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Import Competition and Export Markups: Evidence from Chinese Multi-Product Exporters

Hongkui Liu, Ming Xu, and Tenglong Zhong*

We present evidence using highly disaggregated Chinese firm-product data that increased import competition (resulting from reductions in output tariffs) induces incumbent exporters to increase product markups in export markets. This is driven by the upward markup adjustments of products closer to firms' core competencies, while products farther from core competencies have their markups lowered. We also investigate the underlying mechanisms empirically. Chinese multi-product exporters invest in improving the quality of their core products (which we term "quality-based core competency") and raise the quality more for products closer to their core competencies. This leads to heterogeneity in the responses of prices and markups to import competition. Our findings are robust to using alternative markup and import competition measures and different estimation methods, addressing endogenous issues and controlling for export and input tariffs. This paper contributes to the literature by finding new evidence that import competition can increase the export markups of products closer to firms' core competencies within multi-product exporters.

Key Words: Import competition; Export markups; Multi-product exporters; Core competency.
JEL Classification Numbers: F13, F14, F43, O12.

1. INTRODUCTION

Many studies find that the increased import competition induced by output tariff reductions decreases firms' markups in the domestic market, with consumers benefiting from lower markups of the goods they consume (e.g., Krugman, 1979; Feenstra, 2010; De Loecker et al., 2016). This is termed the pro-competitive effects of trade. However, these studies ignore two im-

* Liu: Institute of Economics, Chinese Academy of Social Sciences, Beijing, China. Email: lhyhnly@126.com; Xu: Institute of Industrial Economics, Chinese Academy of Social Sciences, Beijing, China. Email: xmphd@cass.org.cn; Zhong: Corresponding author. National School of Development, Peking University, Beijing, China. Email: tenglong_zhong@126.com.

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portant questions. First, the effects of import competition on the markups charged by local firms in the foreign market have not been explored. Second, no study has looked at heterogeneity in the markup responses to import competition across products within multi-product firms. In this paper, we close these gaps by answering these questions using Chinese data.

We use the method of De Loecker et al. (2016) to estimate markups at the firm-product level for multi-product firms using a matched dataset of firm production data and trade data from China between 2000 and 2006. This approach requires neither assumptions on the market structure and demand curves faced by firms nor assumptions on how firms allocate their inputs across products. This allows us to use production data for industries in the Chinese manufacturing sector. The markup estimated is what domestic firms charge in export markets. By exploiting the rapid reductions in import tariffs after China's accession to the WTO, we are the first to empirically document a key heterogeneity in how exporters change their export markups in response to import competition. We show that exporters increase their markups following output tariff reductions and that markups increase significantly more for higher performance products. This result is robust to different measures of within-firm heterogeneity and to controlling for a rich set of firm and industry characteristics.

This paper is related to the empirical literature on how trade liberalization leads to an efficient allocation of resources across firms. Goldar and Aggarwal (2005) show empirically that output tariff cuts significantly reduced the markups of India's firms from 1980 to 1997. Konings et al. (2005) use firm-level data from Bulgaria and Romania to find that import competition impacts firm markups with the sign influenced by the market structure of the industry the firm belongs to. Chen et al. (2009) use EU manufacturing firm data to show that trade liberalization has pro-competitive effects by decreasing prices and markups in the short term but that its long-term effects are not clear. De Locker et al. (2016) develop a method to estimate firm-product level markups and use this method to estimate the product markups of India's manufacturing firms from 1989 to 1997. They find evidence of a pro-competitive effect of output tariff reductions lowering firm-product markups. Fan et al. (2018) are the first to estimate the firm-product markups of Chinese manufacturing exporters using the method of De Loecker et al. (2016), but their focus is the effects of input tariff reductions on markups.

This paper complements another strand of literature on how trade liberalization brings an efficient allocation of resources within firms. Eckel and Neary (2010) prove theoretically that globalization tends to reduce the product range of multi-product firms. The reason for this is that firms produce more of their core product and abandon the products made the least efficiently. Bernard et al. (2011) build another theoretical model and conclude that trade liberalization decreases product range. They perform empirical tests using US data to confirm their theoretical prediction. Mayer et al. (2014) find empirical evidence that firms choose to export more of their core product to a destination as competition intensifies. Fan et al. (2016) study the effects of import liberalization on product mix of multi-product exporters, specifically on export value and export scope.

This paper contributes to the literature in three ways. First, we explore the effects of output import tariff reductions on the markups charged by domestic firms in the export market. Second, we study the heterogeneity in the markups adjustment across products within a multi-product exporter, uncovering how resources are reallocated within firms facing trade liberalization. Third, we show that the quality-based core competency strategy plays a key role in the heterogeneous adjustment made by Chinese multi-product firms after output tariff reductions.

The rest of the paper is organized as follows. Section 2 documents two stylized facts regarding import competition and multi-product exporters. Section 3 describes the data, measures and model specifications. Section 4 presents our main econometric results and a variety of robustness checks. Section 5 presents mechanism tests and Section 6 contains the conclusion.

2. STYLIZED FACTS

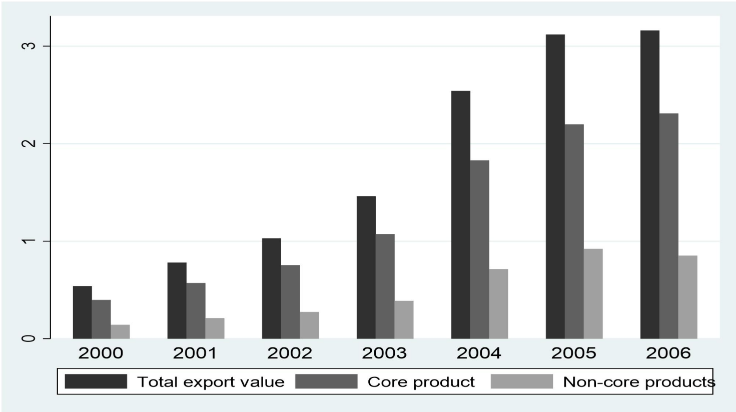
In this section, we document two stylized facts concerning multi-product exporters and the relationship between import competition and the export markups of multi-product firms. The method we use to estimate firm-product markups is described in detail in Section 3. Note that we categorize goods using the HS 6-digit product classification.

We classify a multi-product exporter's product with the highest export value as the firm's core competency (or core product); all other products are classified as non-core products (Eckel and Neary, 2010; Bernard et al., 2011; Eckel et al., 2015). Figure 1 shows a bar chart with the aggregate and component (core product and non-core products) export value of Chinese multi-product exporters. The aggregate exports of Chinese multi-product exporters in our sample increases from 54 million U.S. dollars in 2000 to 316 million U.S. dollars in 2006. More importantly, most exports are core products (74%); non-core products account for only 26% of total exports. This share remains stable over time, leading to our first stylized fact.

Stylized fact 1. Chinese multi-product exporters have core competencies.

Following De Loecker et al. (2016), we estimate the markups for each product exported by multi-product firms in China. The set of multi-product exporters comes from merging production data with customs data (see Section 3 for a detailed description). We then compare core products

FIG. 1. China's multi-product firms' export values (2000-2006)



Notes: 0.1 billion dollars.

with non-core products in terms of their markup levels and dynamics. We compute the yearly mean value of markups across all products and for core and non-core products separately. The results are plotted in Figure 2. In every year, multi-product exporters in China charge significantly higher markups for core products than for non-core products because core products are the firms' most efficient products and they earn the greatest profits from them. Across time, the markups of core products raise more than those of non-core products. It is widely known that China experienced import tariff reductions between 2000 and 2006, so we can say that multi-product exporters adjust the markups of their core products more than those of their non-core products. We summarize the second stylized fact as follows.

