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Export adjustment to input trade liberalization: The role of import wholesaling services

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Abstract

This paper studies how input trade liberalization affects export performance, by stressing the important role played by import wholesaling services. Using data from China, we find that input tariff cuts imply a decline in aggregate export revenues in mostly direct-importing sectors, through the exit of varieties from the export market (extensive margin), and a decrease in the foreign sales of surviving varieties (intensive margin). These effects are due to within-variety efficiency losses, associated with efficiency gains from market share reallocations across varieties. Opposite results are found in sectors that generally rely on wholesalers when importing intermediate inputs.

KEYWORDS

China, export performance, intermediate inputs, trade intermediaries, trade liberalization

JEL CLASSIFICATION

F10; F13; F14

1 | INTRODUCTION

Trade liberalization in intermediate inputs positively affects firm productivity, since firms can access more and/or better input varieties, and the productivity gains from these input tariff reductions are larger than those from output tariff cuts (Amiti & Konings, 2007; Goldberg et al., 2010;

Khandelwal & Topalova, 2011; Schor, 2004). These positive effects regard firms directly involved in import activities but, due to indirect involvement in import activities through wholesalers, they may also concern other firms. However, if firms are unable to import, either directly or indirectly, they may suffer negative productivity effects from input tariff liberalization, since they might lose some domestic input varieties—being pushed out of the market with the arrival of foreign competing varieties—without benefitting from using foreign input varieties (Defever et al., 2020).

As a result, input tariff liberalization may also affect firms' export performance in different ways. Bas (2012) shows that input tariff cuts have positive effects on a firm's decision to export, whereas Chevassus-Lozza et al. (2013) demonstrate that input tariff reductions may decrease the probability of firms starting export activities, and increase the export sales of high-productivity firms at the expense of low-productivity firms.

This paper empirically investigates how input tariff policies may affect export performance, stressing the role played by wholesalers that help firms to access foreign input varieties, by using product/destination level trade data from China in the period 2000–2006, thereby exploiting the drastic trade liberalization after China's accession to the WTO in December 2001.

In the absence of wholesalers, we expect that only the most efficient incumbent export varieties would be able to use foreign intermediate inputs, due to the high fixed costs of importing, and hence enjoy efficiency gains from input tariff reductions. The other export varieties are expected to suffer efficiency losses, which would imply that the least efficient ones exit the international market and, therefore, that foreign sales would reallocate from low- to high-efficiency export varieties. These effects are in line with Chevassus-Lozza et al. (2013). However, when the presence of wholesalers helps the majority of domestic varieties, including all export varieties, to access foreign intermediate inputs, we expect that all incumbent export varieties will enjoy efficiency gains from input tariff reductions, and that new varieties—associated with lower efficiency—will enter the export market, entailing foreign sales reallocation from high- to low-efficiency export varieties.

In line with our expectations, we find that a reduction in input tariffs implies a decrease in aggregate export revenues in mostly direct-importing sectors, since the majority of varieties are unable to use foreign intermediate inputs. Conversely, in mostly indirect-importing sectors, export sales increase following input tariff cuts, because the majority of varieties are able to use foreign inputs, thanks to wholesalers. When exploring whether the change in export revenues is due to the entry-exit of varieties (extensive margin) and/or changes within the surviving varieties (intensive margin), we find that input tariff cuts affect both margins. In mostly direct-importing sectors, exports fall dramatically because of the (net) exit of varieties from the international market, and a decrease in foreign sales of the surviving varieties. These effects tend to shrink in sectors with a larger presence of input importing wholesalers. Indeed, in mostly indirect-importing sectors, export growth from input tariff reductions occurs through the (net) entry of new varieties in the export market, and an increase in the foreign revenues of incumbent varieties.

We also analyze the effects on (quality-adjusted) export prices in order to estimate potential efficiency gains or losses from input tariff liberalization. In the extreme case that imports of intermediate inputs only occur through the direct channel, subsequent to a one-percentage point reduction in input tariffs, we estimate a 12% increase in the export aggregate price. This change is due to within-variety efficiency losses of 12.8%, which are associated with efficiency gains from sales reallocation across varieties by 1.2%. Conversely, in the extreme case that imports only occur through the wholesaling channel, we estimate a 29.5% decline in the export aggregate price, due to within-firm efficiency gains of 31.9%, and efficiency losses of 3.3% from sales reallocation across incumbent varieties. We also document that input tariff liberalization allows the entry of less expensive varieties into the indirect-importing sectors compared to direct-importing sectors.

This paper mainly contributes to the literature on the microeconomic linkage between tariff liberalization and export performance (Bas, 2012; Chevassus-Lozza et al., 2013). While several studies focus on the impact of input and output tariff reductions on firm productivity, a smaller number explore how trade reforms may affect export performance. The most closely related works, which also investigate how cuts in input tariff influence Chinese export performance, are those of Feng et al. (2016), Bas and Strauss-Kahn (2015) and Fan et al. (2015). Using Chinese firm level data and changes in input tariffs, exchange rates and fixed trade costs to instrument changes in the use of imported inputs, Feng et al. (2016) analyze how importing intermediate inputs affects exports. They find that a 1% increase in the value of imported inputs boosts a firm's export value by 1.6%. Using firm/product/country level data from China, Bas and Strauss-Kahn (2015) reach the conclusion that input tariff liberalization generates quality-upgrading effects, by demonstrating that input tariff cuts lead to an increase in both import and export unit values, or the related quality-components measured à la Khandelwal et al. (2013). Similar findings are documented by Fan et al. (2015), who show that the increase in export prices arising from input tariff cuts is associated with an increase in quality and a decline in quality-adjusted price. Unlike these works, we emphasize that the input tariff effects on export sales and (quality-adjusted) prices are dependent on the presence of wholesalers who help firms or varieties to access foreign intermediate inputs.

More generally, this work is related to the literature on trade liberalization and firm performance, showing that input tariff reductions may lead to an increase in productivity, markups, quality and product scope (Amiti & Konings, 2007; De Loecker et al., 2016; Goldberg et al., 2010; Kugler & Verhoogen, 2012). Similar effects are also documented in China (Bas & Strauss-Kahn, 2015; Brandt et al., 2017; Feng et al., 2016; Yu, 2015). However, these studies do not investigate the role of trade intermediaries. The only exception is the study by Defever et al. (2020) on Chinese firms, which explores the input tariff effect on productivity. They find that while direct-importers increase total factor productivity (TFP) thanks to input tariff liberalization, other firms obtain productivity gains from input tariff cuts only if they operate in sectors that rely mainly on wholesaling services when they import intermediate inputs, otherwise they may suffer efficiency losses. Through our work, using product level data, we explore further to see whether import-wholesaling services may also drive the effects of input tariffs on export performance, rather than TFP.

Finally, this paper also contributes to the literature stressing the importance of trade intermediaries in linking firms to their consumers across the borders by reducing search costs (Biglaiser, 1993; Biglaiser & Friedman, 1994). The majority of these studies focus on export intermediation services, showing that trade agents can help firms to export, especially those that find the costs of exporting directly prohibitive (Antràs & Costinot, 2011; Crozet et al., 2013; Felbermayr & Jung, 2011). Using firm-level data from China, Ahn et al. (2011) show that while the most productive firms export directly, other firms may rely on wholesalers to supply the final consumers abroad, especially when they are located in markets that are more difficult to penetrate. In our work, we focus on how (input) import wholesaling services, rather than (output) export wholesaling services, contribute to explaining the growth of exports arising from trade liberalization.

The rest of the paper is organized as follows. Section 2 includes a short theoretical motivation in order to highlight our main empirical specification. Section 3 introduces the data and the main variables. Section 4 provides an empirical analysis of the export adjustments to input tariff liberalization, stressing the role of import wholesaling services. Section 5 includes robustness checks and further investigations. Section 6 concludes.

2 | THEORETICAL MOTIVATION AND EMPIRICAL IMPLEMENTATION

This section provides a theoretical motivation based on the previous literature (Defever et al., 2020; Imbruno, 2020; Melitz, 2003) to guide our empirical analysis.

2.1 | Theoretical background

First, we consider two symmetric countries, where L consumers have CES preferences across final varieties and provide labor at wage rate $w = 1$, as well as two vertically related sectors: the final good sector (y), where firms are heterogeneous in productivity φ_y and mainly use intermediate inputs through a CES production function to produce the final varieties y; and the intermediate goods sector (m), where firms are also heterogeneous in productivity φ_m and mainly use labour through a linear production function to produce the intermediate varieties m.

Second, we assume that any producer in the final good sector faces a fixed cost of production f_D and can use all domestic intermediates, while only firms that pay an additional fixed cost of importing $f_M > f_D$ can also use foreign inputs coming from the most productive suppliers located abroad. Consequently, an importer's input price index is lower than a non-importer's input price index ($P_m^M < P_m^D$).

Therefore the price, revenue and profit in the domestic market for non-importer $s = D$ and importer $s = M$ are respectively:

$$p_y^s = \frac{\sigma}{\sigma - 1} \frac{P_m^s}{\varphi_y} \tag{1}$$

$$r_y^s = \left(p_y^s\right)^{1-\sigma} R_y \left(P_y\right)^{\sigma-1} \tag{2}$$

$$\pi_y^s = \frac{r_y^s}{\sigma} - (f_D + \theta f_M)$$

where σ is the elasticity of substitution between any two final varieties, R_y and P_y, respectively denote the aggregate revenue and the aggregate price within the final good sector, and θ equals one if $s = M$, and zero otherwise. Notice that importers are, on average, more efficient than non-importers in the final good sector because the former are, on average, associated with higher exogenous productivity φ_y and lower input price index P_m, compared to the latter.

Moreover, we assume that if a final good firm wants to export, it needs to face an additional fixed cost $f_X > f_D$, without incurring in any output tariff.[1] This means that firms earn a lower export profit than domestic profit, even though they have the same price and revenue in the foreign market as they do in the domestic market. As a result, exporters are, on average, more productive than non-exporters in the final good sector because the former are, on average, associated with higher exogenous productivity φ_y.

