NBER WORKING PAPER SERIES

TRADE LIBERALIZATION, QUALITY, AND EXPORT PRICES

Haichao Fan
Yao Amber Li
Stephen R. Yeaple

Working Paper 20323
http://www.nber.org/papers/w20323

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
July 2014

We thank Mary Amiti, Keith Head, Amit Khandelwal, Thomas Chaney, Peter Schott, Michael Waugh, Robert Staiger, Hiroyuki Kasahara, Frédèric Warzynski, Kalina Manova, Ann Harrison, Lorenzo Caliendo, Roberto Samaniego, Ping Lin, Larry Qiu, Jiandong Ju, Edwin Lai, David Cook, Pengfei Wang, the participants at numerous seminars. Stephen Yeaple would also like to thank the Human Capital Foundation for support. Yao Amber Li gratefully acknowledges financial support from the Research Grants Council of Hong Kong, China (General Research Funds and Early Career Scheme GRF/ECS Project no. 646112). The views expressed herein are those of the authors and do not necessarily reflect the views of the National Bureau of Economic Research.

Trade Liberalization, Quality, and Export Prices
Haichao Fan, Yao Amber Li, and Stephen R. Yeaple
NBER Working Paper No. 20323
July 2014
JEL No. F0,F1,F14

ABSTRACT

This paper presents theory and evidence from highly disaggregated Chinese data that tariff reductions induce a country's producers to upgrade the quality of the goods that they export. The paper first documents two stylized facts regarding the effect of trade liberalization on export prices and its relation with product differentiation. Next, the paper develops a simple analytic framework that relates a firm's choice of quality to its access to imported intermediates. The model predicts that a reduction in the import tariff induces an incumbent importer/exporter to increase the quality of its exports and to raise its export price in industries where the scope for quality differentiation is large while to lower its export price in industries where the scope for quality differentiation is small. The predictions are consistent with the stylized facts based on Chinese data and robust to various estimation specifications.

Haichao Fan
School of International Business Administration
Shanghai University of Finance and Economics
fan.haichao@mail.shufe.edu.cn

Yao Amber Li
Department of Economics
Hong Kong University of Science and Technology
1 University Road, Clear Water Bay, Kowloon
Hong Kong SAR
yaoli@ust.hk

Stephen R. Yeaple
Department of Economics
The Pennsylvania State University
520 Kern Building
University Park, PA 16802-3306
and NBER
sry3@psu.edu

1 Introduction

Over the last twenty years many developing countries have abruptly and substantially lowered tariffs and scaled back other trade barriers. This policy change has created the opportunity to observe the extent to which trade barriers affect the behavior of individual firms. A rapidly growing literature shows that trade liberalization has led to a surge in imports of intermediate inputs and that the improved access to foreign made inputs has had a large impact on firm productivity and the scope of product offerings at the firm level.[1] Given the transformative impact of trade liberalization on documented productivity, it is natural to consider the effect trade barriers may have had on firms' decisions regarding the quality of the products that they produce.

This paper asks whether lower tariffs on imported intermediates induce firms to upgrade the quality of the goods that they export. Such a link between trade liberalization and export quality is important because the production of high-quality goods is often viewed as a pre-condition for export success and for economic development (Amiti and Khandelwal, 2013).[2] To address this question, we present theory and evidence from highly disaggregated Chinese linked firm-level production data and customs data that tariff reductions induced Chinese exporters to upgrade the quality of the goods that they export, particularly in industries where the scope for quality variation is high. Chinese firms that enjoy the largest tariff reductions are observed to raise the prices of their exports to existing export markets and to shift their export volumes geographically from countries where demand for high quality goods is relatively weak to markets where demand for high quality goods is strong.

We first document two stylized facts regarding the relationship between the arguably exogenous tariff reductions imposed on China by accession to the World Trade Organization (WTO) and the export prices for ordinary (non-processing) Chinese incumbent exporters. We show that in industries in which products are highly differentiated firms raise their export prices in response to a fall in the tariffs they pay on imported inputs. In industries featuring primarily homogeneous goods, the pattern is ambiguous or even reversed: a reduction in imported intermediate tariffs results in lower prices.

We explain these facts in the context of a simple model of firm quality choice. The model generates linear equations that relates changes in the export prices charged by the firm and changes in the output quality produced by the firm to changes in the tariffs of the set of goods imported by the firm. Importantly, the magnitude (and potentially the sign) of the coefficient on import tariffs depends on the scope for quality heterogeneity within the industry.

We then estimate our model using panel data for Chinese firms over the period 2001-2006. The unilateral trade liberalization imposed on China as a condition for WTO accession provides a source

[1] For instance, greater access to foreign intermediate inputs has been associated with higher firm-level productivity (Amiti and Konings, 2007, among others), and other firm-level adjustments such as domestic product scope (e.g., Goldberg et al., 2010).

[2] Schott (2004) shows that international specialization is less about the industrial composition of a country's exports and is more about the level of quality of a fixed set of goods.

of exogenous variation that allows us to estimate the impact of tariff reduction on firm export prices.[3] Another advantage of our data is that it allows us to create very precise firm-level measures of import tariff reductions and so allow us to capture the true extent of within industry heterogeneity in the size of the direct impact of trade liberalization on a firm's marginal costs.[4] By using long-differences within firm-destination-product categories, we eliminate many potential sources of spurious correlation. We also address the potential endogeneity of firm-level import behavior using instrumental variables.

Our coefficient estimates confirm the main predictions of our model. First, firms that face larger reduction in the tariffs imposed on their imported inputs increase rather than decrease their export prices when the good in question is in an industry where the scope for quality differentiation is large but not when the exported good is in an industry where the scope for quality differentiation is small. This result is robust to the inclusion of a wide range of time-varying firm controls, alternative measures of tariff liberalization, and samples confined to only small firms that have little room to adjust mark-ups. Importantly, the result does not obtain in a placebo sample of export processing firms that were never subjected to tariffs. In addition, we present indirect evidence at the extensive margin of quality upgrading: firms experiencing large reductions in tariffs on their imported intermediates tend to enter new markets with relatively highly priced goods and exit markets where prices had tended to be low.

Our paper contributes to a vibrant literature that links improved access to imported intermediate inputs to superior firm performance. Dimensions along which superior performance has been measured include improved total factor productivity (Amiti and Konings, 2007; Kasahara and Rodrigue, 2008; Halpern et al., 2011; Gopinath and Neiman, 2011), expanded product scope (Goldberg et al., 2010), and quality upgrading (Amiti and Khandelwal, 2013).

Within this literature, our paper is most closely related to Amiti and Khandelwal (2013) who compute measures of industry-level quality by export market and who show that a tariff reduction that leads to greater competition in the home market is associated with an increase in export quality. While also focused on quality and prices in export markets, our paper differs from Amiti and Khandelwal (2013) along several dimensions. First, while Amiti and Khandelwal (2013) focus on the effect on the competition effects of tariff reductions in output on quality choice, our focus is on the effect of tariff reductions on inputs. Second, while we focus on the experience of just one country, our data allow us to eliminate compositional effects by relating firm output quality responses to an exogenous shock at product-destination level. Third, our measures of the extent of trade liberalization take into account heterogeneity across firms in the magnitude of the shock and allows for the effects of trade liberalization to vary across industries that differ in their scope for quality upgrading. Fourth, we document how individual firms respond to improved access to imported intermediates by shifting

[3] As is well known, China has long enjoyed MFN treatment by major trading partners prior to joining the WTO. For some trading partners, the MFN treatment was somewhat precarious and so may have discouraged longer-term relationships between foreign partners and Chinese firms.

[4] For robustness, we also consider more conventional measures of tariff reduction using IO table coefficients as weights. Doing so generates qualitatively similar results.

their export sales to markets where demand for high quality goods is strong.

Our paper is also closely related to a literature that relates output quality to imported inputs. An important contribution in this literature is Manova and Zhang (2012a) who establish many facts concerning the pricing decisions of Chinese firms. Most important for our research is their observation that firms that pay more for their imported inputs charge consistently higher prices for their exports while being more successful in export markets as measured by export revenue and the diversity of export destinations.[5] The key papers in this literature, which also include Verhoogen (2008) and Kugler and Verhoogen (2009, 2012), are more geared toward understanding in greater detail the nature of selection across firms into different activities. Our contribution to this literature is to go beyond cross sectional comparisons among firms to carefully investigate the causal impact of trade liberalization on firm output quality holding fixed firm identities.[6]

The remainder of this paper is organized into eight sections. Section 2 describes the data and Section 3 documents the stylized facts. To explain the stylized facts, Section 4 presents a trade model with heterogeneous firms, featuring endogenous product quality and highlighting the difference between goods with large and small scope for quality differentiation. Section 5 introduces the strategy of the empirical analysis and the measurement issues. Section 6 presents the main results and also indirect evidence on extensive margins of exports. Sections 7 and 8 further report more statistical and conceptual robustness checks, respectively. The final section concludes.

2 Data

Our analysis of the effects of tariff reduction on export quality relies on data extracted from three sources. First, firm-product-level export and import data is obtained from China's General Administration of Customs. Second, product-level tariff data is obtained from the World Trade Organization. Finally, measures of the characteristics of Chinese firms are obtained from the National Bureau of Statistics of China (NBSC). We briefly discuss the construction of our dataset but leave the details to Appendix A.

China's General Administration of Customs provides us with the universe of all Chinese trade transactions by importing and by exporting firm at the HS 8-digit level for the years 2001-2006. Each trade transaction includes import and export values, quantities, products, source and destination countries, custom's regime (e.g. "Processing and Assembling"and "Processing with Imported

[5] Kugler and Verhoogen (2009) find a similar pattern among Colombian manufacturing firms. Further, they also show that among the inputs purchased by firms, those that were imported were more expensive, suggesting that they are indeed of higher quality than domestic inputs. These facts are further elaborated in Kugler and Verhoogen (2012) who argue that unit values for inputs and outputs for Colombian firms suggest that the ability to produce high quality output from high quality inputs is a key characteristic of successful firms.

[6] In this sense our paper is related to Verhoogen (2008) who establishes that firms that are induced to export increase their output quality. Of course, quality choice in that paper is driven by real exchange rate changes rather than by tariff reductions.

Materials"), type of enterprise (e.g. state owned, domestic private firms, foreign invested, and joint ventures), and contact information for the firm (e.g., company name, telephone, zip code, contact person).[7] We selected a subsample of firms from this dataset that met several requirements. First, as our interest is the effect of tariff reduction on export quality, we excluded from our main analyses export processing firms because these firms never had to pay tariffs in the first place. As a robustness check, however, we consider a sample of export processors for a placebo analysis. Second, we also exclude all intermediary firms from the customs data, following the similar method as in Ahn et al. (2011) and Tang and Zhang (2012). The trade data is then aggregated to firm-product-country-year. We have aggregated the data to the HS 6-digit level so as to be able to concord it consistently over time because China changed HS 8-digit codes in 2002, and the concordance between the old and new HS 8-digit codes (before and after 2002) is not available. To ensure the consistency of the product categorization over time (2001-2006), we adopt HS 6-digit codes maintained by the World Customs Organization (WCO) and use the conversion table from the UN Comtrade to convert the HS 2002 codes into the HS 1996 codes. For the export price, we compute unit values by dividing deflated export values by physical quantities.[8]

The Chinese import tariff data are obtained from the WTO website, available as MFN (most-favored nation) applied tariff at the HS 8-digit level and our sample period is 2001-2006.[9] To match our trade data, we aggregate the tariff data to the HS 6-digit level using each HS8 tariff line within the same HS6 code. In our analysis, product/variety refers to either HS6 product category or HS6-destination country combination.

Our analysis uses additional information about the characteristics of Chinese exporters for two reasons. First, we use a number of firm characteristics, such as TFP, employment, and capital intensity, as controls. Second, we will want to explore how the size of the effect of import tariff reduction on export quality varies with firm characteristics. We therefore merge the firm-product-level trade data from Chinese Customs with firm-level production data, collected and maintained by the National Bureau of Statistics of China (NBSC). This database covers all state-owned enterprises (SOEs), and non-state-owned enterprises with annual sales of at least 5 million RMB (Chinese currency). The NBSC database contains detailed firm-level information of manufacturing enterprises in China, such as employment, capital stock, gross output, value added, firm identification (e.g., company name, telephone number, zip code, contact person, etc.), and complete information on the three major accounting statements (i.e., balance sheets, profit & loss accounts, and cash flow statements).

