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Trade liberalization, input intermediaries and firm productivity: Evidence from China

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ABSTRACT

We investigate theoretically and empirically the role of wholesalers in mediating the productivity effects of trade liberalization. Intermediaries provide indirect access to foreign produced inputs. The productivity effects of input tariff cuts on firms that do not directly import therefore depends on the extent that wholesalers are a feature of input supply within an industry. Using firm level data from China, we document that wholesalers play no such role for direct importers. However, other firms experience productivity gains from reducing input tariffs if trade intermediation of foreign inputs within their sector is high. They suffer efficiency losses otherwise.

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1. Introduction

The international economics literature provides clear evidence that the productivity of firms improves as a direct consequence of trade liberalization.[1] Several explanations have been put forward to explain these productivity increases.[2] Initially these focused on the effect of output tariffs increasing competition within the industry, in a process labelled 'trimming the fat' (Pavcnik, 2002). More recently the focus has been on the role of inputs. Here it is argued that the ability to import intermediate inputs generates productivity gains for firms through learning, variety and quality effects. Amiti and Konings (2007) were the first to investigate this and report using Indonesian data that the productivity gains from input tariff reductions were around twice as large as those from output tariff changes of the same size. Supportive evidence can be found in Kasahara and Rodrigue (2008) for Chile, Halpern et al. (2015) for Hungary, Khandelwal and Topalova (2011) for India, and Bas and Strauss-Kahn (2015) for France.

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[1] Melitz and Redding (2014) argue that productivity effects are an important component of the 'gains from trade'.

[2] Additional effects on aggregate productivity may occur due to the exit of low productivity firms (Pavcnik, 2002; Bernard et al., 2006), or the reallocation of market shares towards more productive survivors (Pavcnik, 2002).

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Of interest to this paper, Amiti and Konings (2007) also report positive productivity effects from cuts to input tariffs for what are normally labelled as non-importing firms, although they are strongest for those that directly importing intermediate inputs. In this paper, we investigate whether this 'domestic firm puzzle'[3] is explained by the presence of input trade intermediaries. More commonly known as wholesalers, such service sector firms provide indirect access to foreign produced inputs. Our empirical evidence shows that when the intermediation of inputs through wholesalers is a strong feature of input supply within an industry, there are productivity gains for firms not directly importing. In their absence, there are productivity declines. The investigation of these productivity outcomes due to the presence of wholesalers represents the main contribution of the paper to the broader literature.

The economic literature has long recognized the role that wholesalers and retailers play in linking producers with their consumers. Intermediaries have been argued to exist in order to reduce search costs by offering their market expertise or guaranteeing the quality of goods (Rubinstein and Wolinsky, 1987; Yavas, 1994; Biglaiser, 1993; Biglaiser and Friedman, 1994). Their importance in cross-border trade has been revealed only in more recent years. According to Jones (1998), trading companies account for over 40% of exports and over 70% of imports in Japan, while Blum et al. (2009) document that 41% of imports occur through intermediaries in Chile. Using detailed information from trade transaction data, Bernard et al. (2010) estimate that wholesale and retail firms account for 10% of exports and 24% of imports in US. In our data for China, wholesalers account on average for 21.4% of total imports of intermediate inputs across manufacturing sectors. Theoretical developments in this trade literature include Ahn et al. (2011), Akerman (2010), Antràs and Costinot (2010, 2011), Blum et al. (2009), Crozet et al. (2013) Rauch (1999, 2001), Felbermayr and Jung (2011), Petropoulou (2008) and Rauch and Watson (2004). A general finding from this literature is that trade intermediaries provide access to international markets for those firms that would otherwise find the costs of exporting directly prohibitive. A corollary to this outcome for exports, would be that for some domestic firms, wholesalers represent a source of foreign produced intermediate inputs they would not otherwise have.

To empirically evaluate the productivity effects of wholesalers for firms not directly importing during a period of input tariff liberalization we construct a novel industry level measure using Chinese custom data, balance sheet data and input–outputs tables. To separate direct-importers from those that do not directly import we use the customs data matched to balance sheet data. To construct our industry-specific measure of inputs imported by wholesalers, we begin by identifying for each sector the fraction of import transactions by wholesalers and trade intermediaries.[4] Using input-output tables we can then proportion the share of these inputs sold on to other sectors of the economy.[5] Using data for the period 2002–2006, which corresponds to the period soon after China's entry to World Trade Organization (on 11th December 2001), we generate a number of findings. We first show we can replicate the findings from Amiti and Konings (2007) and others, that the revenue-based productivity of direct-importers along with those not directly importing improves as a consequence of input tariff liberalization, and that the benefits to direct importers are greater. To highlight the role played by trade intermediaries we explore how the effect of input tariff cuts differ for firms according to the extent of wholesaling of imported inputs in their industry. The analysis reveals that the productivity of firms not directly importing increases when input tariffs fall, only if wholesalers are an important source of input supply in the industry. When wholesalers are unimportant, our results suggest productivity declines for such firms.

A possible explanation for these results draws from well know reallocation effect as in Melitz (2003), induced by the trade liberalization in the intermediate input sector. As tariffs decrease, direct importers as well as firms importing through wholesalers are able to import new input varieties from more efficient suppliers and, potentially, at a higher quality, which ultimately could increase their productivity. At the same time, non-importing firms may face a decrease in the domestic inputs supplied to them due to the increase of competition in the input supplier sector, leading to a decrease in their productivity. In this case, the effect of input trade liberalization on the productivity of non-direct importers captured by the empirical literature (e.g. Amiti and Konings, 2007) will be a composition of the effects on from firms reliant solely on domestic suppliers and those importing through wholesalers. Ultimately the overall effect will depend on the importance of wholesalers within an industry.

This role for service sector firms to mediate the effects of trade liberalization can be seen to complement other potential explanations, in particular those that come from other manufacturing firms along the supply chain. Fieler et al. (2018) develop a quantitative framework using the ideas of spillovers to generate such outcomes. In their model, firms upgrade quality following the decision to import or export. This leads to an increase in the demand for high-quality inputs at home, implying skill upgrading for labor and quality upgrading for materials inputs. These positive demand effects are amplified through domestic supply chains, including for those not directly involved in trade, who are also induced to upgrade quality. Using Colombian firm-level data Eslava et al. (2015) are also able to show empirically that importing intermediate inputs allows firms to upgrade their technology. They document positive spillover effects, not only for importers, but also for non-importers (or non-traders) they supply inputs to. An alternative mechanism is offered by Tintelnot et al. (2018), who show that non-importing firms may benefit from their links to trading firms. Using firm-to-firm sales for Belgium they show firms can be directly impacted by international trade through imports, as well as indirectly through the inputs that may have been imported by their domestic suppliers. They use this data to estimate models of production networks and international trade including allowing for endogenous network formation. They find within such a model that this amplifies the gains to trade from a positive trade shock.

[3] We credit one of the referees for this paper for naming this puzzle.

[4] As in other international trade data, we are unable to observe the purchases by domestic firms from wholesalers. This explains our use of an industry level of wholesaling.

[5] The balance sheet data also allow us to construct a measure of revenue productivity. Our data do not allow us to measure physical TFP. We make the connection between the predictions and revenue TFP in the next section of the paper.

The presence of spillovers discussed in Eslava et al. (2015), or the endogenous supplier networks in Tintelnot et al. (2018), would ensure that firms both directly and indirectly involved in international trade benefit from imported inputs by other manufacturing firms. In this paper we do not rule out the presence of these additional mechanisms, although our finding of a negative effect for non-direct importing firms when wholesaling is low, would not easily been explained by these alternative forces alone. The identification assumption that underpins our findings is that these other benefits from trade liberalization for firms not directly importing are uncorrelated with links to the service sector that we explore using the measure of industry wholesaling. To provide support for this assumption, we undertake a wide array of robustness tests including falsification tests and tests for treatment heterogeneity. Initial support for this assumption can be drawn from the fact that the presence of wholesalers does not matter for those firms directly importing. We find that firms directly importing benefit from trade liberalization, as would occur within the Eslava et al. (2015) and Tintelnot et al. (2018) models, but there is no heterogeneity across these firms associated with the extent of wholesaling. Wholesalers boosts revenue-based productivity during the period of trade liberalization only for those firms not directly importing.

As an additional falsification test we also show that wholesalers play no role if firms import under processing trade rules, where imports are not subject to tariffs and wholesaling effects are absent. We further extend the analysis to use ownership as a means of capturing those firms for which wholesaling is likely to be a more important feature of input supply. We find from these tests for treatment heterogeneity that wholesalers deliver important productivity impacts for domestically owned firms, whereas for foreign owned firms, who are likely to have access to foreign produced inputs through other channels or have preferential access, they play no role.

A small literature has also shown that increased globalization among service sector firms can affect the productivity performance of firms in the manufacturing sector. For instance, Arnold et al. (2011) and Arnold et al. (2016) document that service sector reforms increased firm performance within downstream manufacturing sectors using those services as inputs in the Czech Republic and India, respectively. Our work differs in that it is the intermediate inputs that serve to raise firm productivity, rather than the service acting as the source of that change. This paper therefore highlights an additional source of productivity gains from trade liberalization through trade intermediation services. We also consider this possible alternative role for wholesalers within the analysis, firstly by removing exporters and then later by constructing an additional measure of wholesaling for exports and for output goods. The results are suggestive of an effect from wholesalers for both output goods and exports, but the main results for imported inputs remain intact.

As a final section on robustness we also attempt to control for these additional mechanisms in a more direct manner by including additional control variables in the regression. We are able to show that our main findings for non-direct importers are robust to the addition of alternative sources of productivity gains, allowing the effects of trade liberalization to differ for these firms according to the degree of import competition, the quality of inputs or their position within the supply chain (upstreamness). They are also robust to the use of an instrumental variable approach to deal with endogeneity concerns about input tariff cuts. Taken together, these results strongly suggest that wholesalers guard against productivity losses from trade liberalization for firms that do not directly import.

In developing this set of findings, we recognise a number of studies that have previously investigated the effects of trade liberalization on Chinese firms. A number of these report productivity effects from input tariff changes and differences across firms or industries. For example, Bas and Strauss-Kahn (2015) show that following an input tariff reduction, firms importing under ordinary trade rules increased both their import and export prices compared to pure processing importers (which by definition are not subject to input tariffs). They conclude from this that input tariff liberalization led to quality upgrading of imported inputs, which in turn, implied quality upgrading of exported outputs. Brandt et al. (2017), Hu and Liu (2014) and Yu (2015) consider the effect of input tariff liberalization across all Chinese manufacturing firms and find positive effects of similar magnitude to ours. Yu (2015) also documents that the productivity gains are weaker for firms importing using processing arrangements. Finally, Yu et al. (2013) show that the increase in import penetration led to productivity improvements for firms producing differentiated goods, while the efficiency of firms producing homogenous goods was negatively affected. The role played by trade intermediation has so far been omitted from this literature.

The remaining paper is organized as follows. Section 2 briefly outlines the theoretical motivation, along with its connection with the data that we have available. A fuller version of the model is available in Appendix A. In Section 3 we discuss the data and construction of the main variables of interest, along with the empirical strategy. The main results of the paper are presented in Section 4, while in Section 5 we draw some final conclusions from the analysis.

2. Theoretical motivation

This section offers some theoretical background behind the intuitions for our empirical analysis, and notably, discusses how trade liberalization in intermediate inputs affects the revenue-based productivity of firms who import directly, versus those firms not directly importing. We include a more formal version within Appendix A.

2.1. Set-up

Final good producers j face the same isoelastic demand function:

$$y_j = C\left(p_j\right)^{-\sigma}, \tag{1}$$

where $\sigma > 1$ is the elasticity of demand, p_j is the price set by the final good producer and C is a constant term from the point of view of the firm.

Final good producers have an exogenous Hicks-neutral productivity Θ_j and integrate together a set of intermediate inputs x_i into final goods, that in turn are sold to consumers, as in Ethier (1982).

$$y_j^m = \Theta_j X^m \text{ with } X^m = \left(\int \left(x_i^H\right)^{\frac{\sigma-1}{\sigma}} di + \delta \int \left(x_i^{F\_m}\right)^{\frac{\sigma-1}{\sigma}} di \right)^{\frac{\sigma}{\sigma-1}} \tag{2}$$

where $\sigma > 1$ is also the elasticity of substitution between intermediate input varieties *i*. The superscript $m = M, I, D$ indicates the import-mode of final good producers: direct-importer (M), indirect-importer (I)[6] and non-importer (D).[7] The subscript *H* indicates inputs produced at Home, while *F* indicates inputs produced in the foreign country.

We model wholesalers as a vehicle through which foreign input varieties can be purchased by indirect-importers. δ is a firm specific dummy variable which takes the value 1 if the final good producer is either a direct or an indirect importer ($m = M, I$) and the value 0 if the final good producer is not importing any inputs ($m = D$).

Given the isoelastic demand function faced by final producers *j*, they will set a price as a constant mark-up over their marginal cost, which depends on both their Hicks-neutral productivity Θ_j and the price index of their intermediate inputs P^m, which will take the following form:

$$p_j^m = \frac{\sigma}{\sigma-1}\frac{P^m}{\Theta_j} \text{ with } P^m = \left(\int \left(p_i^H\right)^{1-\sigma} di + \delta \int \left(p_i^{F\_m}\right)^{1-\sigma} di \right)^{\frac{1}{1-\sigma}} \tag{3}$$

Final good producers that are direct- or indirect-importers (M and I firms) will be able to consume both domestic and foreign varieties, while non-importers (D firms) will only be able to use domestically produced inputs.

2.2. Revenue-based TFP

Empirically, we wish to estimate the impact of input trade liberalization on firms' productivity. A well-known difficulty is that we usually do not observe in the data the quantity of output produced or the quantity of inputs bought by firms. Instead, we use the total revenue of firms and their expenditure on intermediate inputs.

