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Processing trade, export intensity, and input trade liberalization: evidence from Chinese firms

Wei Tian[a] and Miaojie Yu[b]*

[a]*School of International Economics and Trade, University of International Business and Economics, Beijing, China;* [b]*Center for Economic Research (CCER), National School of Development, Peking University, Beijing, China*

How do reductions in input trade costs affect firm's sales decision between domestic and foreign markets? By using Chinese firm-level production data and transaction-level trade data during 2000–2006 to construct firm-specific input trade costs, we find rich evidence that a reduction in input trade cost for *large trading* firms leads to an increase in export intensity (i.e., exports over total sales). The impact is more pronounced for ordinary firms than that for hybrid firms which engage in both processing and ordinary trade since ordinary import enjoys the free-duty treatment in China. The declining input trade costs not only increase the probability of firm's being new exporters (i.e., extensive margin) but also lead to higher export intensity (i.e., intensive margin). Such results are robust to different empirical specification and econometric methods.

Keywords: export intensity; input trade costs; imported intermediate inputs; processing trade

JEL Classifications: F1, F2

1. Introduction

Trade liberalization is one of the most important topics in international trade. It is of particular interests for both academia and policy-makers to understand firm's decision in choosing markets when a country experiences gradual trade liberalization. Previous studies mostly focus on how firms realize productivity gains from trade liberalization (see, for example, Amiti and Konings 2007; Topalova and Khandelwal 2011; Yu Forthcoming). Still, it is equally interesting to understand how import tariffs reduction on final goods, which is regarded as generating tougher import competition, could in turn force domestic firms to adjust their export intensity – the proportion of exports over total sales. More importantly, there is still relatively little research on firm's response to adjust its export intensity upon facing tariffs reductions in input tariffs on intermediate goods. The present paper tries to fill in this gap.

This paper investigates the effects of changing input trade costs on firm's export intensity using a very rich matched Chinese firm-level production data and transaction-level trade data. A novel element of the paper is that input trade costs are measured at and tailored to the firm level, which allow us to exactly measure the input trade costs faced by a firm. Firms face declining input trade costs over the sample period 2000–2006. Gradual tariffs reduction in ordinary imports occurs over time after China acceded to the WTO in 2001. More interestingly, a large extent of Chinese firms self-selects to engage in

*Corresponding author. Email: mjyu@ccer.pku.edu.cn

processing trade which has special tariff treatment – zero import tariffs. Further input tariffs reductions have no impact on firms' export intensity for firms that entirely engage in processing trade, but still have some impact on hybrid firms that engage in both ordinary and processing trade. Thus, the impact of input trade liberalization on export intensity for ordinary firms must be larger than its counterpart for hybrid firms. We find strong evidence to support this rationale.

To accurately estimate the impact of input trade cost on export intensity, we also control for the other two types of trade liberalization: import tariffs on final goods and external tariffs set by Chinese trading partners. As mentioned above, output tariffs reduction in final goods also generates tougher import competition, which could in turn change firm's export intensity. Meanwhile, during the sample period over 2000–2006, many Chinese firms export a variety of products to many countries. Chinese exporters also enjoyed large tariffs reductions in their export destinations. With reductions in foreign trade costs, firms are able to access to larger foreign markets which could possibly result in larger export intensity. We hence construct the firm-level external tariffs to measure the weighted tariffs across trading countries and across products over years. However, although the most ideal way is to obtain a corresponding firm-level import output tariffs, data on each product's domestic sales are unavailable, we hence only control for industry-level output import tariffs in the estimates.

We then decompose and identify the sources of variation in firm-level input trade costs. Firms may engage in processing trade or may not. Input tariffs reduction would have a significant effect on non-processing firm's sales decision, but should not be so for pure-processing firms that 100% engage in processing trade since processing trade is already *de facto* duty-free. Yet, one most interesting case exists: there have some 'hybrid' firms that engage in both processing and ordinary trade. Thus, the variation of hybrid firm's input trade costs could come from two different components: input tariffs reduction in ordinary imports *and/or* the proportion allocation between processing and ordinary import components. Such information is carried to construct the firm-specific input tariffs. Beyond this, we also identify sources of variation in input trade costs by different types of firms: pure ordinary and hybrid firms. Of course, some firms could switch from processing to ordinary trade, or vice versa. We hence also look at the effect of input trade costs on firm's export intensity for such switching firms specifically.

However, in which ways does the reduction in input trade cost affect firm's export intensity? Are they through the extensive margin, or intensive margin, or both? To check this out, we separate exporters to three types: new exporters, exiters, and continuing exporters. In particular, we find that the declining input trade costs not only increase the probability of firm's being new exporters (i.e., extensive margin), but also lead to a higher export intensity (i.e., intensive margin). However, the impact of either extensive margin or intensive margin is insignificant for exiting firms. By contrast, the impact of intensive margin is significant for continuing exporters. Similar findings are present when we turn the interest to the extensive margin – firm's export scope.

The endogeneity of firm-specific input trade costs is also carefully discussed and addressed. Three different sources of endogeneity could present for the constructed firm input tariffs. As firm's export intensity is defined as export over sales, the first endogeneity issue is the possible reverse causality of sales on tariffs. Firms with small amount of sales may blame their tough market situation to stronger import competition due to trade liberation. Accordingly, they would lobby the government for protection. We, therefore, adopt an instrumental variable (IV) approach to control for such a possible reverse causality.

The second endogeneity comes from the possible reserve causality of firm's exports on its imports. Firm's exports are highly correlated with its imports. The last endogeneity issue raises from the measure of the input tariffs itself. Suppose that a firm faces a prohibitive tariff line for a product that it wishes to import, such a tariff is not included in firm's input tariffs due to its zero imports. However, the firm indeed faces a very high (but not zero) tariff. To control for these two endogeneity issues, we use firm's imports in the first year of the sample to construct a fixed weight for firm-specific input tariffs following Topalova and Khandelwal (2011) and Yu (Forthcoming). After controlling for a variety of endogeneity issues, we still find robust evidence that input tariffs reduction leads to an increase in export intensity.

Our last robustness check is to adopt the quantile estimates to examine the heterogeneous impact of input trade cost on firm's export intensity by different quantiles. We first look at their response at the four quartiles and then examine them carefully in which quantiles are allowed to be measured at a continuum version. Both types of quantile analysis yield similar results as the standard fixed-effects ordinary least square (OLS) estimates. They also help us understand the economic magnitude of the estimates: A one-point decrease in firm-specific input trade costs would lead to at most a 5.2% increase in its export intensity.

This paper joins a growing literature on both counts. The first is on the topic of export intensity. Previous studies have recognized that firms only sell a small fraction of their output abroad. This is documented by, among others, Bernard and Jensen (1995), Arkolakis and Muendler (2010), and Eaton, Kortum, and Kramarz (2011). Most of such studies focus on interpreting why export intensity is small. Specifically, Bernard et al. (2003) emphasized a key reason for large countries like the United States is the existence of a relatively large domestic market. Brooks (2006) argued the key reason for small countries like Columbia is due to the low quality of their export products. Besides, Bonaccorsi (1992) found evidence that firm's export intensity is positively associated with its size using Italian manufacturing industry-level data. Greenaway, Sousa, and Wakelin (2004) investigated whether spillovers affect firm's export propensity using British firm-level data.