We use the contact information of manufacturing firms to match the firm-product-level trade data from the Chinese Customs Database to the NBSC Database.[10] Compared with all the exporting and

[7] China's customs data contain only realized transactions and not the "reported" transactions from invoice records. As such we are not concerned about the possibility of fake invoicing.

[8] We deflate the export value using output deflators and the import value using input deflators from Brandt et al. (2012). The deflator is at 4-digit CIC (Chinese industrial classification) industry level (see appendix A for more details).

[9] The tariff data are available at http://tariffdata.wto.org/ReportersAndProducts.aspx.

[10] In the NBSC Database, firms are identified by their corporate representative codes and contact information. While

importing firms under the ordinary trade regime reported by the Customs Database, the matching rate of our sample (in terms of the number of firms) covers 45.3% of exporters and 40.2% of importers, corresponding to 52.4% of total export value and 42% of total import value reported by the Customs Database. Compared with the manufacturing exporting firms in the NBSC Database, the matching rate of our sample (in terms of the number of firms) varies from 54% to 63% between 2001 and 2006, which covers more than 60% of total value of firm exports in the manufacturing sector reported by the NBSC Database. We cannot compare our sample with the NBSC Database regarding the number of importers and total import value because the NBSC Database does not contain any information on firms' imports. To explore whether the reduction in the sample due to the merging of the databases is an issue, we compare the relationship between export prices and quality and import tariffs in the full sample of the Customs Database to the smaller merged sample and find no significant differences.

3 Stylized Facts

This section documents two key facts concerning the relationship between Chinese trade liberalization and Chinese export prices. We proxy for prices with unit values.[11] As China joined the WTO in December of 2001, we use the data from 2001 to represent the pre-liberalization period, and then use the data from 2006 to represent the post-liberalization period. During 2001-2006, most products in China experienced substantial tariff reductions (see Figure A.1 in Appendix). We define a product at either HS6 or HS6-destination combination. Contrasting the changes in the measures of export prices at different levels of aggregation allows us to observe how changes in the composition of export destinations affect the average price received by exporters.

First, we examine the changes in (log) export prices by the incumbent exporting/importing firms that are present in both pre- and post-liberalization periods via the levels of export prices in both 2001 and 2006 (see Table 1). We divide firms into two groups, namely, high-productivity firms and low-productivity firms, according to whether their labor productivity (value added per worker) is above or below the median in the pooled sample in 2001.[12] Within each group, we compute the median and mean (log) export price per product per firm in 2001 and in 2006 as well as the percentage change in parentheses.

Table 1 shows that on average, within each group of firms (i.e., either more productive or less productive firms), the price levels in 2006 are always higher than the price levels in 2001. This suggests that from 2001 to 2006 those incumbent firms all raise unit value export prices. Note that unit value export prices are computed by deflating the export value using the domestic deflator so

in the Customs Database, firms are identified by their corporate custom codes and contact information. These two coding systems are neither consistent, nor transferable with each other.

[11] This is common within the literature. According to (Feenstra and Romalis, forthcoming) "the observed differences in export unit-values are attributed predominantly to quality".

[12] Using estimated total factor productivity (TFP) by various methods as group criteria yields similar patterns.

Table 1: Export Prices in 2001 and 2006

	Productivity ≤50th (in 2001)		Productivity >50th (in 2001)	
	(1)	(2)	(3)	(4)
	2001	2006	2001	2006
Export Price (HS6)				
Per Firm-product, median	1.28	1.46 (14.06%)	1.52	1.63 (7.24%)
Per Firm-product, mean	1.41	1.62 (14.89%)	1.90	1.99 (4.74%)
Export Price (HS6-country)				
Per Firm-product-country, median	1.25	1.41 (12.80%)	1.53	1.59 (3.92%)
Per Firm-product-country, mean	1.36	1.55 (13.97%)	1.90	1.98 (4.21%)

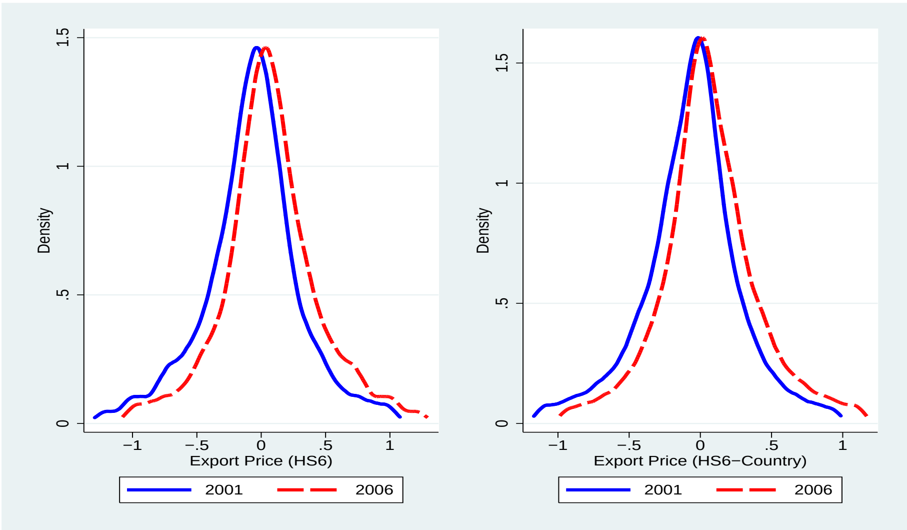

Figure 1: Distribution of Export Prices in 2001 and 2006

firms increase export prices relative to the domestic deflator after trade liberalization. Also, in the same year, the price levels of high-productivity firms are always higher than those of low-productivity firms.

To further illustrate the shifting pattern of export prices from 2001 to 2006, we plot the distributions of the export price (in natural logarithm). In the left panel of Figure 1, we include only firm-HS6 product pairs that are present in both years for the distribution of prices. Then we compare export prices over time by regressing them on firm-HS6 product fixed effects and plotting the residuals. Analogously, in the right panel of Figure 1, we include only firm-product-country combinations that are present in both years. Then we compare export prices for each combination over time by regressing them on firm-product-country fixed effects and plotting the residuals. To ensure that our results are not driven by outliers, we remove outliers in the bottom and top 2nd percentiles. The distributions of export prices for both HS6 product and HS6-country move to the right in 2006. Thus, we summarize the first stylized fact as follows:

Stylized fact 1. ***Firms tend to raise export prices in the post-liberalization period at both***

product-destination level and product level.

Table 2: Change in Export Prices (from 2001 to 2006): Differentiated vs. Homogeneous Products

	(1) Whole sample	(2) Differentiated goods	(3) Homogeneous goods
Change in Export Prices (HS6):			
Per Firm-product, median	11.80%	14.10%	-1.19%
Per Firm-product, mean	15.72%	17.35%	3.43%
Change in Export Prices (HS6-country):			
Per Firm-product-country, median	9.14%	10.36%	-0.02%
Per Firm-product-country, mean	13.30%	14.68%	0.90%

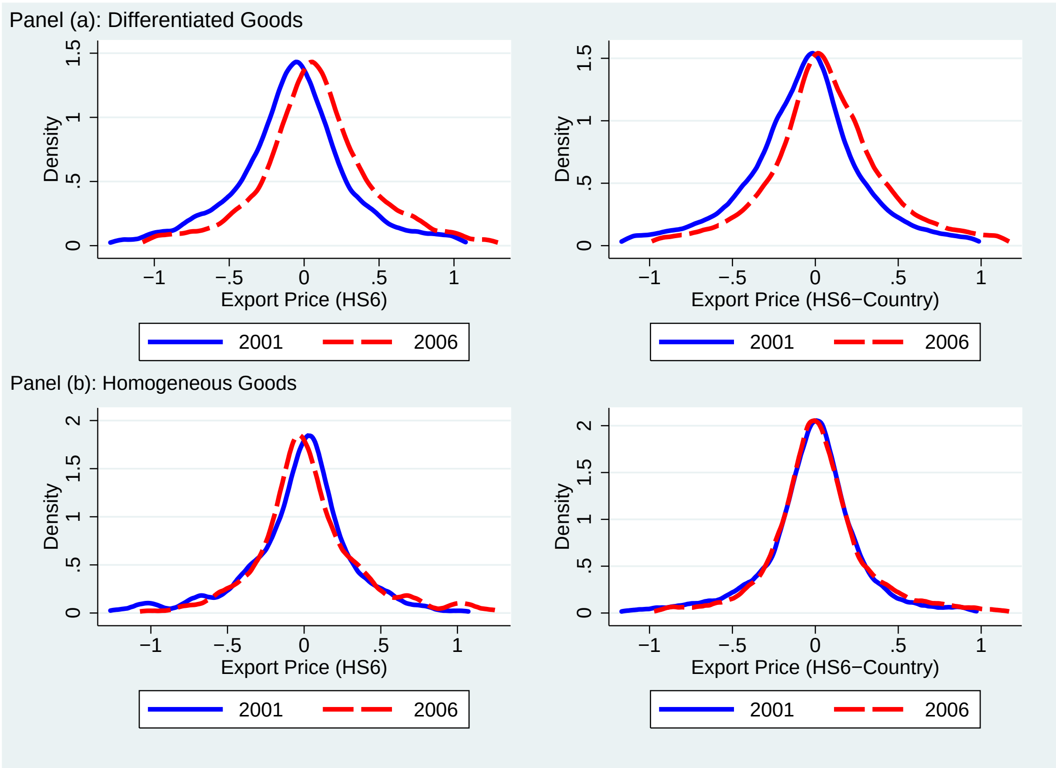

Figure 2: Distribution of Export Prices by Product Differentiation (2001 vs. 2006)

Second, to explore whether the effect of trade liberalization on prices depends on product differentiation, we divide products into two groups: products with large scope for quality differentiation and products with small scope for quality differentiation. Adopting Rauch's product classification (Rauch, 1999), we use differentiated goods and homogeneous goods as proxies for the above two groups, and compute the change in export prices for these two groups of products. Table 2 shows that the price changes of differentiated goods are significantly larger than those of the whole sample and of homogeneous goods, while the price changes in homogeneous goods are ambiguous. To further illustrate the time it takes to adjust price, we also compute the average price change year by year (see Table A.1 in Appendix) and find that the price responses clearly ascend with longer time intervals for the whole sample and for differentiated goods. Figure 2 also presents the differential effect of product differentiation on price distributions: the export prices of differentiated goods significantly increase from 2001 to 2006 (see Panel (a)); while the export prices of homogeneous goods nearly remain unchanged over time, and in part of the distribution (at HS6 level) even decrease after trade liberalization (see Panel (b)). This suggests that the effect of tariff reduction on export prices depends on the scope for product differentiation. The result is summarized as the following finding:

Stylized fact 2. ***In the post-liberalization period, export prices in industries where the scope for quality differentiation is large tend to increase significantly while the change in export prices in industries associated with small scope for quality differentiation is nonsignificant or even ambiguous.***

4 A Model of Export Price and Quality

In this section, we provide a simple, partial equilibrium model to organize our econometric analysis. We consider the behavior of a firm that is sufficiently productive to incur fixed costs to both export a final good and to import intermediate inputs. A reduction in the tariff on imported intermediate inputs lowers the firm's marginal costs on its existing set of imported intermediates (intensive margin) and induces the firm to expand the set of varieties imported (extensive margin). The resulting reduction in the firm's marginal cost has effects that are similar to an increase in the firm's underlying productivity. We allow the firm to choose the quality of the final good that it exports. Higher quality increases demand but comes at the cost of higher marginal costs of production. When goods are sufficiently differentiated in terms of quality, the impact of a tariff reduction on imports is an increase in quality of the export that is sufficiently large that the price of exports increases. When goods are relatively homogeneous, quality increases but by a small enough amount that the price charged by the exporter falls.

