Trade Liberalization, Market Structure, and Firm Markup: 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.

Keywords: Trade liberalization, Input Tariff, Markup, Market Structure
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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 (Levinsohn 1993, Harrison 1994, Lu and Yu 2015).[1] However, this insight is incomplete when intermediate inputs account for two-thirds of international trade (Johnson and Noguera, 2012). In an imperfectly competitive market, when some firms import inputs for production but others do not, lowering tariffs on inputs has 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) in 2001, 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 (Brandt et al. 2017). As shown in the left panel of Figure 1, both the average tariff level and the standard deviation of tariffs across six-digit HS products dropped substantially in 2001. The right panel then highlights that around 75% of China's imports are intermediate inputs, while most of the remainder are capital goods.[2]

[Figure 1 about here]

Thus, 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 by De Loecker et al. (2016), who find incomplete cost pass-through to prices and rising markups for Indian firms responding to input tariff liberalization. Similarly, Fan et al. (2017) investigate how input trade liberalization affects Chinese exporters' markups across different destinations. Brandt et al (2017) show that input tariff cuts tend to reduce domestic prices and raise markups. This paper complements these studies on two

[1]Melitz and Ottaviano (2008), de Blas and Russ (2015), Edmond, Midrigan and Xu (2015), and Feenstra and Weinstein (2015) use different variable-markup models to present the pro-competitive effect of trade.

[2]A large share of Chinese imports is for export processing (Yu 2015; Manova and Yu, 2016), which is duty free. However, input share of non-processing imports is still around 75-80%, verifying the importance of tariffs on intermediate inputs.

fronts: First, we focus on the local impact of input tariff reduction on the markups of importers versus non-importers; Second, we highlight the role of market structure on the responsiveness of firm markup to tariff reductions.

More specifically, we use detailed firm level data from China and obtain several novel empirical findings. First, output tariff reductions reduce markups while input tariff reductions exert opposite impacts on importers versus non-importers.[3] In particular, 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. Compared with the average markups in 2000 (normalized 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 the average markup of about 1% for importers, and a slight decrease for non-importers.

[Figure 2 about here]

Secondly, 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 imported input share 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. To give an example, Figure 3 illustrates changes in markup distribution for two selected industries. Industry A (fertilizer) has a relatively large import penetration rate (i.e., imports divided by total domestic sales), but a small share of imported inputs in its total material inputs. Industry B (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, in contrast, industry B depends more on foreign inputs. Figure 3 presents a striking comparison. The top row shows the percentage changes in average and median markup of the two industries from 2000 to 2007. In both cases, industry A's markup reduced while industry B's markup became larger. The bottom row shows the changes in markup dispersion, using either standard deviation or the interquartile discrepancy. In both cases, industry A (fertilizer) experienced a much larger reduction in markup dispersion than industry B.

[Figure 3 about here]

[3] We estimate revenue-based markups separately for each sector following the method of De Loecker and Warzynski (2012). More details are provided in the estimation section.

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[4] 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 implies that importers tend to have larger increase in markups due to input tariff reduction 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) as a measure of competitiveness, 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 use different measures of market competitiveness, or use import intensity to replace the discrete importer dummy. 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. To deal with the concern that using revenue to estimate markups may introduce omitted output price bias, we augment the benchmark results with markups estimated using output in physical terms. To deal with endogeneity concerns, we adopt an alternative empirical strategy by examining the first-difference between two periods and using instruments for tariff changes.

Our findings imply two underlying forces that jointly determine firm markup dispersion after trade liberalization. To see this, we construct measures of industry level markup dispersion, and find that output tariff reductions 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. This result complements Lu and Yu (2015), who output tariff reductions squeeze industry markup distribution.

Our paper contributes to a growing body of research that highlights the importance of input

[4] 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.

tariff liberalization. These studies show that input tariffs work in different channels than output tariffs, and often plays a more important role 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). 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, resulting in rising markups for Indian firms after trade liberalization. De Loecker and Goldberg (2014) provide the most up-to-date review on how firm performance is affected by trade liberalization.

Our paper also contributes to understanding the impact of China's WTO accession. 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) find that input tariff reductions increase the quality of exporters' products. Brandt et al (2017) find that import competition contributes to significant productivity growth of Chinese firms, mainly through the entry of more productive private firms. We estimate the heterogeneous effect 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; 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 emphasized by De Loecker et al. (2016) in their work on Indian firms.

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

2 Background and Data Preparation

2.1 China's WTO Accession and Tariff Reduction

China has gradually 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.[5] 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:

$$\tau_{jt}^{input} = \sum_k a_{kj} \tau_{kt}^{output} \tag{1}$$

In Figure 4, 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.

[5]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).

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., 2017). 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 4 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} in equation (1) is now the cost share of product k in the production of firm i.

2.2 Estimating Firm Markup

Our main variable of interest is firm markup, defined as the ratio of price to 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. (2012) 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*.[6] 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,

$$Y_{it} = f\left(K_{it}, L_{it}, M_{it}, \omega_{it}\right) e^{\varepsilon_{it}} \tag{2}$$

where K_{it}, L_{it}, and M_{it} denote capital, labor, and material inputs respectively. ω_{it} stands for firm i's productivity and ε_{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:

$$\mathscr{L}\left(K_{it}, L_{it}, M_{it}, \lambda_{it}\right) = P_{m,it} M_{it} + r_{it} K_{it} + w_{it} L_{it} + \lambda_{it}\left(Q_{it} - f\left(K_{it}, L_{it}, M_{it}, \omega_{it}\right)\right) \tag{3}$$

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 the first order condition as,

$$\frac{\partial \mathscr{L}_{it}}{\partial M_{it}} = P_{m,it} - \lambda_{it} \frac{\partial f\left(K_{it}, L_{it}, M_{it}, \omega_{it}\right)}{\partial M_{it}} = 0 \tag{4}$$

where λ_{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

[6] 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.