As regards the input suppliers, we assume that they face a fixed cost of production f_D to produce for the domestic market whereas in order to export their input varieties, they need to incur an additional fixed cost of exporting $f_X > f_D$, as well as an iceberg-type variable cost $\tau_m > 1$ (i.e. an input tariff). Therefore, in the intermediate good sector, exporters are, on average, more productive than non-exporters because the former are, on average, associated with higher exogenous productivity φ_m.

It is worth noting that any change in the input tariff may differently affect the price index of all intermediate inputs competing within a country P_m^M, and the price index of domestically produced intermediate inputs P_m^D. For instance, assuming that all final good firms are able to access foreign inputs (and firm productivity follows a Pareto distribution), Imbruno (2020) shows that input tariff cuts can lead to a decline in P_m^M, since firms can replace the more costly domestic inputs with less expensive foreign inputs, implying efficiency improvements within the firm (gains from input switching). In the same setup, it can be shown that P_m^D may increase due to input tariff cuts, since some domestic suppliers are forced to exit the market. Therefore, in our current framework, while final good firms that are able to import enjoy efficiency gains from input tariff liberalization, those that can use only domestic inputs may suffer efficiency losses, since the number of domestic input varieties may decline. These effects have been empirically confirmed in China using firm-level data on total factor productivity (TFP). Indeed, Defever et al. (2020) found evidence that subsequent to input tariff cuts, firms involved (directly or indirectly) in import activities increase their TFP, whereas the other firms reduce it.

Finally, we need to make an additional assumption about the relationship between the fixed cost of importing f_M and the fixed cost of exporting f_X in order to highlight the sorting of different groups of firms within the final good sector. In particular, we consider two cases. The case of direct importing ($WS^m = 0$), where the fixed cost of importing is relatively high; and the case of indirect importing ($WS^m = 1$), where the fixed cost of importing is relatively low, thanks to the presence of wholesalers who help firms to access foreign intermediate inputs. It is worth noting that, compared to the former case, the latter may also be associated with an additional iceberg-type variable cost of wholesaling services. Indeed, Defever et al. (2020) develop a theoretical model to analyze how the firm's endogenous decision to import directly or indirectly through wholesalers may affect productivity (but not exports). They highlight a trade-off between the direct and indirect import channel: compared to the former, the latter is associated with a lower fixed cost of importing but also with an additional variable cost. As result, the study shows that, in any given sector, the high-productivity firms import directly, the medium-productivity firms import indirectly, and the low-productivity firms do not import at all.

Since the purpose of this paper is to study the impact of input tariff liberalization on exports, mediated by the role of import wholesaling services, we do not take into consideration the effects of import decisions on the two different types, but focus on two alternative and extreme cases.

1. The case of direct importing only ($WS^m = 0$), where the fixed cost of importing is relatively high ($f_D < f_X < f_M$). From Figure 1, we can see that, whereas the least productive firms focus only on the domestic market, and most productive firms are involved in two-way trading, medium-productivity firms export without importing. Since a reduction in input tariff may increase P_m^D and decrease P_m^M, the majority of firms will obtain efficiency losses from input tariff liberalization, and only the high-productivity firms will obtain efficiency gains. Notice that this may lead to an increase in the minimum level

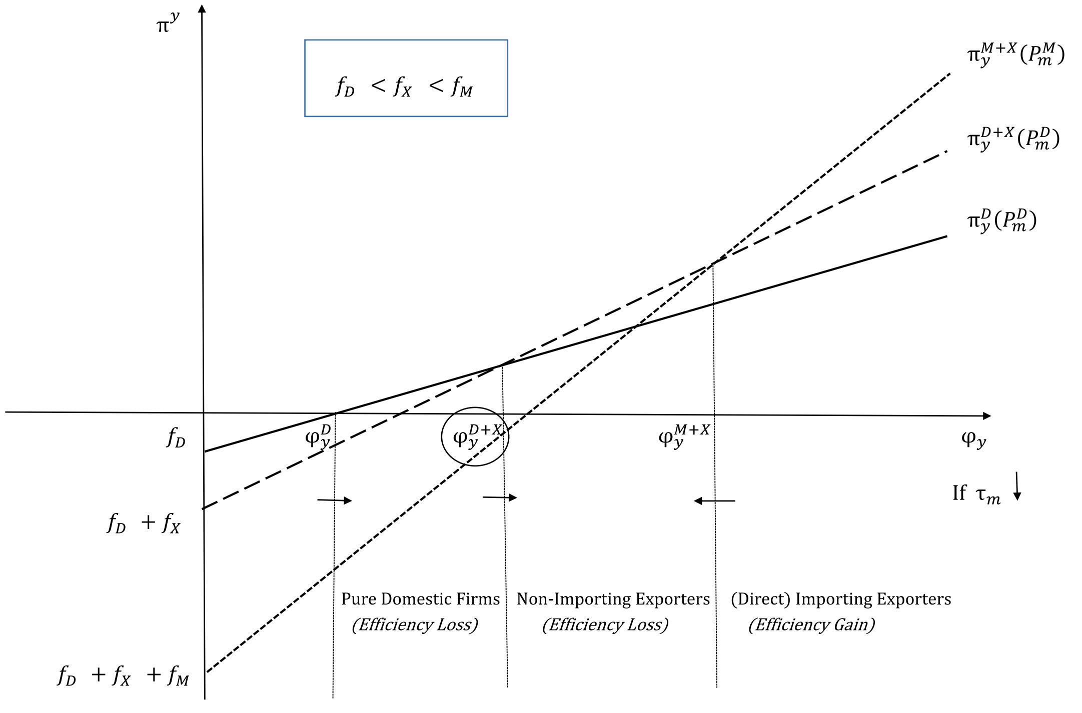

FIGURE 1 Direct importing case

of productivity required to export (denoted by φ_y^{D+X} in Figure 1), which entails exit of the least productive exporters from the international market, as well as export market share reallocation from low- to high-productivity firms.

2. The case of indirect importing only ($WS^m = 1$), where the fixed cost of importing is relatively low ($f_D < f_M < f_X$). From Figure 2, we can observe that while the least productive firms focus only on the domestic market, and the most productive firms are involved in two-way trading, medium-productivity firms import without exporting. Considering again the previously discussed effects of input tariff cuts on P_m^D and P_m^M, the majority of firms will enjoy efficiency gains from input tariff reduction, whereas only low-productivity firms will suffer efficiency losses. This may lead to a decrease in the minimum level of productivity required to export (denoted by φ_y^{M+X} in Figure 2), which would imply the entry of new firms in the export market and, therefore, reallocation of the export market shares from high- to low-productivity firms.

2.2 | Deriving the main econometric equation

By taking the logs of Equations (1) and (2), we can derive our main econometric specifications at the final variety level i (considering that each firm produces a single variety), including also the sub-index t that denotes time:

$$\ln p_{y(it)}^s = \ln P_{m(t)}^s - \ln(\sigma/(\sigma-1)) - \ln\varphi_{y(i)}$$

$$\ln r_{y(it)}^s = \ln R_{y(t)} + (\sigma-1)\ln P_{y(t)} - (\sigma-1)\ln P_{m(t)}^s + (\sigma-1)\ln(\sigma/(\sigma-1)) + (\sigma-1)\ln\varphi_{y(i)}$$

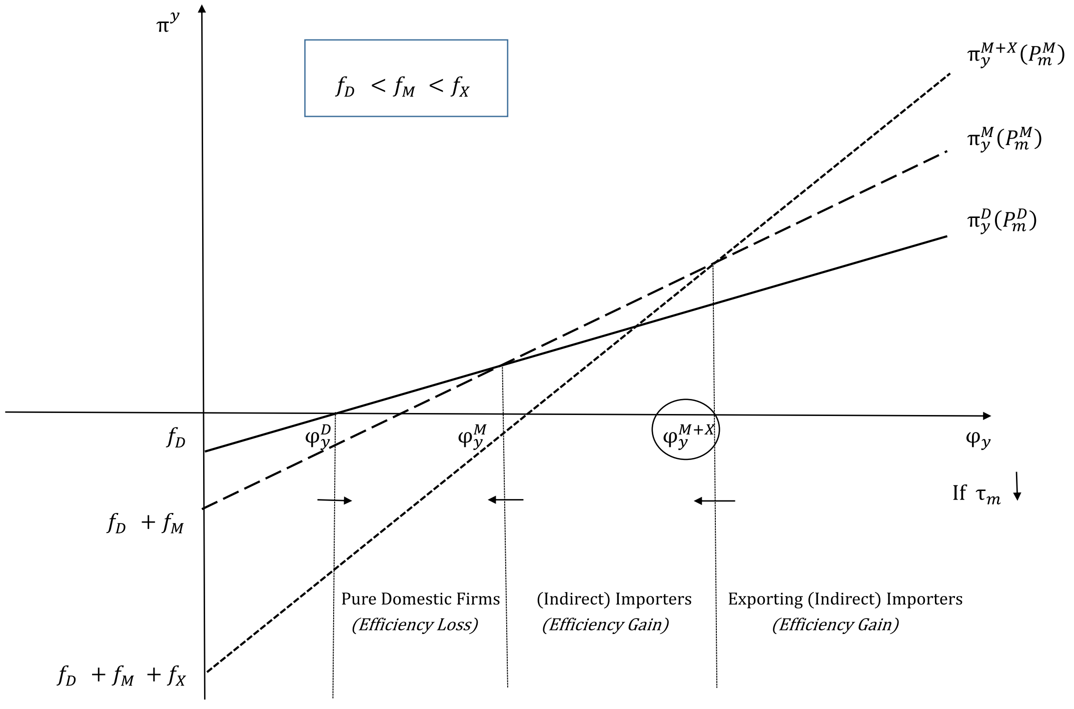

FIGURE 2 Indirect importing case

Considering that the change in $\ln P^s_{m(t)}$ reflects the change in input tariff $\tau_{m(t)}$, we can highlight the following econometric equations to explore the within-variety (i) changes in export outcomes—price or revenue—from industry (j) level changes in input tariffs.

$$\ln p_{it} = \alpha \tau^m_{jt} + \phi_i + \phi_t$$

$$\ln r_{it} = \gamma \tau^m_{jt} + \phi_i + \phi_t$$

From our discussion above, we expect that $\alpha < 0$ and $\gamma > 0$ in the direct importing sector ($WS^m_j = 0$) and $\alpha > 0$ and $\gamma < 0$ in the indirect importing sector ($WS^m_j = 1$). Therefore, we can re-write the full general specification as follows:

$$y_{it} = \beta_1 \tau^m_{jt} + \beta_2 \left(WS^m_j * \tau^m_{jt} \right) + \phi_i + \phi_t \tag{3}$$

where y_{it} refers to $\ln p_{it}$ or $\ln r_{it}$, alternatively.