4.1 Assumptions

As we are interested in how firms behave both within and across industries, we consider the following system of preferences:

$$U = \sum_{i}^{I} \nu_i \ln \left[\int_{\omega \in \Omega_i} q(\omega)^{\frac{\eta_i}{\sigma_i}} x(\omega)^{\frac{\sigma_i - 1}{\sigma_i}} d\omega \right]^{\frac{\sigma_i}{\sigma_i - 1}},$$

where ν_i is the share of industry i in total expenditure, $q(\omega)$ is a measure of **quality** of variety ω, $x(\omega)$ is the quantity of variety ω consumed, $\sigma_i > 1$ is the elasticity of substitution across varieties of good i, $\eta_i > 0$ is a measure of the scope for quality differentiation, and Ω_i is the set of varieties available of good i. These preferences imply that in a market in which aggregate expenditure is E, the demand for variety ω in industry i is

$$x_i(\omega) = \nu_i E P_i^{\sigma_i - 1} q(\omega)^{\eta_i} p(\omega)^{-\sigma_i}. \tag{1}$$

where P_i is the industry-level price index that is exogenous from the point of view of individual firms.

Firms are heterogeneous in terms of their productivity with the productivity of the firm producing variety ω given by $\phi(\omega)$. Final output of variety ω is created using bundles of primary factors, $L(\omega)$, and a composite intermediate input $M(\omega)$ that is firm-specific. The production technology for a firm of productivity $\phi(\omega)$ in industry i producing a variety with quality $q(\omega)$ is given by

$$Y_i(\omega) = \chi \phi(\omega) q(\omega)^{-\alpha} L(\omega)^{1-\mu} M_i(\omega)^{\mu}, \tag{2}$$

where $\mu \in (0,1)$, $\chi = \mu^{\mu}(1-\mu)^{1-\mu}$, and $\alpha > 0$ implies that a higher quality variety (those with a wide range of attributes) require more physical inputs to generate the same level of output as a lower quality variety. The composite intermediate input is costlessly assembled from a continuum of intermediates that are indexed by z according to the production function

$$M_i = \Psi_i \exp\left(\int_0^{\infty} b_i(z) \ln m(z) dz\right) \tag{3}$$

where $\Psi_i = \exp\left(\int_0^{\infty} b_i(z) \ln b_i(z) dz\right)$, $m(z)$ is the quality adjusted level of input z, and the cost shares $b_i(z)$ satisfy $\int_0^{\infty} b_i(z) dz = 1$.

Product design incurs fixed costs and these fixed costs depend on the number of attributes that the firm chooses to build into the variety. We assume that these fixed costs, measured in terms of bundles of the primary inputs is given by fq^{β_i}. The industry subscript on $\beta_i > 0$ indicates that given the nature of goods in some industries, designing products with a larger number of attributes desired by consumers differs. The higher is β_i the more difficult it is to design products that consumers value more. Hence, a large value of β_i or a low value of η_i indicate that the scope for quality differentiation is limited.

4.2 Implications

Choosing a bundle of primary factors as the numeraire, the marginal cost of production of a variety of final output of a firm of productivity ϕ operating in industry i facing technology given by (2) and (3) is

$$C_i(q, P_i^m, \phi) = \frac{q^{\alpha}}{\phi} (P_i^m)^{\mu} \tag{4}$$

where P_i^m is the price of the composite intermediate input. For a cost minimizing firm, the price of the composite intermediate is given by

$$P_i^m = \exp\left(\int_0^{\infty} b_i(z) \ln c_m(z) dz\right),$$

where $c_m(z)$ is the lowest quality-adjusted cost input available to the firm. The cost to the firm of an intermediate of type z depends on whether the intermediate was purchased from a domestic supplier or from a foreign supplier.[13] If the firm purchases intermediate z locally, it pays the domestic unit price $c_m^d(z)$. Alternatively, the firm may incur a fixed cost, f_m, measured in terms of primary factors that gives the firm access to the market for foreign produced inputs. If the firm imports the intermediate z, then it must first pay the international unit price of $c_m^f(z)$ and then pay tariffs of $(\tau - 1)\, c_m^f(z)$, where $\tau > 1$ is one plus the tariff rate. We assume that foreign producers have a comparative advantage in low z goods and domestic producers have a comparative advantage in high z goods. Formally, define $A(z) = c_m^f(z)/c_m^d(z)$. We assume that $A(0) < 1$, $A'(z) > 0$, and $\lim_{z\to\infty} A(z) > 0$. Firm optimization requires that $c_m(z) = \min(\tau c_m^f(z), c_m^d(z))$, and so we can define a cutoff intermediate z^* such that $z < z^*$ are imported and $z > z^*$ are purchased locally, where

$$\tau A(z^*) = 1. \tag{5}$$

It follows that the cost of a bundle of imported intermediates is given by

$$P_i^m = \exp\left(\int_0^{z^*} b_i(z) \ln\left(\tau c_m^f(z)\right) dz + \int_{z^*}^{\infty} b_i(z) \ln c_m^d(z) dz\right). \tag{6}$$

Conditional on its cost-minimizing choice on the source of intermediate inputs, the firm chooses its price, p, and its quality, q, to maximize its export profits of the firm, which are given by

$$\pi(\phi) = \max_{p,q} \left((p - C_i(q, P_i^m, \phi))\, x_i(q, p, \omega) - f q^{\beta_i}\right),$$

where demand $x_i(q, p, \omega)$ is given by (1) and marginal cost C_i is given by (4).[14] Note that we have neglected the domestic market as it is largely irrelevant to our econometric analysis.[15] To obtain an interior solution, we impose the parameter restrictions $\beta_i > \eta_i - \alpha(\sigma_i - 1) > 0$ so that the firm will choose a quality level that is strictly positive but finite. The first-order conditions allow us to solve for the optimal quality, $q(\phi, P_i^m)$, and the optimal price, $p(\phi, P_i^m)$, which are respectively

$$q(\phi, P_i^m) = (\Lambda_i)^{\frac{1}{\beta_i - \eta_i + \alpha(\sigma_i - 1)}} \left(\frac{(P_i^m)^{\mu}}{\phi}\right)^{-\frac{\sigma_i - 1}{\beta_i - \eta_i + \alpha(\sigma_i - 1)}}, \tag{7}$$

$$p(\phi, P_i^m) = \frac{\sigma_i}{\sigma_i - 1} (\Lambda_i)^{\frac{\alpha}{\beta_i - \eta_i + \alpha(\sigma_i - 1)}} \left(\frac{(P_i^m)^{\mu}}{\phi}\right)^{\frac{\beta_i - \eta_i}{\beta_i - \eta_i + \alpha(\sigma_i - 1)}}, \tag{8}$$

where $\Lambda_i \equiv \nu_i \left(\frac{EP_i^{\sigma-1}}{f}\right) \left(\frac{\eta_i - \alpha(\sigma_i - 1)}{\beta_i \sigma_i}\right) \left(\frac{\sigma_i}{\sigma_i - 1}\right)^{1-\sigma_i}$ is a constant that is common to all firms in industry

[13] We assume perfect substitution between imported and domestic intermediates.

[14] To simplify notation, we have omitted any fixed costs associated with accessing international markets. As we focus on firms that both export and import in our empirical analyses, all firms in the dataset would have incurred these costs.

[15] It is worth mentioning that in the data firms produce multiple products for multiple locations making it generally impossible to connect input usage to outputs.

i. Equations (7) and (8) combined with (4) and (6) fully determine the variables of interest.[16]

We begin our analysis of the effect of tariffs on imported inputs by differentiating (6) with respect to τ to obtain

$$\frac{\tau}{P_i^m}\frac{dP_i^m}{d\tau} = \int_0^{z^*} b_i(z)dz + b_i(z^*)\left[\ln\left(\tau c_m^f(z^*)\right) - \ln c_m^d(z^*)\right]\tau\frac{dz^*}{d\tau} > 0, \tag{9}$$

where $dz^*/d\tau < 0$ is obtained by differentiating (5). The first term on the right-hand side is the intensive margin effect of a change in tariffs while the second term is the extensive margin effect. Note that the extensive margin effect is second-order in τ and vanishes for small $d\tau$ as can be seen from (5). Now, simple differentiation of equations (7) and (8) establishes the following two propositions.

Proposition 1. *A reduction in the tariff, τ, induces an incumbent importer/exporter to increase the quality of its exports.*

Proposition 2. *A reduction in the tariff, τ, induces an incumbent importer/exporter to raise its export price in industries where the scope for quality differentiation is large ($\beta_i < \eta_i$) and to lower its export price in industries in which the scope for quality differentiation is small ($\beta_i > \eta_i$).*

The results presented in the propositions are intuitive. Consider first proposition one. A reduction in the tariff lowers the cost of intermediates P_i^m and hence lowers marginal cost C_i for any given quality level. Ceteris paribus, firms would sell a greater number units and so the fixed cost of designing higher quality products is now less onerous relative to the gain in sales associated with expanding quality.

Now consider proposition two. When the scope for quality differentiation is large, firms respond to a reduction in the cost of obtaining intermediate inputs by drastically increasing their quality. The increase in demand for their product due to heightened quality more than compensates for the loss of sales due to a higher price. The opposite occurs when the scope for quality differentiation is small where the benefit of expanding sales through selling more units is relatively more important.

4.3 Estimating Equations

Our empirical analysis will rest primarily on propositions 1 and 2, but it is worth pointing out some additional implications of the model. Logarithmically differentiating equations (7) and (8) yields the basis of our analysis:

$$\Delta \ln q(\phi, P_i^m) = -\frac{\sigma_i - 1}{\beta_i - \eta_i + \alpha(\sigma_i - 1)}\left(\mu\Delta\ln(P_i^m) - \Delta\ln\phi\right), \tag{10}$$

$$\Delta \ln p(\phi, P_i^m) = \frac{\beta_i - \eta_i}{\beta_i - \eta_i + \alpha(\sigma_i - 1)}\left(\mu\Delta\ln(P_i^m) - \Delta\ln\phi\right), \tag{11}$$

where

[16] The net revenue could be written as $\frac{1}{\sigma_i}\nu_i E P_i^{\sigma_i - 1} q(\omega)^{\eta_i - \alpha(\sigma_i - 1)}\left(\frac{\sigma_i}{\sigma_i - 1}\frac{(P_i^m)^\mu}{\phi}\right)^{1-\sigma_i}$ which could be compared with a standard Melitz model for a fixed quality q.

$$\Delta \ln(P_i^m) = \sum_{z \in Z} b_i(z) \Delta \ln \tau(z) + \sum_{z \in Z'} b_i(z) \left(\ln \left[\tau'(z) c_m^f(z) \right] - \ln c_m^d(z) \right) \tag{12}$$

is the empirical analog of (9) that allows for tariff reductions $\Delta \ln \tau(z)$ to vary across intermediates. The first term is the intensive margin for the set of existing intermediates, Z, imported before the tariff reduction. The second term is the extensive margin for the set of newly imported intermediates, Z', and $\tau'(z)$. As the theory suggests that the extensive margin is hard to evaluate, we will ignore this second term in our baseline econometric specifications but we also control for the extensive margin for robustness.[17]

Proposition 2 highlights the heterogeneity across industries in the impact of a tariff reduction based on the scope for quality differentiation. We will allow for this slope heterogeneity by estimating price equations for different sets of industries.

Finally, note that firm productivity $\Delta \log \phi$ enters both equations (10) and (11) so that shocks to TFP could also have an impact on qualities and prices. If these shocks to TFP were correlated with the size of the effect of tariff reductions on imported intermediates, then we could attribute to the lower cost of intermediates some of the impact that works through TFP. For this reason, we will control for the change in TFP at the firm level in some of our econometric specifications below.

5 Empirical Specifications and Measurement

In this section, we specify our econometric models and describe the data that is used to estimate them.

5.1 Baseline Specifications

Our interest is in estimating the effect of tariff reductions, which we maintain to be exogenous to individual firms, on the price that Chinese firms charge for their exported goods and on the inferred quality of these exports. We begin with the determinants of export prices.

