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Unexceptional exporter performance in China? The role of processing trade

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ABSTRACT

The firm level trade literature finds that exporters are exceptional performers for a wide range of countries and measures. Paradoxically, the one documented exception is the world's largest exporter, China. We show that this puzzling finding is entirely driven by firms that engage only in export processing — the activity of assembling tariff exempted imported inputs into final goods for resale in the foreign markets. We find that processing exporters are less productive than non-processing exporters and non-exporters, and have inferior performance in many other aspects such as profitability, wages, R&D and skill intensity. Accounting for processing exporters explains the abnormality in exporter performance in China documented in the previous literature. Low fixed costs of processing exporting, as well as the trade and industrial policies favoring processing exporters are both responsible for the low productivity of processing exporters. Our analysis suggests that distinguishing between processing and non-processing exporters is crucial for understanding firm-level exporting behavior in China. It also provides caveats in analyzing the exporter performance in other developing countries that are highly integrated into the global value chains.

1. Introduction

The nature of international trade has changed — as Grossman and Rossi-Hansberg (2006) put it: It's not wine for cloth anymore. In the modern world, with rapid progress of communication and technology, production processes increasingly involve global value chains (henceforth GVCs) spanning multiple countries, with different stages of the production taking place in several disparate locations. A particular form of this fragmented production technique is processing trade: the activity of assembling tariffs exempted imported inputs into final goods for resale in the foreign markets. The iPhone is a classic example: the different components of an iPhone are manufactured in Japan, Korea, Germany, US, and Taiwan from where these are shipped to China for the final assembly at Foxconn, an exclusive iPhone assembler located in Shenzhen, China. All final assembled products are exported back to the US and other markets. In terms of its sheer magnitude processing trade in China merits special attention. Processing trade accounts for nearly half of China's exports, exceeding total exports for most countries except Germany and USA. Processing/assembly has become popular in other developing countries as well. In 2006, 130 countries had established 3500 Export Processing Zones (EPZs), which employed 66 million people in total. For many countries (Kenya, Malaysia, Argentina, etc.), exports from EPZs accounted for over 80% of their total exports.

To the best of our knowledge, this paper is one of the first to study the performance of processing firms vis-a-vis non-processing ones. Using a comprehensive firm-level data that matches balance-sheet information with trade information by detailed trade regime, we demonstrate that processing exporters in China are very different from the traditional exporters in that they do not exhibit the exceptional performance of exporters as documented for a wide range of countries and measures. We also show that accounting for this difference is crucial. In fact, if all exporters are treated the same in China, a puzzling result emerges: contrary to the accumulated evidence in the literature, exporters are no longer superior performers.[1] We show that these puzzling findings are largely driven by firms purely engaged in processing trade, whereas other types of firms have the usual superior performance.

We first systematically document the performance of processing exporters. Our main findings are as follows. First, processing exporters are less productive than both non-processing exporters and non-exporters. Second, processing exporters are special in other aspects as well. These firms have lower profitability, pay lower wages, are relatively smaller in terms of sales, have lower capital intensity, invest less in R&D, and are less skill intensive. Finally, it is crucial to account for processing exporters separately, since failing to do so make all exporters

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[1] That exporters in China are less productive than non-exporters have been documented in Lu et al. (2010) and Lu (2010).

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appear less productive than non-exporters — even though non-processing exporters' performance is similar to what has been widely documented in the literature. Henceforth, studies of export performance in China (or countries with large processing trade sectors such as Mexico and Vietnam) should account for the distinction between processing and non-processing sectors.

We next investigate why processing exporters are less productive. We propose a selection mechanism rationalizing the lower productivity of processing exporters over non-processing ones. Firms trade-off the benefits and costs of different trade modes. Compared with non-processing trade, processing trade mainly has two benefits. First, it is associated with lower fixed costs of exporting because the exporting costs in distribution, marketing, and R&D are shared by the foreign buyer. Second, the trade and industrial policies favoring processing trade, such as exemptions of input tariffs and reductions of corporate income tax rates, further reduced the costs of doing processing. However, processing trade is also associated with additional costs. Since processing firms generally contribute less than non-processing firms to the value of the final good, they have to share a larger proportion of profits with other producers. Under this framework, firms with different productivity will optimally sort into different trade modes. Less productive firms will select into processing exporting because the benefits of lower fixed costs outweigh the costs of profit sharing, while for more productive firms, the vice versa is true so they select into non-processing.

Empirically, we find that the low fixed costs of exporting, as well as the trade and industrial policies favoring processing trade, are both responsible for the low productivity of processing exporters. For the role of the fixed costs of exporting, we find that processing exporters are particularly less productive in industries that are intensive in distribution, advertising, and R&D-elements which are usually thought to be the important components of the fixed costs of exporting. We also find that the productivity of firms doing pure assembly (which arguably has lower fixed costs of exporting than PWIM because of its passive role in obtaining materials and searching for clients) is lower than firms doing PWIM. For the role of trade and industrial policies, we find input tariffs exemptions and income tax benefits both matter. First, the relative productivity of processing exporters are lower in the sectors where the benefits of input tariffs exemptions are larger. Second, processing firms that are eligible for the income tax benefits granted to export-oriented firms have particularly low productivity. Also, controlling for eligibility to the tax benefits reduces the productivity disadvantage of processing exporters to a large extent.

Our analysis provides a significant caveat in analyzing the exporter performance in countries that are highly integrated into the GVCs. It highlights the fact that the connection between trade, productivity and other firm outcomes within GVCs is likely to be complex, especially when the integration into the global production network is accompanied with discriminative trade and industrial policies. It also underscores the importance of a firm's place and role within a GVC as a potential determinant of its productivity and other performances. It is important to note that we are not aware of any studies that investigate the performance of processing trade firms in countries other than China, so it is yet to be established whether the unexceptional performance of processing firms found in the Chinese data is generalizable to other developing countries as well. For other developing countries interested in increasing GVC participation and learning from China's experience, it will thus be important for future research to examine whether processing trade generally has these kinds of implications.

Our paper is related to the firm level trade literature analyzing the behavior of exporters. Papers like Bernard and Jensen (1995, 1999, 2004); Bernard and Wagner (1997); Clerides et al. (1998); Aw et al. (2000); Pavcnik (2002); Greenaway and Kneller (2004); Blalock and Gertler (2004); Van Biesebroeck (2005), and De De Loecker (2007); to name a few, find that exporters are more productive than non-exporters for a wide range of countries. Two recent papers, however, find the opposite result for China — exporters being less productive than non-exporters. The paper, by Lu et al. (2010), shows that the anomalous result is true only for exporters that are foreign-owned-firms. Another paper, by Lu (2010), finds that exporters are less productive than non-exporters only in labor intensive sectors. In this paper we match the firm level data used in the two prior works to the Chinese customs trade data.[2] The use of merged data allows us to identify a firm's processing status and uncover new systematic patterns about how firms' productivity vary with processing status.

This paper is also related to the literature studying global value chains. Though many papers, both theory and empirical, have studied international vertical specialization and GVCs (Feenstra and Hanson, 1996, 1999, 2005; Hummels et al., 1998; Hummels et al., 2001; Yi, 2003; Hanson et al., 2005; Grossman and Rossi-Hansberg, 2008; Costinot et al., 2013; Johnson and Noguera, 2012, etc.), none of these papers have investigated the firms along the GVCs from a developing country's point of view. The present paper aims to fill this gap.

Lastly, there is an emerging literature documenting the special features and implications of processing trade. At the micro level, recent studies have revealed interesting patterns of processing exporters, including vertical integration (Fernandes and Tang, 2012), product scope (Fernandes and Tang, 2015), and exporting dynamics (Fernandes and Tang, 2015). At the macro level, studies have found that processing trade is associated with aggregate consequences. Bergin et al. (2011) show that industries that are more involved in processing trade are associated with higher volatility. Defever and Riaño (2014) show that subsidies towards processing exporters leads to domestic welfare loss. Finally, processing trade is shown to be important in understanding value-added trade. Koopman et al. (2012) shows that using traditional methods for calculating value added for countries that actively engage in processing trade can overestimate the domestic content of these countries' exports. Kee and Tang (forthcoming) studies the patterns and determinants of domestic value-added of Chinese processing exporters. Our paper is distinct from these studies as we focus on processing trade and productivity. We show that processing exporters are less productive, and accounting for this special feature of processing exporters has important implications in understanding the link between trade and productivity in general.

The paper is organized as follows. Section 2 briefly introduces China's export processing regime. Section 3 describes the data. Section 4 provides several stylized facts about processing exporters in China and relates them to the productivity abnormality documented about Chinese exporters. Section 5 offers possible interpretations about processing exporters' unexceptional performance and how well they are supported by the data, and discusses the dynamics of processing status. The last section concludes.

