# Trade Liberalization, Market Structure, and Firm Markup: Theory and Evidence from China*

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**Abstract**

In an imperfectly competitive market, input tariff reduction may induce importers to partly pass-through the cost reductions and consequently increase their markups. Such effect is heterogeneous across industries, depending on the market structure. We utilize an unprecedented liberalization episode in China, namely its WTO accession, to estimate such heterogeneous impact of trade reform on firm markup. The results show that input tariff reduction increases firm markup, but only for importers. Furthermore, market structure matters: importers' markups increase more due to input tariff reduction in less competitive industries. Finally, in contrast to output tariff, input tariff reduction increases industry markup dispersion.

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# 1 Introduction

Conventional wisdom emphasizes the pro-competitive effect of trade liberalization. That is, increased exposure to international competition forces domestic firms to reduce their markups: see, for example, Levinsohn (1993) and Harrison (1994), or more recently de Blas and Russ (2015), Edmond, Midrigan and Xu (2015), Lu and Yu (2015), and Feenstra and Weinstein (2015). However, this insight is incomplete when trade in intermediate inputs is prevalent (Amiti and Konings, 2007). Johnson and Noguera (2012) document that intermediate inputs account for two thirds of international trade. In an imperfectly competitive market, when some firms import inputs for production but others do not, lowering tariffs on inputs will have a heterogeneous impact. In particular, firms that import inputs may only partly pass through the reduction in their input costs and consequently increase their markups.

In this paper, we utilize an unprecedented liberalization episode in China, namely its accession into the World Trade Organization (WTO), to estimate the heterogeneous impact of trade reform on firm markup. As its commitment to joining the WTO, China substantially reduced its average tariff on manufacturing products within just a few years. As shown in Figure 1 (left panel), both the average tariff level and the standard deviation of tariffs across six-digit HS products dropped substantially in 2001, when China formally joined the WTO. The reduction in tariffs not only led to more competition, but also greatly increased access to foreign inputs. This is because, as highlighted in the right panel, around 75% of China's imports are intermediate inputs, while most of the remainder are capital goods.[1]

[Figure 1 about here]

Such a large-scale trade reform implies profound impacts on firms that go beyond the competitive effect. On the one hand, declines in output tariffs (i.e., tariffs on final goods) induce firms to reduce prices for their products due to import competition, and on the other hand firms that import inputs may benefit from lower marginal costs due to reductions in input tariffs (i.e., tariffs on intermediate inputs). When the price decline is small relative to the decline in marginal costs, firm's markup increases. This is an insight highlighted in the influential study of De Loecker et

[1] A large share of Chinese imports is for export processing (Feenstra and Hanson, 2005; Yu 2015; Manova and Yu, 2012), which is duty free. However, input share of non-processing imports is still around 75-80%, verifying the importance of trade in intermediate inputs.

al. (2016), who find incomplete cost pass-through to prices and rising markups for Indian firms responding to input tariff liberalization.

More specifically, we first extend the Melitz and Ottaviano (2008) model to consider firms' decision in importing intermediate inputs. We show that reduction in input tariffs has a direct effect of increasing firms' markups and also a pro-competitive effect which suppresses markups. In a less competitive industry, the former effect is more likely to dominate the latter.

We then test the theoretical predictions using firm level data from China and obtain several novel empirical findings. First, importers adjust their markups differently from non-importers in response to trade liberalization.[2] To see this, we interact input tariff with an indicator for importing firms. We find that a reduction in input tariffs exerts opposite impacts on importers versus non-importers: it raises markups charged by importing firms but reduces those by non-importing firms. Figure 2 shows the evolution of average markups for importers versus non-importers during the same period. Compared with the average markups in 2000 (normailzed to 1 for both types), importers had faster growth in markups over time. In more rigorous regressions detailed later, the average input tariff dropped from 15% in 2000 to 6.2% in 2007, resulting in an increase in average importer markup of about 1%, and a decrease in non-importer markup of about 0.1%.

[Figure 2 about here]

Secondly, importers raise their markups because their imported inputs become cheaper after trade liberalization. Therefore, consistent with the input-output linkage emphasized by Amiti and Konings (2007) and Amiti et al. (2014), firm's import intensity serves as an important determinant of markup. Firms with larger import shares tend to experience higher increases in their markups. At the industry level, such a heterogeneous impact can be seen by comparing sectors that depend heavily on foreign inputs to those that only have a small share of imported inputs. In Figure 4, we illustrate the evolution of markup distribution for two selected industries. Industry A (left panel, fertilizer production) has a relatively large import penetration rate (i.e., imports divided by total domestic sales), but a relatively small share of imported inputs in total material inputs. Industry B (right panel, rubber) has the opposite pattern: a small import penetration rate but a large foreign inputs share. Thus, industry A is presumably subjected to more import competition, while

[2] We follow De Loecker and Warzynski (2012) to estimate revenue-based markups separately for each sector, and follow De Loecker et al.(2016) to estimate output-based markups as a robustness check. More details are provided in the estimation section.

in contrast industry B depends more on foreign inputs. Figure 3 presents a striking comparison: the markup distribution of industry A shifts left a bit from 2000 to 2007, while for industry B the distribution shifts substantially to the right, indicating substantial improvement in markups.

[Figure 3 about here]

Thirdly, market structure matters: the cost advantage of importers relative to non-importers during liberalization is especially useful when the market is concentrated. Intuitively, a firm's ability to exert market power depends crucially on the market structure. When the market consists of a few large firms that also import inputs[3] and a number of small firms, cheaper access to imported inputs gives importing firms more leverage not to pass the cost reduction through to buyers, resulting in an increase in their markups.

In the empirical model, this heterogeneity across sectors is captured by a three-way interaction among the importer indicator, the input tariff, and a measure of market competitiveness. The negative coefficient for this interaction term then implies that importers tend to have larger increases in markups than do non-importers in less competitive markets/sectors. In the benchmark result, when we use the market concentration ratio of the top 20 firms (i.e., CR20), the importers' markup increases by nearly 0.43% in the 1st quartile industry (in CR20 value), by about 3.63% in the 3rd quartile industry, and over 7% in the 90th percentile industry.

These results are strikingly robust when we alternate with different measures of market competitiveness, or use import intensity to replace importer indicator. The differential impact of input tariff reduction on importers vs. non-importers is also present when we construct a firm-level tariff measure to replace the industry-level input tariff and control for industry-year specific effects. Furthermore, following Lu and Yu (2015), we augment our benchmark results with markups estimated using output in physical terms, therefore avoiding the omitted output price bias. Finally, to deal with the endogeneity concern, we adopt an alternative empirical strategy by examining the first-difference between two periods and using instruments for tariff changes. Our main results hold in these robustness checks.

Finally, our findings document two underlying forces that jointly determine firm markup dispersion after trade liberalization. To see this, we construct measures of industry level markup

[3] Bernard et al. (2009) and Amiti et al. (2014) provide evidence that more productive (and larger) firms tend to be importers at the same time.

dispersion, following Lu and Yu (2015). We find that output tariff reductions, as predicted by previous studies, condense the markup dispersion, whereas input tariff reductions enlarge it. Such opposing effects of output and input tariffs become more prominent when the market becomes more concentrated.

Our paper contributes to a growing body of research that highlights the importance of input tariff liberalization. These studies show that input tariffs work in different channels than output tariffs, and often plays a more important role than output tariff in influencing firm performance such as productivity and new product creation (Amiti and Konings, 2007; Goldberg et al., 2010; Topalova and Khandelwal, 2011; Yu, 2014).[4] De Loecker et al. (2016) provide the first study that accounts for the different impacts of input and output tariffs on precisely measured firm markup. They show that the pro-competitive effect of output tariff reduction is largely offset by access to cheaper imported inputs. They find evidence for rising markups for Indian firms responding to input tariff liberalization.

Our paper also contributes to understanding the impact of China's WTO accession by using firm level data. Yu (2014) shows that input tariff reductions strongly improve the productivities of non-processing exporters in China, with an attenuated effect when the share of processing imports grows. In the same vein, Fan, Li, and Yeaple (2015) ask how input tariff reductions affect the quality of exporters' products. More closely related to our study is Fan, Li, and Luong (2017), who investigate how input trade liberalization affects exporters' markups across different destinations. In contrast, we focus on the local impact of input trade liberalization on the markups of importers versus non-importers and emphasize the role of market structure. China's WTO accession has been widely viewed as creating external competition pressure on firms in the domestic market. Domestic market is also regarded as more important than the export market. Brandt and Thun (2010), for example, document that 80% of China's manufacturing output was sold domestically. The pro-competitive view of WTO accession receives empirical support from Lu and Yu (2015), who show that sector-level markup dispersion narrows due to a reduction in output tariffs. Moreover, Brandt et al. (2012b) find that import competition contributes to significant productivity growth, mainly through the entry of productive private firms. They also show that tariff cuts tend to reduce domestic prices. Our study is complementary to theirs because we estimate the heterogeneous effect

[4] De Loecker and Goldberg (2014) provide the most up-to-date review on how firm performance is affected by trade liberalization.

of input tariff reductions on different types of individual firms, with an emphasis on the role of market structure.

Finally, there is a heated discussion in the trade literature on welfare gains due to trade liberalization based on variable-markup models Arkolakis et al., 2015; and Melitz and Redding, 2015). In particular, under oligopolistic competition, Edmond et al. (2015) quantify a sizable pro-competitive effect of trade for Taiwanese firms, while Hsu et al. (2016) estimate the gain from exposure to import competition in China from 1995 to 2004 to be over 20 percent. Both studies focus on the final goods sector, but our study points out that input trade liberalization may also affect firm markup and markup distribution, and may thus have important implications for welfare gain estimations, a point that has also been emphasized by De Loecker et al. (2016) in their work on Indian firms.

The remainder of this paper is organized as follows. Section 2 provides an extended Melitz and Ottaviano model. Section 3 describes the background of China's trade reform, and introduces the data. Section 4 presents the benchmark results. Section 5 investigates the role of market concentration and presents robustness tests. Section 6 discusses the implication of input trade liberalization on sectoral markup dispersion. Finally, we draw our conclusions in section 7.

# 2 Theoretical Model

To build up the intuition, we use a simple variable-markup model à la Melitz and Ottaviano (2008). We extend the model to consider the input sourcing decisions of firms, and illustrate the channels through which tariff reductions can affect firm markups. We then analyze how the impact of tariff reduction varies across industries with different levels of competition.

## 2.1 Preference

We define an individual consumer's utility over a continuum of differentiated varieties indexed by $i \in \bar{\Omega}$ as,

$$U = q_0 + \alpha \int_{i \in \bar{\Omega}} q_i di - \frac{1}{2}\gamma \int_{i \in \bar{\Omega}} {q_i}^2 di - \frac{1}{2}\eta \left( \int_{i \in \bar{\Omega}} q_i di \right)^2, \quad (1)$$

where $q_0$ denotes the individual's consumption of a homogenous numeraire good and $q_i$ denotes her consumption of variety $i$ of a set $\bar{\Omega}$ of differentiated goods. $\alpha$ and $\eta$ capture the substitution between the set of differentiated goods and the numeraire good: a higher $\alpha$ or a lower $\eta$ shifts demand towards the differentiated goods. A higher $\gamma$ reflects lower substitutability among varieties of the differentiated goods.

Utility maximization gives the inverse individual demand function, which is multiplied by the number of consumers $L$ to get the market demand for variety $i$ as,

$$q_i = \frac{\alpha L}{\eta N + \gamma} - \frac{L}{\gamma} p_i - \frac{\eta N}{\eta N + \gamma} \frac{L}{\gamma} \bar{p}, \forall i \in \Omega \quad (2)$$

where $q_i$ and $p_i$ measure the quantity and price for variety $i$ respectively. $N$ measures the set of varieties with positive consumption level $\Omega$ (a subset of $\bar{\Omega}$). $\bar{p} = \frac{1}{N} \int_{i \in \Omega} p_i di$ measures the average price for all available varieties in $\Omega$. To have nonnegative demand, firms must charge their prices no more than the threshold price $p_{max}$:

$$p_{max} = \frac{1}{\eta N + \gamma} (\gamma \alpha + \eta N \bar{p}) \quad (3)$$

## 2.2 Production

Consider a two-country model, in which we use supercript $^*$ to denote foreign. In each country, heterogeneous firms use intermediate input to produce final goods, with production function $q = (X^\rho + Z^\rho)^{\frac{1}{\rho}} / c$. For simplicity, we assume two types of inputs, type $X$ has to be sourced domestically, while type $Z$ can be sourced from either home or foreign. $1/(1-\rho)$ measures the elasticity of substitution between inputs $X$ and $Z$ (note $0 < \rho < 1$). Finally, $c$ measures the inverse of firm productivity.

Both intermediate inputs are produced by labor. And we assume perfect competition in the input market to focus on the final goods market. The price of domestic input ($X$, as well as $Z$ when it is sourced domestically) is normalized to be 1 , while the price of foreign input is $\tau_m w^*$, where $\tau_m > 1$ represents the input tariff and $w^*$ represents foreign labor cost. Denote the price of input $Z$ to be $P_Z$, then firms' marginal cost $C$ is determined by both the inverse productivity $c$ and the input price $P_Z$.

$$C = c[1 + P_Z^{\frac{\rho}{\rho - 1}}]^{\frac{\rho - 1}{\rho}} \quad (4)$$

where $P_Z = min\{1, \tau_m w^*\}$ depends on where $Z$ is sourced from.

After paying the entry cost, firms simultaneously draw the inverse productivity $c$ and the foreign input price $w^*$ from independent distributions. Following Melitz and Ottaviano (2008), we assume that $1/c$ follows a Pareto distribution with lower bound $1/c_M$ and shape parameter $k \geq 1$. Therefore the cumulative distribution function for $c$ is $F(c) = \left(\frac{c}{c_M}\right)^k$ $(k > 1)$ with support $[0, c_M]$. A higher value for the shape parameter $k$ reflects more concentration in the cost distribution. Meanwhile, $w^*$ follows a uniform distribution $U[a, b]$. We assume $\tau_m a < 1$ and $\tau_m b > 1$, which ensures that some firms import while others do not.

Under this setup, a firm compares the cost between importing intermediate input $\tau_m w^*$ and sourcing domestically (which is normalized to 1). It will use domestic inputs if $\tau_m w^* > 1$, which implies $P_Z = 1$. Or, it will import intermediate inputs if $\tau_m w^* \leq 1$, so $P_Z = \tau_m w^*$. With a uniformly distributed foreign price $w^*$, the probablity of importing is $\frac{1/\tau_m - a}{b-a}$. Thus, when input tariff $\tau_m$ decreases, more firms will import.[5] Furthermore, for firms who have already imported, their import intensity over total expenditure on inputs, $\frac{1}{1+(\tau_m w^*)^{\frac{\rho}{1-\rho}}}$, increases as tariffs drop.