However, there is still limited research for China though it has become the second largest economy and largest exporter in the world. As documented in the later section, although China shares a common phenomenon with other countries in the sense that Chinese firms only export a small proportion of their products, there still exists a sizable proportion of firms that exports all of their products. Such a pattern is known as the U-shape as witnessed by Lu (2011).[1] Therefore, it is worthwhile to ask how the declining input trade costs affect such Chinese firms' export pattern, which hence adds value to the related literature.

Another set of related literature is on input trade liberalization. Among many other papers, Amiti and Konings (2007) found that firm gain from the reduction of input tariffs is at least twice as much as those from cutting output tariffs by using Indonesian firm-level data. Topalova and Khandelwal (2011) confirm that such a difference in gains from trade could be exaggerated to approximately 10 times in magnitude in several industries in India. Turning to the application to China, Yu (Forthcoming) found that the declining output tariffs still have a larger impact on firm productivity than the reduction in input tariffs due, in large part, to the fact that processing trade in China is duty-free. However, to our best knowledge, rare studies, if any, consider the impact of input trade cost on firm's export intensity despite both being tropical topics in the field.

The remainder of the paper is organized as follows. Section 2 describes data used in the present paper. Section 3 introduces the measures for key variables and empirical specifications. Section 4 discusses the estimation results and sensitivity analysis. Finally, Section 5 concludes.

2. Data

To investigate the impact of trade liberalization on firm's export intensity, this paper uses the following three disaggregated large panel data-sets: tariffs data, firm-level production data, and product-level trade data.

Tariff data can be accessed directly from the WTO.[2] China's tariff data are available at harmonized system (HS) six-digit level over years 2000−2006, which are more disaggregated than HS eight-digit transaction-level trade data. Hence, we first aggregate transaction-level trade data to HS six-digit level to concord with tariff data. The average Ad Valorem duties are used to measure trade liberalization given that our main interest is to estimate the effect of trade liberalization on export intensity.

2.1. Firm-level production data

The sample used in this paper comes from a rich firm-level panel data-set which covers around 230,000 manufacturing firms per year over 2000−2006. The data are collected and maintained by China's National Bureau of Statistics in an annual survey of manufacturing enterprises. It contains entire information of three accounting sheets (i.e., balance sheet, loss and benefit sheet, and cash flow sheet). On average, the annual entire value of industrial production covered in such a data-set accounts for around 95% of China's total industrial production by year. Indeed, aggregated data on the industrial sector in the annual China's Statistical Yearbook by the Natural Bureau of Statistics are compiled from this data-set. The data-set includes more than 100 financial variables listed in the main accounting sheets of all these firms. Briefly, it covers two types of manufacturing firms: (1) all state-owned enterprises (SOEs) and (2) non-SOEs whose annual sales are more than five million renminbi (RMB).

However, the raw production data-set is still quite noisy since it still includes many unqualified firms with poor accounting systems.[3] Following Cai and Liu (2009), Feenstra, Li, and Yu (2014), and Yu (Forthcoming), we delete observations according to the basic rules of Generally Accepted Accounting Principles if any of the following are true: (1) liquid assets are higher than total assets; (2) total fixed assets are larger than total assets; (3) the net value of fixed assets is larger than total assets; (4) number of employees is less than eight people as suggested by Brandt, Van Biesebroeck, and Zhang (2012); (4) the firm's identification number is missing; or (5) firm's established time is invalid (e.g., the opening month is later than December or earlier than January). Accordingly, the total number of firms covered in the data-set is reduced to 438,165, around one-third of firms are dropped from the sample after such a filter process.

2.2. Product-level trade data

The disaggregated transaction-level monthly trade data during 2000−2006 are obtained from China's General Administration of Customs. As shown in Column (1) of Table A1, the annual number of observations increases from around 10 million in 2000 to around 16 million in 2006, ending with a huge number of observations, 118,333,831, in total for seven years. Column (2) of Table A1 exhibits that there are 286,819 firms that ever engage in international trade during this period.

For each transaction, the data-set compiles three types of information: (1) basic trade information which includes value (measured at US current dollar), trade status (export or import), quantity, trade unit, and value per unit; (2) trade mode and pattern such as

destination country for exports, original country for imports, routing countries (i.e., whether the product is shipped through an intermediate country/regime), customs regime (e.g., processing trade or ordinary trade), transport mode (i.e., by sea, by truck, by air, or by post), and customs port (i.e., where the product departs or arrives); and (3) firm-level transaction information. In particular, it includes seven variables such as firm's name, identification number set by the customs, city where the firm is located, telephone, zip code, name of the manager/CEO, and even ownership type of firm (e.g., foreign affiliate, private, or state-owned enterprises).

We then match transaction-level trade data, firm-level production data, and tariffs data together. Since trade data and production data have no common identification numbers, the matching is of particular challenge.[4] Briefly, the matched data account for around 30% of number of exporting firms and around 53% of export value.

2.3. The matching results

As shown in Table 1, compared to full-sample trade data-set, the matched data-set has a similar proportion of numbers of ordinary importers and processing importers. Moreover, the merged data-set is skewed toward larger firms in terms of sales, exports, and number of employees, as reported in Yu (Forthcoming). Given that our main interest in the present paper is to investigate Chinese large trading firms, the matched data-set, therefore, is an appropriate data-set to serve for this objective.

Before adopting the matched samples to perform the estimations, it is worthwhile to check whether the distribution of firm's export intensity in the full sample is similar to that in the matched sample. If not, then our estimation results would be a suspect. As seen from Figure 1, firm's export intensity in the matched sample shows a U-shape in the left-hand-side (LHS) of Figure 1(A), which is very similar to that in the full sample in the LHS of Figure 1(B). Of course, around 72% of firms do not export in the full-sample production firm-level data-set, whereas only 17% of firms do not export in the matched data-set given that the matched data, by construction, only cover trading firms (i.e., either export or import, or both). Therefore, the density for the extreme values of firm's export intensity (i.e., zero and one) would be different. However, their non-parametric kernel density after dropping the two-side extreme values are very similar, as shown in the right-hand-side (RHS) of Figure 1(A) and 1(B). Therefore, the matched data-set is a good representative of the full-sample data set even in terms of firm distribution.

3. Measures and empirics

3.1. Firm-specific input tariffs

A firm could import many products in different amounts. Since its imported intermediate input could vary across industries, an aggregated industry-level tariff is insufficient to capture firm heterogeneity within a sector. Therefore, it is essential to construct a firm-specific variable of input trade costs.

Table 1. Comparison of the merged-sample and full-sample trade data.