2. Introduction of China's export-processing regime

The Chinese government has been actively promoting processing trade since the 1980s in order to stimulate exports. Processing trade is defined as "business activities in which the operating enterprise imports all or part of the raw or ancillary materials, spare parts, components, and packaging materials, and re-exports finished products after processing or assembling these materials/parts".[3] Compared with non-processing trade (which is also usually referred to as "ordinary trade"), processing trade involves several notable characteristics. First, processing trade is heavily dependent on importing intermediate inputs. A large proportion of parts and components, especially those embed sophisticated

[2] The firm level data does not provide any information about the firms' processing status. This information is available from the customs data; hence using the merged data is crucial.

[3] The definition is taken from "Measures of the Customs of the People's Republic of China on the Control of Processing-Trade Goods", which is released in 2004 and amended in 2008 and 2010.

technologies, are sourced from abroad. In contrast, ordinary trade is often done exclusively with local inputs. Second, in a processing relationship, the Chinese party is mainly in charge of the manufacturing process, and the foreign buyer is usually responsible for the marketing and distribution of the final product to end users. For non-processing trade, however, the Chinese party is also responsible for the design, marketing and distribution.

Another important aspect of difference between processing and non-processing trade is that processing trade receives special policy treatment from the government. The most distinct difference is input tariffs. For processing exports, imported inputs used in the making of the finished products for export is exempt from any tariffs and import-related taxes. However, all finished products using the duty-free materials have to be re-exported. If such goods have to be sold in the domestic market, approval must be obtained from the commerce authorities in charge of processing trade at the provincial level as well as the Customs authorities. If approved to sell domestically, the processing firm must pay back all the exempted taxes plus interest payments.

Another policy favoring processing exporters is the income tax benefits granted to export-oriented firms.[4] According to China's policies, firms receive a reduction of corporate income tax rate if they export the majority (the most common threshold is 70%) of their production. Depending on the firm's ownership and location, tax rates granted to export-oriented firms are generally 5%–15% lower than firms that are not export-oriented. Although this policy is not specifically targeted towards processing exporters, a large share of processing exporters is export-oriented and thus eligible for such tax benefits. Table A1 in the Appendix demonstrates that processing firms are associated with high export intensity. Processing firms on average export 76% of output, while non-processing firms only export 40%. Over 70% of processing firms have export intensity over 0.7 and 51% firms export their entire production. The corresponding statistics for non-processing firms are respectively 32 and 14%. Thus, compared with non-processing exporters, a larger share of processing exporters are subject to the tax benefits granted to export-oriented firms.

China has two regulatory regimes for processing exports: pure assembly[5] and processing with imported materials (henceforth PWIM).[6] Pure assembly refers to "business activities in which the operating enterprise receives materials/parts from a foreign enterprise without needing to pay foreign exchange for the import, and carries out processing or assembling with the materials/parts as per the requirements of the foreign enterprise, only charging for the processing or assembling, while any finished products are to be sold and marketed by the foreign enterprise". By contrast, PWIM refers to "business activities in which the operating enterprise imports materials/parts by paying foreign exchange for their processing, and exports finished processed products for sale abroad". There exist some key differences between these two processing regimes. First, for pure assembly, a Chinese firm passively receives orders and materials from its foreign client and export all the processed goods to this material supplier. By contrast, for PWIM the firm plays a more active role in obtaining the materials and exporting of the processed goods (though not usually the marketing and distribution in foreign markets). The processed goods can also be sold to firms other than the material supplier. Second, for pure assembly, a Chinese firm obtains raw materials and parts from its foreign trading partners without making any payments. By contrast, for PWIM, the Chinese firm pays for the imported materials. Combining these differences suggest that firms engaged in PWIM are usually faced with higher fixed costs of exporting, either in searching for suppliers and buyers, or in obtaining external finance to cover the costs of exporting. We will exploit these differences across detailed processing regimes in our subsequent analysis.

[4] Defever and Riaño (2014) provided a detailed description of this policy (which they refer to as "subsidies with export share requirements") and analyzed its welfare implications.

[5] Also referred to as "processing with supplied materials".

[6] Pure assembly also refers to "processing with supplied materials" and processing with assembly as adopted in Yu (2015) and Tian and Yu (2015). Correspondingly, PWIM is also called input and assembly and processing with inputs.

3. Data

3.1. Firm-level production data

The firm level data in this paper comes from annual surveys of industrial firms (ASIF) conducted by the National Bureau of Statistics of China from 2000 to 2006. The survey includes all state-owned Enterprises (SOE) and those Non-state-owned Enterprises with annual sales of RMB five million (or equivalently, about $830,000) or more. The data set includes information from balance sheet, profit and loss and cash flow statements of firms, includes about 80 variables, and provides detailed information on firm's identification, ownership, export status, employment, capital stock, revenue, which are of particular use in this paper. These firms contribute about 98% of total Chinese manufacturing exports in the aggregate trade data. To clean the data, following Feenstra et al. (2014) and Yu (2015), we drop observations that report missing or negative values for any of the following variables: total sales, total revenue, total employment, fixed capital, export value, intermediate inputs, if export value exceeds total sales or if share of foreign asset exceeds one. We include firms with at least eight employees. We also restrict the sample to manufacturing firms. However, this data provides no information about a firm's processing status.

3.2. Transaction-level trade data

The transaction-level trade data comes from China's General Administration of Customs and spans from 2000 to 2006. It covers the universe of China's exporters and importers, and contains disaggregate product level information of firms' trading price, quantity and value at the HS8 digit level. Importantly, this data provides information on whether a transaction was processing or not, which allows us to construct firms' processing status.

3.3. Matching the two data sets

Matching the firm level data with the transactions level data is challenging because the firm identifiers used in the two data sets are different — a nine digit identification number in the firm level data versus a ten digit identification number in the customs data, with no common elements. To address such a problem, we match the firms in the two data sets using firm name, telephone number and zip code. The details of the merge variables are provided in Appendix A. Finally we are able to merge about 45% of the exporters in the firm-level production data. These firms account for 58% of total export value in the firm-level production data, and 25% of China's total exports during 2000–2006. Table A1 provides the summary statistics of the merged exporters. In addition to the merged exporters, we also keep all non-exporters in the ASIF data. Taken together, there are 1,244,382 observations from 424,546 firms in our final merged sample. These include 225,853 observations from 68,865 exporters, and 1,018,529 observations from 355,681 non-exporters.

Since the merged sample does not include the universe of exporting firms, one natural concern is sample selection. A good way to examine the representativeness of the data is to check whether the merged data can replicate the counter-Melitz findings documented in the previous literature. Reassuringly, it turns out that the counter-Melitz findings hold very well in the merged data. Exporters in the merged data are less productive in both foreign invested enterprises (FIE) and in labor intensive sectors as in Lu et al. (2010) and Lu (2010). This ensures that firm

selection problem in the merged data does not affect the anomalous behavior of exporters found to hold in the original un-merged data.[7]

4. Stylized facts on processing exporters

4.1. Ownership and sectoral distribution

We start by showing the importance of processing exports in total Chinese exports. We divide all exporting firms into three types depending on their nature of transactions in a given year: (1) firms that only engage in processing transactions (referred to as "processing firms"); (2) firms that only engage in non-processing transactions (referred to as "non-processing firms"); and (3) firms that engage in both processing and non-processing transactions (referred to as "hybrid firms"). Table 1 reports the number of firms and the share of export value for each type of firms. Over the sample period, approximately 14% of firms accounting for 17% of export value are purely engaged in processing trade. These numbers slightly increase to 15% and 21% in the merged data. Another 23% of firms accounting for nearly 60% of export value are engaged in both processing and non-processing.[8]

Next we show the ownership and sectoral distributions of processing exporters. Motivated by the literature on the unexceptional exporter performance in China, we divide all firms into FIE and non-FIE according to their registration type, and all sectors into labor intensive, medium, and capital intensive sectors according to the medium capital–labor ratio in each sector. Table 2 reports the share of exports from three types of exporters as well as the share of processing exports in each subsample. Two facts stand out immediately. First, processing exports are concentrated in multinational firms. 82% of exports of FIEs belong to processing trade, and 25% of them come from pure processing firms. By contrast, in non-FIEs these shares are 27% and 5%, respectively. Second, processing exports are more concentrated in labor intensive sectors than in capital intensive sectors. Processing exports account for 66% of total exports in labor intensive sectors but only 39% in capital intensive sectors. Also the export share of pure processing exporters is higher: 21% in labor intensive sectors and 13% in capital intensive sectors.

The facts that processing exports are concentrated in FIEs and in labor intensive sectors have interesting implications. Previous studies on the exporter performance in China find that Chinese exporters are less productive than non-exporters in FIEs and labor intensive sectors. The concentration of processing firms in these ownerships and sectors suggest that the low productivity of exporters in these ownerships and sectors found in the previous literature is possibly driven by the presence of processing exporters. If processing exporters are less productive than non-exporters in these ownerships and sectors, then pooling all exporters (which are skewed to processing exporters) together will lead to puzzles documented in the literature.