Thus, given marginal cost $C$ in the form of equation (4), profit maximization derives the following first order conditions,

$$q(C) = \frac{L}{\gamma}[p(C) - C] \tag{5}$$

$$q_X^*(C) = \frac{L}{\gamma}[p_X^*(C) - \tau_o C] \tag{6}$$

where $q(C)$ and $p(C)$ are the output and price of a domestic firm with marginal cost $C$, while $q_X^*(C)$ and $p_X^*(C)$ are the export quantity and price in home country by a foreign firm with marginal cost $C$. $\tau_o$ is the output tariff on foreign exports. Denoting the cut-off marginal cost as $C_D$, where the producer earns zero profit, we have $C_D = p(C_D) = p_{max}$. Similarly, the cut-off marginal cost for foreign producer to sell in home country is $C_X^* = C_D/\tau_o$. Finally, firm's markup can be expressed as a function of its marginal cost $C$ and the cut-off $C_D$:

$$\mu(C) = \frac{p(C)}{C} = \frac{1}{2}\left(1 + \frac{C_D}{C}\right) \tag{7}$$

[5]This implies that industries with lower tariffs tend to have larger fraction of importers. We confirm this empirically using a scatterplot appendix Figure A.1.

### 2.3 Equilibrium

In the long-run equilibrium, the cut-off marginal cost $C_D$ as well as the number of surviving firms will be pinned down by the free entry condition, which states that the expected operating profit prior to entry is equal to the sunk entry cost. In the short-run equilibrium, however, the number of potential firms is fixed, denoted by $\bar{N}$ and $\bar{N}^*$ for home and foreign respectively. The number of surviving firms will be determined by the cut-off marginal cost as above. We focus on the short-run equilibrium given the relatively short time period (2000-2007) for our sample. The total number of sellers in home country is,

$$N = \bar{N}G(C_D) + \bar{N}^*G^*(C_X^*), \tag{8}$$

where $G(C)$ and $G^*(C)$ represent the cumulative distribution function of marginal cost for home and foreign country respectively, and $G(C) = \left(\frac{C}{C_M}\right)^k$.[6] Note that the marginal cost $C$ still follows a Pareto distribution with support $[0, C_M]$, while the upper bound, $C_M$, is increasing in input tariffs $\tau_m$ (see the Appendix for the proof). Thus a reduction in input tariffs will reduce the upper bound $C_M$ and intensify competition among firms.

Given Pareto distribution, we can solve the average price in home country as $\bar{p} = \frac{2k+1}{2k+2}C_D$. Combining it with equation (3) yields the following zero profit cut-off condition:

$$N = \frac{2(k+1)\gamma}{\eta}\frac{\alpha - C_D}{C_D}. \tag{9}$$

The equilibrium marginal cost cut-off $C_D$ can be pinned down by jointly solving for equations (8) and (9):

$$\frac{\alpha - C_D}{{C_D}^{k+1}} = \frac{\eta}{2(k+1)\gamma}\left[\frac{\bar{N}}{{C_M}^k} + \frac{\bar{N}^*}{\left(\tau_o C_M^*\right)^k}\right] \tag{10}$$

From equation (7), firm's markup depends on its own marginal cost $C$ and the industry marginal cost cut-off $C_D$. It is straightforward to see that input tariff reduction reduces $C$ for importers, but has no effect on non-importers; while output tariff has no effect on $C$. From equation (10), we can examine the impact of tariff reductions on the cut-off cost $C_D$. For the sake of space, we put the

[6]More specifically, $G(x) = Prob(C \leq x) = Prob(\tau_m w^* \leq 1) \times Prob(c[1 + (\tau_m w^*)^{\frac{\rho}{\rho-1}}]^{\frac{\rho-1}{\rho}} \leq x|\tau_m w^* \leq 1) + Prob(\tau_m w^* > 1) \times Prob(c \leq x|\tau_m w^* > 1) = \left(\frac{x}{C_M}\right)^k$, where $C_M = \xi c_M$, and $\xi = [\frac{b-a}{\int_a^{1/\tau_m}[1+(\tau_m w^*)^\theta]^{\frac{-k}{\theta}}dw^* + b/\tau_m}]^{1/k}$ is a constant related with input tariff and foreign input cost distribution, in which $\theta = \frac{\rho}{\rho-1}$. Detailed proof is provided in the Appendix.

detailed derivation in the appendix, while illustrate the underlying intuition in Figure 4. The left hand side (LHS) of equation (10) is decreasing in the cut-off $C_D$, while the right hand sice (RHS) is a constant affected by other variables. Originally the equilibrium is point A, with zero profit cut-off cost $C_D^0$. When output tariff $\tau_o$ reduces, the RHS rises and the equilibrium moves to point B, with a lower cut-off $C_D^1$. This is because lower $\tau_o$ induces more foreign firms and changes firms' distribution of marginal costs. As a result, the average marginal cost becomes lower, inducing lower markup for domestic firms. This shows the pro-competitive effect of output tariff reduction.

[Figure 4 about here]

Moreover, input tariff affects the upper bound of the marginal cost distribution $C_M$. When input tariff $\tau_m$ drops, the RHS rises while the magnitude depends on the initial number of firms $\bar{N}$. With a small number of firms $\bar{N}$, the increase of the RHS is limited, resulting in a new equilibrium at point C, with cut-off $C_D^2$. With a large $\bar{N}$, the RHS rises more and the new equilibrium is at point D, with cut-off moving to $C_D^3$. The intuition is: on the one hand, input tariff reduction leads to lower input costs for individual importers and therefore increases their markups. On the other hand, it also generates a pro-competitive effect through lowering average costs, leading to lower markups. The aggregate effect depends on the relative magnitude of the two opposite forces: the direct effect on individual markup dominates the pro-competitive effect when $\bar{N}$ is small, while the pro-competitive effect becomes stronger when $\bar{N}$ is large. Finally, for non-importers, input tariff reduction does not affect their marginal costs but still lowers average cost. So non-importer's markup drops due to reduction in input tariffs. To summarize, we have the following testable propositions.

**Propositions:** Under the above-listed assumptions, trade liberalization will have the following effects:[7]

(1). Reduction in output tariffs dampens markups for all firms, that is: $\frac{\partial \mu}{\partial \tau_o} > 0$.

(2). Reduction in input tariffs dampens non-importers' markups, that is: $\frac{\partial \mu}{\partial \tau_m} > 0$ for non-importers.

(3). Reduction in input tariffs has ambiguous effect on importers' markups, depending on its effect on individual firm's markup versus the pro-competitive effect. Input tariff reduction increases

[7]The proof is provided in the Appendix.

importers' markups if the former effect dominates the latter. Formally, $\frac{\partial \mu}{\partial \tau_m} < 0$ for importers, if $\frac{\partial C}{\partial \tau_m}$ is large enough.

(4). Reduction in input tariffs has a stronger positive effect on importers' markups in less competitive industries, that is: $\frac{\partial^2 \mu}{\partial \tilde{N} \partial \tau_m} > 0$.

# 3 Background and Data Preparation

## 3.1 China's WTO Accession and Tariff Reduction

China gradually has embraced globalization since the early 1980s. However, the progress was greatly accelerated by its accession to the WTO in December, 2001 (Branstetter and Lardy, 2006). As shown in Figure 1, after its WTO accession, China achieved an annual average growth at as high as 25%, in both export and import values until 2008. Accompanying the accelerated trade growth was a large-scale reduction in tariffs. By 2005, China had fulfilled most of its commitment to cutting tariffs and eliminating non-tariff measures. The import-weighted average tariff across all 6-digit HS goods was reduced from 15% in 1997 to lower than 5% in 2007. Most of the tariff reductions occurred during 2001 and 2002. Equally remarkable was the decline in the standard deviation of tariffs across products over the same period, as shown by the blue dashed line in the figure (right axis). As a result, the post-reform import tariff rates are uniformly low, implying that products with higher initial tariffs underwent larger tariff reductions after trade liberalization.

To capture the distinct effect of input tariffs on intermediate goods in contrast with output tariffs on final goods, we adopt the extended Chinese Input-Output Table for the benchmark year 2002.[8] The coefficients for the IO matrix ($a_{kj}$) reflect the cost share of input $k$ for producing output $j$; that is, $a_{kj} = \frac{input_{kj}}{\sum_k input_{kj}}$. First, we map each of the six-digit HS product codes to a five-digit IO sector category. Tariff data at the six-digit HS level is from the trade analysis and information system (TRAINS). The output tariff for a sector $k$ is then simply the import-weighted average across all 6-digit HS codes within sector $k$. Finally, the input tariff for each IO sector $j$ is computed as the weighted average of the output tariff, where the weights are given by the IO coefficients:

[8] Our use of the 2002 IO table is based on the assumption that the input-output structure did not change much over the sample period, which is reasonable for a medium time span and is thus also adopted in the literature (Amiti and Konings, 2007; Tapolova and Khandelwal, 2011).

$$\tau_{jt}^{input} = \sum_k a_{kj} \tau_{kt}^{output} \tag{11}$$

In Figures 5, we plot the change in tariffs over the sample period, 2000-2007, as a function of initial tariffs in 2000, for output and input tariffs respectively. Similar to what Amiti and Konings (2007) describe, the sectors with the highest initial tariffs experienced the largest tariff reductions. This fact, combined with the shrinking standard deviation of tariffs across 6-digit HS goods, implies that there was little policy discretion across sectors in the extent of trade liberalization (Brandt et al., 2012b). This would partly alleviate the endogeneity concern related to the tariff reduction. Furthermore, in the robustness checks we employ the fact that sectors with high initial tariffs experienced the largest tariff drops and construct an instrumental variable estimation following Amiti and Konings (2007). Our main results still hold.

[Figure 5 about here]

Another concern is the use of tariffs at the sector level. Even within a narrowly defined sector, firms may be subject to trade liberalization to different extent. Some firms import inputs more intensively than others, and may thus in practice benefit more from tariff cuts. Hence, we map each firm with its detailed import information using Customs data containing the universe of importers. This mapping enables us to construct an index of firm-specific input tariffs, following Yu (2014). Compared with sector-level input tariffs, at the firm level, each firm may import multiple intermediate inputs in different fractions. Hence, $a_{ki}$ is now the cost share of product $k$ in the production of firm $i$.

### 3.2 Estimating Firm Markup

Our main variable of interest is firm markup, defined as the ratio of price over marginal cost. The main production data we use is the Annual Surveys of Industrial Production (ASIP) data, provided by the National Bureau of Statistics of China (NBSC) for the 2000-2007 period. This dataset contains all state-owned enterprises (SOEs) and non-SOEs with annual sales of at least 5 million RMB (around US $ 620,000). It contains detailed firm level production and balance-sheet information such as gross output, value-added, employment, capital stock, etc. The dataset forms the basis for major statistics published in China Statistical Yearbooks and has been widely used in economic research. Brandt et al. (2012a) provide a detailed description of the data.

Given the limited information on output prices, we adopt the methodology proposed by De Loecker and Warzynski (2012) to estimate firm-level markup. Their approach follows the insight of Hall et al. (1986) and relies on the standard cost minimization conditions, with at least one variable input free of adjustment frictions. One advantage of this method is that it does not depend on the settings of the demand system and can thus be conveniently applied to production data. Under any form of imperfect competition, the relevant markup is pinned down by the variable input's revenue share and its output elasticity. To avoid the output price bias pointed out by Klette and Griliches (1996), we further augment our estimation by examining a subset of single-product firms for which we have collected output information on *physical quantity*.[9] Using this subset of firms, we adopt the method of De Loecker et al. (2016) to estimate a quantity-based production function and infer markups for the full sample.

We briefly describe the insight of De Loecker and Warzynski (2012) below. First, assume a continuous and twice-differentiable production function for firm $i$,

$$Y_{it} = f\left(K_{it}, L_{it}, M_{it}, \omega_{it}\right) e^{\varepsilon_{it}} \tag{12}$$

where $K_{it}$, $L_{it}$, and $M_{it}$ denote capital, labor, and material inputs respectively. $\omega_{it}$ stands for firm $i$'s productivity and $\varepsilon_{it}$ stands for unexpected i.i.d. productivity shocks. Let $Q_{it} = f\left(K_{it}, L_{it}, M_{it}, \omega_{it}\right)$.

As firms are cost-minimizers, their optimization problem could be captured by the following Lagrangian function:

$$\mathscr{L}\left(K_{it}, L_{it}, M_{it}, \lambda_{it}\right) = P_{m,it} M_{it} + r_{it} K_{it} + w_{it} L_{it} + \lambda_{it}\left(Q_{it} - f\left(K_{it}, L_{it}, M_{it}, \omega_{it}\right)\right) \tag{13}$$

where $w_{it}$, $r_{it}$, and $P_{m,it}$ denote the wage rate, rental rate for capital, and price for intermediate inputs, respectively. As long as intermediate inputs remain free of adjustment costs, we can solve

[9] This dataset is also sourced from the NBS, including output quantity information at the 5-digit product level for the period 2000-2006. It can be easily matched with the ASIP data using the same firm identity. We use single-product firms for estimation due to lack of price information for multiproduct firms.

the first order condition as,

$$\frac{\partial \mathscr{L}_{it}}{\partial M_{it}} = P_{it} - \lambda_{it} \frac{\partial f\left(K_{it}, L_{it}, M_{it}, \omega_{it}\right)}{\partial M_{it}} = 0 \tag{14}$$

where $\lambda_{it}$ is exactly the marginal cost of production at a certain level of output, because $\frac{\partial \mathscr{L}_{it}}{\partial Q_{it}} = \lambda_{it}$. Then, defining markup as the ratio of price to marginal cost, $\mu_{it} = \frac{P_{it}}{\lambda_{it}}$ , we can re-arrange equation (14) and get,

$$\begin{aligned} \mu_{it} &= \frac{P_{it}}{\lambda_{it}} = \frac{P_{it}}{P_{m,it}} \frac{\partial f\left(K_{it}, L_{it}, M_{it}, \omega_{it}\right)}{\partial M_{it}} \\ &= \frac{\frac{M_{it}}{Q_{it}} \frac{\partial f(K_{it}, L_{it}, M_{it}, \omega_{it})}{\partial M_{it}}}{\frac{M_{it} P_{m,it}}{Q_{it} P_{it}}} = \frac{\theta_{m,it}}{\alpha_{m,it}} \end{aligned} \tag{15}$$

where $\theta_{m,it}$ is the output elasticity of intermediate inputs and $\alpha_{m,it}$ is the revenue share of the expenditure on intermediate inputs.

Both the revenue share of input $\alpha_{m,it}$ and the output elasticity $\theta_{m,it}$ need to be estimated with the production function.[10] Because our input tariffs are derived at the sector level, we will also estimate the production function and firm markup for each sector separately. After matching the ASIP data with the IO sector code, we end up with 71 manufacturing sectors. To obtain reliable estimates of output elasticity, we retain firms that have existed for no less than three years. After obtaining the parameter estimates, we apply them to the full sample to obtain firm markups for the full sample.[11]

De Loecker and Warzynski (2012) suggest a two-step estimation procedure, following the control function approach proposed by Olley and Pakes (1996), Levinsohn and Petrin (2003), and Ackerberg, Caves, and Frazer (2015). In the first step, we lay out the production function,

$$y_{it} = \theta_l l_{it} + \theta_k k_{it} + \theta_m m_{it} + \rho_{pt} + \omega_{it} + \varepsilon_{it} \tag{16}$$

where $\theta_l$, $\theta_k$, and $\theta_m$ are the output elasticities of labor ($l$), capital ($k$), and inputs ($m$) respectively. $\omega_{it}$ is the total factor productivity (TFP). All variables are expressed in logarithm form, and the variables $y_{it}$, and $m_{it}$ are deflated with industry-level output and input deflators from Brandt et al.