First, let us consider the total revenue of the firm $r_j = p_j y_j$. By considering the inverse demand function from (1), the total revenue can be written as:

$$r_j = \left(y_j\right)^{\frac{\sigma-1}{\sigma}} (C)^{\frac{1}{\sigma}} \tag{4}$$

Second, let us rewrite the production function using the expenditure in intermediate inputs $E^m = P^m X^m$ instead of the quantities:

$$y_j^m = \Theta_j X^m = \left[\Theta_j \frac{1}{P^m}\right] P^m X^m = \left[\Theta_j \frac{1}{P^m}\right] E^m \text{ for } m = D, I, M. \tag{5}$$

Using (4) and (5) the production function in terms of revenues and input spending can be expressed as:

$$r_j^m = \left(\Theta_j \frac{1}{P^m}\right)^{\frac{\sigma-1}{\sigma}} (E^m)^{\frac{\sigma-1}{\sigma}} (C)^{\frac{1}{\sigma}} \tag{6}$$

where the firm-level revenue-based Total Factor Productivity (TFP), depends both on the firm-level Hicks-neutral productivity Θ_j and the firm-level price index of their intermediate inputs P^m. By taking the logs and considering that changes in input tariffs over time *t* occur through the input price index, we can highlight the production function to be estimated:

$$\ln r_{jt}^m = \frac{\sigma-1}{\sigma} \ln \Theta_j + \frac{1-\sigma}{\sigma} \ln P_t^m + \frac{\sigma-1}{\sigma} \ln E_{jt} + \ln C_t \tag{7}$$

Thus, the revenue-based TFP of final good producers is positively related to the exogenous productivity Θ_j, and negatively related to the endogenous price index of intermediate input varieties consumed P_t^m. The firm-level Hicks-neutral productivity Θ_j which we expect to be constant over time will be captured by firm-fixed effects while the aggregate component C_t, common

[6] These are defined as firms that import inputs using wholesalers.
[7] These are defined as firms that rely solely on domestic input producers.

across firms will be captured by year dummies. Hence, the change in TFP following a change in input tariff occurs through a change in P^m.

2.3. Trade liberalization in intermediate inputs, reallocation and productivity change

How is the TFP of final-good producers affected by trade liberalization in intermediate inputs? As discussed above, it will be affected directly if it impacts the price index of intermediate inputs bought by firms. Trade liberalization in the input sector will increase import competition and lead some domestic suppliers to exit the market. As a result, the decrease in the number of domestic varieties will increase the input price index for affected firms. At the same time, as tariffs decrease, foreign suppliers will start to supply domestic firms able to import with new input varieties at a cheaper price and, potentially, a higher quality. This effect will ultimately decrease the input price index for such firms.

Crucially, depending on their import mode (non-importers, direct or indirect importers), firms may be affected differently by these various changes in the availability of inputs. Non-importers (D firms) will only be able to consume domestically produced input varieties. As trade costs decrease in the input sector, their intermediate input price index will rise, and accordingly their revenue-based TFP will fall. Direct and indirect importers (M and I firms) will be able to access foreign input varieties. Input trade liberalization could therefore decrease the input price index for these firms, and ultimately increase their revenue-based TFP. As a result, importing firms may experience an improvement in their productivity following input trade liberalization consistent with the empirical evidence by Amiti and Konings (2007).

A basic reallocation effect of this type in the intermediate input sector can be formalized using a similar framework to that developed by Melitz (2003). In Appendix 1, we provide a theoretical illustration, where the intermediate input sector is characterized by monopolistic competition and where heterogeneous input suppliers draw their productivity from a Pareto distribution. There are two main differences between the Melitz (2003) model and such a framework. First, input suppliers sell their inputs to final good firms and not directly to consumers. However, given the CES structure of the intermediate input composite, input suppliers will also face an isoelastic demand function. Second, and more importantly, foreign suppliers will only be able to sell their varieties to the domestic final-good producers that are importing, either directly or through wholesalers. Assuming heterogeneous final good producers with endogenous import decisions, this difference generates the prediction that a reduction in trade costs implies that more suppliers start exporting for the foreign country but also that some final good producers in the home country start importing, entailing an increase in the demand for imported inputs.

As expected, input trade liberalization leads to reallocation effect similar to the one described in Melitz (2003). The more productive suppliers expand their sales abroad, while all suppliers face increasing import competition such that the least productive suppliers exit the market. Final good producers able to buy intermediate inputs from abroad (directly or indirectly) benefit from new foreign input varieties, even when facing a decline in the number of local varieties available to them. Due to the input reallocation effect, non-importers face an increase in their input price index, which ultimately decreases their revenue TFP.

2.4. Empirical implications

Within the data that are available to us we observe two group of firms: direct importers (M firms) and the firms that are not direct importers. The group of non-direct importers will be composed of both the non-importers and the indirect-importers (and so labelled I + D firms). While all those firms will be able to consume domestic input varieties, only a fraction of final-good producers will be able to use additional foreign input varieties sourced through wholesalers.

As a result, the effect of input trade liberalization is expected to be different depending on the prevalence of firms importing through wholesalers among the group of firms that are not directly importing (I + D firms). In an industry where the input wholesaling cost is high, input trade liberalization is expected to decrease TFP. In contrast, within industries where the cost of trade intermediation using wholesalers is lower, the negative productivity effects associated with a loss of domestically produced inputs will be mitigated by the positive revenue TFP effects for those firms able to import through intermediaries. As a result, the relative benefit of input trade liberalization on the TFP of non-direct importers (I + D firms) will be larger in an industry where the share of firms importing indirectly is higher relative to the share of firms not importing at all. The interaction between the measure of input trade liberalization and the prevalence of firms importing through wholesalers will be central in our empirical investigation.

A difficulty when evaluating the impact of input trade liberalization on the group of firms not importing directly in a given sector (I + D firms) is that we do not observe the share of firms importing indirectly in the data. To address this point empirically, we use the input-specific Wholesaler Share at the industry level (WS), i.e. the value of inputs imported via wholesalers in total imported inputs within an industry. In our illustrative theoretical framework, in Appendix 1, we show that WS is a function of the costs associated with imports intermediated by wholesalers. More specifically, WS is inversely related to the wholesaling cost within a sector, and as a result, the variation in WS affects the prevalence of indirect importers within the group of firms not importing directly in a given sector (I + D firms). This theoretical result is the key for the interpretation of our empirical results. Input trade liberalization is expected to decrease TFP in industries with high input wholesaling costs, that is where WS is low. This productivity loss will be mitigated in industries where WS is high. In addition, in our framework, WS appears to be

unaffected by trade liberalization in the intermediate input sector. This provides us with a theoretical foundation for considering WS as a time-invariant sector-specific characteristic in our empirical specification.[8]

Finally, we note that the presence of spillover effects arising from input trade liberalization may affect our empirical results, where a decrease in input tariffs could lead to an increase in productivity of both direct and non-direct importers. In Appendix 1, we briefly describe the effects of introducing a positive spillover effect associated with input trade liberalization in our framework. As a first point we note that such spillovers would increase the TFP of all firms that use domestically sourced inputs. Cross-industry heterogeneity may still be present of course, if the extent of these spillovers varies across industries. Therefore, to empirically identify the effect of wholesalers, it is required that these spillovers are uncorrelated with the prevalence of wholesalers in an industry. In other words, any spillover effects may affect the average TFP change (in a hypothetical industry with an average level of WS), but not the comparison of the effect of tariff changes across industries, and across firms within the industry, due to wholesaling.

3. Data, variable construction and estimating equation

Our analysis relies on firm-level balance sheet data from the Chinese Manufacturing Annual Survey and firm-level international trade activities from the Chinese Custom data. The Chinese Annual Survey of Industrial Firms (CASIF), carried out by the National Bureau of Statistics in China, is an unbalanced panel of close to 480,000 firm-year observations over the period 2000–2006 and includes all state-owned firms and private firms whose annual sales are above 5 million RMB (i.e. about 700 thousand USD). For each firm-year observation the dataset records information on output, sales, fixed assets, intermediate inputs,[9] number of employees, ownership status, location and industry (*National Standard Classification*).[10]

The Chinese Customs Trade Statistics (CCTS), managed by the General Administration of Customs of China, records all international trade transactions over the period 2000–2006. Each transaction includes the name of the firm, its address, as well as the product code of the imported or exported product at the 8-digit level following the Harmonized System (HS) classification, its *fob* value, quantity and unit value, origin and destination country as well as the custom regimes under which it was traded, e.g. ordinary trade regime, processing trade regime etc.

Our empirical analysis relies on a matched version of the balance sheet data from the annual survey and the custom data. We use the CASIF data to compute our firm-level productivity measure and the CCTS to identify direct-importers and to construct our industry level measure of indirect imports. In the absence of unique identifiers for each firm, the merging of the two datasets is based on an algorithm that matches firm names and contact information.[11] Upward et al. (2013) discuss issues surrounding the reliability of these matches, although they note that this information is less likely to be missing or to change over time. We note that the two datasets do not completely intersect as the CASIF data includes large manufacturing firms only, whereas the custom data records all trade transactions from both manufacturing and non-manufacturing sectors without any size threshold. We are able to match about 50% of the firms reporting exports in the annual survey with the custom data. The customs data allows us to identify firms that are directly involved in international trade, i.e. direct importers and direct exporters. Firms with no direct import transactions are defined as I + D firms.

A further advantage of the customs data is that it allows us to observe the customs regime under which imports are made. This is important for our definition of direct importers. Transactions undertaken under different customs regimes are subject to different tariff levels. The most frequent regimes are ordinary trade and processing trade (associated with either assembly or imported materials). Together these represent 84% of total imports in our sample period. Given our interest in the effects of trade liberalization and the fact that transactions completed under processing trade rules are duty free, we focus our empirical analysis on firms that import all goods under ordinary trade rules. To be clear, we remove from our definition of direct importing firms, *any* firm using processing trade in *any* of their import transactions. We retain these observations for use as a placebo test on the role of trade intermediaries in mediating the effects of input tariff changes (see regression 3 in Table 4). Finally, we restrict the sample to a balanced panel of firms that do not change their direct importer status or their main sector activity during our sample period in order to remove any effect that trade liberalization may have on direct-importer status, the main sector of activity of a firm or the probability of survival in an industry.

3.1. Estimating equation

Before detailing the construction of our main variables of interest we briefly introduce the empirical model to be estimated, which takes the following form:

$$TFP_{jt} = \beta_0 \tau^{y}_{kt} + \beta_1 (I+D)_j \tau_{kt} + \beta_2 WS_k (I+D)_j \tau_{kt} + \beta_3 M_j \tau_{kt} + \beta_4 WS_k M_j \tau_{kt} + \beta_5 C_{jt} + \theta_j + \theta_t + \varepsilon_{jt}$$

[8] A further advantage of holding the level of WS constant in our empirical setting is that it allows us to disentangle the input tariff effect from any changes in WS. We consider the robustness to this point in Section 4.

[9] Observations with negative values for intermediate inputs and total fixed assets variables are removed from the sample.

[10] During our period of analysis, two different editions of the four-digit Chinese Industrial Classification are used: GB/T4754–1994 and GB/T4754–2002. Brandt et al. (2017) construct a concordance table, which we use to provide a time-consistent measure of industry for each firm.

[11] See Upward et al. (2013) for more details about the matching procedure.

where TFP_{jt} is the revenue productivity of firm j measured in time t. The variable M_j is a dummy variable that takes value one if firm j directly imports, and zero otherwise, whereas $(I + D)_j$ is a dummy variable that takes value one if firm j does not directly import (i.e. it is an indirect importer or does not rely on foreign inputs).[12] WS_k is our measure of wholesaling of imported inputs used by sector k, while τ_{kt} is the input tariff and τ^{γ}_{kt} is the output tariff for sector k in time t.

We note two main points about this regression model and the interpretation of the estimated coefficients. Firstly, the interpretation of the estimated coefficient β_1 will depend upon the extent of wholesaling within the industry. To aid with its interpretation we centre the value of WS_k on the mean value of wholesaling. In this case, β_1 now captures the effect of input tariff changes on I + D firms in an industry with the average level of wholesalers, while β_2 captures what happens to TFP as wholesaling moves above or below this mean. As a related point, in the presence of spillovers or indirect linkages leading to positive productivity effects associated with trade liberalization to non-direct importers, the coefficient β_1 would increase in absolute magnitude. However, as long as the size of these spillovers or linkages effects are uncorrelated with the importance of wholesalers within an industry, it would not affect the coefficient β_2. We anticipate that $\beta_2 < 0$. A decrease in input tariffs would then imply an increase in productivity for non-direct importers (I + D firms) in sectors with a high wholesaler intensity $WS_{\boldsymbol{k}}$.

Second, the role of wholesalers is identified from variation across sectors and from variation across firms (I + D versus M). In contrast to the expected significance of the interaction with wholesaling for non-direct importers, we anticipate that for direct importers β_4 will not be statistically significant. From the existing literature we would anticipate that $\beta_3 < 0$. That is, we expect that for direct importers, their productivity will increase as a consequence of input tariff declines regardless of any wholesaling of foreign inputs in their industry.

Finally, C_{jt} represents a set of firm-level control variables, namely, a dummy variable taking value one if the firm exports, a dummy variable assuming value one if firm is state-owned, and another one equal to one if the firm is owned by foreign investors, including those from Hong-Kong, Macao or Taiwan. θ_j and θ_t denote firm fixed effects and common time dummies respectively and ε_{jt} is a classical error term, where the errors have been corrected for clustering at the firm level. We include firm fixed effects to control for any time-invariant firm-specific determinants of the productivity and time dummies to control for any common shocks that occur during this time period. The firm fixed effects along with the use of a balanced panel of firms that do not switch direct import or non-direct import status explains the absence of the variables M and I + D within the estimating regression (other than their interaction with the input tariff and wholesaling variables).