Table 1
Share of number of firms and of export value, by processing status.

	Full customs data		Merged data	
	# of firms	Export value	# of firms	Export value
Non-processing	63.00%	24.90%	52.40%	15.00%
Processing	14.10%	16.90%	15.30%	21.30%
Hybrid	22.90%	58.20%	32.20%	63.70%

Note: Non-processing refers to exporters doing non-processing trade only. Processing refers to exporters engaging in processing trade only. Hybrid refers to exporters engaging in both processing and non-processing trades.

4.2. Productivity of processing exporters

In order to examine the productivity of processing exporters versus non-processing exporters and non-exporters, we estimate the following equation:

$$y_{it} = \alpha + \beta_1 PX_{it} + \beta_2 NPX_{it} + \beta_3 BX_{it} + \gamma \mathbf{D}_{it} + \nu_j + \varsigma_p + \lambda_t + e_{it}, \qquad (1)$$

where y_{it} is the productivity for firm i in year t. $PX_{it}$is a dummy which equals one if a firm is a processing exporter (i.e., in any given year these firms only report processing transactions); $NPX_{it}$is the dummy for non-processing exporters (i.e., in any given year these firms only report non-processing transactions); BX_{it} is the dummy for exporters doing both processing and non-processing trade (i.e., in any year the firms report both processing and non-processing transactions); the omitted group is non-exporters. **D** are firm-level control variables. We control for firm size proxied by log total employment, following Bernard and Jensen (1995, 1999) and De Loecker (2007). We also include a FIE dummy since firm's processing status is correlated with its foreign-ownership (See Table 2) and foreign-owned firms usually have higher productivity (Helpman et al., 2004). In addition, we also control for a full set of 4-digit industry dummies (ν_j), province dummies (ς_p) and year dummies (λ_t).[9]

We calculate total factor productivity (TFP) for each firm-year using the standard techniques in the literature. Our preferred approach is the semi-parametric algorithm developed by Olley & Pakes (henceforth OP, 1996). This approach takes into account the simultaneity of productivity shocks and input choice, as well as the endogenous exit of firms — issues ignored by the traditional OLS TFP measure. We provide a detailed description of our estimation of Olley–Pakes TFP in Appendix B. In order to ensure our results are not sensitive to the measurement of productivity, we also calculate TFP using the approach proposed by Ackerberg et al. (henceforth ACF, 2006), which solves the multicollinearity and measurement error issues that the earlier approaches (such as Olley–Pakes and Levinsohn–Petrin) may suffer; Finally, we also calculate TFP using the traditional OLS approach.

Our baseline regression, Eq. (1), allows us to understand the productivity of different types of exporters relative to non-exporters. Table 3 reports our baseline estimation results for the three TFP measures: TFP (OP), TFP (ACF) and TFP (OLS). In columns (1)–(3) we regress TFP against firm's processing status dummies, and control for industry, province and year fixed effects. We find that the coefficient of processing dummy is negative and significant, suggesting that processing exporters are less productive than non-exporters; On the contrary, non-processing exporters are always more productive than non-exporters, consistent with the evidence widely documented by firm-level data in other countries. These results hold consistently for all the TFP measures calculated using different approaches. In columns (4)–(6), we further control for firm size (proxied by log employment) and the foreign-ownership dummy. The productivity ranking between

[7] The results are presented in Table A3 in the Appendix. Column (1) shows that exporters are less productive than non-exporters within foreign owned firms. Column(3) shows that in terms of value added per worker, exporters are less productive in the labor intensive sectors but are more productive in capital intensive sectors.

[8] The main reason why a firm engages in both processing and non-processing trade is that firms may export multiple products, some products through processing while others through non-processing. To see this, Table A4 in the Appendix reports the share of observations with different processing status at different levels of aggregation. We change the level of aggregation from firm-year to firm-product-year (product is defined at HS 6-digit level) then to firm-product-country-year. At the firm-level, 23% of firms export through both processing and non-processing. However, at firm-product level, only 3% of firm-product pairs are exported through both trade modes. This suggests that the dominant majority of firm-product pairs are exported through a single trade mode. At firm-product-country level, the share of observations that are exported through both trade modes are almost the same with firm-product level. Thus, conditional on product, export destinations does not seem to explain why firms engage in both activities. It is the product dimension that makes a large difference.

[9] Industries are based on China Industry Classifications issued by the National Bureau of Statistics. The classification had a revision in 2003. We use a concordance to convert the industry classifications in all years into a consistent basis.

Table 2
Share of exports from different exporters, by ownership and sectoral capital intensity.

Classifications	By ownership		By sectoral capital intensity		
	(1)	(2)	(3)	(4)	(5)
	FIE	Non-FIE	Labor int.	Medium	Capital int.
Non-processing	8.5%	48.8%	17.3%	9.7%	39.9%
Processing	24.6%	4.5%	21.4%	22.8%	12.6%
Hybrid	66.9%	46.7%	61.3%	67.5%	47.5%
Share of processing exports	81.9%	27.1%	66.4%	81.8%	39.2%

Note: This table reports the share of exports from non-processing exporters, processing exporters and exporters doing both activities. Columns (1) and (2) report the share within foreign invested enterprises (FIE) and non-FIE. Columns (3)–(5) report the share within labor intensive, medium and capital intensive sectors. Labor intensive, medium, and capital intensive sectors are defined based on the 33% and 67% quantile of sectoral capital–labor ratio. The last row reports the share of processing exports over total exports in each ownership and each sector group.

processing firms, non-processing firms and non-exporters are qualitatively unchanged. Quantitatively, in the specification where firm size and foreign ownership are controlled for, processing firms are around 23–26% less productive than non-exporters, while non-processing exporters are around 11% more productive than non-exporters. These results suggest that only the processing exporters demonstrate counter-Melitz productivity pattern.

We perform a series of robustness checks on the baseline specification. First, one may worry that processing and non-processing exporters have different production technologies which make their productivity not comparable. To address this, we estimate different production functions for processing and non-processing exporters separately and calculate their measured TFP, respectively.[10] Second, in order to make sure our baseline results are not driven by omitted variables, we have experimented with different sets of fixed effects. Column (2) controls for industry-province-year fixed effects to account for industry-province-year specific shocks, while column (3) controls for firm fixed effects to absorb the impact of other time-invariant firm-level characteristics that may correlate with processing status. Third, we weigh each firm by its value added share within the industry, so that larger firms receive more weight in the regressions. Lastly, we run cross sectional regressions for each sample year in order to account for possible structural breaks brought by China's accession in to the WTO in 2001, as well as other policy changes that affect processing and non-processing firms differently.[11] The results of these robustness checks are reported in Table 4. Our baseline results hold very well in all these situations. Processing firms are always the least productive among all types of firms, and non-processing exporters are always more productive than non-exporters.

The above results show that different processing status is associated with different productivity. However, given that firms do both processing and non-processing exporting, firms with different productivity may also choose the extent of being engaged in processing exports. Thus, we investigate whether firm's processing intensity (share of processing exports over total exports) is associated with productivity. We regress TFP against processing intensity on the sample of firms that do both processing and non-processing. Columns (1) and (2) of Table 5 report the results, column (1) without firm-level controls and column (2) with controls. The results show that firms with higher processing intensity have lower productivity. In column (2), the firm with processing intensity 0.99 (corresponding to the 95th percentile of the processing intensity distribution) is 10% less productive than the firm with processing intensity 0.02 (corresponding to the 5th percentile of the processing intensity distribution). In addition, since the main reason a firm engage in both processing and non-processing is that they export different products through different regimes (see Footnote 8), we also examine whether the firms exporting a larger number of products through processing is associated with lower productivity. Specifically, we regress TFP against the share of products (HS 6-digit) exported through processing (number of products exported through processing over total number of exported products).[12] The results in columns (3)–(4) of Table 5 suggest that firms exporting relatively more product varieties through processing have lower productivity. Taken together, these results suggest that less productive firms are relatively more involved in processing, while more productive firms are more involved in non-processing.

We next demonstrate whether the low productivity of processing exporters can explain the low productivity of exporters in FIEs and labor-intensive sectors as found in the previous literature. First, we repeat the regression of Eq. (1) on the FIE and non-FIE sample, respectively.[13] Columns (1) and (2) of Table 6 shows that regardless of ownership type, processing exporters are the least productive among all exporters. Moreover, among FIEs it is only processing exporters that are less productive than non-exporters. Non-processing exporters have the usual superior performance — these firms are more productive than non-exporters. Thus, the finding in Lu et al. (2010) that Chinese exporters are less productive than non-exporters in FIEs is being mainly driven by low productivity of processing exporters. Because processing exports are concentrated in FIEs, pooling all types of exporters will yield the puzzling result that exporters are less productive in general in FIEs.