Percentage of firms	Merged sample (%)	Full sample (%)
Ordinary importers	38.1	27.3
Processing importers	61.9	72.7

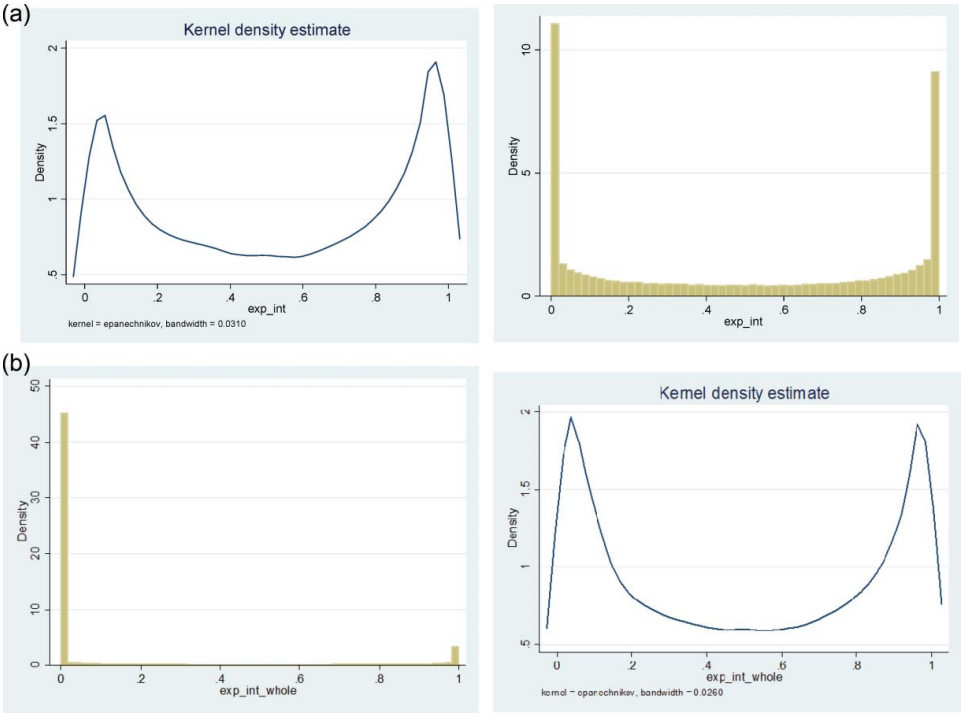

Figure 1. The distribution of firm's export intensity in the (A) matched-sample data and (B) full-sample data.

A special feature of China's import tariffs is that processing imports in China are duty-free. As in Yu (Forthcoming), we construct a firm-specific input tariff index (FIT_{it}) as follows:

$$FIT_{it} = \sum_{k \in O} \frac{m_{it}^k}{\sum_{k \in M} m_{it}^k} \tau_t^k, \tag{1}$$

where m_{it}^k is firm i's import value on product k in year t and, as before, τ_t^k is the *ad valorem* tariff of product k in year t . O is the set of firm's ordinary imports, and M is the set of firm's total imports. That is, $O \cup P = M$ where P is the set of processing imports and, by definition, is 100% duty free. Thus, this set is not included in Equation (1).

3.2. Firm-specific external tariffs

To measure the tariffs reductions in a firm's export destinations, we construct an index of firm-specific external tariffs (FET_{it}) as follows:

$$FET_{it} = \sum_k \left[\left(\frac{X_{it}^k}{\sum_k X_{it}^k} \right) \sum_c \left(\frac{X_{ikt}^c}{\sum_c X_{ikt}^c} \right) \tau_{kt}^c \right], \tag{2}$$

where τ_{kt}^c is product k 's ad valorem tariff imposed by export destination country c at year t . A firm may export multiple types of products to multiple countries. The ratio in the

Table 2. Summary statistics (2000−2006).

Variables	Mean	Std. dev.	Min.	Max.
Year	2003	1.85	2000	2006
Firm's export intensity	.488	.399	0	1
Industry-level output tariffs	12.1	5.91	0	58.7
Firm-level input tariffs	2.56	4.13	0	90
Firm-level input tariffs (fixed weight)	.577	2.27	0	94.5
Firm-level external tariffs	8.10	17.1	0	2,999
Processing indicator	.319	.466	0	1
Predicted processing probability	.449	.130	.026	.826
Extent to processing imports	.552	.474	0	1
Firm's log TFP (Olley−Pakes)	1.27	.350	−1.55	10.4
Log of firm employment	5.35	1.14	2.30	11.9
Firm tenure	10.7	10.3	0	57
Firm scope	6.49	9.84	1	527
SOEs indicator	.020	.141	0	1
Foreign indicator	.615	.486	0	1

second parentheses in Equation (2), $X_{ikt}^{c}/\sum_{c}X_{ikt}^{c}$, measures the export ratio of product k produced by firm i but consumed in country c, yielding a weighted external tariff across Chinese firms' export destinations. Similarly, the first parenthesis in Equation (2), $X_{it}^{k}/\sum_{k}X_{it}^{k}$, measures the proportion of product k's exports over firm i's total exports.

As a control variable, we also include import output tariffs in the estimates to capture the possible pro-competition effects. To measure the impact of import competition for each product, it is a need to have information on domestic sales at product level. However, such data are unavailable. As a compromise, we measure the import output tariffs at the HS two-digit industry level. Table 2 reports the summary statistics for such key variables.

3.3. *Estimation framework*

To investigate the effect of input tariffs reductions on firm's export intensity, we then consider an empirical framework as follows:

$$\begin{aligned}\text{Exp\_int}_{ijt} &= \alpha_0 + \alpha_1 \text{FIT}_{it} + \alpha_2 \text{FET}_{it} + \alpha_3 \text{FET}_{it} \times \text{PE}_{it} + \alpha_4 \text{OT}_{jt} \\ &+ \alpha_5 \text{OT}_{jt} \times \text{PE}_{it} + \alpha_6 \text{PE}_{it} + \boldsymbol{\theta} \mathbf{X}_{it} + \eta_i + \zeta_t + \varepsilon_{it},\end{aligned} \tag{3}$$

where Exp_int_{ijt} measures firm's export intensity for firm i in industry j in year t, as discussed above. FIT_{it} and FET_{it} denote firm-specific weighted input tariff and external tariff in year t, respectively. PE_{it} is a processing indicator which equals one, if firm i engages in processing activity in year t, and zero otherwise. OT_{jt} denotes industry-level tariffs for industry j in year t. $\mathbf{X}_{it}$ denotes other firm characteristics such as type of ownership (i.e., state-owned enterprises or multinational firms), firm size (i.e., log employment), and firm productivity. Finally, the error term is divided into three components: (1) firm-specific fixed effects η_i to control for time-invariant factors such as a firm's location; (2) year-specific fixed effects ζ_t to control for firm-invariant factors such as China's accession to the

WTO in 2001 and Chinese RMB appreciation after 2005; and (3) an idiosyncratic effect ε_{it} with normal distribution $\varepsilon_{it} \sim N(0, \sigma_i^2)$ to control for other unspecified factors.