[10] The revenue share is $\alpha_{m,it} = \frac{M_{it} P_{m,it}}{P_{it} \frac{Y_{it}}{exp(\hat{\varepsilon}_{it})}}$ instead of $\frac{M_{it} P_{m,it}}{Y_{it} P_{it}}$, which eliminates expenditure variations coming from output variations $\varepsilon_{it}$ as we will define in equation (16).

[11] We follow Berkowitz et al. (2016) in retaining firms that have existed for no less than three years for estimation following. However, our results are qualitatively robust if we keep all firms, and if we further include firm exit probability in the estimation to control for selection bias. These results are shown in appendix Table 7.

(2012a). To account for regional differences in factor markets within China (Cheng et al. 2014), we also add province-year fixed effects $\rho_{pt}$. In the robustness check using output in quantity, we also use a translog production function (see Table 7 for details).

Material input choice is affected monotonically by the productivity shocks that are observed by firms but not by econometricians, and we can represent material input as,

$$m_{it} = m_{it}\left(\omega_{it}, l_{it}, k_{it}, FX_{it}, FM_{it}\right) \tag{17}$$

Equation (17) indicates that a firm's input choice is determined by its productivity and factor inputs. It is also affected by the firm's export and import status. We include export status to acknowledge that exporters are faced with different levels of final good demand and may have different input choices. And, we include the importer dummy to account for the fact that importers have different levels of demand for intermediate inputs than do non-importers.

Because more productive firms use more intermediate inputs, we can invert equation (17) and express productivity as a function of inputs, and export and import indicators,

$$\omega_{it} = h_t\left(m_{it}, l_{it}, k_{it}, FX_{it}, FM_{it}\right) \tag{18}$$

Then, combining equations (16) and (18), we can estimate the following equation non-parametrically:

$$y_{it} = \phi_{it}\left(m_{it}, l_{it}, k_{it}, FX_{it}, FM_{it}\right) + \rho_{pt} + \varepsilon_{it} \tag{19}$$

Estimating equation (19) yields predicted output $\hat{\phi}_{it}$ and error term $\hat{\varepsilon}_{it}$. Then, we can recover productivity as,

$$\omega_{it}\left(\Theta\right) = \hat{\phi}_{it} - \theta_l l_{it} - \theta_k k_{it} - \theta_m m_{it} \tag{20}$$

where $\Theta = (\theta_l, \theta_k, \theta_m)$ is the set of output elasticities. In the second step, we estimate $\Theta$ using a GMM approach. We assume that that productivity follows a first order Markov process,

$$\omega_{it} = g\left(\omega_{it-1}\right) + \gamma_x FX_{it-1} + \gamma_m FM_{it-1} + \xi_{it} \tag{21}$$

where $\xi_{it}$ is an i.i.d productivity shock. $g_t\left(.\right)$ is a third order polynomial of $\omega_{it-1}$ .We include lagged export and import status to allow for channels of productivity improvement through exporting or importing. A non-parametric regression of equation (21) obtains the innovation to productivity $\xi_{it}(\Theta)$. As $\xi_{it}(\Theta)$ is not correlated with the lagged flexible inputs (labor and material) and current capital stock because it is pre-determined, we can then use the moment conditions:

$$E\left[\xi_{it}(\Theta)\begin{pmatrix} l_{it-1} \\ m_{it-1} \\ k_{it} \end{pmatrix}\right] = 0 \tag{22}$$

to identify $\Theta$. With $\Theta$ estimated, we can readily compute the firm-level markup as

$$\hat{\mu}_{it} = \frac{\hat{\theta}_m}{\hat{\alpha}_{m,it}} \tag{23}$$

where $\hat{\alpha}_{m,it} = \frac{M_{it}P_{m,it}}{Y_{it}P_{it}/exp(\hat{\varepsilon}_{it})}$.

The distribution of firm markup (in logarithm value) is shown in Figure 6 for 2000 and 2007. A rightward shift in the markup distribution is evident from 2000 to 2007, which is consistent with what De Loecker et al. (2016) found for India. Over time, the distribution also becomes more dispersed. For brevity, we present the complete set of estimation parameters in the appendix, including basis statistics on output elasticity, markup level, and the dispersion.

[Figure 6 about here]

### 3.3 Descriptive statistics

As described above, our main firm-level variables are drawn from the Annual Surveys of Industrial Production (ASIP), 2000-2007. We follow Cai and Liu (2009) and Yu (2014) and use the General Accepted Accounting Principles as guidance to clean the data. We then follow Li et al. (2015) and match this dataset with the firm-level trade data from the Customs Administration to obtain information on firms' import status and import intensity. We drop the top and bottom 1% extreme values for markups, and mis-reported observations. The data cleaning results in an unbalanced panel of 1,575,162 observations with 227,963 importers, distributed across 71 industries (126,718 firms in 2000 and 280,296 firms in 2007).

Table 1 presents the summary statistics of key variables used in our empirical investigation.

Our major interest is firm level markup, which, after we delete the bottom and top 1% sample, ranges from 0.76 to 2.34. Importers are in the minority compared to non-importers, but they have higher markups than non-importers on average. Furthermore, Figure 7 shows that after trade liberalization the overall markup distribution across manufacturing firms shifts rightwards from 2000 to 2007. It worth noting that a substantial fraction of firms exhibit markups smaller than one, because the output elasticity is under-estimated when a revenue-based production function is used without firm-level output and input prices (De Loecker and Goldberg, 2014).[12] However, as long as the output and input price biases do not vary over time, the markup level bias will not affect our results because we focus on within firm changes.

Panel A of Table 1 summarizes all of the control variables we used in later empirical estimations, such as firm import (FM) / export (FX) status, firm age, productivity, and ownership. In addition to firm characteristics, a summary of firm level input tariffs (which only applies to importers) is also presented. There are substantial variations across firms in the tariff burdens that they receive.

Panel B of Table 1 presents statistics at the industry level, mainly related to competitiveness and tariff levels. As detailed later, we use several measures of market competitiveness, including the market share of the top 20 firms (CR20), the (inverse of) log number of firms, the Herfindahl index (HHI), and two size measures (average capital stock and average firm revenue). There are substantial variations in the level of competitiveness across industries. In the most competitive market (cement), the largest 20 firms take only 7 percent of domestic market share, while in the least competitive market (tobacco) there are only 294 firms. Panel C then presents the summary statistics for input and output tariffs at the industry level.

In Panel D, we construct different measures of markup dispersion at 4-digit CIC level, following Lu and Yu (2015). Specifically, these measures include the Theil index, the coefficient of variation (CV), the relative mean deviation (RMD), and the Gini index. The bottom panel (Panel E) summarizes firm outputs and inputs, which are used for markup estimation.

[Table 1 about here]

[12] When a revenue-based production function is estimated, both firm-level output price and input price appear in the residual, and are negatively correlated with the value of inputs. After controlling for output and input prices, De Loecker et al. (2016) find that about 15% of firms have markups lower than 1.

# 4 Benchmark Results

## 4.1 Markup and Tariff Reduction

In this section, we examine the possible link between trade liberalization and firm-level markup. We have known from our model that output tariff reduction dampens all firms' markups. And,importers that have access to foreign inputs benefit from reductions in input tariffs, because they could partially pass the cost saving through to buyers. Meanwhile, input tariff reduction reduces industry average cost and intensifies competition. Thus, we first test propositions (1) to (3) by estimating the following equation:

$$\begin{aligned} ln\left(\mu_{ijt}\right) =& \alpha\tau_{jt}^{o} + \beta_1\tau_{jt}^{m} + \beta_2\tau_{jt}^{m} \times FM_{it} + \beta_3 FM_{it} \\ & + \Gamma X_{it} + \delta_t + \xi_i + \varepsilon_{it} \end{aligned} \tag{24}$$

where $i$, $j$, and $t$ stand for firm, sector, and year respectively. Equation (24) is estimated using OLS. We use the firm fixed effect to control for unobserved firm-specific time-invariant characteristics, and use year dummies to control for macro shocks. All estimations are clustered at the firm level. $\tau_{jt}^{o}$ represents the output tariff, an average tariff across all 6-digit HS products within sector $j$. Proposition (1) states that a fall in $\tau_{jt}^{o}$ is likely to intensify competition in sector $j$, firms may see a drop in their markups. Therefore, we expect $\alpha > 0$. $\tau_{jt}^{m}$ represents the input tariff, calculated as the weighted average of output tariffs of upstream sectors, using equation (11). $FM_{it}$ is an indicator for direct importers of intermediate inputs. $FM_{it} = 1$ if firm $i$ imports any foreign inputs, and 0 otherwise. From Proposition (2) and (3) we expect the impact of input tariff reduction to be different for importers and non-importers, thus we interact the importer indicator $FM_{it}$ with the input tariff $\tau_{jt}^{m}$. Proposition (2) states that non-importers' markups decrease as input tariff reduces, thus the coefficient $\beta_1$ is expected to be positive. Meanwhile, importers will benefit from cheaper access to foreign inputs. Thus, the coefficient of this interaction, $\beta_2$, is expected to be negative. The aggregate effect of input tariff reduction on importers' markup $\beta_1 + \beta_2$ is ambiguous according to Proposition (3) and need to be empirically examined. Besides key explanatory variables, we also include $X_{it}$, control variables that could affect markup, such as firm age, TFP, and export dummy and firm ownership.

Table 2 presents the benchmark results. In column 1, we include only the output tariff. The pro-competitive effect of the output tariff is positive and statistically significant: a 10 percentage point reduction in the output tariff leads to a drop in firm markup by around 0.4%. Column 2 considers the impact of input tariff reduction. The inclusion of an input tariff only slightly reduces the estimated impact of the output tariff. However, lowering the input tariff exerts a heterogeneous impact on importers and non-importers. The input tariff reduction decreases the markups of non-importers ($\beta_1 > 0$), but it substantially raises the markups of importers ($\beta_1 + \beta_2 < 0$). More specifically, on average a 10 percentage point decrease in input tariff raises importers' markups by nearly 1% but reduces non-importers' markups by 0.1%.

[Table 2 about here]

In an imperfectly competitive market, importers enjoy larger markups when they gain cheaper access to foreign inputs. In contrast, firms that do not use imported inputs are at a cost disadvantage. While importers can reduce prices and increase markups at the same time, non-importers have to reduce both prices and markups due to competition. Recent studies have emphasized the importance of input tariff reduction in raising firm productivity (Amiti and Konings, 2007; Topalova and Khandelwal, 2011). We point out an additional channel through which input tariffs may affect firms: importers may increase their markups after input trade liberalization. Besides cheaper foreign inputs, there are other channels through which input tariff reduction may enhance importers' market power. For instance, it may encourage the transfer of foreign technology embedded in imported inputs. Moreover, lower input tariff may also induce importers to source higher-quality inputs, which will increase firms' market power and markups.

Starting from Column (3), we include a set of control variables that may also affect firm markup. Column (3) includes an exporter dummy and the firm age. Consistent with De Loecker and Warzynski (2012), we find that exporters have higher markups. In addition, older firms tend to have lower markups. Column (4) includes the measured TFP for each firm. Consistent with the theoretical predictions of Melitz and Ottaviano (2008), and Atkeson and Burstein (2008), more productive firms tend to charge higher markups. Column (5) adds firm ownership (i.e., foreign or state owned) as a control. The result suggests that state-owned enterprises (SOEs) have higher markups and foreign invested enterprises (FIEs) have lower markups than do private firms.

In all of the regressions, the coefficients on the two types of tariffs remain robust. In particular, input tariff reduction substantially increases importers' markups. This impact is also robust when we replace the importer dummy with a continuous measure of import intensity in Column (6). Importers with higher import shares tend to increase their markups more.

## 4.2 Firm Level Input Tariff and Processing Trade

There are concerns about sector level input tariffs. Even within a narrowly defined industry, importers may be exposed to trade liberalization to different extents, as shown by a wide range of import intensity across importers. Furthermore, other confounding factors such as sector-level policy changes that may bias the estimation above. In this section, we utilize detailed firm-level import information to construct firm-specific input tariffs.

Table 3 shows the results. Column (1) retains the econometric specification in Table 2, except that here we replace the sector level input tariff with a firm level input tariff.[13] Again, all estimations are clustered at the firm level. The results confirm the findings in Table 2. Sector-level output tariff reduction decreases markups while input tariff reduction decreases non-importing firms' markups but increases importers' markups. In column (2), we further include industry-year fixed effects to control for any time-variant sector-specific factors. Note that in this specification the effect of sector-level output tariffs has been suppressed by the industry-year fixed effect. The same pattern remains, although the magnitude falls.

[Table 3 about here]

An observation made of Chinese trade is that a large share of imports are components for export processing. Processing exporters usually import foreign intermediate inputs duty free and export the processed final goods (Yu, 2014). Given this feature, input trade liberalization may affect such firms differently. As a robustness check, in columns (3) we do not include processing firms in the sample. The results are robust.

Columns (4)-(6) focus on the sample of importers. In Column (4) we retain all importers. The results show that input tariff reduction raises importers' markups. As processing imports are not subject to tariffs, we can use processing firms as a placebo test. Thus we divide all importers into two subsamples: ordinary importers and processing importers. Input tariff reduction raises

[13]To compute a firm level input tariff, we must obtain the detailed firm inputs of each sector. Therefore, a firm-level input tariff is only applicable to importers. For non-importers, we still use an industry-level input tariff to represent the general impact.

firm level markup for ordinary importers (Column (5)), whereas it has no significant impact on processing importers (Column (6)).

# 5 Market Structure Matters

## 5.1 Markup, Input Tariff, and Market Concentration

In the previous section, we show an important difference in the effect on firm markup between output and input tariff reduction. In particular, we show that importers respond to input tariff reductions by increasing their markups, while non-importing firms cut their markups. Intuitively, cheaper access to imported intermediate inputs grants importers a cost advantage, with which they can exert market power. However, whether they can do so depends crucially on the market structure, as proved in Propostion (4). In a very competitive market with many importing and non-importing firms, input trade liberalization will reduce input costs for a large number of firms, which means that their markups can not be increased. In a concentrated market where a few large firms import, input tariff reduction would help those firms to cut costs but still keep prices high, leading to increased markups.

Thus, we hypothesize that importers tend to increase their markups more than non-importers in a less competitive sector. To test this hypothesis, we construct a three-way interaction among the importer indicator, input tariff, and a measure of market concentration, specifying the empirical model as,

$$\begin{aligned} ln\left(\mu_{it}\right) =&\beta_1 \tau_{jt}^m \times FM_{it} \times CR_j + \beta_2 \tau_{jt}^m \times FM_{it} + \beta_3 \tau_{jt}^m \times CR_j + \beta_4 \tau_{jt}^m \\ &+ \alpha_1 \tau_{jt}^o + \alpha_2 \tau_{jt}^o \times CR_j + \Gamma \mathrm{X_{it}} + \mathrm{\delta_t} + \mathrm{\xi_i} + \mathrm{\varepsilon_{it}} \end{aligned} \tag{25}$$

where $i$, $j$, and $t$ stand for firm, sector, and year respectively. $CR_j$ stands for the market concentration measure of industry $j$. To be specific, we use the domestic sales share of the top 20 firms to measure market concentration (hereafter, CR20). We use the CR20 in 2000 as a constant measure of sector-level concentration. Presumably the market concentration rate does not change much over time, and using a constant measure also helps to avoid potential endogeneity of market concentration. The results are robust if we instead use a time-variant CR20. All equations include firm fixed effects and a year dummy, and are clustered at the firm level.

