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All-Around Trade Liberalization and Firm-Level Employment: Theory and Evidence from China*

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JEL Classification: F12, F14, F16

Keywords: firm-level employment, firm-level tariffs, heterogeneous firms

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1 Introduction

China's profound trade liberalization has been associated with large employment changes throughout the world. In particular, the rise of China as the world's largest trader has been related to substantial net job destruction in developed countries (see, for example, Autor, Dorn and Hanson, 2013, Acemoglu *et al.*, 2016, Pierce and Schott, 2016, Feenstra and Sasahara, 2017, and Feenstra, Ma and Xu, 2017 for the impact of Chinese competition on U.S. labor markets, and Mion and Zhu (2013) for its impact on employment in Belgium). However, the study of Chinese labor market responses to trade liberalization is a relatively unexplored topic.[1] Using unique firm-level tariff data for trading Chinese manufacturing firms, the goal of this paper is to contribute to fill this gap by estimating the effects of trade liberalization on Chinese firm-level employment, taking into account differences across firms' types and productivities.

Since China's accession to the WTO in December 2001, Chinese firms have been subject to a process of trade liberalization encompassing several dimensions. On the one hand, trade barriers imposed by other countries on Chinese goods declined, which made it easier for Chinese firms to export. On the other hand, China also lowered trade barriers imposed on other countries' final goods—which increased competition for Chinese firms—and on other countries' inputs, which helped Chinese input-importing firms become more productive. Hence, the trade-induced reallocation of labor inside and between Chinese firms is the result of three liberalization forces that are related, but may act through different mechanisms. Crucially, this paper is able to disentangle the firm-level employment effects of these three liberalization forces.

To empirically disentangle the impact of each type of liberalization on Chinese firm-level employment, we use firm-level and customs data for Chinese trading firms from 2000 to 2006. A key feature of our empirical approach is that the richness of our data allows us to calculate *firm-level* tariff measures à la Lileeva and Trefler (2010) and Yu (2015). Hence, for each Chinese firm in each year we compute *(i)* its foreign tariff, which captures the degree of foreign protection the firm's goods face in all its export destinations, *(ii)* its final-good Chinese tariff, which captures the effective rate of protection received by the firm based on the tariff China imposes on products that are similar to the goods the firm produces, and *(iii)* its Chinese input tariff, which captures the firm's cost of importing inputs based on Chinese tariffs on the inputs the firm imports.

Abstracting from firm type, the first part of our empirical analysis focuses on the importance of firm heterogeneity in productivity for the responses of firm-level employment to changes in each type of tariff. We find that foreign and Chinese trade liberalization in final goods are associated with job

[1] An exception is Ma, Qiao and Xu (2015), who provide a picture of the evolution of Chinese job flows from 1998 to 2007.

destruction in the least productive firms, and job creation in the most productive firms. In general, final-good Chinese liberalization causes the stronger effects for both low- and high-productivity firms. These results highlight significant Melitz-type effects by which trade liberalization causes reallocation of market shares from low-productivity firms to high-productivity firms, with direct consequences on firm-level employment.

We then take a step further and separate all manufacturing trading firms into four types of firms: processing firms, non-importing exporters, importing exporters, and importing non-exporters. We find that firm heterogeneity in productivity is also relevant for comparisons across firms of the same type, with both types of liberalization in final goods having similar effects across all types of firms: job destruction in the least productive firms and job creation in the most productive firms. Moreover, after calculating 2000-2006 predicted employment gains and losses for all types of firms due to tariff changes, we find that of the three types of tariffs, Chinese tariffs on final goods are by far the most important driver of employment gains, causing 2.9 times more job creation than foreign final-good tariffs, and 6.6 times more job creation than Chinese input tariffs. On the other hand, changes in foreign tariffs destroy slightly more jobs than Chinese final-good tariffs, and destroy 2.6 times more jobs than input tariffs. Overall, the predicted net employment gains are driven by Chinese final-good tariffs. Regarding firm type, non-importing and importing high-productivity exporters are the main source of net job creation in Chinese trading firms.

The current paper contributes to the literature in at least three important ways. First, we are able to examine the effects of all-around trade liberalization on China's employment. The studies mentioned above look at the effects of import competition from China on the U.S. and other labor markets, and they all find that the growing imports from China reduce employment. But it is also important to understand the other side of the coin: whether China's global booming exports, after its WTO accession, affect China's manufacturing employment. Second, by distinguishing firms according to their type, this paper enriches our understanding of the consequences of China's export structure—heavily based on processing exports (see, Feenstra and Hanson, 2005, Yu, 2015, and Brandt and Morrow, 2017)—on firm-level employment. And third, to motivate the empirical exercise, this paper develops a theoretical model that highlights the different channels through which all-around trade liberalization affects China's firm-level employment.

Our theoretical model includes trade in both final goods and tasks, combining features of the heterogenous-firm model with monopolistic competition of Melitz (2003) and the trade-in-tasks (or inputs) models of Feenstra and Hanson (1996, 1997) and Grossman and Rossi-Hansberg (2008). Notably, the model carefully considers the different types of Chinese firms, which can be classified as either pure processing firms (which import inputs duty free but cannot sell domestically) or ordinary firms (which can import inputs and can access both the domestic and export markets). The model then characterizes how each type of trade liberalization—a reduction in the foreign tariff on final goods, a reduction in the Chinese tariff on final goods, or a reduction in the Chinese tariff on inputs—affects employment in each type of firm.

Within the model, firm-level employment responses are the result of the interaction of three main mechanisms: changes in the competitive environment in China and abroad (competition effects), changes in the fraction of tasks performed inside the firms (task relocation effects), and changes in marginal costs—efficiency gains or losses—due to task relocation effects (productivity effects). In general, trade liberalization is associated with tougher competition in both markets, which is a source of job destruction. On the other hand, the task relocation and productivity effects always drive opposite responses in firm-level employment. For example, after input trade liberalization, ordinary importing firms reduce the number of tasks performed inside the firm (a source of job destruction) but they become more productive, which allows them to charge lower prices and capture larger market shares (a source of job creation).[2] This structure provides a guide for the interpretation of the results from our empirical exercise.

In our model, Chinese liberalization in final goods exposes Chinese firms to tougher competition from foreign firms, which is a source of job destruction that can explain the predicted employment losses for all types of low-productivity firms.[3] Meanwhile, Chinese liberalization in input trade reduces employment in low-productivity ordinary firms, and the impact is almost nil for high-productivity ordinary firms. The negative effects are likely a consequence of competition and task relocation effects, while the nil effect for high productivity firms reveals countervailing forces due to market share reallocations toward more productive firms, as well as market share expansions driven by efficiency gains. Lastly, destruction in low-productivity firms after foreign trade liberalization can be explained by competition effects, with slight job creation for high-productivity firms due to countervailing forces such as an easier domestic environment, the direct expansive effect on exporters, and possible efficiency gains.

The rest of the paper is organized as follows. Section 2 presents the model that help us understand the several channels through which different types of trade liberalization affect the different types of Chinese firms. Section 3 describes our firm-level and trade data, with particular emphasis

[2] In the same vein, Groizard, Ranjan and Rodriguez-Lopez (2014) construct a heterogeneous-firm model of offshoring that describes the effects of input trade liberalization on firm-level employment. They derive similar effects to those described in this paper, but do not consider final-good trade costs, nor the existence of processing firms, which are very important in the Chinese manufacturing industry.

[3] However, a caveat is that our model are not enough to explain the strong predicted employment gains for high-productivity firms, although it also has some channels of job creation for firms that switch status. Possible mechanisms that explain the last result, which are out of the scope of our model, include the existence of market share reallocations within firm type, or firms' decisions to invest and expand as a way to prepare for foreign competition.

in our firm-level tariff measures. In sections 4 and 5 we present our empirical results. Lastly, section 6 concludes.

2 Theoretical Motivation

This section presents the model that motivates our empirical exercise. In a setting with heterogeneous firms à la Melitz, we show how changes in the trinity of trade costs (external final-good trade costs, internal final-good trade costs, and input trade costs) affect Chinese firm-level employment.

There are two countries, China, which we call Home, and the rest of the world, which we call Foreign. Home has a mass of households of size $\mathbb{L}$, while Foreign's size is $\mathbb{L}^*$—Foreign variables are denoted with a star ($*$). Each household in each country provides one unit of labor per unit of time to either a homogeneous-good sector or a heterogeneous-good sector. The homogeneous good is produced under perfect competition and is costlessly traded; on the other hand, differentiated goods are produced under monopolistic competition and each variety is potentially tradable.

The homogeneous good is the numeraire and its production requires only labor. One unit of Home labor produces exactly one unit of the homogeneous good; hence, the wage at Home is 1. At Foreign, however, one unit of labor produces $w^* > 1$ of the homogeneous good, and hence, the wage at Foreign is w^*.

2.1 Preferences and Demand

The utility function of the representative Home household is given by

$$U = H^{1-\eta} Z^{\eta}, \tag{1}$$

where H denotes the consumption of the homogeneous good, $Z = \left(\int_{\omega \in \Omega} z^c(\omega)^{\frac{\sigma-1}{\sigma}} d\omega \right)^{\frac{\sigma}{\sigma-1}}$ is the constant elasticity of substitution (CES) consumption aggregator of differentiated goods, and $\eta \in (0,1)$. In Z, $z^c(\omega)$ denotes the consumption of variety ω, Ω is the set of differentiated goods available for purchase, and $\sigma > 1$ is the elasticity of substitution between varieties. It follows that the representative household spends a fraction η of its income on differentiated goods and the rest on the homogeneous good.

The representative Home household's demand for variety ω is then given by $z^c(\omega) = \frac{p(\omega)^{-\sigma}}{P^{1-\sigma}} \eta$, where $p(\omega)$ is the price of variety ω, and $P = \left[\int_{\omega \in \Omega} p(\omega)^{1-\sigma} d\omega \right]^{\frac{1}{1-\sigma}}$ is the price of the CES aggregator Z. Total Home labor income is $\mathbb{L}$ (there are $\mathbb{L}$ households, and the labor income of each household is 1), and thus, the total expenditure on differentiated goods is $\eta \mathbb{L}$. Hence, the market demand for variety ω is given by

$$z^D(\omega) = \frac{p(\omega)^{-\sigma}}{P^{1-\sigma}} \eta \mathbb{L}. \tag{2}$$

With similar preferences for Foreign households, their total expenditure on differentiated goods is $\eta w^* \mathbb{L}^*$, and hence Foreign's market demand for variety ω is $z^{*D}(\omega) = \frac{P^{*\sigma-1}}{p^*(\omega)^\sigma} \eta w^* \mathbb{L}^*$, where $p^*(\omega)$ is the Foreign price of variety ω, and $P^* = \left[\int_{\omega \in \Omega^*} p^*(\omega)^{1-\sigma} d\omega\right]^{\frac{1}{1-\sigma}}$.

2.2 Production of Differentiated Goods

Differentiated-good firms in both countries are heterogeneous in productivity. As in the Chaney (2008) version of the Melitz (2003) model, there is a constant pool of potential producers in each country, with each of them drawing its productivity φ from a cumulative distribution function $G(\varphi)$. The probability density function is denoted by $g(\varphi)$.

Each differentiated good is produced using a continuum of tasks in the interval $[0, 1]$. A fraction of these tasks is produced inside the firm using domestic labor, while the rest are obtained outside the firm from domestic or foreign input suppliers. Home firms are classified into the following three categories:

1. *Pure processing firms ($\mathcal{P}$):* They import inputs duty-free, but in exchange they must export all their output.

2. *Non-importing firms ($\mathcal{N}$):* They obtain all their inputs domestically, sell for the domestic market, and may also export.

3. *Importing firms ($\mathcal{I}$):* They import inputs (paying input trade costs), and sell for both the domestic and export markets.

This classification, summarized in Figure 1, captures very well the full range of Chinese firms. The assumptions that not all exporters import inputs, but that all importers export fit well our Chinese data, which yields that for ordinary firms, 39% of exporters are also importers, but that 85% of importers are also exporters. This is broadly consistent with the stylized facts described in Feng, Li and Swenson (2016).

The production function of a Home firm with productivity φ and status $s \in \{\mathcal{P}, \mathcal{N}, \mathcal{I}\}$ is $z_s(\varphi) = \varphi Y_s$, where $Y_s = \left[\int_0^1 y_s(\alpha)^{\frac{\theta-1}{\theta}} d\alpha\right]^{\frac{\theta}{\theta-1}}$ is a CES tasks aggregator. In Y_s, $\theta \in [0, \infty)$ is the elasticity of complementarity/substitution between tasks: when $\theta \in [0, 1)$ tasks are complementary, when $\theta = 1$ we obtain the Cobb-Douglas aggregator and tasks are neither substitutes nor complements, and when $\theta > 1$ there is substitutability between tasks.

The production function for task α for a firm with status $s \in \{\mathcal{P}, \mathcal{N}, \mathcal{I}\}$ is given by

$$y_s(\alpha) = \ell + A_{M_s} a_M(\alpha) m, \tag{3}$$

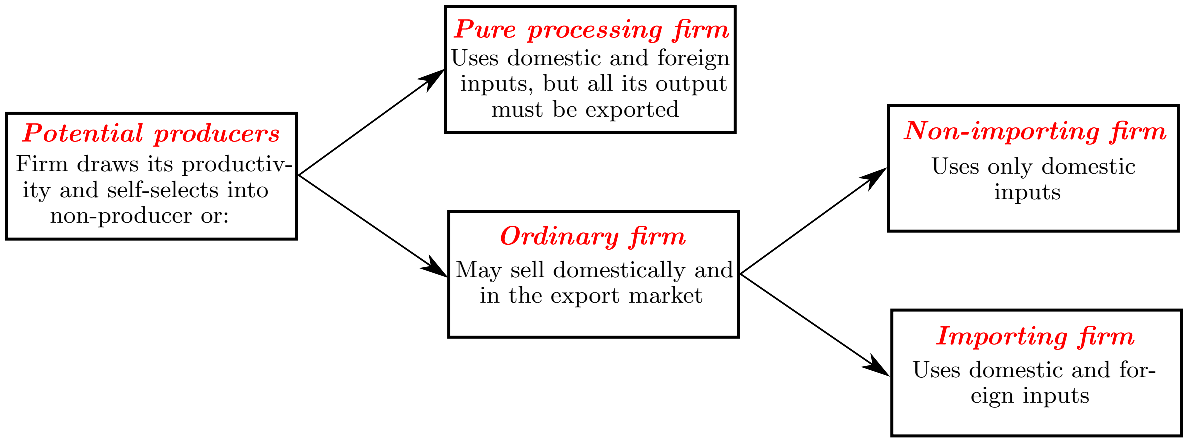

Figure 1: The Types of Home Firms

where ℓ denotes units of Home labor, m denotes units of a composite input—which we call *materials*—procured from outside the firm, A_{Ms} is an aggregate productivity factor for materials, and $a_M(\alpha)$ is a task-specific materials' productivity factor.[4] Given the perfect substitutability between ℓ and m in (3), to obtain one unit of task α a Home firm with status s employs either one unit of domestic labor, or buys $\frac{1}{A_{Ms}a_M(\alpha)}$ units of materials. Letting p_{Ms} denote the price of materials for a firm with status s, it follows that the cost of production of one unit of $y_s(\alpha)$ is the minimum between the cost of producing the task with hired labor, 1, and the cost of procuring the task with materials, $\frac{p_{Ms}}{A_{Ms}a_M(\alpha)}$.

Following Feenstra and Hanson (1996, 1997) and Grossman and Rossi-Hansberg (2008), tasks are ordered in the unit interval so that $a_M(\alpha)$ is strictly increasing: the task-specific productivity of materials is higher for higher indexed tasks, and hence, the comparative advantage of labor declines as we move from 0 to 1. Assuming also that $a_M(0) < \frac{p_{Ms}}{A_{Ms}}$ and $a_M(1) > \frac{p_{Ms}}{A_{Ms}}$ for every s, there exists a cutoff $\hat{\alpha}_s$ such that tasks in the interval $[0, \hat{\alpha}_s)$ are produced inside the firm (with hired domestic labor), and tasks in the interval $[\hat{\alpha}_s, 1]$ are procured using outside materials. At $\hat{\alpha}_s$ the firm is indifferent between producing the input with labor and procuring the input with materials, *i.e.*, $\hat{\alpha}_s$ solves

$$a_M(\hat{\alpha}_s) = \frac{p_{Ms}}{A_{Ms}}. \tag{4}$$

Foreign is better at producing materials than Home. This is reflected in a lower price and a higher aggregate productivity for Foreign materials; that is, $p^*_M < p_M$ and $A^*_M > A_M$. Pure processing firms do not face any tariffs when importing materials and hence $p_{M\mathcal{P}} = p^*_M$. On the other hand, ordinary importing firms incur an import tariff, $\lambda > 0$, so that $p_{M\mathcal{I}} = (1+\lambda)p^*_M$. For

[4]More generally, we could assume that $y_s(\alpha) = A_L a_L(\alpha)\ell + A_{Ms}a_M(\alpha)m$, which follows closely Acemoglu and Autor (2011). For the purposes of this paper it is enough to normalize A_L and $a_L(\alpha)$ to 1, and think of A_{Ms} and $a_M(\alpha)$ as productivity factors that indicate the comparative advantage of materials with respect to labor.