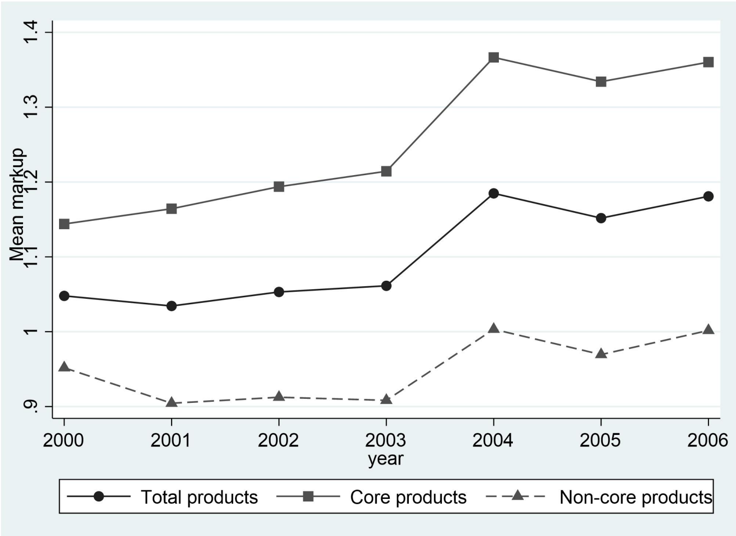
Stylized fact 2. Multi-product exporters in China charge higher markups for core products and adjust markups more for core products when faced with import competition.

3. DATA, MEASURES AND MODEL

3.1. Firm-level production data and firm-product trade data

Firm-level production data. To derive factor output elasticity, we use firm-level production data from National Bureau of Statistics (NBS) covering all state-owned enterprises (SOEs) and non-state-owned enterprises with annual sales of more than 5 million RMB. The NBS dataset contains detailed firm-level information on Chinese manufactures, including capital stock, employment, intermediate inputs, sales revenue, value added and firm contacts (e.g., company name, contact person, telephone and zip

FIG. 2. China's multi-product exporters' markups (2000-2006)



code). We take the following steps to clean the raw dataset. First, we remove observations missing information on critical variables (such as the number of employees, sales, total assets, net value of fixed assets or intermediate inputs). Next, we drop observations that violate accounting protocols in accordance with Cai and Liu (2009), including cases where (a) total assets are less than liquid assets, (b) total assets are less than total fixed assets, (c) total assets are less than the net value of fixed assets or (d) there are fewer than 8 employees. Then, we use the programs developed by Brandt et al. (2012) to match firms over time and generate unique numerical IDs for each firm. Because industry standards were updated in 2002, we identify these two standards using the industry concordances also provided by Brandt et al. (2012). Finally, we keep only manufacturing firms. In the end, we have an unbalanced panel of firms that increases in size from 122,435 firms in 2000 to 256,020 in 2006.

Firm-product level trade data. Our firm-product level trade data are from China's General Administration of Customs, which provides information on each trading firm's transaction records, including trading quantity, value and partners at the HS eight-digit level of products. It also records firm contacts as in the firm-level production data. Because the tariff data we draw from the trade analysis and information system (TRAINS) are at the HS 6-digit level, we aggregate the trade data from the HS 8-digit to the HS 6-digit level.

Matching the two databases. To estimate firm-product markups, we need to obtain export values and export prices from the product-level trade data and input and output information from the firm-level production data. Therefore, we must combine the two datasets. Both datasets report a firm's identification number but use completely different coding systems, so we must rely on common firm contacts. First, we match the two datasets using each firm's Chinese name and year. If a firm shares the same Chinese name in both datasets in a particular year, it should be the same firm. We obtain 222,568 matched firms in total between 2000 and 2006, accounting for 92 percent of all matched firms. Second, we match by telephone number and zip code because firms should have a unique phone number within a postal district. Finally, we match by telephone number and contact person name. The numbers of firms matched using the last two methods are 15,981 and 3,370 respectively, accounting for 6.61 percent and 1.39 percent of all matched firms. Looking at all exporting and importing firms reported in the customs dataset, we have a matching rate of 33.1 percent of all exporters and 35.7 percent of all importers. These correspond to 47.1 percent of total export values and 38.4 percent of total import values as reported by the customs database. Table 1 gives detailed match results.

TABLE 1.

Match results

	# exporters			Export value			# importers		Import value	
year	#	Share in Customs dataset	Share in production dataset	value	Share in Customs dataset	Share in production dataset	#	Share in Customs dataset	value	Share in Customs dataset
2000	17270	31.3%	48.5%	918	35.2%	55.0%	13912	27.4%	695	28.8%
2001	20341	33.7%	51.8%	1110	39.9%	58.9%	16167	30.1%	826	734.6%
2002	23247	32.4%	53.7%	1520	41.9%	65.1%	17726	28.6%	1050	32.7%
2003	27455	31.6%	55.6%	2230	44.3%	72.4%	19868	27.9%	1510	34.1%
2004	41098	37.7%	57.9%	3510	51.7%	71.2%	29101	36.0%	2470	42.8%
2005	42137	32.1%	57.9%	4050	48.5%	71.4%	28867	33.9%	2830	42.9%
2006	49679	32.1%	64.8%	5480	50.8%	73.7%	29040	31.9%	2710	40.5%
2000-2006	221227	33.1%	57.0%	18800	47.1%	69.6%	46829	35.7%	12091	38.4%

3.2. Measure of firm-product markup

Using the matched dataset of production data and trade data, we estimate firm-product markups using the method of De Loecker et al. (2016). As shown by De Loecker and Warzynski (2012), markups at the firm level are equivalent to the ratio of the output elasticity θ of a variable input to the share of input expenditure α. The same holds at the firm-product level. The markup for product g produced by firm f at time t can be expressed as in Equation (1).

$$\mu_{fgt} = \theta^M_{fgt}(\alpha^M_{fgt})^{-1} \tag{1}$$

θ^M_{fgt} denotes the firm-product output elasticity of a firm product variable input material M_{fgt} and α^M_{fgt} is the share of expenditure on input M allocated to product g in the total sales of product g. To calculate this, we need to know the output elasticity θ^M_{fgt} and the ratio of input expenditure to sales α^M_{fgt}.

Following De Loecker et al. (2016), we assume a translog production function for multi-product firms as in Equation (2).

$$q_{fgt} = f(x_{fgt}; \beta) + \varphi_{ft} + \varepsilon_{fgt} \tag{2}$$

Lowercase letters denote the Log of uppercase letters. We write the production function in terms of physical output q_{fgt} rather than revenue because export quantities and prices at the firm-product level are available in our trade data. x_{fgt} denotes a set of firm-product-year specific inputs, including capital (k), labor (l) and material (m). As in De Loecker et al. (2016), the productivity term φ_{ft} is assumed to be Hicks-neutral and firm-specific. The error term ε_{fgt} captures measurement errors in recording output quantities and any unanticipated shocks to output.

However, there are no data recording product-specific inputs in China. The firm-level production data report inputs at the firm level. If we could derive how firms allocate inputs to each product, we could obtain the inputs spent on each product. To do this, we denote the Log of input X's share in producing product g as $\rho_{fgt} = x_{fgt} - x_{ft}$. Substituting this expression into Equation (2) yields Equation(3).

$$q_{fgt} = f(x_{ft}; \beta) + A_{fgt}(\rho_{fgt}; x_{ft}; \beta) + \varphi_{ft} + \varepsilon_{fgt} \tag{3}$$

Equation (3) has two main differences from Equation (2). First, the product-specific inputs vector x_{fgt} are missing in Equation (3) and have been replaced by the firm-level inputs vector x_{ft} and the input allocation share ρ_{fgt}. Second, Equation (3) contains an extra error term $A_{fgt}(\rho_{fgt}; x_{ft}; \beta)$. Multi-product firms differ from single-product firms in allocating inputs across products. This allocation is not observable by econometricians and we capture this in the error term $A_{fgt}(\cdot)$. $A_{fgt}(\cdot)$ has three arguments: the unobserved input shares ρ_{fgt}, the firm-level input expenditure x_{ft} and the production function coefficients β. It is clear from Equation (3) that even after controlling for the unobserved productivity φ_{ft} using standard estimation techniques, the presence of $A_{fgt}(\cdot)$ leads to biased production function coefficients because this term is correlated with the input expenditure x_{ft}. We refer to the bias arising from $A_{fgt}(\cdot)$ as the "input allocation" bias.