4. Empirical results

4.4. Benchmark results

To investigate the impact of firm-specific input tariffs reduction on export intensity, we start from plotting firm's export intensity against firm-specific input tariffs, which are aggregated in industry level over years. Figure 2(A) clearly suggests a negative correlation between the average firm-specific export intensity and input tariffs. Admittedly, such a negative correlation could be just driven by other unspecified factors. In addition to the output import tariffs reductions, the tariffs reduction in China's trading partners may also affect Chinese firm's export intensity. Thus, controlling for tariffs reduction in China's export destinations is also worthwhile in obtaining the precise estimate of the effect of import tariffs reductions on a firm's export intensity. We then control for industrial output tariffs and firm-specific external tariffs, as well as firm's type of ownership (i.e., SOEs and foreign firms) and trade regime (i.e., processing and ordinary firms) in all estimates in Table 3.

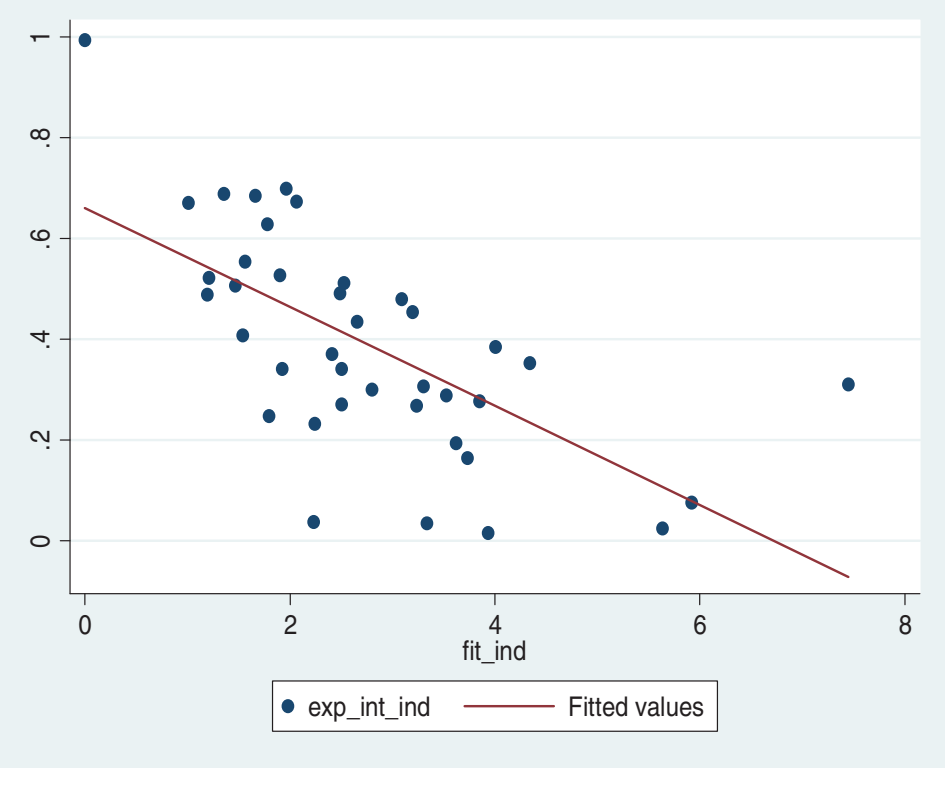

Figure 2. Firm's export intensity against input tariffs by industry.
Note: The residuals in this figure are obtained from benchmark estimates in the last column of Table 3.

Table 3. Estimates of tariffs reduction on firm's export intensity.

Export intensity (Exp_int)	(1)	(2)	(3)	(4)	(5)
Firm input tariffs	−0.002***	−0.002***	−0.002***	−0.002***	−0.003***
	(−4.75)	(−4.67)	(−7.56)	(−4.83)	(−7.89)
Industrial tariffs	0.0004	−0.0001	−0.0001	−0.0002	0.0001
	(1.20)	(−0.17)	(−0.20)	(−0.49)	(0.01)
Industrial tariffs		0.001***	0.001***	0.001***	0.001***
× processing Dummy		(2.92)	(3.16)	(3.11)	(3.07)
firm external tariffs	−0.000	0.000	−0.000	−0.000	−0.000
	(−1.07)	(0.11)	(−0.16)	(−0.26)	(−0.41)
Firm external tariffs		−0.000*	−0.000	−0.000	−0.000
× processing dummy		(−1.92)	(−0.44)	(−1.16)	(−0.88)
Processing dummy	0.001	−0.013**	−0.011**	−0.016***	−0.013**
	(0.25)	(−2.27)	(−2.19)	(−2.71)	(−2.33)
State-owned enterprises	0.019	0.019	0.011	0.017	0.011
	(0.97)	(0.98)	(0.69)	(0.90)	(0.62)
Foreign-invested enterprises	0.033***	0.033***	−0.001	0.021*	−0.010
	(2.74)	(2.74)	(−0.11)	(1.65)	(−0.84)
Obs. dropped if Exp_int = 0	No	No	Yes	No	Yes
Obs. dropped if Exp_int = 1	No	No	No	Yes	Yes
Year-specific fixed effects	Yes	Yes	Yes	Yes	Yes
Firm-specific fixed effects	Yes	Yes	Yes	Yes	Yes
Observations	79,212	79,212	67,086	68,420	56,294
R-squared	0.01	0.01	0.01	0.01	0.01

Notes: Robust *t*-values corrected for clustering at the firm level in parentheses. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

To understand the overall impact of input tariffs reduction on export intensity, the estimate in Column (1) starts from abstracting away the interaction terms of various tariffs reductions and firm's processing status. After controlling for firm-specific fixed effects and year-specific fixed effects, estimates in Column (1) show that firm's input tariffs reduction leads to larger proportion of exports to sales, though the impact of output tariffs and firm-specific external tariffs on export intensity is insignificant. Adding the interaction terms between processing dummy and input tariffs (external tariffs and output tariffs) in Column (2) does not change the estimation results in terms of signs or magnitudes.

One may concern that the large proportion of pure domestic firms which have zero exports may affect our estimation results given that around 17% of Chinese firms have zero exports in our matched data. A similar argument applies to a fairly large proportion of pure exporting firms − 12% exporters export all of their products. Meanwhile, as suggested by Ahn, Khandelwal, and Wei (2011), the carry-along trading companies (i.e., intermediaries) notably do not have their own production activity, but only export goods collected from other domestic firms (i.e., 100% export intensity), or import goods abroad and then sell to other domestic companies (i.e., 0% export intensity). Such firms would result in a unit of export intensity. We hence drop firms whose export intensity is zero in Column (3) and one in Column (4). Column (5) goes further to drop observations if export intensity is either zero or one. Neither of such specifications changes our estimation results of the key variable: the coefficient of firm-specific input tariffs is always negative and highly significant at the conventional statistical level.