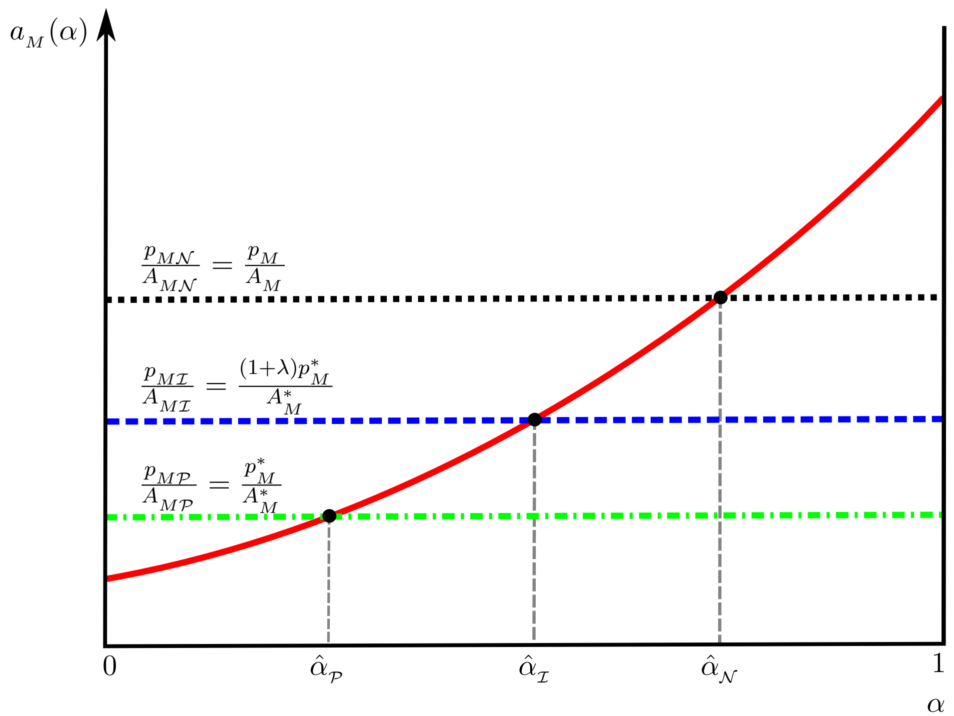

Figure 2: Tasks Performed Inside the Firm with Home Labor (by Type of Firm)

non-importing firms $p_{MN} = p_M$. In addition, we assume that $A_{M\mathcal{P}} = A_{M\mathcal{I}} = A^*_M$, $A_{M\mathcal{N}} = A_M$, and that λ is sufficiently small so that the following ordering always holds:

$$\frac{p_{M\mathcal{P}}}{A_{M\mathcal{P}}} < \frac{p_{M\mathcal{I}}}{A_{M\mathcal{I}}} < \frac{p_{M\mathcal{N}}}{A_{M\mathcal{N}}}. \tag{5}$$

Assumption (5) and equation (4) imply that $\hat{\alpha}_{\mathcal{P}} < \hat{\alpha}_{\mathcal{I}} < \hat{\alpha}_{\mathcal{N}}$; thus, a pure processing firm performs less tasks inside the firm than the other types of firms, and a non-importing firm performs more tasks inside the firm than any other type of firm.[5] Figure 2 summarizes this feature of the model.

We can now rewrite the task aggregator for a firm with status s, Y_s, in terms of required labor and materials, and obtain its unit cost. The following lemma shows these results.

Lemma 1. *Let L_s and M_s denote the total amounts of labor and materials used for the production of the task aggregator Y_s. Then*

$$Y_s = \left(\hat{\alpha}_s^{\frac{1}{\theta}} L_s^{\frac{\theta-1}{\theta}} + \upsilon_s(\hat{\alpha}_s)^{\frac{1}{\theta}} M_s^{\frac{\theta-1}{\theta}} \right)^{\frac{\theta}{\theta-1}} \tag{6}$$

where $\upsilon_s(\hat{\alpha}_s) \equiv \int_{\hat{\alpha}_s}^1 [A_{Ms} a_M(\alpha)]^{\theta-1} d\alpha$. The cost of one unit of Y_s is given by

$$c(\hat{\alpha}_s) = \left\{ \hat{\alpha}_s + \int_{\hat{\alpha}_s}^1 \left[\frac{a_M(\hat{\alpha}_s)}{a_M(\alpha)} \right]^{1-\theta} d\alpha \right\}^{\frac{1}{1-\theta}} < 1, \tag{7}$$

[5]In China, pure processing firms perform (on average) few and very specific tasks, *e.g.*, assembly and packaging (which are very unskilled tasks).

which is strictly increasing in $\hat{\alpha}_s$ (i.e., $c'(\hat{\alpha}_s) > 0$), and approaches 1 as $\hat{\alpha}_s \to 1$.

Therefore, the marginal cost of a Home firm with status $s \in \{\mathcal{P}, \mathcal{N}, \mathcal{I}\}$ and productivity φ is $\frac{c(\hat{\alpha}_s)}{\varphi}$. If the firm decides to export its finished good, its marginal cost from selling at Foreign is $\frac{(1+\tau)c(\hat{\alpha}_s)}{\varphi}$, where $\tau > 0$ is the tariff imposed by Foreign on differentiated-good imports from Home.

2.3 Pricing and Profits

Assuming market segmentation and given CES preferences, the prices that a Home firm with productivity φ and status s sets in the domestic (D) and export (X) markets are given by $p_{D_s}(\varphi) = \left(\frac{\sigma}{\sigma-1}\right)\frac{c(\hat{\alpha}_s)}{\varphi}$ and $p_{X_s}(\varphi) = \left(\frac{\sigma}{\sigma-1}\right)\frac{(1+\tau)c(\hat{\alpha}_s)}{\varphi}$, respectively. Using these pricing equations and the market demand functions, we obtain that the firm's gross profit functions—before deducting fixed costs—from selling in each market are

$$\pi_{D_s}(\varphi) = \frac{1}{\sigma}\left[\frac{P}{p_{D_s}(\varphi)}\right]^{\sigma-1}\eta\mathbb{L} \quad \text{and} \quad \pi_{X_s}(\varphi) = \frac{1}{\sigma}\left[\frac{P^*}{p_{X_s}(\varphi)}\right]^{\sigma-1}\eta w^*\mathbb{L}^*. \tag{8}$$

As usual, for $r \in \{D, X\}$ and $s \in \{\mathcal{P}, \mathcal{N}, \mathcal{I}\}$, $p'_{rs}(\varphi) < 0$ and $\pi'_{rs}(\varphi) > 0$ so that more productive firms charge lower prices and obtain larger profits.

Foreign differentiated-good firms do not have incentives to purchase materials from Home; thus, the production function of a Foreign firm with productivity φ is $z^*(\varphi) = A^*\varphi Y^*$, where A^* is an aggregate productivity factor for Foreign firms (normalized to 1 for Home firms) and $Y^* = \left[\int_0^1 y^*(\alpha)^{\frac{\theta-1}{\theta}} d\alpha\right]^{\frac{\theta}{\theta-1}}$ is the CES task aggregator. The Foreign firms' task production function is analogous to (3), their cost of producing one unit of task α with Foreign labor is w^*, and their cost of producing it with materials is $\frac{p_M^*}{A_M^* a_M^*(\alpha)}$. It follows that the fraction of tasks produced inside a Foreign firm with Foreign labor, $\hat{\alpha}^*$, is the solution to

$$a_M^*(\hat{\alpha}^*) = \frac{p_M^*}{A_M^* w^*}. \tag{9}$$

Analogously to Lemma 1, the unit cost of Y^* is $c^*(\hat{\alpha}^*)w^*$, where $c^*(\hat{\alpha}^*)$ is similar to (7) but with $\hat{\alpha}^*$ and $a_M^*(\cdot)$ instead of $\hat{\alpha}_s$ and $a_M(\cdot)$. The marginal cost for a Foreign firm with productivity φ is then $\frac{c^*(\hat{\alpha}^*)w^*}{A^*\varphi}$ from selling domestically, and $\frac{(1+\tau^*)c^*(\hat{\alpha}^*)w^*}{A^*\varphi}$ from selling in the Home market, with $\tau^* > 0$ denoting the tariff imposed by Home on differentiated-good imports from Foreign. Hence, the prices set by a Foreign firm with productivity φ are $p_D^*(\varphi) = \left(\frac{\sigma}{\sigma-1}\right)\frac{c^*(\hat{\alpha}^*)w^*}{A^*\varphi}$ in the domestic market, and $p_X^*(\varphi) = \left(\frac{\sigma}{\sigma-1}\right)\frac{(1+\tau^*)c^*(\hat{\alpha}^*)w^*}{A^*\varphi}$ in the export market. The firm's gross profit functions from selling in each market are

$$\pi_D^*(\varphi) = \frac{1}{\sigma}\left[\frac{P^*}{p_D^*(\varphi)}\right]^{\sigma-1}\eta w^*\mathbb{L}^* \quad \text{and} \quad \pi_X^*(\varphi) = \frac{1}{\sigma}\left[\frac{P}{p_X^*(\varphi)}\right]^{\sigma-1}\eta\mathbb{L}. \tag{10}$$

2.4 Cutoff Productivity Levels and the Masses of Firms

By Lemma 1 and $\hat{\alpha}_{\mathcal{P}} < \hat{\alpha}_{\mathcal{I}} < \hat{\alpha}_{\mathcal{N}}$, it is the case that $c(\hat{\alpha}_{\mathcal{P}}) < c(\hat{\alpha}_{\mathcal{I}}) < c(\hat{\alpha}_{\mathcal{N}})$. Although pure processing firms face the lowest cost of the task aggregator, the trade-off is that they are not allowed to access the domestic market (and they are not exempt of Foreign tariffs). There are fixed costs of importing inputs for both processing and ordinary firms, and there are fixed costs of selling in each market. These fixed costs along with the CES demand system imply the existence of cutoff productivity levels that determine firm status s (for Home firms) and the tradability of each differentiated good in each market.

There are four cutoff productivity levels for Home firms: one for pure processing firms, $\hat{\varphi}_{\mathcal{P}}$, one for non-importing firms selling only in the domestic market, $\hat{\varphi}_D$, one for non-importing firms selling to both the domestic and export markets, $\hat{\varphi}_X$, and one for importing-exporting firms, $\hat{\varphi}_{\mathcal{I}}$. In our Chinese data, Dai, Maitra and Yu (2016) show that processing firms are on average the least productive of all types of firms, and importing firms (of which the vast majority, 85 percent, are also exporters) are on average the most productive. Accordingly, we assume parameters such that $\hat{\varphi}_{\mathcal{P}} < \hat{\varphi}_D < \hat{\varphi}_X < \hat{\varphi}_{\mathcal{I}}$ always holds. Then, for example, a Home firm with productivity below $\hat{\varphi}_{\mathcal{P}}$ does not produce, while a firm with productivity between $\hat{\varphi}_X$ and $\hat{\varphi}_{\mathcal{I}}$ is an ordinary non-importing firm that sells to both markets. For Foreign firms there are only two cutoff productivity levels, $\hat{\varphi}^*_D$ and $\hat{\varphi}^*_X$, and we assume fixed costs and trade costs such that $\hat{\varphi}^*_D < \hat{\varphi}^*_X$ always holds.

Fixed costs are in terms of the homogeneous good. For $r \in \{D, X\}$, let f_r be the fixed cost of selling in market r for Home ordinary firms, and let f^*_r be the fixed cost of selling in market r for Foreign firms. The fixed cost for Home processing firms, $f_{\mathcal{P}}$, includes both importing and exporting fixed costs. On the other hand, ordinary importing firms pay $f_{\mathcal{I}}$ in addition to f_D and f_X. Hence, based on net profits, the cutoff productivity levels satisfy the following indifference conditions:

$$\pi_{X\mathcal{P}}(\hat{\varphi}_{\mathcal{P}}) = f_{\mathcal{P}} \tag{11}$$

$$\pi_{D\mathcal{N}}(\hat{\varphi}_D) - f_D = \pi_{X\mathcal{P}}(\hat{\varphi}_D) - f_{\mathcal{P}}, \tag{12}$$

$$\pi_{X\mathcal{N}}(\hat{\varphi}_X) = f_X, \tag{13}$$

$$\pi_{D\mathcal{I}}(\hat{\varphi}_{\mathcal{I}}) + \pi_{X\mathcal{I}}(\hat{\varphi}_{\mathcal{I}}) - f_{\mathcal{I}} = \pi_{D\mathcal{N}}(\hat{\varphi}_{\mathcal{I}}) + \pi_{X\mathcal{N}}(\hat{\varphi}_{\mathcal{I}}), \tag{14}$$

$$\pi^*_D(\hat{\varphi}^*_D) = f^*_D, \tag{15}$$

$$\pi^*_X(\hat{\varphi}^*_X) = f^*_X, \tag{16}$$

where the profit functions are given by (8) and (10). Figure 3 shows the partition of firms for Home producers. The four marked intersections represent the indifference conditions (11)-(14). For example, a firm with productivity $\hat{\varphi}_{\mathcal{I}}$—shown in condition (14)—is indifferent between being

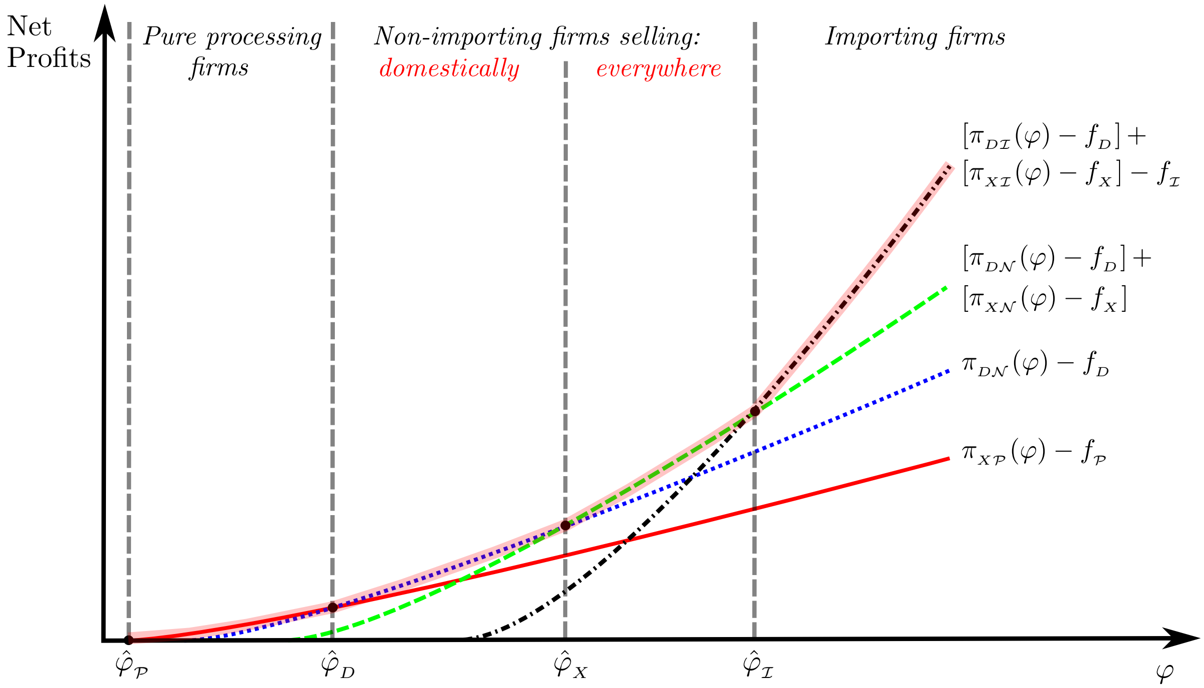

Figure 3: Cutoff Productivity Levels and the Partition of Firms

an ordinary non-importing firm accessing both markets, and being an ordinary importing firm accessing both markets.

There is a mass of $\bar{N}$ potential producers at Home, and a mass of $\bar{N}^*$ potential producers at Foreign. For Home producers, $N_{\mathcal{P}}$ is the mass of pure processing firms (who can only sell to the export market), $N_{r\mathcal{N}}$ is the mass of ordinary non-importing firms selling to market r, for $r \in \{D, X\}$, and $N_{\mathcal{I}}$ is the mass of ordinary importing firms (who always sell to both markets). With firm productivity distributed with distribution function $G(\varphi)$ and given the ordering of the cutoff productivity levels in Figure 3, the masses of each type of Home producers are

$$N_{\mathcal{P}} = [G(\hat{\varphi}_D) - G(\hat{\varphi}_{\mathcal{P}})]\bar{N} \tag{17}$$

$$N_{D\mathcal{N}} = [G(\hat{\varphi}_{\mathcal{I}}) - G(\hat{\varphi}_D)]\bar{N}, \tag{18}$$

$$N_{X\mathcal{N}} = [G(\hat{\varphi}_{\mathcal{I}}) - G(\hat{\varphi}_X)]\bar{N}, \tag{19}$$

$$N_{\mathcal{I}} = [1 - G(\hat{\varphi}_{\mathcal{I}})]\bar{N}. \tag{20}$$

Foreign potential producers have the same productivity distribution as Home potential producers, and thus the mass of Foreign producers selling in their domestic market, N_D^*, and the mass of Foreign exporters, N_X^*, are given by

$$N_D^* = [1 - G(\hat{\varphi}_D^*)]\bar{N}^*, \tag{21}$$

$$N_X^* = [1 - G(\hat{\varphi}_X^*)]\bar{N}^*. \tag{22}$$

With N denoting the mass of differentiated-good varieties available for purchase at Home, and N^* denoting the mass of varieties available at Foreign, it follows that

$$N = N_{D\mathcal{N}} + N_{\mathcal{I}} + N^*_X, \tag{23}$$

$$N^* = N^*_D + N_{\mathcal{P}} + N_{X\mathcal{N}} + N_{\mathcal{I}}. \tag{24}$$

2.5 Equilibrium and Trade Liberalization

To close the model we rely on the expressions for the CES prices indexes P and P^*:

$$P = \left[N_{D\mathcal{N}}\bar{p}_{D\mathcal{N}}^{1-\sigma} + N_{\mathcal{I}}\bar{p}_{D\mathcal{I}}^{1-\sigma} + N^*_X\bar{p}_X^{*1-\sigma}\right]^{\frac{1}{1-\sigma}}, \tag{25}$$

$$P^* = \left[N^*_D\bar{p}_D^{*1-\sigma} + N_{\mathcal{P}}\bar{p}_{X\mathcal{P}}^{1-\sigma} + N_{X\mathcal{N}}\bar{p}_{X\mathcal{N}}^{1-\sigma} + N_{\mathcal{I}}\bar{p}_{X\mathcal{I}}^{1-\sigma}\right]^{\frac{1}{1-\sigma}}, \tag{26}$$

where the masses of firms are given by (17)-(22), $\bar{p}_{rs} \equiv p_{rs}(\bar{\varphi}_{rs})$ is the average price of Home firms with status s selling in market r, $\bar{p}^*_r \equiv p^*_r(\bar{\varphi}^*_r)$ is the average price of Foreign firms selling in market r, $\bar{\varphi}_{rs} = \left[\int_{\varphi\in\Phi_{rs}} \varphi^{\sigma-1}g(\varphi \mid \varphi \in \Phi_{rs})d\varphi\right]^{\frac{1}{\sigma-1}}$ is the average productivity for status-s firms that sell in market r (with Φ_{rs} denoting the set of productivity values they take), and $\bar{\varphi}^*_r = \left[\int_{\hat{\varphi}^*_r}^{\infty} \varphi^{\sigma-1}g(\varphi \mid \varphi \in [\hat{\varphi}^*_r, \infty))d\varphi\right]^{\frac{1}{\sigma-1}}$ is the average productivity of Foreign firms selling in market r. We can now describe the equilibrium.