Following De Loecker et al. (2016), we write $A_{fgt}(\cdot)$ as $\hat{a}_{ft}\rho_{fgt}+\hat{b}_{ft}\rho_{fgt}^2+\hat{c}_{ft}\rho_{fgt}^3$ by applying our translog production function. The coefficients $\hat{a}_{ft}$, $\hat{b}_{ft}$ and $\hat{c}_{ft}$ are functions of the estimated parameter vector β[1], which is estimated using firm-level production survey data from NBS with the method of De Loecker and Warzynski (2012).

To eliminate unanticipated shocks and measurement errors that are present in the output data at the firm-product level, which correspond to q_{fgt} in Equation (3), we project product g's export quantity q_{fgt} in year t on a list of variables to obtain its predicted value. The variables include inputs, input/output tariffs, the output price, processing trade dummies, interactions between processing trade dummies and input/output tariffs, region and industry-product dummies and time fixed effects (Fan et al., 2018).

Equation(3) can then be rewritten as follows.

$$E(q_{fgt}) - f(x_{ft}, \hat{\beta}) = \varphi_{ft} + \hat{a}\rho_{fgt} + \hat{b}_{ft}\rho_{fgt}^2 + \hat{c}_{ft}\rho_{fgt}^3 \tag{4}$$

$E(q_{fgt})$ is the fitted value of q_{fgt}, so the error term in Equation (3) is diminished. $\hat{\beta}$ is the estimated vector of β. The left part of Equation (4) is known and $\hat{a}_{ft}$, $\hat{b}_{ft}$ and $\hat{c}_{ft}$ on the right part are also known. We solve for the $J+1$ unknowns $(\varphi_{ft}, \rho_{f1t}, \ldots, \rho_{fgt})$ using a system of $J+1$ equations. Note that we need to modify the proportional assumption made by De Loecker et al. (2016), which says that the sum of input shares across products within a firm equals to one. This modification is due to the limitations of the Chinese data. Most firms in our sample are not pure exporters and therefore also have domestic sales that are not observable at the firm-product level. As a result, we cannot use the same assumption as De Loecker et al. (2016). Instead, following Kee and Tang (2016), we assume that the share of inputs allocated to exports production is proportional to the share of exporting value in total sales. This implies that for any firm f at time t, the sum of ρ_{fgt} across products is equal to the ratio of total exports to total sales. Fan et al. (2018) also use this assumption.

We use a numerical procedure to solve the aforementioned system of $J+1$ equations for each firm in each year. We now have all the ingredients

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[1]

$$\begin{aligned}
\hat{a}_{ft} &= \hat{\beta}_l + \hat{\beta}_m + \hat{\beta}_k + 2(\hat{\beta}_{ll}l_{ft} + \hat{\beta}_{mm}m_{ft} + \hat{\beta}_{kk}k_{ft}) \\
&\quad + \hat{\beta}_{lm}(l_{ft} + m_{ft}) + \hat{\beta}_{lk}(l_{ft} + k_{ft}) + \hat{\beta}_{mk}(m_{ft} + k_{ft}) \\
&\quad + \hat{\beta}_{lmk}(lm_{ft} + lk_{ft} + mk_{ft}) \\
\hat{b}_{ft} &= \hat{\beta}_{ll} + \hat{\beta}_{mm} + \hat{\beta}_{kk} + \hat{\beta}_{lm} + \hat{\beta}_{lk} + \hat{\beta}_{mk} \\
&\quad + \hat{\beta}_{lmk}(l_{ft} + m_{ft} + k_{ft}) \\
\hat{c}_{ft} &= \hat{\beta}_{lmk}
\end{aligned}$$

needed to compute markups and the implied marginal costs for each multi-product firm according to Equation (1).

$$\hat{\mu}_{fgt} = \hat{\theta}^M_{fgt}(\hat{\alpha}_{fgt})^{-1} \tag{5}$$

Where,

$$\begin{aligned}\hat{\theta}^M_{fgt} &= \hat{\beta}_m + 2\hat{\beta}_{mm}(\hat{\rho}_{fgt} + m_{ft}) + \hat{\beta}_{lm}(\hat{\rho}_{fgt} + l_{ft}) \\ &\quad + \hat{\beta}_{mk}(\hat{\rho}_{fgt} + k_{ft}) + \hat{\beta}_{lmk}(\hat{\rho}_{fgt} + l_{ft})(\hat{\rho}_{fgt} + k_{ft}) \\ \hat{\alpha}_{fgt} &= \frac{\exp(\hat{\rho}_{fgt}) P^M_{ft} V^M_{ft}}{\widehat{P_{fgt} Q_f} gt}\end{aligned}$$

Finally, the marginal costs for product g at time t are recovered by subtracting the markup from the Log price according to Equation (6).

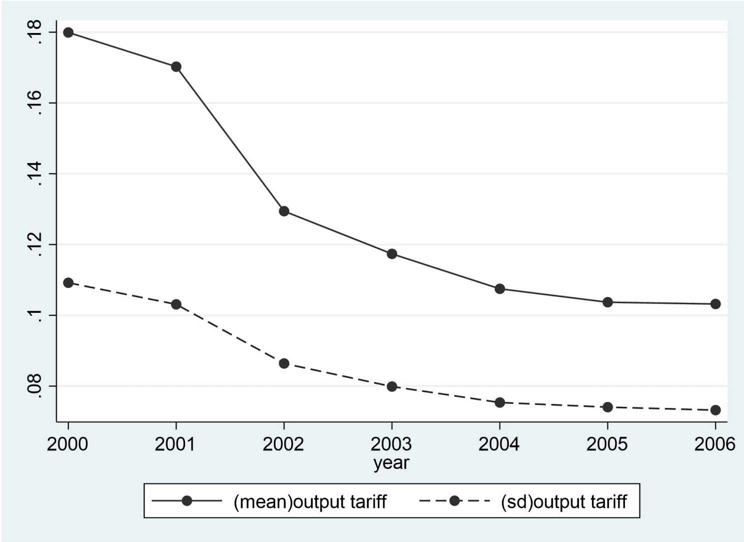
$$\widehat{MC}_{fgt} = \ln(P_{fgt}) - \hat{\mu}_{fgt} \tag{6}$$

3.3. Measure of import competition

We use output tariff reductions to characterize import competition as in Amiti and Khandelwal (2013). In a robustness test, we use import penetration as an alternative proxy (Dhyne et al., 2017). Import penetration at the CIC 4-digit level is defined as the ratio of import value over output. The import value at the CIC 4-digit level is calculated using data from CEPII-BACI. The output at the CIC 4-digit level is aggregated using the gross output of firms within CIC 4-digit industries.

To construct output tariffs, we first draw the tariff lines from the trade analysis and information system (TRAINS). The tariff lines are at the HS 6-digit level. Our production data use CIC 4-digit codes, so we need to map HS 6-digit codes to CIC 4-digit codes. This mapping is provided by Upward and Wang (2013). Following Amiti and Konings (2007), output tariffs at the CIC 4-digit level are obtained by taking a simple average of the HS 6-digit codes within each 4-digit CIC industry code. The reason for not using weighted import tariffs is to avoid introducing endogeneity into the tariffs; imports are negatively correlated with tariffs. Figure 3 presents our calculations for output tariffs in China between 2000 and 2006. The upper and lower lines show the annual mean and standard deviation respectively, both of which trend downwards. This means that both the level and the dispersion of markups within CIC 4-digit industries have dropped drastically since China became a member of the WTO in 2001. This suggests that this period reflects increased import competition from decreasing tariffs, which is why we use 2000 to 2006 as the sample period.