3.2. TFP

We construct our measure of revenue TFP for each firm by first estimating the following log-linearized Cobb-Douglas production function:

$$y_{jt} = \gamma_0 + \gamma_l k_{jt} + \gamma_k l_{jt} + \gamma_n n_{jt} + u_{jt}$$

where γ_l, γ_k and γ_n stand for the factor shares of production and y_{jt}, l_{jt}, k_{jt} and n_{jt} denote respectively the natural logs of output, labor, capital and intermediate inputs of a firm j at time t. Output is measured by the nominal value of sales deflated by factory price index at 2-digit industry level, labor is proxied by the number of employees, capital is measured by total fixed assets, deflated by a province-specific fixed asset investment price index, and intermediate inputs are measured by total expenditures on intermediate goods deflated by the weighted-average price index for intermediates at 2-digit industry level.[13]

Following Amiti and Konings (2007), the production function is estimated separately for each 2-digit CIC sector using a modified version of Olley and Pakes (1996). Specifically, we correct the estimates of TFP for simultaneity between productivity shock and firm's decision to import and to export – by considering that firms have to pay sunk fixed costs if they want to be involved in international trade – in addition to the problem of simultaneity between input choices and productivity shocks,[14] and the problem of sample selection.[15] By assuming the error term u_{jt} is composed of two components, a white noise component η_{it} and a time-varying productivity shock ε_{jt}, $u_{jt} = \eta_{jt} + \varepsilon_{jt}$, Olley and Pakes (1996) showed that the investment demand I_{jt} depends on two state variables, capital k_{jt} and productivity ω_{jt}, i.e. $I_{jt} = i(k_{jt}, \varepsilon_{jt})$. They also demonstrated, under certain conditions, this investment function is monotonically increasing in productivity, so that the latter variable can be expressed as function of capital and investment, i.e. $\varepsilon_{jt} = i(k_{jt}, I_{jt})$. Moreover, assuming that firm's decision to trade takes place as the same time as its decision to invest, Amiti and Konings (2007) included two additional state variables, import status M_{jt} and exports status X_{jt}, so that the productivity can be written as the following function: $\varepsilon_{jt} = i(k_{jt}, I_{jt}, M_{jt}, X_{jt})$. By substituting the latter equation into the production function above – $y_{jt} = \gamma_0 + \gamma_k l_{jt} + \gamma_n n_{jt} + \phi(k_{jt}, I_{jt}, M_{jt}, X_{jt}) + \eta_{jt}$ – consistent estimates of input coefficients can be computed through using non-parametric techniques. In the first step, consistent estimates of γ_l and γ_n can be obtained. In the second step, the probability of the

[12] As explained above, by construction firms are uniquely defined as either direct importers, M firms, or non-direct importers, $I + D$ firms, in the sample.

[13] De Loecker (2011) argues that using this information to proxy the output, the coefficients of production function can still suffer problems of omitted price variable bias. Unfortunately, we do not have the data required to cover this kind of problem (i.e. product-firm level data).

[14] The correlation between productivity shocks and inputs choice makes OLS estimates of production function inconsistent.

[15] Firms can exit the market if productivity falls below a certain threshold, and consequently OLS estimates can be inconsistent. Given that we allow for the productivity shocks arising from surviving firms only.

firm exiting is then estimated, and in the final step, coefficients for state variables are estimated. Once input coefficients are estimated, we can define the natural log of measured revenue *TFP* of firm j at time *t* as

$$\boldsymbol{TFP_{jt}} = y_{jt} - \hat{\gamma}_l k_{jt} + \hat{\gamma}_k l_{jt} + \hat{\gamma}_n n_{jt}$$

The Olley-Pakes coefficients of the production function are displayed in Table 1 together with OLS coefficients for a comparison. Table 2 provides summary statistics on the sample used to estimate productivity. In our sample of manufacturing firms for the year 2002, 13.7% of firms are directly involved in importing. The TFP of these direct importers is higher on average than firms that do not directly import. This holds irrespective of whether firm TFP is measured using Olley-Pakes or a production function estimated using OLS. In 2006, share of direct importers increased to 15.0%, but the productivity advantage of these firms relative to firms that do not directly import remained.

3.3. Share of wholesalers in imported inputs (WS)

Our industry-level measure capturing the importance of wholesaling in importing intermediate inputs is constructed using a combination of the Chinese customs data (CCTS) and Chinese input-output tables. We begin by identifying wholesalers, retailers and other trade agents within the Chinese Custom data following Upward et al. (2013) and Ahn et al. (2011). To do so we search firm names for a set of keywords specifically linked to intermediary activity. We use this to measure the value of 8-digit HS products that are imported by wholesalers and trade intermediaries into China. As an example, 7.3% of the 2002 Chinese ordinary imports for the product HS-85016100 (Electric Motors with an output not exceeding 75KVA) were realized by firms, whose names implied that they were involved in intermediary activities. In the same year, 49.8% of the Chinese ordinary imports of the product HS-85016200 (Electric Motors with an output exceeding 75KVA but not exceeding 375 KVA) would be classified as imported through wholesalers under our definition. The 8-digit HS codes of the customs data are matched to the 4-digit CIC industry codes using the concordance table provided by Upward et al. (2013), which in turn are matched to 3-digit IO industry codes of the input-output table using the concordance table constructed by Brandt et al. (2017).

Retaining only ordinary trade transactions from the Custom data, we then calculate for the first year of our sample (2002) the share of total imports within an industry through wholesalers at the 3-digit IO industry level. We label this industry-level variable WS_k^y, the share of final goods imported by wholesalers.

Our measure of the share of intermediate inputs imported by wholesalers within a sector, WS_k, is constructed using these wholesale shares, WS_k^y, and proportioning them to different sectors using as weights the industry input shares from the 2002

Table 1
Coefficients of the production function.

2-digit sector	Labor		Capital		Materials	
	OLS	O&P	OLS	O&P	OLS	O&P
13–14 Processing of foods	0.045	0.042	0.013	0.040	0.916	0.923
15 Beverages	0.055	0.043	0.018	0.046	0.927	0.941
17 Textiles	0.055	0.052	0.016	0.029	0.895	0.899
18 Clothing	0.097	0.096	0.027	0.048	0.843	0.843
19 Leather/fur/feather	0.064	0.062	0.019	0.032	0.900	0.900
20 Timber/wood	0.060	0.054	0.011	0.037	0.907	0.927
21 Furniture	0.064	0.055	0.016	0.030	0.904	0.921
22 Paper products	0.039	0.036	0.019	0.038	0.914	0.928
23 Printing	0.051	0.047	0.038	0.039	0.908	0.911
24 Office equipment	0.077	0.084	0.027	0.039	0.868	0.852
25 Petroleum/coking	0.070	0.065	0.025	0.034	0.888	0.890
26 Raw chemical materials	0.045	0.035	0.028	0.048	0.888	0.899
27 Medicines	0.060	0.054	0.040	0.059	0.880	0.879
28 Chemical fiber	0.040	0.039	0.013	0.029	0.930	0.929
29 Rubber	0.075	0.075	0.036	0.023	0.850	0.845
30 Plastics	0.072	0.066	0.030	0.051	0.871	0.875
31 Non-metallic minerals	0.083	0.068	0.017	0.005	0.881	0.895
32 Ferrous metals	0.043	0.037	0.020	0.037	0.921	0.933
33 Non-ferrous metals	0.057	0.052	0.016	0.030	0.905	0.913
34 Metal products	0.070	0.068	0.035	0.067	0.856	0.844
35 General machinery	0.014	0.021	0.025	0.056	0.909	0.912
36 Special machinery	0.009	0.013	0.018	0.078	0.915	0.922
37 Transport equipment	0.052	0.051	0.016	0.045	0.902	0.899
39 Electrical equipment	0.047	0.041	0.025	0.049	0.890	0.906
40 Electronic equipment	0.081	0.075	0.036	0.073	0.858	0.861
41 Measuring instruments	0.050	0.041	0.030	0.062	0.862	0.878
All manufacturing sectors	0.055	0.050	0.023	0.043	0.892	0.898

Notes: The table refers to estimated elasticities on labor, capital and materials from a Cobb-Douglas production function using either OLS or Olley and Pakes (1996) methodology as outlined in Section 3.

Table 2
Sample of Chinese manufacturing firms.

Year	Firm status	Percentage of firms	*TFP* (O&P)	*TFP* (OLS)
2002	Not direct importers (I + D)	86.3	0.623	0.829
	Direct importers (M)	13.7	0.701	0.910
	All firms	100.0	0.634	0.840
2006	Not Direct importers (I + D)	85.0	0.802	1.010
	Direct Importers (M)	15.0	0.874	1.083
	All firms	100.0	0.813	1.021

Chinese Input-Output (IO) table.

$$WS_k = \sum_{k\prime} a_{k\prime k}.WS^y_{k\prime} = \sum_{k\prime} a_{k\prime k}.\frac{\text{imports through wholesalers}_{k\prime}}{\text{total imports}_{k\prime}}$$

where the terms $a_{k'k}$ refer to input weights of industry *k'* in the production of a good in industry *k*. In this way we capture the indirect imports of inputs into an industry that come through wholesalers. It is worth noting that we calculate the weights $a_{k'k}$ using the input cost of industry *k'* used in the production of a good in industry *k* divided by the total intermediate inputs consumed by the industry k. A similar approach to the construction of import weights is taken by Amiti and Konings (2007). The final wholesaling variable is available at the 3-digit IO industry level. As noted above, in line with our theoretical motivation above we fix the measure of import wholesaling over time. We have constructed a time-varying version of import wholesaling, although in general there is relatively little cross-time variation. We report results using this time varying measure of wholesaling in Table 5 column 7.

Summary statistics on our measure of indirect importing at the 2-digit industry level are displayed in Table 3. For reference we also report in the table the share of final goods that are imported through wholesalers. The table shows quite clearly that wholesaling of final good imports display different patterns to the wholesaling of imported intermediate inputs. For example, the share of wholesalers in total imports for the food sector (WS^y_k) is 0.5, while the share of intermediate inputs that are imported through wholesalers (WS_k) is 0.094. That is, 50.0% of all foreign food products consumed in China have been imported by wholesalers, while 9.4% of foreign intermediate inputs used for Chinese food production have been imported through wholesalers. There is

Table 3
Indirect imports of final output, indirect imports of intermediate inputs, and inputs tariffs by industry.

2-digit sector	Indirect imports of final output goods (WS^y_k)	Indirect imports of intermediate inputs (WS_k)	Input tariffs τ_{kt}	
	2002	2002	2002	2006
13–14 Processing of foods	0.500	0.094	0.047	0.036
15 Beverages	0.370	0.210	0.114	0.090
17 Textiles	0.394	0.266	0.098	0.057
18 Clothing	0.588	0.312	0.126	0.076
19 Leather/fur/feather	0.459	0.303	0.115	0.096
20 Timber/wood	0.440	0.233	0.054	0.039
21 Furniture	0.393	0.265	0.071	0.053
22 Paper products	0.383	0.221	0.069	0.044
23 Printing	0.435	0.293	0.087	0.055
24 Office equipment	0.489	0.297	0.089	0.066
25 Petroleum/coking	0.149	0.042	0.013	0.011
26 Raw chemical materials	0.361	0.213	0.060	0.051
27 Medicines	0.349	0.209	0.055	0.045
28 Chemical fiber	0.609	0.321	0.068	0.048
29 Rubber	0.369	0.185	0.055	0.046
30 Plastics	0.313	0.293	0.089	0.070
31 Non-metallic minerals	0.233	0.157	0.050	0.042
32 Ferrous metals	0.321	0.138	0.028	0.026
33 Non-ferrous metals	0.321	0.198	0.027	0.025
34 Metal products	0.396	0.243	0.057	0.052
35 General machinery	0.393	0.266	0.068	0.059
36 Special machinery	0.434	0.278	0.072	0.061
37 Transport equipment	0.429	0.275	0.098	0.074
39 Electrical equipment	0.385	0.261	0.076	0.065
40 Electronic equipment	0.342	0.223	0.060	0.046
41 Measuring instruments	0.439	0.242	0.070	0.060
All manufacturing sectors	0.384	0.214	0.068	0.053

Notes: The variables WS^y refers to the share of total imports in each sector that occur through wholesalers. *WS* is a measure of the share of intermediate inputs in each sector that are imported by wholesalers. Further details on the construction of these variables can be found in Section 3.

also considerable variation in the extent of input wholesaling across sectors. For example, sectors such as Petroleum/coking (4.2%) and Food (9.4%) rely more heavily on direct importing, whereas Chemical fiber (32.1%) and Clothing (31.2%) source a greater share of imported inputs from wholesalers.

3.4. Input and output tariffs

In the last decade, China's international trade policy has been altered by its entry into the World Trade Organization (WTO) in December 2001. Through the WTO accession protocol, China bound 100% of its tariffs at *ad valorem* rates, and started to charge the MFN duty rate to all WTO members. In addition, it made several commitments to reduce all tariff and non-tariff trade barriers. Our measure of trade liberalization are constructed using tariff data from the WITS database at the 8-digit HS level[16] which provides information about *MFN current bound duty rates, MFN applied duty rates* and *General duty rates*. From these we construct both output and input tariff variables using the same methodology found in Amiti and Konings (2007). *Output tariffs* τ^{y}_{kt} are measured at the 4-digit CIC level as the simple average of 8-digit HS level tariffs (using *ad valorem MFN applied* duties). *Input tariffs* τ_{kt} are then measured at the 3-digit IO industry level and calculated as a weighted average of output tariffs, weighted by the importance of that input in production, where these weights are taken from the Chinese Input-Output table:

$$\tau^{m}_{kt} = \sum_{k} a_{k/k}.\tau^{y}_{k/t}$$

The tariff rates for intermediate inputs in 2002 and 2006 are provided in Table 3. A comparison of the tables shows that average input tariff was 6.8% in 2002 and 5.3% in 2006.

