
γ_{2005}	-0.495***	-0.496***	-0.503***	-0.495***	-0.180	-0.497***	-0.441***
	(0.029)	(0.029)	(0.029)	(0.029)	(0.251)	(0.029)	(0.033)
γ_{2006}	-0.365***	-0.366***	-0.376***	-0.365***	-0.121	-0.360***	-0.322***
	(0.031)	(0.031)	(0.031)	(0.031)	(0.274)	(0.031)	(0.031)
$\left(\frac{P^D M^D + P^I M^I}{PY}\right)_{it}$		-0.0206	-0.0165	-0.0206	0.808	-0.0149	0.0417
		(0.053)	(0.053)	(0.053)	(0.794)	(0.055)	(0.043)
$\ln(\text{wage rate})_{it}$			0.0157				
			(0.016)				
$\left(\frac{wL}{PY}\right)_{it}$				-0.00852	-0.379	-0.00674	-0.0128
				(0.012)	(0.773)	(0.010)	(0.016)
N	10285	10285	10170	10285	506	9562	7827
R-sq	.103	.103	.105	.103	.156	.108	.094

Note: Firm and year fixed effects are always included. Data set: merged NBS and customs data.
Columns (1)-(4) use the whole sample; columns (5) and (6) include only private, domestic private, and foreign-invested firms, respectively.
Standard errors are in parentheses. * $p<0.10$; ** $p<0.05$; *** $p<0.01$.

Table 7: Products that used to be imported by processing 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 variety)

	(1)	(2)	(3)	(4)	(5)	(6)
Sample	all	all	all	all	dom private	foreign
θ_{2001}	-0.0614***	-0.0623***	-0.0677***	-0.0618***	0.338**	-0.0532**
	(0.023)	(0.023)	(0.023)	(0.023)	(0.165)	(0.023)
θ_{2002}	0.0281	0.0258	0.0288	0.0270	0.504**	0.0447*
	(0.026)	(0.026)	(0.026)	(0.026)	(0.197)	(0.026)
θ_{2003}	0.0791***	0.0767***	0.0737***	0.0774***	0.755***	0.0841***
	(0.027)	(0.027)	(0.027)	(0.027)	(0.253)	(0.028)
θ_{2004}	0.112***	0.111***	0.108***	0.112***	0.953***	0.112***
	(0.030)	(0.030)	(0.031)	(0.030)	(0.220)	(0.031)
θ_{2005}	0.188***	0.184***	0.179***	0.185***	1.070***	0.184***
	(0.031)	(0.032)	(0.033)	(0.032)	(0.234)	(0.032)
θ_{2006}	0.278***	0.274***	0.268***	0.276***	1.159***	0.274***
	(0.033)	(0.034)	(0.035)	(0.034)	(0.263)	(0.034)
$\left(\frac{P^D M^D + P^I M^I}{PY}\right)_{it}$		-0.0743	-0.0762	-0.0744	-0.209	-0.0745
		(0.060)	(0.060)	(0.060)	(0.602)	(0.060)
$\left(\frac{wL}{PY}\right)_{it}$				-0.0347***	-0.151	-0.0350***
				(0.009)	(0.638)	(0.008)
ln(wage rate)$_{it}$			0.0104			
			(0.018)			
N	10285	10285	10170	10285	506	9562
R-sq	.0435	.0442	.0444	.0446	.167	.0433

Note: Firm and year fixed effects are always included. Data set: merged NBS and customs data.
Columns (1)-(4) use the whole sample; column (5) and (6) include only domestic private and foreign-invested firms, respectively.
Standard errors are in parentheses. * p<0.10; ** p<0.05; *** p<0.01.