FIG. 3. Annual mean and standard deviation of output tariffs in China (2000-2006)



3.4. Measureof firm-product quality

With reference to Khandelw al et al. (2013), quality is estimated as the residual from the OLS regression in Equation (7) with a specific value for σ

$$\ln x_{fgdt} + \sigma \ln p_{fgdt} = f_h + f_{dt} + \varepsilon_{fgdt} \tag{7}$$

f_{dt} is a fixed effect that collects the destination country's income and price index, and the product fixed effect f_h is included because prices and quantities are not necessarily comparable across product categories. We assume $\sigma = 5$, the median elasticity of substitution reported by Broda and Weinstein (2006), and also close to the value estimated by Lo (2016) using Chinese trade data. The estimated quality is $q_{fgdt} = \varepsilon_{fgdt}/(\sigma - 1)$. We then aggregate to the firm-product level with the normalized value of q_{fgdt}

3.5. Measure of product ladder

We measure the product ladder using the volume of exports of each product within each firm-year pair. For any firm-year pair, the product with the greatest sales abroad is the core product, the second most sold product is the next after the core product, and so on. Three different measures of the ladder are used. Log ranking is the logged ranking of export sales of all products within firm-year pairs, with lower ranks associated with products with higher export sales. The ranking goes from 1 to N, with N indicating the firm's product scope. Non-core is an indicator variable for whether a product is not the product with the highest export sales in each firm-year pair, i.e., it is not the core product. Bottom is an indicator variable for whether a product is below the median ranking of export sales within each firm-year pair.

3.6. Empirical model

We build the following econometric models to quantitatively examine how firms' markups respond to tariff reductions following China's trade liberalization. We focus on the pro-competitive effects of changes in output tariffs, which is only included as the core explanatory variable. In a robustness test, we also include input tariffs to consider marginal-cost channel effects. We study whether there exists heterogeneity across products in the responsiveness to output tariff reductions of markups within firm-year pairs in China. Therefore, when using the first econometric model, we include an interaction term between output tariffs and the product ladder and a single term for the product ladder.

$$\log(\text{Markup}_{fgt}) = \beta_0 + \beta_1 \text{Tariff\_output}_{it} + \theta X_{ft} + \delta_s + \delta_{fg} + \delta_t + \varepsilon_{fgt} \quad (8)$$

$$\log(\text{Markup}_{fgt}) = \beta_0 + \beta_1 \text{Tariff\_output}_{it} + \beta_2 \text{Tariff\_output}_{it} \times \text{Ladder}_{fgt} + \text{Ladder}_{fgt} + \theta X_{ft} + \delta_s + \delta_{fg} + \delta_t + \varepsilon_{fgt} \quad (9)$$

$\log(\text{Markup}_{fgt})$ is the Log of the estimated firm-product markups for HS6 product g produced by firm f in year t; the subscript i denotes the 4-digit CIC industry.

The controls X_{ift} account for firm characteristics such as productivity (TFP), capital-labor ratio (KLR), material input share in gross output (Input), average wage (Wage), subsidy share in value added (Subsidy), tax share in value added (Tax), firm age, interest expenditure share in value added (Interest), export intensity and firm ownership indicators (SOE and FOE are indicators for state owned enterprises and foreign owned enterprises respectively). We also control for time fixed effects (δ_t), 2-digit CIC sector fixed effects (δ_s) and firm-product fixed effects (δ_{fg}) to account for all factors that are time, sector or firm-product related. Because the 4-digit CIC industry-level tariff is the variable of interest in Equations (8) and (9), we cluster error terms at the industry-year pair to address the issue of potential correlations between errors within each industry over time. ε_{fgt} is the error term.

4. EMPIRICAL RESULTS

4.1. Baseline estimates

Average response in product markups. First, we run several regressions as specified by Equation (8) with samples of multi-product exporters. The results are reported in Table 3. As can be seen, the estimated coeffi-

TABLE 2.

Summary statistics of the main variables

Variables	Observations	Mean	Sd.	Min	Max
log(Markup)	658403	−0.1635	0.7255	−7.4945	2.0441
Tariff_output	658403	0.1384	0.0691	0.0000	0.6500
log(MC)	658403	−3.1766	1.9075	−11.8055	13.2794
log(Price)	658403	−3.3401	1.9104	−14.0173	13.4173
Quality	569022	0.5569	0.1655	0.0000	1.0000
log(Ranking)	658403	1.2287	0.9701	0.0000	5.8464
Non_core	658403	0.7661	0.4233	0.0000	1.0000
Buttom	658403	0.4365	0.4960	0.0000	1.0000
log(TFP)	658403	1.4777	0.1992	0.3613	2.1634
log(KLR)	658403	3.3262	1.3335	−5.8569	9.0620
log(Input)	658403	−0.3724	0.3037	−5.1385	6.6646
log(Wage)	658403	2.6136	0.6082	−5.2030	6.9925
log(Subsidy)	658403	0.0070	0.0476	0.0000	4.8675
log(Tax)	658403	0.1107	0.2205	−1.3901	3.6760
log(Age)	658403	2.0157	0.6699	0.0000	4.0604
Interest	658403	0.0417	0.1445	−0.1905	2.8817
Exp_density	658403	0.1568	0.1734	0.0001	0.9999
SOE	658403	0.0733	0.2606	0.0000	1.0000
FOE	658403	0.5144	0.4998	0.0000	1.0000

cients of output tariffs are significantly negative. A 1% reduction in output tariffs leads to an increase in markups of 0.6-0.8%. Each column reports the result for different sets of fixed effects and controls. Columns 1 through 3 include no controls but vary in which fixed effects are included. Column 1 includes year and firm fixed effects, which control for factors that vary over time but not across firms and for factors that do not vary over time but do across firms respectively. Column 2 includes year fixed effects and firm-product group fixed effects instead of firm fixed effects. The reason to control for fixed effects at the firm-product group level is that the dependent variable in Equation (8) is at the firm-product-year level. It is only by controlling for firm-product group fixed effects that we can say we are using the standard fixed effects estimation method. Because we estimate a translog production function at the 2-digit CIC sector level, we control for 2-digit CIC sector fixed effects in column 3. Columns 4 through 7 gradually introduce additional controls using the same fixed effects as in column 3. The magnitude of the output tariff effects on export product markups is stable across all seven columns.

Heterogeneous response in product markups. To study whether the increase in markups following output tariff reductions is larger for prod-

TABLE 3.

Impact of output tariffs on markups of multi-product exporters

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Tariff_output	-0.8457^{***}	-0.7857^{***}	-0.8647^{***}	-0.6742^{***}	-0.6389^{***}	-0.6376^{***}	-0.6289^{***}
	(0.0977)	(0.1046)	(0.1159)	(0.0940)	(0.0986)	(0.0983)	(0.0976)
log(TFP)				1.1834^{***}	1.1810^{***}	1.1816^{***}	1.2958^{***}
				(0.0895)	(0.0940)	(0.0940)	(0.1015)
log(KLR)				0.0051^{*}	0.0048^{*}	0.0048^{*}	0.0047
				(0.0029)	(0.0029)	(0.0029)	(0.0029)
log(Input)				-0.2291^{***}	-0.2049^{***}	-0.2047^{***}	-0.2022^{***}
				(0.0128)	(0.0121)	(0.0120)	(0.0121)
log(Wage)				-0.0374^{***}	-0.0346^{***}	-0.0346^{***}	-0.0343^{***}
				(0.0042)	(0.0040)	(0.0040)	(0.0039)
log(Subsidy)					0.0213	0.0213	0.0210
					(0.0248)	(0.0247)	(0.0249)
log(Tax)					-0.0119^{*}	-0.0119^{*}	-0.0118^{*}
					(0.0065)	(0.0064)	(0.0065)
log(Age)					-0.0232^{***}	-0.0232^{***}	-0.0259^{***}
					(0.0063)	(0.0063)	(0.0064)
Interest					0.0478^{***}	0.0478^{***}	0.0474^{***}
					(0.0119)	(0.0119)	(0.0119)
Exp_density					0.2936^{***}	0.2939^{***}	0.2898^{***}
					(0.0452)	(0.0452)	(0.0452)
SOE							0.0558^{***}
							(0.0108)
FOE							-0.0210^{***}
							(0.0065)
Year Fixed Effects	YES	YES	YES	YES	YES	YES	YES
Firm Fixed Effects	YES	-	-	-	-	-	-
Firm-Product Fixed Effects	NO	YES	YES	YES	YES	YES	YES
Sector Fixed Effects	NO	NO	YES	YES	YES	YES	YES
Observations	658,403	658,403	658,403	658,403	658,403	658,403	658,403
R-squared	0.8278	0.9568	0.9570	0.9604	0.9608	0.9608	0.9609

ucts closer to a firm's core competency, we estimate the second econometric model with a variable capturing the interaction between output tariff and ladder.