4. Results

In Table 4 we report the effect of changes to input and output tariffs on revenue productivity. In column 1, we replicate the baseline regressions found in Amiti and Konings (2007), albeit where we use data on Chinese rather than their data on Indonesian firms. Consistent with that study we find evidence that trade liberalization significantly affects revenue productivity, even when controlling for firm fixed effects. Higher output tariffs and input tariffs have the expected negative effect on productivity, where the latter are statistically significant for firms that either directly import their inputs (M firms) as well as for those who do not (I + D firms). The effect of reductions in input tariffs on productivity in column 1 are strongest for those firms that are direct importers. According to the results, a one percentage point decline in input tariffs increases the revenue productivity of direct importers by 3.65% and for firms that do not directly import by 0.93%. These findings are consistent with a number of interpretations that include trade liberalization allowing importers to access intermediate inputs produced abroad through wholesalers or through indirect effects on domestic input producers. These results also support the previous literature on Chinese importers found in Bas and Strauss-Kahn (2015). For intermediate inputs Brandt et al. (2017) and Hu and Liu (2014) and Yu (2015) report similar sized coefficients for direct importers and for other firms to those found here.[17]

Having demonstrated we can replicate results from the previous literature we next move to the main empirical contribution of our paper and allow the effects of input tariffs to differ according to the share wholesaling of foreign intermediate inputs. The results from this regression are reported in column 2. As noted already, to ease the interpretation of the interaction terms in this regression we centre the wholesaling variable by subtracting its mean value. Using this approach, the estimated coefficient on the input tariff variable in column 2 provides the estimated productivity effect for firms in an industry with the average level of wholesaling. The interaction term then indicates how productivity is affected as the wholesaling of inputs moves away from this mean.

We begin by noting that the results for the wholesaling of intermediate inputs differs for firms not directly importing (I + D) firms compared to direct importers (M). We find evidence that wholesaling of imported inputs matters for the productivity response to input tariff cuts only for firms that do not directly import (I + D firms).[18] As expected, for firms that directly import there is no evidence that wholesalers have a statically significant role in moderating the productivity gains that result from the liberalization of input tariffs. According to the results in column 2, direct importers benefit from input tariff liberalization, regardless of the presence of input wholesalers. Heterogeneity in the effects of wholesalers across direct importers and firms not directly importing forms part of the identification strategy that we use.

As discussed in Section 2, the positive revenue productivity effects from input tariff reductions for non-direct importers are increasing in the importance of wholesalers as a source of foreign inputs. When the wholesaling share is relatively low, firms may suffer productivity losses if previously domestically produced inputs are lost. Our results are consistent with an interpretation that not all firms benefit from trade liberalization if wholesalers are not present. As implied by the interaction terms, the productivity effects from reductions in input tariffs for those firms that are not direct importers passes from negative to positive

[16] 1997 tariff data refer to HS-1996 classification, whereas tariff data over 2002–2006 period refer to HS-2002 classification. This problem is solved through a concordance table.

[17] Input tariffs are always estimated to have strongly negative effects on productivity, with benchmark estimates in Brandt et al. (2017) implying that a 1% input tariff cut increases Chinese manufacturing firms productivity between 1.79% and 1.62%. In their baseline results, Hu and Liu (2014) report an estimate of 1.56% while Yu (2015) report an elasticity of 1.47%.

[18] These results are robust to the inclusion of firms that import some, but not all, inputs using ordinary trade rules.

Table 4
Trade liberalization and Firm productivity.

Regression no.	(1)	(2)	(3)	(4)	(5)	(6)		
	Amiti and Konings	Baseline model	Including Processing trade importers	OLS TFP	Excluding exporters	Ownership		
Dependent variable	TFP_{jt}	TFP_{jt}	TFP_{jt}	TFP_{jt}	TFP_{jt}		TFP_{jt}	
Output $tariff_{kt}$	−0.367***	−0.488***	−0.476***	−0.490***	−0.534***		−0.518***	
	(0.0711)	(0.0714)	(0.0712)	(0.0714)	(0.0745)		(0.0715)	
Not direct importers $(I+D)_j$						*Private*	*State owned*	*Foreign*
× Input $Tariff_{kt}$	−0.928***	0.661*	0.617	0.779**	0.566	0.937**	0.429	−0.241
	(0.307)	(0.382)	(0.380)	(0.382)	(0.407)	(0.384)	(0.569)	(0.619)
× Input $Tariff_{kt}$ × WS_k		−18.28***	−18.09***	−18.90***	−19.15***	−19.39***	−26.87***	−4.805
		(3.390)	(3.388)	(3.389)	(3.674)	(3.392)	(5.858)	(5.327)
Direct importers $(M)_j$								
× Input $Tariff_{kt}$	−3.650**	−3.035*	−3.077*	−3.099*	−3.085*		−2.879*	
	(1.435)	(1.712)	(1.705)	(1.704)	(1.613)		(1.682)	
× Input $Tariff_{kt}$ × WS_k		5.048	5.203	6.951	−5.567		3.044	
		(25.83)	(25.76)	(25.42)	(32.27)		(25.85)	
Import processing firms $_j$								
× Input $Tariff_{kt}$			5.877					
			(6.790)					
× Input $Tariff_{kt}$ × WS_k			−57.39					
			(71.57)					
Export status	√	√	√	√			√	
Ownership	√	√	√	√	√		√	
Firm fixed effects	√	√	√	√	√		√	
Time dummies	√	√	√	√	√		√	
Observations	40,443	40,443	40,748	40,443	36,673		40,443	
R-squared	0.040	0.041	0.040	0.044	0.038		0.041	
Number of firms	8247	8247	8308	8247	7479		8247	

Notes: Robust standard-errors clustered at the firm-level reported in parentheses. ***, **, *, indicate significance at the 1%, 5%, and 10% level. *j* denotes firms, *k* industries and *t* time. Ownership are State Owned, Foreign Owned or Private Domestically Owned firms. *WS* refers to the wholesaling of imported inputs for the year 2002. The estimation sample is balanced panel of firms don't switch sectors and importer status.

depending on the wholesaling share. As the wholesaling variable is centred on its mean value, the estimated coefficient on the input-tariff variable provides information as the effect of input tariffs for firm in industries with average levels of wholesaling (of 22.4%). Our results suggest that firms in this average industry, along with others in industries with below average levels of wholesaling, there are productivity declines because of input tariff liberalization.

The value of wholesaling for which the effect of input tariffs cuts on productivity passes from negative to positive is 0.26 (26%).[19] According to Table 3, there are fourteen out of twenty-six 2-digit sectors where the value of wholesaling is below this critical value, including food & beverages, metals & non-metallic minerals, and raw chemicals & medicines. For the mean value of wholesaling and the mean change in input tariffs (−1.5 percentage points), our results estimate imply a revenue TFP decline of about 1%. For an industry where intermediaries are of greater importance, such as Clothing, which has an indirect importing of inputs share of 0.312, the productivity gains from trade liberalization are 1.42%. We also note that the results in this column could imply that indirect importers would benefit more from trade liberalization than direct importers if WS was higher than 0.45 (45%). However, as the highest value for WS is 0.321, such an industry does not exist in the data. At the maximum observed value of wholesaling in the data, the productivity benefit implied by our results would be 1.167, which is about three times lower than the effect found for direct importers.

To further strengthen the conclusion that wholesaling matters for the productivity effects of trade liberalization, we consider further placebo tests. For the results generated in columns 1 and 2 we include in the sample only those firms that used imported inputs that are subject to tariffs (they are imported under ordinary trade rules). That is, we excluded firms which used any inputs imported under processing trade rules, which would be tariff-free. As a placebo test in column 3 we add to the regression firms that *only* import inputs under processing trade rules. Given the absence of tariffs on the imported inputs of processing firms, we would expect that trade liberalization and its interaction with wholesaling should have no effect on their productivity over this time period. Significance of the estimated coefficients for these processing firms would therefore serve to undermine our conclusions. Fortunately, we find instead there are no statistically significant effects from input tariff cuts on the productivity of processing firms, and in addition that wholesalers play no role as an indirect source of inputs for these firms. In contrast, we continue to find that firms that do not directly import benefit from the presence of wholesalers, while firms that directly import under ordinary trade rules enjoy productivity gains from input trade liberalization, but there is no effect from wholesalers for such firms.

[19] Looking at column 2 in Table 5, we use the coefficients associated with input tariff and input tariff interacted with WS, and notice that 0.661–18.28*WS = 0 for WS = 0.036. As the wholesaler variable is centred on its mean value, which is 0.224, we obtain the value of WS for which the effect is zero as 0.224 + 0.036 = 0.26.

In the remainder of Table 4 we undertake further tests of the robustness for the main set of findings. We begin by considering the possible sensitivity of our results to the measure of revenue TFP. For this task we use a measure based on a production function estimated by OLS as it imposes fewer assumptions compared to the Olley-Pakes measure. The results appear very similar to the regression in column 2. Thus far, we have included the export status of the firm as a control variable. It remains possible that firms that both export and import may respond differently to input tariff reductions compared to firms that import only (directly or indirectly) or do neither. In support of this view, Fieler et al. (2018) consider the productivity effects that arise from export expansion and returns to scale and their interconnection with imports. Alternatively, exporters might further benefit from wholesalers if these provide intermediate services for such firms (Arnold et al., 2011; Arnold et al., 2016).[20] By excluding exporters from our sample in column 5, we are able to identify the effect of inputs tariff cuts on direct importers and those not directly involved in import activities, while abstracting from the scale effects generated by trade liberalization or those through the use of services as an intermediate input. Again, we find that the main results are robust to the exclusion of these firms.

As further means of establishing the credibility for our interpretation of the results, in column 6 we explore alternative forms of cross-firm heterogeneity in the effects of wholesalers for non-direct importers. In this regression we allow the effects of input tariffs to differ according to whether non-direct importers are privately owned, state owned or foreign owned. Here we anticipate that the beneficial effects of trade liberalization of input tariffs are likely to be strongest for those firms that were previously most constrained in their access to foreign produced inputs. In the context of China, these constrained firms are most likely to be privately owned Chinese firms and state owned enterprises. The plants owned by foreign firms are likely to have access to foreign produced inputs through other preferential channels.

We find strong evidence of different productivity responses to input tariff cuts across these different types of firms. Among firms that did not directly import, we find that the interaction between changes to input tariffs and the extent of wholesaling is statistically significant for private and state-owned. There is no significant effect found for foreign-owned firms. For privately owned firms, the effect of input tariffs changes on productivity becomes positive once wholesaling reaches 27.2%. This is slightly higher than in the baseline model in column 2 (26%). For state owned firms the threshold is at a level of wholesaling equal to 24.0%. The effects of wholesaling are therefore strongest for those firms that are most likely to benefit from their presence during periods of trade liberalization. Again, while this finding that wholesaling matters more for those firms most constrained in their access to higher quality inputs does not completely rule out the possibility that there may be alternative explanations for our results, it makes it less likely.

4.1. Directly controlling for alternative mechanisms

In Table 5, we consider a more direct approach to the question of alternative explanations for our findings by adding additional controls for industry characteristics. The construction of these industry control variables IC_k , have a similar structure to that used to generate the wholesaling of imported inputs variable and takes the common general form:

$$IC_k = \sum_{k\prime} a_{k\prime k}.IC^y_{k\prime}$$

In this equation *IC* is the weighted average of the output-specific industry characteristic $IC^y_{k'}$ in the upstream sector, where weights $a_{k'k}$ are from the Chinese IO table and variables are measured at the 3-digit IO industry level.

We begin by exploring the robustness of our main findings to whether the estimated coefficient on the wholesaling interaction variable in fact captures some aspect of import competition between firms in the input sector, or alternatively this import variable is correlated with spillovers in Fieler et al. (2018). The hypothesis here would be that domestic firms operating in industries in which the share of importing, including indirect imports through wholesalers, is high, are subject to stronger forces of competition. This greater competition may encourage firms to strive to become more efficient, the effects of which are then passed along the supply chain to downstream firms. In support of the idea that competition has an important effect on productivity during periods of trade liberalization, Pavcnik (2002) finds results consistent with such an interpretation using a measure of output-tariffs. An alternative explanation found in Fieler et al. (2017) would be that import competition is correlated with the increased incentive to invest in input quality generating spillovers to firms not directly importing.

To construct this variable, we begin by measuring import competition at the sectoral level as a ratio of the weighted average of imports over sales minus exports in upstream sectors, i.e. by setting $IC^y_k = \frac{\text{imports}_k}{(\text{sales}-\text{exports})_k}$. We then calculate this for the input sector using the equation set out above. As highlighted by Amiti and Konings (2007) this variable may also capture the indirect effect of imported inputs embodied in domestically produced inputs. The results in column 1 of Table 5 suggest that changes in import competition in the input sector have no statistically significant effect on the productivity of those firms that they supply. There is also no difference in the effect of import competition in the upstream sector according to whether the firm directly imports or not. The effects of trade liberalization through wholesalers are, in contrast, significant despite the addition of these new controls.

In column 2, we address a concern that the use of wholesalers for the purchase of intermediate inputs within an industry may be positively correlated with how close the firm is to the end of the production process. Here we might anticipate that industries

[20] We return to this point below.

Table 5
Trade liberalization and Firm productivity: Alternative Channels.