Second, we check whether the low productivity of exporters in labor intensive sectors are also driven by processing exporters. We run the baseline regressions by capital intensity of the sector (low, medium or high capital intensity).[14] Columns (3)–(5) of Table 6 reports the results. Again, it is seen that regardless of the capital intensity of the sector, non-processing exporters are always significantly more productive than non-exporters. It is only the processing exporters that demonstrate the counter-Melitz property. In addition, the productivity disadvantage of processing exporters are most pronounced in labor intensive sectors, being 28% compared with 8% in capital intensive sectors. Therefore, the earlier findings that exporters in general are less productive in labor intensive sectors in China are driven by the fact that processing exporters are particularly less productive in these sectors, and that these sectors have a disproportionately large share of processing exports as in Table 2.

4.3. Other performances of processing exporters

As is evident from the previous analysis, contrary to the widely-documented productivity premium of exporters, the productivity of processing exporters are lower than non-exporters. Actually, processing exporters are special not only in productivity, but also in many other attributes which exporters are found to have superior performances. Table 7 reports the regression results of Eq. (1) using various firm performance as the dependent variable: capital–labor ratio, total sales, average wages, R&D expenditure, as well as skill intensity (defined by the share of workers with college education and above).[15] In the literature, exporters are usually found to be larger, more capital intensive,

[10] The estimated production function coefficients are reported in Table A5 in the Appendix.

[11] We only report the results for 2006 because of space limitations. Results for other years are qualitatively similar and are available upon request.

[12] We define a product to be exported through processing if more than half of its export value belongs to processing. The results are similar if we change the threshold to 1/3, 2/3, or drop products that are exported through both regime.

[13] We use two methods to identify a firm's ownership type. In the first method, we use the self-reported registration type of the firm, and in the second we calculate a firm's share of stocks owned by foreign partners. Following the definition from the National Bureau of Statistics, we define FIE to be a firm with over 25% foreign-owned stocks. The two methods yield qualitatively the same results, so we only report results using the first method.

[14] The capital intensity of a sector is constructed at the 2-digit industry level as the median capital-labor ratio in the sector. Similar results are obtained by using the aggregate capital intensity of the sector.

[15] The data for employment by education is only available in 2004, so the regression is run only for that year.

Table 3
Benchmark estimates.

Dep. var.	(1)	(2)	(3)	(4)	(5)	(6)
	TFP (OP)	TFP (ACF)	TFP (OLS)	TFP (OP)	TFP (ACF)	TFP (OLS)
Non-processing	0.230***	0.069***	0.185***	0.109***	0.119***	0.113***
	(0.005)	(0.005)	(0.005)	(0.005)	(0.006)	(0.005)
Processing	−0.060***	−0.299***	−0.134***	−0.262***	−0.236***	−0.265***
	(0.010)	(0.011)	(0.010)	(0.011)	(0.012)	(0.010)
Hybrid	0.280***	0.004	0.207***	0.075***	0.080***	0.080***
	(0.007)	(0.007)	(0.007)	(0.007)	(0.008)	(0.007)
Size and FIE dummy	No	No	No	Yes	Yes	Yes
Observations	801,829	801,829	801,829	801,829	801,829	801,829
R-squared	0.302	0.401	0.336	0.314	0.405	0.339

Note: This table reports the regression results of Eq. (1). OP: Olley–Pakes, ACF: Ackerberg, Caves, Frazer. Omitted group is non-exporters. All regressions include 4-digit Chinese industry, province and year dummies. Columns (4)–(6) further include log employment and foreign-invested-enterprise dummy. Standard errors are clustered at firm level.
*** $p < 0.01$.

more profitable, pay higher wages, more R&D intensive, and employ relatively more skilled workers compared with non-exporters. In Table 7, we see that this is indeed the case for non-processing exporters, as are suggested by the positive coefficients before the non-processing dummy. In sharp contrast, the performances of processing exporters are strikingly different. Compared with non-exporters, they are smaller in sales, pay lower wages, less profitable, invest less intensively in R&D, and employ less skilled workers. These facts further highlight the special nature of processing exporters.

5. Possible explanations for the performance of processing exporters

The results in Section 4 show that processing exporters are not exceptional performers. In this section we provide possible explanations for their relatively poor performance. We will mainly focus our discussions on why processing firms have lower productivity, because productivity plays a central role in the heterogeneous-firm trade literature. Lower productivity will naturally lead to smaller firm size, lower wages, lower R&D investments and lower skill intensity given certain additional assumptions.

Basically, we believe two factors are mainly responsible for the low productivity of processing exporters. First, processing exports are associated with lower fixed costs of exporting. Second, the trade and industrial policies favoring processing exports, in particular, input tariffs exemptions and corporate income tax benefits granted to export-oriented firms, induce low productivity firms to select into processing trade.

5.1. Low fixed cost of processing exports

The first reason for the low productivity of processing exporters is the low fixed costs of exporting associated with processing. There are several reasons why the fixed cost of exporting might be low. (1) Low distribution cost. In a processing trade relationship, the foreign buyer is responsible for marketing and distribution of the final product. As distribution costs usually account for a large share of total costs (Goldberg and Campa, 2010), the cost saving effect can be large. (2) Low research and development cost. Successful exporting usually requires tailoring the product to consumer tastes or quality upgrading (Verhoogen, 2008), which requires substantial investment in R&D. However, in a processing relationship, since the foreign buyer usually provides the know-hows and blueprint of the final product, the research and development costs on the processing firm side can be very low. (3) Processing exports usually require less up-front costs, and therefore reduces the fixed costs of obtaining external sources of finance. This is especially true for pure assembly, where processing firms receive parts and components for processing without any payment. In sum, the production sharing between the processing exporter and the foreign buyer will help reduce the fixed costs of exporting born by the processing exporter, making firms that are not productive enough to export through the non-processing regime to profitably export through the processing regime.

However, if the lower fixed exporting cost is the only difference between processing and non-processing transactions, all firms will select into the processing regime to take advantage of this lower cost.

Table 4
Additional robustness checks for processing exporters.

Dep. var.: TFP (OP)	(1)	(2)	(3)	(4)	(5)
	Different technology for proc./non-proc. exporters	Industry-year FE	Firm FE	Weighted regression	Cross-section regression
Non-processing	0.124***	0.111***	0.155***	0.156***	0.112***
	(0.005)	(0.005)	(0.006)	(0.019)	(0.007)
Processing	−0.283***	−0.266***	−0.393***	−0.187***	−0.231***
	(0.010)	(0.010)	(0.012)	(0.039)	(0.016)
Hybrid	0.063***	0.072***	0.023***	0.097***	0.085***
	(0.007)	(0.007)	(0.009)	(0.025)	(0.010)
Time coverage	2000–2006				2006
Observations	801,829	801,829	801,829	801,525	162,858
R-squared	0.252	0.338	0.012	0.422	0.326

Note: This table reports the results of regression of Eq. (1). Dependent variables are TFP (Olley–Pakes). TFP in column (1) is estimated separately for processing and non-processing firms, thus allowing the two types of firms to have different production technology. Column (2) includes industry-province-year fixed effects. Column (3) includes firm fixed effects. Column (4) runs weighted regression using value-added share as weights. Column (5) reports results for 2006. All columns except (3) include firm-level log employment and FIE dummy. Columns (1), (4), and (5) include 4-digit CIC industry, province and year dummies. Standard errors are clustered at firm level.
*** $p < 0.01$.

Table 5
Productivity and processing intensity.

Dep. var. TFP (OP)	(1)	(2)	(3)	(4)
Share of processing exports	−0.049***	−0.107***		
	(0.017)	(0.016)		
Share of processing products			−0.413***	−0.416***
			(0.028)	(0.027)
Size and FIE dummy	No	Yes	No	Yes
Observations	52,514	52,514	52,514	52,514
R-squared	0.324	0.367	0.329	0.372

Note: The sample is firms doing both processing and non-processing. Share of processing exports = (value of processing exports / total value of exports). Share of processing products = (# products exported through processing / # of all exported products). A product is defined to be exported through processing if more than half of its export value belongs to processing. All regressions include 4-digit Chinese industry, province and year dummies. Columns (2) and (4) further include log employment and foreign-invested-enterprise dummy. Standard errors are clustered at firm level.
*** $p < 0.01$.

Table 6
Productivity of exporters by processing, ownership and capital intensity.