(4) and get,

$$\begin{aligned}\mu_{it} &= \frac{P_{it}}{\lambda_{it}} = \frac{P_{it}}{P_{m,it}} \frac{\partial f\left(K_{it}, L_{it}, M_{it}, \omega_{it}\right)}{\partial M_{it}} \\ &= \frac{\frac{M_{it}}{Q_{it}} \frac{\partial f(K_{it}, L_{it}, M_{it}, \omega_{it})}{\partial M_{it}}}{\frac{M_{it} P_{m,it}}{Q_{it} P_{it}}} = \frac{\theta_{m,it}}{\alpha_{m,it}}\end{aligned} \tag{5}$$

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.[7] 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.[8]

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,

$$y_{it} = \theta_l l_{it} + \theta_k k_{it} + \theta_m m_{it} + \rho_{pt} + \omega_{it} + \varepsilon_{it} \tag{6}$$

where θ_l, θ_k, and θ_m are the output elasticities of labor (l), capital (k), and inputs (m) respectively. ω_{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. (2012). To account for regional differences in factor markets within China (Cheng et al. 2014), we also add province-year fixed effects ρ_{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

[7] 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 ε_{it} as we will define in equation (6).

[8] We follow Berkowitz et al. (2017) 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.

firms but not by econometricians, and we can represent material input as,

$$m_{it} = m_{it}\left(\omega_{it}, l_{it}, k_{it}, FX_{it}, FM_{it}\right) \tag{7}$$

Equation (7) 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 (7) and express productivity as a function of inputs, and export and import indicators,

$$\omega_{it} = h_t\left(m_{it}, l_{it}, k_{it}, FX_{it}, FM_{it}\right) \tag{8}$$

Then, combining equations (6) and (8), we can estimate the following equation non-parametrically:

$$y_{it} = \phi_{it}\left(m_{it}, l_{it}, k_{it}, FX_{it}, FM_{it}\right) + \rho_{pt} + \varepsilon_{it} \tag{9}$$

Estimating equation (9) yields predicted output $\hat{\phi}_{it}$ and error term $\hat{\varepsilon}_{it}$. Then, we can recover productivity as,

$$\omega_{it}\left(\Theta\right) = \hat{\phi}_{it} - \theta_l l_{it} - \theta_k k_{it} - \theta_m m_{it} \tag{10}$$

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

$$\omega_{it} = g\left(\omega_{it-1}\right) + \gamma_x FX_{it-1} + \gamma_m FM_{it-1} + \xi_{it} \tag{11}$$

where ξ_{it} is an i.i.d productivity shock. $g_t\left(.\right)$ is a third order polynomial of ω_{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 (11) obtains the innovation to productivity $\xi_{it}\left(\Theta\right)$. As $\xi_{it}\left(\Theta\right)$ 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:

$$E\left[\xi_{it}\left(\Theta\right)\begin{pmatrix} l_{it-1} \\ m_{it-1} \\ k_{it} \end{pmatrix}\right]=0 \tag{12}$$

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

$$\hat{\mu}_{it}=\frac{\hat{\theta}_m}{\hat{\alpha}_{m,it}} \tag{13}$$

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 5 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 basic statistics on output elasticity, markup level, and the dispersion.

[Figure 5 about here]

2.3 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 misreported 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 5 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).[9] 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 also summarizes firm level control variables we used in later empirical estimations, such as firm import (FM) / export (FX) status, firm age, productivity, and ownership. In addition, we also construct a measure firm level input tariffs (which only applies to importers). There are substantial variations across firms in their tariff burdens.

Panel B of Table 1 presents measures of industry level 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 the domestic market share, while in the least competitive market (tobacco) there are only 294 firms. As a supplementary measure, we also use the inverse of the elasticity of substitution (at 4-digit CIC level) where the original estimates come from Broad and Weinstein (2006).

Panel C presents the summary statistics for input and output tariffs at the industry level. To construct input tariffs, we follow Amiti and Konings (2007). Panel D shows different measures of industry markup dispersion, 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. Finally, Panel E summarizes firm outputs and inputs, which are used for markup estimation.

[Table 1 about here]

[9] 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.

3 Benchmark Results

3.1 Markup and Tariff Reduction

In this section, we examine the possible link between trade liberalization and firm-level markup. Importers that have access to foreign inputs may benefit from reductions in input tariffs, because they could partially pass the cost saving through to buyers. Thus, the first testable hypothesis is that input tariff reduction increases importers markups. We test it by estimating the following equation:

$$\begin{aligned} ln\left(\mu_{ijt}\right) =& \alpha\tau^{o}_{jt} + \beta_1\tau^{m}_{jt} + \beta_2\tau^{m}_{jt} \times FM_{it} + \beta_3 FM_{it} \\ &+ \Gamma X_{it} + \delta_t + \xi_i + \varepsilon_{it} \end{aligned} \tag{14}$$

where i, j, and t stand for firm, sector, and year respectively. Equation (14) 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. τ^{o}_{jt} represents the output tariff, an average tariff across all 6-digit HS products within sector j. Because a fall in τ^{o}_{jt} is likely to intensify competition in sector j, firms may see a drop in their markups. Therefore, we expect $\alpha > 0$. τ^{m}_{jt} represents the input tariff, calculated as the weighted average of output tariffs of upstream sectors, using equation (1). FM_{it} is an indicator for direct importers of intermediate inputs. $FM_{it} = 1$ if firm i imports any foreign inputs, and 0 otherwise. 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 τ^{m}_{jt}. Importers will benefit from cheaper access to foreign inputs. Thus, the coefficient of this interaction, β_2, is expected to be negative. 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 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.

3.2 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.[10] 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 is 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 firm level markup for ordinary importers (Column (5)), whereas it has no significant impact on processing importers (Column (6)).

[10] 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.