Table 4 reports the regression results corresponding to Equation (9). Each pair of columns correspond to one of the three different specifications of the ladder variable. The coefficient estimates for output tariffs remain negative and significant at the 1% level. The absolute values of the coefficients are between 0.66 and 0.74 in the estimates with control variables and depend on which ladder variable is used, as shown by columns 2, 4 and 6. This implies that a reduction in output tariffs, which leads to increased import competition, increases producer markups for core products in China.

The coefficient estimates for the interaction between output tariffs and each of the three ladder variables are always positive and significantly different from zero. This implies that the within-firm responsiveness of producer markups to import competition is lower for products farther away from a firm's core competency. In the main specification where log ranking is used as the ladder variable, the point estimates are 0.1596 and 0.1159 when not including and including controls respectively.

We note that the coefficient estimates for the three ladder variables are always negative and significantly different from zero. This implies that products closer to a firm's core competency have higher markups.

TABLE 4.

The effect of output tariffs on markups for different product ladders

	(1)	(2)	(3)	(4)	(5)	(6)
Tariff_output	-1.0230^{***}	-0.7419^{***}	-0.9555^{***}	-0.7082^{***}	-0.8912^{***}	-0.6582^{***}
	(0.1227)	(0.1026)	(0.1187)	(0.0996)	(0.1165)	(0.0986)
Tariff_output× log(Ranking)	0.1596^{***}	0.1159^{***}				
	(0.0389)	(0.0371)				
log(Ranking)	-0.0531^{***}	-0.0511^{***}				
	(0.0062)	(0.0061)				
Tariff_output×Non_core			0.1348^{***}	0.1186^{***}		
			(0.0394)	(0.0360)		
Non_core			-0.0454^{***}	-0.0454^{***}		
			(0.0062)	(0.0059)		
Tariff_output×Buttom					0.0749^{***}	0.0829^{***}
					(0.0275)	(0.0268)
Buttom					-0.0240^{***}	-0.0227^{***}
					(0.0044)	(0.0042)
log(TFP)		1.2801^{***}		1.2929^{***}		1.2962^{***}
		(0.1019)		(0.1019)		(0.1015)
Year Fixed Effect	YES	YES	YES	YES	YES	YES
Firm-Product Fixed Effect	YES	YES	YES	YES	YES	YES
Sector Fixed Effect	YES	YES	YES	YES	YES	YES
Other Controls	NO	YES	NO	YES	NO	YES
Observations	658,403	658,403	658,403	658,403	658,403	658,403
R-squared	0.9572	0.9611	0.9571	0.9610	0.9570	0.9609

4.2. Difference estimator

In this section, we use an alternative econometric approach of computing the difference estimators with lags ranging from 1 to 3 years. We include controls for changes in firm-level characteristics and year fixed effects. However, we remove firm-product and sector fixed effects.

The results of the difference estimations are reported in Table 5. We adopt first-difference and long-difference estimators to evaluate the impact of output tariff changes on markup adjustments. The advantage of this approach is that differencing removes the latent heterogeneity in the model, addressing the omitted variables problems in our panel data model. The results using this method are consistent with those from the main method.

TABLE 5.

The effect of tariffs on markups: difference estimator

	1-year Difference		2-year Difference		3-year Difference	
log(Markup)	(1)	(2)	(3)	(4)	(5)	(6)
Tariff_output	-0.7306^{***}	-0.6577^{***}	-0.5918^{***}	-0.6450^{***}	-0.6244^{***}	-0.6650^{***}
	(0.0757)	(0.0735)	((0.0660)	(0.0642)	(0.0819)	(0.0841)
Tariff_output× log(Ranking)		0.0727^{**}		0.0711^{***}		0.0625^{*}
		0.0329)		(0.0265)		(0.0388)
log(Ranking)		-0.0349^{***}		-0.0276^{***}		-0.0254^{***}
		(0.0048)		(0.0041)		(0.0061)
Year Fixed Effect	YES	YES	YES	YES	YES	YES
Controls	YES	YES	YES	YES	YES	YES
Observations	223,719	223,719	94,589	94,589	39,935	39,935
R-squared	0.0958	0.0988	0.1108	0.1125	0.1211	0.1225

4.3. Long-run effects

In this section, we study the long-run effects of output tariff reductions on markups. Output tariff reductions intensify import competition in the domestic market. In response, domestic firms must improve their production efficiency and improve their product quality to survive. However,it is difficult for firms to significantly improve efficiency or product quality in a short time, so we predict output tariff reductions have lagged effects on markup adjustments.

The results of long-run effects estimation are reported in Table 6. Columns 1, 3 and 5 show the results of Equation (8) with lags of 1 to 3 years of output tariffs and all control variables. The coefficient estimates for output tariffs are always negative and significantly different from zero at the 5% significance level. This implies that import competition has significant long-run effects on firm export markups for at least 3 years.

Columns 2, 4 and 6 report the results of Equation (9) with lags of 1 to 3 years of output tariffs and all control variables but no lags of the Log product ranking. The coefficient estimates for output tariffs are still negative and significantly different from zero. This implies that import competition has long-run effects on markups for core products within firms. The coefficient estimates for the interaction of output tariffs and Log product ranking are positive but only significant for the 1-and 2-year lags. This implies that after year 2, output tariff reductions no longer lead to differences in the markup adjustments of core and non-coreproducts within firms.

TABLE 6.

The effects of tariffs on markups: long-run effects

	1-year Lag		2-year Lag		3-year Lag	
	(1)	(2)	(3)	(4)	(5)	(6)
Tariff_output	-0.2839^{***}	-0.3884^{***}	-0.2257^{**}	-0.3800^{***}	-0.3147^{**}	-0.3828^{***}
	(0.0968)	(0.0962)	(0.1041)	(0.0995)	(0.1383)	(0.1368)
Tariff_output× log(Ranking)		0.1218^{***}		0.1827^{***}		0.0774
		(0.0373)		(0.0626)		(0.0827)
log(Ranking)		-0.0441^{***}		-0.0551^{***}		-0.0401^{***}
		(0.0064)		(0.0109)		(0.0154)
Year Fixed Effect	YES	YES	YES	YES	YES	YES
Firm-Product Fixed Effect	YES	YES	YES	YES	YES	YES
Sector Fixed Effect	YES	YES	YES	YES	YES	YES
Controls	YES	YES	YES	YES	YES	YES
Observations	223,719	223,719	122,647	122,647	66,835	66,835
R-squared	0.9600	0.9601	0.9658	0.9660	0.9725	0.9726

4.4. Robust estimates

In this section, we show the robustness of our results by addressing endogeneity, using alternative measures of firm-product markups and import competition, using firm-specific output tariff, testing the sensitivity of our results to the sample selection, controlling for export tariffs, exchange rates, input tariffs and product-year group fixed effects and eliminating outliers.

4.4.1. Endogeneity

In this subsection, we discuss a potential endogeneity issue for tariffs which could bias estimations from firm fixed-effects models as explained by Amiti and Konings (2007). In our baseline regressions, we include sector and firm-product fixed effects because, from an individual firm's perspective, tariff reductions should be exogeneous. However, it is possible that tariff levels are set subject to lobbying efforts. Industries with more market power (which correspond to higher markups) might be especially able to lobby to raise import tariffs. Therefore, we use instrument variables for output tariffs. Following Brandt et al. (2017), we use the output tariff in 1999 as the instrument variable and the results are shown in Table 7.