Category	By ownership		By sectoral capital intensity		
	(1)	(2)	(3)	(4)	(5)
Dep. var.: TFP (OP)	FIE	Non-FIE	Labor int.	Medium	Capital int.
Non-processing	0.065***	0.142***	0.104***	0.095***	0.145***
	(0.009)	(0.006)	(0.008)	(0.008)	(0.012)
Processing	−0.261***	0.021	−0.277***	−0.241***	−0.079**
	(0.013)	(0.030)	(0.016)	(0.015)	(0.036)
Hybrid	0.004	0.280***	0.061***	0.104***	0.137***
	(0.010)	(0.013)	(0.011)	(0.011)	(0.020)
Observations	164,617	637,212	223,997	361,288	216,544
R-squared	0.307	0.321	0.167	0.359	0.328

Note: This table reports the regression results of Eq. (1). Columns (1) and (2) report results for FIE and non-FIE; columns (3)–(5) report results for labor intensive, medium and capital intensive sectors. Labor intensive, medium, and capital intensive sectors are defined based on the 33% and 67% quantile of sectoral capital–labor ratio. Dependent variable is TFP (Olley–Pakes). The omitted group is non-exporters. All regressions include firm-level log employment and 4-digit Chinese industry, province and year dummies. Columns (3)–(5) also include ownership dummies. Standard errors are clustered at firm level.
** $p < 0.05$.
*** $p < 0.01$.

This cannot explain why in the data some firms choose to export through the non-processing regime, and why firms choosing the non-processing regime are more productive. Therefore, we need another dimension of heterogeneity to rationalize the sorting pattern observed in the data. We argue that this heterogeneity comes from the differences between variable profit rates of the two trade regimes. Processing transactions are associated with lower variable profit rate than non-processing transactions. This could arise in an environment of incomplete contracts where the processing exporter and foreign buyer bargain over the distribution of total variable profit, and the share of profits accruing to each party depends on their contributions of value-added to the production process. Since processing firms generally contribute less value-added than non-processing firms in the production process (Manova and Yu, forthcoming), they get a smaller share of profit and this transmits into a lower variable profit rate.[16]

When processing and non-processing transactions differ in terms of both fixed exporting cost and variable profit rate, firms will face a trade-off in their selection of exporting mode. Specifically, for firms with a given productivity, non-processing exports yield a higher variable profit rate, but also requires more fixed exporting costs. Firms will choose non-processing over processing if the gains of additional variable profits outweigh the costs of extra fixed payment. Since more productive firms have larger sales, their total variable profits will increase more than the less productive firms for a given increase in profit rate. As a result, in equilibrium, firms with higher productivity will optimally select into the non-processing regime, whereas firms with lower productivity select into the processing regime-a pattern consistent with our empirical findings. In Appendix C we provide a sketch of an augmented Melitz (2003) model that endogenizes the choice of processing versus non-processing exports. Under the assumptions that (i) the fixed costs of processing exports are lower than that of non-processing exports; and (ii) the slope of the profit function with respect to productivity is less steep for processing exports, implying that processing activities are associated with lower variable profit, the model shows that less productive firms will self-select into processing exports, while more productive firms into non-processing exports.

In general, it is difficult to directly test the validity of such selection mechanism, since doing this requires the data on the fixed exporting costs for both processing and non-processing transactions, which to our knowledge is not available. However, in the following we attempt to give some indirect evidence suggesting that the selection story we proposed explains the observed data patterns. First, we try to exploit the variation across industries in their fixed costs of exporting. Our underlying assumption is that the relative fixed costs of non-processing exports are higher in industries with higher fixed costs of exporting. Thus, the productivity of pure processing firms relative to the non-processing ones should be lower in the industries where the fixed costs of exporting are high. To proxy for the fixed cost of exporting across sectors, we use three industry-level indicators constructed by averaging across all *exporters* within an industry: (1) sales intensity (sales cost over total sales); (2) advertisement intensity (advertisement expenditure over total sales) (these two indicators capture the fixed costs of exporting associated with product distribution and marketing); and (3) R&D intensity (R&D expenditure over total sales), which captures the fixed costs of exporting associated with design, quality upgrading or product or process innovation. We further divide all industries into two groups by using the median of each indicator as cutoffs. To compare the productivity between processing and non-processing exporters, we regress TFP on a dummy indicating processing exporting and a dummy indicating both processing and non-processing. The omitted group is non-processing exporters. We run regressions for each industry group.

The results are reported in Table 8. In all industry groups, processing exporters are less productive than non-processing exporters. However, in industries where the fixed cost of exporting is high, processing exporters' productivity disadvantage is more pronounced. This holds true regardless which indicator we use to proxy for the fixed cost of exporting. Therefore, the data is in support of our theoretical model that highlights the lower fixed cost of processing exports as the main determinants of processing exporters' lower productivity. In addition, the TFP disadvantage of processing exporters is around 8% larger in high sales and advertisement industries, and 6% larger in R&D intensive industries. This suggests that the lower fixed cost of exporting for processing exports come from both lower distribution and marketing costs, as well as lower research and development costs, though the distribution cost channel seems to play a more important role.

Further evidence on the fixed cost story can be obtained by exploiting sources of variation that come from the different natures of transactions across China's detailed processing trade regimes. As described in the introduction, compared with pure assembly, processing with imported materials requires the processing firm to play a more active role in sourcing inputs, searching for clients and exporting the final goods. In addition, PWIM requires up-front payment for the imported components and materials, which brings more needs for liquidity that might be financed through external sources. Obtaining such external finance is associated with considerable fixed costs in China where financial frictions are severe (Allen et al., 2005;

[16] Although we don't have data on the variable profits of firms, column (4) of Table 7 does show that the profitability (profit per worker) are lower for processing firms.

Table 7
Other performance of processing exporters.

Dep. var.:	(1)	(2)	(3)	(4)	(5)	(6)
	Log(K/L)	Log wages	Log sales	Profitability	Log R&D	Skill intensity
Non-processing	0.177***	0.108***	0.215***	3.040***	0.335***	0.028***
	(0.007)	(0.003)	(0.005)	(0.602)	(0.010)	(0.001)
Processing	0.021	−0.023***	−0.136***	−7.658***	−0.241***	−0.060***
	(0.015)	(0.006)	(0.012)	(1.094)	(0.013)	(0.002)
Hybrid	0.262***	0.157***	0.245***	1.501*	0.179***	−0.001
	(0.010)	(0.004)	(0.008)	(0.790)	(0.014)	(0.002)
Observations	801,829	801,827	801,829	801,829	801,829	156,347
R-squared	0.173	0.327	0.521	0.034	0.141	0.261

Note: This table reports the regression results of Eq. (1). Dependent variables in columns (1)–(6) are the follows: log capital–labor ratio, log average wage, log total sales, profit per worker, log R&D expenditure, and the share of skilled workers (workers with at least college education) over total number of workers. Omitted group is non-exporters. All regressions include firm-level log employment, FIE dummy, and 4-digit Chinese industry, province and year dummies. Standard errors are clustered at firm level.
* $p < 0.1$.
*** $p < 0.01$.

Table 8
Productivity of processing exporters across sectors.

Dep. var.: TFP (OP)	Advertisement intensity		Sales intensity		R&D intensity	
	(1)	(2)	(3)	(4)	(5)	(6)
	Low	High	Low	High	Low	High
Processing	−0.245***	−0.324***	−0.261***	−0.349***	−0.259***	−0.313***
	(0.016)	(0.018)	(0.013)	(0.027)	(0.014)	(0.021)
Hybrid	0.012	−0.028**	−0.001	−0.014	−0.010	0.005
	(0.010)	(0.012)	(0.009)	(0.016)	(0.009)	(0.014)
Observations	86,049	76,743	115,632	47,160	101,688	61,104
R-squared	0.300	0.338	0.308	0.374	0.317	0.356

Note: Dependent variables are TFP (Olley–Pakes). Omitted group is non-processing exporters. Columns (1)–(6) report results in industries with high (low) sales intensity, advertisement intensity, and R&D intensity. High/low sales (advertisement, R&D) intensity industries are defined based on the median sectoral ratio of selling expenses to total sales (ratio of advertising expenses to total sales, ratio of R&D expenses to total sales). All regressions include firm-level log employment, FIE dummy, and 4-digit Chinese industry, province and year dummies. Standard errors are clustered at firm level.
** $p < 0.05$.
*** $p < 0.01$.

Boyreau-Debray and Wei, 2005). Thus, the theory would predict that the productivity disadvantage of pure assembly exporters should be larger than PWIM exporters. To test this, we regress TFP (various measures) on a pure assembly dummy (which equals 1 when firms are engaged only in pure assembly), a PWIM dummy (which equals 1 when firms are engaged only in PWIM), and a dummy indicating hybrid trade regimes. The omitted group is again non-processing exporters. Results in Table 9 indicate that pure assembly exporters are indeed the least productive, being around 43% less productive than non-processing exporters. The productivity disadvantage of PWIM exporters are around 30%. Therefore, productivity ranking for firms in different processing trade regimes also supports the fixed cost argument.

5.2. Tax and tariffs policies favoring processing exports

As described in Section 2, processing exports are subject to various forms of policy benefits. First, the imported inputs that are used to produce output for re-export are completely duty-free. Second, conditional on exporting a dominant proportion of output, processing exporters can also enjoy favorable treatment in corporate income tax. These policy incentives encourage more firms to participate in processing exports and lower the productivity threshold of processing exporters. In the theoretical model in Appendix C, we show that a reduction in variable trade cost of processing exports relative to non-processing exports, which can be interpreted as policies favoring processing exporters such as exemption of input tariffs or reduction of corporate income tax, increase the productivity gap between processing and non-processing exporters. We now empirically investigate the role of input tariffs exemptions and the income tax benefits granted to export-oriented firms.