4 Market Structure Matters

4.1 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. 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,

$$\begin{aligned} ln\left(\mu_{it}\right) =& \beta_1 \tau_{jt}^m \times FM_{it} \times CR_j + \beta_2 \tau_{jt}^m \times FM_{it} + \beta_3 \tau_{jt}^m \times CR_j + \beta_4 \tau_{jt}^m \\ & + \alpha_1 \tau_{jt}^o + \alpha_2 \tau_{jt}^o \times CR_j + \Gamma \mathrm{X_{it}} + \delta_\mathrm{t} + \xi_\mathrm{i} + \varepsilon_\mathrm{it} \end{aligned} \tag{15}$$

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. Figure A1 in the Appendix shows that CR20 in 2007 is highly correlated with CR20 in 2000 and the scatterplots are located along the 45° line, implying that the market concentration rate does not change much over time. Similarly idea is applied by Evans et.al (1993) and Davis (2005), where lagged market structure is used as an instrument for current market structure. Using a constant measure helps to avoid potential endogeneity of market concentration. Yet the results are robust if we instead use a time-variant CR20, or other measures of market concentration, as discussed later. 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, β_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

$$\frac{\partial ln\,(\mu_{it})}{\partial \tau_{jt}^{m}} |\,(FM_{it} = 1) = (\beta_1 + \beta_3) \times CR_j + (\beta_2 + \beta_4) \tag{16}$$

and that for non-importers is

$$\frac{\partial ln\,(\mu_{it})}{\partial \tau_{jt}^{m}} |\,(FM_{it} = 0) = \beta_3 \times CR_j + \beta_4 \tag{17}$$

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 β_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 6 is a straightforward illustration of the quantitative effects of input tariff reduction. The left 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 4 and 5: 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.

[Figure 6 about here]

The right panel 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 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 a striking 10% rise in markup.

4.2 Alternative Measures for Market Competitiveness

Our results are robust across different measures of market competitiveness. In particular, Table 6 reports the results using (the inverse of) the 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 market concentration. A more general measure is the inverse of the elasticity of substitution, drawn from Broda and Weinstein (2006) and updated by Soderbery (2013) (column (5)) . We get consistent results from all specifications: $(\beta_1 + \beta_3)$ is significantly negative, so input tariff reduction increases importers' markups by more in less competitive sectors. We report the computed elasticities using alternative measures of market concentration in appendix Table A3.

[Table 6 about here]

4.3 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.[11] Thus in Columns (4), we exclude SOEs in our markup estimations and in regression. 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 multi-product firms. After getting estimates for key parameters, we assume that multi-product 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 for the full sample. 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 in Appendix Table A4.

[Table 7 about here]

4.4 First-Difference Estimation

So far, our estimations are based on panel regressions with firm fixed effects and year dummies. In the first three columns of 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 in industries with different market structure, analogous to Table 4. In column (1), we use the three-period first difference of log 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 coefficient of the interaction term of input tariff, importer dummy, and the market competitiveness 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.

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

[Table 8 about here]

4.5 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 1. Furthermore, as shown in Figure 4, 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., 2017).

Based on this argument, Column (4) to (6) in Table 8 addresses 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.Again we take three-period, four-period, and five-period first difference of log markup to investigate the medium to long 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.[12] All regressions confirm our hypothesis.

5 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

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

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 9 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.[13] The Theil index is an entropy measure commonly used to characterize the degree of dispersion, which is given by equation (18):

$$Theil_{jt} = \frac{1}{N_{jt}} \sum_{i=1}^{N_{jt}} \frac{\mu_{ijt}}{\bar{\mu}_{jt}} log(\frac{\mu_{ijt}}{\bar{\mu}_{jt}}) \tag{18}$$

where i, j, and t stands for firm, industry, and year, respectively. μ_{ijt} is firm markup, $\bar{\mu}_{jt}$ is the 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,

$$ln(Theil_{jt}) = \beta_1 \tau^o_{jt} + \beta_2 \tau^o_{jt} \times CR_j + \alpha_1 \tau^m_{jt} + \alpha_2 \tau^m_{jt} \times CR_j + \Gamma X_{jt} + \delta_t + \xi_j + \varepsilon_{jt}. \tag{19}$$

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 include 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 9 examines the impact of output tariffs on the industry Theil index as in

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

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 9 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.[14] The results for both input and output tariffs are similar.

[Table 9 about here]

6 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

[14]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 μ_{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.

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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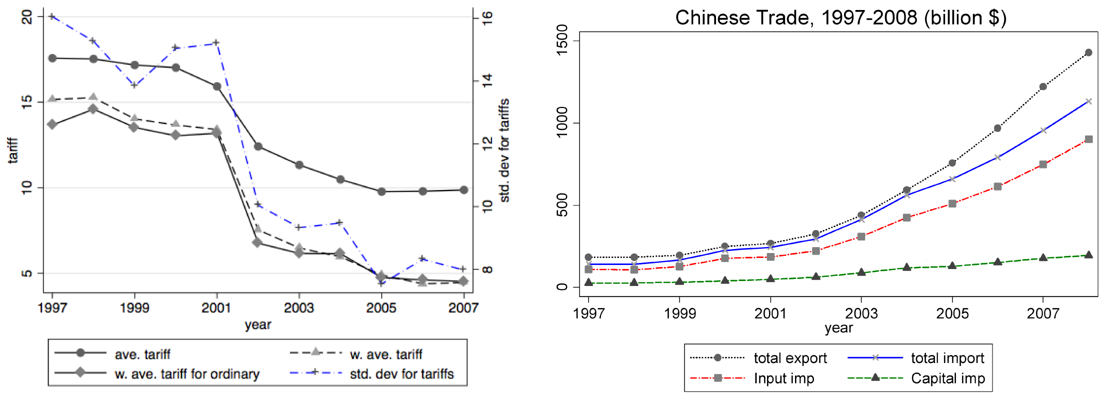

Figure 1: Tariff Reduction and China's Imports, 1997 - 2007

Data Source: Tariff data from WITS, and Chinese trade data from China Customs General Office.
Note: The mean and standard deviation of tariffs are calculated across six-digit HS products.