Definition 1. *An equilibrium in this model obtains $\hat{\alpha}_s$ for every s from* (4)*, $\hat{\alpha}^*$ from* (9)*, $c(\hat{\alpha}_s)$ for every s and $c^*(\hat{\alpha}^*)$ from Lemma 1, and then uses the indifference conditions* (11)*-*(16) *along with* (25) *and* (26) *to solve for P, P^*, $\hat{\varphi}_{\mathcal{P}}$, $\hat{\varphi}_D$, $\hat{\varphi}_X$, $\hat{\varphi}_{\mathcal{I}}$, $\hat{\varphi}^*_D$, and $\hat{\varphi}^*_X$.*

Our trade liberalization exogenous variables are τ, τ^*, and λ—recall that τ is the Foreign tariff on final goods from Home, τ^* is the Home tariff on final goods from Foreign, and λ is the Home tariff on inputs from Foreign. Therefore, in this paper we refer to a decline in τ as "Foreign trade liberalization", to a decline in τ^* as "Home trade liberalization in final goods", and to a decline in λ as "Home trade liberalization in inputs".

To understand the model's implications for the impact of each type of trade liberalization on firm-level employment, first we need to look at how equilibrium aggregate prices, cutoff productivity levels, and task cutoffs respond. Based on numerical comparative statics, Table 1 shows the responses of our endogenous variables to a reduction in each type of tariff.

For the cutoff task levels, it is evident from Figure 2 that changes in τ and τ^* do not affect $\hat{\alpha}_s$ for every $s \in \{\mathcal{P}, \mathcal{N}, \mathcal{I}\}$. Note also that the input tariff, λ, does not affect $\hat{\alpha}_{\mathcal{P}}$ and $\hat{\alpha}_{\mathcal{N}}$, but it does affect $\hat{\alpha}_{\mathcal{I}}$. In particular, Home trade liberalization in inputs ($\downarrow \lambda$) makes materials' imports cheaper and reduces the fraction of tasks performed with Home labor in ordinary importing Home

Table 1: Responses of Prices and Cutoff Levels to Tariff Reductions

	$\hat{\alpha}_{\mathcal{I}}$	P	P^*	$\hat{\varphi}_{\mathcal{P}}$	$\hat{\varphi}_D$	$\hat{\varphi}_X$	$\hat{\varphi}_{\mathcal{I}}$	$\hat{\varphi}^*_D$	$\hat{\varphi}^*_X$
$\downarrow \tau$	0	$\uparrow$	$\downarrow$	$\downarrow$	$\uparrow$	$\downarrow$	$\downarrow$	$\uparrow$	$\downarrow$
$\downarrow \tau^*$	0	$\downarrow$	$\downarrow$	$\uparrow$	$\uparrow$	$\uparrow$	$\uparrow$	$\uparrow$	$\downarrow$
$\downarrow \lambda$	$\downarrow$	$\downarrow$	$\downarrow$	$\uparrow$	$\uparrow$	$\uparrow$	$\downarrow$	$\uparrow$	$\uparrow$

firms (*i.e.*, $\frac{d\hat{\alpha}_{\mathcal{I}}}{d\lambda} > 0$); this can be seen in Figure 2 with a decline in the $\frac{(1+\lambda)p^*_M}{A^*_M}$ horizontal line. As trade liberalization (no matter the type) does not affect $\hat{\alpha}_{\mathcal{P}}$ and $\hat{\alpha}_{\mathcal{N}}$, Table 1 only includes $\hat{\alpha}_{\mathcal{I}}$.

The responses of aggregate prices summarize the changes in the competitive environment in each market. For example, a decline in P indicates a tougher competitive environment at Home—from (2), note that a decline in P implies that the demand for each differentiated-good variety shifts to the left. Therefore, the second and third columns of Table 1 show that Home trade liberalization in either final goods or inputs—a decline in τ^* or λ—causes tougher competitive environments in both countries (P and P^* decline), while Foreign trade liberalization—a decline in τ—toughens the competitive environment at Foreign but softens it at Home (P^* declines but P increases).

Pure processing firms play a crucial role in the decline in P^* after Home liberalization in final goods ($\downarrow \tau^*$), and in the increase in P after Foreign trade liberalization ($\downarrow \tau$). In the first case, the reduction in τ^* makes Foreign firms more competitive at Home, which drives some Home firms to switch from ordinary to pure processing status to avoid the competition from Foreign firms inside Home ($\hat{\varphi}_D$ increases). This effect is strong enough to increase the number of firms selling in Foreign, which drives up competition and lowers the aggregate price, P^*. In the second case, the decline in τ encourages Home firms to export, with some of them deciding to change their status from ordinary non-importing firms to pure processing firms ($\hat{\varphi}_D$ increases), which negatively affects the number of varieties sold at Home—recall that pure processing firms are not allowed to sell in the Home market. These firms are then replaced in the Home market by less productive Foreign firms, which yields the increase in the aggregate price P.

Regarding cutoff levels for Home firms, Foreign trade liberalization ($\downarrow \tau$) makes it easier for Home firms to export, which is translated to lower $\hat{\varphi}_{\mathcal{P}}$, $\hat{\varphi}_X$, and $\hat{\varphi}_{\mathcal{I}}$. As mentioned before, $\hat{\varphi}_D$ increases as some Home non-importing firms selling only domestically decide to become pure processing firms. Home trade liberalization in final goods ($\downarrow \tau^*$) exposes all Home firms to tougher competition from Foreign firms in both markets, which leads to an increase in all the cutoff levels for Home firms. Lastly, Home trade liberalization in inputs ($\downarrow \lambda$) drives a decline in $\hat{\varphi}_{\mathcal{I}}$, as profit opportunities for ordinary importing firms increase; given that the marginal costs of new importing firms decline, it becomes harder for other types of Home firms to compete and $\hat{\varphi}_{\mathcal{P}}$, $\hat{\varphi}_D$, and $\hat{\varphi}_X$ rise.

2.6 Trade Liberalization and Firm-Level Employment

We can now obtain the amount of labor employed by each type of Home firm. We assume that supply of labor is perfectly elastic and hence the amount of employment in equilibrium is demand-determined. As described above, a Home firm with status s uses domestic labor to produce the tasks in the interval $[0, \hat{\alpha}_s)$, while tasks in the interval $[\hat{\alpha}_s, 1]$ are procured using material inputs from outside the firm. The following lemma shows the firm-level demand for Home labor from selling in each market.

Lemma 2. *For a producing Home firm whose productivity φ sorts it into status $s \in \{\mathcal{P}, \mathcal{N}, \mathcal{I}\}$, its demands for domestic labor to produce for each market are given by*

$$L_{Ds}(\varphi) = \frac{\Upsilon \varphi^{\sigma-1} \hat{\alpha}_s P^{\sigma-1} \mathbb{L}}{c(\hat{\alpha}_s)^{\sigma-\theta}}, \tag{27}$$

$$L_{Xs}(\varphi) = \frac{\Upsilon \varphi^{\sigma-1} \hat{\alpha}_s P^{*\sigma-1} w^* \mathbb{L}^*}{c(\hat{\alpha}_s)^{\sigma-\theta}(1+\tau)^{\sigma-1}}, \tag{28}$$

where $\Upsilon \equiv \left(\frac{\sigma-1}{\sigma}\right)^{\sigma} \eta$ is a constant. The two exceptions to (27)-(28) are (1) $L_{D\mathcal{P}}(\varphi) = 0$ because pure processing firms are not allowed to sell domestically, and (2) $L_{X\mathcal{N}}(\varphi) = 0$ if $\varphi \in [\hat{\varphi}_D, \hat{\varphi}_X)$ because these non-importing firms do not export.

Given the results in Table 1, equations (27) and (28) indicate that trade liberalization affects firm-level employment at Home through the following channels: *(i)* by affecting each country's competitive environment (as reflected by changes in P and P^*), *(ii)* in the case of foreign trade liberalization ($\downarrow \tau$), by directly expanding employment in exporting firms, which become instantly more competitive in the Foreign market, *(iii)* in the case of input trade liberalization ($\downarrow \lambda$), by reducing the fraction of tasks performed inside the firm by ordinary importing firms ($\downarrow \hat{\alpha}_{\mathcal{I}}$), with the consequent reduction on these firms' unit cost of the task aggregator ($\downarrow c(\hat{\alpha}_{\mathcal{I}})$).

In addition, Table 1 shows that all types of trade liberalization affect the cutoff productivity levels, and hence, some firms change their status $s \in \{\mathcal{P}, \mathcal{N}, \mathcal{I}\}$ and market destinations $r \in \{D, X\}$, which also alters their employment (*e.g.*, an initially ordinary non-importing and non-exporting firm that becomes a pure processing firm after trade liberalization—due to the increase in $\hat{\varphi}_D$—changes its employment from $L_{D\mathcal{N}}(\varphi)$ to $L_{X\mathcal{P}}(\varphi)$). In the following sections we describe the model's implications regarding the employment effects of each type of trade liberalization for each type of firm. In the end of this section, Table 2 summarizes the results.

2.6.1 Pure Processing Firms ($\mathcal{P}$)

The employment of a pure processing firm with productivity φ is $L_{X\mathcal{P}}(\varphi) = \frac{\Upsilon \varphi^{\sigma-1} \hat{\alpha}_{\mathcal{P}} P^{*\sigma-1} w^* \mathbb{L}^*}{c(\hat{\alpha}_{\mathcal{P}})^{\sigma-\theta}(1+\tau)^{\sigma-1}}$. We describe first the case of firms that have status $\mathcal{P}$ before and after a trade cost shock, and then we study the case of firms that switch their status to $\mathcal{P}$ after the shock.

For firms that keep status $\mathcal{P}$, note first from Table 1 that all types of trade liberalization cause a decline in P^* (the competitive environment becomes tougher at Foreign). This is a source of job destruction in $L_{X\mathcal{P}}(\varphi)$, and the only active channel in these firms after Home trade liberalization in final goods ($\downarrow \tau^*$) or in inputs ($\downarrow \lambda$). With Foreign trade liberalization ($\downarrow \tau$), however, there is a direct countervailing force of job creation in $L_{X\mathcal{P}}(\varphi)$ as Home exporters become more competitive abroad.

Table 1 shows that all types of trade liberalization increase the cutoff productivity level that separates pure processing firms and ordinary non-importing firms, $\hat{\varphi}_D$, so that some firms switch from status $\mathcal{N}$ to status $\mathcal{P}$. Let $\hat{\varphi}'_D$ denote the post-liberalization cutoff. Hence, for a Home firm with productivity $\varphi \in [\hat{\varphi}_D, \hat{\varphi}'_D)$, its domestic employment switches from $L_{D\mathcal{N}}(\varphi)$ to $L_{X\mathcal{P}}(\varphi)$. From (27) and (28), the ratio between the firm's post-liberalization and pre-liberalization employment is given by

$$\frac{L_{X\mathcal{P}}(\varphi)}{L_{D\mathcal{N}}(\varphi)} = \left(\frac{\hat{\alpha}_{\mathcal{P}}}{\hat{\alpha}_{\mathcal{N}}}\right) \left[\frac{c(\hat{\alpha}_{\mathcal{N}})}{c(\hat{\alpha}_{\mathcal{P}})}\right]^{\sigma-\theta} \left[\frac{P^{*\sigma-1} w^* \mathbb{L}^*}{(1+\tau)^{\sigma-1} P^{\sigma-1} \mathbb{L}}\right].$$

This firm's increase or decrease in employment depends on three channels. First, there is a reduction in the fraction of tasks performed inside the firm (recall that $\hat{\alpha}_{\mathcal{P}} < \hat{\alpha}_{\mathcal{N}}$), which is a source of job destruction. Second, there is a reduction in the firm's cost of the task aggregator, $c(\hat{\alpha}_{\mathcal{P}}) < c(\hat{\alpha}_{\mathcal{N}})$, which yields efficiency gains and is a source of job creation as long as $\sigma > \theta$ (*i.e.*, as long as the substitutability across varieties is higher than the substitutability across tasks). And third, as the firm switches between markets, the effect of trade liberalization on the firm's employment also depends on the size of the Foreign market (adjusted by the export cost) relative to the size of the Home market.

In the case of Foreign trade liberalization ($\downarrow \tau$) there is also a decline in $\hat{\varphi}_{\mathcal{P}}$. Thus, some previously inactive firms become pure processing producers. For these firms their employment jumps from 0 to $L_{X\mathcal{P}}(\varphi)$.

2.6.2 Ordinary Non-Importing Firms ($\mathcal{N}$)

Ordinary non-importing firms may sell only domestically or also export. We describe first the employment changes in non-exporting firms, and then we discuss the impact on exporting firms.

Home trade liberalization in final goods ($\downarrow \tau^*$) or in inputs ($\downarrow \lambda$) cause a tougher competitive environment at Home (P declines), while the opposite happens for Foreign trade liberalization (a decline in τ increases P). Therefore, from (27) it follows that each continuing non-exporting firm reduces its employment after Home trade liberalization (in final goods or in inputs), but expands its employment after Foreign trade liberalization. Either type of Home trade liberalization also makes exporting harder for ordinary non-importing firms, and thus, some previously exporting firms become non-exporters ($\hat{\varphi}_X$ rises), which also causes these firms' to reduce their employment.

The total demand for domestic labor of an ordinary non-importing firm that also exports is given by $L_{D\mathcal{N}}(\varphi) + L_{X\mathcal{N}}(\varphi)$. Such a firm faces tougher competitive environments in both markets after either type of Home trade liberalization (P and P^* fall after a decline in either τ^* or λ), which implies job destruction. On the other hand, this type of firm is more likely to create jobs after Foreign trade liberalization ($\downarrow \tau$). In that case, there is an increase in $L_{D\mathcal{N}}(\varphi)$ because the competitive environment becomes easier at Home (P rises), and in spite of a tougher competitive environment at Foreign (P^* falls), an expansion in $L_{X\mathcal{N}}(\varphi)$ is also possible due to the direct countervailing impact of a lower τ. In addition, Foreign trade liberalization causes a decline in $\hat{\varphi}_X$, which drives an expansion in employment in the new exporting firms.

Home trade liberalization in final goods causes a reduction in profits for all Home firms, as they become subject to stronger competition from Foreign firms. As a consequence, some ordinary importing firms are no longer able to cover the fixed cost of importing inputs and switch their status to non-importing ($\mathcal{N}$)—note from Table 1 that $\hat{\varphi}_{\mathcal{I}}$ rises after a decline in τ^*. Hence, those firms with productivities between the old and new $\hat{\varphi}_{\mathcal{I}}$ change their employment from $L_{D\mathcal{I}}(\varphi) + L_{X\mathcal{I}}(\varphi)$ to $L_{D\mathcal{N}}(\varphi) + L_{X\mathcal{N}}(\varphi)$, so that

$$\frac{L_{D\mathcal{N}}(\varphi) + L_{X\mathcal{N}}(\varphi)}{L_{D\mathcal{I}}(\varphi) + L_{X\mathcal{I}}(\varphi)} = \left(\frac{\hat{\alpha}_{\mathcal{N}}}{\hat{\alpha}_{\mathcal{I}}}\right) \left[\frac{c(\hat{\alpha}_{\mathcal{I}})}{c(\hat{\alpha}_{\mathcal{N}})}\right]^{\sigma-\theta} \left[\frac{(1+\tau)^{\sigma-1} P'^{\sigma-1}\mathbb{L} + P^{*\prime\sigma-1} w^* \mathbb{L}^*}{(1+\tau)^{\sigma-1} P^{\sigma-1}\mathbb{L} + P^{*\sigma-1} w^* \mathbb{L}^*}\right],$$

where P' and $P^{*\prime}$ are the post-liberalization aggregate prices. This expression shows one source of job creation and three sources of job destruction for these firms. First, the share of tasks performed inside these firms rises from $\hat{\alpha}_{\mathcal{I}}$ to $\hat{\alpha}_{\mathcal{N}}$, which is a source of job creation. Second, these firms' cost of the task aggregator rises from $c(\hat{\alpha}_{\mathcal{I}})$ to $c(\hat{\alpha}_{\mathcal{N}})$, which increases their marginal costs and prices, and thus makes them less competitive with respect to the other types of firms; this is a source of job destruction as long as $\sigma > \theta$. Lastly, tougher competitive environments at Home and Foreign ($P' < P$ and $P^{*\prime} < P^*$) are sources of job destruction.

2.6.3 Ordinary Importing Firms ($\mathcal{I}$)

In this model, ordinary importing firms are the most productive of the three types and they sell in both markets. After trade liberalization in final goods ($\downarrow \tau$ or $\downarrow \tau^*$), the response of firm-level employment in a continuing ordinary importer is similar to the response of a continuing non-importing exporters: job destruction after a decline in τ^* due to tougher competition in both markets, but possible job creation after a decline in τ due to Home firms become instantly more competitive at Foreign and a weaker competitive environment at Home (a job destruction force is also present when

τ declines, however, as the increase in Home exporters cause a tougher competitive environment at Foreign).

Table 1 shows trade liberalization in inputs ($\downarrow \lambda$) causes a decline in $\hat{\alpha}_{\mathcal{I}}$ (so that the fraction of imported inputs rises) and hence $c(\hat{\alpha}_{\mathcal{I}})$ falls. From (27) and (28), note that these changes generate two opposing effects on importing firms' employment: job destruction due to the lower fraction of tasks performed inside these firms ($\downarrow \hat{\alpha}_{\mathcal{I}}$), and job creation due to the fall in these firms' marginal costs—driven by the decline in the unit cost of the task aggregator, $c(\hat{\alpha}_{\mathcal{I}})$—which allows them to charge lower prices and capture larger market shares. In turn, the increase in importing firms' efficiency toughens the competitive environment in both countries (P and P^* fall after a decline in λ), which causes further job destruction. In the end, these firms will create jobs after a decline in λ only if efficiency gains are very strong.