To assure the validity of our instrument, we construct two joint tests. The first statistic is derived from a Langrange Multiplier (LM) test, which diagnoses under-identification using the Kleibergen and Paap (2006) rk statistic. The Kleibergen and Paap (2006) rk statistic tests whether an instrument is relevant to the endogenous variable. We reject the null hypothesis of an under-identified model at the 0.1% significance level. The second statistic is derived from the Kleibergen and Paap (2006) Wald test, which checks whether an instrument is weakly correlated with the endogenous variable. The Kleibergen and Paap (2006) Wald F-statistics provide strong evidence to reject the null hypothesis; the first stage is weakly identified at a highly significant level. Therefore, our instrumental variables provide a good fit in the first stage and can be considered as valid instruments in all specifications.

The results shown in Table 7 conform to our previous findings; output tariff reductions lead to significant increases in firm-product markups, and this effect is more profound for core products than for non-core products within multi-product exporters.

TABLE 7.

The effect of tariffs on markups: instrumental variable estimation

	(1)	(2)	(3)	(4)
Tariff_output	-0.8602^{***}	-0.6329^{***}	-0.8962^{***}	-0.6533^{***}
	(0.1173)	(0.1282)	(0.0395)	(0.0379)
Tariff_output× log(Ranking)			0.0318^{*}	0.0231^{*}
			(0.0171)	(0.0133)
log(Ranking)			-0.0344^{***}	-0.0375^{***}
			(0.0027)	(0.0026)
Year Fixed Effect	YES	YES	YES	YES
Firm-Product Fixed Effect	YES	YES	YES	YES
Sector Fixed Effect	YES	YES	YES	YES
Controls	NO	YES	NO	YES
Observations	658,041	658,041	658,041	658,041
R-squared	0.9570	0.9609	0.9572	0.9611
Kleibergen-Paap rk LM $\chi^2(1)$ statistic	$241.4^{\dagger}$	$243.3^{\dagger}$	$244676^{\dagger}$	$245042^{\dagger}$
Weak Instrument (F statistic)	$931.4^{\dagger}$	$946.7^{\dagger}$	$78668^{\dagger}$	$78852^{\dagger}$

Notes: † indicates significance at the 0.1% level ($p - value < 0.001$).

4.4.2. Alternative measures of firm-product markups and import competition

In this subsection, we estimate firm-product markups using an alternative methodology and check the sensitivity of our benchmark results to the new measure. The firm-product markups used in the benchmark regressions are estimated using export values deflated by the industry price index as the output variable. However, it is possible that firms are subject to firm-specific prices and using an industry price index instead of firm-specific prices creates an omitted-variable bias. To solve this omitted-variable problem, we use export quantities at the firm-product level as the output variable. Column 1 in Table 8 reports the estimation results from Equation (9) when using the newly estimated firm-product markups based on export quantities[2]. Our previous conclusions hold.

Because of data limitations, we cannot use the assumption used by De Loecker et al. (2016) that input shares sum up to one across all products when measuring firm-product level markups. We replace this assumption with the one made by Kee and Tang (2016) that the share of inputs allocated to export production is proportional to the share of exports in total sales. To show that this assumption replacement does not drive our results, column 2 of Table 8 reports the results of estimating Equation (9) using the subsample of firms who export all their products (pure exporters). This subsample accounts for approximately 18% of the observations in our baseline sample. In this subsample, we can use the original assumption by De Loecker et al. (2016). Our baseline results still hold.

Output tariff reductions do not reflect the removal of non-tariff barriers, which also inhibit import competition. Following Dhyne et al. (2017), we use import penetration (Imp_ratio) as another proxy for import competition. Columns 3 and 4 report the estimation results for Equation (9) when including firm-product markups estimated using export revenue and export quantities respectively. The coefficient estimates for import penetration are positive and significantly different from zero and the coefficient estimates for the interaction term between import penetration and Log product ranking are significantly negative. This conforms to our benchmark results.

[2]For the remainder of the paper, we only report the robustness estimation results of Equation (9), which is the focus of this paper. We also conducted corresponding robustness tests for Equation (8) and the results always agreed with the benchmark results. Details are available upon request.

TABLE 8.

Robustness: alternative estimates of firm-product markup

	Quantity-based markups	Pure exporters	Import penetration		Firm-specific tariffs	
	(1)	(2)	(3)	(4)	(5)	(6)
Tariff_output	-0.7719^{***}	-0.6149^{***}			-0.7803^{***}	-0.8301^{***}
	(0.1024)	(0.1489)			(0.0533)	(0.0642)
Tariff_output× log(Ranking)	0.1002^{***}	0.1142^{*}			0.2236^{***}	0.2103^{***}
	(0.0388)	(0.0620)			(0.0377)	(0.0404)
Imp_ratio			5.1524^{*}	15.4908^{***}	-0.0575^{***}	-0.0741^{***}
			(2.6506)	(3.4675)	(0.0063)	(0.0071)
Imp_ratio× log(Ranking)			-1.6269^{*}	-11.5926^{***}		
			(0.9115)	(2.0521)		
log(Ranking)	-0.0650^{***}	-0.0483^{***}	-0.0338^{***}	-0.0467^{***}		
	(0.0062)	(0.0103)	(0.0027)	(0.0017)		
Year Fixed Effect	YES	YES	YES	YES	YES	YES
Firm-Product Fixed Effect	YES	YES	YES	YES	YES	YES
Sector Fixed Effect	YES	YES	YES	YES	YES	YES
Controls	YES	YES	YES	YES	YES	YES
Observations	646,783	118512	658,403	646,783	658,403	646,783
R-squared	0.9275	0.9679	0.8826	0.7068	0.9571	0.9248

4.4.3. Firm-specific tariffs

In our main results, we use output tariffs at the CIC-4d industry level to characterize import competition. The reason for this is that we cannot calculate firm-specific output tariffs precisely because we have no data on sales revenue the at firm-product level. The disadvantage of using industry output tariffs is this obscures the heterogeneity in firms facing output tariff reductions even within a narrow industry. Following Yu (2015), we use export revenue at the firm-product level as a proxy for firm-product total sales and calculate a measure of firm-specific output tariffs.

Columns 5 and 6 in Table 8 report the estimation results for Equation (9) when using firm-specific output tariffs instead of industry-level output tariffs and firm-product markups estimated by export revenue and export quantities respectively. The results agree with our benchmark results.

4.4.4. Sensitivity to export tariffs, exchange rates, outliers, trade regimes, input tariffs and more severe fixed effects

To control for the effects of export tariffs faced by firms in export markets, we follow Yu (2015) in building an export tariff index (Tariff_export) and estimate Equation (9) including export tariffs as another control. Column 1 in Table 9 reports the results, which suggest that our benchmark results are unchanged by controlling for export tariffs.

Next, we show that our results are not driven by movements in the exchange rates between the RMB and other currencies. Because the RMB appreciated substantially in late 2005, we exclude observations from 2005 through 2006 and conduct robustness checks based on the pre-appreciation period of 2000 to 2004. The results are reported in column 2 of Table 9. The results are consistent with our previous findings.

Additionally, we dispel misgivings about the potential effects of outliers. Column 3 repeats the benchmark exercises after dropping observations ranked in the top or bottom 2.5 percent according to their firm-product markups. Again, our findings are unchanged.

Amiti and Konings (2007) argue that input tariff reductions play an important role in improving firms' efficiency by lowering import costs and improving access to higher quality inputs. Therefore, we control for the effect of input tariffs on markups to estimate the net effect of output tariffs on markups. The results are reported in column 4. The estimated coefficient for input tariffs is negative and significantly different from zero, implying that input tariff reductions also raise markups. However, the coefficients for output tariffs and the interaction term do not change significantly after controlling for input tariffs.

In the benchmark model, we control for factors that vary across products but not over time. In column 5, we control for all factors that vary both across products and over time. The estimates conform to the previous results.