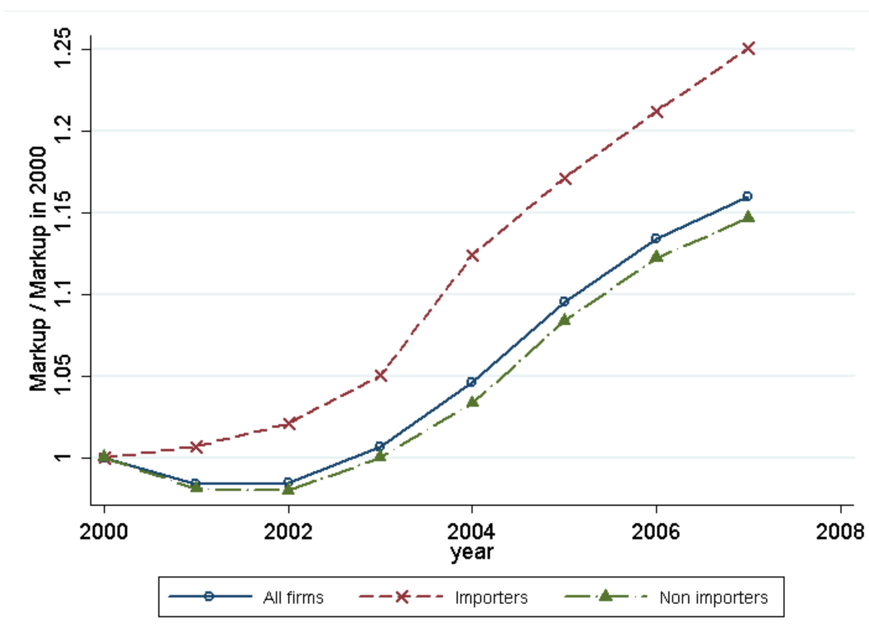

Figure 2: Evolution of Average Markups for Importers versus Non-importers

Data Source: authors' own calculation.

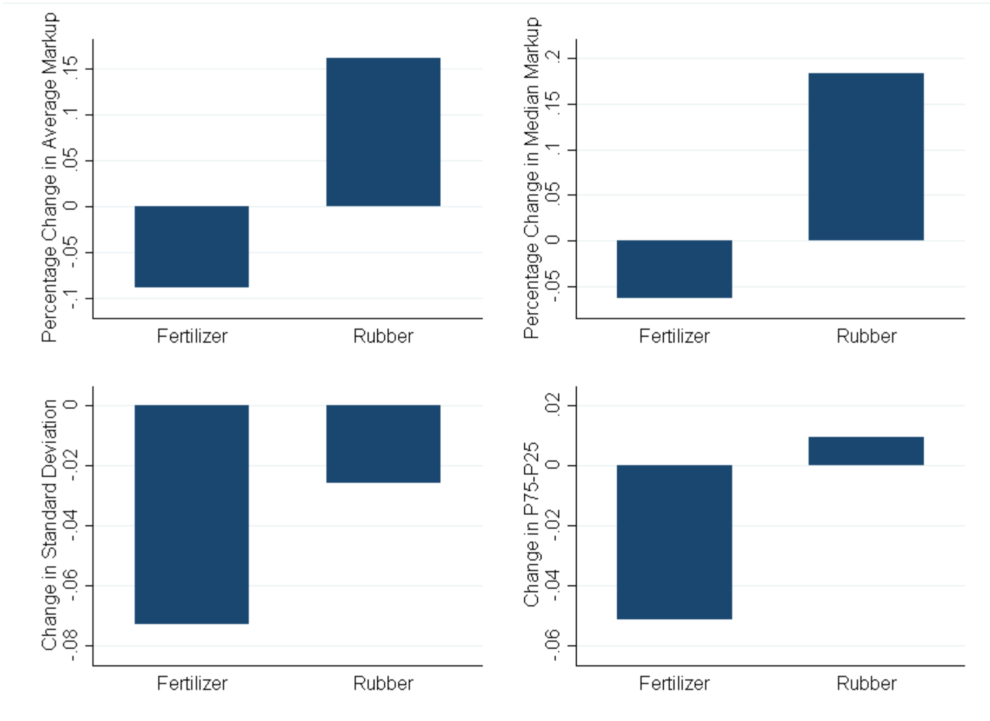

Figure 3: Markup Change in Two Selected Industries

Note: The above figures show the level and dispersion of markups for two distinct industries. Fertilizer industry has relatively large import penetration rate, but a small share of imported inputs in total material input. Rubber industry has a relatively small import penetration rate but large share of imported input share.

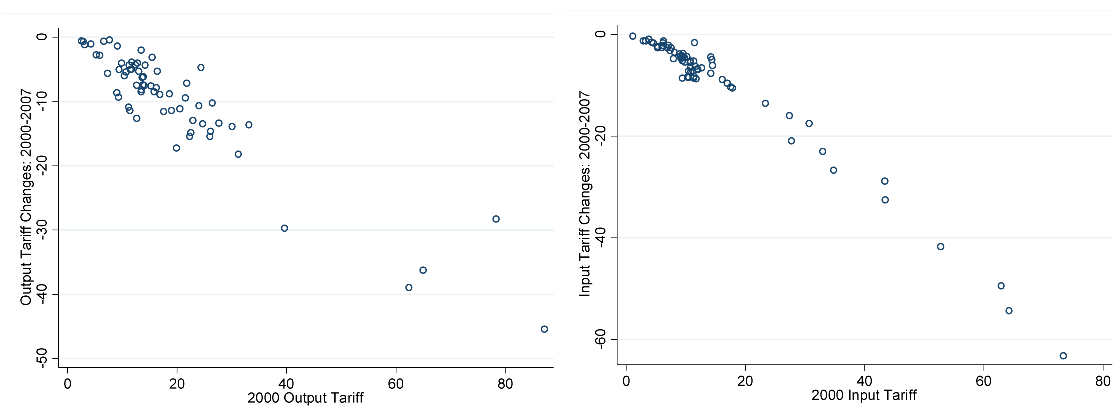

Figure 4: Output Tariff and Input Tariff Reduction

Note: This figure shows that industries that had larger initial tariff level (in 2000) are subject to larger decline from 2000-2007. A few industries experienced increase in tariffs and are excluded from the figure. These are industries 13017 and 17024 for input tariff; 24034, 25036, 26039, 31049, and 37069 for output tariff.