When estimating the coefficients of these two equations, we expect $\beta_1 < 0$, $\beta_2 > 0$ when $y_{it} = \ln p_{it}$, and $\beta_1 > 0$, $\beta_2 < 0$ when $y_{it} = \ln r_{it}$. Notice that we will use the continuous version of WS^m_j, which is more informative than the binary version of WS^m_j, since we have data to measure the industry-level indirect import share of intermediate inputs which, hypothetically, can take any value between 0 (Wholly-Direct-Importing case) and 1 (Wholly-Indirect-Importing case).

3 | DATA AND MAIN VARIABLES

To explore input tariff effects on export performance, mediated by the role of wholesalers in importing intermediate inputs, we use data from the Chinese manufacturing sector over the period 2000–2006. During this period, subsequent to its accession to the WTO in December 2001, China experienced drastic trade liberalization, enabling it to become one of the first top-traders in the world. More specifically, we use panel data from the BACI database, which provides information on bilateral trade at the 6-digit HS product level, such as value[2] and quantity,[3] by means of which we are able to compute our main variables of interest, i.e. the export revenues and export price (arising from the unit value) for each Chinese variety (i.e. 6-digit HS product/destination pair).

3.1 | Export performance: Revenues and prices

Table 1 shows that export growth during the period 2000–2006 was due to both the extensive and intensive margins. Indeed, while the number of exported varieties increased by about 67%, the average exports per variety increased by about 33%. These changes were associated with a decrease in average unit value by about 30%. Notice that these average changes are due both to the entry-exit of varieties and to changes within the incumbent varieties. Indeed, when focusing on incumbent varieties, average export revenues increased at a higher rate (by about 134%), while average export unit values decreased at a lower rate (by about 21%). This implies that the new varieties were associated with lower prices and smaller sales compared to exiting varieties, whereas incumbent varieties further increased their sales through price reductions.

Recent literature highlights that a change in unit value may be due to either changes in efficiency or changes in quality. Using firm/product/destination level data from China, Bas and Strauss-Kahn (2015) document that input tariff liberalization allows ordinary importers to access higher quality inputs, through which higher quality products can be produced and exported. Thus, an increase in variety-level export price arising from input tariff reductions may be due to efficiency losses or quality upgrading. Unlike Bas and Strauss-Kahn (2015), we focus on input tariff effects on efficiency, rather than quality, we therefore remove the quality component from the price by computing the quality-adjusted price following Khandelwal et al. (2013). First, the

TABLE 1 Summary statistics: Export revenues, unit values, and (quality-adjusted) prices of varieties

	2000		2006	
	Obs.	**Mean**	**Obs.**	**Mean**
(a) Unbalanced panel				
r_{idt}	211,845	4.099	354,377	4.425
uv_{idt}	211,845	2.016	354,377	1.713
p_{idt}	211,611	2.237	353,936	1.591
(b) Balanced panel				
r_{idt}	144,046	4.768	144,046	6.113
uv_{idt}	144,046	2.021	144,046	1.814
p_{idt}	143,888	2.205	143,888	1.598

Note: 6-digit product/destination (*id*) level Chinese export data from BACI. r_{idt} is the revenue, uv_{idt} is the unit value, and p_{idt} is the quality-adjusted price.

quality for each variety-year observation has been estimated as residual from the following OLS regression:

$$q_{idt} + \sigma_j * uv_{idt} = \alpha_i + \alpha_{dt} + \varepsilon_{idt}$$

where uv_{idt} and q_{idt} are the (log) export unit value and (log) quantity at the 6-digit product/destination level; σ_j is the 3-digit HS sector-specific elasticity of substitution between products, computed for China by Broda et al. (2006); α_{dt} are destination/year pair fixed effects and capture the consumer's aggregate price index and total expenditure (income spent) in each destination and year, and α_i are product fixed effects necessary to control for time-invariant product characteristics, given that prices and quantities may be not comparable across products. The estimated (log) quality is then $\lambda_{idt} = \hat{\varepsilon}_{idt} / \left(\sigma_j - 1\right)$, and the (log) quality-adjusted price is $p_{idt} = uv_{idt} - \lambda_{idt}$.

Table 1 shows that the negative change in quality-adjusted price was even larger in magnitude (by about 65%) than the unit value change, and was mostly due to changes within the incumbent varieties (by about 61%).[4] Thus, this summary statistics suggests that, whereas the entering varieties during the sample period were slightly more efficient than exiting varieties, incumbent varieties enjoyed efficiency improvements.[5] Hereafter, we refer with price to quality-adjusted price.

3.2 | Input trade liberalization

Coherently with previous studies (Amiti & Konings, 2007), we use tariff data from WITS[6] database to compute one of our main explanatory variables, the industry-level input tariff τ^m_{jt}, which corresponds to the weighted average of output tariffs in upstream sectors τ^y_{kt}:

$$\tau^m_{jt} = \sum_k w_{kj} * \tau^y_{kt}$$

where the weight w_{kj} is from the Chinese input-output (I/O) table for the 2002, and refers to the share of inputs purchased by industry j from industry k. We firstly used the 8-digit HS level *ad valorem* Most-Favorite-Nation applied duties to compute the average output tariff at the 2-digit I/O level through the concordance table between I/O and HS classification. Then, after computing the input tariffs at the 2-digit I/O level, we converted them to the 2-digit HS level through the same concordance table.

Thus, a fall in τ^m_{jt} implies further trade liberalization in intermediate inputs. Figure 3 shows how input tariffs applied by China decreased, on average, from about 10.8% in 2000 to 5.8% in 2006, with the largest cuts occurring after China joined the WTO (on 11th December 2001).

It is worth noting that trade policies may be endogenous and, in our context, we could therefore have potential problems of reverse-causality with regard to export revenues and/or prices. For example, larger and/or high-productivity exporters are also more likely to import intermediate inputs and, therefore, may lobby to have lower input tariffs. However, recent studies on China have highlighted that trade policies were very likely to be exogenous during the period around China's accession to the WTO, since willingness to be part of the WTO system went beyond any specific group of interests (Brandt et al., 2017; Branstetter & Lardy, 2008). In particular, Bas and Strauss-Kahn (2015) highlighted that, during our sample period (2000–2006), changes in input tariffs were not

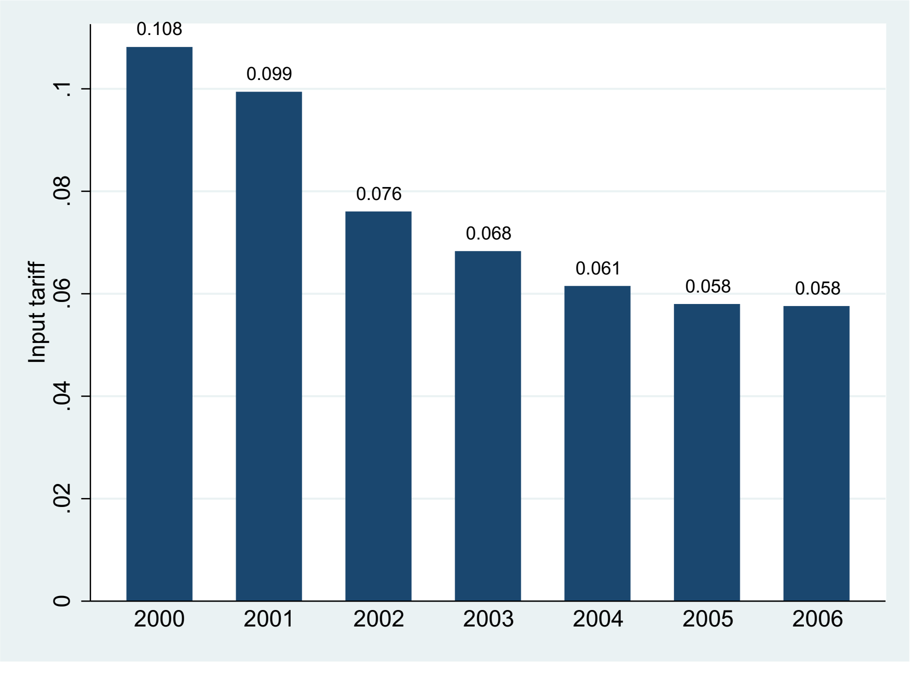

FIGURE 3 Input tariffs in China over time [Colour figure can be viewed at wileyonlinelibrary.com]

TABLE 2 Sector-level linkage between change in input tariffs (2000–2006) and initial exports and prices (2000)

Dependent variable: Change in input tariffs	$\Delta\tau^m_{j,2000-2006}$ (1)	$\Delta\tau^m_{j,2000-2006}$ (2)
$r_{j,2000}$	0.000851	
	(0.00278)	
$p_{j,2000}$		−0.000201
		(0.000359)
Observations	80	79
R-squared	0.001	0.002

Note: $r_{j,2000}$ and $p_{j,2000}$ are respectively the average revenue and the average quality-adjusted price for sector j in year 2000, $\Delta\tau^m_{j,2006-2000}$ is the change in input tariff for sector j during the period 2000–2006. Robust standard errors are in parentheses. Significance at $^{***}p < .01$, $^{**}p < .05$, $^{*}p < .1$.

correlated at all with various initial industry characteristics in China. In Table 2, we further confirm that reverse-causality can be ruled out when exploring the input tariff effect on export performance, since changes in input tariffs are found to be uncorrelated with the initial levels of (average) export revenues and prices at the 2-digit sector level.