5.1.1 Price Equations

As noted earlier, our theory relates export prices to import tariffs through equations (11) and (12). We will estimate two types of econometric models motivated by these equations that differ in whether they are estimated in levels or in long-differences. These equations are respectively given by

$$\ln(p_{fh(c)t}) = \beta_\tau Duty_{ft} + \boldsymbol{\beta}_f \boldsymbol{\chi}_{ft} + \beta_i HHI_{it} + \varphi_{fh(c)} + \varphi_t + \epsilon_{fh(c)t}, \tag{13}$$

[17] We include both intensive margin and extensive margin in one of the alternative tariff measures and our results are robust. Please see Section 5.2 for details of constructing alternative tariff measures and Section 7.1 for robustness results.

and

$$\Delta \ln(p_{fh(c)}) = \beta_\tau \Delta Duty_f + \boldsymbol{\beta}_f \Delta \boldsymbol{\chi}_f + \beta_i HHI_i + \epsilon_{fh(c)}, \tag{14}$$

where $p_{fh(c)}$ denotes the unit value export price of HS6 product h exported by firm f (to destination country c when product is defined as HS6-country combination), and the key explanatory variable, $Duty_f$, is import tariff faced by firm f, which is computed by aggregating all import tariffs across firm f's intermediates (see Section 5.2 for details). In addition to these key variables, we include a vector of firm level controls, $\boldsymbol{\chi}_f$, and an industry level measure of competition, the Herfindahl index, HHI_i. When we estimate the model in levels, we include firm-product(-country) and time dummies. When estimating the model in long-differences, Δ denotes a change in any variable during a five-year period, i.e, between 2001 and 2006.

We will focus on the long difference specification given by (14). Adjustment to the shock of trade liberalization may be slow and there may be issues of autocorrelation when estimating the model in levels (see, for instance, Trefler (2004)). Results associated with shorter differences are qualitatively similar, however, and are reported in Table A.2 in Appendix.

The vector $\boldsymbol{\chi}_f$ consists of the observables at firm level that potentially impact export prices to control for productivity, imported varieties, and any effect of firm scale. Specifically, these controls include estimated TFP, capital intensity, firm size (measured by total employment), average wage bill per worker, and the number of imported varieties.[18] We also control for the effect of changing competition within industry i by adding Herfindahl index, HHI_i, computed at the 4-digit CIC (Chinese Industrial Classification) industry level in the initial year 2001. As the variable of interest in equation (14) is the change in firm-level tariffs, $\Delta Duty_f$, we cluster error terms at the level of the firm to address the potential correlation of errors within each firm across different products.[19] Thus, identification in the baseline specification is based on changes over time in the export prices within a firm for each product due to changes in tariffs.

We estimate (13) and (14) at various levels of aggregation in order to infer how changes in the composition of a firm's export destinations might vary over time. Our main focus will be at the firm-product-country level, but we will also consider weighted average of export prices across export destinations. By contrasting the coefficient estimates in these two different samples, we can obtain a feel for how important changes in the portfolio of export destinations were over this period of time. In addition, we adopt a variant of equation (14), with dependent variable Δp_f representing the price change at the firm level that is constructed using a Tornqvist index, as in Smeets and Warzynski (2013):

$$\Delta p_f = \sum_h \bar{s}_{fh} \Delta \ln(p_{fh}) \tag{15}$$

[18] By adding the change in the number of imported varieties, we partially control for the extensive margin effect.

[19] Our main tariff measure is firm specific, not firm-product specific because the tariff measure is computed across all imported inputs for each firm. Nevertheless, we also construct an alternative firm-product specific measure of tariff reductions and cluster the error term at firm-product level. See related discussion in Section 5.2.

where

$$\Delta \ln(p_{fh}) = \ln(p_{fht}) - \ln(p_{fh(t-5)})$$

and

$$\bar{s}_{fh} = \left(s_{fht} + s_{fh(t-5)}\right)/2$$

where t is set to be 2006, p_{fht} is the average price of product h by firm f in year t, and s_{fht} is the share of exported product h in firm f's total export sales at year t. Therefore, Δp_f is computed as a weighted average of the growth in prices for all the individual products within firm f.

5.1.2 Quality Equations

We follow the majority of the trade literature in defining "quality" as unobserved attributes of a variety that make consumers willing to purchase relatively large quantities of the variety despite relatively high prices charged for the variety. Following Khandelwal et al. (forthcoming), we estimate the "effective quality" (quality as it enters consumer's utility) of exported product h shipped to destination country c by firm f in year t, $(q_{fhct})^{\eta}$, via the following empirical demand equation:

$$x_{fhct} = q^{\eta}_{fhct} p^{-\sigma}_{fhct} P^{\sigma-1}_{ct} Y_{ct} \tag{16}$$

where x_{fhct} denotes the demand for a particular firm f's export of product h in destination country c in year t and Y_{ct} is total income in country c. We take logs of the above equation, and then use the residual from the following OLS regression to infer quality:

$$\ln(x_{fhct}) + \sigma \ln(p_{fhct}) = \varphi_h + \varphi_{ct} + \epsilon_{fhct} \tag{17}$$

where the country-year fixed effect φ_{ct} collects both the destination price index P_{ct} and income Y_{ct}; the product fixed effect φ_h captures the difference in prices and quantities across product categories due to the inherent characteristics of products. Then estimated quality is $\ln(\hat{q}_{fhct}) = \hat{\epsilon}_{fhct}$.[20] Consequently, quality-adjusted prices are the observed log prices less estimated effective quality, i.e., $\ln(p_{fhct}) - \ln(\hat{q}_{fhct})$, denoted by $\ln(\widetilde{p}_{fhct})$. The intuition behind this approach is that conditional on price, a variety with a higher quantity is assigned higher quality. Given the value of the elasticity of substitution σ, we are able to estimate quality from equation (17). Note that this approach to measuring quality is similar to the measurement of "TFP", i.e. it is a residual.

The literature yields and employs various estimates of σ. For example, Anderson and van Wincoop (2004) survey gravity-based estimates of the Armington substitution elasticity, such as Head and Ries (2001), and conclude that a reasonable range is $\sigma \in [5, 10]$. In our estimation, we use different values at $\sigma = 5$ and $\sigma = 10$. We also allow the elasticity of substitution to vary across industries (σ_i) using

[20]Here $\hat{q}_{fhct} \equiv q^{\eta}_{fhct}$. In other words, the estimated quality $\hat{q}$ is corresponding to q^{η} in our model.

the estimates of Broda and Weinstein (2006).[21]

As a robustness check, we inferred quality by estimating σ_i using Chinese data and an IV strategy. As the estimation results based on the quality estimates using this method were highly similar to those based on Broda and Weinstein's estimates, we report the estimation details of this method and the related results in Appendix D.1.

5.2 The Measurement of Tariff Reductions

As the main interest of this paper is to explore the effect of trade liberalization on export prices and product quality, it is important to measure properly the effective tariff reductions that are actually faced by firms. There are many ways to aggregate tariffs on intermediate inputs that have various pros and cons. On the one hand, one can construct firm-specific measures that use information on the exact initial bundle of intermediates imported by firms employing heterogeneous technologies. These measures provide high resolution to the firm-specific intensive margin effects of tariff reduction, and are indeed suggested by our theory, but they may miss extensive margin effects and they raise issues of endogeneity. On the other hand, one can construct industry-level measures that better capture the potential to import more intermediates and which are arguably orthogonal to firm-specific characteristics, but which may miss much of the action on the intensive margin. Given these concerns, we consider a wide range of tariff measures that collectively can paint a more comprehensive picture of the effect of trade liberalization on export upgrading. Our focus on firm-specific measures is driven by their consistency with our theory.

We begin by describing the construction of our firm-specific measures. We consider several different formulations of these measures which have various different strengths and weaknesses beginning with those that are most closely motivated by our model. According to our theoretical derivation (see the first term in the right hand side of equation (12) in Section 4.3), we compute a firm-specific measure of tariff reductions, $\Delta \ln \tau = \sum_{h \in Z} w_h \Delta \ln \tau_h$, to capture the weighted tariff reduction across intermediates, where the weight w_h is the import share of product h in the total import value by the firm in the initial year, and the HS6 product index h is the empirical counterpart of intermediate type z in the model.[22] In computing the firm-specific tariff reduction, $\Delta Duty$, we use an approximation that at product level $\Delta \ln \tau_h \approx \Delta Duty_h$ since $\tau > 1$ is one plus the tariff rate. This firm-specific input tariff reduction measure is theoretically justified, and can reflect the changes in effective tariffs faced by each firm due to its responses to trade liberalization.[23] Also because our main tariff measure is firm specific, we cluster the error terms at firm level rather than firm-product level in our main

[21] Broda and Weinstein (2006) estimate the elasticity of substitution for disaggregated categories and report that the average and median elasticity is 7.5 and 2.8, respectively. We use their estimates aggregated to HS 2-digit level and merge with our sample.

[22] We only use the import shares as weights because we data on domestic intermediate usage.

[23] When we use the five-year difference, this main measure is not subject to the problem of the weight change as the year 2001 is the only initial year. However, when we use other period differences, for instance, three-year difference and four-year difference, the weight will change according to different import shares in different initial years.

econometric specifications.

In addition to this baseline specification of $\Delta Duty$, we adopt four alternative measures of firm-specific tariff reductions and one industry-specific measure to shed additional light on the mechanisms at work in the data and to assess robustness.

The first measure is the unweighted firm-specific tariff change, $\Delta Duty = \sum_{h \in Z} \Delta Duty_h$. Estimates generated using this measure, compared with the main measure (weighted tariff change), shed light on the role of good-specific input weights in the pricing and quality decisions of firms.

The second measure is the arithmetic mean of product-level tariff reductions across all imported varieties both before and after the trade liberalization. More formally, $\Delta Duty = \left(\sum_{h \in Z \cup Z'} \Delta Duty_h\right) / |Z \cup Z'|$, where Z is the set of varieties imported before the tariff reduction (intensive margin), Z' is the set of newly imported varieties after the tariff reduction (extensive margin), and $|Z \cup Z'|$ denotes the total number of imported varieties by the firm over the whole sample period. This measure includes tariff changes relevant to both the intensive margin and the extensive margin (see the second term in the right hand side of equation (12)). By fixing the total number of imported varieties over the sample period, this measure isolates pure changes in tariffs rather than the changes in input bundles (Ge et al., 2011).

The third measure is computed as the weighted average as in the main measure of tariffs, but assigns positive weights to tariff reductions only to goods that are clearly intermediate inputs. The final goods and intermediate goods are defined by the Broad Economic Categories (BEC) classification. Note this measure of tariff reduction generates smaller sample size as it loses those firms that only import final goods as inputs to produce exported products.[24]

The fourth measure attempts to connect individual tariff reductions on intermediate inputs to specific goods in the firm's export portfolio of products. We follow Manova and Zhang (2012b) to focus on foreign inputs in the same broad industry classification as the output product. For example, if a firm buys brakes and seat belts and sells cars, both its exports and imports would be recorded in the motor vehicles industry. If the company also manufactures cell phones, tariff reduction in SIM cards would enter the measure of import tariff change of its cell phones but not that of its cars. Therefore, for each exported product by a particular firm, we construct the weighted average tariff change across all the inputs imported by the firm (e.g. brakes, seat belts) in a given HS2 category (e.g. motor vehicle) and assign this average tariff change to all products exported by this firm in the same HS2 category. Using this method we eventually compute the firm-product specific tariff change $\Delta Duty_{fh}$ for each product h exported by firm f.[25] Among all the firm-specific tariff reduction measures, this one generates the smallest sample size as it loses those exported products that have

[24] Using this measure loses approximately 10% observations in our sample.

[25] When we use this firm-product specific tariff measure, we cluster standard errors at firm-product level instead of firm level. We also compute this tariff measure at HS4 level by assigning the average tariff across all the imported inputs in a given HS4 category to all products exported by the same firm within the same HS4 category and it yields the similar results. Those results are available upon request.

no imported inputs in the same HS2 category. Summary statistics of those various measures of tariff cuts are presented in Table 3.