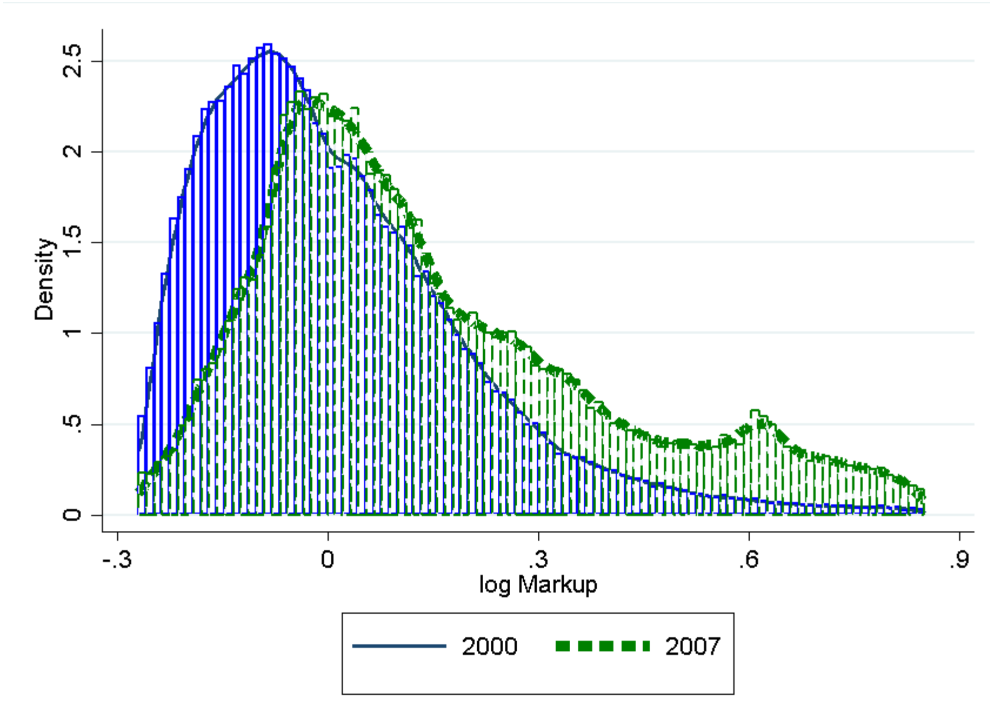

Figure 5: Markup Distribution: 2000 and 2007

Note: This figure shows the evolution of the markup dispersion for all firms in 2000 and 2007 respectively. Firm markups are estimated using the algorithm of De Loecker and Warzynski (2012) for each industry. Top and bottom 1% extreme values for markups are dropped.

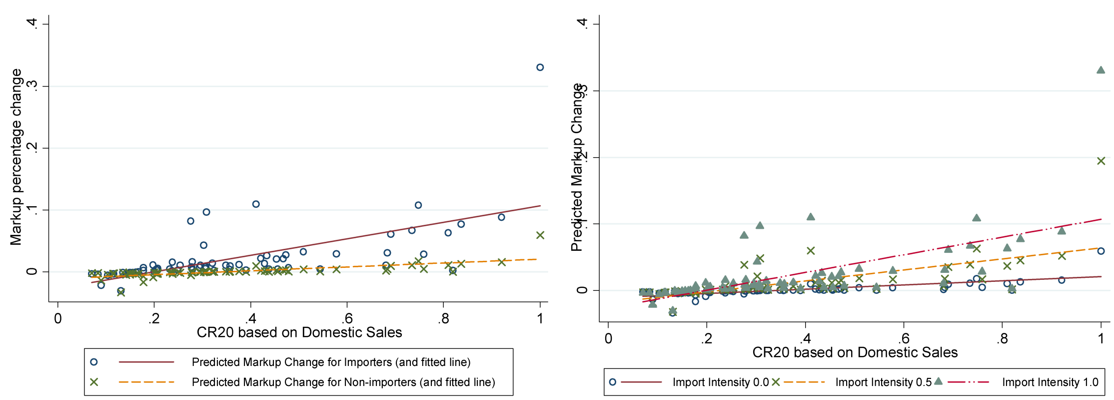

Figure 6: Predicted Markup Changes due to Input Tariff Reduction

Note: This figure shows the predicted changes in markup due to input tariff reductions, which is a multiplication between input tariff reduction (in absolute value) and the elasticity of markup w.r.t input tariff estimated in Table 5. Each dot stands for one industry. There is no systematic relation evident between input tariff reduction and the CR rate across sectors, as shown in Figure A2.

Table 1: Descriptive Summary

Variable	Obs	Mean	Std. Dev.	Min	Max
A: Firm Characteristics (2000-2007)					
Markup of Importers	227,963	1.108	0.251	0.764	2.341
Markup of Non-importers	1,347,199	1.102	0.271	0.764	2.342
Export Dummy	1,575,162	0.288	0.453	0	1
Import Dummy	1,575,162	0.145	0.352	0	1
Incum. Importer Dummy	1,575,162	0.107	0.309	0	1
Import Intensity for Importers	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
Foreign Firm Dummy	1,575,162	0.217	0.412	0	1
Firm Input Tariff	227,963	0.055	0.062	0	1.21
B: Start of Period Industrial Characteristics					
CR20	71	0.364	0.221	0.071	0.999
1/Ln (Number 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
Elasticity of Substitution	423	6.601	6.481	1.945	40.644
C: Tariff at Industry Level (2000-2007)					
Input Tariff	568	0.093	0.09	0	0.734
Output Tariff	568	0.142	0.145	0	0.892
D: Markup Dispersion at Industry 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

Note: This table describes the key variables of interest used in the empirical estimations. Firm level variables include estimated markups and firm characteristics are from the Annual Survey of Industrial Production (ASIP, various years). Industry level variables include the tariff rates (from WITS at 6-digit HS level, and aggregated to IO industry level), market concentration measures (calculated from the ASIP dataset), and markup dispersion (calculated from estimated firm level markups).