The variable that we are most interested in is the interaction term among the importer indicator, input tariff, and the measure of market concentration. We expect its coefficient, $\beta_1$, to be negative, implying that importers have more market power to charge high markups in less competitive markets. However, it is also important to quantify the difference between importers and non-importers in their ability to adjust markups. To understand this, it is straightforward to separately compute the elasticity of markup with respect to the input tariff for importers and non-importers. The elasticity for importers is

$$\frac{\partial ln\left(\mu_{it}\right)}{\partial \tau_{jt}^{m}}|\left(FM_{it}=1\right)=\left(\beta_1+\beta_3\right)\times CR_j+\left(\beta_2+\beta_4\right) \tag{26}$$

and that for non-importers is

$$\frac{\partial ln\left(\mu_{it}\right)}{\partial \tau_{jt}^{m}}|\left(FM_{it}=0\right)=\beta_3\times CR_j+\beta_4 \tag{27}$$

First, importers see more chances to charge higher markups in more concentrated markets, and we thus expect $\beta_1+\beta_3<0$. Furthermore, the gap between importers and non-importers in their markups after liberalization is given by $\beta_1\times CR_j+\beta_2$. We expect this gap to be increasing in market concentration, thus $\beta_1<0$.

In Table 4, column (1) presents the basic results and column (2) adds a set of additional controls including exporter dummy, age, ownership, and TFP. In both columns, our hypothesis is confirmed. Less competitive markets tend to have larger elasticity of markup with respect to input tariff. Interestingly, we find that $\beta_3$ is negative, suggesting that in a very concentrated market it may be strategically optimal for even non-importing firms to charge higher markups. Finally, the interaction between output tariff and market concentration has a positive coefficient ($\alpha_2<0$), reflecting a more drastic competition effect in more concentrated markets that are pushing down firms' markups.

[Table 4 about here]

Columns (3) and (4) replicate the first two columns but replace the importer dummy with an indicator for incumbent importers. The estimates are similar when we focus on incumbent importers, suggesting the results are not driven by new importer entries. Columns (5) and (6) replace the discrete importer dummy with a continuous measure of import intensity. The results still hold.

To quantify the impact of input tariff reduction, in Table 5 we report the elasticity of markup with respect to the input tariff at different percentiles of market concentration. Column (1) lists the value of CR20 for each sector, and column (2) the corresponding percentile. Equation (16) gives the formula for computing the elasticity. Column (3) shows the corresponding elasticity. In a very competitive market, such as plastic products ($CR20 = 0.1$), even importers experience falling markups due to trade liberalization. As CR20 increases, importers' markup elasticity becomes negative and grows larger in magnitude. In the industry with the median concentration level (0.306, fireproof products), a 10 percentage point reduction in the input tariff raises importers' markups by 1.9%. Moreover, in a very concentrated industry (95th percentile, petroleum refining), where CR20 is 0.82, the corresponding rise in markups is 9%. Finally, we report the corresponding markup elasticity to input tariff for incumbent importers, or for import intensity (using the mean value), in columns (4) and (5) respectively. Both confirm the results of Column (3).

[Table 5 about here]

Figure 7 is a more straightforward illustration of the quantitative effects of input tariff reduction. The top panel shows a scatterplot of input tariff reduction (in absolute value) across the 71 manufacturing sectors,[14] with no systematic relation evident between input tariff reduction and the CR rate across sectors. The upward-sloping solid line is the markup elasticity for importers, and the dashed line is for non-importers. The two lines diverge as the market becomes more concentrated.

[Figure 7 about here]

The middle panel plots the multiplication between input tariff reduction and markup elasticity, resulting in actual markup changes (in percentage) for importers (circle) and non-importers (x). The fitted lines clearly depict the pattern in Tables 3 and 4: moving from a low CR sector to a high CR sector, importers enjoy larger increases in markups than do non-importers within the same sectors.

The bottom panel of Figure 8 considers differences among firms with different import intensities. We plot markup changes in each sector for non-importing firms, firms that import 50% of inputs, and

[14]Two sectors (IO 17024 and 13017) are dropped, their input tariffs increased during the sample period.

those that import all inputs. Consistently, firms with higher import intensities have larger increases in markups in more concentrated markets. For example, in the industry with 25th percentile concentration level (0.20, pottery, china and earthware), the input tariff drops 7.64% from 2000 to 2007, with a markup elasticity w.r.t. input tariff of -0.05 for importers, and the corresponding markup growth (due to input tariff reduction) is 0.40%. In contrast, in the household electric appliances sector, (90th percentile concentration level, 0.735), the input tariff reduction is 13.5% and the markup elasticity for importers is -0.78, with the corresponding rise in markup strikingly around 10%.

### 5.2 Alternative Measures for Market Competitiveness

Our results are robust across different measures of market competitiveness. In particular, Table 6 reports the results when we use number of firms (column (1)), and the Herfindahl-Hirschman Index (HHI, column (2)). Furthermore, average firm size may indicate the barrier for a firm to enter the market (Bain, 1956), so columns (3) and (4) use average capital stock and average domestic sales to measure the degree of competition. All of the results are consistent with the previous ones. $(\beta_1 + \beta_3)$ is significantly negative, so an input tariff reduction increases importers' markups more in less competitive sectors. Finally, as in Table 5, we report the computed elasticities using alternative measures of market concentration in appendix Table A3.

[Table 6 about here]

### 5.3 Robustness Checks on Markup Estimation

There may also be concerns about the robustness of markup estimation. We explore these issues in Table 7. Our benchmark estimations are based on the sample of firms that had been operating for at least three years. Nonetheless, in Column (1), we use the complete sample of firms in markup estimation. Columns (2) considers the inconsistency when we estimate the impact of a tariff reduction on firm markup. In the Markov process of productivity estimation, we assume that the current productivity realization is a surprise conditional on lagged productivity and import/export behavior. However, tariff levels are known to firms and can directly affect firms production decisions. We correct for this inconsistency by incorporating the tariffs in productivity estimation process, following the "direct approach" of Fernandez (2007) and Topalova and Khandelwal (2011). We utilize the cross-firm variations in the firm-level input tariff and conduct the estimation for each industry separately. Columns (3) corrects for the possible selection bias by considering firms' exit probability, following Olley and Pakes (1996). Also, certain group of firms may behave differently. In particular, state-owned enterprises (SOEs) may not be profit maximizers or face soft budget constraint.[15] Thus in Columns (4), we exclude SOEs in our markup estimations. After all corrections, our benchmark regression results in Table 4 still hold, with similar magnitude.

Another concern is that we use the deflated revenue output data to estimate firm's output elasticity. As pointed out by Klette and Griliches (1996) and De Loecker et al. (2016), this may result in omitted output price bias. Thus we follow Lu and Yu (2015) to augment our benchmark results with markups estimated using output in physical terms. Columns (5) and (6) report the results. The markup estimation relies on a subset of single-product firms for which we have collected output information on physical quantity. We use single-product firms for estimation due to lack of price information for multiproduct firms. After getting estimates for key parameters, we assume that multiproduct firms use the same technology as single-product firms in the same industry. This way we are able to calculate the firm-product level markups and then take average to get firm-level markups. More specifically, Column (5) uses Cobb-Douglas production function while Column (6) is based on the more flexible translog production function. The results in both columns show that in more concentrated industries, input tariff reduction generates larger markup increases for importers. To save space, we report the computed elasticities (as in Table 5) in appendix Table A4.

[Table 7 about here]

### 5.4 First Difference Estimations

So far, our estimations are based on panel regressions with firm fixed effects and year dummies. In Table 8, we experiment with alternative specifications to investigate the medium to long run effect of input trade liberalization. More specifically, we take first-difference to wipe out the firm-specific characteristics. Columns (1)-(3) examine the heterogeneous response of importers vs. non-importers, analogous to Table 3. In column (1), we use the three-period first difference of log

[15]See Brown, Earle, and Telegdy (2006) and Konings, Van Cayseele, Warzynski (2005) for evidence on SOEs in transition economies.

markup as the dependent variable, and all of the explanatory variables are also three-period first differenced. In columns (2)-(3), we take four-period and five-period difference respectively. The magnitudes of the coefficients are similar to those in column (1), but are larger than the level regressions. A 10 percentage point reduction of output tariff causes firms' markups to drop 0.60% on average in three years. While a 10 percentage point drop of the input tariff raises importers' markups by 1.15% but reduces non-importing firms' markups by 0.33%.

[Table 8 about here]

In columns (4)-(6), we add all interaction terms between tariffs and market competitiveness, in comparison with Table 4. The coefficient of the interaction term of input tariff, importer dummy, and the market concentration, is significantly negative, implying a similar pattern. The inferred markup elasticity w.r.t. input tariff (in three years) is -0.11 in the 5th percentile CR industry and -0.27 in the 95th percentile CR industry.

### 5.5 Instrumental Variable Estimation

There are also concerns about the potential endogeneity of tariffs. In general, the direction of the bias caused by the endogeneity is ambiguous. Some industries may receive protection for various reasons, such as lobby from powerful interest group, or governmental priority given to maintaining employment. However, the authorities liberalize different industries to different extents according to a political agenda or economic calculations. Yet, during China's trade liberalization episode, both output and input tariffs were cut drastically and uniformly. In particular, one well-cited motivation for China's WTO accession was a commitment to market-oriented reforms of its domestic economic system. This commitment is evident in the uniform reduction in tariffs across sectors, as shown by the sharp decrease in both tariff levels and variation in Figure 2. Furthermore, as shown in Figures 6, a common feature of China's tariff reduction is that the higher the initial tariff level before liberalization, the larger the drop after liberalization. This pattern lends support to the argument that over the liberalization episode, there was very little policy discretion in the extent of trade liberalization in each sector (Brandt et al., 2012b).

[Table 9 about here]

Based on this argument, in Table 9 we address the endogeneity concern through an instrumental variable approach following Amiti and Konings (2007). In particular, we instrument the input tariffs, output tariffs, and their respective interactions with an importer dummy, and/or the market competitiveness measure, using the initial pre-WTO tariff levels (in 2000) and their corresponding interaction terms. Same as Table 8, we take three-period, four-period, and five-period first difference of log markup to investigate the medium tolong run effects. The direct first stage results of initial tariff levels on tariff reductions, for both input and output tariffs, are provided in the lower panel.[16] All regressions confirm our hypothesis.

## 6 Input Tariff Reduction and Markup Dispersion

The trade literature states that exposure to international trade intensifies competition, and thus reduces both the level and dispersion of markups across firms. Using an oligopolistic competition model as in Atkinson and Burstein (2008), Edmond et al. (2015) show that the welfare gain can be large because of the drop in markup dispersion, particularly when the initial misallocation is large. Hsu et al. (2016) document large pro-competitive gain from China's trade liberalization from 1995 to 2004. Lu and Yu (2015) provide empirical evidence that output tariff reductions during China's WTO accession reduced markup dispersion.

All of these studies focus on the final goods sector and investigate the impact of output tariffs. In comparison, our study emphasizes the role of input trade liberalization. Our empirical findings show that input tariff reductions may also affect firm markups and markup distribution. Importantly, as output and input tariff reductions affect markup levels to the opposite direction, they will also have opposite effects on firm markup dispersion. Such effects, as we demonstrate in previous sections, should also vary across industries.

Table 10 examines the joint effect of output and input tariff reductions on industry markup dispersion. We first construct a measure of firms' markup dispersion, namely, the Theil index.[17] The Theil index is an entropy measure commonly used to characterize the degree of dispersion,

[16] The whole set of first stage results is available upon request.

[17] Summary statistics of markup dispersion measures are reported in Table 1 (Panel D).

which is given by equation (28):

$$Theil_{jt} = \frac{1}{N_{jt}} \sum_{i=1}^{N_{jt}} \frac{\mu_{ijt}}{\bar{\mu}_{jt}} log(\frac{\mu_{ijt}}{\bar{\mu}_{jt}}) \tag{28}$$

where $i$, $j$, and $t$ stands for firm, industry, and year, respectively. $\mu_{ijt}$ is firm markup, $\bar{\mu}_{jt}$ is average markup of industry $j$, and $N_{it}$ is the total firm number. Then, we follow Lu and Yu (2015) to examine the following empirical model, specified as follows,

$$ln(Theil_{jt}) = \beta_1 \tau^o_{jt} + \beta_2 \tau^o_{jt} \times CR_j + \alpha_1 \tau^m_{jt} + \alpha_2 \tau^m_{jt} \times CR_j + \Gamma X_{jt} + \delta_t + \xi_j + \varepsilon_{jt}. \tag{29}$$

Hence $\beta_1 + \beta_2 \times CR$ captures the elasticity of markup dispersion w.r.t. output tariff, and $\alpha_1 + \alpha_2 \times CR$ captures that of input tariff. For additional controls, we includes SOE revenue share (SOE share), average wage per worker (Log wage), average asset (log K), total firm number (Log number), and export intensity. We find that an increase in SOE revenue share reduces markup dispersion. However, an increase in average assets, indicating a higher entry barrier, results in more dispersed markups.

Column (1) of Table 10 examines the impact of output tariffs on the industry Theil index as in Lu and Yu (2015), at the four-digit industry level with industry fixed effects and a year dummy. All results are clustered at the industry level. The results confirm the pro-competitive effect documented by Edmond et al. (2015) and Lu and Yu (2015). The positive coefficient on the output tariff indicates that the reduction in final good tariffs lowers markup dispersion. More specifically, 1 percentage point reduction in the output tariff lowers markup dispersion (measured by Theil index) at the four-digit CIC level by 1.72%. The interaction term between output tariff and CR20, however, is not significant.

Column (2) of Table 10 considers the effects of both output and input tariffs. Consistent with our hypothesis, input tariff reduction tends to increase markup dispersion in more concentrated markets, as indicated by the negative and significant coefficient for the interaction between the input tariff and CR value. For example, in an industry with a median CR value, a one percentage point drop in output tariff reduces markup dispersion (as measured by the Theil index) by 1.45%, while a one percentage point drop in input tariff increases markup dispersion by 6.39%. Therefore, our results imply that input tariff reduction has a much stronger effect on markup dispersion than output tariff. In Columns (3) to (5), we experiment with three alternative measures of markup dispersion, following Lu and Yu (2015). These indices include the coefficient of variation (CV), the relative mean deviation (RMD), and the Gini index.[18] The results for both input and output tariffs are similar.