From Table 1, note that $\hat{\varphi}_{\mathcal{I}}$ falls after a decline in τ or λ. Therefore, after Foreign trade liberalization or Home input trade liberalization some firms switch status from non-importing to importing, changing their employment from $L_{D\mathcal{N}}(\varphi) + L_{X\mathcal{N}}(\varphi)$ to $L_{D\mathcal{I}}(\varphi) + L_{X\mathcal{I}}(\varphi)$. These firms reduce the number of tasks performed inside the firm ($\hat{\alpha}_{\mathcal{I}} < \hat{\alpha}_{\mathcal{N}}$), which destroys jobs, but they also have efficiency gains that lead to job creation (as long as $\sigma > \theta$) because their cost of the task aggregator falls, $c(\hat{\alpha}_{\mathcal{I}}) < c(\hat{\alpha}_{\mathcal{N}})$. Home input trade liberalization toughens competition in both countries, causing further job destruction in these firms. Foreign trade liberalization also toughens competition in the Foreign market, but also promotes job creation in these firms through its direct positive impact on all Home exporters and the softening of competition at Home.

2.6.4 Summary

As a guide for the interpretation of the results of the empirical exercise below, Table 2 presents a summary of the model's implications for the employment responses of trading firms to each type of trade liberalization. The table excludes ordinary non-importing firms that do not export because our data only includes trading firms.

3 Data and Measures

This section describes the data and the construction of our tariff measures. The key advantage of our empirical approach is that we are able to exploit firm-level differences in exposure to each type of trade liberalization by constructing firm-level tariffs.

Table 2: Trading Firms' Employment Responses to Trade Liberalization

<table>
<tr><th rowspan="2"></th><th rowspan="2">Foreign trade liberalization
($\downarrow \tau$)</th><th colspan="2">Home trade liberalization</th></tr>
<tr><th>in final goods
($\downarrow \tau^*$)</th><th>in inputs
($\downarrow \lambda$)</th></tr>
<tr><td>Pure processing firms ($\mathcal{P}$)</td><td>Same as next column, plus creation from direct effect on exporters, and creation from new $\mathcal{P}$ firms.</td><td colspan="2">Destruction from tougher competition at Foreign. For $\mathcal{N} \rightarrow \mathcal{P}$ switchers, destruction from task relocation, creation from efficiency gains, and destruction or creation from market size effect.</td></tr>
<tr><td>Ordinary non-importing firms ($\mathcal{N}$) that export</td><td>Destruction from tougher competition at Foreign, creation from easier competition at Home, creation from direct effect, and creation from new exporters.</td><td>Destruction from tougher competition in both markets. Other channels for $\mathcal{I} \rightarrow \mathcal{N}$ switchers: creation from task relocation, destruction from efficiency losses.</td><td>Destruction from tougher competition in both markets.</td></tr>
<tr><td>Ordinary importing firms ($\mathcal{I}$)</td><td>Destruction from tougher competition at Foreign, creation from easier competition at Home, creation from direct effect. Other channels for $\mathcal{N} \rightarrow \mathcal{I}$ switchers: destruction from task relocation, creation from efficiency gains.</td><td>Destruction from tougher competition in both markets.</td><td>Destruction from tougher competition in both markets, destruction from task relocation, creation from efficiency gains. Same channels for $\mathcal{N} \rightarrow \mathcal{I}$ switchers.</td></tr>
</table>

3.1 Data

We study the effects of each type of trade liberalization on Chinese firm-level employment from 2000 to 2006 using three highly disaggregated panel data sets: firm-level production data, tariff data, and product-level trade data. These datasets will allow us to compute firm productivity, firm-level tariffs, as well as other important firm-level control variables.

The firm-level production data comes from China's National Bureau of Statistics (NBS) annual survey on manufacturing firms, which includes all state-owned enterprises (SOEs) and non-SOEs whose annual sales exceed RMB 5 million (or equivalently \$725,000). The sample used in this paper has approximately 230,000 manufacturing firms per year, varying from 162,885 firms in 2000 to 301,961 firms in 2006. On average, the sample accounts for more than 95 percent of China's total annual output in the manufacturing sector.[6] As seen from Figure B.1 in the Appendix, the output of firms in the manufacturing sector accounts for around 40.4 percent of China's GDP

[6] In 2006, the total value added of all the firms included in the survey was RMB 9,107 billion, which accounted for 99 percent of the value added of all firms in the manufacturing sector (RMB 9,131 billion), as reported by the 2007 China' s Statistics Yearbook.

in 2000 and around 43.4 percent of China's GDP in 2006. The dataset covers more than 100 accounting variables and contains all of the information from the main accounting sheets, which includes balance sheets, loss and profit sheets, and cash flow statements.

However, as documented by Brandt, Van Biesebroeck and Zhang (2012) and other studies, the firm-level production dataset has obvious errors and omissions. Therefore, we clean the dataset following the procedures of Cai and Liu (2009) and Feenstra, Li and Yu (2014). In particular, manufacturing firms are kept in our sample only if they meet the requirements of the Generally Accepted Accounting Principles (GAAP).[7] After this rigorous filter is applied, approximately one-third of the total number of firms and one-quarter of firm sales are dropped.

Data on both China's exports and imports are accessed from China's General Administration of Customs. The trade data is compiled at the HS eight-digit product level and includes information of each product's quantity, value (in U.S. dollars), type of trade (*i.e.*, processing or non-processing), and even export destination (or import source). The tariff data comes from the World Integrated Trade Solution (WITS) database of the World Bank, and consists of *ad valorem* duties imposed by China and its trading partners at the six-digit level Harmonized System (HS).

The construction of firm-level tariffs requires matching firm-level production data and product-level trade data. Following Yu (2015), we use the firms' zip code, telephone numbers, and Chinese names, which in the end allow us to match 76,823 common trading firms, including both exporters and importers. The merged sample is skewed towards large firms, as reflected by the higher averages in firm-level employment and exports. The merged dataset accounts for around 40% of the manufacturing firms reported in the NBS manufacturing survey and contains about half of the export value reported in the customs dataset.[8]

3.2 Firm-Level Tariff Measures

Even if a firm belongs to a narrowly-defined industry, it could produce multiple products and, thus, its employment could be affected by multiple tariff lines. Inspired by Lileeva and Trefler (2010), who highlight the potential aggregation bias from using industry-level tariffs, we construct firm-specific tariffs to better capture the impact of each type of trade liberalization on Chinese firm-level employment. For each Chinese firm (indexed by i) at time t, we calculate the foreign tariff against its final goods (τ_{it}), the Chinese tariff against competing final goods (τ^*_{it}), and the Chinese tariff

[7] We keep observations if all of the following hold: (1) total fixed assets cannot exceed total assets; (2) liquid assets cannot exceed total assets; (3) the net value of fixed assets is less than that of total assets; (4) number of employees cannot be less than eight; (5) the firm's identification number exists and is unique, and (6) the established time is valid.

[8] See Yu (2015) for a detailed description. Also, some of the firms in the data are pure trade intermediaries that do not have production activities. To ensure the precision of our estimates, we exclude these firms from the sample. Trade intermediaries are identified according to the procedures of Ahn, Khandelwal and Wei (2011).

on inputs the firm imports (λ_{it}).

Firms not only export multiple products, but also export them to multiple countries, with different subsets of products for different countries. The foreign tariff for Chinese firm i at time t, τ_{it}, captures the degree of foreign protection faced by the firm's products. Based on tariffs on the firm's goods in all its export destinations, τ_{it} is given by

$$\tau_{it} = \sum_{j \in J_i} \left[\frac{X_0^{ij}}{\sum_{j \in J_i} X_0^{ij}} \sum_{k \in K_i} \left(\frac{X_0^{ijk}}{X_0^{ij}} \right) \mathcal{T}_t^{jk} \right], \tag{29}$$

where $\mathcal{T}_t^{jk}$ is good j's *ad valorem* tariff imposed by country k in year t, X_0^{ijk} is the value of firm i's exports of good j to country k in the first year the product appears in the sample, $X_0^{ij} = \sum_{k \in K_{it}} X_0^{ijk}$, K_i is the set of export destinations of firm i, and J_i is the set of goods produced by firm i. Following Topalova and Khandelwal (2011), we fix exports for each good at the initial period to avoid possible reverse causality (an endogeneity problem) in firm's exports with respect to foreign tariffs. The ratio X_0^{ijk}/X_0^{ij} governs the share of firm i's good j exported to country k in the first year the firm appears in the sample; it captures the relative importance of $\mathcal{T}_t^{jk}$ in affecting firm i's exports of good j.

Chinese tariffs on final goods shield Chinese firms from foreign competition in the domestic market. Our measure for the Chinese tariff on final goods for firm i at time t, τ_{it}^*, captures the effective rate of protection received by the firm based on the tariffs China imposes on products that are similar to the goods the firm produces (see Qiu and Yu, 2016). A tariff line has a more pronounced impact if the firm has a larger share of the corresponding good in its total domestic sales. Hence, τ_{it}^* should be calculated as the average of all relevant tariffs weighted by the share of each good's domestic sales. Our firm-level production dataset, however, reports information on a firm's total domestic sales but not on each product's domestic sales. Following Yu (2015), we adopt a less satisfactory measure for τ_{it}^* that approximates the share of a good on a firm's domestic sales with the good's share on the firm's exports so that

$$\tau_{it}^* = \sum_{j \in J_i} \left(\frac{X_0^{ij}}{\sum_{j \in J_i} X_0^{ij}} \right) \mathcal{T}_t^{j}, \tag{30}$$

where $\mathcal{T}_t^{j}$ is China's *ad valorem* tariff on product j in year t.

Our measure for the input tariff faced by an ordinary Chinese firm i at time t, λ_{it}, captures the firm's cost of importing inputs as a result of Chinese tariffs on the products imported by the firm. As discussed here and in other works (see, *e.g.*, Feenstra and Hanson, 2005), processing imports are duty-free in China and that is the reason why pure processing firms face no input tariffs. An ordinary Chinese firm, however, may engage in both processing imports and non-processing imports. Therefore, λ_{it} is constructed as

$$\lambda_{it} = \sum_{j \in J_i^O} \left(\frac{M_0^{ij}}{\sum_{j \in J_i^M} M_0^{ij}} \right) \mathcal{T}_t^j, \tag{31}$$

where M_0^{ij} is firm i's imports of product j in the first year the firm appears in the sample, J_i^M is the set of firm i's imported products, and $J_i^O \subset J_i^M$ is the set of firm i's ordinary (non-processing) imported products. Note that (31) takes into account the zero tariff on the firm's processing imports. As with τ_{it} and τ_{it}^*, we use time-invariant weights to avoid an endogeneity problem due to the negative relationship between imports and tariffs.

Table B.1 in the Appendix shows the mean and standard deviation per year of our firm-level tariffs in (29), (30), and (31). Average Chinese tariffs on final goods fall the most during the period (from 15.47 percent to 7.46 percent), while the reductions in average foreign tariffs and Chinese input tariffs are rather small. Nevertheless, the standard deviations indicate large cross-sectional variation throughout the period. Note that firm-level input tariffs are small (about 2 percent on average for the entire period), which is a consequence of the large share of (duty-free) processing imports in ordinary firms (see Yu, 2015). Important for the precise estimation of the impact of each type of tariff reduction on firm-level employment, the pairwise simple correlations among foreign tariffs, Chinese final-good tariffs, and Chinese input tariffs are extremely low: the correlation is 0.01 between foreign tariffs and both Chinese final-good and input tariffs, and is 0.012 between Chinese final-good tariffs and input tariffs.

4 Liberalization and Chinese Firm-Level Employment

This section presents our empirical analysis for the effects of foreign tariffs (τ), Chinese final-good tariffs (τ^*), and Chinese input tariffs (λ) on firm-level employment. We start with specifications that ignore firm type to focus on the importance of firm heterogeneity in productivity, and later we consider specifications that capture differences across the different types of firms.

4.1 The Relevance of Heterogeneity in Productivity

Let $\mathbb{E}_{it}$ denote the employment of firm i at time t. Ignoring firm type, the econometric specification for the linearized firm-level labor demand is

$$E_{it} = \beta_\tau \tau_{it} + \gamma_\tau \Phi_{it} \tau_{it} + \beta_{\tau^*} \tau_{it}^* + \gamma_{\tau^*} \Phi_{it} \tau_{it}^* + \beta_\lambda \lambda_{it} + \gamma_\lambda \Phi_{it} \lambda_{it} + \psi_i + \nu_t + \kappa \Psi_{it} + \varepsilon_{it}, \tag{32}$$

where $E_{it} = \ln \mathbb{E}_{it}$, τ_{it}, τ_{it}^* and λ_{it} are the firm-level tariffs described above, ψ_i is a firm fixed effect, ν_t denotes a time fixed effect, Ψ_{it} is a vector of firm-level characteristics, and ε_{it} is the error term.

Table 3: Firm-Level Tariffs and Net Employment Responses with Different TFP Measures

	Log employment					
	Labor Productivity	*OLS*	*Augmented Olley-Pakes*	*Levinsohn-Petrin*	*ACF*	*System GMM*
	(1)	(2)	(3)	(4)	(5)	(6)
Foreign tariff (τ_{it})	0.184***	2.220***	0.835***	0.440**	0.591***	2.357***
	(3.89)	(8.49)	(5.60)	(2.52)	(6.89)	(8.97)
$\times$ Productivity	-2.178***	-0.686***	-0.165***	-0.061**	-0.189***	-0.899***
	(-4.06)	(-8.35)	(-5.46)	(-2.31)	(-6.85)	(-8.78)
Chinese tariff (τ^*_{it})	0.231***	4.929***	1.797***	0.527*	1.214***	4.660***
	(3.08)	(10.76)	(8.04)	(1.84)	(8.79)	(10.10)
$\times$ Productivity	-2.633***	-1.564***	-0.390***	-0.084*	-0.430***	-1.834***
	(-4.75)	(-10.68)	(-8.84)	(-1.94)	(-10.44)	(-9.99)
Input tariff (λ_{it})	0.066	1.810*	1.079**	0.506	0.683**	1.997*
	(0.55)	(1.73)	(2.02)	(0.78)	(2.52)	(1.74)
$\times$ Productivity	0.142	-0.521	-0.175*	-0.041	-0.155*	-0.720
	(0.13)	(-1.63)	(-1.67)	(-0.45)	(-1.94)	(-1.63)
Firm-level fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Other controls	Yes	Yes	Yes	Yes	Yes	Yes
Observations	56,766	56,549	39,480	38,952	39,480	56,549
R-squared	0.22	0.25	0.25	0.24	0.26	0.26

Notes: All regressions include state-owned status, foreign-owned status, export status, and log sales as controls. Robust t-statistics (in parentheses) clustered at the firm level. Firm productivity is measured by value-added labor productivity in column 1, by standard OLS TFP in column 2, by augmented Olley-Pakes TFP in column 3, by the Levinsohn-Petrin TFP in column 4, by the Ackerberg-Caves-Frazer TFP in column 5, and by system-GMM in column 6. The coefficients are statistically significant at the *10%, **5%, or ***1% level.

The variable Φ_{it} is a measure of the productivity of firm i at time t, which interacted with firm-level tariffs allows us to capture heterogeneous impacts on firm-level employment. The coefficients of interest are $\{\beta_\tau, \gamma_\tau\}$, $\{\beta_{\tau^*}, \gamma_{\tau^*}\}$, $\{\beta_\lambda, \gamma_\lambda\}$, with each pair characterizing the response of firm-level employment to a change in each type of tariff. For example, the semi-elasticity of employment with respect to foreign tariffs for firm i at time t is given by $\beta_\tau + \gamma_\tau \Phi_{it}$, so that for a one percentage point increase in the firm's foreign tariff (*e.g.*, from 6% to 7%), the firm's employment changes by $\beta_\tau + \gamma_\tau \Phi_{it}$ percent.

Firm productivity is typically measured by total factor productivity (TFP). The most popular methods to compute TFP are the semi-parametric approaches of Olley and Pakes (1996), Levinsohn and Petrin (2003), and Ackerberg, Caves and Frazer (2015). Table 3 reports the estimation of (32) under different productivity measures. Column 1 starts with the value-added labor productivity and column 2 uses the standard OLS TFP measure. We then use the augmented Olley and Pakes (1996) TFP in column 3, the Levinsohn and Petrin (2003) TFP in column 4, and the Ackerberg, Caves and Frazer (2015) TFP in column 5. Gandhi, Navarro and Rivers (2016) point out that labor—as one of the most important inputs—may also be correlated with unobserved productivity shocks, and that the standard semi-parametric approaches may not yield enough variation to correctly identify the labor coefficient in the TFP estimation. This concern is especially relevant for labor-abundant countries such as China. Taking this into account, we also measure productivity for Chinese firms using the system-GMM approach of Blundell and Bond (1998), which better captures the dynamic effects of all inputs including labor, capital and materials (Yu, 2015). Thus, column 6 shows the estimation results using the system-GMM TFP.

All our specifications in Table 3 include firm-level fixed effects and time fixed effects. As firm size, ownership type, and export status may influence firm-level employment, our specifications include as controls firm-level log sales (as a proxy for firm size), a state-owned-enterprise (SOE) indicator, a foreign-owned status indicator, and an export-status indicator. To preserve space we do not report the estimated coefficients for these controls in any of our tables; however, and consistent with the conventional wisdom, we find statistically significant evidence that SOEs, foreign firms, exporting firms, and large firms hire more workers.[9]

In all columns of Table 3, the coefficients of interest for foreign and Chinese final-good tariffs are highly significant, with $\hat{\beta}_{\tau^*} > \hat{\beta}_{\tau} > 0$ and $\hat{\gamma}_{\tau^*} < \hat{\gamma}_{\tau} < 0$. The estimate for β_{λ} is positive and significant in four of the specifications, while the interaction coefficient is negative in five specifications but only mildly significant in two of them. The positive $\hat{\beta}$'s indicate that for the least productive firms (those with $\Phi_{it} \to 0$) a decline in either type of tariff is associated with job destruction, while the magnitude of the $\hat{\beta}$'s imply that these firms' employment responds the most to Chinese liberalization in final goods and responds the least to Chinese liberalization in inputs. The negative $\hat{\gamma}$'s, on the other hand, show that as productivity increases the negative employment effect of each type of trade liberalization starts to wear off. Table B.2 in the Appendix reports a mean value of 2.57 for the system-GMM TFP used in column 6, and thus $\hat{\beta} + \hat{\gamma}\bar{\Phi}$ equals 0.047 for foreign tariffs, -0.053 for Chinese final-good tariffs, and 0.147 for Chinese input tariffs. Hence, for the firm in the mean there is slight job destruction after either a reduction in foreign tariffs or Chinese input tariffs, but slight job creation after a decline in Chinese final-good tariffs.