Regression no.	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Additional control variable	Input import competition	Upstreamness	Input quality	Processing imports	Wholesaling of output goods	Export wholesaling	Time varying wholesaling
Dependent variable	TFP_{jt}	TFP_{jt}	TFP_{jt}	TFP_{jt}	TFP_{jt}	TFP_{jt}	TFP_{jt}
Output $tariff_{kt}$	−0.490***	−0.477***	−0.493***	−0.512***	−0.493***	−0.384***	−0.445***
	(0.0714)	(0.0712)	(0.0716)	(0.0720)	(0.0717)	(0.0720)	(0.0723)
Output $tariff_{kt} \times WS^{v}_{k}$					0.931*		
					(0.545)		
Not direct importers $(I + D)_j$							
×Input $tariff_{kt}$	0.441	0.660*	0.543	0.257	0.662*	0.512	4.794***
	(0.447)	(0.382)	(0.398)	(0.380)	(0.381)	(0.378)	(0.632)
×Input $tariff_{kt} \times WS_k$	−17.53***	−21.18***	−18.22***	−70.67***	−19.56***	−8.116**	−31.92***
	(3.474)	(4.470)	(3.390)	(6.085)	(3.453)	(3.670)	(3.058)
Direct importers $(M)_j$							
×Input $tariff_{kt}$	−3.404*	−3.046*	−3.225*	−3.585**	−3.319*	−3.030*	−3.173
	(1.837)	(1.733)	(1.873)	(1.684)	(1.757)	(1.800)	(3.168)
×Input $tariff_{kt} \times WS_k$	6.720	5.444	5.147	28.93	7.771	6.460	−1.713
	(25.46)	(30.76)	(26.11)	(55.33)	(26.02)	(24.17)	(16.98)
Additional controls							
$(I + D)_j \times$ Input $tariff_{kt} \times$ Additional control	−2.970	0.403	9.948*	17.28***		−10.37***	
	(3.243)	(0.394)	(5.154)	(1.635)		(1.697)	
$(M)_j \times$ Input $tariff_{kt} \times$ Additional control	−14.09	−0.0562	9.205	−6.963		−2.974	
	(24.30)	(2.804)	(33.68)	(17.72)		(9.961)	
Export status	√	√	√	√	√	√	√
Ownership	√	√	√	√	√	√	√
Firm fixed effects	√	√	√	√	√	√	√
Time dummies	√	√	√	√	√	√	√
Observations	40,443	40,443	40,443	40,443	40,443	40,443	40,443
R-squared	0.041	0.041	0.041	0.046	0.041	0.042	0.045
Number of firms	8247	8247	8247	8247	8247	8247	8247

Notes: Robust standard-errors clustered at the firm-level reported in parentheses. ***, **, *, indicate significance at the 1%, 5%, and 10% level. j denotes firms, k industries and t time. Ownership are State Owned, Foreign Owned or Private Domestically Owned firms. *WS* refers to the wholesaling of imported inputs for the year 2002. The estimation sample is balanced panel of firms don't switch sectors and importer status. The additional control variable is listed in the column heading. The construction of these can be found in Section 5.

closer to the consumer are offered greater opportunities for spillovers or input upgrading (Tintelnot et al., 2018) through the supply chain and therefore should benefit more from trade liberalization. Labelled upstreamness, to construct this measure we first compute an output-specific industry upstreamness measure (IC^{v}_{k} in the above equation) following the methodology outlined in Antràs et al. (2012). We then convert this to the input level using weights from the input-output table.

It would appear that this issue of how close the firm is to the end of the production process has no bearing on the benefits from trade liberalization. Moreover, how close the firm is to the final consumer does not modify the productivity effects of input tariff reductions previously found for either direct importers or those that do not directly import. The wholesaling of intermediate inputs remains a significant determinant of revenue productivity during periods of trade liberalization only for firms not directly importing.

Next, in column 3 we explore a more direct measure of the quality of inputs that are produced abroad. This effect of trade liberalization is outlined in Fieler et al. (2018). We follow Khandelwal et al. (2013) and measure product quality using quantity and average unit values at the 6-digit product-origin pair, together with the elasticity of substitution between products computed by Broda et al. (2006) for China. We then construct the $IC^{\gamma}_{k'}$ measure as the average quality of 6-digit product/origin pairs within the industry *k'*, before converting it into an input measure for each sector.

The results presented in column 3 indicate that this works to lower the productivity of firms that do not directly import. Industries in which product quality is higher are associated with a decline in productivity when input tariffs are reduced. The size of the estimated coefficient is similar for direct importers, but it is poorly identified and therefore statistically insignificant. Again, the results for the wholesaling interaction term are left unaltered by the inclusion of this additional interaction term.

The construction of the measure of import wholesaling used within the paper relies only on import transactions conducted using ordinary trade rules. This raises a possibility that sectors with more wholesaling of imports have by construction less international trade conducted under processing trade rules. To explore whether the omission of these processing trade imports can explain our main findings, in column 4 we add a control for the share of processing import within total intermediate inputs. Using the share of processing imports at the industry level, we convert it at the input level using input-output weights as for the other additional industry variable. The main results for wholesaling in column 4 are unchanged compared to those in the

baseline regressions despite the addition of these new interaction terms, although we note that the effect of wholesaling for non-direct importers increases in magnitude in this regression. For the processing trade variable, the results indicate that the productivity of non-direct importers (I + D firms) is higher when there is a higher concentration of processing imported inputs. There are no such effects for direct importers (M firms).

As already discussed above, Arnold et al. (2011) and Arnold et al. (2016) document that the increased globalization of the service sector can improve performance within downstream manufacturing sectors using those services as inputs. In the next two columns of Table 5 we explore whether wholesalers affect firm productivity through channels other than the supply of inputs. In column 5 we explore whether the effects of output tariffs also depend on the presence of wholesalers, and in column 6 we explore intermediaries also matter for exports. In column 5 we introduce an interaction term between output tariffs and a mean centred measure of import wholesaling constructed for the output sector WS_k^y (defined in the data section above). In column 6 we control for the presence of export wholesalers within the industry using the same methodology applied in the construction of the equivalent import version. These export transactions must also be completed under ordinary trade rules in the Chinese Customs data.

The results are suggestive of an effect from wholesalers for both output goods and exports, although with opposite signs. In column 5 there is evidence that the positive productivity effects from reductions to output tariffs are lower when the presence of intermediaries in the output sector of the firm is greater. This suggests that wholesalers contribute to a loss of market share for firms in the domestic market, which moves them up their average cost curve, lowering their revenue productivity. In column 6, we also find some evidence that the productivity benefits for non-direct importers from reductions to input tariffs are smaller when the wholesaling share of exporting is higher. That is, exporters also appear to benefit from the presence of wholesalers. Throughout this, we note that the role import wholesalers play in determining the productivity effects from input tariff reductions retains the same sign and statistical significance.

Thus far, we have assumed that the variable WS, the share of import through wholesaling within an industry, is fixed at its pre-liberalization value. In column 7 we relax this assumption by using measure for WS that we calculate for each year.[21] The effect of using the time varying measure of input wholesaling in column 7 has little effect on the pattern of results found previously. The results from this regression indicate that the intermediation of imported inputs through wholesalers matters for whether firms not directly importing gain or lose following input tariff reductions. When wholesalers provide firms in the domestic market with access to foreign produced inputs the productivity effects of tariff cuts are positive. In contrast they are negative when wholesalers are not present. For direct importers we note their productivity is unaffected by the presence of wholesalers but also the insignificance of the effect of input tariff cuts for direct importing firms, where this had previously been significant. This would appear to be due to a large increase in the standard error in this regression and not to a change in the size of the estimated coefficient. This indicates an increase in noise when using the time-varying measure of wholesaling such that the effect has become less precisely estimated.

4.2. Endogeneity

In this final section, we consider the possibility that trade policy is endogenous. In our context this endogeneity bias is likely to occur because firms within high productivity sectors lobby for lower input tariffs, generating a problem of reverse causality. We instrument for changes in output tariffs and changes in input tariffs (and their interactions) using 1997 levels of output tariffs, 1997 levels of input tariffs (and their interactions) as well as the proportion of workers involved in labor unions (measured at the industry level). Instruments based on initial tariffs have been used previously by Amiti and Konings (2007) and Goldberg and Pavcnik (2005), while Trefler (1993) argues that labor unions can lobby for trade protection. The use of tariff levels prior to the start of our sample period (i.e. the period of WTO liberalization) follows Goldberg and Pavcnik (2005), who show for Colombia that those sectors with the largest change in tariffs over the WTO liberalization period corresponded to the sectors with highest pre-WTO entry tariff levels since WTO negotiations were aimed to reach a uniform tariff rate across sectors.

Following the argument in Amiti and Konings (2007) that it is easier to find instruments for changes in tariffs rather than for levels, we estimate a time differenced model that corresponds to the baseline specification in column 2 of Table 4. This allows for the possibility that tariff changes have different short- versus longer-run outcomes. We difference the model across one, two, three and four year- periods accordingly. The related first-stage regressions are displayed in Tables B1 to B4 of Appendix B. The instruments pass the standard test of weak identification in all specifications.[22] Moreover, the endogeneity test always rejects the null hypothesis that our instrumented variables are exogenous.[23]

Qualitatively the results in Table 6 behave similarly to those in previous tables and change little as we alter the number of years over which the data are time-differenced. While direct importers' productivity improves as a results of input tariff reductions, these same firms appear unaffected by the extent of wholesaling of inputs within the sector. This contrasts with those

[21] As the wholesaling now varies across time in this regression it is no longer collinear with the firm fixed effects. The coefficient on this variable interacted with the not direct importer (I + D) dummy is positive and statistically significant with a coefficient (standard error) of 1.261 (0.176). The same variable interacted with the direct import dummy has a coefficient (standard error) of −0.214 (0.721) and is therefore insignificantly different from zero at conventional levels.

[22] Kleibergen-Paap rk Wald F statistic is above the critical values listed in the Table 1 of Stock and Yogo (2005) in all specifications (it ranges from 189.2 and 237.7).

[23] The *p*-value of Endogeneity statistic is 0.000 across all specifications.

Table 6
Trade liberalization and firm productivity: IV regressions.

Regression no.	(1)	(2)	(3)	(4)
	One-year change	Two-year change	Three-year change	Fourth-year change
Dependent variable	ΔTFP_{jt}	ΔTFP_{jt}	ΔTFP_{jt}	ΔTFP_{jt}
ΔOutput tariff	−0.270	−0.376**	−0.372**	−0.271
	(0.200)	(0.190)	(0.188)	(0.194)
Not direct importers (I + D)$_j$				
×ΔInput tariff$_{kt}$	−1.494*	−1.426*	−1.458*	−1.497**
	(0.764)	(0.791)	(0.786)	(0.752)
×ΔInput tariff$_{kt}$ × WS$_k$	−24.58***	−33.27***	−32.98***	−24.81***
	(5.159)	(5.350)	(5.312)	(5.105)
Direct importers (M) $_j$				
× ΔInput tariff$_{kt}$	−6.742**	−6.179**	−6.426**	−7.095**
	(2.932)	(2.792)	(2.799)	(2.985)
× ΔInput tariff$_{kt}$ × WS$_k$	11.92	4.928	5.843	10.49
	(37.35)	(41.64)	(41.74)	(39.02)
Export status	√	√	√	√
Ownership	√	√	√	√
Firm fixed effects	√	√	√	√
Time dummies	√	√	√	√
Observations	32,013	23,999	15,924	7951
F-statistic for weak identification	216.6	189.2	191.4	237.7
Endogeneity statistic	59.008	223.441	375.488	490.072
p-value	0.000	0.000	0.000	0.000

Notes: Robust standard-errors clustered at the firm-level reported in parentheses. ***, **, *, indicate significance at the 1%, 5%, and 10% level. **j** denotes firms, *k* industries and *t* time. Ownership are State Owned, Foreign Owned or Private Domestically Owned firms. *WS* refers to the wholesaling of imported inputs for the year 2002. The estimation sample is balanced panel of firms don't switch sectors and importer status. The instruments used in these regressions include the output tariff in 1997; input tariffs in 1997 interacted with not direct and direct importer status; input tariffs in 1997 interacted with the 2002 share of wholesaled inputs (*WS*) and not direct and direct importer status; and the labor union share.

firms that do not directly import. For such firms we continue to find evidence of productivity increases from declines in input tariffs, where those gains are largest in sectors where the wholesaling of imports was of greatest importance.

There are differences compared to the baseline model in Table 4 however. Firstly, in Table 6 we consistently find that the effect of input tariff liberalization on the productivity of firms not directly importing is positive in an industry with average levels of wholesaling. In Table 4 the effect of input tariff reductions at the average level of wholesaling was negative. The value of wholesaling at which the input tariff effect turns from negative to positive is correspondingly lower than before, at between 16 and 18% depending on the regression. A second difference compared to the baseline model comes from the size of the productivity gains, which are larger than those suggested by the baseline model in Table 4. For the average reduction in input tariff rates (1.6 percentage points) and at the mean value of import wholesaling (0.151), we now estimate that firm productivity increased by between 2.3% (columns 1 and 4 in Table 6) and 2.4% (columns 2 and 3 in Table 6).

5. Conclusion

Using Chinese data, this paper provides the first evidence of the role played by wholesaling services in determining firm productivity during periods of input trade liberalization in the manufacturing sector. Consistent with other studies in the literature, we find that the productivity of both direct importers as well as the other firms that do not directly import increases following a decrease in input tariffs, where this effect is larger for firms directly involved in importing. While the revenue productivity gains for direct importers can be easily connected to their access to more and/or better foreign intermediate inputs, as several trade theories predict, understanding the nature of the productivity gains for non-direct importing firms has been underexplored. In this paper, we highlight an alternative mechanism: the productivity gains of firms not directly engaged in import activities occur because of their *indirect* access to foreign inputs through wholesalers. We document that firms not directly involved in importing enjoy productivity gains from input tariff reduction only if intermediation of foreign inputs within their sector is high. When wholesalers are not a strong feature of input supply within the industry there are productivity losses from input trade liberalization. This is a potentially important effect from trade liberalization and suggests policy makers should pay more attention to the role played by trade intermediation services.