In China, processing import trade is duty free, so we expect that exporters partly engaged in processing trade will be less affected by output tariff reductions as shown by Yu (2015). In columns 6 and 7, the absolute values of the estimated coefficients in the ordinary subsample are clearly larger than those in the processing subsample. Moreover, the coefficient estimate of the interaction term in the processing subsample is not significantly different from zero. This implies that output tariff reductions do not have different effects on markups for core and non-core products. These results conform to our predictions.

5. MECHANISM

5.1. Price and marginal cost channels

Markups are defined as the ratio of price to marginal cost. We use prices and the estimates for marginal costs to examine the mechanisms behind

TABLE 9.

Other robust estimate results

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Tariff_output	-0.7879^{***}	-0.5771^{***}	-0.6650^{***}	-0.6916^{***}	-0.7219^{***}	-0.7087^{***}	-0.4079^{***}
	(0.1094)	(0.1002)	(0.0972)	(0.1005)	(0.0666)	(0.1099)	(0.0619)
Tariff_output× log(Ranking)	0.1053^{***}	0.1028^{*}	0.1131^{***}	0.1202^{***}	0.1617^{***}	0.1172^{**}	0.0169
	(0.0352)	(0.0533)	(0.0310)	(0.0388)	(0.0344)	(0.0469)	(0.0243)
log(Ranking)	-0.0495^{***}	-0.0448^{***}	-0.0485^{***}	-0.0518^{***}	-0.0562^{***}	-0.0539^{***}	-0.0121^{***}
	(0.0058)	(0.0096)	(0.0053)	(0.0061)	(0.0050)	(0.0069)	(0.0044)
Tariff_export	0.1291						
	(0.1033)						
Tariff_input				-0.3128^{***}			
				(0.0894)			
Year Fixed Effect	YES	YES	YES	YES	YES	YES	YES
Firm-Product Fixed Effect	YES	YES	YES	YES	YES	YES	YES
Sector Fixed Effect	YES	YES	YES	YES	YES	YES	YES
Controls	YES	YES	YES	YES	YES	YES	YES
Product-Year Fixed Effect	NO	NO	NO	NO	YES	NO	NO
Observations	641,462	366,648	625,483	658,403	658,403	541,231	117,172
R-squared	0.9616	0.9717	0.9436	0.9611	0.9731	0.9624	0.8832

the markup changes. We re-run Equations (8) and (9) using prices and marginal costs as the dependent variables.

We first focus on the price regressions, reported in columns 1 and 2 of Table 10. The coefficient on output tariffs is statistically insignificant in column 1, suggesting that export prices are insensitive to output tariff liberalization. However, in column 2, the coefficient estimate of output tariffs is significantly negative. The coefficient on the interaction between output tariffs and Log ranking is positive and significantly different from zero. These results imply that import competition does not have significant overall effects on export prices but does have significant and heterogeneous effects on the export prices of different products within multi-product exporters. Import competition improves export prices for core products and this improvement is lower for products farther away from a firm's core competency; the effect can become negative when a product is far from the firm's core competency. We calculate the threshold ranking from the coefficient estimates from column 2 as 5.5 (exp(0.2417/0.1419)). That is, import competition has a negative effect on export prices for products ranked higher than 5.5.

We now focus on the marginal cost regressions reported in columns 3 and 4 of Table 10. The coefficients on output tariffs in the two columns are always positive and significantly different from zero but the coefficient on the interaction term is insignificant. This implies that output tariff liberalization results in large cost declines but that this effect does not differ significantly across products within a firm.

We note that the sum of the absolute values of the coefficients in columns 1 and 3 of Table 10 equals the coefficient in column 7 of Table 3 and that the sum of the absolute values of the coefficients in columns 2 and 4 of Table 10 equals the coefficient in column 2 of Table 4. Output tariff liberalization raises average export markups mainly because of reductions in marginal cost and heterogeneous markup responses are present because there are heterogeneous prices adjustments within firms.

TABLE 10.

Test of channels of prices and marginal costs

VARIABLES	log(Price)	log(Price)	log(MC)	log(MC)	log(Quality)
	(1)	(2)	(3)	(4)	(5)
Tariff_output	-0.1048	-0.2417^{**}	0.5241^{***}	0.5001^{***}	-0.0436^{**}
	(0.1135)	(0.1205)	(0.1308)	(0.1306)	(0.0187)
Tariff_output× log(Ranking)		0.1419^{**}		0.0260	0.0306^{***}
		(0.0659)		(0.0659)	(0.0077)
log(Ranking)		-0.0909^{***}		-0.0398^{***}	-0.0539^{***}
		(0.0134)		(0.0123)	(0.0015)
Year Fixed Effect	YES	YES	YES	YES	YES
Firm-Product Fixed Effect	YES	YES	YES	YES	YES
Sector Fixed Effect	YES	YES	YES	YES	YES
Controls	YES	YES	YES	YES	YES
Observations	658,403	658,403	658,403	658,403	569,022
R-squared	0.9716	0.9718	0.9735	0.9735	0.9502

5.2. Discussion

Why do output tariff reductions have no significant effect on overall export prices, as indicated by column 1 of Table 10? As pointed out by Melitz and Ottaviano (2008), output tariff liberalization exacerbates competition in domestic markets with little effect on domestic firms' export markets. Therefore, export prices should not be affected directly by import competition. Import competition raises the prices of products close to firms' core competencies but lowers the prices of products far from firms' core competencies. These two effects offset each other, leading to an insignificant overall effect.

Why do output tariff reductions lead to decreases in marginal costs, as indicated by column 3 of Table 10? It is well understood that import competition raises firm productivity (e.g. Yu, 2015; Brandt et al., 2017). Marginal costs fall with higher productivity or efficiency (Melitz, 2003). Therefore, output tariffs have an indirect positive effect on marginal costs through their raising of the productivity of local firms.

We now discuss why import competition has different effects on the markups of products with different rankings. In the Melitz (2003) model, more efficient firms have lower marginal costs, allowing them to set lower prices for their goods. Firms respond to import competition by lowering their marginal costs and prices. Antoniades (2015) includes endogenous quality choice and endogenous markups in the Melitz (2003) model. He finds that firms can also respond to import competition by raising their scope for quality differentiation, which enables firms to set higher prices for higher quality products. If firms decide to invest in upgrading quality, they can avoid import competition by producing higher quality products (Aghion et al., 2005). Firms who do this can set even higher prices because consumers prefer higher quality products and are willing to spend more money on them. Eckel et al. (2015) study this question in the framework of multi-product firms. In their model with flexible manufacturing, a firm's core competence has lower costs. Therefore, firms either choose to produce more of those products without upgrading quality or to invest in improving quality because of higher margins on core products. These two choices lead to two completely different core competence patterns. The former is termed "cost-based competence" and corresponds to the case where a firm's core products are sold at lower prices to induce consumers to buy more. As a result, the profile of prices across a firm's products is inversely correlated with its profile of sales. The other pattern is named "quality-based competence" and corresponds to the case where the dominant effect comes from firms investing in enhancing the quality of their core products. As a result, these products command higher prices and so the profile of prices across a firm's products is positively correlated with its profile of sales.

If multi-product exporters conform to the quality-based competence pattern, we can explain why firms increase prices for products closer to their core competency when faced with import competition. In the quality-based competence pattern, multi-product firms choose to invest in enhancing the quality of core products. Products closer to the firm's core competency are of higher quality than those farther away from the firm's core competency. The literature finds that firms tend to improve the quality of products which have higher initial quality (Amiti and Khandelwal, 2013). As a result, firms raise the quality, prices and markups more for products closer to their core products with higher initial quality. Wang and Xie (2018) also find evidence that openness to trade shifts resources toward fast-growing sectors at more aggregate level.

Following Eckel et al. (2015), we build the following model to test the core competency pattern of Chinese multi-product exporters.

$$\ln P_{fgt} = \delta_0 + \delta_1 \log(\text{Ranking}_{fgt}) + \omega_{ft} + \nu_{gt} + \varepsilon_{fgt} \tag{10}$$

The dependent variable is the Log of the unit value of product g from firm f at time t. Ranking_{fgt} has the same meaning as in Equation (9). ω_{ft} is a firm-year fixed effect, ν_{gt} is a product-year fixed effect and ε_{fgt} is a stochastic error term. The results are reported in Table 11. The coefficient estimates for Log ranking are significantly negative. This implies that the profile of prices across a firm's products is positively correlated with its profile of sales, proving that Chinese multi-product exporters use a quality-based competency strategy.