A drawback of using raw TFP measures—as in Table 3—is that firm-level TFP is not directly comparable across industries (see Arkolakis, 2010). To solve this problem, Table 4 shows the estimation of (32) under different versions of our system-GMM productivity measure. We first construct a *relative* system-GMM TFP measure that normalizes the raw system-GMM TFP by two-digit industry. Specifically, we construct $\Phi_{it} \in (0, 1)$ based on the firm's TFP rank relative to

[9]In spite of including firm-level fixed effects in every specification, we are still able to estimate coefficients for the SOE and foreign-owned indicators. This is possible because some firms switch their ownerships during the sample period (Hsieh and Song, 2015).

Table 4: Firm-Level Tariffs and Net Employment Responses

	Log employment				
	Relative SGMM	*High productivity indicator*			
	(1)	(2)	(3)	(4)	(5)
Foreign tariff (τ_{it})	1.083***	0.244***	0.226**	0.252***	0.177*
	(8.93)	(5.99)	(2.25)	(5.28)	(1.80)
× Productivity	-3.783***	-0.402***	-0.401***	-0.390***	-0.654***
	(-8.67)	(-7.20)	(-7.19)	(-6.15)	(-4.24)
× Export indicator			0.020		
			(0.20)		
Chinese tariff (τ^*_{it})	2.608***	0.504***	0.382***	0.499***	0.540***
	(10.71)	(6.82)	(2.86)	(5.53)	(2.75)
× Productivity	-9.109***	-0.917***	-0.919***	-0.860***	-1.137***
	(-10.58)	(-14.12)	(-14.13)	(-11.01)	(-5.96)
× Export indicator			0.001		
			(1.11)		
Input tariff (λ_{it})	0.965**	0.185	0.379	0.382***	
	(2.10)	(1.26)	(1.62)	(2.91)	
× Productivity	-3.013**	-0.163	-0.159	-0.376**	
	(-2.05)	(-1.01)	(-0.99)	(-2.40)	
× Export indicator			-0.002		
			(-1.09)		
Firm-level fixed effects	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes
Other controls	Yes	Yes	Yes	Yes	Yes
Pure processing firms	Yes	Yes	Yes	No	Only
Observations	56,549	56,549	56,549	46,443	10,106
R-squared	0.25	0.24	0.24	0.25	0.22

Notes: All regressions include state-owned status, foreign-owned status, export status, and log sales as controls. Robust t-statistics (in parentheses) clustered at the firm level. Firm productivity is measured by normalized system-GMM TFP in column 1, and by a high-TFP indicator in columns 2-5. The coefficients are statistically significant at the *10%, **5%, or ***1% level.

its industry peers at time t: the least productive firm in the industry takes a value close to zero, the firm at the median takes a value of 0.5, and the most productive firm takes a value close to 1. This also greatly simplifies the interpretation of the results: for a given tariff, the estimated semi-elasticity of employment for the least productive firm is $\hat{\beta}$, and for the most productive firm is $\hat{\beta} + \hat{\gamma}$. Column 1 shows the estimation results using the relative system-GMM TFP measure. Each type of trade liberalization is associated with job destruction in the least productive firms ($\hat{\beta} > 0$) and with job creation in the most productive firms ($\hat{\beta} + \hat{\gamma} < 0$). The magnitude of the semi-elasticities indicate that firm-level employment responds the most to Chinese liberalization in final-good trade, and the least to Chinese liberalization in input trade.

In columns 2-5 of Table 4 we use instead a high-productivity indicator, $\Phi_{it} \in \{0, 1\}$, based on the relative system-GMM TFP measure—firms within an industry with a productivity higher than the mean receive a value of 1, and zero otherwise. In this case the estimated semi-elasticity of employment for low-productivity firms is $\hat{\beta}$, and for high-productivity firms is $\hat{\beta} + \hat{\gamma}$. Column 2 shows qualitatively similar results to those in column 1; however, the coefficients on input tariffs lose statistical significance. Column 3 adds an interaction term between each type of tariff and export status, but the interaction coefficients are not statistically significant and the results from column 3 barely change.

Pure processing firms face zero input tariffs and enjoy preferential treatment from their international partners (see Ludema *et al.*, 2017). To account for this, and as a preview of our analysis by type of firm, columns 4 and 5 presents the estimation of equation (32) after splitting the sample into ordinary firms and pure processing firms. The contrast between columns 4 and 5 yields interesting insights. On the one hand, note that a decline in foreign tariffs is related to job destruction in both types (ordinary and pure processing) of low-productivity firms, but the effect is smaller and less statistically significant in pure processing firms. On the other hand, although high-productivity firms of both types are expected to create jobs after a decline in foreign tariffs, the impact is much larger for pure processing firms (the magnitude of $\hat{\beta}_\tau + \hat{\gamma}_\tau$ is more than three time larger in column 5 than in column 4). Hence, a decline in foreign tariffs benefits employment in pure processing firms the most. The effects of Chinese final-good liberalization are qualitatively similar for both types of firms—job destruction in low productivity firms and job creation in high productivity firms. Lastly, note that the coefficients for input tariffs regain their statistical significance for ordinary firms, with a decline in λ being associated with job destruction in both low- and high-productivity firms ($\hat{\beta}_\lambda > \hat{\beta}_\lambda + \hat{\gamma}_\lambda > 0$), suggesting that Chinese labor is replaced with imported intermediate inputs when input tariffs fall (Chen, Yu and Yu, 2017).[10]

The exercise in this section highlights the relevance of firm-level productivity for the employment effects of each type of trade liberalization. The results indicate standard Melitz's type effects, with changes in firm-level employment likely driven by trade-induced market share reallocations from low-productivity firms to high-productivity firms. Also, here we showed that the size of such employment effects crucially depends on liberalization type and on the distinction between ordinary and pure processing firms.

4.2 Expansions and Contractions

It may be argued that employment or tariffs are non-stationary variables, so that the results from the estimation in levels of equation (32) are not reliable. To account for this potential problem,

[10]Given that input tariffs are always zero for pure processing firms, the input-tariff regressor are automatically dropped from the regression in column 5.

in this section we use instead first differences of our variables of interest. Our first-difference econometric specification is

$$\Delta E_{it} = \beta_{\tau}\Delta\tau_{it} + \gamma_{\tau}\Phi_{it}\Delta\tau_{it} + \beta_{\tau^*}\Delta\tau^*_{it} + \gamma_{\tau^*}\Phi_{it}\Delta\tau^*_{it} + \beta_{\lambda}\Delta\lambda_{it} + \gamma_{\lambda}\Phi_{it}\Delta\lambda_{it} + \kappa\Delta\Psi_{it} + \Delta\nu_t + \Delta\varepsilon_{it}, \quad (33)$$

where Δ represents the first difference of a variable so that, for example, ΔE_{it} is the log change in firm i's employment from $t-1$ to t.

The estimated responses of firm-level employment to tariff changes are the result of firms' expansion and contraction decisions. For example, if firms are expected to face net job destruction after a tariff reduction, the mechanism of destruction can be through a decline in the rate of job expansion, or an increase in the rate of job destruction, or a combination of both. As a by-product of the first-difference estimation, we are able to break down firm-level employment responses to tariff reductions into their expansions and contractions components. Following Davis, Haltiwanger and Schuh (1996), let e_{it} represent the rate of job creation by expansion for firm i between $t-1$ and t, and let c_{it} denote the firm's rate of job destruction by contraction. Using ΔE_{it}, e_{it} and c_{it} are defined as

$$e_{it} = \max(\Delta E_{it}, 0),$$
$$c_{it} = \max(-\Delta E_{it}, 0),$$

and thus $\Delta E_{it} \equiv e_{it} - c_{it}$. It follows that we can split our specification in (33) as

$$e_{it} = \beta^e_{\tau}\Delta\tau_{it} + \gamma^e_{\tau}\Phi_{it}\Delta\tau_{it} + \beta^e_{\tau^*}\Delta\tau^*_{it} + \gamma^e_{\tau^*}\Phi_{it}\Delta\tau^*_{it} + \beta^e_{\lambda}\Delta\lambda_{it} + \gamma^e_{\lambda}\Phi_{it}\Delta\lambda_{it} + \kappa^e\Delta\Psi_{it} + \Delta\nu^e_t + \Delta\varepsilon^e_{it}, \quad (34)$$

$$c_{it} = \beta^c_{\tau}\Delta\tau_{it} + \gamma^c_{\tau}\Phi_{it}\Delta\tau_{it} + \beta^c_{\tau^*}\Delta\tau^*_{it} + \gamma^c_{\tau^*}\Phi_{it}\Delta\tau^*_{it} + \beta^c_{\lambda}\Delta\lambda_{it} + \gamma^c_{\lambda}\Phi_{it}\Delta\lambda_{it} + \kappa^c\Delta\Psi_{it} + \Delta\nu^c_t + \Delta\varepsilon^c_{it}, \quad (35)$$

where by construction, each coefficient on (33) is identical to the difference of the respective coefficients in (34) and (35) (*e.g.*, $\beta_{\tau} \equiv \beta^e_{\tau} - \beta^c_{\tau}$).

Table 5 presents the first-difference estimation results. The net-employment-change regression in column 1 can be compared to the regression in column 2 of Table 4, while regressions in columns 2 and 3 can be compared respectively to regressions in columns 4 and 5 in Table 4. Comparing these columns, note that the estimated coefficients for the β's and γ's are very similar in sign, magnitudes, and significance, so that the conclusions obtained from the regressions in levels in the previous section are mostly unaltered for the first-difference regressions.

Two differences that stand out are the reductions in the magnitudes of $\hat{\beta}_{\tau}$ and $\hat{\gamma}_{\tau}$ for pure processing firms, which change from 0.177 and -0.654 in Table 4 to 0.070 (non-significant) and -0.377 in Table 5. Hence, after foreign trade liberalization, the first-difference regression indicates no statistically significant job destruction in low-productivity pure processing firms, but shows

Table 5: First-Difference Estimation, Expansions, and Contractions

	Net employment change ($\boldsymbol{\Delta E \equiv e-c}$)			**Job expansions ($\boldsymbol{e}$)**			**Job contractions ($\boldsymbol{c}$)**		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
$\triangle$Foreign tariff ($\triangle\tau_{it}$)	0.196***	0.225***	0.070	0.138***	0.153***	0.068	-0.058**	-0.072***	-0.002
	(4.68)	(4.81)	(0.81)	(4.63)	(4.5)	(1.17)	(-2.43)	(-2.78)	(-0.04)
× Productivity	-0.343***	-0.349***	-0.377***	-0.256***	-0.254***	-0.318***	0.087***	0.096***	0.059
	(-6.05)	(-5.64)	(-2.89)	(-6.33)	(-5.62)	(-3.45)	(2.71)	(2.76)	(0.75)
$\triangle$Chinese tariff ($\triangle\tau^*_{it}$)	0.320***	0.277***	0.473**	0.136**	0.114*	0.212	-0.184***	-0.163***	-0.261**
	(3.75)	(2.97)	(2.2)	(2.16)	(1.64)	(1.4)	(-3.87)	(-3.22)	(-1.99)
× Productivity	-0.836***	-0.786***	-1.039***	-0.548***	-0.508***	-0.723***	0.288***	0.277***	0.316***
	(-12.11)	(-10.17)	(-7.09)	(-10.80)	(-9.00)	(-6.42)	(7.65)	(6.55)	(4.06)
$\triangle$Input tariff ($\triangle\lambda_{it}$)	0.293**	0.351***	0.276	0.229**	0.267***	0.223	-0.064	-0.085	-0.053
	(2.35)	(2.76)	(0.46)	(2.37)	(2.69)	(0.65)	(-0.98)	(-1.28)	(-0.15)
× Productivity	-0.242	-0.297*	-1.898*	-0.192	-0.243**	-0.886	0.050	0.054	1.012**
	(-1.59)	(-1.90)	(-1.95)	(-1.62)	(-1.99)	(-1.19)	(0.62)	(0.67)	(2.43)
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Other controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Pure processing firms	Yes	No	Only	Yes	No	Only	Yes	No	Only
Observations	17,064	14,546	2,518	17,064	14,546	2,518	17,064	14,546	2,518
R-squared	0.12	0.13	0.11	0.10	0.10	0.09	0.05	0.05	0.05

Notes: All regressions include first-differences of state-owned status, foreign-owned status, export status, and log sales as controls. Robust t-statistics (in parentheses) clustered at the firm level. Firm productivity is measured by a high-TFP indicator. The coefficients are statistically significant at the *10%, **5%, or ***1% level.

slightly smaller job creation for high-productivity firms ($0.177 - 0.654 = -0.477$ vs $0.070 - 0.377 = -0.307$). Note also that in contrast to column 5 of Table 4, column 3 of Table 5 shows input-tariff coefficients for pure processing firms. This is a consequence of firms that switch status from ordinary to pure processing, with the large and significant coefficient for $\hat{\gamma}_{\lambda}$ showing that as input tariffs drop to zero, high-productivity firms that switch to pure processing status have large increases in employment.

Using all firms, columns 4 and 7 in Table 5 show the expansions (e) and contractions (c) specifications from (34)-(35). The coefficients from column 1 are identical to the difference between the coefficients in columns 4 and 7. Hence, the result that each coefficient in the third column has the opposite sign to the coefficient in the second column shows that after a change in any type of trade cost, changes in job creation by expansion and job destruction by contraction *reinforce each other* to generate the net firm-level employment results. For example, after a 10 percentage point decline in foreign tariffs, low-productivity firms reduce their employment in 1.38% due to a decline in the rate of job expansions, and in 0.58% due to an increase in the rate of job contractions, for a total employment reduction of 1.96%. On the other hand, high-productivity firms increase their employment in 1.18% ($0.138 - 0.256$) due to an increase in the rate of job expansions, and in 0.29% ($0.087 - 0.058$) due to a reduction in the rate of job contractions, for a total increase in employment of 1.47%. Note that the bulk of the effect of foreign trade liberalization on firm-level employment happens through changes in the rate of job expansions, rather than through job contractions.

After a 10 percentage point reduction in Chinese final-good tariffs, Table 5 shows that for the associated 3.2% net job destruction in low-productivity firms, the increase in the rate of job contractions plays a slightly larger role than the reduction in the rate of job expansions—the former reduces employment by 1.84% and the latter by 1.36%. For high-productivity firms, however, the increase in the rate of job expansions plays a larger role on the associated employment increase—the increase in job expansions rises employment by 4.12% ($0.136 - 0.548$), and the reduction in job contractions drives an employment increase of 1.04% ($0.288 - 0.184$). Regarding Chinese input trade liberalization, only $\hat{\beta}^{e}_{\lambda}$ is statistically significant, showing that after a 10 percentage point decline in input tariffs, the 2.93% net employment decline in low-productivity firms is mostly associated with a decline in job expansions (2.29%).

Table 5 shows the estimation of specifications (34) and (35) for ordinary firms in columns 5 and 8, and for pure processing firms in columns 6 and 9. The results for ordinary firms are very similar to those obtained using all firms in columns 4 and 7. For pure processing firms, the net employment increase in high-productivity firms after a decline in foreign tariffs is mostly due to an increase in the rate of job expansions. After a decline in Chinese final-good tariffs, the consequences on expansions and contractions for pure processing firms are qualitatively similar to those for ordinary firms: changes in job contractions play a slightly larger role in the net employment reduction of low-productivity firms, but changes in job expansions are more important in the net employment increase of high-productivity firms. Lastly, the net employment increase in high-productivity firms that switch from ordinary to pure processing firms—and who see their input tariffs drop to zero—is mainly driven by a reduction in the rate of job contractions.

Given the massive Chinese economic expansion during the early 2000s, it is not surprising that (with the few exceptions described above) in response to trade liberalization, Chinese firms' adjustments in the rate of job expansions tend to be more important than adjustments in the rate of job contractions.

4.3 Heterogenous Impact of Trade Liberalization by Firm Type

The previous results show that productivity matters for the impact of the different types of trade liberalization on firm-level employment. They also show that the effects depend on whether the firm is ordinary or pure processing. This section expands our empirical analysis by further distinguishing between the types of trading ordinary firms: non-importing exporters, importing exporters, and importing non-exporters. We then compare the empirical results for the different types of firms against our theoretical model's predictions in Table 2 to shed light on the relative importance of each channel through which trade liberalization affects firm-level employment—competition effects, task relocation and efficiency effects, and the direct effect of foreign liberalization. Although our model does not include importing non-exporters, it still provide guidelines to understand these firms' responses.

As shown in Figure 3, in our model a firm self-selects into each type based on its productivity and the cutoff productivity levels: there is a perfect partition of firms so that two firms with the same productivity level always have the same status $s \in \{\mathcal{P}, \mathcal{N}, \mathcal{I}\}$. Thus, within the model (with $\hat{\varphi}_{\mathcal{P}} < \hat{\varphi}_D < \hat{\varphi}_X < \hat{\varphi}_{\mathcal{I}}$) all pure processing firms are less productive than all ordinary non-importing firms, who are in turn less productive than all ordinary importing firms. In practice, however, there is overlapping across all types of firms (*e.g.*, there is coexistence of high-productivity pure processing firms and low-productivity importing firms), which can be explained by other dimensions of firm heterogeneity such as differences across firms' fixed costs or managerial abilities. Recognizing this important fact, the empirical analysis in this section continues to distinguish between low- and high-productivity firms, but now *within* each firm type.