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Appendix A: A model of input trade liberalization, wholesaling and TFP

This section offers a simple theoretical background to support our empirical analysis, and notably, details how trade liberalization in intermediate inputs affects the revenue productivity of firms who import directly, versus those firms who do not.

We consider a model with two identical countries. Within each country, final good producers j produce using intermediate inputs i provided either by domestic or by foreign input suppliers. Input suppliers are heterogeneous in their productivity and endogenously decide to export or to only sell their output domestically. Final good producers, who are also heterogeneous in their productivity, endogenously decide their import-mode, that is to import directly from foreign input suppliers (M), to import indirectly through wholesalers (I) or to not import at all (D).

The Eqs. (1), (2) and (3) are identical to the one presented in Section 2. We report them below for completeness. The two identical countries and populated by L consumers. Consumers have constant elasticity of substitution (CES) preferences across differentiated final goods. As a result, final good producers face the same isoelastic demand function:

$$y_j = C\left(p_j\right)^{-\sigma}$$

where $\sigma > 1$ is the constant elasticity of substitution between any two varieties j and $C = \mathbb{E}(\mathbb{P})^{\sigma-1}$, with $\mathbb{P}$ the final good price index and $\mathbb{E}$ denotes total revenue. The wage rate w is our *numeraire* and is normalized to one. As a result, total revenue $\mathbb{E} = L$ in the differentiated good sector is also constant.

Final good producers have an exogenous Hicks-neutral productivity level Θ_j and integrate together a set of intermediate inputs x_i into final goods as in Ethier (1982), that in turn are sold to consumers.

$$y_j^m = \Theta_j X^m \text{ with } X^m = \left(\int \left(x_i^H\right)^{\frac{\sigma-1}{\sigma}} di + \delta \int \left(x_i^{F\_m}\right)^{\frac{\sigma-1}{\sigma}} di\right)^{\frac{\sigma}{\sigma-1}}$$

where $\sigma > 1$ is also the elasticity of substitution between intermediate input varieties i. The subscript H indicates inputs produced at Home, while F indicates inputs produced in the foreign country. δ is a firm specific dummy variable which takes the value 1 if the final good producer is either a direct or an indirect importer ($m = M, I$) and the value 0 if the final good producer is not importing any inputs ($m = D$).

Given the isoelastic demand function faced by final producers j, these firms will set a price as a constant mark-up over their marginal cost, which depends on both their Hicks-neutral productivity Θ_j and the price index of their intermediate inputs P^m, which will take the following form:

$$p_j^m = \frac{\sigma}{\sigma-1}\frac{P^m}{\Theta_j} \text{ with } P^m = \left(\int \left(p_i^H\right)^{1-\sigma} di + \delta \int \left(p_i^{F\_m}\right)^{1-\sigma} di\right)^{\frac{1}{1-\sigma}}$$

Final good producers that are direct- or indirect-importers (M and I firms) will be able to consume both domestic and foreign varieties, while non-importers (D firms) will only be able to use domestic inputs.

A.1. Demand function for intermediate inputs

Final good producers minimize total cost of intermediate inputs, subject to the production technology in (2).

$$\min_{x_i} \int p_i x_i \qquad \text{Subject to: } \frac{y_j}{\Theta_j} \geq \left(\int x_i^{\frac{\sigma-1}{\sigma}}\right)^{\frac{\sigma}{\sigma-1}}$$

As a result, the firm-level demand function for intermediate inputs takes the following form:

$$x_i^m = \left(\frac{p_i}{P^m}\right)^{-\sigma}\frac{y_j}{\Theta_j} \tag{A1}$$

Replacing y_j using (1) and then adding (3), we obtain a unique demand function for each input variety for all type of final good producers (direct-importers, indirect-importers and non-importers):

$$x_i = \Theta_j{}^{\sigma-1}B(p_i)^{-\sigma} \text{ with } B = \frac{\mathbb{E}}{(\mathbb{P})^{1-\sigma}}\left(\frac{\sigma}{\sigma-1}\right)^{-\sigma} \tag{A2}$$

Summing the demand across all final good producers that are non-importers (D), indirect-importers (I) and direct importers (M) in each country and multiplying by the price, we then obtain the total revenue generated by a given input i in the domestic market:

$$r_i^H = BA^H(p_i)^{1-\sigma} \text{with } A^H = \int_D \Theta_j{}^{\sigma-1}dj + \int_I \Theta_j{}^{\sigma-1}dj + \int_M \Theta_j{}^{\sigma-1}dj \tag{A3}$$

The foreign revenue arising from all direct importers is given by $r_i^{FM} = B(p_i^F)^{1-\sigma}\int_M \Theta_j{}^{\sigma-1}dj$, while the foreign revenue of input variety coming from all indirect importers is given by $r_i^{FI} = B(p_i^{FI})^{1-\sigma}\int_I \Theta_j{}^{\sigma-1}dj$. Summing both the foreign demand by direct and indirect importers, we obtain the total foreign revenue:

$$r_i^F = BA^F\left(p_i^F\right)^{1-\sigma} \text{with } A^F = (\gamma)^{1-\sigma}\int_I \Theta_j{}^{\sigma-1}dj + \int_M \Theta_j{}^{\sigma-1}dj \tag{A4}$$

Where $\gamma = p_i^{F\_I}/p_i^F$ reflects the relative price difference of exporting goods via wholesalers at price $p_i^{F\_I}$, compared to exporting good directly at price p_i^F. In the model we assume the extra cost γ associated with imports via wholsalers will take the form of an extra iceberg cost.

A.2. Production and profit function for intermediate inputs

The intermediate input sector is characterized by a continuum of heterogeneous monopolistically competitive suppliers. Intermediate input suppliers produce using the following technology:

$$q_i = \varphi_i l\,(1+\mu(\tau)) \tag{A5}$$

where φ_i is the input supplier i's idiosyncratic productivity and l is the amount of labor hired. Suppliers can sell output to final goods producers located in both countries. Suppliers face an iceberg transport cost τ when selling abroad. When selling to indirect-importers, an extra iceberg cost γ will also be included, which already have been integrated when defining the total foreign revenue Θ^F. Finally, we consider the possibility for spillover effects related to trade liberalization, $1+\mu(\tau)$, increasing homogeneously the productivity level of all suppliers in the intermediate sector when τ decreases. Given the isoelastic aggregate demand functions, input suppliers set their prices as a constant mark-up over marginal costs:

$$p_i^H = \frac{\sigma}{\sigma-1}\frac{1}{\varphi[1+\mu(\tau)]} \text{ and } p_i^F = \tau p_i^H, \tag{A6}$$

Domestic and foreign operating profits (before incurring any fixed cost) will be a constant ratio of their revenue, so that profits can be written as follows:

$$\pi_i^l = \frac{r_i^l}{\sigma} - f_l = \frac{1}{\sigma}BA^l\left(p_i^l\right)^{1-\sigma} - f_l, \text{with } l = (H, F) \tag{A7}$$

Placing prices into the profit functions and considering both domestic and export zero profit conditions, we obtain the following domestic and export productivity cut-offs:

$$\varphi_H = \frac{\sigma}{\sigma-1}\frac{1}{[1+\mu(\tau)]}\left(\frac{\sigma f_H}{BA^H}\right)^{\frac{1}{\sigma-1}} \text{ and } \varphi_F = \varphi_H\tau\left(\frac{A^F f_H}{A^H f_F}\right)^{\frac{1}{1-\sigma}}, \tag{A8}$$

Assuming $f_F \geq (\tau)^{1-\sigma}(A^F/A^H)f_H$ the selection into exporting will be similar to Melitz (2003), where only the most productive input suppliers will be able to export, while the least productive may decide not to produce.

A.3. Intermediate input price indexes

We assume that productivity is drawn from a known Pareto cumulative distribution function $G(\varphi) = 1 - \varphi^{-\kappa}$, and probability distribution function $g(\varphi) = \kappa\,\varphi^{-1-\kappa}$, with $k > \sigma - 1$. Using domestic and foreign prices p_i^H and p_i^F and recalling that $p_i^{F\_I} = \gamma p_i^F$, using the PDF of the Pareto distribution, solving for the integrals and then replacing the entry and export cut-off in the equations (φ_H,φ_F), we obtain:

$$P^D = \left(\int_{\varphi_H}^{\infty} p_i^H(i)^{1-\sigma}\frac{g(\varphi)d\varphi}{1-G(\varphi_H)}\right)^{\frac{1}{1-\sigma}}$$

$$= \left(\frac{k}{\kappa-(\sigma-1)}\right)^{\frac{1}{1-\sigma}}\frac{\sigma}{\sigma-1}N_H^{\frac{1}{1-\sigma}}[\varphi_H[1+\mu(\tau)]]^{-1} \tag{A9}$$

$$P^M = \left(\int_{\varphi_H}^{\infty} p_i^H(i)^{1-\sigma}\frac{g(\varphi)d\varphi}{1-G(\varphi_H)} + \int_{\varphi_F}^{\infty} p_i^{F\_M}(i)^{1-\sigma}\frac{g(\varphi)d\varphi}{1-G(\varphi_H)}\right)^{\frac{1}{1-\sigma}}$$

$$= \left[1+(\tau)^{-k}\left(\frac{A^F f_H}{A^H f_F}\right)^{\frac{\sigma-\kappa-1}{1-\sigma}}\right]^{\frac{1}{1-\sigma}}P^D \tag{A10}$$

$$P^I = \left(\int_{\varphi_H}^{\infty} p_i^H(i)^{1-\sigma}\frac{g(\varphi)d\varphi}{1-G(\varphi_H)} + \int_{\varphi_F}^{\infty} p_i^{F\_I}(i)^{1-\sigma}\frac{g(\varphi)d\varphi}{1-G(\varphi_H)}\right)^{\frac{1}{1-\sigma}}$$

$$= \left[1+(\gamma)^{1-\sigma}(\tau)^{-k}\left(\frac{A^F f_H}{A^H f_F}\right)^{\frac{\sigma-\kappa-1}{1-\sigma}}\right]^{\frac{1}{1-\sigma}}P^D \tag{A11}$$

A.4. Free entry condition and number of input varieties

Solving the inputs' price index of non-importers P^D requires both the entry cut-off φ_H and the number of active firms N_H. As in Melitz (2003), suppliers have to pay a sunk cost of entry f_e in order to discover their idiosyncratic productivity level φ. Suppliers then decide whether to exit the market, or stay and produce only for the domestic market or for both the domestic and export markets.

$$\tilde{\pi} = \int \pi(\varphi)dG(\varphi) = \frac{f_e}{1-G(\varphi_H)} \overset{yields}{\rightarrow} \varphi_H = \left[\frac{\tilde{\pi}}{f_e}\right]^{\frac{1}{k}} = \left[\frac{\tilde{r}-\sigma\tilde{f}}{\sigma f_e}\right]^{\frac{1}{k}} \tag{A12}$$

We obtain the average revenue $\bar{r}$ of active suppliers by using the expression for r_i^H and r_i^F and the PDF of the Pareto distribution, solving for the integrals and then replacing the entry and export cut-off in the equations (φ_H,φ_F), we obtain the following expression:

$$\tilde{r} = \int_{\varphi_H}^{\infty} r_D\frac{g(\varphi)d\varphi}{1-G(\varphi_H)} + \int_{\varphi_F}^{\infty} r_F\frac{g(\varphi)d\varphi}{1-G(\varphi_H)}$$

$$= \frac{\sigma\kappa}{\kappa-(\sigma-1)} f_H \left\{ 1 + (\tau)^{-k} \frac{A^F}{A^H} \left(\frac{A^F f_H}{A^H f_F} \right)^{\frac{\sigma-\kappa-1}{1-\sigma}} \right\} \tag{A13}$$

All active suppliers pay the fixed cost of producing f_H while only a fraction $[1 - G(\varphi_F)\ ]/[1 - G(\varphi_H)\ ] = (\varphi_F/\varphi_H)^{-\kappa}$ are exporting and pay an additional fixed cost f_F, such that the average fixed-cost $\bar{f}$ of active suppliers is given by:

$$\tilde{f} = f_H \left\{ 1 + (\tau)^{-k} \frac{A^F}{A^H} \left(\frac{A^F f_H}{A^H f_F} \right)^{\frac{\sigma-\kappa-1}{1-\sigma}} \right\} \tag{A14}$$

The mass of suppliers producing for the domestic market N_H id obtained by dividing the aggregate revenue in the intermediate input sector R by the average revenue $\bar{r}$ of active suppliers: $N_H = R/\tilde{r}$.

$$N_H = \frac{R}{\frac{\sigma\kappa}{\kappa-(\sigma-1)} f_H \left\{ 1 + (\tau)^{-k} \frac{A^F}{A^H} \left(\frac{A^F f_H}{A^H f_F} \right)^{\frac{\sigma-\kappa-1}{1-\sigma}} \right\}} \tag{A15}$$

By replacing $\tilde{r}$ and $\tilde{f}$, taken from Eqs. (A13) and (A14) respectively, into eq. (A12), we obtain the entry cut-off φ_H.

$$\varphi_H = \left[\frac{1}{\sigma f_e} \right]^{\frac{1}{k}} \left[\frac{\sigma(\sigma-1)}{\kappa-(\sigma-1)} f_H \left\{ 1 + (\tau)^{-k} \frac{A^F}{A^H} \left(\frac{A^F f_H}{A^H f_F} \right)^{\frac{\sigma-\kappa-1}{1-\sigma}} \right\} \right]^{\frac{1}{k}} \tag{A16}$$

Replacing the entry cut-off φ_H and the number of active firms N_H in (A9), we obtain the following expression for P^D:

$$P^D \propto \left(1 + \frac{A^F}{A^H} (\tau)^{-k} \left(\frac{A^F f_H}{A^H f_F} \right)^{\frac{\sigma-\kappa-1}{1-\sigma}} \right)^{\frac{k-(\sigma-1)}{k(\sigma-1)}} [[1 + \mu(\tau)]]^{-1} \tag{A17}$$