Table 3: Summary Statistics of Tariff Cuts (from 2001 to 2006):

		Average Tariff Changes	Maximum Tariff Changes
Tariff Cuts for All HS Products in Customs Data:			
	By HS6 product	-5.89%	-112.60%
	By HS4 product	-5.43%	-112.60%
	By HS4 product	-5.77%	-29.06%
Firm-Specific Tariff Cuts in Our Sample:			
	Main Measure	-5.98%	-110.88%
	Alternative Measure 1	-6.05%	-70.00%
	Alternative Measure 2	-5.94%	-70.00%
	Alternative Measure 3	-5.44%	-110.88%
	Alternative Measure 4	-6.06%	-70.00%

Finally, we also compute changes in industry input and output tariffs using input-output tables to create weights on the tariff reductions. This industry-level input-output table based measure of tariff cuts would be more comprehensive in capturing the effect of imported inputs if firms obtain some of the foreign intermediates from other Chinese importing firms which is possible but cannot be reflected in the current data using firm-specific measure of tariff reductions. In addition to the benefits discussed earlier of using industry rather than firm-specific measure, including specifications that use industry tariffs has the benefit of making our results comparable to the literature. Nevertheless, using all alternative measures of tariff cuts (including both firm-specific and industry-level measures) does not alter our main results.

5.3 Productivity

To control for the change in firm productivity in some of our regressions, we estimate both total factor productivity (TFP) and labor productivity (measured by value added per worker). Our primary TFP measure is based on the augmented Olley-Pakes (hereafter OP) method (Olley and Pakes, 1996).[26] The augmentation takes into account a number of additional firm level decisions. For instance, we allow a firm's trade status in the TFP realization, as in Amiti and Konings (2007), by including two trade-status dummy variables-an export dummy (equal to one for exports and zero otherwise) and an import dummy (equal to one for imports and zero otherwise). Finally, we include a WTO dummy (i.e., one for a year since 2002 and zero for before) in the Olley-Pakes estimation as the accession to WTO represents a positive demand shock for China's exports. We use value-added to measure production output, and deflate firms' inputs (e.g., capital) and value added, using the input price deflators and

[26] Our results are robust to different approaches in estimating TFP, including the OLS method, the Levinsohn-Petrin method (Levinsohn and Petrin, 2003), and the Ackerberg-Caves-Frazer augmented O-P and L-P methods (Ackerberg et al., 2006). These results are available upon request.

output price deflators from Brandt et al. (2012).[27] Then we construct the real investment variable by adopting the perpetual inventory method to investigate the law of motion for real capital and real investment. To measure the depreciation rate, we use each firm's real depreciation rate provided by the NBSC firm-production database.

6 Main Results

In this section, we present the results of estimating variants of equations (14) and (17) using a sample of ordinary Chinese manufacturing exporters, i.e. those that are not part of the export processing regime that allows firms to import intermediates tariff-free.[28] We begin by considering a pooled sample of all industries to find the average effect of falling tariffs on firms' export prices and on their quality choices. We then consider two subsamples defined by the scope for quality differentiation and show that the response of export prices to falling tariffs differs substantially across these types of industries as predicted by Proposition 2. In all specifications, we present results at different levels of aggregation within the firm so as to shed light on compositional effects associated with tariff reductions. Lastly, we present evidence at extensive margins to supplement our discussion of quality upgrading and export price increase.

6.1 Import Tariffs and Export Prices

Table 4 reports the results of our baseline regression, equation (14). We first discuss the results associated with long differences at the firm-product-destination level shown in columns 1-3. In column 1, we report the coefficient estimate of simple bivariate regression of log changes in export prices on log changes in the intensive margin measure of tariff reductions. The negative, and statistically significant coefficient, indicates that tariff reductions on imported inputs are associated with higher export prices. This result is consistent with Proposition 2 where the average industry has a large scope for quality differentiation: a fall in firm-specific import tariffs of 10 percentage points increases unit value export prices at firm-product-destination level by 4.8 percent.

A concern with respect to the bivariate regression is that it does not control for firm characteristics, such as changes in firm TFP, and that the coefficient on intensive margin tariff reductions might be picking up extensive margin effects. In columns 2 and 3 we add firm controls and the Herfindahl index (HHI) at industry level, respectively. While the individual coefficients shown in these columns need to be interpreted with care due to the fact that some of these controls are likely endogenous, the most important feature of the coefficients reported in columns 2 and 3 is that the coefficient on

[27] The output deflators are constructed using "reference price"information from China's Statistical Yearbooks, and the input deflators are constructed based on output deflators and China's national input-output table (2002). The data can be accessed via http://www.econ.kuleuven.be/public/N07057/CHINA/appendix/.

[28] We show in section 8, that export processing firms are not affected by falling tariffs.

Table 4: Basic Results (Long-difference Estimation, 2006-2001)

	Dependent Variable								
	$\Delta\ln(\text{Export Price}_{fhc})$			$\Delta\ln(\text{Export Price}_{fh})$			$\Delta\text{Export Price Index}_{f}$		
Regressor:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
ΔDuty	-0.481**	-0.484**	-0.517**	-0.659**	-0.661**	-0.704**	-0.642**	-0.632**	-0.643**
	(0.222)	(0.216)	(0.223)	(0.289)	(0.277)	(0.279)	(0.305)	(0.306)	(0.307)
Δln(TFP)		0.042***	0.042***		0.041**	0.041**		0.046***	0.045***
		(0.012)	(0.012)		(0.017)	(0.017)		(0.017)	(0.017)
Δln(Capital/Labor)		0.023	0.023		0.036	0.036		-0.00002	0.001
		(0.016)	(0.016)		(0.026)	(0.025)		(0.021)	(0.021)
Δln(Labor)		0.001	0.002		0.003	0.006		-0.003	-0.003
		(0.018)	(0.017)		(0.027)	(0.027)		(0.026)	(0.026)
Δln(Wage)		0.020	0.019		0.024	0.023		0.046*	0.046*
		(0.022)	(0.022)		(0.027)	(0.026)		(0.025)	(0.025)
Δln(Import Varieties)		0.012	0.012		0.021	0.020		0.009	0.009
		(0.013)	(0.013)		(0.015)	(0.015)		(0.018)	(0.018)
HHI			-0.442			-0.781*			-0.241
			(0.306)			(0.406)			(0.233)
Observations	14439	14439	14439	7595	7595	7595	2368	2368	2368
R-squared	.001	.003	.004	.001	.004	.005	.002	.007	.007

Notes: ***, **, and * indicate significance at the 1%, 5%, and 10% level. Robust standard errors corrected for clustering at the firm level in parentheses. All regressions include a constant term. Herfindahl index (HHI) is computed in the initial year (2001) at the 4-digit CIC industry in China.

$\Delta Duty$ is highly robust in both its magnitude and in terms of its statistical significance compared to the coefficient in column 1. Omitted variable bias does not appear to be a problem with respect to the simple regression results shown in column 1.[29] Two other observations are worthy of comment. First, firms that displayed large increases in measured TFP (second row) were observed to increase their export prices, which is consistent with some of that TFP increase being the result of producing higher quality. Second, the coefficient on $\Delta\ln$(Import Varieties) is positive but is not statistically significant. The lack of statistical significance may be due to the high correlation between this variable and $\Delta Duty$.

Columns 4-6 report the results with the price change at firm-product level as dependent variable. Not surprisingly, all coefficients on tariff reductions are significantly negative, confirming that tariff reductions increase export prices at various aggregation levels. The fact that the coefficient estimates tend to be larger in the more aggregated measures of export prices, suggests a modest compositional effect: lower tariffs induce Chinese firms to redirect their exports to countries where higher prices can be charged. Lastly, columns 7-9 report the results based on the firm-level price change as dependent variable, and coefficients on tariff reductions are also significantly negative.

We also conducted estimations on specifications with various period differences, such as four-, three-, and two-year differences and results remain substantially similar (see Table A.2 in Appendix).

[29]Table A.4, columns 1-3, in the appendix presents results where only the change in $\ln(TFP)$ is included as a control. The coefficients and their standard errors in these specifications are virtually unchanged.

These significantly negative coefficients on tariff reductions support the prediction of Proposition 2 that a tariff reduction induces an incumbent importer/exporter to raise its export price in industries where the scope for quality differentiation is large. As to the opposite prediction where the scope for quality differentiation is small, we leave to the later discussion.

Table 5: Effect of Tariff Reductions on Quality Upgrading

	Dependent Variable: $\Delta \ln(\hat{q}_{fhc})$					
	$\sigma = 5$		$\sigma = 10$		$\sigma = \sigma_i$ Broda and Weinstein (2006)	
	(1)	(2)	(3)	(4)	(5)	(6)
ΔDuty	-3.093**	-3.125**	-6.351***	-6.623***	-3.339***	-3.304***
	(1.262)	(1.253)	(2.331)	(2.340)	(1.063)	(1.054)
Δln(TFP)		0.301***		0.496***		0.236***
		(0.063)		(0.118)		(0.056)
Δln(Capital/Labor)		0.159*		0.230		0.0948
		(0.088)		(0.160)		(0.071)
Δln(Labor)		0.263***		0.210		0.278***
		(0.092)		(0.163)		(0.091)
Δln(Wage)		0.150		0.251		0.110
		(0.111)		(0.209)		(0.090)
Δln(Import Varieties)		0.118*		0.181		0.118**
		(0.064)		(0.125)		(0.051)
HHI		-1.690		-4.386		-1.227
		(1.501)		(2.903)		(1.209)
Observations	14439	14439	14439	14439	14439	14439
R-squared	.001	.007	.001	.006	.002	.008

Notes: ***, **, and * indicate significance at the 1%, 5%, and 10% level. Robust standard errors corrected for clustering at the firm level in parentheses. All regressions include a constant term. Herfindahl index (HHI) is computed in the initial year (2001) at the 4-digit CIC industry in China.

6.2 Import Tariffs and Export Quality

The key mechanism of our model is the choice of quality. The results in Table 4 support the prediction from Proposition 2 that tariff reduction induces an incumbent firm to raise its export price when quality differentiation is large. However, whether the increase in unit value export prices essentially reflects the quality improvement remains to be answered. Therefore, we regress estimated product quality on tariff reductions to test Proposition 1.

Table 5 reports the estimation results of equation (14) with the change in estimated effective quality as the dependent variable. Different columns correspond to using different values of elasticity of substitution in estimating quality. Note that all coefficients on tariff reductions are significantly negative, supporting the prediction of Proposition 1 that a reduction in import tariff induces an incumbent importer/exporter to raise the quality of its exports. Again, all coefficients on control variables are consistent with our expectation as in the baseline regressions in Table 4. Given that the primary variables, quality estimates, are generated from regressions, we also bootstrap standard errors for all specifications in Table 5 and the main results remain robust (see Table A.3 in the Appendix). As one may be concerned that the key effect is perhaps biased by many firm-level controls, we present all the baseline regressions on prices and quality (as in Tables 4 and 5) with only $\Delta \ln(TFP)$ as firm control, and present consistent results in Table A.4 in the Appendix. We also add 2-digit CIC industry fixed effects into the baseline regressions and report similar results in Table A.5.

Finally, we explored the estimation of equation (14) when the price has been quality adjusted, i.e. $\ln(p_{fhct})-\ln(\hat{q}_{fhct})$ as the dependent variable. To save space, we report these results in Table A.6 in the Appendix. We find that reductions in import tariffs indeed induce an incumbent importer/exporter to lower their *quality-adjusted* prices.

6.3 The Role of Quality Differentiation

According to Proposition 2, the effect of tariff reduction on export prices depends on the scope for quality differentiation within an industry. Firms increase export prices with tariff reductions in industries where the scope for quality differentiation is large and decrease export prices in industries where the scope for quality differentiation is small. From Stylized fact 2, we know that over the period 2001-2006 export prices are essentially unchanged for homogeneous goods.