[Table 10 about here]

## 7 Conclusion

In this paper, we examine firms' markup responses to trade liberalization using a large-scale firm-level data from China. A large body of both theoretical and empirical trade literature emphasizes the pro-competitive effect due to declines in output tariffs. However, the impact of lower input tariffs on firm performance has only received attention recently. Our starting point is to account for both channels of trade liberalization and more specifically examine the impact of input tariff reduction on firm markup distribution. In an imperfectly competitive market, input tariff reduction gives importers a cost advantage, which importers may not easily pass through to consumers. Crucially, the magnitude of the pass-through, therefore the markup elasticity with respect to input tariffs, depends on the market structure.

We utilize an unprecedented liberalization episode in China, namely its WTO accession, to estimate the heterogeneous impact of trade reform on firm markups. The results show that input tariff reduction increases firm markups, but only for importers. Furthermore, market structure matters: importers' markups increase more due to input tariff reduction in less competitive industries. Alternative specifications and the instrumental variable approach both confirm our benchmark results. Finally, in contrast to output tariff, input tariff reduction increases industry markup dispersion.

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[18] The formulas used to compute CV and RMD are $CV = \frac{\sqrt{V_{jt}}}{\bar{\mu}_{jt}}$ and $RMD = \frac{1}{N_{jt}} \sum_{i=1}^{N_{jt}} |\frac{\mu_{ijt}}{\bar{\mu}_{jt}} - 1|$, where $\mu_{ijt}$ is the the firm markup, $\bar{\mu}_{jt}$ is the average markup of industry $j$, $N_{jt}$ is the total number of firms and $V_{jt}$ is the variance of markup in industry $j$.

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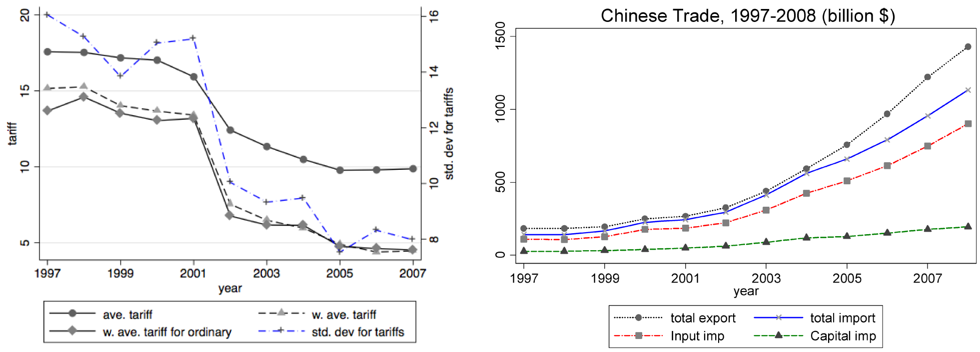