3.3 | Import wholesaling of intermediate inputs

Following Defever et al. (2020), we use ordinary import transaction data[7] in 2000 from the database of Chinese Customs Trade Statistics (CCTS), managed by the General Administration of

Customs of China, to compute the indirect import share of intermediate inputs at the sector level WS_{jt}^{m}, in order to distinguish manufacturing sectors that rely mostly on wholesaling companies to access foreign intermediate inputs from other sectors. This variable is computed as the weighted average of indirect import shares in upstream sectors WS_{k}^{y}:

$$WS_{j}^{m} = \sum_{k} w_{kj} * WS_{k}^{y}$$

where w_{kj} is again from the Chinese I/O table for the year 2002 and refers to the share of inputs purchased by industry j from industry k. Thus, we firstly used 6-digit HS level product data on imports through trade agents and total imports to compute the share of imports occurring through wholesaling companies for each product (WS_{j}^{y}). Then, using the concordance table between I/O and HS classification, we measured the 2-digit I/O level average value of the indirect import share required to compute the 2-digit I/O *input-specific* indirect import share. Finally, we again used the concordance table to measure the wholesaling share of imported inputs at the 2-digit HS level.

Thus, WS_{jt}^{m} proxies the presence of wholesalers in importing intermediate inputs (subject to tariffs) for each sector, which is on average around 29.3% within the manufacturing sector.

Figure 4 shows that input trade intermediation is heterogeneous across 18 aggregate sectors.[8] It appears, on average, relatively lower for the macro-sectors of *Food, beverages & tobacco,* and *Minerals*; and relatively higher for the macro-sectors of *Vehicles,* and *Arms & ammunition*. Thus, we expect that, subsequent to input tariff reductions, the former sectors are more likely to be associated with a decrease in aggregate export prices through the reallocation mechanism, and an increase in export prices within the varieties; whereas the reverse is true for the latter sectors.

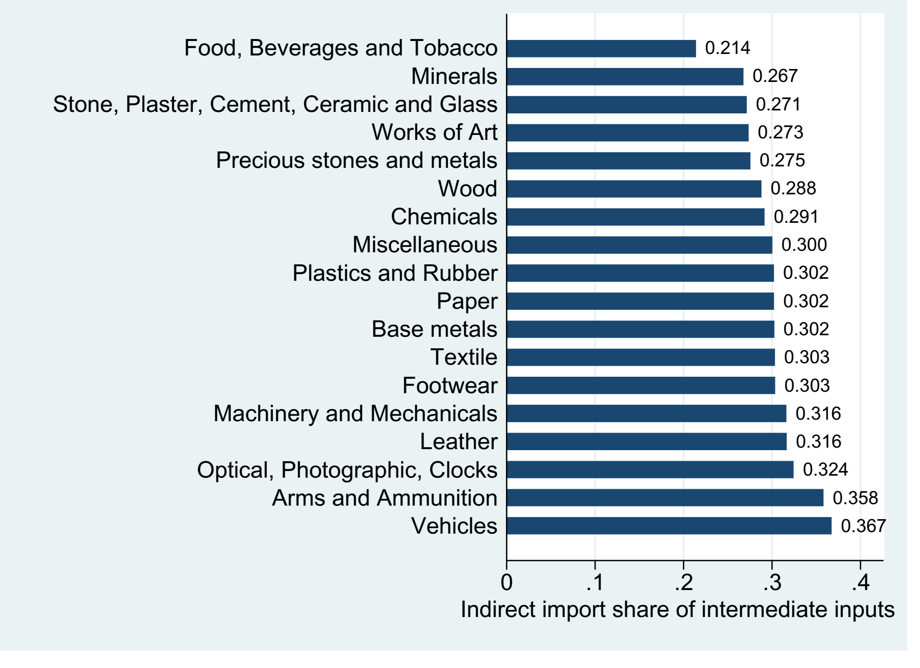

FIGURE 4 Indirect import share of intermediate inputs across sectors in 2000 [Colour figure can be viewed at wileyonlinelibrary.com]

4 | EXPORT ADJUSTMENTS TO INPUT TRADE LIBERALIZATION

In this section, we empirically analyze how export revenues and prices react to input trade liberalization, distinguishing between sectors according to their propensity to import foreign inputs through wholesalers. In Section 2, we highlight that in sectors where wholesalers play an insignificant role in importing intermediate inputs, only a few incumbent export varieties, the most efficient, are able to use foreign intermediate inputs due to the high fixed costs of importing, and can therefore benefit from input tariff reductions. The majority of export varieties are instead expected to suffer efficiency losses, implying the exit of the least efficient varieties from the foreign market and, therefore, reallocation of foreign market shares from low- to high-efficiency export varieties. Conversely, in sectors where wholesalers play an important role in importing intermediate inputs, we expect the majority of domestic varieties, including all incumbent export varieties, to enjoy efficiency gains from input tariff reductions, and that new varieties—associated with lower efficiency—will enter the export market, entailing reallocation of foreign sales from high- to low-efficiency export varieties.

We first carry out an analysis at the sector level, in order to disentangle how the different components of aggregate export outcomes (revenues or prices) are affected by input tariff cuts, and then we move to a product level analysis to account for variety heterogeneity.

4.1 | Sector-level analysis

First, it is worth noting that a single Chinese 6-digit product can be exported to several different foreign countries. Thus, the product-level export performance, in terms of both sales and price, may be different across foreign destinations, because of country heterogeneity (i.e. country-specific demand shocks). For this reason, we collapsed the data at the 4-digit sector/destination level, rather than at the 4-digit sector level.

4.1.1 | Exports revenues

To explore the relationship between export revenues and input tariffs at the sector/destination *(jd)* level, we consider the following specification:

$$R_{jdt} = \beta_1 \tau^m_{jt-1} + \beta_2 \left(\tau^m_{jt-1} * WS^m_j \right) + \beta_3 X_{j(d)t-1} + \phi_{jd} + \phi_t + \varepsilon_{jdt}$$

where R_{jdt} is the aggregate export revenues (in log) of sector/destination pair jd at time t; τ^m_{jt} is the industry-level input tariff at time t; and WS^m_j measures the initial indirect import share of intermediate inputs at the industry level.[9] $X_{j(d)t}$ includes additional time-varying controls at the industry(/destination) level, which are extremely relevant to our analysis, i.e. output tariffs and the Herfindahl index of (export) turnover, which capture the import competition effect and the Chinese competition effect, respectively.[10] ϕ_{jd} and ϕ_t respectively denote sector/destination fixed effects and year dummies to control for time-invariant characteristics at both sector and destination level, as well as macroeconomic shocks common to all industry/destination pairs; and ε_{jdt} is the error term. Notice that this equation is very similar to the product-level specification derived in Section 2 (Equation 3).

The main difference is that the product(/destination)-level variables are collapsed to the sector(/destination) level, all explanatory variables are lagged by one period, in order to further reduce potential concerns of reverse causality, and additional control variables are included to make sure that input tariff effects are not confounded with other factors.

To be coherent with subsequent price analysis, we take the first difference of the former equation, which automatically eliminates any time-invariant heterogeneity at the sector/destination level:

$$\Delta R_{jdt} = \beta_1 \Delta \tau^m_{jt-1} + \beta_2 \Delta \left(\tau^m_{jt-1} * WS^m_j \right) + \beta_3 \Delta X_{j(d)t-1} + \phi_t + \varepsilon_{jdt} \tag{4}$$

From our discussion above, we expect $\beta_1 > 0$, and $\beta_2 < 0$. Table 3, where standard errors have been corrected for clustering at the sector/year pair level, shows the results. In line with our expectations, column 1 shows that a reduction in input tariffs implies a decrease in aggregate export revenues in mostly direct-importing sectors, since the majority of varieties are unable to use foreign intermediate inputs. Conversely, in mostly indirect-importing sectors, export sales increase following input tariff cuts, because the majority of varieties are able to use foreign inputs, thanks to wholesalers. More specifically, subsequent to a one-percentage-point fall in input tariffs, in the extreme case that imports occur only through a direct channel, aggregate exports decline by about 17%, but they increase by 36.6% in the extreme case that all imports occur indirectly through wholesalers. We also find that export sales are positively correlated with tougher import competition and negatively correlated with tougher Chinese competition, which suggests that Chinese varieties mainly learn new technologies that are embodied in additional foreign varieties, and suffer market share losses from additional domestic varieties. These results are robust when they include destination/year pair fixed effects in column 2, to control for time-varying destination characteristics, such as foreign countries' demand shocks.

Moreover, we split our dependent variable in two components to see whether the change in export revenues is due to the entry-exit of varieties (extensive margin) and/or changes within the surviving varieties (intensive margin). Columns 3 and 4 show that input tariff cuts affect both margins. In mostly direct-importing sectors, exports fall drastically because of the (net) exit of varieties from the international market, and a decrease in the foreign sales of surviving varieties. These effects tend to shrink in sectors with a larger presence of input importing wholesalers. Indeed, in mostly indirect-importing sectors, we find that input tariff cuts enable new varieties to enter the export market, as well as leading to an increase in the export revenues of incumbent varieties. Finally, while both export margins increase following output tariff liberalization, higher Chinese competition is associated with the (net) exit of varieties and the increasing sales of surviving varieties.

We reach similar conclusions when measuring the extensive and intensive margins of exports as, respectively, the number of exported varieties (in log) and the average export revenues per variety (in log). The results are reported in Table 4. The results from our baseline specification in columns 1 and 2 confirm that a reduction in input tariffs leads to an increase in both margins within indirect-importing sectors, and to a decrease within the direct-importing sectors. Therefore, subsequent to input tariff cuts, new varieties are more likely to enter export markets, and incumbent varieties to increase their foreign sales, when they rely mainly on wholesaling services to import intermediate inputs; whereas, when such wholesaling services are limited, incumbent varieties decrease their foreign sales, implying the exit of some varieties from the export markets. When including the destination/year pair fixed effects in columns 3 and 4, the

TABLE 3 Sector/destination level linkage between exports and input tariffs: Role of input trade intermediation

Dependent variable: Change in export revenues	**Aggregate**		**Due to the extensive margin (net entry of varieties)**	**Due to the intensive margin (surviving varieties)**
	ΔR^{AGG}_{jdt}	ΔR^{AGG}_{jdt}	ΔR^{NE}_{jdt}	ΔR^{S}_{jdt}
	(1)	**(2)**	**(3)**	**(4)**
$\Delta\tau^{m}_{jt-1}$	17.13***	16.43***	48.85***	14.33***
	(5.140)	(5.166)	(15.76)	(4.497)
$\Delta(\tau^{m}_{jt-1} * WS^{m}_{j})$	−36.63***	−34.29***	−96.67**	−28.95**
	(12.95)	(13.03)	(40.89)	(11.36)
$\Delta\tau^{y}_{jt-1}$	−1.067***	−1.132***	−2.331***	−1.098***
	(0.287)	(0.284)	(0.690)	(0.267)
$\Delta HERF_{jdt-1}$	0.109***	0.103***	1.182***	−0.318***
	(0.0134)	(0.0125)	(0.0331)	(0.0106)
Year FE	YES	NO	NO	NO
Destination/year pair FE	NO	YES	YES	YES
Observations	379,954	379,940	133,218	370,965
R-squared	0.002	0.041	0.081	0.037

Note: τ^{m}_{jt-1} is the input tariff; and WS^{m}_{j} is the initial indirect import share of intermediate inputs, τ^{y}_{jt-1} is the output tariff, and $HERF_{jdt-1}$ is the Herfindahl index of (export) turnover. *j, d,* and *t* respectively denote sector, destination, and time. Standard errors (in parentheses) are corrected for clustering at 2-digit sector/year pair level. Significance at ***$p < .01$, **$p < .05$, *$p < .1$.