To test whether the scope for quality differentiation indeed matters, first, we use Rauch's (1999) to create two separate samples, one composed of differentiated goods and the other composed of homogeneous goods (see the Appendix for details). It is natural to believe that differentiated goods present greater scope for quality differentiation than do homogeneous goods. We also allow for heterogeneity in the response of export prices to tariff reductions in two ways. First, we estimate our econometric model on the two subsamples separately and compare the two coefficients on $\Delta Duty_f$. Second, we interact $\Delta Duty_f$ with a dummy variable for whether the product is in a homogeneous goods industry. In particular, we used the pooled sample to estimate

$$\Delta \ln(p_{fhc}) = \beta_\tau \Delta Duty_f + \beta_H \Delta Duty_f \times HOMOGENEOUS_h + \boldsymbol{\beta}_f \Delta \boldsymbol{\chi}_f + \beta_i HHI_{i(2001)} + \epsilon_{fhc}, \quad (18)$$

where $HOMOGENEOUS_h$ is a dummy variable which is equal to one for homogeneous goods and zero for differentiated goods. We expect a positive β_H and a negative β_τ. We also estimate the quality equation with the change in estimated effective quality $\Delta \ln(\hat{q}_{fhc})$ as the dependent variable in (18).

Table 6 (Panel A) reports the estimation results of the above approaches. Columns 1-3 report estimation results when we regress the change in (log) price for HS6-country product on tariff reductions; columns 4-6 report regression results with the change in (log) estimated quality for HS6-country product as dependent variable; columns 7-9 report the results with the change in (log) price for HS6 product as dependent variable. In each of the three columns, the first column uses the subsample of differentiated products and therefore presents the significantly negative coefficient on tariff reductions (see columns 1, 4, and 7) according to Propositions 1 and 2; the second uses the subsample of homoge-

Table 6: Effect of Tariff Reductions and Quality Differentiation

	Dependent Variable								
	$\Delta \ln(p_{fhc})$			$\Delta \ln(\hat{q}_{fhc})$			$\Delta \ln(p_{fh})$		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Panel A: Differentiated Goods vs. Homogeneous Goods									
ΔDuty	-0.653***	0.527	-0.695***	-4.326***	3.397*	-4.031***	-1.021***	0.832*	-1.005***
	(0.248)	(0.392)	(0.231)	(1.150)	(1.960)	(1.092)	(0.318)	(0.475)	(0.290)
ΔDuty $\times HOMOGENEOUS$			1.466***			5.974***			1.841***
			(0.316)			(1.695)			(0.379)
Observations	12805	1634	14439	12805	1634	14439	6620	975	7595
R-squared	.005	.003	.005	.009	.006	.009	.007	.005	.008
Panel B: quality heterogeneity based on dispersion of quality									
ΔDuty	-0.901***	-0.0773	-0.707***	-4.340***	-1.260	-5.315***	-1.264***	-0.172	-1.176***
	(0.317)	(0.277)	(0.263)	(1.566)	(1.176)	(1.308)	(0.462)	(0.270)	(0.342)
ΔDuty $\times QUALITY^{Dispersion}$			0.462*			4.875***			0.934***
			(0.269)			(1.304)			(0.305)
Observations	7207	7232	14439	7207	7232	14439	3785	3810	7595
R-squared	.004	.005	.004	.009	.009	.010	.007	.005	.007
Panel C: quality differentiation based on G-M (Gollop-Monahan) Index									
ΔDuty	-0.626**	-0.045	-0.750***	-4.924***	0.978	-4.296***	-1.188***	0.247	-1.352***
	(0.263)	(0.414)	(0.247)	(1.351)	(1.735)	(1.117)	(0.398)	(0.409)	(0.336)
ΔDuty $\times QUALITY^{Diff}$			1.011***			4.175***			1.774***
			(0.313)			(1.501)			(0.380)
Observations	6679	6284	12963	6679	6284	12963	3252	3505	6757
R-squared	.004	.006	.006	.014	.006	.010	.008	.008	.010
Panels A, B, and C:									
Firm-level Controls	yes	yes	yes	yes	yes	yes	yes	yes	yes
Industry-level Competition Control	yes	yes	yes	yes	yes	yes	yes	yes	yes

Notes: ***, **, and * indicate significance at the 1%, 5%, and 10% level. Robust standard errors corrected for clustering at the firm level in parentheses. All regressions include a constant term, firm-level controls, and industry-level competition control. Industry-level competition control refers to Herfindahl index (HHI), which is computed in the initial year (2001) at the 4-digit CIC industry in China. Using ΔHHI as industry-level competition control does not alter the main results. Firm-level controls include the changes between 2006 and 2001 in the following variables: TFP, the number of imported varieties, capital intensity, average wage, and firm size (measured by total employment). Quality estimates are based on elasticities of substitution from Broda and Weinstein (2006).

neous goods and thus yields positive but less significant coefficients on tariff reductions (see columns 2 and 8) according to Proposition 2;[30] the third presents the estimation results of equation (18) or its variants with different dependent variables (see columns 3, 6, and 9). All coefficients on interaction terms are significantly positive at the (at least) 1 percent level. The results are consistent with our expectation and further substantiates Propositions 1 and 2.[31]

Panel B of Table 6 reports the estimation results of a similar equation using quality heterogeneity

[30] Proposition 1 does not directly differentiate between the two cases with scope for large and for small quality differentiation, respectively. However, it could be derived that when the scope for quality differentiation is small, the rise in quality would be smaller and less significant than the quality upgrading when the scope for quality differentiation is large. Therefore, we expect a nonsignificant coefficient on $\Delta Duty$ when the regressand is the change in quality for homogeneous goods. The result in column 5 is consistent with this expectation.

[31] Our results also remain robust when we use Rauch index, computed as a fractional value at industry level. The results of using Rauch index are not reported here for the sake of saving space, but available upon request.

(measured by quality dispersion) instead of product differentiation (measured by Rauch classification):

$$\Delta \ln(p_{fhc}) = \beta_\tau \Delta Duty_f + \beta_H \Delta Duty_f \times QUALITY_h^{Dispersion} + \boldsymbol{\beta}_f \Delta \boldsymbol{\chi}_f + \beta_i HHI_{i(2001)} + \epsilon_{fhc}, \quad (19)$$

where $QUALITY_h^{Dispersion}$ is a dummy variable which is equal to one for goods with highly dispersed quality and zero otherwise; the dependent variable could be either price (at different aggregation levels) or estimated quality. We compute quality dispersion by using the estimated quality (at fhc level) to compute a quality variance for each HS6 product. Then we use the median of quality variances of all goods to distinguish products with highly-dispersed quality and less-dispersed quality. Again we expect a positive β_H and a negative β_τ. The result is consistent with our expectation (see columns 3, 6, and 9). The results in panel B using the subsample of goods with highly-dispersed quality also show significantly negative coefficients on tariff reductions (see columns 1, 4, and 7), while those using the subsample of goods with less-dispersed quality present similar patterns as homogeneous goods (see columns 2, 5, and 8). Note that the coefficient on $\Delta Duty_f$ in column 1 doubles relatively to the coefficient obtained by estimating the model on the pooled sample (see Table 4).

We now check the robustness of our results to using the Gollop-Monahan index to measure the scope for quality differentiation within an industry. This index measures the dissimilarity of input mixes across firms in an industry and is defined for the relevant intermediate-input sector. Higher value of Gollop-Monahan index indicates larger scope for product quality differentiation.[32] Panel C of Table 6 reports estimation results of the following equation based on G-M index and presents analogous specifications as well as similar results:

$$\Delta \ln(p_{fh(c)}) = \beta_\tau \Delta Duty_f + \beta_H \Delta Duty_f \times QUALITY_h^{Diff} + \boldsymbol{\beta}_f \Delta \boldsymbol{\chi}_f + \beta_i HHI_{i(2001)} + \epsilon_{fh(c)}, \quad (20)$$

where $QUALITY_h^{Diff}$ is a dummy variable which is equal to one for goods with highly differentiated quality (if that product h's G-M index value is above the median of G-M indices for all goods) and zero otherwise.

6.4 Extension: Evidence at Extensive Margin

To keep our model simple, we abstracted from the decision of a firm to enter export markets. A natural extension would have fixed costs to entering foreign market that were increasing in the quality of the good that would be sold there. In such a model, a tariff reduction that induced an upgrade in output quality would also induce an upgrade in the types of markets entered: lower tariffs on imported intermediates ought to steer exporters to markets that demand higher quality goods. We refer to such

[32]The idea is that products become more differentiated if the underlying inputs are more different, which is consistent with our mechanism that firms adjust their product quality as response to tariff reductions through both intensive and extensive margins of their intermediates. The G-M index has been used by some previous studies, including Kugler and Verhoogen (2012), Tang and Zhang (2012), among others. We obtain the data of the G-M index from Kugler and Verhoogen (2012) and the detailed description is contained in Appendix B.

a compositional shift as a change in the extensive margin.[33] We now show that tariff reductions on intermediate inputs induce exactly such a shift.[34]

To address shifts in the extensive margin of export markets, we distinguish different types of firm-product-country and firm-product (hereafter fhc and fh, respectively, for short) combinations, according to their status in the pre-liberalization period (2001) and post-liberalization period (2006). We then define three types of fhc and fh combinations: "entry", "continuing", and "exit". If a fhc or fh combination is present in both 2001 and 2006, it is defined as "continuing" type; if it appears in 2006 but not in 2001, it is characterized as "entry" type; if it appears in 2001 but not in 2006, it is characterized as "exit" type.

Next we compare the (log) price level for an average fhc or fh combination by type (see Table 7). The average price for "entry" type is always higher than that for "continuing" type (see column 1 vs. column 2), and the average price for "continuing" type is in general higher than that for "exit" type (see column 3 vs. column 4). This suggests that we observe the exit of relatively lower priced goods and entry of relatively higher priced goods. This also implies that the tariff liberalization had the effect of shifting Chinese exports geographically from countries where demand for high quality goods is relatively weak to markets where demand for high quality goods is strong and thus higher export prices could be charged.

Table 7: (log) price for different types of firm-product(-country) combinations

	2006		2001	
	(1) entry	(2) continuing	(3) continuing	(4) exit
Per Firm-product-country, median	1.52	1.29	1.16	1.12
Per Firm-product-country, mean	1.87	1.48	1.35	1.37
Per Firm-product, median	1.36	1.29	1.16	1.10
Per Firm-product, mean	1.66	1.48	1.35	1.33

Now we focus on the price change within firm-product across different types of destination countries. We compute two measures of changes in export prices within firm-product: (1) the price change for continuing markets, and (2) the price change for markets of "entry" versus markets of "exit". Within each firm-product, the price change for "entry-exit" is computed by the average price of each firm-product across all its newly added markets (markets of entry) in 2006 minus the average price

[33] In addition to the extensive margin effect described here, there are other potential channels of quality upgrading that could supplement the quality adjustment mechanism in our model. For example, high-quality output may require high-quality inputs. This has been theoretically derived (see, e.g., Kugler and Verhoogen, 2012, among others) and empirically tested by the previous studies, for example, Manova and Zhang (2012a) show that firms that charge higher export prices import more expensive inputs.

[34] As our primary focus in this paper is to address the quality upgrading at the intensive margin for existing products, we acknowledge that here we only present indirect evidence of extensive margin effect but we do not test how tariff reductions affect the probabilities of firm entry/exit and product (or product-country) adding/dropping as well as their connection with quality upgrading. A more through analysis of quality upgrading along different types of extensive margins would be fruitful for future research.

across all its dropped markets (markets of exit) in 2001. We regress the change in price on the change in import tariff and report results in Table 8.[35]

Table 8: Effect of Tariff Reductions for Continuing Markets and Markets of Entry vs. Exit

	Dependent Variable: $\Delta \ln(p_{fh})$					
	all goods		differentiated goods		homogeneous goods	
	(1)	(2)	(3)	(4)	(5)	(6)
	continuing	entry vs. exit	continuing	entry vs. exit	continuing	entry vs. exit
ΔDuty	-0.562**	-0.844**	-0.818***	-1.160***	0.491	2.898**
	(0.259)	(0.405)	(0.293)	(0.427)	(0.443)	(1.352)
Firm-level controls	yes	yes	yes	yes	yes	yes
Industry-level competition controls	yes	yes	yes	yes	yes	yes
Observations	5945	3846	5193	3363	752	483
R-squared	.004	.009	.006	.012	.007	.020

Notes: ***, **, and * indicate significance at the 1%, 5%, and 10% level. Robust standard errors corrected for clustering at the firm level in parentheses. All regressions include a constant term. Industry-level Competition Control refers to Herfindahl index (HHI), which is computed in the initial year (2001) at the 4-digit CIC industry in China. Using ΔHHI as industry-level competition control does not alter the main results. Firm-level controls include the changes between 2006 and 2001 in the following variables: TFP, the number of imported varieties, capital intensity, average wage, and firm size (measured by total employment).