Table B.3 in the Appendix provides statistics about the composition of firms in our sample of trading firms. Most firms in our sample are non-importing exporters, accounting from 70.4 percent of all firms in 2000, and 56.1 percent in 2006. Pure processing firms accounted for 10.4 percent of trading firms in 2000, and for 8.3 percent in 2006. Importing firms made up for the decline in the fraction of pure processing and non-importing exporters from 2000 to 2006, with importing exporters raising their share from 12.5 to 16.8 percent, and importing non-exporters increasing their share from 6.7 to 18.8 percent. Regarding the fraction of high-productivity firms within each type, in 2000 only non-importing exporters had the majority of firms classified as high productivity, while in 2006 all types of firms have 50 percent or more of firms classified as high productivity. Consistent with our ordering assumption in Figure 3, pure processing firms have the lowest share of high-productivity firms in both years. Moreover, although in 2000 importing exporters had a lower fraction of high-productivity firms than non-importing exporters (45.1 percent versus 79.3 percent), by 2006 the relationship has changed in favor of importing exporters (69.4 percent versus 60.7 percent).

Table 6 reports the outcome of our specification in (32) extended to account for different β's and γ's across the different types of firms.[11] The first two columns show a single regression—the first column shows the estimates of β and the second column shows the estimates of γ—with three types of firms: pure processing firms, non-importing exporters, and importing firms. In our model, however, importing firms are also exporters. Therefore, the last two columns in Table 6 present the outcome of a regression that further splits importing firms into importing non-exporters and importing exporters.

In the two regressions, all the estimates of the β's and γ's for foreign and Chinese final-good tariffs are highly statistically significant, showing that for all types of firms a reduction in any of these tariffs is associated with job destruction in low-productivity firms and job creation in high-productivity firms. On the other hand, a decline in input tariffs is only statistically relevant for importing exporters, with the usual employment effects for low- and high- productivity firms.

Summarizing the results of columns 3 and 4 in Table 6, Figure 4 shows the estimated responses of firm-level employment to a 1 percent decline in tariffs for low-productivity firms ($-\hat{\beta}$) and high-productivity firms ($-\hat{\beta} - \hat{\gamma}$), along with 95 percent confidence intervals. The figure makes evident the higher importance of Chinese final-good trade liberalization—relative to the other liberalization types—for all types of firms, low- and high-productivity. The only exception is for the positive employment impact of a decline in foreign tariffs for high-productivity pure processing firms, which is slightly larger than the impact of a decline in Chinese tariffs (0.457 versus 0.425). From Table 4, section 4.1 describes that a decline in foreign tariffs benefits employment in high-productivity pure processing firms the most, when compared to high-productivity trading ordinary firms. Figure 4

[11] Similar to column 5 in Table 4, pure processing firms face a zero input tariff and hence there are no input-tariff coefficient estimates for this type of firm in Table 6.

Table 6: Firm-Level Trade Costs and Net Employment Responses

	Log employment			
	One group of ordinary importers		*Two groups of ordinary importers*	
	(β)	(γ)	(β)	(γ)
Pure processing firms ($\mathcal{P}$)				
Foreign tariff (τ_{it})	0.178**	-0.643***	0.179**	-0.647***
	(2.40)	(-5.48)	(2.41)	(-5.52)
Chinese tariff (τ^*_{it})	0.524***	-0.879***	0.523***	-0.869***
	(5.73)	(-7.76)	(5.72)	(-7.67)
Non-importing exporter ($\mathcal{N}$)				
Foreign tariff (τ_{it})	0.306***	-0.359***	0.306***	-0.355***
	(4.79)	(-3.99)	(4.80)	(-3.95)
Chinese tariff (τ^*_{it})	0.535***	-1.013***	0.535***	-1.006***
	(6.16)	(-11.00)	(6.15)	(-10.91)
Input tariff (λ_{it})	0.036	0.005	0.040	0.003
	(0.18)	(0.02)	(0.20)	(0.01)
Importing firms				
Foreign tariff (τ_{it})	0.226***	-0.379***		
	(3.74)	(-4.89)		
Chinese tariff (τ^*_{it})	0.449***	-0.830***		
	(5.25)	(-9.57)		
Input tariff (λ_{it})	0.348**	-0.376*		
	(2.12)	(-1.80)		
Importing exporter ($\mathcal{I}$)				
Foreign tariff (τ_{it})			0.181***	-0.277***
			(2.75)	(-3.33)
Chinese tariff (τ^*_{it})			0.472***	-0.745***
			(5.12)	(-7.98)
Input tariff (λ_{it})			0.437***	-0.649***
			(2.59)	(-2.98)
Importing non-exporter				
Foreign tariff (τ_{it})			0.344***	-0.668***
			(2.62)	(-3.90)
Chinese tariff (τ^*_{it})			0.368***	-1.068***
			(3.00)	(-5.93)
Input tariff (λ_{it})			0.149	0.234
			(0.46)	(0.59)
Firm-level fixed effects	Yes		Yes	
Year fixed effects	Yes		Yes	
Other controls	Yes		Yes	
Observations	56,549		56,549	
R-squared	0.24		0.24	

Notes: The regression includes state-owned status, foreign-owned status, export status, and log sales as controls. Robust t-statistics (in parentheses) clustered at the firm level. Firm productivity is measured by a high-TFP indicator. The coefficients are statistically significant at the *10%, **5%, or ***1% level.

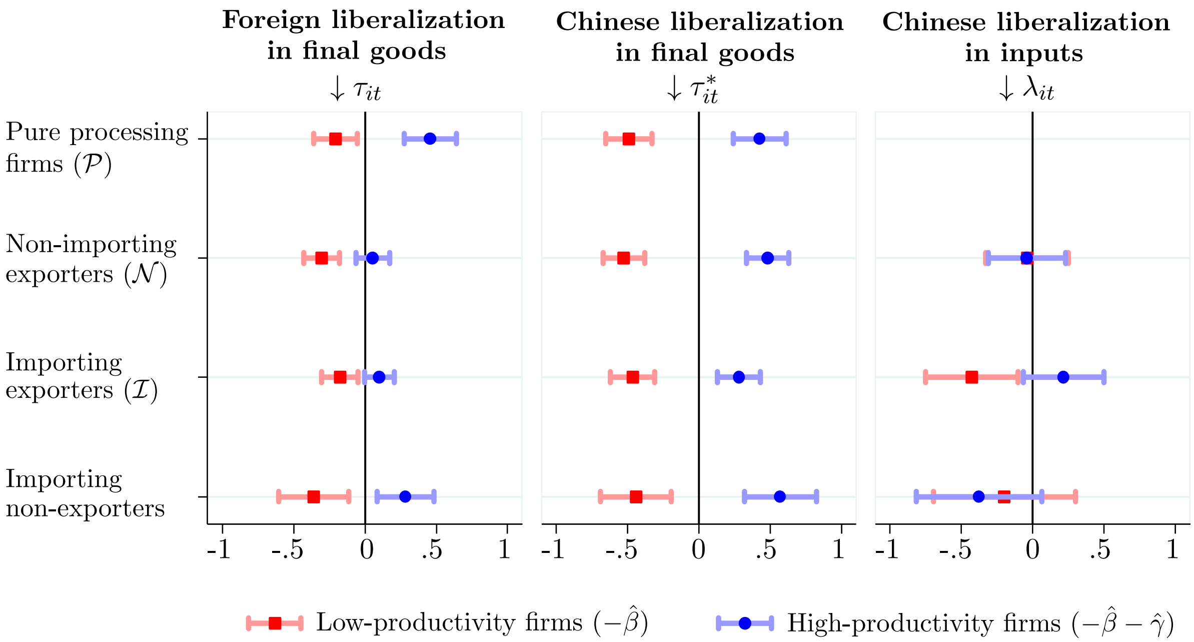

Figure 4: Employment Responses to a 1% Decline in Tariffs, with 95% Confidence Intervals (from Estimation in Levels)

shows that this result continues to hold after splitting trading ordinary firms into their three types. Lastly, a decline in Chinese input tariffs is only statistically relevant for low-productivity importing exporters, who destroy domestic jobs.

Using as guide the theoretical results summarized in Table 2, the destruction in low-productivity firms after foreign or Chinese trade liberalization in final goods can be explained by competition effects: trade liberalization increases competition, driving down aggregate prices—which shifts to the left the residual demand each firm faces—and causing firm-level employment reductions in low-productivity firms. There is lower destruction after a decline in foreign tariffs because in that case only the foreign market becomes tougher and there are more countervailing forces, such as an easier competitive environment in the domestic market, the expansive direct effect on exporters (who become instantly more competitive in the foreign market), and possible efficiency gains for new pure processing firms and importers.

After Home trade liberalization in final goods, Table 2 shows sources of job creation only for firms that switch from non-importing to pure processing (from efficiency gains and market size effects) and for firms that switch from importing to non-importing (from task relocation effects). Hence, although the model provides insights on the channels that can explain job creation in high-productivity pure processing firms after a reduction in Chinese final-good tariffs, it faces limitations to explain the estimated job creation in other types of high-productivity firms. Combined with the observed job destruction in low-productivity firms, a potential explanation is the existence of market share reallocation effects from low-productivity firms to high-productivity firms within each firm type. This is a channel that is absent from our model, which obtains that all firms with the same status have the same employment elasticities to tariff changes.

After Chinese input trade liberalization, the statistically significant job destruction in low-productivity importing exporters is explained by tougher competition in both markets, as well as task relocation effects. Importing exporters also have efficiency gains because their marginal costs decline ($c(\hat{\alpha}_{\mathcal{I}})$ falls), which allow them to charge lower prices and capture larger market shares. Although there is evidence of important job-creating efficiency gains for high-productivity importing exporters (the estimated γ, -0.647, is large in magnitude and highly significant), the net effect, $-0.429 + 0.647 = 0.218$, implies more employment for these firms but is not statistically significant at conventional levels.

Table 7 shows the estimation of the first-difference specifications in (33), (34), and (35) by type of firm. Figure 5 shows the responses of net employment changes for each type of firm to a 1 percent reduction in each type of tariff, along with 95 percent confidence intervals. Note that Figure 5 is very similar to Figure 4, which shows that the estimation in levels in Table 6 is not subject to non-stationarity problems. The only new statistically significant result in Figure 5 is the net job destruction in low-productivity non-importing exporters after a decline in Chinese input tariffs. From Table 2, this is likely the result of tougher competition in both markets stemming from more efficient importing firms who are able to set lower prices and capture larger market shares, at the expense of non-importing firms.

Figures 4 and 5 show that across the four types of firms, pure processing firms benefit the most from foreign trade liberalization: they suffer from little job destruction in low-productivity firms but enjoy large job creation in high-productivity firms. Given that these firms do not access the domestic market, it is not surprising that the positive employment effects of a decline in foreign tariffs—the direct effect on exporters and market size effects—are larger than for those firms that also care about the domestic market.

By decomposing the net employment change into its expansions and contractions components, in Table 7 we see that after a decline in foreign tariffs, changes in expansions drive job creation in the most productive firms, and job destruction in the least productive firms (contractions are almost as important for importing exporters). After a decline in input tariffs, a reduction in expansions drive job destruction in the least productive (importing and non-importing) exporters, and an increase in expansions drives job creation in the most productive importing firms. Lastly, note that job contractions play an important role after a decline in Chinese final-good tariffs: contractions are the most important driver of job destruction in low-productivity firms. This result

Table 7: First-Difference Estimation by Type of Firm

	Net employment change ($\Delta E \equiv e - c$)		**Job expansions (e)**		**Job contractions (c)**	
	(β)	(γ)	(β^e)	(γ^e)	(β^c)	(γ^c)
Pure processing firms ($\mathcal{P}$)						
$\triangle$Foreign tariff ($\triangle\tau_{it}$)	0.043	-0.547***	0.099*	-0.441***	0.056	0.106
	(0.57)	(-4.62)	(1.95)	(-5.25)	(1.19)	(1.56)
$\triangle$Chinese tariff ($\triangle\tau^*_{it}$)	0.468***	-0.864***	0.224***	-0.591***	-0.243***	0.273***
	(4.54)	(-7.22)	(3.05)	(-6.63)	(-4.11)	(4.29)
Non-importing exporter ($\mathcal{N}$)						
$\triangle$Foreign tariff ($\triangle\tau_{it}$)	0.185***	-0.248***	0.145***	-0.214***	-0.040	0.034
	(3.06)	(-3.17)	(3.48)	(-3.81)	(-1.21)	(0.79)
$\triangle$Chinese tariff ($\triangle\tau^*_{it}$)	0.291***	-0.866***	0.108	-0.550***	-0.183***	0.316***
	(2.97)	(-9.03)	(1.51)	(-7.85)	(-3.39)	(6.38)
$\triangle$Input tariff ($\triangle\lambda_{it}$)	0.321**	-0.175	0.249**	-0.166	-0.072	0.009
	(2.20)	(-0.98)	(2.14)	(-1.19)	(-1.00)	(0.10)
Importing exporter ($\mathcal{I}$)						
$\triangle$Foreign tariff ($\triangle\tau_{it}$)	0.228***	-0.334***	0.119**	-0.186***	-0.110***	0.148***
	(3.37)	(-3.64)	(2.40)	(-2.83)	(-2.75)	(2.73)
$\triangle$Chinese tariff ($\triangle\tau^*_{it}$)	0.234**	-0.702***	0.095	-0.484***	-0.139***	0.217***
	(2.42)	(-7.64)	(1.31)	(-7.12)	(-2.62)	(4.12)
$\triangle$Input tariff ($\triangle\lambda_{it}$)	0.370**	-0.529**	0.312**	-0.433**	-0.058	0.096
	(2.26)	(-2.33)	(2.42)	(-2.32)	(-0.72)	(0.86)
Importing non-exporter						
$\triangle$Foreign tariff ($\triangle\tau_{it}$)	0.432**	-0.603***	0.263*	-0.473***	-0.169*	0.129
	(2.36)	(-2.83)	(1.87)	(-2.95)	(-1.73)	(1.10)
$\triangle$Chinese tariff ($\triangle\tau^*_{it}$)	0.330**	-1.035***	0.147	-0.624***	-0.183*	0.410***
	(2.03)	(-5.30)	(1.28)	(-4.41)	(-1.95)	(3.74)
$\triangle$Input tariff ($\triangle\lambda_{it}$)	0.283	0.078	0.201	0.099	-0.082	0.021
	(0.77)	(0.20)	(0.73)	(0.32)	(-0.40)	(0.10)
Year fixed effects	Yes		Yes		Yes	
Other controls	Yes		Yes		Yes	
Observations	17,064		17,064		17,064	
R-squared	0.13		0.10		0.05	

Notes: All regressions include first-differences of state-owned status, foreign-owned status, export status, and log sales as controls. Robust t-statistics (in parentheses) clustered at the firm level. Firm productivity is measured by a high-TFP indicator. The coefficients are statistically significant at the *10%, **5%, or ***1% level.

indicates that within firm type, there are large labor reallocation effects from low-productivity to high-productivity firms.

To conclude this section, we calculate employment gains and losses following a procedure similar to Autor, Dorn and Hanson (2013) and Acemoglu *et al.* (2016). Let $\mathbb{E}_{i\tau}$ denote firm i's employment had the firm's foreign tariff not changed between 2000 and 2006 (*i.e.* the counterfactual employment), and let $\mathbb{E}_{i\text{END}}$ denote firm i's actual employment during the last year it appears in the sample. If $\Delta\tau_i$ is the change in firm i's foreign tariff during our period of study, if follows that firm

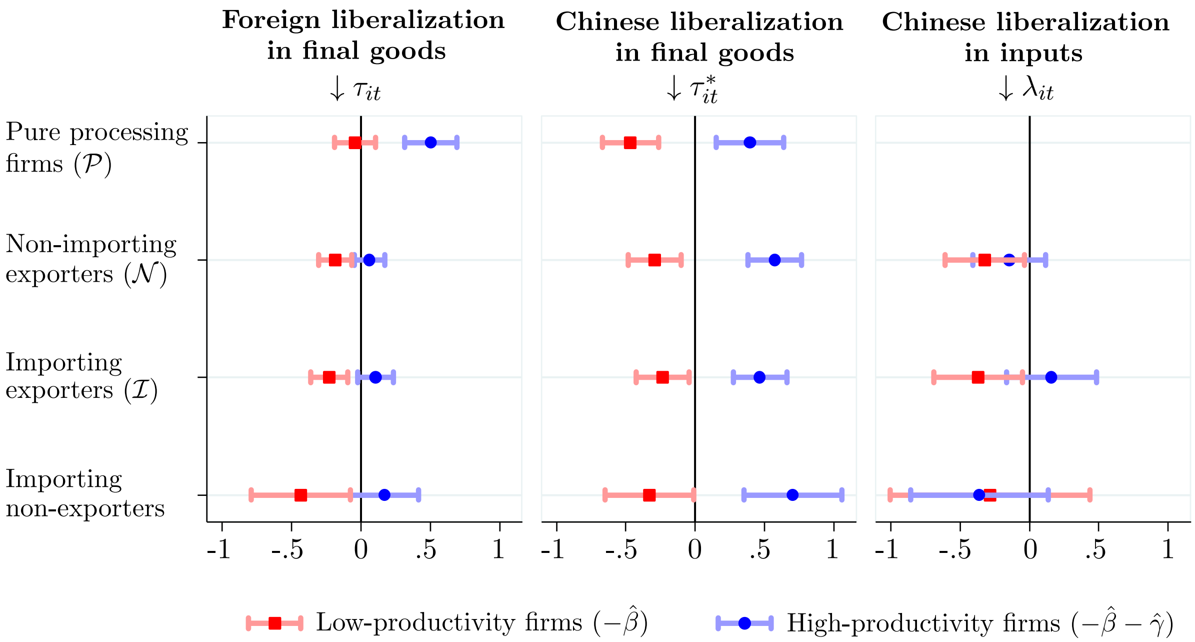

Figure 5: Employment Responses to a 1% Decline in Tariffs, with 95% Confidence Intervals (from Net Employment Change)

i's predicted log-employment change due to the foreign tariff change is $\ln \mathbb{E}_{i\text{END}} - \ln \mathbb{E}_{i\tau} = \hat{\beta}_\tau \Delta\tau_i$, so that

$$\Delta\mathbb{E}_{i\tau} \equiv \mathbb{E}_{i\text{END}} - \mathbb{E}_{i\tau} \equiv \mathbb{E}_{i\text{END}} \left(1 - e^{\hat{\beta}_\tau \Delta\tau_i}\right),$$

where $\Delta\mathbb{E}_{i\tau}$ is firm i's predicted employment change from τ. Similarly, we calculate firm i's predicted employment changes from τ^* and λ, $\Delta\mathbb{E}_{i\tau^*}$ and $\Delta\mathbb{E}_{i\lambda}$.