TABLE 4 Sector/destination level linkage between export margins and input tariffs: Role of input trade intermediation

Dependent variable: Change in export outcome	Extensive margin (number of varieties) ΔN_{jdt} (1)	Intensive margin (average revenues per variety) $\Delta \bar{r}_{jdt}$ (2)	Extensive margin (number of varieties) ΔN_{jdt} (3)	Intensive margin (average revenues per variety) $\Delta \bar{r}_{jdt}$ (4)
$\Delta \tau^{m}_{jt-1}$	2.635**	14.50***	1.503	14.92***
	(1.296)	(4.436)	(1.290)	(4.529)
$\Delta(\tau^{m}_{jt-1} * WS^{m}_{j})$	−7.169**	−29.46***	−3.253	−31.03***
	(3.395)	(11.11)	(3.349)	(11.38)
$\Delta \tau^{y}_{jt-1}$	−0.236***	−0.831***	−0.147*	−0.985***
	(0.0770)	(0.250)	(0.0781)	(0.253)
$\Delta HERF_{jdt-1}$	0.461***	−0.352***	0.462***	−0.360***
	(0.00595)	(0.0104)	(0.00553)	(0.0101)
Year FE	YES	YES		
Destination/year pair FE			YES	YES
Observations	379,954	379,954	379,940	379,940
R-squared	0.064	0.006	0.112	0.033

Note: τ^{m}_{jt-1} is the input tariff; and WS^{m}_{j} is the initial indirect import share of intermediate inputs, τ^{y}_{jt-1} is the output tariff, and $HERF_{jdt-1}$ is the Herfindahl index of (export) turnover. *j, d,* and *t* respectively denote sector, destination, and time. Standard errors (in parentheses) are corrected for clustering at 2-digit sector/year pair level. Significance at ***$p < .01$, **$p < .05$, *$p < .1$.

results remain similar, although those related to the extensive margin appear to be statistically not significant.

4.1.2 | Export prices

Following Khandelwal et al. (2013), for each 4-digit sector/destination pair (jd) and year (t), we first compute the aggregate export price P_{jdt}^{AGG}, as the weighted average price across all varieties' export prices (in log) p_{ijdt}, using their market shares s_{ijdt} as weights[11]:

$$P_{jdt}^{AGG} = \sum_{i\in\Omega_{jdt}} s_{ijdt} * p_{ijdt} = \overline{P}_{jdt} + \sum_{i\in\Omega_{jdt}} \left(s_{ijdt} - \overline{s}_{jdt}\right)\left(p_{ijdt} - \overline{P}_{jdt}\right) = \overline{P}_{jdt} + \text{cov}_{jdt}$$

where $\overline{P}_{jdt}$ and $\overline{s}_{jdt}$ represent the unweighted average price and the unweighted mean market share within each 4-digit sector/destination pair (jd) in a given year (t), respectively. Therefore, in each year, the aggregate price can be written as the sum of the unweighted average price and the covariance between product price and market share.

Next, we calculate the change in aggregate price between two years $\Delta P_{jdt}^{AGG} = \left(P_{jdt}^{AGG} - P_{jdt-1}^{AGG}\right)$, which can be further split into four components, using the approach for dynamic Olley-Pakes productivity decomposition proposed by Melitz and Polanec (2015). In particular, we can highlight the contribution given by the entry of new varieties (E), the exit of old varieties (X), as well as both within-change and between-change of incumbent varieties (S):

$$\Delta P_{jdt}^{AGG} = \Delta\overline{P}_{jdt}^{S} + \Delta cov_{jdt}^{S} + s_{jdt}^{E}\left(P_{jdt}^{E} - P_{jdt}^{S}\right) + s_{jdt-1}^{X}\left(P_{jdt-1}^{S} - P_{jdt-1}^{X}\right)$$

where $s_{jdt}^{G} = \sum_{i\in G_{jdt}} s_{ijdt}$ and $P_{jdt}^{G} = \sum_{i\in G_{jdt}} \left(\frac{s_{ijdt}}{s_{jdt}^{G}}\right) * p_{ijdt}$ represent the aggregate market share and the aggregate price of each group of varieties ($G = E, X, S$). The first two components capture the changes in aggregate price of incumbents, due to within-variety price changes ($\Delta\overline{P}_{jdt}^{S}$) and market share reallocation across varieties ($\Delta\text{cov}_{jdt}^{S}$), whereas the third and fourth components capture the changes due to the entering and exiting varieties, respectively.

In order to analyze the effect of input trade liberalization on aggregate price at the 4-digit industry/destination level, we consider the following baseline specification:

$$\Delta R_{jdt} = \beta_1 \Delta\tau_{jt-1}^{m} + \beta_2 \Delta\left(\tau_{jt-1}^{m} * WS_j^m\right) + \beta_3 \Delta X_{j(d)t-1} + \phi_t + \varepsilon_{jdt} \tag{5}$$

where P_{jdt} is the estimated aggregate price of sector/destination pair jd at time t (P_{jdt}^{AGG}), or alternatively the component of each aggregate price; the explanatory variables are the same as in the former specification (Equation 4).[12]

From our discussions above, we expect $\beta_1 < 0, \beta_2 > 0$, for intra-variety component and $\beta_1 > 0, \beta_2 < 0$, for inter-variety component of the aggregate prices of surviving varieties since, on average, varieties tend to increase their export prices following input tariff cuts when WS_j^m is relatively low, in association with market share reallocation towards low-price varieties. These effects tend to be smaller when WS_j^m is relatively high, as the majority of surviving varieties tend to enjoy efficiency gains.

The effects on both the entry and exit components of aggregate export prices are not straightforward. For example, the input tariff effect on the exit-component in direct-importing sectors is ambiguous. Indeed, from Figure 1, we observe that input tariff cuts lead to the least productive exported varieties firstly suffering efficiency losses—which positively contribute to the change in the exit-component ($\beta_1 < 0$)—and then exiting the foreign market—which negatively contributes to the change in the exit-component, due to their lower exogenous productivity compared to the surviving exporters ($\beta_1 > 0$). These two countervailing effects within a change in the exit-component tend to decrease in magnitude when moving toward indirect-importing sectors (i.e.β_2 has opposite sign compared to β_1). We reach the opposite conclusion when focusing on the entry-component of aggregate export price, since the entry discussion can be seen as a mirror of the exit discussion.[13]

It is worth emphasizing that inclusion of the 4-digit industry/destination level Herfindahl index of (export) turnover also allows us to control for changes in markups: changes in aggregate export prices arising from tariff reductions could be due to heterogeneous changes in markups within varieties, rather than to changes in marginal costs, also implying market share reallocation (Melitz & Ottaviano, 2008). Finally, we included 4-digit industry level output tariffs to control for changes in aggregate export prices arising from tougher import competition: more efficient varieties may be induced to upgrade their technology through innovation, implying a reduction in their prices, and therefore, business reallocation across varieties within the industry (Bustos, 2011). Indeed, using data from Chinese firms, Brandt et al. (2017) document that, on average, mark-ups decreased following output tariff reductions and increased following input tariff cuts, while productivity improved thanks to both sides of tariff liberalization.

Table 5 displays the results concerning specification (5), where standard errors have been clustered at the sector/year pair level.

From panel (a), it appears that in sectors where input trade wholesaling is close to zero, the aggregate export price dramatically increases following input tariff reductions (column 1), mainly due to changes concerning incumbent varieties (column 5), rather than the entry-exit dynamics of varieties (column 2). More specifically, these effects are associated, on average, with an increase in the within-variety component (column 6) and a decrease in the between-variety component (column 7), which suggests that efficiency losses within the variety, and efficiency gains from market share reallocation, occur thanks to input tariff liberalization. The magnitude of these effects tends to decrease when moving from low to high input-wholesaling based sectors. Indeed, in the extreme case where $WS_j^m = 1$, the aggregate export price would decrease following input tariff cuts, because of efficiency gains within the incumbent variety (mostly) and losses from market share reallocation across incumbent varieties.