4.2. First-difference estimates

Firm's export intensity could be affected by other factors that are unspecified in the estimations above. Although we have employed firm-specific fixed effects and year-specific fixed effects to control for factors that are only variant across firms and over years, respectively. It is still possible that there exist some other omitted factors that change both across firms and over years. For instance, China's government allowed some exportable products to enjoy the privilege of 'export value-added tax rebate'. The value-added tax rebate ratio differs across industries and over year.[5] We hence perform the following first-difference estimate to control for such possible unobserved firm heterogeneity as suggested by Trefler (2004) and Amiti and Konings (2007):

$$\begin{aligned}\Delta \text{Exp\_int}_{ijt} = {} & \alpha_0 + \alpha_1 \Delta \text{FIT}_{it} + \alpha_2 \Delta \text{FET}_{it} + \alpha_3 \Delta \text{FET}_{it} \times \text{PE}_{it} + \alpha_4 \Delta \text{OT}_{jt} \\ & + \alpha_5 \Delta \text{OT}_{jt} \times \text{PE}_{it} + \alpha_6 \text{PE}_{it} + \boldsymbol{\theta} \mathbf{X}_{it} + \varpi_i + \eta_t + \mu_{it},\end{aligned} \tag{4}$$

where Δy_{it} is the first difference of the variable $y_{it} \in \left\{\text{Exp\_int}_{ijt}, \text{FIT}_{it}, \text{FET}_{it}, \text{OT}_{jt}\right\}$ denoting $y_{it} - y_{it-1}$. We also include the firm (year)-specific fixed effects to control for the time-invariant (variant) growth factors.

As shown in Column (1) of Table 4, the variable of first difference in firm input tariffs is still negative and significant. To check whether such results are sensitive to the extreme

Table 4. First-difference estimates of firm input tariffs on export intensity.

First difference in export Intensity (ΔExp_int)	(1)	(2)	(3)	(4)
First difference in firm input tariffs	−0.001	−0.001*	−0.001	−0.001**
	(−1.04)	(−1.88)	(−1.28)	(−2.11)
First difference in industrial tariffs	−0.000	0.001	−0.000	0.001
	(−0.08)	(1.01)	(−0.31)	(0.85)
First difference in industrial tariffs	−0.000	−0.000	0.001	0.000
× processing dummy	(−0.36)	(−0.32)	(0.52)	(0.34)
First difference in firm external tariffs	−0.000	0.000	−0.000	−0.000
	(−0.08)	(0.01)	(−0.30)	(−0.03)
First difference in firm external tariffs	−0.000	0.000	0.000	0.000
× processing dummy	(−0.76)	(1.34)	(0.54)	(0.90)
Processing dummy	0.000	0.002	0.002	0.003
	(0.04)	(0.49)	(0.34)	(0.61)
State-owned enterprises	0.003	−0.002	0.001	−0.005
	(0.07)	(−0.06)	(0.02)	(−0.13)
Foreign-invested enterprises	0.040	0.023	0.023	0.001
	(1.51)	(0.97)	(0.83)	(0.03)
Obs. dropped if Exp_int = 0	No	Yes	No	Yes
Obs. dropped if Expint = 1	No	No	Yes	Yes
Year-specific fixed effects	Yes	Yes	Yes	Yes
Firm-specific fixed effects	Yes	Yes	Yes	Yes
Observations	36,266	31,623	31,707	27,064
R-squared	0.02	0.01	0.01	0.01

Notes: Robust *t*-values corrected for clustering at the firm level in parentheses. *, **, and *** indicate significance at the 10%, 5%, and 1%t levels, respectively.

values of firm's export intensity, we drop samples with zero export intensity in Column (2) and samples with a unit of export intensity in Column (3). Finally, we even drop samples whose export intensity is zero or one. All of such specifications yield a similar result: the reduction in firm-specific input tariffs leads to an increase in export intensity.

4.3. *Estimates for entry and exit*

We have seen much evidence that a reduction in input trade costs leads to an increase in export intensity. But, how does this happen? Are they through the extensive margin, or intensive margin, or both? Previous studies like Blum, Claro, and Horstmann (2012) found that Chilean firms reduce their domestic sales when they enter foreign markets. For continuing exporters, Chilean firms' foreign and domestic sales are negatively correlated over time. We now go to check whether this is also true for Chinese firms.

Estimates of Column (1) in Table 5 first check the case for starters that include both exporters and non-exporters. The LHS variable in the Probit estimate is a dummy of firm's operation status which takes one if it is a starter and zero otherwise. We see that a reduction in firm input trade costs leads to a higher probability of firms to become new starters. One reason is that the reduction in input trade costs helps firms generate more profit and hence it can overcome the entry fixed costs (Melitz 2003). Column (2) keeps new exporters only and focuses on the effect of intensive margin. Clearly, the estimate shows that a reduction in input trade costs leads to higher export intensity. For comparison, Columns (3) and (4) include all exiters (i.e., both exporter and non-exporters) and exiting exporters, respectively. It turns out that the reduction in input trade costs does not help much to prevent firms exiting from the market since the coefficient of input trade costs is insignificant. Such an observation also holds for exiting exporters shown in Column (4).

By way of comparison, Columns (5) and (6) just include continuing exporters. The coefficient of firm-specific input trade costs in Column (5) is negative and significant, suggesting that once again the reduction in input trade cost leads to higher export intensity even for continuing firms. Yet, it is still interesting to understand whether the reduction in input trade costs can introduce exporters to export more varieties (i.e., the extensive margin). We hence perform the negative binomial estimate in the last column of Table 5, given that the regressand is a positive integer. Clearly, the negative and significant sign of input trade costs suggests that the reduction in input trade costs also leads to an increase in export scope.

4.4. *Sources of the reduction in input trade costs*

It is also worthwhile to ask why firm's input trade costs decline over time. The first natural answer is due to the reduction in import tariffs. In the measure of firm-specific input tariffs (Equation (1)), if τ_t^k decreases, firm input tariffs FIT_{it} would decrease even when other components are unchanged.[6] Meanwhile, there still exists another source for input tariffs reduction. Faced by some negative demand shocks, firms may adjust their production structure between processing and ordinary imports. Since processing activities have a lower threshold to entry, firms may engage in more processing activities when they are low productive (Yu Forthcoming). If firms have more weights in processing activities, they would be able to bear a lower firm-specific input tariff. Of course, in the reality, such two sources are combined automatically. Therefore, it is worthwhile to decompose the two sources and identify their effects one by one.

Table 6, therefore, picks up such a task. Column (1) only includes pure ordinary firms. Column (2) covers hybrid firms that have some ordinary imports and some processing

Table 5. Estimates of firm input tariffs on export intensity by entry and exit.