Using the coefficients from the net-employment-change regression in Table 7's first two columns, Table 8 shows 2000-2006 predicted employment gains and losses for each type of firm and productivity level, from changes in each type of tariff. There are gains and losses for every type of firm and for each tariff because some firms faced reductions in tariffs, while others faced increases in tariffs. Hence, for example, high-productivity importing exporters created 49,353 jobs due to reductions in Chinese final-good tariffs, and destroyed 11,219 jobs due to increases in Chinese final-good tariffs.

Table 8 shows net employment losses after changes in foreign final-good tariffs and Chinese input tariffs, and net employment gains from changes in Chinese final-good tariffs. Hence, Chinese final-good tariffs are the main driver of the predicted overall net job creation. Notice that these tariffs cause 2.9 times more job creation than foreign final-good tariffs, and 6.6 times more job creation than Chinese input tariffs. Job destruction, however, is at the same order of magnitude for changes in Chinese and foreign-final good tariffs, and is about 2.6 times larger than job destruction due to changes in input tariffs.

By type of firm, note that pure processing firms are shedding jobs, which is mainly a consequence

Table 8: Total Predicted Employment Changes, 2000-2006

	Change in foreign final-good tariff (τ)		**Change in Chinese final-good tariff (τ^*)**		**Change in Chinese input tariff (λ)**		**Total by firm type**	
	Creation	*Destruction*	*Creation*	*Destruction*	*Creation*	*Destruction*	*Creation*	*Destruction*
Pure processing firms ($\mathcal{P}$)								
Low-productivity	697	-524	936	-6,099			1,633	-6,622
High-productivity	6,926	-13,330	7,686	-1,331			14,612	-14,661
Non-importing exporter ($\mathcal{N}$)								
Low-productivity	5,146	-5,513	725	-9,950	2,287	-2,920	8,158	-18,384
High-productivity	5,050	-4,507	46,140	-7,907	3,486	-5,751	54,676	-18,165
Importing exporter ($\mathcal{I}$)								
Low-productivity	4,669	-5,392	426	-4,671	1,629	-2,925	6,724	-12,988
High-productivity	11,964	-13,018	49,353	-11,219	9,080	-3,996	70,397	-28,234
Importing non-exporter								
Low-productivity	2,028	-1,985	335	-1,801	402	-433	2,765	-4,219
High-productivity	3,398	-3,208	9,535	-1,801	438	-2,095	13,370	-7,104
Total by liberalization type	39,878	-47,478	115,136	-44,779	17,321	-18,120	172,336	-110,377

Notes: Employment gains or losses are calculated based on the regression for net employment changes in the first two columns of Table 7.

of high-productivity pure processing firms facing higher foreign final-good tariffs. On the other hand, high-productivity non-importing and importing exporters are the main source of net job creation in Chinese trading firms, accounting for 73 percent of job creation, but only for 42 percent of job destruction.

An important caveat of the predicted employment changes in Table 8 is that it only reports gains or losses at the intensive margin for firms that do not change firm status. Thus, it ignores firms that switch their type due to a tariff change, but more importantly, it misses the impact of tariffs on the extensive margin of employment. That is, it ignores job creation and destruction due to births and deaths of firms, which may be more important than the intensive margin of employment. Unfortunately, our data is not well suited to study changes at the extensive margin because a large fraction of year-to-year changes in the number of firms in the sample is simply due to better collection methods.

4.4 Employment Responses of Switchers

The summary of our model in Table 2 includes a description of the employment responses to trade liberalization for firms that change their status to either $\mathcal{P}$, $\mathcal{N}$, or $\mathcal{I}$. This section looks at how switchers in our data respond to each type of tariff, and relies on the model's implications to guide the interpretation of the observed empirical responses . Using first-difference regressions (for net employment changes, expansions, and contractions), Table 9 presents our empirical results for switching firms.

For firms that switch to pure processing status, there is statistically significant job creation for high-productivity firms after foreign trade liberalization. According to Table 2, the predicted job creation is a consequence of efficiency gains (firms have reductions in their marginal costs, which allow them to charge lower prices and capture larger market shares) and access to foreign markets that are larger than the no-longer accessible domestic market. While for high-productivity firms these channels dominate the task relocation effect (which is a source of job destruction for switchers to $\mathcal{P}$), for low-productivity firms the latter effect dominates but the net result is not statistically significant.

For switchers to $\mathcal{P}$ after Chinese liberalization in final goods (a reduction in τ^*), we observe large and statistically significant net job creation for both low- and high-productivity firms. For low-productivity firms, the net effect is driven by a decline in the rate of job contractions, while for high-productivity firms the net effect is driven by both a decline in the rate of job contractions and an increase in the rate of job expansions. From Table 2, the net job creation for these switchers is likely the results of dominating effects due to efficiency gains and a larger foreign market size.

Table 9: Estimation of Employment Response of Switchers

	Switchers to pure processing firm ($\mathcal{P}$)			**Switchers to non-importing exporter ($\mathcal{N}$)**			**Switchers to importing exporter ($\mathcal{I}$)**		
	($\Delta E \equiv e–c$)	(e)	(c)	($\Delta E \equiv e–c$)	(e)	(c)	($\Delta E \equiv e–c$)	(e)	(c)
△Foreign tariff ($\triangle\tau_{it}$)	0.077	0.061	-0.016	0.238*	0.146	-0.093	0.255	0.167	-0.088
	(0.39)	(0.44)	(-0.14)	(1.90)	(1.55)	(-1.30)	(1.58)	(1.26)	(-1.24)
× Productivity	-0.748*	-0.302	0.446	-0.221	-0.096	0.125	-0.780***	-0.578***	0.202*
	(-1.76)	(-1.37)	(1.32)	(-1.21)	(-0.66)	(1.36)	(-3.32)	(-2.98)	(1.92)
△Chinese tariff ($\triangle\tau^*_{it}$)	-0.830**	-0.050	0.780***	-0.065	0.025	0.091	0.490	0.277	-0.214
	(-2.55)	(-0.30)	(2.78)	(-0.24)	(0.12)	(0.76)	(1.18)	(0.97)	(-0.86)
× Productivity	-0.552**	-0.426***	0.126	-0.628***	-0.584***	0.043	-1.146***	-0.899***	0.247*
	(-2.27)	(-2.60)	(0.88)	(-3.30)	(-3.77)	(0.50)	(-3.96)	(-3.78)	(1.88)
△Input tariff ($\triangle\lambda_{it}$)	0.220	-0.313	-0.533	0.823	0.598	-0.224	-0.550	-0.064	0.486
	(0.26)	(-0.67)	(-1.06)	(1.28)	(1.03)	(-1.02)	(-1.31)	(-0.21)	(1.57)
× Productivity	-0.262	0.571	0.833	-1.013	-0.593	0.421	0.742	0.538	-0.204
	(-0.25)	(0.81)	(1.39)	(-1.06)	(-0.66)	(1.42)	(1.41)	(1.35)	(-0.64)
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Other controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	518	518	518	1,590	1,590	1,590	1,030	1,030	1,030
R-squared	0.13	0.06	0.11	0.12	0.13	0.03	0.14	0.10	0.08

Notes: All regressions include first-differences of state-owned status, foreign-owned status, export status, and log sales as controls. Robust t-statistics (in parentheses) clustered at the firm level. Firm productivity is measured by a high-TFP indicator. The coefficients are statistically significant at the *10%, **5%, or ***1% level.

These results indicate that these switching Chinese firms saw the decline in domestic tariffs as an opportunity to restructure and expand: facing a threat in the domestic market due to lower τ^*, these Chinese firms decided to escape competition in the domestic market altogether by switching to pure processing status and, while focusing on a narrower set of tasks, expanded their employment to meet foreign demand.

For firms that switch to non-importing exporter status ($\mathcal{N}$), there is statistically significant net job destruction in low-productivity firms after a decline in foreign tariffs, and net job creation in high-productivity firms after a decline in Chinese final-good tariffs. From Table 2, the model does not predict switchers to $\mathcal{N}$ (from $\mathcal{P}$ or $\mathcal{I}$), and therefore, the net job destruction in low-productivity switchers to $\mathcal{N}$ should be explained by channels that are not captured by our model, such as market share reallocations from low to high-productivity firms within each firm type. The net job creation in high-productivity $\mathcal{N}$ switchers after Chinese liberalization in final goods can also be explained by within-type market share reallocations, but also by strong task relocation effects from firms that stop importing inputs.

For switchers to importing exporter status ($\mathcal{I}$), there is statistically significant net job creation (driven mostly by expansions) in high-productivity firms after reductions in either foreign tariffs or Chinese final-good tariffs. According to Table 2, the employment growth in these firms after a decline in foreign tariffs implies that job creation from easier domestic competition, the direct positive effect on exporters, and efficiency gains dominate the job destruction associated with task relocation effects and the tougher competitive environment abroad. The model does not predict switchers to $\mathcal{I}$ after Chinese liberalization in final goods (it predicts destruction in $\mathcal{I}$ firms due to tougher environments at home and abroad, along with switchers from $\mathcal{I}$ to $\mathcal{N}$). An explanation is that these firms switch to $\mathcal{I}$ status to become more efficient competitors in both markets: facing tougher environments in both markets, the opportunity cost of restructuring to reduce marginal costs (by procuring inputs from abroad) declines. As firms switch to $\mathcal{I}$, those with high-productivity increase their employment as a result of efficiency gains and within-type reallocation effects.

5 Robustness

In the previous estimations, all types of trade liberalization were treated as exogenous. However, tariff formation could be endogenous in the sense that firm employment could have a reverse causality effect on tariff changes: with a fall in employment, workers could blame free trade policies and form labor unions to lobby the government for temporary trade protection (Bagwell and Staiger, 1990; Grossman and Helpman, 1994). Although this happens in developed countries like the United States (Goldberg and Maggi, 1999), it is less likely to happen in China because its labor unions are symbolic organizations (see, *e.g.*, Branstetter and Feenstra, 2002 and Chen, Yu and Yu, 2017).[12] Nevertheless, for the sake of the completeness, we use an instrumental variables (IV) approach to control for such possible reverse causality.

Identifying a qualified instrument for tariffs is always a challenging task. Inspired by the works of Trefler (2004) and Amiti and Davis (2011), we use one-year lagged tariffs as instruments of the first difference in tariffs. Table 10 presents the IV second-stage results for our first-difference specification in (33), with one-year lags of firm-level Chinese final-good tariffs, Chinese input tariffs, and foreign tariffs serving as instruments of their corresponding first-difference values. Column 1 in Table 10 shows first-difference OLS estimates, using normalized TFP as our measure of productivity (as in column 1 of Table 4). Column 3, which presents the IV estimation, shows coefficients that are all very close to their counterparts in column 1. All the estimates for β are positive and significant, whereas all the estimates for γ are negative, larger in magnitude, and significant. Such results are consistent with our findings in the previous tables.

As described above, our firm-level Chinese final-good tariffs are constructed using equation (30), which makes the strong assumption that exported and domestic shares of a product are identical. However, China plays an important role in global supply chains and produces some intermediate goods that cannot be used in the domestic production sector, and as a consequence, the product composition of Chinese exports may be very different from the composition of products sold in the domestic market (Kee and Tang, 2016). Since this problem would bias the measure of firm-level final-good tariffs differently depending on the industry, we experiment with two robustness checks.

First we separate all firms into two groups: those belonging to highly-integrated global supply chain (GSC) sectors, and those belonging to lowly-integrated GSC sectors. After calculating each industry's ratio of value added to gross industrial output, the GSC-integrated indicator takes the value of one if the ratio of an industry is *lower* than the mean ratio and is zero otherwise.[13] The coefficients of input tariffs for high GSC industries in the IV estimates of column 5 are insignificant and much smaller than its counterparts for low GSC industries in column 4. This is exactly what we expect: input tariffs in the high GSC sectors should be insignificant as such sectors heavily engage in duty-free processing imports. Second, following Yu (2015), we check whether our estimation results are sensitive to our particular measure of firm-level final-goods tariffs by using instead conventional industry-level tariffs. Column 6 in Table 10 reports our IV estimation that replaces

[12] In addition, the case for tariff endogeneity is weaker for firm-level specifications. Using plant-level specifications for employment growth in Canada, Trefler (2004) strongly rejects tariff endogeneity and mentions that "this likely reflects the fact that tariffs, even if endogenous to the industry, are exogenous to the plant."

[13] As a perfect example of a high-GSC integrated product, the iPhone is assembled by China but its parts and intermediates are made by several countries. Accordingly, the value-added of China on the iPhone production is very low.

Table 10: First-Difference IV Estimation

	OLS		IV				
	Relative SGMM	*De Loecker*	*Relative SGMM*				*De Loecker*
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
△Foreign tariff ($\triangle\tau_{it}$)	0.542***	0.453***	0.510***	0.552***	0.419	0.232	0.475*
	(4.14)	(2.94)	(3.19)	(2.80)	(1.45)	(1.43)	(1.85)
× Productivity	-2.009***	-0.918***	-1.956***	-2.134***	-1.545*	-1.058*	-0.930*
	(-4.57)	(-3.19)	(-3.60)	(-3.06)	(-1.69)	(-1.92)	(-1.87)
△Chinese tariff ($\triangle\tau_{it}^*$)	2.712***	0.976***	2.256***	2.128***	2.645***	2.715***	0.981
	(11.21)	(3.64)	(6.87)	(5.06)	(4.43)	(9.18)	(1.62)
× Productivity	-9.944***	-2.302***	-9.528***	-7.877***	-11.923***	-9.843***	-3.366***
	(-13.11)	(-5.09)	(-9.02)	(-6.20)	(-5.91)	(-10.57)	(-2.95)
△Input tariff ($\triangle\lambda_{it}$)	1.182**	0.573	1.493**	2.060**	0.712	1.183*	-0.826
	(2.53)	(1.08)	(2.28)	(2.53)	(0.64)	(1.77)	(-0.58)
× Productivity	-3.478**	-0.956	-4.475**	-5.998**	-2.395	-3.595	2.187
	(-2.35)	(-0.96)	(-2.02)	(-2.17)	(-0.64)	(-1.60)	(0.76)
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Other controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Chinese tariff measure	Firm	Firm	Firm	Firm	Firm	Industry	Firm
Included industries	All	All	All	Low GSC	High GSC	All	All
Observations	16,975	9,709	16,975	10,954	6,021	14,848	9,709

Notes: All regressions include first-differences of state-owned status, foreign-owned status, export status, and log sales as controls. Robust t-statistics (in parentheses) clustered at the firm level. The coefficients are statistically significant at the *10%, **5%, or ***1% level.

firm-level Chinese final-good tariffs with industry-level tariffs. Compared to column 3, our results remain robust.

Thus far, firm productivity is assumed to be exogenous and would not be affected by trade liberalization. However, there is a growing literature exploring firm-level productivity improvements in response to trade liberalization. Ignoring such productivity gains from trade liberalization may generate some estimation bias. To address this concern, we follow De Loecker (2013) and develop an augmented Olley-Pakes TFP by allowing firm-level productivity to react to changes in both foreign and home tariffs over time.[14] Hence, the OLS estimates in column 2 and the IV estimates in column 7 use "De Loecker's TFP" to measure firm productivity. Although the magnitudes of the coefficients are not directly comparable to those in columns 1 and 3—because of the different productivity measures—they yield qualitatively similar results for the effects of foreign tariffs and Chinese final-good tariffs (the coefficients on inputs tariffs are very imprecise and insignificant under De Loecker's TFP).

Table 11 presents an IV robustness check that splits firms by status (pure processing firms, non-importing firms, importing firms, and importing non-exporters) and uses the high-TFP indicator as our measure of productivity. The table shows first-difference IV regressions for net employment changes using different subsets of firms. The first two columns report the estimation results for all trading firms, which are comparable to the first-difference OLS estimates shown in the first two columns of Table 7. Note that although some of the estimated coefficients for low-productivity firms lose statistical significance, the IV estimation results are very close to the OLS results for high-productivity firms. The rest of the columns in Table 11 verify whether ownership status matters for our results by estimating separate IV regressions for private firms and foreign-invested firms. The two middle columns show the IV estimation using private firms, and the last two columns show the estimation using foreign invested firms. For both types of groups, the results are qualitatively similar to those presented in the first two columns. Hence, our main estimation results remain robust.

6 Conclusion

Using firm-level tariff measures, this paper separated out the effects of foreign and Chinese trade liberalization in final goods, as well as of Chinese trade liberalization in inputs, on Chinese employment in trading firms. We distinguish firms according to their productivity and type—pure processing, non-importing exporter, importing exporter, and importing non-exporter—and found

[14] Similar to De Loecker (2013), a firm's productivity process is given by $\varphi_{it+1} = g(\varphi_{it}, \tau_{it}, \tau^*_{it}, \lambda_{it}) + \varsigma_{it+1}$ where ς_{it+1} is the productivity innovation. This process adopts a fourth-order polynomial form, $g(\cdot) = \sum_{sm} \beta_{sm}(\varphi^s_{it}\tau^m_{it} + \varphi^s_{it}\tau^{*m}_{it} + \varphi^s_{it}\lambda^m_{it})$ for $s \in \{1,2,3,4\}$ and $m \in \{1,2,3,4\}$, with $E(\varsigma_{it+1}\tau_{it}) = 0$, $E(\varsigma_{it+1}\tau^*_{it}) = 0$, and $E(\varsigma_{it+1}\lambda_{it}) = 0$.