More specifically, in the extreme case that imports only occur through a direct (indirect) channel, a one-percentage-point reduction in input tariffs leads to a 12% increase (29.5% decrease) in the export aggregate price. This change is due to efficiency losses (gains) within the incumbent variety by 12.8% (31.9%) and efficiency gains (losses) from reallocation across incumbent varieties by 1.2% (3.3%). These coefficients are apparently higher compared to those of firm-level studies, probably because we are using more aggregate data. Indeed, when using ordinary trade transaction data from China, Fan et al. (2015) found that a one-percentage point fall in the firm-specific input tariff implies an increase in the export unit value at the firm/product/destination level by 0.48%. This effect increased to 0.64% when considering the export price index at the firm

TABLE 5 Sector/destination level linkage between export prices and input tariffs: Role of input trade intermediation

Dependent variable: Change in (quality-adjusted) export price	Aggregate	Due to the extensive margin (net entry of varieties)			Due to the intensive margin (surviving varieties)		
	Total	Total	Entry of varieties	Exit of varieties	Total	Within variety change	Market share reallocation
	ΔP^{AGG}_{jdt}	ΔP^{NE}_{jdt}	ΔP^{E}_{jdt}	ΔP^{X}_{jdt}	ΔP^{S}_{jdt}	ΔP^{WITHIN}_{jdt}	ΔP^{REAL}_{jdt}
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Panel (a)							
$\Delta\tau^{m}_{jt-1}$	−11.95**	−0.304	−1.561*	1.257	−11.65**	−12.84**	1.195*
	(5.862)	(0.622)	(0.893)	(0.980)	(5.252)	(5.275)	(0.645)
$\Delta(\tau^{m}_{jt-1} * WS^{m}_{j})$	29.46*	0.737	4.515*	−3.778	28.58**	31.91**	−3.325*
	(15.30)	(1.638)	(2.388)	(2.626)	(13.74)	(13.79)	(1.827)
$\Delta\tau^{y}_{jt-1}$	1.121**	0.00962	0.125	−0.115	1.107**	1.166**	−0.0593
	(0.508)	(0.0543)	(0.0937)	(0.109)	(0.504)	(0.520)	(0.0657)
$\Delta HERF_{jdt-1}$	0.212***	−0.0432***	−0.0197***	−0.0234***	0.266***	0.0131	0.253***
	(0.0204)	(0.00580)	(0.00374)	(0.00389)	(0.0225)	(0.0159)	(0.0133)
Year FE	YES	YES	YES	YES	YES	YES	YES
Observations	376,344	367,784	367,784	367,784	367,307	367,307	367,307
R-squared	0.008	0.001	0.000	0.001	0.009	0.008	0.017
Panel (b)							
$\Delta\tau^{m}_{jt-1}$	−9.337	−0.208	−1.174	0.966	−8.960*	−10.17**	1.207*
	(5.677)	(0.623)	(0.871)	(0.962)	(5.082)	(5.111)	(0.651)
$\Delta(\tau^{m}_{jt-1} * WS^{m}_{j})$	20.19	0.468	3.212	−2.744	19.21	22.62*	−3.412*
	(14.76)	(1.645)	(2.317)	(2.556)	(13.21)	(13.27)	(1.857)
$\Delta\tau^{y}_{jt-1}$	0.776	0.00351	0.0865	−0.0830	0.747	0.812	−0.0657
	(0.499)	(0.0549)	(0.0929)	(0.109)	(0.494)	(0.512)	(0.0666)

TABLE 5 (Continued)

Dependent variable: Change in (quality-adjusted) export price	Aggregate	Due to the extensive margin (net entry of varieties)			Due to the intensive margin (surviving varieties)		
	Total	Total	Entry of varieties	Exit of varieties	Total	Within variety change	Market share reallocation
	ΔP^{AGG}_{jdt}	ΔP^{NE}_{jdt}	ΔP^{E}_{jdt}	ΔP^{X}_{jdt}	ΔP^{S}_{jdt}	ΔP^{WITHIN}_{jdt}	ΔP^{REAL}_{jdt}
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
$\Delta HERF_{jdt-1}$	0.168***	−0.0426***	−0.0210***	−0.0216***	0.218***	−0.0375***	0.256***
	(0.0176)	(0.00586)	(0.00374)	(0.00393)	(0.0193)	(0.0130)	(0.0133)
Destination/year pair FE	YES	YES	YES	YES	YES	YES	YES
Observations	376,329	367,769	367,769	367,769	367,292	367,292	367,292
R-squared	0.284	0.005	0.006	0.007	0.296	0.309	0.020

Note: τ^{m}_{jt-1} is the input tariff; and WS^{m}_{j} is the initial indirect import share of intermediate inputs, τ^{y}_{jt-1} is the output tariff, and $HERF_{jdt-1}$ is the Herfindahl index of (export) turnover. j, d, and t respectively denote sector, destination, and time. Standard errors (in parentheses) are corrected for clustering at 2-digit sector/year pair level. Significance at ***$p < .01$, **$p < .05$, *$p < .1$.

level, and to 1.7% when considering the input tariff at the industry level. It also worth noting that when considering the input tariff alone in our specification (column 1 in Table 5), i.e. without the interaction term, the magnitude of the coefficient is more similar in magnitude (−1.5%), although it is not statistically significant.[14]

Notice that although the aggregate export price change is apparently not affected by the net entry of varieties, when decomposing it between the entry and exit components, we find some evidence that input tariff liberalization allows less expensive varieties to enter indirect-importing sectors by comparison with direct-importing sectors. These results confirm that export starters within indirect-importing sectors enjoyed significant efficiency gains, since they were very likely to use foreign inputs through wholesalers, whereas export starters within direct-importing sectors suffered efficiency losses from input tariff reduction, as they were unlikely to use foreign inputs.

While tougher import competition linked to output tariff cuts seems to enable incumbent varieties to become more efficient (Bustos, 2011) without any relevant reallocation effect, tougher Chinese competition within industry leads to a decrease in the industry aggregate export price, mainly due to market share reallocation toward the most efficient incumbent products. It is worth noting that the latter effect is partially offset by the change in the net-entry component, i.e. it would appear that increasing Chinese competition is associated with the entry of more expensive varieties in the international market, and the exit of the cheapest ones.

Finally, in panel (b), we also control for time-varying country characteristics, through the inclusion of fixed effects at the destination/year pair level. While the input tariff effects on surviving varieties' components are strongly confirmed, those related to the entry-exit varieties appear less robust.

4.2 | Product-level analysis

Sector-level analysis has highlighted that the input tariff effects on export revenues occur through both the extensive and the intensive margin, whereas the input tariff effects on aggregate export prices mainly concern incumbent varieties. However, these results do not account for variety heterogeneity. This sub-section further explores the input tariff impact on export status, export revenues and prices at the 6-digit product/destination-level data. In particular, starting from the product-level specification derived in Section 2, we firstly include the destination (d) dimension and the industry-level control variables, and then lag all explanatory variables by one period for the same reasons explained in Section 4.1. Therefore, Equation (3) becomes

$$y_{idt} = \beta_1 \tau^m_{jt-1} + \beta_2 \left(\tau^m_{jt-1} * WS^m_j \right) + \beta_3 X_{j(d)t-1} + \phi_{id} + \phi_t + \varepsilon_{idt}$$

where the dependent variable y_{idt} is alternatively the export dummy EXP_{idt} – which takes value one if the variety is exported and zero otherwise—the (log) export revenue r_{idt}, or the (log) price p_{idt} of the 6-digit level product/destination pair id at time t, while the explanatory variables are the same as previously.[15]

Then, coherently with the sector-level analysis, we estimate the first-difference version of the former equation, which automatically eliminates any time-invariant heterogeneity at the product/destination level:

$$\Delta y_{idt} = \beta_1 \Delta \tau^m_{jt-1} + \beta_2 \Delta \left(\tau^m_{jt-1} * WS^m_j \right) + \beta_3 \Delta X_{j(d)t-1} + \phi_t + \epsilon_{idt} \quad (6)$$

From the discussion in Section 2, we expect $\beta_1 > 0$, $\beta_2 < 0$ when the dependent variable is either export status or export revenue, and $\beta_1 < 0$, $\beta_2 > 0$ when it is export price. Again, the standard errors are corrected for clustering at sector/year pair level.

Table 6 shows the results concerning export sales, which appear to be coherent with the findings above: varieties decrease their export sales following input tariff reductions within the low-WS^m industries, and increase their export revenues within the high-WS^m sectors (column 3). Since these results can still be driven by the entry/exit of varieties throughout the entire period, column 5 displays the results based on the balanced panel, which strongly confirm the previous findings.

Moreover, when exploring the input tariff effect on the extensive margin of exports, we also account for time-invariant variety characteristics, i.e. the probability that a variety is exported, through using a change in export status as dependent variable (column 1). In line with our expectations, we find that input tariff reduction leads to a decrease in the probability of exporting in low-WS^m sectors, where the majority of firms are unable to use foreign inputs. These negative effects shrink as WS^m tends to increase, becoming positive when WS^m is sufficiently high. This confirms the probability of exporting increases following input tariff liberalization in sectors where the majority of firms are able to access foreign inputs thanks to wholesalers. All results are robust to the inclusion of destination/year pair fixed effects (columns 2, 4, 6).

Table 7 contains the results relating to export prices, which strongly corroborate the findings on within-variety effects documented in the sector-level analysis, with an even larger magnitude (column 1). The results are also robust when including destination/year pair fixed effects (column 2) and/or focusing on the balanced panel (columns 3 and 4). Thus, on average, input tariff liberalization entails efficiency gains for varieties within the indirect-importing sectors, and efficiency losses for varieties within the direct-importing sectors.

Moreover, we find evidence that while tougher foreign competition enables Chinese varieties to increase sales by decreasing prices, due to potential learning/innovation effects; it seems that tougher Chinese competition has the opposite effect on Chinese varieties, i.e. they tend toward a higher average cost, following a decrease in market shares.

Finally, we explore whether there is any heterogeneity by considering the initial level of the export price. We expect that these effects would be greater for high-price than low-price varieties, since the former are more likely to access foreign intermediate inputs exclusively through wholesalers or not at all, whereas the latter are in any case very likely to import foreign inputs directly. Results based on the balanced panel in Table 8 strongly confirm this hypothesis, in terms of both export revenues and prices. In other words, if there are no wholesalers, high-price varieties lose relatively more from input tariff liberalization, in terms of both efficiency and market share, whereas in sectors mostly based on indirect imports, high-price varieties gain relatively more.