Figure 1: Tariff Reduction and China's Imports, 1997 - 2007

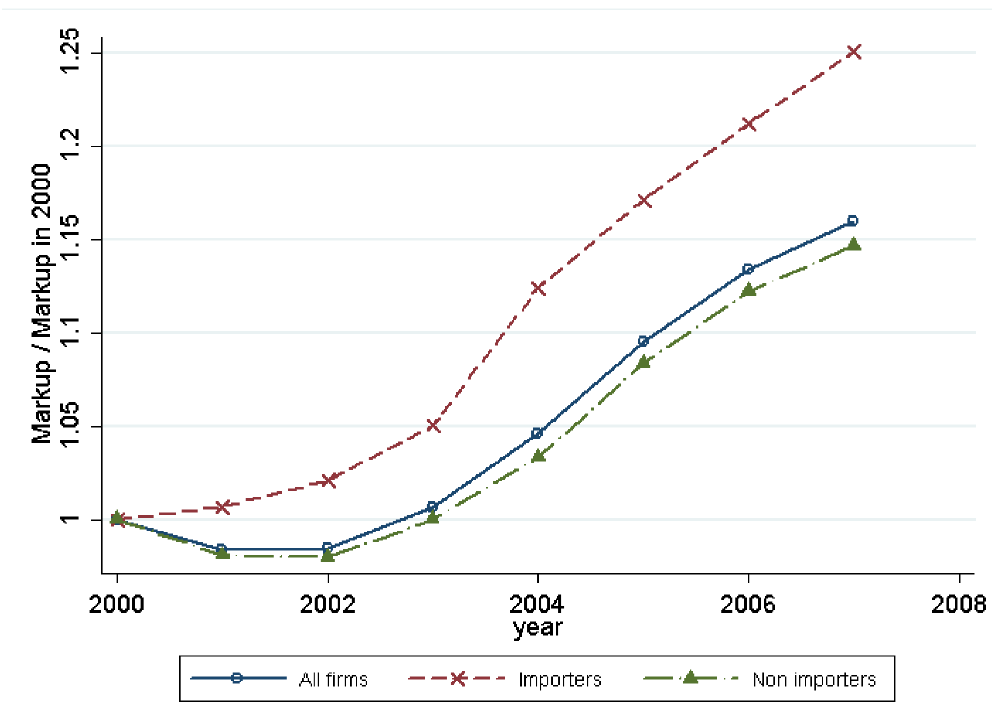


Figure 2: Markup Trend: Importers and Non-importers

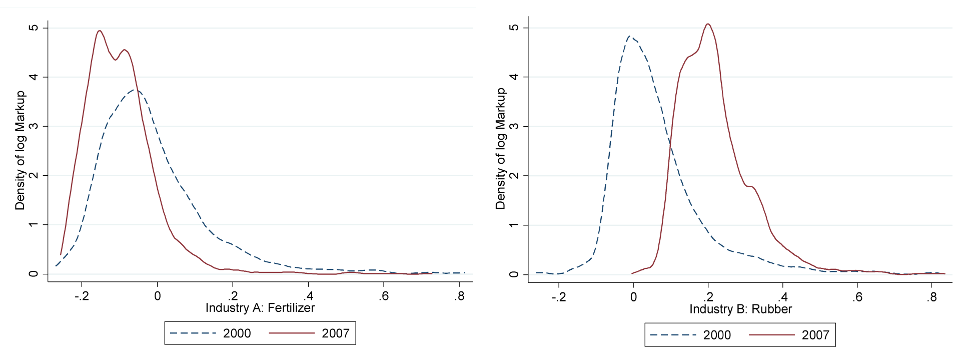


Figure 3: Markup Distributions of Two Selected Industries

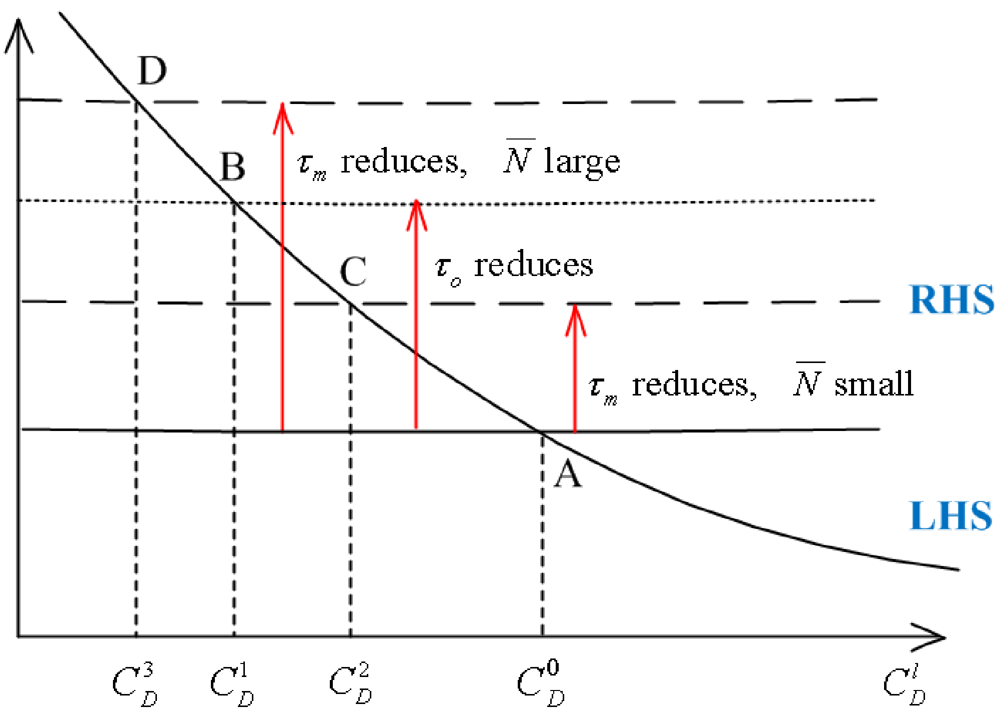


Figure 4: Illustration of the Model

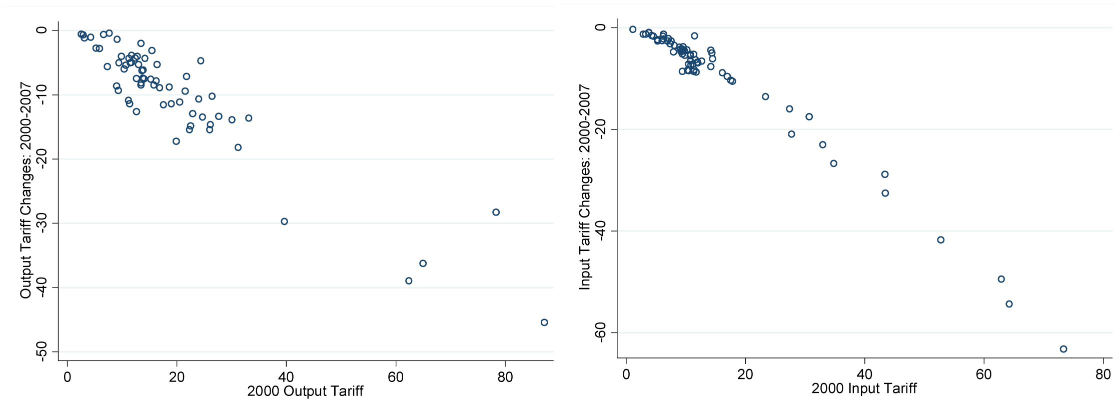


Figure 5: Output Tariff and Input Tariff Reduction

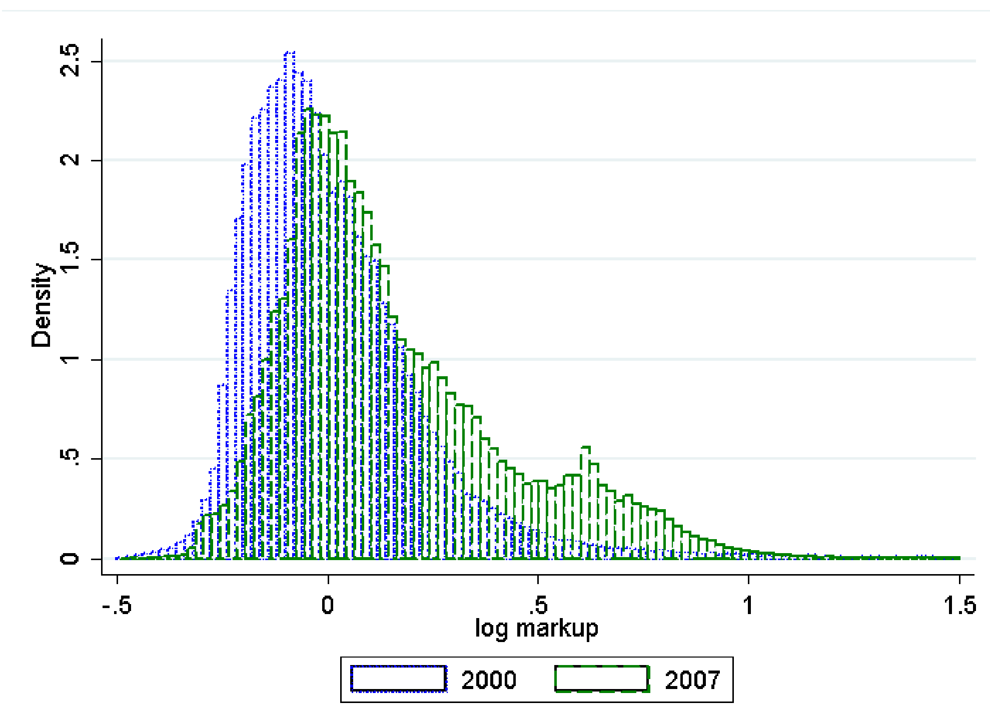


Figure 6: Markup Distribution: 2000 and 2007

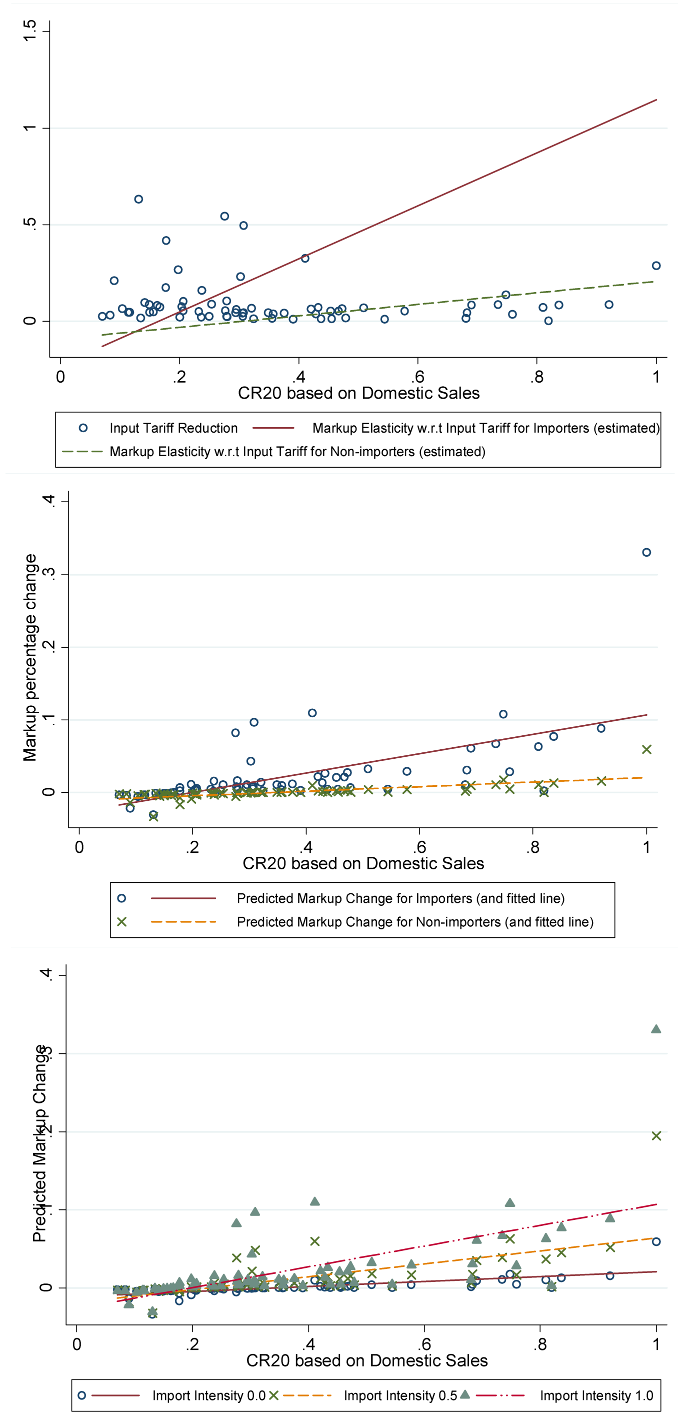


Figure 7: Predicted Markup Changes due to Input Tariff Reduction

Table 1: Data Summary

| Variable | Obs | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| A: Firm Characteristics (2000-2007) | | | | | |
| Markup if FM=1 | 227,963 | 1.108 | 0.251 | 0.764 | 2.341 |
| Markup if FM=0 | 1,347,199 | 1.102 | 0.271 | 0.764 | 2.342 |
| FX | 1,575,162 | 0.288 | 0.453 | 0 | 1 |
| FM | 1,575,162 | 0.145 | 0.352 | 0 | 1 |
| Incum. FM | 1,575,162 | 0.107 | 0.309 | 0 | 1 |
| Import intensity if FM=1 | 227,963 | 0.288 | 0.333 | 0 | 1 |
| Age (in log) | 1,575,162 | 1.968 | 0.862 | 0 | 4.615 |
| TFP (in log) | 1,575,162 | 1.415 | 0.456 | -1.482 | 4.839 |
| SOE dummy | 1,575,162 | 0.09 | 0.287 | 0 | 1 |
| FIE dummy | 1,575,162 | 0.217 | 0.412 | 0 | 1 |
| Firm Input Tariff | 227,963 | 0.055 | 0.062 | 0 | 1.21 |
| B: Industrial Features at IO2002 level (2000) | | | | | |
| CR20 | 71 | 0.364 | 0.221 | 0.071 | 0.999 |
| 1/log (# of firms) | 71 | 0.147 | 0.033 | 0.112 | 0.353 |
| HHI | 71 | 0.024 | 0.058 | 0.001 | 0.458 |
| Average Capital (in log) | 71 | 10.305 | 0.931 | 8.73 | 13.688 |
| Average Revenue (in log) | 71 | 10.894 | 0.903 | 9.542 | 13.463 |
| C: Tariff at IO2002 level (2000-2007) | | | | | |
| Input Tariff ($t^m$) | 568 | 0.093 | 0.09 | 0 | 0.734 |
| Output Tariff ($t^o$) | 568 | 0.142 | 0.145 | 0 | 0.892 |
| D: Markup Dispersion at 4-digit CIC level (2000-2007) | | | | | |
| Theil | 3,361 | 0.011 | 0.014 | 0.000 | 0.420 |
| CV | 3,349 | 0.150 | 0.076 | 0.009 | 1.320 |
| RMD | 3,361 | 0.095 | 0.039 | 0.000 | 0.636 |
| Gini | 3,361 | 0.065 | 0.025 | 0.000 | 0.343 |
| E: Production Variables (2000-2007) | | | | | |
| Output/1000 | 1,608,402 | 76157.82 | 657008.60 | 17.147 | 2.03E+08 |
| Material Input/1000 | 1,608,402 | 53547.36 | 483408.10 | 10 | 1.68E+08 |
| Employment | 1,608,402 | 253.84 | 923.06 | 11 | 1.88E+05 |
| Real Capital/1000 | 1,608,402 | 26869.85 | 326224.00 | 0.625 | 9.74E+07 |

Table 2: Tariffs and Markup

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| $FM =$ | | | Importer dummy | | | Import intensity |
| $t^o$ | 0.0367*** | 0.0351*** | 0.0346*** | 0.0386*** | 0.0388*** | 0.0390*** |
| | (6.95) | (6.05) | (5.96) | (6.60) | (6.62) | (6.66) |
| $t^m$ | | 0.0118*** | 0.0124*** | 0.0102** | 0.00905** | 0.00785* |
| | | (2.73) | (2.88) | (2.36) | (2.10) | (1.82) |
| $t^m \times FM$ | | -0.108*** | -0.113*** | -0.116*** | -0.114*** | -0.408*** |
| | | (-10.39) | (-10.83) | (-11.15) | (-10.94) | (-12.25) |
| $FM$ | | 0.0295*** | 0.0298*** | 0.0295*** | 0.0295*** | 0.126*** |
| | | (28.53) | (28.85) | (28.52) | (28.55) | (38.39) |
| $Age$ | | | -0.00637*** | -0.00643*** | -0.00706*** | -0.00693*** |
| | | | (-16.32) | (-16.45) | (-18.11) | (-17.78) |
| $FX$ | | | 0.00230*** | 0.00208*** | 0.00213*** | 0.00254*** |
| | | | (4.22) | (3.82) | (3.91) | (4.68) |
| $TFP$ | | | | 0.0162*** | 0.0163*** | 0.0175*** |
| | | | | (13.62) | (13.70) | (14.69) |
| $SOE$ | | | | | 0.0149*** | 0.0149*** |
| | | | | | (12.31) | (12.32) |
| $FIE$ | | | | | -0.00632*** | -0.00591*** |
| | | | | | (-4.15) | (-3.88) |
| $N$ | 1575162 | 1575162 | 1575162 | 1575162 | 1575162 | 1575162 |
| $adj.R^2$ | 0.237 | 0.238 | 0.239 | 0.240 | 0.240 | 0.243 |

t statistics in parentheses, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. With firm fixed effects and year dummy. All results are clustered at firm level.

Table 3: Firm Level Input Tariff and Processing Trade

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| | Full Sample | Full Sample | Exclude Processing | Total Importers | Ordinary Importers | Processing Importers |
| $t^o$ | 0.0298*** | - | - | - | - | - |
| | (5.19) | | | | | |
| $t^m$ | 0.0206*** | 0.0184*** | 0.0274*** | -0.0241*** | -0.0187*** | -0.0289 |
| | (5.03) | (2.69) | (3.68) | (-4.93) | (-2.96) | (-1.18) |
| $t^m \times FM$ | -0.0735*** | -0.0377*** | -0.0463*** | - | - | - |
| | (-10.55) | (-5.14) | (-6.00) | | | |
| $FM$ | 0.0252*** | 0.0267*** | 0.0274*** | - | - | - |
| | (31.72) | (39.26) | (39.46) | | | |
| $Age$ | -0.00700*** | -0.00778*** | -0.00765*** | -0.0109*** | -0.00887*** | -0.0166*** |
| | (-17.94) | (-29.44) | (-28.86) | (-11.31) | (-8.82) | (-5.72) |
| $FX$ | 0.00214*** | -0.00110*** | -0.000954** | -0.00707*** | -0.00732*** | -0.00592** |
| | -3.93 | (-2.85) | (-2.45) | (-7.93) | (-7.73) | (-2.20) |
| $TFP$ | 0.0161*** | -0.0443*** | -0.0416*** | -0.0322*** | -0.00494 | -0.173*** |
| | -13.53 | (-33.76) | (-31.56) | (-8.38) | (-1.20) | (-15.49) |
| $SOE$ | 0.0149*** | 0.00880*** | 0.00878*** | 0.00319 | 0.00306 | 0.0259 |
| | (12.35) | (10.04) | (10.00) | (1.15) | (1.08) | (1.37) |
| $FIE$ | -0.00636*** | -0.00313*** | -0.00366*** | 0.00459** | 0.00189 | 0.00464 |
| | (-4.17) | (-3.31) | (-3.82) | (2.06) | (0.77) | (0.78) |
| $N$ | 1575162 | 1575162 | 1528081 | 227963 | 180882 | 47081 |
| Firm FE | YES | YES | YES | YES | YES | YES |
| Ind*Year | NO | YES | YES | YES | YES | YES |
| Year FE | YES | NO | NO | NO | NO | NO |
| $adj.R^2$ | 0.240 | 0.576 | 0.575 | 0.645 | 0.658 | 0.644 |

t statistics in parentheses, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. All results are clustered at firm level. Processing firm definition: firms whose export goods are all processing.

Table 4: Market Concentration, Tariffs and Markup

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| FM = | Importer | | Incumbent Importer | | Import Intensity | |
| $t^m \times FM \times CR$ | -1.091*** | -1.075*** | -1.372*** | -1.353*** | -1.387*** | -1.341*** |
| | (-12.49) | (-12.34) | (-13.60) | (-13.50) | (-6.56) | (-6.29) |
| $t^m \times FM$ | 0.147*** | 0.136*** | 0.164*** | 0.152*** | -0.0651 | -0.0908 |
| | (6.89) | (6.37) | (6.56) | (6.10) | (-1.09) | (-1.51) |
| $t^m \times CR$ | -0.245*** | -0.298*** | -0.243*** | -0.297*** | -0.290*** | -0.346*** |
| | (-5.49) | (-6.61) | (-5.46) | (-6.61) | (-6.51) | (-7.68) |
| $t^m$ | 0.0811*** | 0.0918*** | 0.0817*** | 0.0926*** | 0.0910*** | 0.102*** |
| | (8.09) | (9.06) | (8.18) | (9.16) | (9.09) | (10.06) |
| $t^o$ | -0.139*** | -0.162*** | -0.139*** | -0.163*** | -0.143*** | -0.168*** |
| | (-13.54) | (-15.57) | (-13.60) | (-15.68) | (-13.95) | (-16.08) |
| $t^o \times CR$ | 0.570*** | 0.662*** | 0.571*** | 0.666*** | 0.581*** | 0.679*** |
| | (17.91) | (20.42) | (17.99) | (20.58) | (18.15) | (20.79) |
| $FM \times CR$ | 0.0927*** | 0.0926*** | 0.129*** | 0.128*** | 0.0519*** | 0.0502*** |
| | (12.30) | (12.28) | (18.44) | (18.38) | (3.04) | (2.93) |
| $FM$ | 0.00723*** | 0.00719*** | -0.0100*** | -0.00926*** | 0.111*** | 0.113*** |
| | (3.65) | (3.64) | (-5.08) | (-4.69) | -20.59 | -20.89 |
| $Age$ | | -0.00712*** | | -0.00731*** | | -0.00698*** |
| | | (-18.27) | | (-18.75) | | (-17.93) |
| $FX$ | | 0.00201*** | | 0.00269*** | | 0.00244*** |
| | | (3.69) | | (4.96) | | (4.49) |
| $TFP$ | | 0.0212*** | | 0.0217*** | | 0.0224*** |
| | | (17.69) | | (18.12) | | (18.68) |
| $SOE$ | | 0.0148*** | | 0.0148*** | | 0.0149*** |
| | | (12.29) | | (12.24) | | (12.34) |
| $FIE$ | | -0.00603*** | | -0.00485*** | | -0.00568*** |
| | | (-3.96) | | (-3.19) | | (-3.74) |
| $N$ | 1575162 | 1575162 | 1575162 | 1575162 | 1575162 | 1575162 |
| $adj.R^2$ | 0.239 | 0.242 | 0.239 | 0.242 | 0.242 | 0.244 |

t statistics in parentheses, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. With firm fixed effects and year dummy. All results are clustered at firm level.

Table 5: Markup Elasticity w.r.t Input Tariff

| CR20 | Percentile | Elasticity: markup w.r.t input tariff Importers | Incumbent Importers | Mean Import Intensity |
|---|---|---|---|---|
| 0.104 | 0.05 | 0.085 | 0.073 | 0.027 |
| 0.135 | 0.10 | 0.043 | 0.022 | 0.005 |
| 0.200 | 0.25 | -0.047 | -0.085 | -0.042 |
| 0.306 | 0.50 | -0.193 | -0.261 | -0.119 |
| 0.456 | 0.75 | -0.398 | -0.508 | -0.227 |
| 0.735 | 0.90 | -0.781 | -0.968 | -0.428 |
| 0.820 | 0.95 | -0.897 | -1.108 | -0.489 |

Table 6: Alternative Measure for Competitiveness

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| Comp = | 1/logN | HHI | log K | log R |
| $t^m \times FM \times Comp$ | -3.900*** | -2.101*** | -0.0500*** | -0.145*** |
| | (-5.95) | (-4.73) | (-3.18) | (-7.28) |
| $t^m \times FM$ | 0.409*** | -0.0888*** | 0.386** | 1.411*** |
| | (4.76) | (-8.27) | (2.48) | (6.75) |
| $t^m \times Comp$ | -6.042*** | -5.661*** | -0.121*** | -0.0705*** |
| | (-14.67) | (-10.81) | (-17.65) | (-8.51) |
| $t^m$ | 0.833*** | 0.0447*** | 1.172*** | 0.753*** |
| | (15.00) | (8.42) | (18.01) | (8.83) |
| $t^o$ | -0.863*** | -0.0263*** | -1.121*** | -1.223*** |
| | (-15.34) | (-3.41) | (-20.55) | (-17.61) |
| $t^o \times Comp$ | 6.454*** | 5.234*** | 0.116*** | 0.118*** |
| | (15.79) | (10.71) | (21.17) | (18.07) |
| $FM \times Comp$ | 0.823*** | 0.679*** | 0.000567 | 0.00124 |
| | (12.09) | (10.54) | (0.35) | (0.63) |
| $FM$ | -0.0787*** | 0.0231*** | 0.0232 | 0.0164 |
| | (-8.89) | (20.29) | (1.45) | (0.79) |
| $Age$ | -0.00710*** | -0.00713*** | -0.00701*** | -0.00708*** |
| | (-18.21) | (-18.30) | (-17.99) | (-18.17) |
| $FX$ | 0.00205*** | 0.00204*** | 0.00212*** | 0.00207*** |
| | (3.76) | (3.75) | (3.90) | (3.80) |
| $TFP$ | 0.0195*** | 0.0196*** | 0.0186*** | 0.0190*** |
| | (16.32) | (16.43) | (15.69) | (15.97) |
| $SOE$ | 0.0148*** | 0.0149*** | 0.0151*** | 0.0148*** |
| | (12.28) | (12.30) | (12.47) | (12.25) |
| $FIE$ | -0.00636*** | -0.00625*** | -0.00628*** | -0.00613*** |
| | (-4.18) | (-4.10) | (-4.12) | (-4.03) |
| $N$ | 1575162 | 1575162 | 1575162 | 1575162 |
| $adj.R^2$ | 0.241 | 0.241 | 0.241 | 0.241 |

t statistics in parentheses, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. With firm fixed effects and year dummy. All results are clustered at firm level.