Table 8 shows that for all goods and differentiated goods, the tariff reductions significantly induce firms to increase export prices in continuing markets (see columns 1 and 3) and to enter higher-priced markets and to exit lower-priced markets (see columns 2 and 4). It is worth noting that the effect of tariff reduction is stronger for "entry-versus-exit" markets than for continuing markets. Therefore, compared with our baseline results in column 6 of Table 4 for all goods, it is obvious that the effect of tariff reduction on price change at firm-product level is in general a combined effect of both continuing markets and entry-versus-exit markets, i.e., the magnitude of the coefficient on tariff reduction for the aggregate price change at firm-product level is smaller than that for entry-versus-exit market while larger than that for continuing market.[36] For differentiated goods, the effect of tariff reduction is stronger than its counterparts for all goods; while for homogenous goods, the effect of tariff reduction is weaker or even reversed (see columns 5 and 6). This corresponds to the previous proposition on quality differentiation. Again, the tariff effect is stronger in entry-versus-exit markets than that in continuing markets for both differentiated goods and homogenous goods.[37]

We further decompose the "continuing" type into two sub-types: "growing" and "shrinking". Given that a fhc or fh combination is present in both 2001 and 2006, if its total export value increases from 2001 to 2006, it is characterized as "growing" type; if its total export value decreases, it is defined as "shrinking" type. We report estimation results for growing-versus-shrinking types in Table A.8 in the Appendix. The effect of tariff reductions is more significant for "growing" type than for "shrinking" type and all results are consistent with Propositions 1 and 2.

[35] The data presented in Table 8 define "entry" and "exit" only at fhc level so we could compare entry versus exit for the same fh combination. This way allows the price for the same HS6 product to be compared across markets.

[36] See the coefficient on tariff reduction in column 6 in Table 4 and compare with those in columns 1 and 2 in Table 8.

[37] For differentiated goods, compare columns 3 and 4 in Table 8 with column 7 in panel A of Table 6; for homogeneous goods, compare columns 5 and 6 in Table 8 with column 8 in panel A of Table 6.

7 Robustness I – Statistical

We conduct four exercises to show the statistical robustness of our results. First, we present the results based on alternative measures of firm-specific tariff reductions. Second, we show that our results remain robust when we use conventional measures of industry input/output tariffs. Third, we use instrumental variable estimation to address the potential issue of endogenous tariff reductions. Last, but not least, we confirm that our results are not biased towards big firms using the whole customs data without matching to the manufacturing firm survey.

7.1 Alternative Measures of Firm-Specific Tariff Cuts

In Section 5 we proposed a number of ways to measure the impact of tariff cuts on the cost to Chinese firms of procuring foreign made intermediates. Our main measure, which we have used exclusively so far, has the benefit of being consistent with the intensive margin impact across firms. We now show how well the alternative tariff reduction measures predict price changes across firms.

Table 9: Alternative Firm-Specific Tariff Reduction Measures

	Firm-specific Tariff Reduction Measures							
	Measure 1		Measure 2		Measure 3		Measure 4	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A: dependent variable $= \Delta\ln(p_{fh})$								
ΔDuty	-0.658*	-0.778**	-1.131**	-1.090*	-0.619**	-0.884***	-0.197	-0.227
	(0.350)	(0.349)	(0.574)	(0.563)	(0.276)	(0.286)	(0.304)	(0.320)
ΔDuty × HOMOGENEOUS		1.880***		2.003***		1.884***		0.198
		(0.494)		(0.552)		(0.440)		(0.507)
Industry-level Competition Control	yes	yes	yes	yes	yes	yes	yes	yes
Firm-level Controls	yes	yes	yes	yes	yes	yes	yes	yes
Observations	7595	7595	7595	7595	6830	6830	4302	4302
R-squared	.005	.006	.005	.006	.003	.005	.007	.007
Panel B: dependent variable $= \Delta\ln(p_{fhc})$								
ΔDuty	-0.213	-0.273	-0.808*	-0.798*	-0.581***	-0.770***	-0.103	-0.161
	(0.273)	(0.272)	(0.452)	(0.450)	(0.221)	(0.233)	(0.271)	(0.283)
ΔDuty × HOMOGENEOUS		1.480***		1.649***		1.668***		0.611
		(0.415)		(0.479)		(0.366)		(0.446)
Industry-level Competition Controls	yes	yes	yes	yes	yes	yes	yes	yes
Firm-level Controls	yes	yes	yes	yes	yes	yes	yes	yes
Observations	14439	14439	14439	14439	12947	12947	8859	8859
R-squared	.003	.004	.004	.005	.004	.006	.006	.006

Notes: ***, **, and * indicate significance at the 1%, 5%, and 10% level. Robust standard errors corrected for clustering at the firm level in parentheses, except that in regressions using measure 4 (firm-product specific tariff reduction) we cluster standard errors at firm-product level instead of firm level. All regressions include a constant term. Industry-level Competition Control refers to Herfindahl index (HHI), which is computed in the initial year (2001) at the 4-digit CIC industry in China. Using ΔHHI as industry-level competition control does not alter the main results. Firm-level controls include the changes between 2006 and 2001 in the following variables: TFP, the number of imported varieties, capital intensity, average wage, and firm size (measured by total employment). By construction, tariff measure 3 yields fewer observations in the sample; tariff measure 4 provides fewest observations and thus presents the smallest sample size.

In Table 9 different columns correspond to different measures of the tariff (see detailed description in Section 5.2). Specifications 1 and 2 use unweighted firm-specific tariff reductions; specifications 3 and 4 adopt the tariff reduction measure as in Ge et al. (2011) by fixing the total number of imported varieties during the whole sample period; specifications 5 and 6 employ the weighted firm-specific import tariff reductions of only intermediate goods; specifications 7 and 8 use the tariff reduction measure constructed by following the mapping between inputs and outputs as in Manova and Zhang (2012b). Panel A reports the results with average prices of HS6 products across destinations and Panel B presents the results with prices of HS6-country products.

In most specifications, the coefficients on the change in import tariff are significantly negative, indicating that import tariff reduction leads to higher export prices. Also, the coefficients on the interaction terms are all significantly positive, except for using measure 4, implying that the effect of import tariff reduction on export price increase is more significant for products in industries where the scope for quality differentiation is large.

Comparing measure 1 (unweighted tariff reductions) with the main measure (weighted tariff reductions as in Table 4) the results are far stronger for measures of tariff reduction that allow different input tariffs to receive different weights. This indicates that allowing for more important inputs to receive a higher weight is important: large tariff reductions have a bigger impact the more that intermediate is used in production.

By construction, measure 2 (tariff cuts measured based on the entire set of imported inputs from 2001 as well as 2006) captures both the intensive and extensive margin impact on Chinese importers. As our main measure and measure 1 capture only the intensive margin, we would expect the coefficient estimate based on measure 2 to be substantially larger in these specifications. This is indeed the case as the coefficients in columns 3 and 4 are substantially larger in absolute value than those in Tables 4 and 6.[38]

Limiting the set of imported intermediates to those clearly classified as such has little impact on the coefficient estimates as can be seen in columns 5 and 6. Finally, attempting to directly connect import industries to export industries as is the case in the final two columns delivers weaker results. This is perhaps not surprising as the mapping is highly imperfect and the sample size falls substantially.

7.2 Using Industry Input/Output Tariff Cuts

One might worry that the reduction in import tariffs on intermediate inputs might be correlated with cuts in tariffs on firms' outputs and that our results might be supriously picking up the competition effects that are the focus of Amiti and Khandelwal (2013). Further, one might wonder as to whether a broader measure of tariff cuts on intermediate inputs that included all likely relevant tariffs delivers similar results. We now address these two potential concerns by including output tariffs per exported

[38]The only other difference between the main measure and measure 1 is that the former is weighted while the latter is unweighted. See Table 4 for the results based on the main measure of tariff reductions.

Table 10: Industry Input and Output Tariff Cuts

	Industry Input/Output Tariff							
	Dependent variable: $\Delta \ln(p_{fhc})$				Dependent variable: $\Delta \ln(p_{fh})$			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\Delta \text{Duty}^{output}$	-0.377		0.508		-0.256		0.442	
	(0.343)		(0.410)		(0.313)		(0.411)	
$\Delta \text{Duty}^{input}$		-1.749***	-2.237***	-1.802***		-1.191***	-1.584***	-1.219***
		(0.419)	(0.530)	(0.417)		(0.450)	(0.567)	(0.447)
$\Delta \text{Duty}^{input} \times$ HOMOGENEOUS				1.583***				1.567**
				(0.481)				(0.797)
Industry-level Competition Control	yes	yes	yes	yes	yes	yes	yes	yes
Firm-level Controls	yes	yes	yes	yes	yes	yes	yes	yes
Observations	14439	14439	14439	14439	7595	7595	7595	7595
R-squared	.003	.005	.005	.006	.004	.005	.005	.006

Notes: ***, **, and * indicate significance at the 1%, 5%, and 10% level. Robust standard errors corrected for clustering at the HS6 product level in parentheses, because we use the concordance between HS6 products and Chinese input-output sector to compute industry input/output tariffs. All regressions include a constant term. Industry-level Competition Control refers to Herfindahl index (HHI), which is computed in the initial year (2001) at the 4-digit CIC industry in China. Using ΔHHI as industry-level competition control does not alter the main results. Firm-level controls include the changes between 2006 and 2001 in the following variables: TFP, the number of imported varieties, capital intensity, average wage, and firm size (measured by total employment).

product and input tariffs constructed using input-output matrixes.

Table 10 reports the results based on industry input and output tariffs. Columns 1-4 present the results using the price change for HS6-country product as the dependent variable, and columns 5-8 report the results with the price change for HS6 product. When we regress the price change on the industry output tariff change (see columns 1 and 5), the coefficients on output tariff are negative yet insignificant. When we regress the price change on industry input tariffs using the broadest measure of input tariff relevance (see columns 2 and 6), the coefficients on input tariff are significantly negative and very large in terms of their magnitude, implying that lower input tariffs can raise export prices through the quality effect that is the focus of our paper. The large magnitude of the coefficient suggests that the extensive margin is important as is the potential impact of tariff cuts on the price of competing domestic inputs.

When we include both input and output tariff as explanatory variables, the effect of input tariff, the key variable of our interest, is still significantly negative (see columns 3 and 7), which further confirms that input tariff reductions raise export prices. Lastly, we estimate equation (18) with industry input tariff in columns 4 and 8. As expected, the coefficients on input tariff are significantly negative, while the coefficients on the interaction terms are significantly positive, confirming Proposition 2 that prices significantly increase with tariff reductions in industries with large scope for quality differentiation while in industries with small scope for quality differentiation the price increase is significantly smaller. Thus, adopting industry-level tariffs does not alter our results.[39]

[39]To provide more evidence on the relationship between tariffs and export prices, we also conduct the baseline regression in levels (see equation (13)) with industry input/output tariffs in Table A.9 in the Appendix. We present the results of level regressions with industry- instead of firm-specific tariffs because we do not have theoretical justification of firm-

7.3 Instrumental Variable Estimation

Now, we address the issue of the potential endogeneity of tariff changes. It is common in literature to use the past levels of tariffs as instruments for changes in tariffs (e.g., Goldberg and Pavcnik, 2005; Amiti and Konings, 2007). The idea is that the past tariffs are usually strongly correlated with the current changes in tariffs, but the past tariffs are uncorrelated with the error term or any other determinants of the dependent variable in the baseline regressions (i.e., the exclusion restriction). Therefore, we also employ past levels of tariffs as instruments and report the results in Table 11. In specifications 1 and 2, we employ the 1997 tariff level as the fixed past level to instrument the change in tariffs between 2001 and 2006; in specifications 3 and 4, we use the initial level to instrument the change, i.e., we use the 2001 tariff level to instrument $\Delta Duty_{2006-2001}$. Again, we report results for both firm-product-country prices in Panel A and firm-product prices in Panel B.