To summarize, subsequent to input tariff liberalization in sectors with a small share of input trade intermediation, there is a decrease in aggregate efficiency through a reduction in variety-level efficiency, and an increase through a reallocation of market shares toward the most efficient

TABLE 6 Product/destination level linkage between exports and input tariffs: Role of input trade intermediation

Dependent variable: Change in export outcome	Export dummy		Export revenues: Unbalanced panel		Export revenues: Balanced panel	
	ΔEXP_{idt}	ΔEXP_{idt}	Δr_{idt}	Δr_{idt}	Δr_{idt}	Δr_{idt}
	(1)	(2)	(3)	(4)	(5)	(6)
$\Delta\tau^{m}_{jt-1}$	2.503**	2.337**	19.96***	19.15***	14.60***	13.52***
	(1.144)	(1.121)	(5.646)	(5.563)	(4.648)	(4.584)
$\Delta(\tau^{m}_{jt-1} * WS^{m}_{j})$	−7.009**	−6.421**	−41.60***	−39.35***	−31.47***	−28.47**
	(2.906)	(2.840)	(14.19)	(13.95)	(11.69)	(11.51)
$\Delta\tau^{y}_{jt-1}$	−0.114***	−0.122***	−0.836***	−0.932***	−0.705***	−0.773***
	(0.0432)	(0.0430)	(0.239)	(0.236)	(0.235)	(0.229)
$\Delta HERF_{jdt-1}$	0.185***	0.186***	0.112***	0.120***	0.0969***	0.109***
	(0.00365)	(0.00323)	(0.0102)	(0.00988)	(0.0109)	(0.0107)
Year FE	YES	NO	YES	NO	YES	NO
Destination/year pair FE	NO	YES	NO	YES	NO	YES
Observations	1,748,435	1,748,424	1,144,327	1,144,313	736,335	736,325
R-squared	0.007	0.028	0.002	0.022	0.002	0.030

Note: τ^{m}_{jt-1} is the input tariff; and WS^{m}_{j} is the initial indirect import share of intermediate inputs, τ^{y}_{jt-1} is the output tariff, and $HERF_{jdt-1}$ is the Herfindahl index of (export) turnover. *i, j, d,* and *t* respectively denote product, sector, destination, and time. Standard errors (in parentheses) are corrected for clustering at 2-digit sector/year pair level. Significance at ***$p < .01$, **$p < .05$, *$p < .1$.

TABLE 7 Product/destination level linkage between export prices and input tariffs: Role of input trade intermediation

Dependent variable: Change in (quality-adjusted) export price	**Unbalanced panel**		**Balanced panel**	
	Δp_{idt}	Δp_{idt}	Δp_{idt}	Δp_{idt}
	(1)	**(2)**	**(3)**	**(4)**
$\Delta\tau^{m}_{jt-1}$	−19.64***	−16.55**	−12.93***	−10.01**
	(6.769)	(6.615)	(4.425)	(4.087)
$\Delta(\tau^{m}_{jt-1} * WS^{m}_{j})$	48.19***	38.24**	31.43***	23.31**
	(17.88)	(17.35)	(11.91)	(10.92)
$\Delta\tau^{y}_{jt-1}$	1.114***	0.816*	0.710**	0.469*
	(0.424)	(0.415)	(0.276)	(0.268)
$\Delta HERF_{jdt-1}$	0.00571	−0.0514***	−0.0317*	−0.0509***
	(0.0169)	(0.0138)	(0.0163)	(0.0122)
Year FE	YES	NO	YES	NO
Destination/Year pair FE	NO	YES	NO	YES
Observations	1,130,017	1,130,002	718,105	718,095
R-squared	0.007	0.254	0.009	0.280

Note: τ^{m}_{jt-1} is the input tariff; and WS^{m}_{j} is the initial indirect import share of intermediate inputs, τ^{y}_{jt-1} is the output tariff, and $HERF_{jdt-1}$ is the Herfindahl index of (export) turnover. *i, j, d,* and *t* respectively denote product, sector, destination, and time. Standard errors (in parentheses) are corrected for clustering at 2-digit sector/year pair level. Significance at ***$p < .01$, **$p < .05$, *$p < .1$.

varieties. We find opposite results in the sectors associated with a sufficiently high share of input trade intermediation.

5 | ROBUSTNESS CHECKS AND FURTHER INVESTIGATION

In this section, we provide robustness checks and further investigation at the product/destination level by considering the most complete specification, i.e. including the destination/year pair fixed effects, rather than year fixed effect alone, in addition to the industry(/destination) level control variables. All related tables are reported in the Appendix.

5.1 | Alternative econometric approaches

To eliminate the time-invariant characteristics at the product/destination level, we can estimate a first-difference equation without product/destination fixed effects or an equation in levels with product/destination fixed effects. The main reason why we preferred to use the former specification is that the decomposition of sector aggregate prices, based on Melitz and Polanec (2015), refers to changes, rather than to levels. Therefore, in the sector-level analysis, it is more convenient to relate the changes in aggregate prices (and the related components) to the changes in input tariffs. For the sake of coherence, we then used the same specification for the product-level analysis. However, since our preferred approach may imply a greater loss of observations, we have

TABLE 8 Product/destination level linkage between export sales, input tariffs, input trade intermediation: High versus low initial prices (balanced panel)

Dependent variable: Change in export outcome	Export revenues			(Quality-adjusted) export prices		
	Initially low price varieties	Initially medium price varieties	Initially high price varieties	Initially low price varieties	Initially medium price varieties	Initially high price varieties
	Δr^L_{idt}	Δr^M_{idt}	Δr^H_{idt}	Δp^L_{idt}	Δp^M_{idt}	Δp^H_{idt}
	(2)	(3)	(4)	(6)	(7)	(8)
$\Delta\tau^m_{jt-1}$	13.83**	12.51***	21.62***	−12.36**	−8.541**	−23.71**
	(6.797)	(4.303)	(8.288)	(6.019)	(3.763)	(9.617)
$\Delta(\tau^m_{jt-1} * WS^m_j)$	−22.85	−26.57**	−50.28**	27.69*	20.01**	57.84**
	(17.24)	(10.80)	(22.36)	(15.98)	(10.10)	(26.18)
$\Delta\tau^y_{jt-1}$	−0.516*	−0.813***	−0.867*	0.459	0.399	1.056**
	(0.312)	(0.209)	(0.484)	(0.335)	(0.253)	(0.521)
$\Delta HERF_{jdt-1}$	0.140***	0.0868***	0.379***	−0.0645*	−0.0409***	−0.179***
	(0.0430)	(0.0111)	(0.0502)	(0.0335)	(0.0123)	(0.0411)
Destination/Year pair FE	YES	YES	YES	YES	YES	YES
Observations	80,852	556,317	80,856	80,852	556,317	80,856
R-squared	0.053	0.031	0.037	0.314	0.284	0.236

Note: τ^m_{jt-1} is the input tariff; and WS^m_j is the initial indirect import share of intermediate inputs, τ^y_{jt-1} is the output tariff, and $HERF_{jdt-1}$ is the Herfindahl index of (export) turnover. *i, j, d,* and *t* respectively denote product, sector, destination, and time. Standard errors (in parentheses) are corrected for clustering at 2-digit sector/year pair level. Significance at $^{***}p < .01$, $^{**}p < .05$, $^{*}p < .1$.

now also estimated the equation in levels. The results are reported in Table A1 and show that all the coefficients have identical signs with regard to our preferred specification, and the statistical significance is strongly confirmed, except for the effects on the extensive margin, which turn out to be not statistically significant.

Since the main explanatory variable (input tariff) varies only with 2-digit sector and year, but the outcome variables (export revenues and prices) also vary across 6-digit products and destinations, we cluster standard errors to allow for correlation between error terms within the same sector and year. A similar approach has been adopted by recent studies analyzing sector-level trade or FDI integration on microeconomic export performance (Bajgar & Javorcik, 2020; Chevassus-Lozza et al., 2013). In Table A2, we report the results based on our preferred equation, using alternatively clustered standard errors at the sector level (*panel a*) and robust standard errors (*panel b*). In the latter case, the statistical significance is higher across all specifications, whereas in the former case, it becomes weaker because the results related to export participation and export prices appear to be statistically not significant.

5.2 | Differentiated versus homogeneous goods

When splitting the sample in Table A3 between differentiated goods (*panel a*) and homogenous goods (*panel b*), according to Rauch (1999)'s classification, we find that the results related to export probability, export revenues and export prices are strongly confirmed for differentiated goods, coherently with our theoretical framework. As regards homogeneous goods, only the results related to export revenues are strongly confirmed, since export probability is found to be positively affected by input tariff cuts only within direct-importing sectors, and export prices are not influenced at all. These heterogeneous input tariff effects on export prices are in line with those found by the previous studies (Bas & Strauss-Kahn, 2015; Fan et al., 2015), which also document statistically significant effects on the subsample of differentiated goods and ambiguous effects on the subsample of homogeneous goods.

5.3 | Effects on quality

In the current study, we focus on the efficiency channel. However, previous studies found input trade liberalization had positive effects on the quality of export products in China (Bas & Strauss-Kahn, 2015; Fan et al., 2015). Observing the impact of input tariff cuts on export quality mediated by the presence of input wholesaling services in Table A4, we find evidence that input tariff reductions, on average, lead to quality upgrading for varieties within the sectors that rely on wholesaling services when intermediate inputs are imported, and quality downgrading for varieties within the other sectors. Therefore, wholesaling companies help manufacturing firms to access a larger number of input varieties, associated not only with greater efficiency, but also with higher quality, generating positive effects on the quality of exported products.

6 | CONCLUSION

The impact of input trade liberalization on export performance depends upon the presence of wholesalers when importing intermediate inputs. Using variety (product/country pair) level data from China in the period 2000–2006, we document that input tariff reductions lead to a decline in aggregate export revenues in mostly direct-importing sectors, through the exit of varieties from the export market, and a decrease in the foreign sales of surviving varieties. These effects are due to within-variety efficiency losses, associated with market share reallocations from low- to high-efficiency varieties. The results are opposite in sectors that generally rely on wholesalers when importing intermediate inputs: aggregate export revenues increase following input tariff liberalization, through the entry of new varieties in the export market, and an increase in the foreign sales of incumbent varieties, mainly due to within-variety efficiency gains, associated with market share reallocations from high- to low-efficiency varieties.

Therefore, these findings suggest that policy-makers should pay more attention to the role of trade intermediation services when implementing trade liberalization reforms. Indeed, wholesaling companies may help manufacturing domestic firms or varieties to become more competitive in the international markets, not only via export wholesaling services, which allow firms to reach foreign output markets that are more difficult to penetrate (Ahn et al., 2011), but also via import wholesaling services that improve access to foreign input markets.

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ENDNOTES

1 For the sake of simplicity, we assume duty-free trade in final goods, since our focus is on the impact of trade liberalization in intermediate goods.