5.2.1. Input tariffs exemptions

Our empirical strategy of examining the role of input tariffs is to exploit the variation of input tariffs levels across industries. Specifically, we investigate whether the productivity gap between processing exporters and non-exporters are higher in industries with higher level of input tariffs. Since processing exports are duty-free, a high input tariffs level makes the tariffs exemptions granted to processing exporters more attractive, thus increasing the benefits of processing exports and enabling less productive firms to be engaged in processing. On the other hand, a high input tariffs level raise the productivity threshold of non-processing exports because only the very productive firms will find it optimal to afford the input tariffs costs by exporting through the non-processing regime. Thus, the theory suggests that the productivity gap between processing and non-processing firms should be larger if input tariffs is higher.

To empirically examine this prediction, we construct input tariffs for each 4-digit industry, drawing on product-level tariffs data and China's 2002 input–output table.[17] We then divide all sectors into “low input tariffs industries” and “high input tariffs industries”.[18] To compare the

[17] We calculate the input tariff of each industry in the input–output table (henceforth IO industry) as weighted average of output tariff of its upstream industries, with weights reflecting the input structure of the industry. The output tariff of each IO industry is calculated as the simple average of the tariffs of the corresponding HS 6-digit products. We use a concordance to map HS 6-digit products to IO industries. After getting the input tariff data at the IO industry level, we map IO industries to 4-digit CIC using the concordance from the NBS. The industry classification in China's 2002 input–output table is more aggregated than 4-digit CIC, so the input tariffs are approximately at the 3-digit CIC level. The results we get are highly consistent with Brandt et al. (2012).

[18] The year average of tariff rates for the low and high tariff industries are 7.4% and 12.9%, respectively.

Table 9
Productivity of exporters by detailed processing regime.

Dep. var.:	(1)	(2)	(3)
	TFP (OP)	TFP (ACF)	TFP (OLS)
Pure assembly	−0.435***	−0.426***	−0.350***
	(0.083)	(0.055)	(0.066)
Processing w/imported inputs	−0.326***	−0.296***	−0.245***
	(0.081)	(0.051)	(0.062)
Hybrid	−0.075**	−0.057*	0.003
	(0.080)	(0.050)	(0.061)
Observations	162,792	162,792	162,792
R-squared	0.330	0.509	0.331

Note: Dependent variables in columns (1)–(3) are the following: TFP (Olley–Pakes), TFP (Ackerberg, Caves, Frazer), TFP (OLS). Omitted group is non-processing exporters. All regressions include firm-level log employment, FIE dummy, as well as 4-digit Chinese industry, province and year dummies. Standard errors are clustered at firm level.
* $p < 0.1$.
** $p < 0.05$.
*** $p < 0.01$.

productivity of processing and non-processing exporters, we regress TFP against a processing exporter dummy and a "hybrid" dummy, with the omitted group being non-processing exporters. The results are reported in columns (1) and (2) of Table 10. According to the theory, processing exporters should be particularly less productive (compared with non-processing exporters) in industries with high input tariffs. The results are supportive of the theoretical predictions. In low input tariffs industries, pure processing exporters are 24% less productive than non-processing exporters, while in high input tariffs industries, the productivity gap is 30%. As an alternative specification, we add into the regression an interaction term between log input tariffs and the processing exporter dummy, as well as an interaction term between log input tariffs and the "hybrid" dummy. The results are reported in column (5). We get a negative significant coefficient before the processing × log(tariffs) interaction term. This confirms that in sectors with higher tariffs, the productivity of pure processing exporters are even less than that of non-processing exporters. To see how large are the differences across industries, note that the log input tariffs rates for the lowest tariffs sector (corresponding to the 5th percentile of the input tariffs distribution) and the highest tariffs sector (corresponding to the 95th percentile of the input tariffs distribution) are respectively 1.56 and 2.89, so the regression results suggest that in the industry with highest input tariffs, the productivity disadvantage of pure processing exporters is 13% ($0.096 \times (2.89 - 1.56)$) larger than the industry with lowest input tariffs.

Table 10
The role of input tariffs exemptions.

Dep. var.: TFP (OP)	(1)	(2)	(3)	(4)	(5)
	Low input tariffs ind.	High input tariffs ind.	Low input tariffs ind.	High input tariffs ind.	All firms
Processing	−0.249***	−0.302***			−0.070*
	(0.013)	(0.010)			(0.040)
Hybrid	0.011	−0.017**			0.154***
	(0.009)	(0.007)			(0.030)
Processing × log(tariffs)					−0.096***
					(0.018)
Hybrid × log(tariffs)					−0.073***
					(0.013)
Processing share			−0.109***	−0.206***	
			(0.011)	(0.008)	
Observations	62,155	100,637	62,155	100,637	162,792
R-squared	0.337	0.327	0.334	0.325	0.330

Note: Columns (1)–(2) regress TFP on a processing exporter dummy and a both dummy, respectively in low input tariffs industries and high input tariffs industries. The omitted group is non-processing exporter. Columns (3)–(4) regress TFP on the share of processing exports in firm's total exports. Low and high input tariffs industries are classified according to the median of the input tariffs levels at 4-digit CIC level. All regressions include firm-level log employment, FIE dummy, as well as 4-digit Chinese industry, province and year dummies. Standard errors are clustered at firm level.
* $p < 0.1$.
** $p < 0.05$.
*** $p < 0.01$.

As an alternative check, we also examined whether the negative relationship between firm's processing intensity and productivity (as found in Table 5) is more pronounced in industries with higher input tariffs. Similar to our previous exercise, we run the regression of productivity against firm's processing intensity separately for low input tariffs sectors and high input tariffs sectors. The results are reported in columns (3) and (4) of Table 10. It is seen that productivity declines with processing intensity at a faster rate in high input tariffs sectors. Raising processing intensity from 0 to 1 is associated with 10% productivity reduction in the low input tariffs sectors, while 20% productivity reduction in the high input tariffs sectors.

In sum, all the above results indicate that in industries in which the benefit of input tariffs exemptions are larger (i.e. industries with higher input tariffs), the negative relationship between productivity and processing exports is more pronounced. This implies that the input tariffs exemptions offered to processing exporters is indeed an important source of the unexceptional productivity of processing exporters in China.

5.2.2. Tax benefits granted to export-oriented firms

Another form of favorable policy treatment granted to processing exporters is the reduction of corporate income tax. As described in the introduction, these tax reductions are not granted specifically to processing exporters, but to firms exporting a large proportion of their output (export-oriented firms). However, since processing exporters usually have high export intensity, they are more likely to be subject to these tax benefits.

To examine how much the tax benefits granted to the export-oriented firms explain the low productivity of processing firms, firstly, we check whether firms that are eligible for the tax benefits have lower productivity. Since most regulations in China takes export intensity of 0.7 as the threshold of being an export-oriented firm, we regress TFP against a dummy variable which takes the value of 1 if the firm's export intensity is greater than 0.7. Column (1) of Table 11 shows that being eligible for tax benefits does matter for productivity. Exporters that are eligible are 11% less productive than exporters that are not eligible.[19]

Next, we investigate to what extent being eligible for tax benefits can explain the low productivity of processing firms. In order to show this, we repeat our baseline regression of TFP against processing status, as in Eq. (1), but now include the eligible dummy as an additional regressor. The idea is to see conditional on being eligible for tax benefits or not, whether firm's processing status is still associated with productivity differences. If the low productivity of processing exporters is partially explained by being eligible for tax benefits, controlling for the eligible dummy will reduce the magnitude of processing firms' productivity disadvantage. We see in column (2) that this is indeed the case. After controlling for whether the firm is eligible for tax benefits, processing exporters are only 15% less productive than non-exporters, compared with the 26% difference in the baseline results in Table 4. It should be noted, however, that even after controlling for the eligible dummy, processing exporters are still less productive than non-processing exporters and non-exporters. This suggests that there exist other forces other than the tax benefits that explain the low productivity of processing exporters.

[19] We also tried other threshold such as 0.9 and 1. The results are qualitatively similar: firms above the threshold have lower productivity.

Table 11
The role of income tax benefits granted to export-oriented firms.