Table 7: Robustness Checks on Markup Estimation

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| | Full Sample | Include Input tariff | Include Exit | Exclude SOE | Quantity C-D | Quantity Translog |
| $t^m \times FM \times CR$ | -1.159*** | -1.164*** | -1.363*** | -1.128*** | -0.619*** | -0.696** |
| | (-12.28) | (-12.28) | (-16.12) | (-10.66) | (-5.92) | (-2.55) |
| $t^m \times FM$ | 0.291*** | 0.287*** | 0.148*** | 0.224*** | 0.190*** | 0.0953 |
| | (12.43) | (12.22) | (6.85) | (8.32) | (7.38) | (1.52) |
| $t^m \times CR$ | -0.114** | -0.122*** | -0.391*** | -0.112** | 0.172*** | -4.609*** |
| | (-2.48) | (-2.63) | (-7.38) | (-2.20) | (3.15) | (-29.32) |
| $t^m$ | 0.117*** | 0.112*** | 0.101*** | 0.107*** | -0.000703 | 0.968*** |
| | (11.44) | (10.94) | (7.93) | (8.88) | (-0.06) | (29.38) |
| $t^o$ | -0.0985*** | -0.0942*** | -0.216*** | -0.0605*** | -0.138*** | -0.348*** |
| | (-9.31) | (-8.92) | (-15.18) | (-5.09) | (-11.84) | (-9.37) |
| $t^o \times CR$ | 0.148*** | 0.151*** | 0.969*** | -0.0437 | -0.0444 | 2.716*** |
| | (4.62) | (4.71) | (24.65) | (-1.21) | (-1.12) | (18.60) |
| $FM \times CR$ | 0.0792*** | 0.0732*** | 0.0960*** | 0.0705*** | 0.0863*** | -0.211*** |
| | (9.76) | (9.06) | (13.43) | (7.76) | (8.67) | (-7.72) |
| $FM$ | -0.00859*** | -0.00676*** | 0.00760*** | -0.00596** | -0.0165*** | 0.0489*** |
| | (-3.79) | (-3.00) | (3.85) | (-2.23) | (-6.49) | (7.17) |
| $Age$ | -0.00778*** | -0.00789*** | -0.00686*** | -0.0101*** | -0.00698*** | -0.00341*** |
| | (-18.60) | (-18.84) | (-16.85) | (-22.01) | (-16.99) | (-3.03) |
| $FX$ | -0.00209*** | -0.00215*** | 0.00106* | 0.000885 | -0.00679*** | -0.0103*** |
| | (-3.27) | (-3.36) | (1.92) | (1.24) | (-10.86) | (-6.52) |
| $TFP$ | 0.0435*** | 0.0429*** | 0.0991*** | 0.0480*** | 0.0666*** | 0.253*** |
| | (36.12) | (35.73) | (75.42) | (35.86) | (50.48) | (57.78) |
| $SOE$ | 0.00932*** | 0.00900*** | 0.0193*** | 0.0106*** | 0.0154*** | 0.0272*** |
| | (6.82) | (6.57) | (15.36) | (6.67) | (12.21) | (8.70) |
| $FIE$ | -0.00231 | -0.00257 | -0.00529*** | 0.00219 | -0.00302* | -0.00423 |
| | (-1.35) | (-1.51) | (-3.40) | (1.11) | (-1.79) | (-0.90) |
| $N$ | 1,586,154 | 1,586,154 | 1,586,105 | 1,586,144 | 1,567,673 | 1,545,015 |
| $adj.R^2$ | 0.117 | 0.118 | 0.259 | 0.101 | 0.192 | 0.064 |

Note: We delete top and bottom one percent markup distribution after each estimation. Also we delete those with missing values for control variables. Therefore the sample sizes slightly change in different columns.
t statistics in parentheses, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. With firm fixed effects and year dummy. All results are clustered at firm level.

Table 8: First Difference Estimation

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| | Δ3 m | Δ4 m | Δ5 m | Δ3 m | Δ4 m | Δ5 m |
| $\Delta t^m \times FM \times CR$ | | | | -0.825*** | -1.375*** | -1.964*** |
| | | | | (-9.52) | (-11.54) | (-14.06) |
| $\Delta t^m \times FM$ | -0.148*** | -0.212*** | -0.184*** | 0.0364 | 0.0958*** | 0.254*** |
| | (-12.78) | (-14.36) | (-11.60) | (1.63) | (3.25) | (7.67) |
| $\Delta t^m \times CR$ | | | | 0.603*** | 0.697*** | 0.749*** |
| | | | | (17.80) | (15.42) | (14.38) |
| $\Delta t^m$ | 0.0331*** | 0.0754*** | 0.0694*** | -0.0862*** | -0.0611*** | -0.0790*** |
| | (5.95) | (10.59) | (9.00) | (-10.39) | (-5.61) | (-6.33) |
| $\Delta t^o$ | 0.0599*** | 0.0480*** | 0.0341*** | 0.0428*** | 0.0317*** | 0.0198* |
| | (8.95) | (5.22) | (3.21) | (6.56) | (3.53) | (1.91) |
| $\Delta FM \times CR$ | | | | 0.0788*** | 0.125*** | 0.192*** |
| | | | | (9.04) | (10.40) | (13.01) |
| $\Delta FM$ | 0.0324*** | 0.0349*** | 0.0308*** | 0.0142*** | 0.00621** | -0.0133*** |
| | (25.61) | (20.2) | (14.66) | (6.10) | (1.97) | (-3.43) |
| $\Delta FX$ | 0.00285*** | 0.00395*** | 0.00274** | 0.00290*** | 0.00391*** | 0.00252* |
| | (3.90) | (3.70) | (2.01) | (3.97) | (3.67) | (1.85) |
| $\Delta SOE$ | 0.0123*** | 0.0151*** | 0.0195*** | 0.0124*** | 0.0151*** | 0.0195*** |
| | (8.80) | (8.13) | (8.63) | (8.88) | (8.14) | (8.65) |
| $\Delta FIE$ | -0.00772*** | -0.00886*** | -0.00920*** | -0.00763*** | -0.00871*** | -0.00898*** |
| | (-4.45) | (-3.88) | (-3.31) | (-4.40) | (-3.81) | (-3.23) |
| $\Delta TFP$ | 0.0232*** | 0.0494*** | 0.0658*** | 0.0259*** | 0.0523*** | 0.0686*** |
| | (16.63) | (27.38) | (29.89) | (18.51) | (28.84) | (31.09) |
| $\Delta Age$ | -0.00610*** | -0.00433*** | -0.00281*** | -0.00612*** | -0.00433*** | -0.00288*** |
| | (-14.17) | (-7.47) | (-3.84) | (-14.24) | (-7.48) | (-3.94) |
| $N$ | 539543 | 336872 | 214355 | 539543 | 336872 | 214355 |
| $adj.R^2$ | 0.0287 | 0.0228 | 0.0216 | 0.0304 | 0.0254 | 0.0258 |

t statistics in parentheses, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. With year fixed effects. All results are clustered at firm level.

Table 9: Instrumental Variable Estimation

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| | Δ3 m | Δ4 m | Δ5 m | Δ3 m | Δ4 m | Δ5 m |
| $\Delta t^m \times FM \times CR$ | | | | -6.814*** | -5.391*** | -4.269*** |
| | | | | (-13.68) | (-10.69) | (-10.17) |
| $\Delta t^m \times FM$ | -0.592*** | -0.634*** | -0.521*** | 0.895*** | 0.442*** | 0.361*** |
| | (-20.75) | (-20.21) | (-17.41) | (9.12) | (4.32) | (4.27) |
| $\Delta t^m \times CR$ | | | | 1.943*** | 0.963*** | 1.054*** |
| | | | | (5.94) | (2.79) | (3.72) |
| $\Delta t^m$ | 0.0932** | -0.176*** | -0.0213 | -0.480*** | -0.945*** | -0.530*** |
| | (2.21) | (-3.81) | (-0.47) | (-3.71) | (-5.98) | (-3.92) |
| $\Delta t^o$ | 0.260*** | 0.297*** | 0.179*** | 0.411*** | 0.978*** | 0.522*** |
| | (16.00) | (14.95) | (9.21) | (4.27) | (7.60) | (4.16) |
| $\Delta FM \times CR$ | | | | 0.393*** | 0.358*** | 0.330*** |
| | | | | (16.73) | (14.26) | (13.75) |
| $\Delta FM$ | 0.0290*** | 0.0299*** | 0.0287*** | -0.0191*** | -0.000631 | -0.00802 |
| | (31.91) | (22.88) | (16.90) | (-3.95) | (-0.12) | (-1.49) |
| $\Delta FX$ | 0.00270*** | 0.00378*** | 0.00262* | 0.00298*** | 0.00378*** | 0.00202 |
| | (3.69) | (3.55) | (1.93) | (3.88) | (3.34) | (1.45) |
| $\Delta SOE$ | 0.0112*** | 0.0153*** | 0.0188*** | 0.0119*** | 0.0168*** | 0.0201*** |
| | (7.90) | (8.14) | (8.16) | (7.96) | (8.33) | (8.42) |
| $\Delta FIE$ | -0.00735*** | -0.00815*** | -0.00867*** | -0.00639*** | -0.00523** | -0.00663** |
| | (-4.24) | (-3.57) | (-3.11) | (-3.58) | (-2.15) | (-2.30) |
| $\Delta TFP$ | 0.0248*** | 0.0527*** | 0.0679*** | 0.0329*** | 0.0617*** | 0.0740*** |
| | (17.65) | (28.86) | (30.56) | (13.95) | (22.51) | (26.87) |
| $\Delta Age$ | -0.00637*** | -0.00480*** | -0.00348*** | -0.00642*** | -0.00451*** | -0.00356*** |
| | (-14.78) | (-8.27) | (-4.75) | (-14.50) | (-7.34) | (-4.79) |
| first. $t^o$ | -0.174*** | -0.226*** | -0.311*** | -0.190*** | -0.238*** | -0.335*** |
| | (-79.72) | (-66.69) | (-66.97) | (-88.59) | (-68.08) | (-73.39) |
| first. $t^m$ | -0.388*** | -0.561*** | -0.743*** | -0.171*** | -0.311*** | -0.325*** |
| | (-55.31) | (-55.82) | (-47.17) | (-20.18) | (-25.60) | (-18.76) |
| *N* | 539543 | 336872 | 214355 | 539543 | 336872 | 214355 |
| *Under Ind.* | 451.4 | 253.4 | 209.7 | 500.4 | 371.6 | 356.4 |
| *Weak Ins.(F)* | 148.6 | 80.56 | 66.42 | 101.4 | 72.46 | 69.43 |

t statistics in parentheses, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. With year fixed effects. All results are clustered at firm level.

Table 10: Tariffs, Market Structure and Markup Dispersion

| | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| | Logtheil | Logtheil | LogRMD | LogCV | Gini |
| $t^o$ | 1.716** | -1.003 | -0.242 | -0.544 | -0.0344 |
| | (2.32) | (-1.13) | (-0.56) | (-1.12) | (-0.97) |
| $t^o \times CR$ | -1.739 | 3.981** | 1.453* | 2.105** | 0.179*** |
| | (-1.48) | (2.30) | (1.76) | (2.20) | (2.60) |
| $t^m$ | | 5.786 | 0.726 | 3.004 | 0.00884 |
| | | (1.60) | (0.42) | (1.56) | (0.06) |
| $t^m \times CR$ | | -19.76*** | -6.644*** | -10.57*** | -0.517*** |
| | | (-4.03) | (-2.90) | (-3.94) | (-2.74) |
| *SOE Share* | -0.208** | -0.231** | -0.102** | -0.113** | -0.00526 |
| | (-2.30) | (-2.55) | (-2.47) | (-2.35) | (-1.57) |
| *Log wage* | -0.0109 | -0.0133 | -0.0223 | -0.00995 | 0.00146 |
| | (-0.17) | (-0.20) | (-0.71) | (-0.31) | (0.50) |
| *Log K* | 0.968*** | 1.038*** | 0.595*** | 0.575*** | 0.0502*** |
| | (2.86) | (3.12) | (3.75) | (3.44) | (4.11) |
| *Log #* | -0.0452 | -0.0544 | -0.0462* | -0.0495* | 0.000801 |
| | (-0.86) | (-1.02) | (-1.87) | (-1.79) | (0.40) |
| *Export Intensity* | -0.0589 | -0.119 | -0.0479 | -0.0614 | -0.00315 |
| | (-0.21) | (-0.42) | (-0.37) | (-0.42) | (-0.40) |
| $N$ | 3349 | 3349 | 3349 | 3349 | 3361 |
| $adj.R^2$ | 0.323 | 0.332 | 0.347 | 0.330 | 0.312 |

t statistics in parentheses, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. With industry fixed effects and year dummy. All results are clustered at industry level.
We define industry at 4-digit CIC level, with 422 industries in 2002. The sample size of markup dispersion from 2000 to 2007 is 3361 (which is smaller than $3376 = 422 \times 8$) since in some years there exists no firm in certain industries. Further more, some industries report zero dispersion in markup, resulting in 3349 observations for dispersion measure in logarithm (Column 1 to 4).

# Online Appendix

### Derivation of Marginal Cost Distribution Function

First of all, we need to compute the distribution function $G(C)$ for marginal cost $C$:

$$\begin{aligned}
G(x) &= Prob(C \leq x) \\
&= Prob(\tau_m w^* \leq 1) \times Prob(c[1 + (\tau_m w^*)^{\frac{\rho}{\rho-1}}]^{\frac{\rho-1}{\rho}} \leq x | \tau_m w^* \leq 1) \\
&\quad + Prob(\tau_m w^* > 1) \times Prob(c \leq x | \tau_m w^* > 1) \\
&= \frac{\int_a^{\frac{1}{\tau_m}} [1 + (\tau_m w^*)^\theta]^{\frac{-k}{\theta}} dw^*}{b-a} \left(\frac{x}{c_M}\right)^k + \frac{b - \frac{1}{\tau_m}}{b-a} \left(\frac{x}{c_M}\right)^k \\
&= \left(\frac{x}{C_M}\right)^k
\end{aligned} \tag{A1}$$

where $\theta = \frac{\rho}{\rho-1}$, $C_M = \xi c_M$, and $\xi^k = \frac{b-a}{\int_a^{\frac{1}{\tau_m}} [1+(\tau_m w^*)^\theta]^{\frac{-k}{\theta}} dw^* + b \frac{1}{\tau_m}}$ is a constant related with input tariff and foreign input cost distribution. In implies marginal cost $C$ follows Pareto distribution with cumulative distribution function $G(C) = \left(\frac{C}{C_M}\right)^k$ with support $[0, C_M]$. However, $C_M$ becomes a function of $\tau_m$. Notice that,

$$(b-a)\frac{\partial \xi^{-k}}{\partial \tau_m} = \frac{1}{\tau_m^2}(-b - 2^{-\frac{k}{\theta}}) - k\tau_m^{\theta-1} \int_a^{\frac{1}{\tau_m}} w^{*\theta} (1 + (\tau_m w^*)^\theta)^{-\frac{k}{\theta}-1} dw^* \tag{A2}$$

We can see that $\frac{\partial \xi^{-k}}{\partial \tau_m} < 0$, thus $\frac{\partial C_M}{\partial \tau_m} > 0$. It indictes lowering input tariff reduces marginal cost upper bound $C_M$, which implies tougher competition.

**Proof for Testable Propositions**

First of all, we notice from equation 10 that

$$\frac{\partial C_D}{\partial \tau_o} = \frac{k\eta \bar{N}^*}{2(k+1)\gamma {C_M^*}^k {\tau_o}^{k+1}} \frac{{C_D}^{k+2}}{\alpha(k+1) - kC_D} > 0 \tag{A3}$$

$$\frac{\partial C_D}{\partial C_M} = \frac{k\eta \bar{N}^*}{2(k+1)\gamma {C_M}^{k+1}} \frac{{C_D}^{k+2}}{\alpha(k+1) - kC_D} > 0 \tag{A4}$$

where we require $C_D < \alpha \frac{k+1}{k}$. It is naturally satisfied since equation 10 requires $C_D < \alpha$, which is the same with Melitz and Ottaviano (2008). Combining with equation 7 we have

$$\frac{\partial \mu}{\partial \tau_o} = \frac{1}{2C}\frac{\partial C_D}{\partial \tau_o} > 0 \tag{A5}$$

That proves Proposition 1.