2 Trade data are reported free on board (FOB) in USD. Thus, we have deflated them by deflators downloaded from the IMF's World Economic Outlook Database.

3 See Gaulier and Zignago (2010) for further details about the database.

4 The number of products for both quality-adjusted price and quality is lower than the number of products for unit values because of missing data on elasticity of substitution in one 3-digit HS96 sector (i.e. 970).

5 Notice that the negative change in average unit value is smaller in magnitude than the change in average quality-adjusted price; this means that exported varieties in China are also associated with quality upgrading.

6 The World Integrated Trade Solution (WITS) is a software developed by the World Bank, in close collaboration with several International Organizations (UNCTAD, ITC, UNSD and WTO).

7 This means that imports under processing trade regime are excluded, since they are duty-free.

8 Each sector in the figure corresponds to an HS section that can include more than one of 81 2-digit sectors.

9 We decide to keep this variable constant over time, to ensure that the related coefficient captures only the change in input tariff over time, without picking up any change in sector propensity to import indirectly through wholesalers.

10 More specifically, we include the 4-digit industry level output tariff τ^{y}_{jt}, computed as simple average of 6-digit tariffs, and the 4-digit industry/destination level Herfindahl index of (export) turnover, constructed as $HERF_{jdt} = \sum_{i=1}^{N} \left[r_{idt}/r_{jdt}\right]^2$, where r denotes export revenues, while i, j, d and t stand for 6-digit product, 4-digit industry, destination and time, respectively. Notice that the latter index ranges between 0 and 1, and the higher

HERF value indicates greater export market concentration, i.e. less Chinese competition (in a given export market). For each control variable, we expect either a positive or negative coefficient, as tougher competition—stemming from a reduction in the output tariff or Herfindahl index—may force Chinese firms/varieties to lose market shares, entailing an increase in their average cost (due to the presence of economies of scale), or to invest in better technologies to face competition, implying higher efficiency and larger sales.

[11] Bear in mind that, from here onwards, price refers to quality-adjusted price, since our focus is on the efficiency component of prices, rather than on the quality component.

[12] See footnote [10] for description and discussion about control variables.

[13] For example, within the indirect-importing sectors, the input tariff effect on the entry-component is ambiguous. From Figure 2, we can see that input tariff reductions enable the most productive non-exported varieties firstly to obtain efficiency gains and then to enter the foreign market. Therefore the entry of new varieties in the export market can contribute positively to the change in the entry-component, due to lower exogenous productivity compared to incumbent exporters ($\beta_2 < 0$), or negatively, since they obtained improvements in efficiency ($\beta_2 > 0$). These two countervailing effects within a change in the entry-component tend to decrease in magnitude when moving toward direct-importing sectors (i.e.β_1 has opposite sign compared to β_2).

[14] This statistical insignificance is not surprising because our export data also include flows under processing trade regime that are duty-free, in addition to flows under ordinary trade regime. Indeed, Brandt and Morrow (2017) document that input tariff effects might be ambiguous when considering both trade regimes together. This problem is alleviated in our specification through including the interaction term with the wholesaling share of imported intermediate inputs, which has been computed using ordinary trade data alone.

[15] The only difference is that the output tariff is expressed at the 6-digit product level, rather than at the 4-digit sector level.

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APPENDIX

TABLE A1 Product/destination level linkage between export outcomes, input tariffs, and input trade intermediation: Alternative specification

Dependent variable: Export outcome	Unbalanced panel			Balanced panel	
	Export dummy	Export revenue	Export price	Export revenue	Export price
	EXP_{idt}	r_{idt}	p_{idt}	r_{idt}	p_{idt}
	(1)	(2)	(3)	(4)	(5)
τ^m_{jt-1}	0.986	31.18***	−25.53**	25.75***	−18.53**
	(1.125)	(5.699)	(10.03)	(5.302)	(7.745)
$\tau^m_{jt-1} * WS^m_j$	−0.408	−68.00***	60.73**	−56.44***	44.13**
	(2.793)	(14.33)	(26.66)	(13.38)	(20.79)
Controls	YES	YES	YES	YES	YES
Destination-Year FE	YES	YES	YES	YES	YES
Observations	2,237,869	1,551,057	1,534,739	883,638	861,762
R-squared	0.549	0.859	0.862	0.876	0.876

Note: τ^m_{jt-1} is the input tariff; and WS^m_j is the initial indirect import share of intermediate inputs. Control variables are the output tariff τ^y_{jt-1}, and the Herfindahl index of (export) turnover $HERF_{jdt-1}$. *i, j, d,* and *t* respectively denote product, sector, destination, and time. Standard errors (in parentheses) are corrected for clustering at 2-digit sector/year pair level. Significance at ***$p < .01$, **$p < .05$, *$p < .1$.

TABLE A2 Product/destination level linkage between export outcomes, input tariffs, and input trade intermediation: Alternative corrections for standard errors

Dependent variable: Change in export outcome	Unbalanced panel			Balanced panel	
	Export dummy	Export revenue	Export price	Export revenue	Export price
	ΔEXP_{idt}	Δr_{idt}	Δp_{idt}	Δr_{idt}	Δp_{idt}
	(1)	(2)	(3)	(4)	(5)
Panel (a): Standard errors are corrected for clustering at 2-digit sector level					
$\Delta\tau^m_{jt-1}$	2.337	19.15**	−16.55	19.15**	−10.01
	(1.573)	(7.866)	(12.17)	(7.866)	(7.051)
$\Delta(\tau^m_{jt-1} * WS^m_j)$	−6.421	−39.35*	38.24	−39.35*	23.31
	(4.192)	(19.87)	(32.50)	(19.87)	(19.09)
Controls	YES	YES	YES	YES	YES
Destination-Year FE	YES	YES	YES	YES	YES
Observations	1,748,424	1,144,313	1,130,002	1,144,313	718,095
R-squared	0.028	0.022	0.254	0.022	0.280
Panel (b): Robust standard errors					
$\Delta\tau^m_{jt-1}$	2.337***	19.15***	−16.55***	13.52***	−10.01***
	(0.271)	(0.970)	(1.047)	(0.997)	(1.038)
$\Delta(\tau^m_{jt-1} * WS^m_j)$	−6.421***	−39.35***	38.24***	−28.47***	23.31***
	(0.712)	(2.588)	(2.783)	(2.639)	(2.751)
Controls	YES	YES	YES	YES	YES
Destination-Year FE	YES	YES	YES	YES	YES
Observations	1,748,424	1,144,313	1,130,002	736,325	718,095
R-squared	0.028	0.022	0.254	0.030	0.280

Note: τ^m_{jt-1} is the input tariff; and WS^m_j is the initial indirect import share of intermediate inputs. Control variables are the output tariff τ^y_{jt-1}, and the Herfindahl index of (export) turnover $HERF_{jdt-1}$. *i, j, d,* and *t* respectively denote product, sector, destination, and time. Standard errors are displayed in parentheses. Significance at $^{***}p < .01$, $^{**}p < .05$, $^{*}p < .1$.

TABLE A3 Product/destination level linkage between export outcomes, input tariffs, and input trade intermediation: Differentiated versus homogeneous goods

	Unbalanced panel			Balanced panel	
	Export dummy	Export revenue	Export price	Export revenue	Export price
	ΔEXP_{idt}	Δr_{idt}	Δp_{idt}	Δr_{idt}	Δp_{idt}
Dependent variable: Change in export outcome	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**
Panel (a): Differentiated goods					
$\Delta\tau^m_{jt-1}$	2.455*	18.30***	−19.87**	11.49**	−10.75**
	(1.335)	(6.547)	(8.749)	(5.263)	(5.202)
$\Delta(\tau^m_{jt-1} * WS^m_j)$	−5.709*	−34.59**	43.84*	−20.86	22.81*
	(3.336)	(16.51)	(22.49)	(13.22)	(13.60)
Controls	YES	YES	YES	YES	YES
Destination-Year FE	YES	YES	YES	YES	YES
Observations	1,369,676	920,026	907,592	603,976	587,956
R-squared	0.031	0.027	0.256	0.036	0.284
Panel (b): Homogeneous goods					
$\Delta\tau^m_{jt-1}$	2.327	21.42***	−2.232	20.94***	−4.679
	(2.078)	(7.284)	(3.681)	(6.281)	(3.715)
$\Delta(\tau^m_{jt-1} * WS^m_j)$	−10.65*	−52.92**	3.201	−57.18***	13.71
	(6.439)	(20.48)	(10.87)	(17.63)	(10.94)
Controls	YES	YES	YES	YES	YES
Destination-Year FE	YES	YES	YES	YES	YES
Observations	378,735	224,259	222,382	132,289	130,079
R-squared	0.023	0.015	0.255	0.020	0.269

Note: τ^m_{jt-1} is the input tariff; and WS^m_j is the initial indirect import share of intermediate inputs. Control variables are the output tariff τ^y_{jt-1}, and the Herfindahl index of (export) turnover $HERF_{jdt-1}$. *i, j, d,* and *t* respectively denote product, sector, destination, and time. Standard errors (in parentheses) are corrected for clustering at 2-digit sector/year pair level. Significance at ***$p < .01$, **$p < .05$, *$p < .1$.

TABLE A4 Product/destination level linkage between export quality, input tariffs, and input trade intermediation

Dependent variable: Change in export quality	Unbalanced panel $\Delta\lambda_{idt}$ (1)	Balanced panel $\Delta\lambda_{idt}$ (2)
$\Delta\tau^m_{jt-1}$	23.71***	18.27***
	(7.496)	(5.055)
$\Delta(\tau^m_{jt-1} * WS^m_j)$	−54.73***	−41.61***
	(19.70)	(13.39)
Controls	YES	YES
Destination-Year FE	YES	YES
Observations	1,130,002	718,095
R-squared	0.052	0.052

Note: τ^m_{jt-1} is the input tariff; and WS^m_j is the initial indirect import share of intermediate inputs. Control variables are the output tariff τ^y_{jt-1}, and the Herfindahl index of (export) turnover $HERF_{jdt-1}$. $i, j, d,$ and t respectively denote product, sector, destination, and time. Standard errors (in parentheses) are corrected for clustering at 2-digit sector/year pair level. Significance at ***$p < .01$, **$p < .05$, *$p < .1$.