Type	New exporters		Exiters		Continuing exporters	
Regressand	Export Dummy	Export Intensity	Export Dummy	Export Intensity	Export Intensity	Export Scope
Econometric method	Probit	FE	Probit	FE	FE	Neg. Binomial
	(1)	(2)	(3)	(4)	(5)	(6)
Firm input tariffs	−0.009***	−0.002*	−0.000	−0.001	−0.002***	−0.007***
	(−6.00)	(−1.77)	(−0.24)	(−0.84)	(−3.15)	(−4.17)
Industrial tariffs	0.005***	−0.001	0.004*	−0.003*	−0.001	−0.001
	(2.79)	(−0.41)	(1.89)	(−1.68)	(−1.33)	(−0.67)
Industrial tariffs	−0.004**	−0.000	−0.003	0.003	0.002***	0.002
× processing dummy	(−2.08)	(−0.04)	(−1.08)	(1.44)	(2.72)	(0.85)
Firm external tariffs	−0.002**	−0.001	−0.000	0.000	−0.000	0.001
	(−1.99)	(−0.89)	(−0.41)	(0.57)	(−0.75)	(0.71)
Firm external tariffs	0.001	0.001	0.001	0.000	0.000	0.001
× processing dummy	(1.57)	(0.94)	(1.05)	(0.52)	(0.16)	(0.45)
Processing dummy	0.128***	−0.017	0.101***	−0.047*	−0.022**	−0.042
	(4.65)	(−0.65)	(3.05)	(−1.90)	(−2.31)	(−1.37)
Firm's TFP	−0.102***	−0.039***	0.039**	−0.031**	−0.042***	0.054***
	(−6.56)	(−2.87)	(2.22)	(−2.04)	(−4.76)	(2.95)
State-owned enterprises	−0.202***	−0.047	0.346***	0.039	−0.001	−0.097
	(−4.20)	(−1.25)	(7.21)	(1.28)	(−0.02)	(−1.02)
Foreign-invested enterprises	0.089***	−0.075*	0.134***	0.006	−0.028	0.258***
	(6.95)	(−1.66)	(8.57)	(0.11)	(−1.19)	(3.80)
Observations	65,422	21,624	46,862	32,098	18,053	11,677
R-squared	–	0.02	–	0.01	0.02	–
Year-specific fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	No	Yes	No	No	No
Firm-specific fixed effects	No	Yes	No	Yes	Yes	Yes

Notes: Robust *t*-values corrected for clustering at the firm level in parentheses. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

Table 6. Estimates for sources of input tariffs variations.

Export intensity	Pure	Hybrid	Switching firms from		
	Ordinary Firms	Firms	Pure ord. to hybrid	Pure proc. to hybrid	Hybrid to non-hybrid
	(1)	(2)	(3)	(4)	(5)
Firm input tariffs	−0.002***		−0.004**	−0.002	−0.001
	(−5.21)		(−2.04)	(−0.10)	(−0.39)
Firm input tariffs		−0.001***			
(Fixed tariffs)		(−2.96)			
Industrial tariffs	−0.000	0.000	0.001	0.005	−0.000
	(−0.76)	(0.68)	(0.66)	(0.85)	(−0.19)
Firm external tariffs	−0.000	0.000	−0.000	−0.001	0.000
	(−0.50)	(0.03)	(−0.50)	(−0.68)	(0.19)
State-owned enterprises	0.008	0.014	0.023	–	0.005
	(0.43)	(0.47)	(0.27)		(0.06)
Foreign-invested enterprises	−0.011	0.029	0.060	0.416**	0.006
	(−0.66)	(1.63)	(1.37)	(2.32)	(0.07)
Year-specific fixed effects	Yes	Yes	Yes	Yes	Yes
Firm-specific fixed effects	Yes	Yes	Yes	Yes	Yes
Observations	31,740	46,831	12,524	3,644	9,395
R-squared	0.01	0.01	0.01	0.03	0.02

Notes: Robust *t*-values corrected for clustering at the firm level in parentheses. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

imports. However, since the firm-specific input tariffs, as in Equation (1), still reflect the changes in both processing share and tariffs change, we fix the tariffs by using the tariffs line for products in the initial year (i.e., 2000), so that one can clearly observe the impact of changing processing share on the export intensity. That is, the firm-specific input tariffs in Column (2) are measured as $\sum_{k\in O}\frac{m_{it}^{k}}{\sum_{k\in M}m_{it}^{k}}\tau_{2000}^{k}$. It turns out that the coefficients of firm-specific input tariffs are negative and significant in Columns (1) and (2), indicating that changes in both tariffs and processing share matter for firms to realizing the increase in export intensity. More importantly, the effect of input trade liberalization on export intensity for ordinary firms in Column (1) is larger than its counterpart for hybrid firms in Column (2).

We now go further to explore the transition probability for trade regime switching. The intuition is straightforward. Given that the threshold of processing trade is low in China, pure ordinary firms would engage in processing trade only when the market is tough (Dai, Maitra, and Yu 2012). In contrast, pure-processing firms would start to engage in ordinary trade if the market is ease. Columns (3)−(5) hence preform the estimates for firms that switch from ordinary to hybrid, from pure processing to hybrid, and from hybrid to non-hybrid firms, respectively. It turns out that only the effect of input tariffs on export intensity for firms that switch from ordinary to hybrid is negative and significant.

4.5. Endogeneity of the measure of input tariffs

Furthermore, the weight construction in firm-specific input tariffs in Equation (1) is still endogenous because goods with high tariffs would be imported less, thus generating a lower import weight in Equation (1). Taking an extreme example, if China imposes a prohibitive tariff on product k, then its import share on such a good would be zero, because m_{it}^{k} in Equation (1) is zero. Meanwhile, firm's exports are also possibly related to its imports since firms with more exports usually use more intermediate imports, as documented by Feng, Li, and Swensen (2012). If so, the LHS variable, firm's export intensity, also reversely affects the import weight in the firm-specific input tariffs FIT_{it}.

Hence, the input tariffs that a firm face may be underestimated. Thus, to avoid such a problem, following Topalova and Khandelwal (2011), we choose firm's import value in the initial year (i.e., 2000) to construct a fixed weight in the firm-specific input tariffs (FIT_{it}^{2000}) as follows:

$$\mathrm{FIT}_{it}^{2000}=\sum_{k\in O}\frac{m_{i,\,2000}^{k}}{\sum_{k\in M}m_{i,\,2000}^{k}}\tau_{t}^{k}, \tag{5}$$

where $m_{i,\,2000}^{k}$ is firm i 's imports of product k in 2000. As a result, the import weight is unaffected by tariffs reductions. We then use this measure of tariffs reductions to run regressions as a robustness check.

Table 7 reports the estimates using firm-level tariffs with fixed weights. In all estimates, we use the extent to processing imports to measure firm's processing activities. Columns (1) and (2) first abstracts away the interaction terms between extent to processing and output tariffs (firm external tariffs) for a while, whereas the rest of the table includes such two interaction terms. Estimates in Column (1) confirm that the effect of firm-specific input tariffs on export intensity is negative and significant. It is worthwhile to check whether the effects of firm-level input tariffs on export intensity pick up the role of firm size given that large firms usually have larger export intensity (Bonaccorsi 1992). We hence include firm size measured by the log of firm's employment since Column (2). It turns out that larger firms usually have higher export intensity. Column (3) drops

Table 7. Estimates using firm-level tariffs with fixed weights.