Secondly, we notice

$$\frac{\partial \mu}{\partial \tau_m} = \frac{1}{2C}\left(\frac{\partial C_D}{\partial C_M}\frac{\partial C_M}{\partial \tau_m} - \frac{C_D}{C}\frac{\partial C}{\partial \tau_m}\right) \tag{A6}$$

where $\frac{\partial C}{\partial \tau_m}$ equals $w$ for incumbent importers, is non-negative and less than $w$ for new importers, and equals 0 for non-importers. Therefore, for non-importers,

$$\frac{\partial \mu}{\partial \tau_m}|Non - importer = \frac{1}{2C}\frac{\partial C_D}{\partial C_M}\frac{\partial C_M}{\partial \tau_m} > 0 \tag{A7}$$

That proves Proposition 1. For importers, generally speaking, the sign of $\frac{\partial \mu}{\partial \tau_m}$ is ambiguous. However, the condition for it to be negative is,

$$\begin{aligned}\frac{\partial C}{\partial \tau_m} >& \frac{C}{C_D}\frac{\partial C_D}{\partial C_M}\frac{\partial C_M}{\partial \tau_m} \\ =& \frac{k\eta \bar{N}^*}{2(k+1)\gamma\xi}\frac{C C_D^{k+1}}{kC_D + \alpha(k+1)}\frac{\partial \xi}{\partial \tau_m}\end{aligned} \tag{A8}$$

Therefore, when $\frac{\partial C}{\partial \tau_m}$ is large enough that satisfies equation A8, $\frac{\partial \mu}{\partial \tau_m} < 0$, i.e. input tariff reduction increases importers' markups. That proves for Proposition 3.

Next we'll examine how market structure shapes the impact of input tariff reduction on importers' markups. First, notice that from equation 11 we know

$$\frac{\partial C_D}{\partial N} = -\frac{\eta}{2(k+1)\gamma C_M^k}\frac{C_D^{k+2}}{\alpha(k+1) - kC_D} < 0 \tag{A10}$$

Take derivative w.r.t $\bar{N}$ at both side of equation A6 we have

$$\begin{aligned}\frac{\partial}{\partial \bar{N}}\frac{\partial \mu}{\partial \tau_m}|Importers =& \frac{\partial}{\partial \bar{N}}\left(\frac{1}{2C}\frac{\partial C_D}{\partial C_M}\frac{\partial C_M}{\partial \tau_m} - \frac{C_D}{2C^2}\frac{\partial C}{\partial \tau_m}\right) \\ =& \frac{1}{2C}\frac{k\eta}{2(k+1)\gamma C_M^{k+1}}\frac{C_D^{k+2}}{\alpha(k+1) - kC_D}\frac{\partial C_M}{\partial \tau_m} - \frac{1}{2C^2}\frac{\partial C_D}{\partial \bar{N}}\frac{\partial C}{\partial \tau_m} \\ >& 0\end{aligned} \tag{A9}$$

That proves Proposition 3.

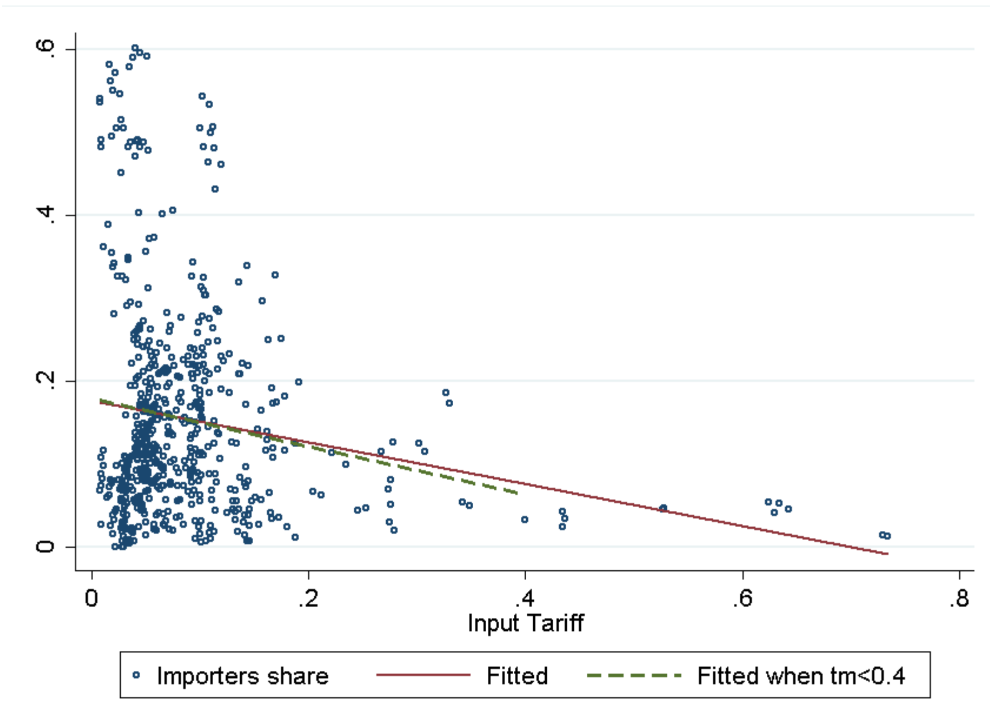


Figure A1:Importers Share and Input Tariff

The slope ( standard error) = -0.25 (0.06), t=-4.29; exclude industries with input tariff higher than 40%, the slope ( standard error) = -0.29 (0.10), t=-3.02.
The slope of regression year by year (standard error) = -0.18 (0.12), -0.18 (0.10), -0.47(0.31), -0.66 (0.34), -0.79 (0.29), -1.30 (0.52), -0.92 (0.33), -0.77 (0.32) for the year of 2000-2007, respectively.

Table A1: Output Elasticities

| **IO2002** | **bl** | **bm** | **bk** | **RTC** | **IO2002** | **bl** | **bm** | **bk** | **RTC** |
|---|---|---|---|---|---|---|---|---|---|
| 13013 | 0.271 | 0.649 | 0.051 | 0.971 | 31049 | 0.120 | 0.805 | 0.074 | 0.999 |
| 13014 | 0.285 | 0.739 | 0.040 | 1.064 | 31050 | 0.266 | 0.657 | 0.097 | 1.020 |
| 13015 | 0.269 | 0.674 | 0.086 | 1.029 | 31051 | 0.061 | 0.887 | 0.039 | 0.987 |
| 13016 | 0.060 | 0.911 | 0.033 | 1.003 | 31052 | 0.048 | 0.845 | 0.085 | 0.978 |
| 13017 | 0.279 | 0.711 | 0.027 | 1.017 | 31053 | 0.065 | 0.846 | 0.039 | 0.950 |
| 13018 | 0.235 | 0.721 | 0.039 | 0.996 | 32054 | 0.251 | 0.704 | 0.051 | 1.007 |
| 13019 | 0.230 | 0.774 | 0.043 | 1.047 | 32055 | 0.126 | 0.737 | 0.115 | 0.978 |
| 15020 | 0.227 | 0.712 | 0.056 | 0.996 | 32056 | 0.236 | 0.783 | 0.037 | 1.057 |
| 15021 | 0.123 | 0.713 | 0.093 | 0.930 | 32057 | 0.238 | 0.722 | 0.024 | 0.984 |
| 16022 | 0.297 | 0.692 | 0.204 | 1.194 | 33058 | 0.250 | 0.705 | 0.049 | 1.004 |
| 17023 | 0.244 | 0.689 | 0.037 | 0.970 | 33059 | 0.238 | 0.772 | 0.036 | 1.045 |
| 17024 | 0.233 | 0.738 | 0.033 | 1.004 | 34060 | 0.255 | 0.769 | 0.046 | 1.069 |
| 17025 | 0.214 | 0.709 | 0.032 | 0.956 | 35061 | 0.243 | 0.713 | 0.053 | 1.009 |
| 17026 | 0.250 | 0.766 | 0.039 | 1.054 | 35062 | 0.258 | 0.798 | 0.036 | 1.092 |
| 17027 | 0.287 | 0.686 | 0.056 | 1.029 | 35063 | 0.143 | 0.694 | 0.135 | 0.973 |
| 18028 | 0.301 | 0.670 | 0.049 | 1.020 | 36064 | 0.057 | 0.714 | 0.041 | 0.812 |
| 19029 | 0.286 | 0.662 | 0.052 | 1.001 | 36065 | 0.171 | 0.690 | 0.133 | 0.994 |
| 20030 | 0.071 | 0.686 | 0.113 | 0.870 | 37066 | 0.276 | 0.630 | 0.083 | 0.989 |
| 21031 | 0.108 | 0.877 | 0.037 | 1.022 | 37067 | 0.078 | 0.866 | 0.066 | 1.009 |
| 22032 | 0.064 | 0.710 | 0.134 | 0.907 | 37068 | 0.257 | 0.677 | 0.096 | 1.030 |
| 23033 | 0.074 | 0.867 | 0.089 | 1.030 | 37069 | 0.344 | 0.624 | 0.090 | 1.059 |
| 24034 | 0.109 | 0.836 | 0.047 | 0.991 | 37071 | 0.248 | 0.757 | 0.042 | 1.047 |
| 24035 | 0.296 | 0.652 | 0.045 | 0.993 | 39072 | 0.258 | 0.776 | 0.043 | 1.077 |
| 25036 | 0.248 | 0.658 | 0.147 | 1.053 | 39073 | 0.255 | 0.773 | 0.042 | 1.070 |
| 25037 | 0.219 | 0.918 | 0.031 | 1.168 | 39074 | 0.265 | 0.684 | 0.116 | 1.064 |
| 26038 | 0.208 | 0.700 | 0.051 | 0.959 | 40075 | 0.111 | 0.688 | 0.141 | 0.940 |
| 26039 | 0.243 | 0.706 | 0.045 | 0.993 | 40076 | 0.136 | 0.877 | 0.005 | 1.019 |
| 26040 | 0.252 | 0.694 | 0.049 | 0.995 | 40077 | 0.292 | 0.655 | 0.084 | 1.031 |
| 26041 | 0.226 | 0.784 | 0.047 | 1.057 | 40078 | 0.295 | 0.685 | 0.073 | 1.053 |
| 26042 | 0.230 | 0.768 | 0.065 | 1.063 | 40079 | 0.303 | 0.789 | 0.051 | 1.144 |
| 26043 | 0.252 | 0.697 | 0.046 | 0.994 | 40080 | 0.107 | 0.785 | 0.068 | 0.960 |
| 26044 | 0.246 | 0.741 | 0.050 | 1.037 | 41081 | 0.197 | 0.803 | 0.045 | 1.045 |
| 27045 | 0.250 | 0.694 | 0.066 | 1.010 | 41082 | 0.206 | 0.859 | 0.037 | 1.103 |
| 28046 | 0.149 | 0.735 | 0.087 | 0.972 | 42083 | 0.281 | 0.736 | 0.039 | 1.056 |
| 29047 | 0.261 | 0.773 | 0.041 | 1.075 | 42084 | 0.261 | 0.688 | 0.052 | 1.001 |
| 30048 | 0.267 | 0.668 | 0.072 | 1.007 | | | | | |

Table A2: Markup Summary

| year | p25 | p50 | p75 | mean | sd | p75-p25 |
|---|---|---|---|---|---|---|
| 2000 | 0.882 | 0.975 | 1.117 | 1.032 | 0.220 | 0.235 |
| 2001 | 0.882 | 0.968 | 1.094 | 1.016 | 0.199 | 0.212 |
| 2002 | 0.889 | 0.970 | 1.092 | 1.016 | 0.191 | 0.204 |
| 2003 | 0.907 | 0.989 | 1.126 | 1.039 | 0.195 | 0.219 |
| 2004 | 0.921 | 1.017 | 1.180 | 1.079 | 0.222 | 0.259 |
| 2005 | 0.939 | 1.047 | 1.243 | 1.130 | 0.271 | 0.304 |
| 2006 | 0.952 | 1.074 | 1.295 | 1.170 | 0.307 | 0.343 |
| 2007 | 0.966 | 1.086 | 1.327 | 1.197 | 0.330 | 0.361 |
| Total | 0.923 | 1.024 | 1.196 | 1.103 | 0.268 | 0.273 |

Table A3: Markup Elasticities w.r.t Input Tariff: Alternative Measure for Competitiveness

| Pecentile | Percentiles | | | | Input Tariff Elasticity | | | |
|---|---|---|---|---|---|---|---|---|
| | 1/log Firm # | HHI | Mean Capital (log) | Mean Revenue (log) | 1/ log Firm # | HHI | Mean Capital (log) | Mean Revenue (log) |
| 5% | 0.115 | 0.001 | 9.037 | 9.916 | 0.101 | -0.053 | 0.013 | 0.027 |
| 10% | 0.119 | 0.002 | 9.265 | 10.084 | 0.057 | -0.059 | -0.026 | -0.009 |
| 25% | 0.129 | 0.004 | 9.644 | 10.278 | -0.038 | -0.073 | -0.091 | -0.051 |
| 50% | 0.141 | 0.008 | 10.220 | 10.682 | -0.156 | -0.109 | -0.190 | -0.138 |
| 75% | 0.159 | 0.022 | 10.784 | 11.046 | -0.336 | -0.218 | -0.286 | -0.216 |
| 90% | 0.180 | 0.054 | 11.255 | 12.502 | -0.547 | -0.462 | -0.367 | -0.530 |
| 95% | 0.189 | 0.067 | 12.201 | 12.947 | -0.638 | -0.563 | -0.528 | -0.626 |

Table A4: Robustness Markup and Quality Elasticities w.r.t Input Tariff

| CR20 | Percentile | Elasticity: markup w.r.t input tariff (for importers) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Full Sample | Include Input tariff | Include Exit | Exclude SOE | Exclude Int.Exporter | Quantity C-D | Quantity Translog |
| 0.104 | 0.05 | 0.276 | 0.265 | 0.067 | 0.202 | 0.093 | 0.143 | 0.512 |
| 0.135 | 0.10 | 0.236 | 0.225 | 0.012 | 0.164 | 0.063 | 0.129 | 0.347 |
| 0.200 | 0.25 | 0.153 | 0.142 | -0.102 | 0.083 | 0.001 | 0.100 | 0.002 |
| 0.306 | 0.50 | 0.018 | 0.005 | -0.288 | -0.048 | -0.101 | 0.053 | -0.560 |
| 0.456 | 0.75 | -0.172 | -0.187 | -0.551 | -0.234 | -0.245 | -0.015 | -1.356 |
| 0.735 | 0.90 | -0.528 | -0.546 | -1.040 | -0.580 | -0.513 | -0.139 | -2.836 |
| 0.820 | 0.95 | -0.636 | -0.656 | -1.189 | -0.686 | -0.594 | -0.177 | -3.287 |