Table 2: Input Tariff and Firm Markup

	(1)	(2)	(3)	(4)	(5)	(6)
			Dependent Variable: Ln(Markup)			
FM =			Importer dummy			Import intensity
Output Tariff	0.0367***	0.0351***	0.0346***	0.0386***	0.0388***	0.0390***
	(0.0053)	(0.0058)	(0.0058)	(0.0059)	(0.0059)	(0.0059)
Input Tariff		0.0118***	0.0124***	0.0102**	0.00905**	0.00785*
		(0.0043)	(0.0043)	(0.0043)	(0.0043)	(0.0043)
Input Tariff × FM		-0.108***	-0.113***	-0.116***	-0.114***	-0.408***
		(0.0104)	(0.0104)	(0.0104)	(0.0104)	(0.0334)
FM		0.0295***	0.0298***	0.0295***	0.0295***	0.126***
		(0.0010)	(0.0010)	(0.0010)	(0.0010)	(0.0033)
Age			-0.00637***	-0.00643***	-0.00706***	-0.00693***
			(0.0004)	(0.0004)	(0.0004)	(0.0004)
Exporter Dummy			0.00230***	0.00208***	0.00213***	0.00254***
			(0.0005)	(0.0005)	(0.0005)	(0.0005)
TFP				0.0162***	0.0163***	0.0175***
				(0.0012)	(0.0012)	(0.0012)
SOE					0.0149***	0.0149***
					(0.0012)	(0.0012)
Foreign Firm					-0.00632***	-0.00591***
					(0.0015)	(0.0015)
N	1575162	1575162	1575162	1575162	1575162	1575162
$adj.R^2$	0.237	0.238	0.239	0.240	0.240	0.243

Note: Firm level regressions of markups on output tariffs, input tariffs, importer dummy, and control variables. Both output tariffs and input tariffs are measured at industry level. Variable FM stands for the importer dummy in Column (1) to (5), while it is replaced by import intensity (defined as imported inputs over total material inputs) in Column (6). Other control variables include firm age, exporter dummy, productivity (TFP), state-owned dummy and foreign firm dummy. All regressions include year dummies and firm fixed effect, standard errors are clustered at firm level. Standard error in parentheses, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 3: Firm Level Input Tariff and Firm Markup

	(1)	(2)	(3)	(4)	(5)	(6)
	Dependent Variable: Ln(Markup)					
	Full Sample	Full Sample	Exclude Processing	All Importers	Ordinary Importers	Processing Importers
Output Tariff	0.0298***	-	-	-	-	-
	(0.0057)					
Input Tariff	0.0206***	0.0184***	0.0274***	-0.0241***	-0.0187***	-0.0289
	(0.0041)	(0.0068)	(0.0074)	(0.0049)	(0.0063)	(0.0245)
Input Tariff × FM	-0.0735***	-0.0377***	-0.0463***	-	-	-
	(0.0070)	(0.0073)	(0.0077)			
FM	0.0252***	0.0267***	0.0274***	-	-	-
	(0.0008)	(0.0007)	(0.0007)			
Control Variables	YES	YES	YES	YES	YES	YES
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

Note: Firm level regressions of markup on tariffs, importer dummy, and control variables. Input tariffs are constructed at firm level, while output tariff is at industry level. Variable FM stands for importer dummy. All regressions include the same set of control variables as in Table 2, suppressed to save space and available upon request. All regressions include firm fixed effect, year dummies (col.1) or industry-year dummies (col.2-6). Standard errors are clustered at firm level. Standard error in parentheses, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 4: Input Tariff and Firm Markup: The Role of Market Structure

	(1)	(2)	(3)	(4)	(5)	(6)
	Dependent Variable: Ln(Markup)					
FM =	Importer		Incumbent Importer		Import Intensity	
Input Tariff × FM × CR	-1.091***	-1.075***	-1.372***	-1.353***	-1.387***	-1.341***
	(0.0873)	(0.0871)	(0.1008)	(0.1002)	(0.2114)	(0.2132)
Input Tariff × FM	0.147***	0.136***	0.164***	0.152***	-0.0651	-0.0908
	(0.0214)	(0.0213)	(0.0250)	(0.0249)	(0.0597)	(0.0601)
Input Tariff × CR	-0.245***	-0.298***	-0.243***	-0.297***	-0.290***	-0.346***
	(0.0447)	(0.0450)	(0.0445)	(0.0449)	(0.0446)	(0.0450)
Input Tariff	0.0811***	0.0918***	0.0817***	0.0926***	0.0910***	0.102***
	(0.0100)	(0.0101)	(0.01000)	(0.0101)	(0.0100)	(0.0101)
Output Tariff	-0.139***	-0.162***	-0.139***	-0.163***	-0.143***	-0.168***
	(0.0102)	(0.0104)	(0.0102)	(0.0104)	(0.0103)	(0.0104)
Output Tariff × CR	0.570***	0.662***	0.571***	0.666***	0.581***	0.679***
	(0.0318)	(0.0324)	(0.0317)	(0.0323)	(0.0320)	(0.0326)
FM×CR	0.0927***	0.0926***	0.129***	0.128***	0.0519***	0.0502***
	(0.0075)	(0.0075)	(0.0070)	(0.0070)	(0.0171)	(0.0172)
FM	0.00723***	0.00719***	-0.0100***	-0.00926***	0.111***	0.113***
	(0.0020)	(0.0020)	(0.0020)	(0.0020)	(0.0054)	(0.0054)
Control Variables	NO	YES	NO	YES	NO	YES
N	1575162	1575162	1575162	1575162	1575162	1575162
$adj.R^2$	0.239	0.242	0.239	0.242	0.242	0.244

Note: Firm level regressions of firm markups on interaction terms among tariffs, importer dummy and industrial concentration ratio (CR). Input and output tariffs are at industry level. Variable FM stands for importer dummy in Column (1) and (2), for incumbent importer dummy in Column (3) to (4), and for import intensity in Column (5) to (6). CR stands for the market share of largest 20 firms in one industry in the year of 2000. Regressions in even columns include the same set of control variables as in Table 2, suppressed to save space and available upon request. All regressions include firm fixed effect and year dummies. Standard errors are clustered at firm level. Standard error in parentheses, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

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

(1)	(2)	(3)	(4)	(5)
		Elasticity: Markup w.r.t Input Tariff		
CR20	Percentile	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

Note: Column (1) lists the value of CR20 for the corresponding percentile industries (col. 2). Column (3) to (5) report the elasticity of markup with respect to input tariffs for importers, incumbent importers, and importers with median import intensity, respectively. The elasticities are computed from estimated coefficients in Table 4.