Table 9: Firm ln(1-DVAR) and Firm-specific Exchange Rates

	(1)	(2)	(3)	(4)
Exchange rate measure		CPI-deflated		nominal
ln(imp-weighted exr)$_{it}$	0.092		0.051	0.095
	(0.148)		(0.157)	(0.138)
ln(exp-weighted exr)$_{it}$		0.191	0.176	0.020
		(0.182)	(0.193)	(0.184)
$\ln\left(\frac{P^D M^D + P^I M^I}{PY}\right)_{it}$	0.261***	0.260***	0.261***	0.261***
	(0.037)	(0.037)	(0.037)	(0.037)
N	8834	8834	8834	8834
R-sq	.0168	.0171	.0171	.0169

Note: All regressions include firm fixed effects. Dependent variable is firm ln(1-DVAR).
Columns (1)-(3) use firm-specific exchange rate index calculated using bilateral nominal exchange rates deflated by China's and destination countries' CPI.
Column (4) uses firm-specific exchange rate index calculated using bilateral nominal exchange rates. See eq. (21) for the definition.
Robust standard errors are in parentheses. * p<0.10; ** p<0.05; *** p<0.01.

Table 10: Firm ln(1-DVAR), FDI, and Upstream Variety

	(1)	(2)	(3)
Estimation Method	OLS		2SLS
ln(foreign capital stock)$_{st}$		-0.069***	
		(0.010)	
ln(upstream variety)$_{st}$	-12.268***		-17.509***
	(1.860)		(3.112)
$\ln\left(\frac{P^D M^D + P^I M^I}{PY}\right)_{it}$	0.213***	0.250***	0.180***
	(0.034)	(0.034)	(0.032)
N	9433	9433	9433
R-sq	0.112	0.069	0.095
First Stage			
ln(foreign capital stock)$_{st}$			0.0039***
			(0.0004)
Kleibergen-Paap F-stat			891.46

All regressions include firm fixed effects. Dependent variable is firm ln(1-DVAR). Standard errors, clustered at the industry-section level, are in parentheses. * p<0.10; ** p<0.05; *** p<0.01.
In column (3), all regressors besides ln(upstream) in the second stage are also included in the first stage as instruments.

Table A1: Share of Processing Exports in Top Export 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: Weighted Average of DVAR

year	DVAR (filter 1)	DVAR (filter 2)	DVAR (filter 3)	DVAR (filter 4)
2000	0.384	0.362	0.380	0.355
2001	0.390	0.365	0.382	0.354
2002	0.452	0.423	0.444	0.416
2003	0.466	0.442	0.458	0.438
2004	0.460	0.437	0.452	0.428
2005	0.540	0.513	0.534	0.508
2006	0.535	0.501	0.528	0.493

Filter 1: Include exporters that have mat/sales>=imp/exp & exp>=imp & mat>=imp & sales>=0.9y
Filter 2: Include exporters that satisfy Filter 1 and dvar<dvar_OT
Filter 3: Include exporters that satisfy Filter 1 and dvar<dvar_OT_med
Filter 4: Include exporters that satisfy Filter 1 and dvar<dvar_OT_25