A.5. Endogenous import decision of final-good producers

The operating profit (before incurring any fixed cost) will be a constant ratio of their revenue, so that the domestic profit can be written as follows:

$$\pi_j^m = \frac{1}{\sigma} \left(p_j^m \right)^{1-\sigma} \mathbb{E} (\mathbb{P})^{\sigma-1} - f_m \tag{A18}$$

Assume $f_M > f_I > f_D$. Zero-profit condition of non-importers is given by $\pi_j^D(\Theta^D) = 0$. Indirect-import cutoff is given by $\pi_j^I(\Theta^I) - \pi_j^D(\Theta^I) = 0$, while direct-import cutoff is $\pi_j^M(\Theta^M) - \pi_j^I(\Theta^M) = 0$.

$$\Theta^D = \frac{\sigma}{\sigma-1} \left(\frac{1}{\sigma f_D} \mathbb{E} \right)^{\frac{1}{1-\sigma}} \frac{P^D}{\mathbb{P}} \tag{A19}$$

$$\Theta^I = \frac{\sigma}{\sigma-1} \left(\frac{1}{\sigma} \mathbb{E} \right)^{\frac{1}{1-\sigma}} \frac{1}{\mathbb{P}} \left[\frac{\left(P^I \right)^{1-\sigma} - \left(P^D \right)^{1-\sigma}}{f_I - f_D} \right]^{\frac{1}{1-\sigma}}$$

$$= \Theta^D \left[\frac{f_D}{f_I - f_D} (\gamma)^{1-\sigma} (\tau)^{-k} \left(\frac{A^F f_H}{A^H f_F} \right)^{\frac{\sigma-\kappa-1}{1-\sigma}} \right]^{\frac{1}{1-\sigma}} \tag{A20}$$

$$\Theta^M = \frac{\sigma}{\sigma-1}\left(\frac{1}{\sigma}\mathbb{E}\right)^{\frac{1}{1-\sigma}}\frac{1}{\mathbb{P}}\left[\frac{\left(P^M\right)^{1-\sigma}-\left(P^I\right)^{1-\sigma}}{f_M-f_I}\right]^{\frac{1}{1-\sigma}}$$

$$= \Theta^D\left[\frac{f_D}{f_M-f_I}\left[1-(\gamma)^{1-\sigma}\right](\tau)^{-k}\left(\frac{A^F f_H}{A^H f_F}\right)^{\frac{\sigma-\kappa-1}{1-\sigma}}\right]^{\frac{1}{1-\sigma}} \tag{A21}$$

We assume that final-good producers also draw their productivity from a known Pareto cumulative distribution function H $(\Theta) = 1 - \Theta^{-\nu}$, and probability distribution function $h(\Theta) = \nu\,\Theta^{-1-\nu}$, with $\nu > \sigma - 1$. With this assumption in hand, we can calculate the share of final-good producers χ^m with $m = (D,I,M)$, that are non-importers (D), indirect-importers (I) or direct-importers (M) among all active final-good producers:

$$\chi^I = \left(\frac{\Theta^I}{\Theta^D}\right)^{-\nu} - \left(\frac{\Theta^M}{\Theta^D}\right)^{-\nu} = \left[(\tau)^{-k}\left(\frac{A^F f_H}{A^H f_F}\right)^{\frac{\sigma-\kappa-1}{1-\sigma}}\right]^{\frac{\nu}{\sigma-1}}\left(\left[\frac{f_D}{f_I-f_D}(\gamma)^{1-\sigma}\right]^{\frac{\nu}{\sigma-1}} - \left[\frac{f_D}{f_M-f_I}\left[1-(\gamma)^{1-\sigma}\right]\right]^{\frac{\nu}{\sigma-1}}\right) \tag{A22}$$

$$\chi^D = 1-\left(\frac{\Theta^I}{\Theta^D}\right)^{-\nu} = 1-\left[\frac{f_D}{f_I-f_D}(\gamma)^{1-\sigma}(\tau)^{-k}\left(\frac{A^F f_H}{A^H f_F}\right)^{\frac{\sigma-\kappa-1}{1-\sigma}}\right]^{\frac{\nu}{\sigma-1}} \tag{A23}$$

The share of firms importing directly will simply be $\chi^M = 1 - (\chi^I + \chi^D)$.
Using (A3) and (A4) we can also rewrite A^H and A^F across all K final-good producers as follow:

$$A^H = K\left[\int_{\Theta^D}^{\Theta^I}\Theta_j^{\sigma-1}\frac{h(\theta)}{1-H(\Theta^D)} + \int_{\Theta^I}^{\Theta^M}\Theta_j^{\sigma-1}\frac{h(\theta)}{1-H(\Theta^D)} + \int_{\Theta^M}^{\infty}\Theta_j^{\sigma-1}\frac{h(\theta)}{1-H(\Theta^D)}\right]$$

$$A^F = K\left[(\gamma)^{1-\sigma}\int_{\Theta^I}^{\Theta^M}\Theta_j^{\sigma-1}\frac{h(\theta)}{1-H(\Theta^D)} + \int_{\Theta^M}^{\infty}\Theta_j^{\sigma-1}\frac{h(\theta)}{1-H(\Theta^D)}\right]$$

Solving for the ratio A^F/A^H, we obtain:

$$\frac{A^F}{A^H} = \left[(\gamma)^{1-\sigma}\left[\frac{f_D(\gamma)^{1-\sigma}}{f_I-f_D}\right]^{\frac{\nu-(\sigma-1)}{\sigma-1}} + \left(1-(\gamma)^{1-\sigma}\right)\left[\frac{f_D\left[1-(\gamma)^{1-\sigma}\right]}{f_M-f_I}\right]^{\frac{\nu-(\sigma-1)}{\sigma-1}}\right]^{\frac{(\sigma-1)(\sigma-1)}{\delta}}$$

$$\times\left[\frac{f_H}{f_F}\right]^{\frac{(\nu-(\sigma-1))(k-(\sigma-1))}{\delta}}(\tau)^{-k\frac{(\sigma-1)(\nu-(\sigma-1))}{\delta}} \tag{A24}$$

where we assume $\delta = \nu(\sigma-1) + k(\sigma-1) - k\nu > 0$. This condition is required to ensure that the ratio A^F/A^H is indeed less than one - which should be the case by definition. In this case, a decrease of the input trade cost τ or of the fixed cost of exporting f_F leads to a reallocation effect where export revenue increases compared to domestic revenue.

A.6. Empirical implications of the model

The effect of input trade liberalization is expected to be different depending on the prevalence of firms importing through wholesalers among the group of firms that are not directly importing (I + D firms).

First, we abstract from potential positive spillover effects related to trade liberalization, $1 + \mu(\tau)$. Recall that the inputs' price index of non- importers (D firms) given by equation (*A*17) is:

$$P^D \propto \left(1 + \frac{A^F}{A^H}(\tau)^{-k}\left(\frac{A^F f_H}{A^H f_F}\right)^{\frac{k-(\sigma-1)}{\sigma-1}}\right)^{\frac{k-(\sigma-1)}{k(\sigma-1)}} [[1+\mu(\tau)]]^{-1}$$

Holding A^H and A^F constant, it follows directly from this expression that as the input trade cost τ decreases, the price index of intermediate inputs faced by non-importers, P^D, increases. It also follows directly that a decrease in τ implies an increase in the ratio A^F/A^H, reinforcing this increase.

As a result, in an industry where the cost associated with intermediaries is high enough such that no firms choose to import using wholesalers, then $P^{I+D} = P^D$. As P^D is increasing with input trade liberalization, a negative effect on firms' revenue-based TFP is expected from input trade liberalization in an industry where the costs of intermediation are high.

Considering industries with lower cost of intermediation, this negative effect will be mitigated by the increase in the share of firms able to import through intermediaries. In fact, trade liberalization in intermediate inputs decreases P^I/P^D. To see this, using Eq. (A11), recall that:

$$\frac{P^I}{P^D} = \left[1 + (\gamma)^{1-\sigma}(\tau)^{-k}\left(\frac{A^F f_H}{A^H f_F}\right)^{\frac{k-(\sigma-1)}{\sigma-1}}\right]^{\frac{1}{1-\sigma}}$$

As a result, the relative benefit of trade liberalization on the revenue-based TFP of non-direct importers (I + D firms) will be higher in an industry where the share of firms importing indirectly is high compared to the share of firms not importing at all.

Second, a difficulty when evaluating the impact of input trade liberalization on the group of firms not importing directly in a given sector (I + D firms) is that we do not observe the share of firms importing indirectly in the data. In addition, the cost associated with intermediaries within an industry is also not observable empirically. However, we can show that there is an inverse relationship between the Wholesaler Share (WS) variable, i.e. the share of final-good producers importing via wholesalers among all importers, and the cost associated with intermediaries within an industry, γ.

$$WS = \frac{\chi^I}{(\chi^M + \chi^I)} = 1 - \left(\frac{\Theta^M}{\Theta^I}\right)^{-v} = 1 - \left[\frac{f_I - f_D\left[1-(\gamma)^{1-\sigma}\right]}{f_M - f_I \quad (\gamma)^{1-\sigma}}\right]^{\frac{v}{\sigma-1}}$$

where WS is decreasing in γ. The Wholesaler Share (WS) variable can also be expressed as the share of the import expenditure via wholesalers in total import of intermediate inputs purchased within the final good sector.

$$WS\_value = \frac{r_i^{F\_I}}{r_i^{F\_M} + r_i^{F\_I}} = 1 - \left[\left(\frac{f_I - f_D\left[1-(\gamma)^{1-\sigma}\right]}{f_M - f_I \quad \left[(\gamma)^{1-\sigma}\right]}\right)^{-\frac{v-(\sigma-1)}{\sigma-1}} \gamma^{1-\sigma} + \left(1-(\gamma)^{1-\sigma}\right)\right]^{-1}$$

where it can be shown increasing the cost associated with intermediaries, γ, decrease the import expenditure via wholesalers within an industry, that is $\partial WS\_value/\partial\gamma < 0$. This theoretical result is key for the interpretation of our empirical results. Input trade liberalization is expected to decrease TFP in an industry with high input wholesaling cost, that is where WS is low, while this negative productivity loss will be mitigated in an industry with low input wholesaling cost, that is where WS is high.

Critically, both measures for WS are independent of the iceberg transport cost τ and so are unaffected by trade liberalization in the intermediate input sector. For this reason, we will consider WS in our empirical specification as an industry characteristics invariant over time.

Third, let us consider the possibility for a spillover effect related to trade liberalization, increasing the productivity level of all suppliers in the intermediate sector by $1 + \mu(\tau)$ as in eq. (A6). As a result, the intermediate input price indices reported in Eqs. (A9)–(A11) for all final good producers decreases and the revenue-based TFP of all final-good producers increase homogeneously.

In an industry with high intermediaries cost such that no firm choose to import using wholesalers, a positive spillover effect could potentially counter-balance the negative effect of input trade liberalization described above. In this case, P^D may decrease with input trade liberalization and all firms experience an increase of their revenue-based TFP.

Nevertheless, a homogeneous positive spillover would not affect the relative gains from input trade liberalization experienced by firms importing using wholesalers. In fact, P^I/P^D is not affected by the spillover effect. In this case, the positive spillover effects associated with input liberalization will increase firms' revenue-based TFP but would not affect the magnitude of the range of effects when comparing industry where WS is high with an industry where WS is low. In other words, any spillover effects will affect the average change in TFP (in a hypothetical industry with an average level of WS), but not the coefficient associated with interaction between tariff changes and WS that is of interest to us.

Appendix B. Instrumental variable approach: First-stage regressions

Table B1
First stage in IV estimation (One-period difference).

Variables	(1)	(2)	(3)	(4)	(5)
		Non-importers		*Direct importers*	
	ΔOutput tariff	ΔInput tariff	Δ(Input tariff × WS_{2002})	ΔInput tariff	Δ(Input tariff × WS_{2002})
Output $tariff_{1997}$	−0.0573***	−0.0019***	−4.23e-05***	−3.35e-05***	2.00e-07
	(0.0014)	(0.0002)	(1.35e-05)	(1.25e-05)	(7.85e-07)
Not direct importers $(I + D)_j$					
× Input $tariff_{1997}$	−0.0526***	−0.0692***	−0.0009***	−0.0002***	−6.72e-06*
	(0.00545)	(0.0008)	(4.47e-05)	(5.83e-05)	(3.97e-06)
× Input $tariff_{1997}$ × WS	0.131***	−0.0061	−0.0463***	0.0006***	2.20e-05
	(0.0334)	(0.0041)	(0.0004)	(0.0002)	(1.46e-05)
Direct importers $(M)_j$					
× Input $tariff_{1997}$	−0.0542***	−0.0337***	−0.0009***	−0.0371***	1.54e-05
	(0.0115)	(0.0014)	(6.27e-05)	(0.0023)	(0.0001)
× Input $tariff_{1997}$ × WS	0.132	0.141***	0.0037***	−0.113**	−0.0492***
	(0.166)	(0.0224)	(0.0008)	(0.0507)	(0.0058)
Labor union share	6.25e-06***	2.74e-06***	2.79e-07***	3.08e-09	2.04e-09**
	(7.25e-07)	(8.49e-08)	(6.34e-09)	(1.52e-08)	(8.41e-10)
Δ Export status	√	√	√	√	√
Δ Ownership	√	√	√	√	√
Time dummies	√	√	√	√	√
Observations	32,013	32,013	32,013	32,013	32,013

Notes: The dependent variable is firm's total factor productivity estimated by Olley-Pakes (2003)'s methodology. *WS* refers to the wholesaling of imported inputs for the year 2002. Ownership are State Owned, Foreign Owned or Private Domestically Owned firms. Robust standard-errors clustered at the firm-level reported in parentheses. ***, **, *, indicate significance at the 1%, 5%, and 10% level.