Dep. var.: TFP (OP)	(1)	(2)	(3)
Eligible (expint > 0.7)	−0.115***	−0.176***	
	(0.008)	(0.007)	
Non-processing		0.158***	
		(0.006)	
Processing		−0.150***	
		(0.011)	
Hybrid		0.162***	
		(0.008)	
Non-processing + not eligible			0.134***
			(0.006)
Non-processing + eligible			0.033***
			(0.007)
Processing + not eligible			−0.056***
			(0.016)
Processing + eligible			−0.363***
			(0.012)
Hybrid + not eligible			0.195***
			(0.010)
Hybrid + eligible			−0.039***
			(0.009)
Observations	137,126	801,829	801,829
R-squared	0.342	0.315	0.315

Note: Column (1) regress TFP on an eligible dummy. Eligible = 1 if the firm has export intensity above 0.7. Column (2) regress TFP on processing status, adding the eligible dummy as additional regressor. Column (3) regress TFP on group dummies defined by firms' "processing status + eligible status". Omitted group in all columns are non-exporters. All regressions include firm-level log employment, FIE dummy, as well as 4-digit Chinese industry, province and year dummies. Standard errors are clustered at firm level.
*** p < 0.01.

To see this point more clearly, in column (3) we divide firms into subgroups by both their processing status and tax benefits eligibility, and regress TFP against the group dummies (omitted group is non-exporters). This approach allows us to compare, for example, firms with the same processing status but different tax benefits eligibility. We can also compare firms with the same tax eligibility but different processing status. By doing this we can separate the role of tax benefits from other factors that affect the productivity of processing firms. Several messages emerge from the results in column (3). First, for a given processing status, eligibility of tax benefits still matters. For example, among pure processing exporters, the eligible firms are about 30% less productive than the non-eligible firms. Among non-processing exporters, eligible firms are about 10% less productive. Second, given the same eligibility, the productivity of processing and non-processing firms are still systematically different. For instance, among the non-eligible firms, processing exporters are 19% less productive than non-processing exporters, and 6% less productive than non-exporters. Among eligible firms, processing exporters are 40% less productive than non-processing exporters.

Taking these results together, we conclude that the favorable tax policy towards export-oriented firms is indeed one driving force behind the low productivity of processing exporters. However, the productivity disadvantage of processing exporters is still present when the eligibility of tax benefits are controlled for. Thus, other factors (such as different fixed costs) also play important roles.

5.3. Alternative explanations

5.3.1. Issues of TFP measure

It is possible that TFP measurement issues may make processing exporters appear less productive. Since we use revenue-based TFP to measure productivity (i.e. we use value, instead of quantity, of output and intermediate inputs in the production function estimation), the measured productivity will be biased downwards for firms with lower output prices or higher input prices. Processing exporters may appear less productive if they export at a lower price or import intermediate inputs at a higher price. To check this, we directly compare the export and import price of processing and non-processing transactions using the following regressions:

$$\log UV_{ipcht} = \alpha + \beta_1 PX_{ipcht} + \gamma \mathrm{FIE}_{it} + \nu_{pct} + \varepsilon_{ipcht} \quad (2)$$

where UV_{ipcht} is the export or import unit-value of product (HS 6-digit) p by firm i to (or from) country c through processing status h. PX_{ipcht} is a dummy variable which equals one for processing transactions. The omitted group is non-processing transactions. We control for product-country-year fixed effects (ν_{pct}) to absorb any product-country-year specific shocks that may affect export or import price. Thus, the coefficient β_1 in Eq. (2) reflects the price differences between processing and non-processing transactions within a product-country category and in the same year. In addition, Ge et al. (2015) find that multinationals charge higher export price in China. Considering the high correlation between processing status and foreign ownership, we include a foreign-invested-enterprise dummy (FIE_{it}) in all regressions.

Table 12
Export price of processing and non-processing transaction.

Dep. var.: $\log(UV)_{ipcht}$	Full customs data		Merged data	
	(1)	(2)	(3)	(4)
	Export price	Import price	Export price	Import price
Processing	−0.032***	−0.862***	−0.066***	−0.837***
	(0.003)	(0.006)	(0.003)	(0.008)
FIE	0.406***	0.310***	0.089***	0.116***
	(0.003)	(0.002)	(0.002)	(0.005)
Product-country-year FE	Yes	Yes	Yes	Yes
Observations	25,031,434	15,671,611	5,268,129	6,362,401
R-squared	0.711	0.760	0.740	0.768

Note: This table reports regression results of Eq. (2). Dependent variable is log export or import unit-value for a firm-hs6-country-processing-year pair. The omitted group is non-processing transactions. Columns (1) and (2) use the full customs data, while Columns (3) and (4) use the merged data. All regressions include product-country-year fixed effects and an FIE dummy. Standard errors are clustered at product-country-year level.
*** p < 0.01.

We run the price regression on the full customs data and the merged data. The results are reported in Table 12. Column (1) reports the result for export price using the customs data. It is seen that the export price of processing transactions are around 3% lower than that of non-processing exports.[20] Considering that the majority of output for processing firms are exported, this suggests that the output price for processing exporters are likely to be lower, translating into lower value of output and revenue-based TFP. However, we also need to look at price at the input side. A higher input price would lead to downward bias in revenue-based TFP. Column (2) reports the result for import prices.[21] The results, on the contrary, indicate that import prices of processing exports are 86% lower than that of non-processing exports. Therefore, price differences at the input side will translate into lower input use and thus higher revenue-based TFP for processing exporters. Taking export and import prices together, it is not clear how the price differences between processing and non-processing exports will bias the measured TFP of processing firms upwards or downwards. Results using the merged data in columns (3) and (4) reveal the same message.

Admittedly, an exact evaluation of the bias due to price differences is difficult unless we have very detailed data on all of the firm's outputs and inputs (including domestic and foreign). However, there are several

[20] As in Ge et al. (forthcoming), we also find multinationals charge higher export price.
[21] Since all firms in our merged data are manufactures, their imports are likely to be intermediate inputs rather than final goods. We also tried running the regression on the imports of "intermediate inputs" according to the BEC classification, the results are similar.

reasons we believe that our baseline results are reflecting the true productivity differences between processing and non-processing firms rather than driven by measurement errors. First, we have found that processing exporters are inferior in a wide range of performance indicators, such as wages, R&D expenditures, and skill intensity. These indicators are less susceptible to measurement errors than TFP. The firm heterogeneity literature has established that more productive firms pay higher wages (Amiti and Davis, 2011), invest more on R&D (Bustos, 2011), and are more skill intensive (Burstein and Vogel, 2012), thus processing exporters' poor performance in these aspects are consistent with their low productivity. Second, we have found that the lower productivity of processing exporters are also correlated with input tariffs or tax benefits granted to export-oriented in a systematic way. Productivity differences that are entirely driven by measurement errors are not likely to demonstrate such systematic heterogeneity. Third, we have found that processing exporters charge lower price for exports and pay lower price for imported inputs. This itself is consistent with the theory that processing exporters are less productive, thus import lower-quality inputs to produce lower-quality outputs (Kugler and Verhoogen, 2012).

Another related issue is transfer pricing. Subsidiaries of multinationals may repatriate profits to their related parties in other countries by exporting output at an artificially low price, or import inputs at a artificially high price. Both activities will translate into low revenue-based TFP. However, we believe transfer pricing does not play a key role in explaining the low productivity of processing exporters. First, the corporate tax rate in most of China's major FDI source countries are higher than China. According to Ge et al. (2015), among the top ten countries investing in China (which in total account for about 90% of foreign firms), the corporate tax rates range from 24.5% (Singapore) to 38 (Canada). China's statutory corporate tax rate is 30%. However, FIEs receive a great deal of tax holidays and exemptions. Corporate tax for FIEs are completely waived during the first two profitable years and reduced by half in the subsequent three years. In the ASIF data, we find the average of the effective corporate tax rate for FIEs is only 7.5%. Thus, a profit-maximizing transfer pricing strategy would require foreign subsidiaries in China to export at a high price and import at a low price, both of which translate into a higher revenue-based TFP. If the low productivity of processing firms are purely driven by transfer pricing issues, we would expect the productivity disadvantage of processing exporters to be smaller in FIEs (assuming that transfer pricing is more likely in FIEs and in processing exporters). However, Table 6 finds just the opposite. Second, the literature finds no evidence that transfer pricing issues drive the export price premium of multinational in China (Ge et al., 2015). One possible reason is that transfer pricing of intangibles (e.g. royalty payments) rather than physical output could be a more effective way for multinationals to repatriate profits.

5.3.2. Other policies

This section discusses the impact of other policies that may explain the poor productivity of processing exporters.

5.3.2.1. Export license. The first policy we consider is the export license system. Back in 1990s, the Chinese government restricted the right of firms to engage in foreign trade. Although the number of firms that were granted trading rights increased substantially throughout the 1990s and early 2000s, the designated trading system was not abolished until 2004. After 2004, except a narrow set of product categories, all firms active in China were given the right to export (Branstetter and Lardy, 2008). When the export license system was present, it is possible that the government may choose to grant more trading rights to processing exporters but restricted the trading rights of non-processing exports to a narrower set of productive firms. This may also help explain the low productivity of processing exporters.