Export Intensity (Exp_int)	(1)	(2)	(3)	(4)
Firm input tariffs (fixed weights)	−0.001*	−0.001*	−0.002**	−0.002**
	(−1.66)	(−1.66)	(−2.32)	(−1.99)
Industrial tariffs	0.000	0.000	−0.000	−0.000
	(0.65)	(0.65)	(−0.74)	(−0.23)
Industrial tariffs			0.001**	0.001**
× extent to processing			(2.50)	(2.13)
Firm external tariffs	−0.000	−0.000	−0.000	−0.000
	(−1.14)	(−1.14)	(−0.78)	(−0.95)
Firm external tariffs			−0.000*	−0.000*
× extent to processing			(−1.81)	(−1.80)
Extent to processing	0.017***	0.017***	0.011	0.012
	(3.85)	(3.85)	(1.63)	(1.52)
State-owned enterprises	0.043	0.043	0.031	0.031
	(1.54)	(1.54)	(1.32)	(1.26)
Foreign-invested enterprises	0.043**	0.043**	0.016	0.011
	(2.49)	(2.49)	(1.10)	(0.62)
Log employment			0.008**	0.013***
			(2.57)	(3.28)
Obs. dropped if Exp_int = 0	No	No	Yes	Yes
Obs. dropped if Exp_int = 1	No	No	No	Yes
Year-specific fixed effects	Yes	Yes	Yes	Yes
Firm-specific fixed effects	Yes	Yes	Yes	Yes
Observations	50,779	50,779	42,819	35,440
R-squared	0.01	0.01	0.01	0.01

Notes: Robust *t*-values corrected for clustering at the firm level in parentheses. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

observations if firms have no foreign sales. Finally, Column (4) only keeps those firms that have both foreign and domestic sales in the estimation. Nevertheless, the effect of firm-specific input tariffs on export intensity is negative and significant in all estimates; more encouragingly, their magnitudes are also close to their counterparts in the previous tables.

4.6. Further quantile estimates

Finally, another possible concern is whether or not the OLS estimates are appropriate for estimation given that the sample of firm's export intensity exhibits a U-shape, which is far from the normal distribution that requires for OLS estimates. However, this is not a problem since that the U-shape of firm's export intensity across firms is due, in large part, to the variation of firm's characteristics. Given that we have already controlled for firm-specific fixed effects and year-specific fixed effects, such omitted characteristics have been well controlled.

Still, the U-shape of firm's export intensity hints us that the response of input trade costs to export intensity may not be identical across all firms. The fixed-effect OLS estimates so far only focus on the mean level of the response of firm input tariff. The rich

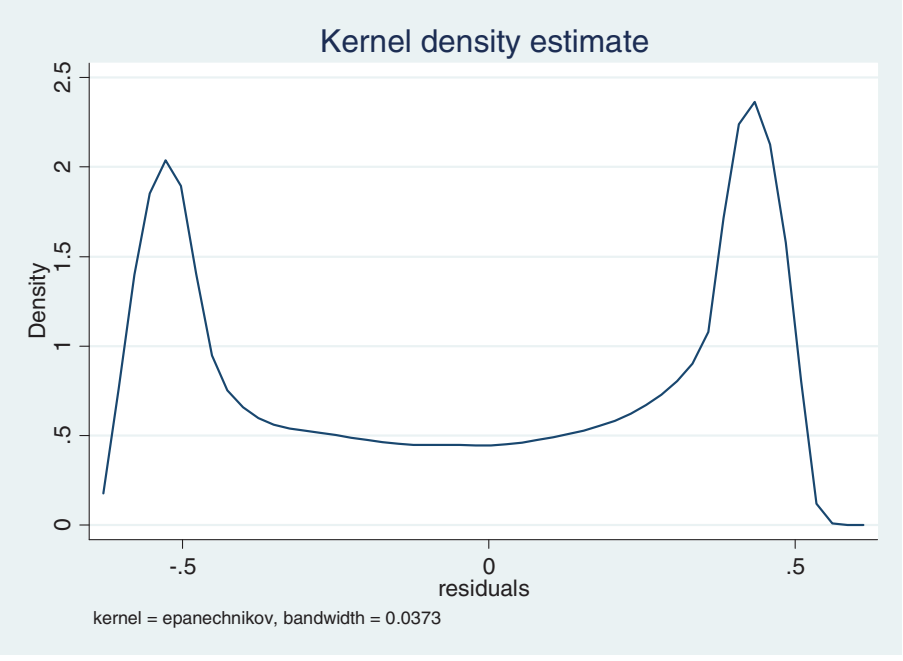

Figure 3. The distribution of residuals in the benchmark estimates.

heterogeneity across all firms is hence abstracted away. To gain a better understanding, the economic magnitude of the effect of input trade costs on firm's export intensity, the quantile estimates would be a plus for us to identify such heterogeneous magnitudes across firms.

The other reason to appeal to the quantile estimates is that, as shown in Figure 3, the residual obtained from the benchmark estimates in the last column of Table 3 is asymmetric, which deviates from the requirement of standard OLS estimates. Therefore, the quantile analysis is also a need (Koenker-Bassett 1978). Different from minimizing the sum of square errors in the OLS estimates, the quantile estimates propose to minimize the weight of the estimation residual as follows:

$$\beta_q = \text{argmin}\sum_{i\ :\ y_i ? \mathrm{X}_i\beta_q}^{n} q|y_i - \mathrm{X}_i\beta_q| + \sum_{i\ :\ y_i < \mathrm{X}_i\beta_q}^{n} (1-q)|y_i - \mathrm{X}_i\beta_q| \tag{6}$$

where q is the quantile level, y_i is the LHS variable, and $\mathbf{X}_i\boldsymbol{\beta}_q$ are the fitted values at quantile q. Intuitively, the quantile estimates give much more weights for those observations that are lower than their fitted value at every quantile q. In this way, the estimates would be able to capture the heterogeneous behavior of firm's export intensity.

Table 8, therefore, reports the quantile estimates for the first quantile, median, and the third quantile. To capture the impact of various tariffs reductions on export intensity, we abstract away other control variables but only include firm-specific input tariffs, output import tariffs, and external tariffs. For comparison, we also include the OLS estimate in Column (1). It turns out that the impact of firm-specific input tariffs reduction leads to an increase in export intensity in all estimates.

Table 8. Quantile estimates.

Export intensity	OLS	Quantile 25%	Quantile 50%	Quantile 75%
Industrial tariffs	0.010**	0.010**	0.020**	0.005**
	(40.08)	(38.26)	(45.25)	(41.51)
Firm input tariffs	−0.027**	−0.016**	−0.052**	−0.035**
	(−55.35)	(−56.49)	(−89.1)	(−189.2)
Firm external tariffs	−0.0001	−.0000	−0.001**	−0.001**
	(−1.46)	(−0.99)	(−10.21)	(−8.45)
Constant	0.469**	0.0641**	0.479**	0.920**
	(120.63)	(17.39)	(76.47)	(568.6)

Notes: Robust *t*-values corrected for clustering at the firm level in parentheses. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

Finally, we take a step further to perform the quantile estimates in a continuous version that the quantiles vary from zero to one. Figure 4 shows the heterogeneous response of the coefficients for industry-level output tariffs, firm-specific input tariffs, firm-specific external tariffs, and the constant intercept term. Clearly, the coefficients of firm-specific input tariffs exhibit a concave shape. Similarly, the coefficients of output tariffs exhibit a hump shape. These two figures suggest that the coefficient of the firm input tariffs should reach its maximum around the median level in an absolute value. This is exactly consistent with the empirical findings shown in Table 8.