Table B2
First stage in IV estimation (Two-period difference).

Variables	(1)	(2)	(3)	(4)	(5)
		Non-importers		*Direct importers*	
	ΔOutput tariff	ΔInput tariff	Δ(Input tariff × WS_{2002})	ΔInput tariff	Δ(Input tariff × WS_{2002})
Output $tariff_{1997}$	−0.119***	−0.0045***	−0.0002***	−7.46e-05***	−3.90e-08
	(0.0032)	(0.0004)	(2.87e-05)	(2.71e-05)	(1.67e-06)
Not direct importers $(I + D)_j$					
×Input $tariff_{1997}$	−0.119***	−0.143***	−0.0020***	−0.0004***	−1.51e-05*
	(0.0120)	(0.0017)	(9.87e-05)	(0.000124)	(8.45e-06)
×Input $tariff_{1997}$ × WS	0.287***	−0.0459***	−0.0971***	0.0013***	4.80e-05
	(0.0745)	(0.0089)	(0.000877)	(0.0005)	(3.07e-05)
Direct importers $(M)_j$					
×Input $tariff_{1997}$	−0.133***	−0.0717***	−0.0020***	−0.0748***	1.14e-05
	(0.0221)	(0.0029)	(0.0001)	(0.0050)	(0.0002)
×Input $tariff_{1997}$ × WS	0.485*	0.305***	0.0088***	−0.270**	−0.103***
	(0.277)	(0.0464)	(0.0019)	(0.114)	(0.0136)
Labor union share	1.58e-05***	6.89e-06***	6.31e-07***	1.36e-08	4.49e-09**
	(1.50e-06)	(1.86e-07)	(1.46e-08)	(3.25e-08)	(1.91e-09)
Δ Export status	√	√	√	√	√
Δ Ownership	√	√	√	√	√
Time dummies	√	√	√	√	√
Observations	23,999	23,999	23,999	23,999	23,999

Notes: The dependent variable is firm's total factor productivity estimated by Olley-Pakes (2003)'s methodology. *WS* refers to the wholesaling of imported inputs for the year 2002. Ownership are State Owned, Foreign Owned or Private Domestically Owned firms. Robust standard-errors clustered at the firm-level reported in parentheses. ***, **, *, indicate significance at the 1%, 5%, and 10% level.

Table B3
First stage in IV estimation (Three-period difference).

Variables	(1)	(2)	(3)	(4)	(5)
		Non-importers		*Direct importers*	
	ΔOutput tariff	ΔInput tariff	Δ(Input tariff × WS_{2002})	ΔInput tariff	Δ(Input tariff × WS_{2002})
Output $tariff_{1997}$	−0.182***	−0.0071***	−0.0002***	−0.0001***	−5.86e-07
	(0.0047)	(0.0007)	(4.31e-05)	(3.90e-05)	(2.36e-06)
Not direct importers $(I + D)_j$					
×Input $tariff_{1997}$	−0.176***	−0.215***	−0.0029***	−0.0005***	−2.11e-05*
	(0.0181)	(0.00251)	(0.000148)	(0.0002)	(1.24e-05)
×Input $tariff_{1997}$ × WS	0.424***	−0.0660***	−0.146***	0.0018***	7.00e-05
	(0.112)	(0.0134)	(0.00131)	(0.000677)	(4.52e-05)
Direct importers $(M)_j$					
×Input $tariff_{1997}$	−0.196***	−0.108***	−0.0030***	−0.113***	2.54e-06
	(0.0332)	(0.0043)	(0.0002)	(0.0074)	(0.0004)
×Input $tariff_{1997}$ × WS	0.743*	0.460***	0.0131***	−0.407**	−0.155***
	(0.416)	(0.0690)	(0.00276)	(0.169)	(0.0203)
Labor union share	2.36e-05***	1.03e-05***	9.52e-07***	1.78e-08	6.49e-09**
	(2.26e-06)	(2.78e-07)	(2.20e-08)	(4.80e-08)	(2.77e-09)
Δ Export status	√	√	√	√	√
Δ Ownership	√	√	√	√	√
Time dummies	√	√	√	√	√
Observations	15,924	15,924	15,924	15,924	15,924

Notes: The dependent variable is firm's total factor productivity estimated by Olley-Pakes (2003)'s methodology. *WS* refers to the wholesaling of imported inputs for the year 2002. Ownership are State Owned, Foreign Owned or Private Domestically Owned firms. Robust standard-errors clustered at the firm-level reported in parentheses. ***, **, *, indicate significance at the 1%, 5%, and 10% level.

Table B4
First stage in IV estimation (Four-period difference).

Variables	(1)	(2)	(3)	(4)	(5)
		Non-importers		*Direct importers*	
	ΔOutput tariff	ΔInput tariff	Δ(Input tariff × WS_{2002})	ΔInput tariff	Δ(Input tariff × WS_{2002})
Output $tariff_{1997}$	−0.237***	−0.0079***	−0.0001**	−0.0002***	−1.69e-07
	(0.0055)	(0.0009)	(5.40e-05)	(5.02e-05)	(3.05e-06)
Not direct importers $(I + D)_j$					
×Input $tariff_{1997}$	−0.196***	−0.278***	−0.0034***	−0.0006***	−2.34e-05
	(0.0221)	(0.0031)	(0.0002)	(0.0002)	(1.57e-05)
×Input $tariff_{1997}$ × WS	0.452***	−0.0219	−0.186***	0.0021**	7.51e-05
	(0.135)	(0.0163)	(0.0016)	(0.0009)	(5.74e-05)
Direct importers $(M)_j$					
×Input $tariff_{1997}$	−0.220***	−0.135***	−0.0034***	−0.149***	2.13e-05
	(0.0434)	(0.0054)	(0.0002)	(0.0093)	(0.0004)
× Input $tariff_{1997}$ × WS	0.816	0.579***	0.0150***	−0.469**	−0.199***
	(0.591)	(0.0863)	(0.0032)	(0.200)	(0.0232)
Labor union share	2.59e-05***	1.12e-05***	1.11e-06***	−4.23e-09	6.68e-09**
	(2.95e-06)	(3.40e-07)	(2.54e-08)	(5.78e-08)	(3.00e-09)
Δ Export status	√	√	√	√	√
Δ Ownership	√	√	√	√	√
Observations	7951		7951	7951	

Notes: The dependent variable is firm's total factor productivity estimated by Olley-Pakes (2003)'s methodology. *WS* refers to the wholesaling of imported inputs for the year 2002. Ownership are State Owned, Foreign Owned or Private Domestically Owned firms. Robust standard-errors clustered at the firm-level reported in parentheses. ***, **, *, indicate significance at the 1%, 5%, and 10% level.

References

Ahn, J., Khandelwal, A.K., Wei, S.-J., 2011. The role of intermediaries in facilitating trade. J. Int. Econ. 84 (1), 73–85.
Akerman, A., 2010. A Theory on the Role of Wholesalers in International Trade Based on Economies of Scope, Research Papers in Economics 2010:1. Stockholm University, Department of Economics.
Amiti, M., Konings, J., 2007. Trade liberalization, intermediate inputs, and productivity: Evidence from Indonesia. Am. Econ. Rev. 97 (5), 1611–1638.
Antràs, P., Costinot, A., 2010. Intermediation and economic integration. Am. Econ. Rev. Pap. Proc. 100 (2), 424–428.
Antràs, P., Costinot, A., 2011. Intermediated trade. Q. J. Econ. 126 (3), 1319–1374.
Antràs, P.D., Chor, T. Fally, Hillberry, R., 2012. Measuring the upstreamness of production and trade flows. Am. Econ. Rev. Pap. Proc. 102 (3), 412–416.
Arnold, J.M., Javorcik, B.S., Matoo, A., 2011. Does services liberalization benefit manufacturing firms: evidence from the Czech Republic. J. Int. Econ. 85 (1), 136–146.
Arnold, J.M., Javorcik, B.S., Lipscomb, M., Matoo, A., 2016. Services reform and manufacturing performance: Evidence from India. Econ. J. 126 (590), 1–39.
Bas, M., Strauss-Kahn, V., 2015. Input-trade liberalization, export prices and quality upgrading. J. Int. Econ. 95 (2), 250–262.
Bernard, A.B., Jensen, J.B., Schott, P.K., 2006. Trade costs, firms and productivity. J. Monet. Econ. 53 (5), 917–937.
Bernard, A.B., Jensen, J.B., Redding, S.J., Schott, P.K., 2010. Wholesalers and retailers in US trade. Am. Econ. Rev. 100 (2), 408–413.
Biglaiser, G., 1993. Middlemen as experts. RAND J. Econ. 24 (2), 212–223.
Biglaiser, G., Friedman, J.W., 1994. Middlemen as guarantors of quality. Int. J. Indus. Organ. 12 (4), 509–531.
Blum, B.S., Claro, S., Horstmann, I.J., 2009. Intermediation and the Nature of Trade Intermediation and the Nature of Trade. University of Toronto, Mimeo.
Brandt, L., Van Biesebroeck, J., Wang, L., Zhang, Y., 2017. WTO accession and performance of Chinese manufacturing firms. Am. Econ. Rev. 107 (9), 2784–2820.
Broda, C., Greenfield, J., Weinstein, D., 2006. From groundnuts to globalization: A structural estimate of trade and growth. NBER Working Paper No. 12512, Sept. 2006.
Crozet, M., Lalanne, G., Poncet, S., 2013. Wholesalers in international trade. Eur. Econ. Rev. 58 (C), 1–17.
Eslava, M., Fieler, A.C., Xu, D.Y., 2015. (Indirect) input linkages. Am. Econ. Rev. 105 (5), 662–666.
Ethier, W., 1982. National and international returns to scale in the modern theory of international trade. Am. Econ. Rev. 72 (3), 389–405.
Felbermayr, G., Jung, B., 2011. Trade intermediation and the organization of exporters. Rev. Int. Econ. 19 (4), 634–648.
Fieler, A.C., Eslava, M., Xu, D.X., 2018. Trade, quality upgrading, and input linkages: Theory and evidence from Colombia. Am. Econ. Rev. 108 (1), 109–146.
Goldberg, P.K., Pavcnik, N., 2005. Trade, wages, and the political economy of trade protection: Evidence from the Colombian trade reforms. J. Int. Econ. 66 (1), 75–105.
Halpern, L., Koren, M., Szeidl, A., 2015. Imported inputs and productivity. Am. Econ. Rev. 105 (12), 3660–3703.
Hu, A.G., Liu, Z., 2014. Trade liberalization and firm productivity: Evidence from Chinese manufacturing industries. Rev. Int. Econ. 22 (3), 488–512.
Jones, G., 1998. Multinational trading companies in history and theory. In: Jones, G. (Ed.), The Multinational Traders. Routledge, London, pp. 1–21.
Kasahara, H., Rodrigue, J., 2008. Does the use of imported intermediates increase productivity? Plant-level evidence. J. Dev. Econ. 87 (1), 106–118.
Khandelwal, A., Topalova, P., 2011. Trade liberalization and firm productivity: The case of India. Rev. Econ. Stat. 93 (3), 995–1009.
Khandelwal, A., Schott, P., Wei, J.S., 2013. Trade liberalization and embedded institutional reform: Evidence from Chinese exporters. Am. Econ. Rev. 103 (6), 2169–2195.
Loecker, De, 2011. Product differentiation, multi-product firms and estimating the impact of trade liberalization on productivity. Econometrica 79 (5), 1407–1451.
Melitz, M.J., 2003. The impact of trade on intra-industry reallocations and aggregate industry productivity. Econometrica 71 (6), 1695–1725.
Melitz, M.J., Redding, S., 2014. Missing gains from trade? Am. Econ. Rev. 104 (5), 317–321.
Olley, G.S., Pakes, A., 1996. The dynamics of productivity in the telecommunications equipment industry. Econometrica 64 (6), 1263–1297.
Pavcnik, N., 2002. Trade liberalization, exit, and productivity improvements: Evidence from Chilean plants. Rev. Econ. Stud. 69 (1), 245–276.
Petropoulou, D., 2008. Information costs, networks and intermediation in international trade. Discussion Paper. Centre for Economic Performance, London School of Economics and Political Science, London.
Rauch, J.E., 1999. Networks versus markets in international trade. J. Int. Econ. 48 (1), 7–35.
Rauch, J.E., 2001. Business and social networks in international trade. J. Econ. Lit. 39 (4), 1177–1203.
Rauch, J.E., Watson, J., 2004. Network intermediaries in international trade. J. Econ. Manag. Strat. 13 (1), 69–93.
Rubinstein, A., Wolinsky, A., 1987. Middlemen. Q. J. Econ. 102 (3), 581–593.
Stock, J.H., Yogo, M., 2005. Asymptotic distributions of instrumental variables statistics with many weak instruments. In: DWK, Andrews (Ed.), Identification and Inference for Econometric Models. Cambridge University Press, New York, pp. 80–108.
Tintelnot, F., Kikkawa, A.K., Mogstad, M., Dhyne, E., 2018. Trade and domestic production networks. National Bank of Belgium Working Paper No. 344.
Trefler, D., 1993. Trade liberalization and the theory of endogenous protection: An econometric study of U.S. import policy. J. Polit. Econ. 101 (1), 138–160.
Upward, R., Wang, Z., Zheng, J., 2013. Weighing China's export basket: The domestic content and technology intensity of Chinese exports. J. Comp. Econ. 41 (2), 527–543.
Yavas, A., 1994. Middlemen in bilateral search markets. J. Labor Econ. 12 (3), 406–429.
Yu, M., 2015. Processing trade, tariff reductions and firm productivity: Evidence from Chinese firms. Econ. J. 125 (585), 943–988.
Yu, M., Ye, G., Qu, B., 2013. Trade liberalization, product complexity and productivity improvement: Evidence from Chinese firms. World Econ. 36 (7), 912–934.