In order to examine the role of the export license system, we did two exercises. First, since the major reform regarding the export license system occurred in 2004, we examine the productivity of processing exporters before and after the abolishing of the export license system. Column (1) of Table 13 reports the results before the reform and column (2) the results after the reform. We see that the productivity of processing exporters relative to non-processing exporters and non-exporters barely changed before and after the abolishing of the export license system.

Second, Chinese government has set a subgroup of product categories with tight control of the export license (even after 2004). Thus, we examine whether the low productivity of processing exporters still exist in the industries under the restrictions of the export license system, and in the industries that are not restricted. Column (3) reports the results for restricted industries and column (4) for unrestricted industries.[22] According to the results, the productivity gap between processing and non-processing exporters are almost identical in restricted and unrestricted industries (around 35%). Compared to non-exporters, the productivity disadvantage of processing exporters are *smaller* in restricted industries (18% in restricted industries and 26% in unrestricted industries). Thus, we do not find evidence that the export license system contributes to the low productivity of processing exporters.

5.3.2.2. Exchange rate reform. Exchange rate changes may affect the cost of imported intermediate inputs, which are shown to be important determinants of productivity (Amiti and Konings, 2007; Halpern et al., 2015). The exchange rate changes of the RMB may explain the low productivity of processing exporters if, say, processing exporters benefit less from cheaper imported inputs due to the appreciation of the RMB. To examine this, we first divide all the sample years into two sub-periods: 2000–2005, during which the RMB was effectively depreciating against other currencies, and 2006, during which the RMB began to effectively appreciate. Results in columns (5) and (6) of Table 13 show that in the two sub-periods, the productivity disadvantage of processing exporters are only slightly different, and is smaller for the appreciation period. This is not consistent with the conjuncture that processing firms may benefit less from the RMB appreciation.

5.3.3. Further discussion: dynamics of processing status

Our focus in the previous sections is mainly on the static comparison of processing and non-processing firms. We find that less productive firms select into processing while more productive firms select into non-processing. However, another important issue is the dynamics of processing trade. Does a firm's processing status evolve over time as firm productivity grows? Do firms start with processing exports and gradually switch into non-processing exports? Admittedly, a detailed analysis on these dynamic issues is beyond the scope of this paper. However, in this sub-section we provide some preliminary evidence.

Our strategy is to look at the transition matrix of processing status over time. Specifically, given the firm's processing status (non-processing, processing, hybrid) in a certain year t, we calculate the probability of each processing status in year $t + k$. Table 14a reports the matrix for $k = 1$ (which we call "short run") while Table 14b reports the matrix for $k = 6$ (which we call "long run").

Several patterns emerge. First, firm's processing status is quite persistent over time, at least in the short run. This can be seen by the large numbers on the diagonal of the matrix. Over one year, more than 80% of processing exporters still do processing only. For non-processing exporters, the share is even larger (94%). Over six years, over 60% of processing exporters are still doing processing trade only, and 85% non-processing exporters are still fully engaged in non-processing trade.

Second, it is more common for firms to start with processing and then switch into (at least some) non-processing trade, rather than

[22] Export license data for 2000–2006 is collected from the annual circulars of the Ministry of Commerce. The original list is at HS 8-digit or 10-digit level, we use a concordance to map it to 4-digit CIC industries. In 2006, there were 31 (out of 422) industries that are restricted.

Table 13
Other policies.

Dep. var.: TFP (OP)	Export license				Exchange rate reform	
	(1)	(2)	(3)	(4)	(5)	(6)
	Before reform	After reform	Restricted ind.	Unrestricted ind.	Before reform	After reform
Non-processing	0.117***	0.105***	0.170***	0.103***	0.110***	0.112***
	(0.006)	(0.006)	(0.017)	(0.005)	(0.006)	(0.007)
Processing	−0.271***	−0.268***	−0.180***	−0.263***	−0.277***	−0.231***
	(0.012)	(0.014)	(0.053)	(0.011)	(0.011)	(0.016)
Hybrid	0.074***	0.072***	0.169***	0.070***	0.070***	0.085***
	(0.009)	(0.009)	(0.030)	(0.008)	(0.008)	(0.010)
Observations	518,053	283,776	59,896	741,933	638,971	162,858
R-squared	0.292	0.323	0.196	0.322	0.304	0.326

Note: This table reports the regression results of Eq. (1). Dependent variable is TFP (Olley–Pakes). The omitted group is non-exporters. Columns (1)–(4) examine the role of export license system. Columns (1) and (2) respectively report the results before the abolishing of the export license system (2000–2004) and after the abolishing of the system (2005–2006). Columns (3) and (4) respectively report the results for industries that are restricted by export license and those that are not restricted. Columns (5)–(6) examine the role of China's exchange rate reform. Column (5) reports the results before the reform (2000–2005) and column (6) after the reform (2006) All regressions include firm-level log employment and 4-digit Chinese industry, province and year dummies. Standard errors are clustered at firm level.
*** $p < 0.01$.

the reverse. Over one year, 17% of pure processing exporters will start to do some non-processing trade, and 1% will turn into pure non-processing firms. On the contrary, only 6% of non-processing exporters will start to do some processing, and essentially no firms will transit from pure non-processing exporters to pure processing exporters. For firms that start with both activities, 12% will turn into pure non-processing firms, while only 6% will become pure processing exporters. Over six years, the evolution into non-processing trade becomes even more evident. 36% of pure processing exporters will start to do at least some non-processing trade, and 7% will become pure non-processing exporters. On the contrary, only 15% of pure non-processing exporters will start to do some processing, and no firms will become pure processing exporters. For firms start with both activities, 30% will become pure non-processing exporters, while only 7% will become pure processing exporters.

In summary, these results suggest that although firms' processing status evolves slowly, there is indeed evidence that firms start with processing trade and then gradually switch to non-processing trade. This is also consistent with our story that processing trade is an "easier" activity (in the sense that it is associated with lower fixed costs, or receive more favorable policy treatments), so it makes sense for firms to start with processing and switch to non-processing as its productivity grows.

6. Concluding remarks

Processing trade, in which parts are sourced globally and assembled at one place to be shipped to the final destination, explains bulk of the trade for the exporting powerhouse — China. This paper, merging Chinese firm level balance sheet data with the customs trade data, provides new stylized facts about performance of processing exporters. We show that processing exporters are fundamentally different from non-processing exporters — the former being not only less productive than the latter but also less productive than non-exporters. The firm level trade literature usually finds exporters to be exceptional performers. However, some recent papers on China document exporters to be less productive than non-exporters, both among foreign affiliates and in labor intensive sectors. We show that these anomalies are driven by the existence of processing exporters who are the least productive among all types of firms. Our results imply that it is essential to consider processing trade separately from ordinary exporting activity when analyzing exporter performance in countries that have large processing trade sectors.

We also explore possible reasons for the low productivity of processing exporters. We propose a selection mechanism where firms with different productivity select into different trade regimes. Compared with non-processing trade, processing trade is associated with lower fixed costs of exporting because of international production fragmentation. Also, it is subject to favorable trade and industrial policies such as input tariffs exemptions and income tax benefits. We find supportive evidence that both factors are responsible for the low productivity of processing exporters in China.

Our findings have important policy implications. On one hand, the re-allocation predictions in the presence of processing exporters are opposite to that in the Melitz (2003) model, in which a move towards exporting increases aggregate productivity of the sector since exporters are more productive than non-exporters. A processing trade driven export surge, contrary to this belief, would not imply a higher aggregate productivity since processing firms are the less productive ones. On the other hand, there could be knowledge spillover or learning by doing from processing, so less productive firms could benefit dynamically from their participation in the global production network. It thus becomes imperative to look into the costs and benefits of export processing. Exporting is often encouraged by countries on the ground that exporters are more productive and grow faster, so that they can act as an engine of growth. Given our findings, it also makes sense to conduct a more detailed evaluation of learning from processing. This will have important implications for countries conducting processing trade or planning to do so. We plan to study this in the future.

Table 14a
Transition matrix of processing status, 1 year interval.

	$\text{Nonprocessing}_{t+1}$	Processing_{t+1}	Hybrid_{t+1}
Nonprocessing_t	0.94	0.00	0.06
Processing_t	0.01	0.83	0.16
Hybrid_t	0.12	0.06	0.82

Table 14b
Transition matrix of processing status, 6 year interval.

	$\text{Nonprocessing}_{t+6}$	Processing_{t+6}	Hybrid_{t+6}
Nonprocessing_t	0.85	0.00	0.15
Processing_t	0.07	0.64	0.29
Hybrid_t	0.30	0.07	0.63

Note: Each number in the table is the probability of the firm's processing status in $t + k$, conditional on the processing status in t. Table 14a reports the results for $k = 1$ and this table reports the results for $k = 6$.

Appendix A. Supplementary data

Supplementary data to this article can be found online at http://dx.doi.org/10.1016/j.jdeveco.2016.03.007.

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