Table A3: DVAR by Industry Section and Year

Industry Section	Year						
	2000	2001	2002	2003	2004	2005	2006
01:live animals (1-5)	-	0.409	0.397	0.369	0.428	0.680	0.633
02:vegetables (6-14)	-	0.637	0.236	0.364	0.446	0.480	0.679
03:animal or vegetable oil (15)	0.173	0.245	0.281	-	0.319	0.465	0.399
04:beverages & spirit (16-24)	0.473	0.575	0.366	0.655	0.577	0.452	0.474
05:mineral products (25-27)	0.318	-	0.163	-	0.345	0.114	-
06:chemical products (28-38)	0.234	0.434	0.445	0.478	0.370	0.412	0.518
07:plastics & rubber (39-40)	0.318	0.353	0.315	0.337	0.370	0.465	0.325
08:raw hides & skins (41-43)	0.395	0.171	0.293	0.332	0.425	0.423	0.548
09:wood & articles (44-46)	0.568	0.508	0.313	0.190	0.508	0.583	0.499
10:pulp of wood (47-49)	0.286	0.255	0.367	0.374	0.259	0.342	0.450
11:textiles (50-63)	0.365	0.351	0.444	0.449	0.453	0.500	0.531
12:footwear & headgear, etc. (64-67)	0.464	0.488	0.534	0.563	0.589	0.588	0.610
13:stone, plaster, cement, etc. (68-70)	0.531	0.557	0.562	0.529	0.598	0.568	0.467
14:precious metals (71)	0.346	0.372	0.109	0.168	0.218	0.238	0.315
15:base metals (72-83)	0.395	0.455	0.476	0.403	0.520	0.385	0.557
16:machinery, mechanical electrical & equipmt (84-85)	0.319	0.301	0.402	0.432	0.404	0.530	0.475
17:vehicles & aircraft (86-89)	0.339	0.529	0.484	0.529	0.481	0.563	0.690
18:optical, photographic, etc. (90-92)	0.345	0.378	0.456	0.407	0.420	0.419	0.447
20:misc manufacturing (94-96)	0.453	0.434	0.490	0.501	0.562	0.556	0.608

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

Table A4: Median of Materials to Sales Ratio by Industry Section and Year

Industry Section	Year						
	2000	2001	2002	2003	2004	2005	2006
01:live animals (1-5)	0.782	0.844	0.732	0.667	0.716	0.675	0.746
02:vegetables (6-14)	0.774	0.789	0.754	0.730	0.845	0.747	0.750
03:animal or vegetable oil (15)	0.880	0.988	0.731	0.730	0.668	0.762	0.595
04:beverages & spirit (16-24)	0.832	0.770	0.783	0.728	0.820	0.762	0.764
05:mineral products (25-27)	0.805	0.994	0.765	0.865	0.710	0.854	0.827
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 A5: 25th-percentile of Ordinary Exporters' DVAR by Industry Section and Year

Industry Section	Year						
	2000	2001	2002	2003	2004	2005	2006
01:live animals (1-5)	0.845	0.983	0.986	0.940	0.938	0.943	0.982
02:vegetables (6-14)		0.858	0.920	0.935	0.948	0.957	0.957
03:animal or vegetable oil (15)							
04:beverages & spirit (16-24)	0.754	0.826	0.737	0.843	0.843	0.859	0.865
05:mineral products (25-27)	0.832		0.833		0.502	0.914	
06:chemical products (28-38)	0.820	0.839	0.899	0.927	0.899	0.897	0.932
07:plastics & rubber (39-40)	0.773	0.906	0.854	0.635	0.826	0.805	0.727
08:raw hides & skins (41-43)	0.908	0.945	0.961	0.978	0.907	0.875	0.950
09:wood & articles (44-46)	0.907	0.778	0.890	0.857	0.928	0.892	0.907
10:pulp of wood (47-49)	0.982	0.600	0.967	0.878	0.566	0.624	0.764
11:textiles (50-63)	0.904	0.893	0.933	0.936	0.924	0.954	0.942
12:footwear & headgear, etc. (64-67)	0.785	0.959	0.985	0.987	0.961	0.957	0.972
13:stone, plaster, cement, etc. (68-70)	0.947	0.936	0.883	0.914	0.890	0.931	0.913
14:precious metals (71)	1.000	0.998	0.942	0.991	0.946	0.993	0.970
15:base metals (72-83)	0.819	0.914	0.886	0.934	0.947	0.929	0.947
16:machinery, mechanical eletrical & equipmt (84-85)	0.908	0.831	0.830	0.871	0.851	0.896	0.894
17:vehicles & aircraft (86-89)	0.854	0.855	0.888	0.861	0.847	0.958	0.945
18:optical, photographic, etc. (90-92)	0.834	0.912	0.925	0.787	0.876	0.848	0.724
20:misc manufacturing (94-96)	0.862	0.917	0.944	0.971	0.963	0.960	0.971

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

Table A6: Upstream Variety Counts

Industry Section	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