Furthermore, we re-run Equation (10) using quality as the dependent variable. The coefficient on Log ranking is significantly negative. This indicates that products closer to a firm's core competency have higher quality than those farther away, suggesting that multi-product exporters in China invest in their quality.

Finally, we re-run Equation (9) replacing the dependent variable with product quality. The results are reported in column 5 of Table 10. The coefficients on output tariff and on the interaction term are significantly negative and positive respectively. This conforms to our prediction that firms respond to import competition by raising quality more for products that are closer to their core products and that have higher initial quality.

5.3. Placebo test: effects of tariffs on firm-level markup

Reductions in import tariffs on final goods intensify competition in the domestic market by allowing foreign goods more access. Domestic firms respond by lowering prices and markups, which are pro-competitive effects. Several empirical studies find evidence of pro-competitive effects (for example, Goldar and Anggarwal, 2005; Noria, 2013; De Loecker et al., 2016; Brandt et al., 2017; Fan et al., 2018). Note that the markups we measure only reflect the pricing ability above marginal costs of products in the

TABLE 11.

Price profiles for multi-product exporters in China

	log(Price)	Quality
	(1)	(2)
log(Ranking)	-0.0875^{***}	-0.0753^{***}
	(0.0023)	(0.0003)
Firm-Year Fixed Effects	YES	YES
Product-Year Fixed Effects	YES	YES
Observations	658,403	569,022
R-squared	0.8310	0.7543

export market. Import tariff reductions do not affect competition in the export market (Melitz and Ottaviano, 2008). Therefore, pro-competitive effects may not exist in the export market. However, import tariff reductions still affect export markups through the channels of marginal cost reduction and quality upgrading. As shown by Table 10, output tariff reductions decrease marginal costs and improve the qualities of core products within multi-product exporters. These two effects lead to significant increases in the markups of core products. The marginal cost effects show no significant differences between core products and non-core products but the quality upgrading effects decrease significantly with a product's distance from core products. Therefore, the markup increasing effect of output tariff reductions decreases with a product's distance from coreproducts.

To compare our results with the literature, we use firm-level markups as the explained variable to test for pro-competency effects. We divide the whole sample into exporters and non-exporters to test whether import competition has different effects on the markups of exporters and of non-exporters. Furthermore, we also divide CIC 4-digit industries into heterogenous industries and homogeneous industries following Rauch (1999). Compared to firms in homogeneous industries, firms in heterogeneous industries are more likely to invest in improving product quality and use the quality-based competitive strategy (Kugler and Verhoogen, 2011; Manova and Zhang, 2012; Eckel et al., 2015). We have three predictions. First, output tariff reductions decrease firm-level markups because of pro-competitive effects and this effect is more profound for non-exporters. Second, output tariff reductions increase markups for firms in heterogeneous industries and this effect is more profound for exporters. Third, output tariff reductions decrease markups for firms in homogeneous industries and this effect is more profound among non-exporters. The estimation results shown in Table 12 confirm our predictions.

TABLE 12.

Firm-level estimation results

	The whole industries			Heterogeneous industries			Homogeneous industries		
	All	Exporters	Non-exporters	All	Exporters	Non-exporters	All	Exporters	Non-exporters
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Tariff_output	0.1008***	0.0285	0.1219***	−0.0609**	−0.1453***	−0.0106	0.1880***	0.1648***	0.3886***
	(0.0158)	(0.0271)	(0.0147)	(0.0263)	(0.0349)	(0.0247)	(0.0248)	(0.0236)	(0.0396)
log(TFP)	0.1018***	0.1303***	0.0977***	0.2301***	0.3004***	0.2109***	0.0524***	0.0516***	0.0554***
	(0.0088)	(0.0157)	(0.0089)	(0.0179)	(0.0157)	(0.0191)	(0.0133)	(0.0139)	(0.0121)
log(Wage)	−0.0242***	−0.0208***	−0.0248***	−0.0241***	−0.0172***	−0.0253***	−0.0262***	−0.0262***	−0.0292***
	(0.0007)	(0.0012)	(0.0008)	(0.0008)	(0.0013)	(0.0008)	(0.0016)	(0.0016)	(0.0022)
log(Subsidy)	0.0295***	0.0394***	0.0274***	0.0393***	0.0434***	0.0376***	0.0139***	0.0135***	0.0189
	(0.0030)	(0.0078)	(0.0031)	(0.0045)	(0.0091)	(0.0048)	(0.0048)	(0.0048)	(0.0128)
Tax	−0.0092***	−0.0163***	−0.0074***	−0.0102***	−0.0123***	−0.0094***	−0.0043	−0.0027	−0.0121***
	(0.0012)	(0.0019)	(0.0013)	(0.0010)	(0.0019)	(0.0009)	(0.0030)	(0.0031)	(0.0040)
log(Age)	0.0039***	0.0073***	0.0031***	0.0060***	0.0098***	0.0050***	−0.0001	0.0001	−0.0026*
	(0.0005)	(0.0006)	(0.0005)	(0.0005)	(0.0005)	(0.0006)	(0.0009)	(0.0010)	(0.0013)
Interest	0.0304***	0.0428***	0.0271***	0.0333***	0.0415***	0.0304***	0.0230***	0.0219***	0.0295***
	(0.0010)	(0.0018)	(0.0011)	(0.0010)	(0.0020)	(0.0011)	(0.0019)	(0.0020)	(0.0034)
FOE	0.0526***	0.0574***	0.0487***	0.0413***	0.0455***	0.0379***	0.0731***	0.0668***	0.0711***
	(0.0016)	(0.0015)	(0.0017)	(0.0014)	(0.0013)	(0.0015)	(0.0031)	(0.0035)	(0.0032)
Firm Fixed Effect	YES	YES	YES	YES	YES	YES	YES	YES	YES
Year Fixed Effect	YES	YES	YES	YES	YES	YES	YES	YES	YES
Observations	1,197,329	328,840	868,489	842,860	271,923	570,937	354,469	297,552	56,917
R-squared	0.8090	0.8340	0.7994	0.8609	0.8995	0.8469	0.7794	0.7697	0.8260

Column 1 in Table 12 confirms the existence of pro-competitive effects; output tariff reductions decrease the markups of domestic firms. The other columns in Table 12 show that firm export status and the competitive strategy a firm uses (proxied for by industry differentiation degree) play a key role in determining the effect of output tariff reductions on markups. Therefore, export status and the competitive strategy a firm uses are two important factors that need to be considered when studying the effects of trade policies such as output tariff reductions. We focus on export markups and find that output tariff reductions increase export markups through marginal cost reduction effects and quality upgrading effects. Moreover, Chinese multi-product exporters use quality-based core competency strategies, and Chinese multi-product firms tend to upgrade quality more for core products than for non-core products as shown in Table 11. Heterogeneity in the effects lead to heterogeneity in the adjustments of markups within multi-product exporters. Therefore, our results do not contradict those of other studies.

6. CONCLUSIONS

We uncover patterns in the markup adjustments of multi-product firms facing import competition. Our results strongly suggest that output import tariff reductions can substantially increase firms' market power in export markets, especially for products closer to a firm's core competency. We document two stylized facts. One, regarding the features of Chinese multi-product exporters, is that core products dominate the export market. The other concerns markups dynamics between 2000 and 2006, a period of rapid output tariff cuts, and is that the markups of core products increase more than those of non-core products. We devise two econometric models based on these stylized facts. After estimating these models based on Chinese production and customs data during China's WTO accession period, we find strong and robust evidence that increased import competition raises overall export markups and that there is difference in the effect depending on if a product is a core product or a peripheral product for the firm. We investigate the underlying mechanisms empirically, discovering that the quality-based competency strategy Chinese multi-product exporters use drives these heterogeneous effects.

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