Table 6: Robustness Check: Alternative Measure for Competitiveness

	(1)	(2)	(3)	(4)	(5)
	Dependent Variable: Ln(Markup)				
Comp =	1/Ln(N)	HHI	Ln K	Ln R	$1/\sigma$
Input Tariff × FM × Comp	-3.900***	-2.101***	-0.0500***	-0.145***	-3.250***
	(0.6555)	(0.4442)	(0.0157)	(0.0199)	(0.1580)
Input Tariff × FM	0.409***	-0.0888***	0.386**	1.411***	0.667***
	(0.0859)	(0.0107)	(0.1556)	(0.2090)	(0.0401)
Input Tariff × Comp	-6.042***	-5.661***	-0.121***	-0.0705***	-1.106***
	(0.4119)	(0.5236)	(0.0068)	(0.0083)	(0.0724)
Input Tariff	0.833***	0.0447***	1.172***	0.753***	0.247***
	(0.0555)	(0.0053)	(0.0651)	(0.0853)	(0.0163)
Output Tariff	-0.863***	-0.0263***	-1.121***	-1.223***	-0.0471***
	(0.0563)	(0.0077)	(0.0546)	(0.0694)	(0.0149)
Output Tariff × Comp	6.454***	5.234***	0.116***	0.118***	0.262***
	(0.4087)	(0.4887)	(0.0055)	(0.0065)	(0.0580)
FM × Comp	0.823***	0.679***	0.000567	0.00124	0.220***
	(0.0681)	(0.0644)	(0.0016)	(0.0020)	(0.0118)
FM	-0.0787***	0.0231***	0.0232	0.0164	-0.0246***
	(0.0089)	(0.0011)	(0.0160)	(0.0208)	(0.0032)
Control Variables	YES	YES	YES	YES	YES
N	1575162	1575162	1575162	1575162	1569035
$adj.R^2$	0.241	0.241	0.241	0.241	0.2408

Note: Firm level regressions of markup on interaction terms among tariffs, importer dummy and different measures for industrial competitiveness. Tariffs are measured at industry level. Variable FM stands for importer dummy. Measures for start-of-period market concentration include the inverse of firm number in log (col.1), Herfindahl-Hirschman Index (HHI, col.2), average capital stock in log(col. 3), and average log firm sales (col.4), and the inverse of the elasticity of substitution (col.5), respectively. All regressions include the same set of control variables as in Table 2, suppressed to save space and available upon request. All regressions include firm fixed effect and year dummies. Standard errors are clustered at firm level. Standard error in parentheses, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 7: Robustness Checks on Markup Estimation

	(1)	(2)	(3)	(4)	(5)	(6)
	Dependent Variable: Ln(Markup)					
	Full Sample	Include Input tariff	Include Exit	Exclude SOEs	Quantity C-D	Quantity Translog
Input Tariff × FM × CR	-1.159***	-1.363***	-1.164***	-1.200***	-0.619***	-0.696**
	(0.0944)	(0.0846)	(0.0948)	(0.1126)	(0.1046)	(0.2729)
Input Tariff × FM	0.291***	0.148***	0.287***	0.233***	0.190***	0.0953
	(0.0234)	(0.0216)	(0.0235)	(0.0298)	(0.0257)	(0.0628)
Input Tariff × CR	-0.114**	-0.391***	-0.122***	-0.0638	0.172***	-4.609***
	(0.0461)	(0.0530)	(0.0463)	(0.0598)	(0.0545)	(0.1572)
Input Tariff	0.117***	0.101***	0.112***	0.111***	-0.000703	0.968***
	(0.0103)	(0.0127)	(0.0103)	(0.0138)	(0.0119)	(0.0330)
Output Tariff	-0.0985***	-0.216***	-0.0942***	-0.0316**	-0.138***	-0.348***
	(0.0106)	(0.0142)	(0.0106)	(0.0134)	(0.0116)	(0.0372)
Output Tariff × CR	0.148***	0.969***	0.151***	-0.155***	-0.0444	2.716***
	(0.0320)	(0.0393)	(0.0320)	(0.0423)	(0.0395)	(0.1460)
FM × CR	0.0792***	0.0960***	0.0732***	0.0762***	0.0863***	-0.211***
	(0.0081)	(0.0072)	(0.0081)	(0.0096)	(0.0100)	(0.0273)
FM	-0.00859***	0.00760***	-0.00676***	-0.00400	-0.0165***	0.0489***
	(0.0023)	(0.0020)	(0.0023)	(0.0028)	(0.0025)	(0.0068)
Control Variables	YES	YES	YES	YES	YES	YES
N	1,586,154	1,564,575	1,564,657	1,442,679	1,569,846	1,545,098
$adj.R^2$	0.117	0.118	0.259	0.101	0.192	0.064

Note: Regression settings are the same as Table 4 but the firm markups are estimated with alternative methods or using different samples. Column (1) uses the complete sample of firms. Column (2) includes input tariff in the Markov process of productivity when estimating production function in section 2. Column (3) further controls for firm exit in markup estimation. Column (1) to (3) differ in the production function estimation yet keep the same sample for regression. Column (4) excludes SOEs. in both markup estimation process as well as regression. Markups in Column (5) and (6) are estimated using output in physical terms instead of in revenue. Column (5) uses Cobb-Douglas production function while Column (6) uses translog function. We drop the top and bottom 1% markup values after each estimation, therefore the sample size varies a little due to missing value of control variables. Standard errors are clustered at firm level. Standard error in parentheses, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 8: First Difference and Instrumental Variable Estimation