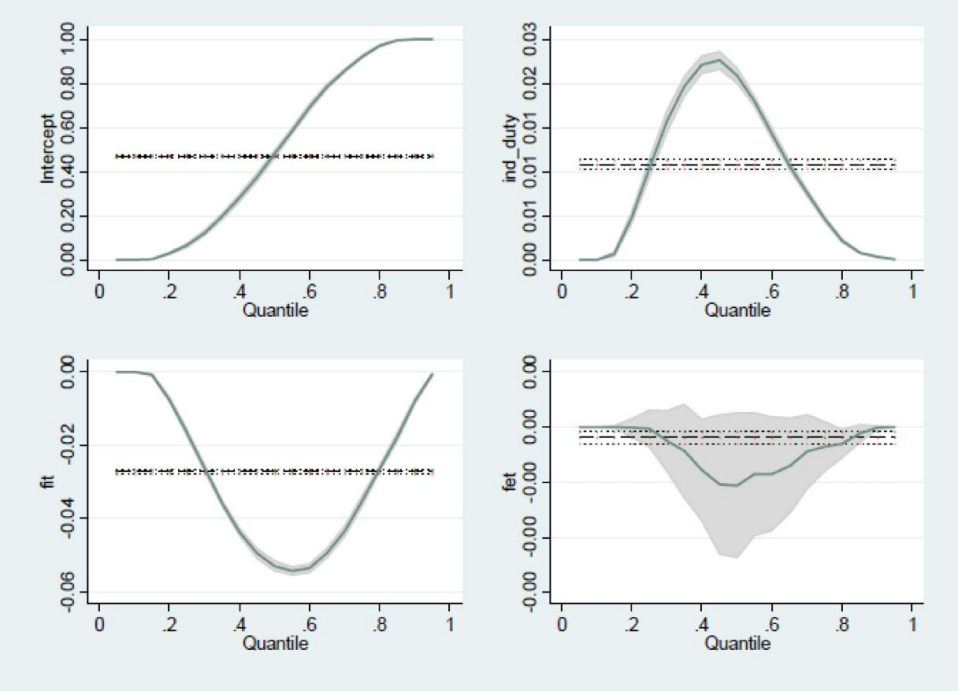

Figure 4. The quantile estimates of various tariffs reductions.

Our final remark is about the economic magnitude of firm's export intensity in response to the input trade costs reduction. As shown in both Figure 4 and Table 8, the coefficient of input trade costs reaches, in the absolute value, its maximum of 0.052 at the mean level but records a relatively low number of 0.016 at the first-quarter level and of 0.035 at the third-quarter level. This suggests that a one-point declining in input trade costs leads to a 5.2% increase in export intensity for firms with median level of export intensity, and a 1.6 (3.5)% increase in export intensity for firms around the first (third)-quarter level of export intensity. Given that the mean of input trade costs is 2.73% and of export intensity is 48.8% as shown in Table 1, firm's export intensity would increase to around 62.1% if input trade costs were reduced to zero. Such impact indeed is economically sizable.

5. Concluding remarks

The paper explores how reductions in input trade costs affect firms' export intensity by exploiting the special tariff treatment afforded to the imported inputs by processing firms as opposed to non-processing firms in China. As a popular trade pattern in a large number of Asia-Pacific countries such as China and Indonesia, processing trade plays an important role in firm's decision to choose domestic and foreign markets. By using Chinese firm-level production and transaction-level trade data, an intensive empirical search shows that a reduction in input trade costs leads to an increase in export intensity for Chinese large trading firms. As ordinary import enjoys the free-duty treatment in China, the impact is more pronounced for ordinary firms than that for hybrid firms which engage in both processing and ordinary trades.

The present paper is one of the first to explore the role of processing trade on firm's export share. The rich Chinese data-set enables the determination of whether a firm engages in processing trade and the examination of the effect of the firms' extent of processing trade engagement on export intensity. With such information, firm-specific input tariffs were also constructed, as one of the first attempts in the literature, which, in turn, enriches the understanding of the economic effect of trade liberalization on firm's sales decision.

Our paper also has rich policy implications. Trade liberalization is not only able to boost firm productivity via generating tougher import competition (Yu Forthcoming). Moreover, input trade liberalization can also help firms access to larger foreign market and realize more gains from trade. To maintain comparative advantage of Chinese exportable goods (Yao and Yu 2009), Chinese government needs to deeply engage in more multinational trade agreements to push further input (and output) trade liberalization in China.

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Disclosure statement

No potential conflict of interest was reported by the authors.

Notes

1. Lu, Lu, and Tao (2010) also use Chinese firm-level data to find that, among foreign affiliates, exporters are less productive than non-exporters. Dai, Maitra, and Yu (2012) points out the key reason for such a phenomenon is due to the prevalence of processing trade in China.
2. Source of the data: http://tariffdata.wto.org/ReportersAndProducts.aspx.
3. For example, some family-based firms, which usually have no formal accounting system in place, reports their production information based on a unit of one RMB, whereas the official requirement is a unit of 1000 RMB.
4. The detailed method and technique can be found from Yu (2013).
5. Most commodities are mandatory to pay 13% or 17% value-added tax for their value added in China. However, if such commodities are exportable goods, firms can get the value-added tax rebate when such products are exported. The value-added tax rate is set as 5%, 9%, 11%, 13%, or 17%, which is contingent on products.
6. Of course, when tariff τ_t^k decreases, the import weight m_{it}^k for the product k for firm i could change as well. However, change the weight to a fixed weight using the initial year in the period ($m_{i,\,2000}^k$) or a floating one-period lag weight (m_{it-1}^k) does not change our estimation results.

Notes on contributors

Wei Tian works in the School of International Trade and Economics, University of International Business and Economics. Her current main research interests focus on outward FDI and export intensity of Chinese firms. She has published papers in *Review of Development Economics*, *Journal of China and Global Economics*, and *Economic Research Journal* (in Chinese).

Miaojie Yu is a professor in the China Center for Economic Research (CCER), National School of Development, Peking University. His current research focuses on processing trade, firm productivity, trade liberalization, and credit constraints. He has published papers in *The Economic Journal*, *Review of Economics and Statistics*, and *Journal of Development Economics*. He is the deputy editor of *China Economic Journal* and an editorial board member of *China Economic Review*.

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Appendix

Table A1. Firm's switching by type.

Panel A: transition probability from pure-processing firms to non-processing firms

	Pure processing next year		
Pure processing today	0	1	Total
0	45.70	54.30	100.00
1	6.27	93.73	100.00
Total	11.18	88.82	100.00

Notes: 0 means pure-processing firms, 1 means non-pure processing firms.

Panel B: transition probability from ordinary firms to non-ordinary firms

	Ordinary next year		
Ordinary today	0	1	Total
0	85.23	14.77	100.00
1	34.08	65.92	100.00
Total	67.85	32.15	100.00

Notes: 0 means ordinary firms, 1 means non-ordinary firms.

Panel C: transition probability from hybrid firms to non-hybrid firms

	Hybrid next year		
Hybrid today	0	1	Total
0	81.45	18.55	100.00
1	52.06	47.94	100.00
Total	73.46	26.54	100.00

Notes: 0 means hybrid firms, 1 means non-hybrid firms.