Table 11: First-Difference IV Estimation by Type of Firm

	All Firms		**Private Firms**		**Foreign Invested Firms**	
	(β)	(γ)	(β^p)	(γ^p)	(β^f)	(γ^f)
Pure processing firms ($\mathcal{P}$)						
$\triangle$Foreign tariff ($\triangle\tau_{it}$)	-0.092	-0.554**	-0.095	-0.574**	-0.101	-0.534**
	(-0.64)	(-2.48)	(-0.66)	(-2.55)	(-0.68)	(-2.24)
$\triangle$Chinese tariff ($\triangle\tau_{it}^*$)	0.046	-0.621***	0.085	-0.677***	-0.109	-0.731***
	(0.21)	(-2.86)	(0.37)	(-3.08)	(-0.44)	(-3.08)
Non-importing exporter ($\mathcal{N}$)						
$\triangle$Foreign tariff ($\triangle\tau_{it}$)	0.185*	-0.299**	0.198*	-0.316**	0.216*	-0.367**
	(1.79)	(-2.13)	(1.88)	(-2.22)	(1.81)	(-2.25)
$\triangle$Chinese tariff ($\triangle\tau_{it}^*$)	-0.039	-0.683***	-0.042	-0.686***	-0.211	-0.637***
	(-0.20)	(-4.47)	(-0.21)	(-4.43)	(-0.94)	(-3.52)
$\triangle$Input tariff ($\triangle\lambda_{it}$)	0.347	0.009	0.364	0.068	0.296	-0.079
	(1.08)	(0.03)	(1.13)	(0.19)	(0.75)	(-0.17)
Importing exporter ($\mathcal{I}$)						
$\triangle$Foreign tariff ($\triangle\tau_{it}$)	0.248**	-0.423***	0.248**	-0.430***	0.330***	-0.593***
	(2.30)	(-3.14)	(2.27)	(-3.15)	(2.81)	(-3.99)
$\triangle$Chinese tariff ($\triangle\tau_{it}^*$)	-0.050	-0.477***	-0.040	-0.491***	-0.295	-0.418**
	(-0.24)	(-3.08)	(-0.19)	(-3.10)	(-1.30)	(-2.41)
$\triangle$Input tariff ($\triangle\lambda_{it}$)	0.083	-0.053	0.113	-0.026	0.052	0.026
	(0.25)	(-0.14)	(0.34)	(-0.07)	(0.13)	(0.06)
Importing non-exporter						
$\triangle$Foreign tariff ($\triangle\tau_{it}$)	0.347	-0.626**	0.355	-0.637**	0.164	-0.692**
	(1.62)	(-2.37)	(1.64)	(-2.39)	(0.68)	(-2.31)
$\triangle$Chinese tariff ($\triangle\tau_{it}^*$)	0.128	-0.654**	0.137	-0.698**	0.036	-0.752**
	(0.50)	(-2.46)	(0.53)	(-2.55)	(0.13)	(-2.56)
$\triangle$Input tariff ($\triangle\lambda_{it}$)	-0.394	0.930	-0.361	0.944	0.654	0.087
	(-0.61)	(1.32)	(-0.55)	(1.33)	(0.89)	(0.10)
Year fixed effects	Yes		Yes		Yes	
Other controls	Yes		Yes		Yes	
Observations	17,064		16,827		12,936	

Notes: All regressions include first-differences of state-owned status, foreign-owned status, export status, and log sales as controls. Robust t-statistics (in parentheses) clustered at the firm level. Firm productivity is measured by a high-TFP indicator. The coefficients are statistically significant at the *10%, **5%, or ***1% level.

that *(i)* for all types of firms, reductions in Chinese and foreign final-good tariffs are associated with job destruction in low-productivity firms and job creation in high-productivity firms, and that *(ii)* after a reduction in input tariffs, there is job destruction in low-productivity ordinary exporters, but not statistically significant job creation in high-productivity firms.

Empirically, changes in Chinese final-good tariffs are by far the most important source of employment gains, while changes in input tariffs have the least impact on both job creation and destruction. Theoretically, the model that we introduce to guide the interpretation of the empirical results describes channels of job creation and destruction in response to changes in every type of tariff. It cannot explain, however, the large positive employment responses of all types of high-productivity firms to reductions in Chinese final-good tariffs. This empirical result presents a theoretical challenge, as it is difficult to explain with conventional mechanisms the employment expansion of firms due to a shock that brings tougher competition from foreign firms.

A possible explanation to this result is the existence of *escape-competition* effects as described by Aghion *et al.* (2005): facing tougher competition, some firms decide to invest and expand as a way to "escape competition". This type of effect can be included in our model by introducing a lumpy investment decision with non-convex adjustment costs: tougher competition causes a reduction in the opportunity cost of investing, driving some firms to invest and expand. Another possible explanation is the existence of market share reallocations from low- to high-productivity firms within firm type. This is absent from our model because all firms of the same type have identical employment elasticities to tariff changes. Model's extensions that would capture within-type reallocations include assuming random fixed costs of trading activities, or assuming preferences with endogenous markups.

Due to data limitations, our analysis focuses on the intensive margin of employment: job creation and destruction due to expansions or contractions of existing firms. Hence, we miss all the job creation and destruction due to births and deaths of firms. Although more recent Chinese firm-level data is more reliable for the study of the extensive margin of employment, gathering and processing this data is a challenge by itself; this forces us to leave the study of the responses of the extensive margin of Chinese employment to trade liberalization as a future project.

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A Theoretical Appendix: Proofs

Proof of Lemma 1. We know that for every s, there exists a cutoff $\hat{\alpha}_s$ so that tasks in the range $[0, \hat{\alpha}_s)$ are produced inside the firm (with hired domestic labor), and tasks in the range $[\hat{\alpha}_s, 1]$ are procured using outside materials. From (3) and given $\hat{\alpha}_s$, it follows that $y_s(\alpha) = \ell$ if $\alpha < \hat{\alpha}_s$ and $y_s(\alpha) = A_{M_s} a_M(\alpha) m$ if $\alpha \geq \hat{\alpha}_s$, so that $Y_s = \left[\int_0^1 y_s(\alpha)^{\frac{\theta-1}{\theta}} d\alpha\right]^{\frac{\theta}{\theta-1}}$ can be rewritten as

$$Y_s = \left\{\int_0^{\hat{\alpha}_s} \ell(\alpha)^{\frac{\theta-1}{\theta}} d\alpha + \int_{\hat{\alpha}_s}^1 \left[A_{M_s} a_M(\alpha) m(\alpha)\right]^{\frac{\theta-1}{\theta}} d\alpha\right\}^{\frac{\theta}{\theta-1}}. \tag{A-1}$$

Optimality conditions requiere that $\frac{dY_s}{d\ell(\alpha)} = \frac{dY_s}{d\ell(\alpha')}$ and $\frac{dY_s}{dm(\alpha)} = \frac{dY_s}{dm(\alpha')}$ and therefore, $\ell(\alpha) = \ell(\alpha')$ and $a_M(\alpha)^{1-\theta} m(\alpha) = a_M(\alpha')^{1-\theta} m(\alpha')$.

Let L_s and M_s denote the total amounts of labor and materials used for the production of the task aggregator Y_s, so that

$$L_s = \int_0^{\hat{\alpha}_s} \ell(\alpha) d\alpha, \tag{A-2}$$

$$M_s = \int_{\hat{\alpha}_s}^1 m(\alpha) d\alpha. \tag{A-3}$$

Given that $\ell(\alpha) = \ell(\hat{\alpha}_s)$, it follows from (A-2) that $L_s = \hat{\alpha}_s \ell(\hat{\alpha}_s)$, and then

$$\ell(\alpha) = \frac{L_s}{\hat{\alpha}_s}. \tag{A-4}$$

Similarly, we know that $a_M(\alpha)^{1-\theta} m(\alpha) = a_M(\hat{\alpha}_s)^{1-\theta} m(\hat{\alpha}_s)$, which plugged into (A-3) yields $M_s = a_M(\hat{\alpha}_s)^{1-\theta} m(\hat{\alpha}_s) \int_{\hat{\alpha}_s}^1 a_M(\alpha)^{\theta-1} d\alpha$. It follows that

$$m(\alpha) = \frac{a_M(\alpha)^{\theta-1} M_s}{\int_{\hat{\alpha}_s}^1 a_M(\alpha)^{\theta-1} d\alpha}. \tag{A-5}$$

Plugging in (A-4) and (A-5) into (A-1) yields

$$Y_s = \left(\hat{\alpha}_s^{\frac{1}{\theta}} L_s^{\frac{\theta-1}{\theta}} + \upsilon_s(\hat{\alpha}_s)^{\frac{1}{\theta}} M_s^{\frac{\theta-1}{\theta}}\right)^{\frac{\theta}{\theta-1}}. \tag{A-6}$$

where

$$\upsilon_s(\hat{\alpha}_s) \equiv \int_{\hat{\alpha}_s}^1 \left[A_{M_s} a_M(\alpha)\right]^{\theta-1} d\alpha. \tag{A-7}$$

Note that if $\theta = 1$, $\upsilon_s(\hat{\alpha}_s) = 1 - \hat{\alpha}_s$.

The second step is to obtain the unit cost for Y_s, which we call $c(\hat{\alpha}_s)$. For a firm with status s, $c(\hat{\alpha}_s)$ is the minimum cost, $L + p_{M_s} M_s$, such that $Y_s = 1$. The Lagrangean is then given by

$$\mathcal{L} = L + p_{M_s} M_s + \varpi \left[1 - \left(\hat{\alpha}_s^{\frac{1}{\theta}} L_s^{\frac{\theta-1}{\theta}} + \upsilon_s(\hat{\alpha}_s)^{\frac{1}{\theta}} M_s^{\frac{\theta-1}{\theta}}\right)^{\frac{\theta}{\theta-1}}\right].$$

The first order conditions are

$$1-\varpi\left(\hat{\alpha}_s^{\frac{1}{\theta}}L_s^{\frac{\theta-1}{\theta}}+\upsilon_s(\hat{\alpha}_s)^{\frac{1}{\theta}}M_s^{\frac{\theta-1}{\theta}}\right)^{\frac{1}{\theta-1}}\hat{\alpha}_s^{\frac{1}{\theta}}L_s^{-\frac{1}{\theta}}=0 \tag{A-8}$$

$$p_{Ms}-\varpi\left(\hat{\alpha}_s^{\frac{1}{\theta}}L_s^{\frac{\theta-1}{\theta}}+\upsilon_s(\hat{\alpha}_s)^{\frac{1}{\theta}}M_s^{\frac{\theta-1}{\theta}}\right)^{\frac{1}{\theta-1}}\upsilon_s(\hat{\alpha}_s)^{\frac{1}{\theta}}M_s^{-\frac{1}{\theta}}=0 \tag{A-9}$$

$$\hat{\alpha}_s^{\frac{1}{\theta}}L_s^{\frac{\theta-1}{\theta}}+\upsilon_s(\hat{\alpha}_s)^{\frac{1}{\theta}}M_s^{\frac{\theta-1}{\theta}}=1. \tag{A-10}$$

From (A-8) and (A-9) we get

$$M_s=\frac{\upsilon_s(\hat{\alpha}_s)L_s}{p_{Ms}^{\theta}\hat{\alpha}_s} \tag{A-11}$$

which combined with (A-10) yields

$$L_{s,Y_s=1}=\frac{\hat{\alpha}_s}{\left[\hat{\alpha}_s+\upsilon_s(\hat{\alpha}_s)p_{Ms}^{1-\theta}\right]^{\frac{\theta}{\theta-1}}}, \tag{A-12}$$

$$M_{s,Y_s=1}=\frac{\upsilon_s(\hat{\alpha}_s)p_{Ms}^{-\theta}}{\left[\hat{\alpha}_s+\upsilon_s(\hat{\alpha}_s)p_{Ms}^{1-\theta}\right]^{\frac{\theta}{\theta-1}}}. \tag{A-13}$$

It follows that $c(\hat{\alpha}_s)=L_{s,Y_s=1}+p_{Ms}M_{s,Y_s=1}$ is

$$c(\hat{\alpha}_s)=\left[\hat{\alpha}_s+\upsilon_s(\hat{\alpha}_s)p_{Ms}^{1-\theta}\right]^{\frac{1}{1-\theta}}. \tag{A-14}$$

From (4) we know that $p_{Ms}=A_{Ms}a_M(\hat{\alpha}_s)$, which along with (A-7) implies that $\upsilon_s(\hat{\alpha}_s)p_{Ms}^{1-\theta}=\int_{\hat{\alpha}_s}^1\left[\frac{a_M(\hat{\alpha}_s)}{a_M(\alpha)}\right]^{1-\theta}d\alpha$. Hence, we rewrite (A-14) as

$$c(\hat{\alpha}_s)=\left\{\hat{\alpha}_s+\int_{\hat{\alpha}_s}^1\left[\frac{a_M(\hat{\alpha}_s)}{a_M(\alpha)}\right]^{1-\theta}d\alpha\right\}^{\frac{1}{1-\theta}}<1. \tag{A-15}$$

Taking the derivative of $c(\hat{\alpha}_s)$ with respect to $\hat{\alpha}_s$ we get

$$\frac{dc(\hat{\alpha}_s)}{d\hat{\alpha}_s}=\left\{\int_{\hat{\alpha}_s}^1\left[\frac{a_M(\hat{\alpha}_s)}{a_M(\alpha)}\right]^{1-\theta}d\alpha\right\}\frac{c(\hat{\alpha}_s)^{-\theta}a_M'(\hat{\alpha}_s)}{a_M(\hat{\alpha}_s)}>0,$$

because $a_M(\alpha)$ is strictly increasing in α. Note from (A-15) that $\lim_{\hat{\alpha}_s\to 1}c(\hat{\alpha}_s)=1$. Given that $\hat{\alpha}_{\mathcal{P}}<\hat{\alpha}_{\mathcal{I}}<\hat{\alpha}_{\mathcal{N}}$, it is also the case that $c(\hat{\alpha}_{\mathcal{P}})<c(\hat{\alpha}_{\mathcal{I}})<c(\hat{\alpha}_{\mathcal{N}})$. □

Proof of Lemma 2. From the proof of Lemma 1 we know that the firm-level demand for domestic labor to produce for market r of a Home firm with productivity φ and status s is given by $L_{rs}(\varphi)=\hat{\alpha}_s c(\hat{\alpha}_s)^{\theta}Y_{rs}(\varphi)$. Given the production function and the iceberg trade cost the firm faces when exporting, the amount of task aggregator it requires to produce for market r is $Y_{rs}(\varphi)=\frac{\tau^{\mathbb{1}\{r=X\}}z_{rs}(\varphi)}{\varphi}$. Equations (27) and (28) then follow after noting that $z_{rs}(\varphi)=\frac{\sigma\pi_{rs}(\varphi)}{p_{rs}(\varphi)}$, with $\pi_{rs}(\varphi)$ given by (8), and $p_{rs}(\varphi)=\left(\frac{\sigma}{\sigma-1}\right)\frac{\tau^{\mathbb{1}\{r=X\}}c(\hat{\alpha}_s)}{\varphi}$. The two exceptions are a consequence of the ordering of the cutoff levels ($\hat{\varphi}_{\mathcal{P}}<\hat{\varphi}_D<\hat{\varphi}_X<\hat{\varphi}_{\mathcal{I}}$) and of the assumption that pure processing firms are not allowed to access the domestic market. □

B Supporting Tables and Figures

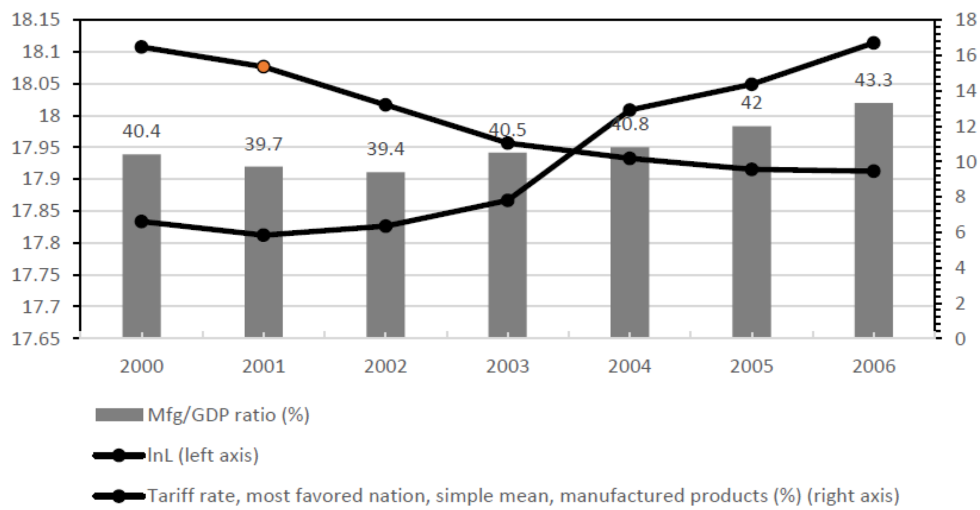

Figure B.1: Chinese Employment in the Manufacturing Sector and the MFN Tariff Rate

Table B.1: Summary Statistics for Firm-Level Tariffs

Year	**Foreign Tariffs** (τ_{it})		**Chinese Tariffs** (τ^*_{it})		**Input Tariffs** (λ_{it})	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
2000	7.71	7.20	15.57	12.03	2.54	4.90
2001	8.16	7.72	12.39	9.40	2.37	5.06
2002	8.72	8.00	9.63	8.22	1.68	3.53
2003	7.46	6.88	8.82	7.51	1.94	3.70
2004	6.91	6.76	7.59	7.08	1.87	3.59
2005	6.90	6.64	7.00	6.78	1.71	3.53
2006	7.61	7.14	7.46	6.46	2.18	3.72
All years	7.47	7.10	8.29	7.65	1.98	3.82

Table B.2: Summary Statistics of Key Variables (2000–2006)

	Mean	Std. Dev.
Log of Firm Employment	5.54	1.18
System-GMM TFP	2.57	.408
Relative System-GMM TFP	.277	.086
High TFP Indicator	.517	.499
Log of Firm Sales	10.84	1.38
SOE Indicator	.015	.121
Foreign Indicator	.739	.439
Exporter Indicator	.849	.357

Table B.3: The Types of Chinese Trading Firms

	Fraction of each firm type (within sample)		**Fraction of high-productivity firms (within type)**	
	2000	**2006**	**2000**	**2006**
Pure processing firms ($\mathcal{P}$)	10.4	8.3	27.9	50.0
Non-importing exporters ($\mathcal{N}$)	70.4	56.1	79.3	60.7
Importing exporters ($\mathcal{I}$)	12.5	16.8	45.1	69.4
Importing non-exporters	6.7	18.8	34.2	58.1