	(1)	(2)	(3)	(4)	(5)	(6)
	Dependent Variable: $Ln(Markup_{i,t}) - Ln(Markup_{i,t-s})$					
	$s=3$	$s=4$	$s=5$	$s=3$	$s=4$	$s=5$
	First Difference			Instrumental Variable		
Δ^s Input Tariff$_{j,t}$	-0.825***	-1.375***	-1.964***	-6.8137***	-5.3915***	-4.2685***
$\times$ FM$_{i,t-s}\times$CR$_j$	(0.0866)	(0.1192)	(0.1397)	(0.4979)	(0.5045)	(0.4196)
Δ^s Input Tariff$_{j,t}$	0.0364	0.0958***	0.254***	0.8949***	0.4420***	0.3608***
$\times$FM$_{i,t-s}$	(0.0223)	(0.0294)	(0.0331)	(0.0981)	(0.1024)	(0.0846)
Δ^sInput Tariff$_{j,t}$	0.603***	0.697***	0.749***	1.9435***	0.9634***	1.0536***
$\times$CR$_j$	(0.0339)	(0.0452)	(0.0521)	(0.3271)	(0.3455)	(0.2834)
Δ^sInput Tariff$_{j,t}$	-0.0862***	-0.0611***	-0.0790***	-0.4803***	-0.9446***	-0.5301***
	(0.0083)	(0.0109)	(0.0125)	(0.1294)	(0.1579)	(0.1352)
Δ^sOutput Tariff^j_t	0.0428***	0.0317***	0.0198*	0.4105***	0.9777***	0.5220***
	(0.0065)	(0.0090)	(0.0104)	(0.0962)	(0.1287)	(0.1255)
Δ^sFM$_{i,t}\times$CR$_j$	0.0788***	0.125***	0.192***	0.3930***	0.3577***	0.3296***
	(0.0087)	(0.0120)	(0.0148)	(0.0235)	(0.0251)	(0.0240)
Δ^sFM$_{i,t}$	0.0142***	0.00621**	-0.0133***	-0.0191***	-0.0006	-0.0080
	(0.0023)	(0.0032)	(0.0039)	(0.0048)	(0.0054)	(0.0054)
Control Variables	YES	YES	YES	YES	YES	YES
first. Output Tariff	\	\	\	-0.190***	-0.238***	-0.335***
	\	\	\	(0.0021)	(0.0035)	(0.0046)
first. Input Tariff	\	\	\	-0.171***	-0.311***	-0.325***
	\	\	\	(0.0085)	(0.0121)	(0.0173)
N	539543	336872	214355	539543	336872	214355
Under Ind.	\	\	\	500.4	371.6	356.4
Weak Ins.(F)	\	\	\	101.4	72.46	69.43

Note: Coefficients are from s-period first difference regressions. i,j,t stands for firm, industry and year, respectively. Variable FM stands for importer dummy. CR stands for the market share of largest 20 firms in one industry in the year of 2000. Column (1)-(3) are results for first difference estimations and Column (4)-(6) for those for instrumental variable estimations we discuss in section 5.5. 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. i,j,t stands for firm, industry and year, respectively. Variable FM stands for importer dummy. CR stands for the market share of largest 20 firms in one industry in the year of 2000. Year dummies are included. The direct first stage results of initial tariff levels on tariff reductions, for both input and output tariffs, are provided in the lower panel. The coefficients on control variables and the whole set of first stage results is available upon request. All results are clustered at firm level. Standard error in parentheses, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 9: Tariffs, Market Structure and Markup Dispersion

	(1)	(2)	(3)	(4)	(5)
	Dependent Variable: Within-industry Markup Dispersion				
	Ln Theil	Ln Theil	Ln RMD	Ln CV	Gini
Output Tariff	1.716**	-1.003	-0.242	-0.544	-0.0344
	(0.7397)	(0.8876)	(0.4321)	(0.4857)	(0.0355)
Output Tariff × CR	-1.739	3.981**	1.453*	2.105**	0.179***
	(1.1750)	(1.7309)	(0.8256)	(0.9568)	(0.0688)
Input Tariff		5.786	0.726	3.004	0.00884
		(3.6163)	(1.7286)	(1.9256)	(0.1473)
Input Tariff × CR		-19.76***	-6.644***	-10.57***	-0.517***
		(4.9032)	(2.2910)	(2.6827)	(0.1887)
SOE Share	-0.208**	-0.231**	-0.102**	-0.113**	-0.00526
	(0.0904)	(0.0906)	(0.0413)	(0.0481)	(0.0034)
Ln Wage	-0.0109	-0.0133	-0.0223	-0.00995	0.00146
	(0.0642)	(0.0665)	(0.0314)	(0.0321)	(0.0030)
Ln K	0.968***	1.038***	0.595***	0.575***	0.0502***
	(0.3385)	(0.3327)	(0.1587)	(0.1672)	(0.0122)
Ln Firm Number	-0.0452	-0.0544	-0.0462*	-0.0495*	0.000801
	(0.0526)	(0.0533)	(0.0247)	(0.0277)	(0.0020)
Export Intensity	-0.0589	-0.119	-0.0479	-0.0614	-0.00315
	(0.2805)	(0.2833)	(0.1295)	(0.1462)	(0.0079)
N	3349	3349	3349	3349	3361
$adj.R^2$	0.323	0.332	0.347	0.330	0.312

Note: Industry level regressions of markup dispersion on tariffs, the interaction of tariffs and industrial concentration. There are 422 4-digit CIC industries. All regressions include year dummies and industry fixed effects. Control variables include market share of SOEs, average wage bill (in log), average capital stock (in log), total firm number (in log) and aggregate export intensity. All results are clustered at industry level. Standard error in parentheses, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.