We conduct two tests to verify the quality of the instruments. The first diagnostic statistic for assessing the strength of identification is based on a Langrange-Multiplier (LM) test for underidentification using the Kleibergen and Paap (2006) rk statistic, because in our econometric model, the error term is assumed to be heteroskedastic and thus the usual canonical correlation likelihood ratio test (Anderson, 1984) is invalid.[40] The Kleibergen and Paap (2006) rk statistic is to test whether an instrument is relevant to an endogenous variable (i.e., the change in tariffs). The null hypothesis that the model is underidentified is rejected at the 0.1 percent significance level. The second diagnostic test we perform is the Kleibergen and Paap (2006) Wald statistic to check whether the instrument is weakly correlated with the endogenous variable. The Kleibergen and Paap (2006) Wald F-statistics provide strong evidence to reject the null hypothesis that the first stage is weakly identified at a highly significant level. That is to say, in all specifications, the instruments provide a good fit in the first stage, and perform as valid instruments.

Table 11 clearly illustrates that in all specifications, the coefficients on the interaction terms (ΔDuty $\times$ $HOMOGENEOUS$) are significantly positive, and the coefficients on tariff change are all significantly negative, at 1 percent significance level. This is consistent with the main predictions of our model that tariff reductions lead to higher export prices while this effect increases in product differentiation and thus, the goods with small scope for quality differentiation have a smaller increase, or even a reduction, in their export prices.

The fact that coefficients in the IV regressions are considerably larger than the OLS coefficients could have multiple explanations. On the one hand, this could simply be an issue of measurement error as relating tariff reductions to marginal costs of individual products within the firm is by necessity indirect. On the other hand, it could be that the firms that faced the highest average tariffs on their

specific tariffs in levels. Our theoretically derived firm-specific measures refer to tariff reductions at the firm level. The results of level regressions show that higher export prices are also associated with lower input tariffs.

[40] In all of the specifications, the Cragg-Donald F statistic is also well above the critical values listed in Stock and Yogo (2005). However, we do not report them since critical values are for i.i.d. errors while in our econometric model the error term is assumed to be heteroskedastic.

Table 11: Instrumental Variable Estimation

	instrumented by $Duty_{1997}$		instrumented by $Duty_{2001}$	
	(1)	(2)	(3)	(4)
Panel A: dependent variable $= \Delta\ln(p_{fhc})$				
ΔDuty	-1.339***	-1.542***	-1.000***	-1.237***
	(0.405)	(0.402)	(0.299)	(0.306)
ΔDuty $\times HOMOGENEOUS$		2.066***		1.941***
		(0.381)		(0.356)
Industry-level Competition Control	yes	yes	yes	yes
Firm-level Controls	yes	yes	yes	yes
Kleibergen-Paap rk LM $\chi^2(1)$ statistic	107.266†	111.730†	33.513†	33.977†
Weak Instrument (F statistic)	239.197†	124.807†	317.716†	150.973†
Observations	14439	14439	14439	14439
R-squared	.002	.004	.003	.005
Prob > F	.000	.000	.000	.000
Panel B: dependent variable $= \Delta\ln(p_{fh})$				
ΔDuty	-1.539***	-1.821***	-1.026***	-1.383***
	(0.509)	(0.498)	(0.381)	(0.375)
ΔDuty $\times HOMOGENEOUS$		2.246***		2.108***
		(0.457)		(0.419)
Industry-level Competition Control	yes	yes	yes	yes
Firm-level Controls	yes	yes	yes	yes
Kleibergen-Paap rk LM $\chi^2(1)$ statistic	94.272†	99.725†	35.359†	39.634†
Weak Instrument (F statistic)	200.338†	110.314†	630.419†	382.221†
Observations	7595	7595	7595	7595
R-squared	.004	.006	.005	.007
Prob > F	.001	.000	.002	.000

Notes: ***, **, and * indicate significance at the 1%, 5%, and 10% level. † indicates significance at the 0.01 percent level (p-value < 0.0001). Robust standard errors corrected for clustering at the firm level in parentheses. All regressions include a constant term. Industry-level Competition Control refers to Herfindahl index (HHI), which is computed in the initial year (2001) at the 4-digit CIC industry in China. Using ΔHHI as industry-level competition control does not alter the main results. Firm-level controls include the changes between 2006 and 2001 in the following variables: TFP, the number of imported varieties, capital intensity, average wage, and firm size (measured by total employment).

imported intermediates were those with the greatest potential for increasing their product quality once tariffs came down.

7.4 Large Sample Test Using Whole Customs Data

So far our empirical results are based on the merged data built upon the NBSC manufacturing survey database and the Customs database. However, the NBSC manufacturing survey only includes above-scale firms, which may lead to sample selection bias. Therefore, to further verify that our results are not biased towards big firms, we replicate baseline regressions with both firm-specific tariff reductions and industry input tariff reductions in Table 12. The results show that all coefficients on the interaction terms ($\Delta Duty\times\ HOMOGENEOUS$) are significantly positive and most coefficients on $\Delta Duty$ are significantly negative. This fully supports the main predictions of our model that firms increase

Table 12: Long-Difference Estimation Based on Whole Customs Data

	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: dependent variable = $\Delta\ln(p_{fhc})$						
ΔDuty	-0.477***	-0.161	-0.691**	-0.427***	-0.069	-0.925***
	(0.156)	(0.191)	(0.295)	(0.155)	(0.148)	(0.338)
ΔDuty × HOMOGENEOUS	1.166***	1.572***	1.949***	1.080***	1.069***	1.724***
	(0.287)	(0.274)	(0.297)	(0.301)	(0.307)	(0.313)
Observations	48095	48095	48095	44232	27923	48095
R-squared	.001	.001	.002	.001	.001	.002
Panel B: dependent variable = $\Delta\ln(p_{fh})$						
ΔDuty	-0.321	-0.546**	-0.906**	-0.407*	-0.281*	-0.784**
	(0.211)	(0.236)	(0.386)	(0.225)	(0.168)	(0.318)
ΔDuty × HOMOGENEOUS	1.317***	1.524***	1.714***	1.392***	0.837***	1.565***
	(0.256)	(0.286)	(0.311)	(0.293)	(0.290)	(0.302)
Observations	31245	31245	31245	29229	16315	31245
R-squared	.001	.001	.001	.001	.0005	.001

Notes: The first five columns correspond to firm-specific measures of tariff reductions and the last one corresponds to industry input tariff reduction measure. Among the five columns of using firm-specific measures of tariff reductions, the first one adopts our main tariff reduction measure, and the rest four employ the four alternative measures of tariff reductions as described in order in Section 5.2.

***, **, and * indicate significance at the 1%, 5%, and 10% level. Robust standard errors are corrected for clustering at firm level for firm-specific tariff reductions (see columns 1-4), at firm-product level for firm-product-specific tariff reductions (see column 5) and at HS6 product level for industry input tariff reductions (see column 6) in parentheses.

export prices with tariff reductions when the scope for quality differentiation is large but may decrease prices when the scope for quality differentiation is small. We also plot the price distribution based on the whole customs data in Figure 3 to confirm the different patterns of price change by product differentiation. Similar as in Figure 2 based on the merged data in stylized facts, the price distribution apparently shifts to the right for differentiated goods, while this price shifting pattern is nonsignificant or even reversed for homogeneous goods.

8 Robustness II – Alternative Explanations

We now assess the robustness of our interpretation of the results relative to alternate explanations. First, we show that our results do not seem to be due to firms' adjustment of markups in the wake of the tariff reduction. Second, our main results do not appear to be driven by other potential mechanisms, including policy uncertainty regarding market access, currency appreciation, and changes in the degree of product market competition (competition effect). Lastly, we use processing exporters as comparison group to show that our quality upgrading mechanism is specific to ordinary exporters because processing trade firms do not pay tariffs.

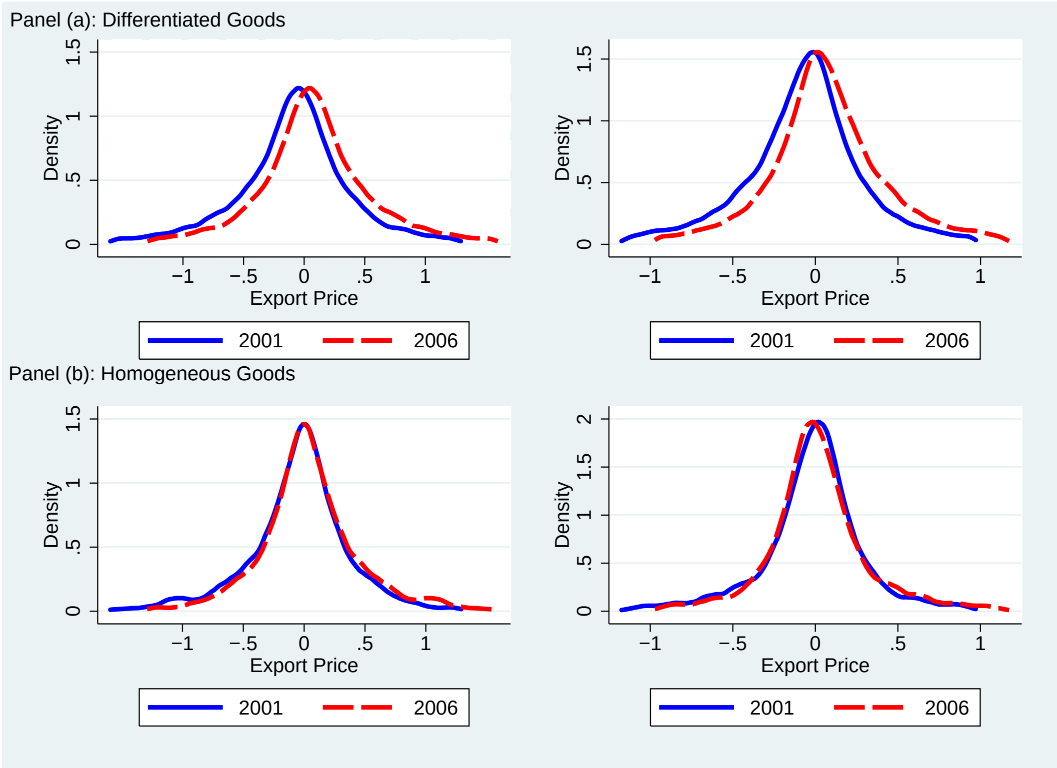

Figure 3: Distribution of Export Prices Based on Whole Customs Data (2001 vs. 2006)
Note: The graphs in the left and the right columns refer to HS6 and HS6-country product, respectively.

8.1 Markup Adjustments

A natural concern is whether results reflect heterogeneous responses across firms in adjusting their markups that happen to be correlated with the size of the tariff reductions that they experience (see, for example, Halpern and Koren (2007)). According to Melitz and Ottaviano (2008) and Amiti et al. (forthcoming), in markets where the firm has a small market share, it has a small markup and so it is hard for the firm to adjust its markup in those markets.[41] The change in prices in those markets is mainly driven by the change in marginal costs. Therefore, we rank all firms based on their market share in each destination market and keep the firms with small market shares by picking up the bottom 10, 30, and 50 percentiles. This exercise would alleviate the concern that our results reflect markup variation rather than quality adjustments. The price and quality estimation results are reported in Table 13. All coefficients on tariff reduction are significantly negative, and the interaction term with homogeneous goods are always significantly positive. Further note the stability of the coefficients across different samples, suggesting that potential market power plays a relatively unimportant role in export markets. Finally, we note before leaving the subject of markup adjustments that our extensive margin results shown in Table 8 support our underlying mechanism in a manner that is free of markup

[41] Amiti et al. (*AER, forthcoming*) prove that market share of the firm is a sufficient statistic for its markup; markup variability is monotonically increasing in the market share (see Proposition 1 in their model). Although this prediction is also model-specific, their empirical analysis provides support for this monotonic relationship.

adjustment concerns. We conclude that our results are not primarily driven by changes in markups.

Table 13: Results for Firms with Small Markups

	≤10 percentile		≤30 percentile		≤50 percentile	
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: dependent variable = $\Delta\ln(p_{fhc})$						
ΔDuty	-0.580**	-0.725***	-0.657***	-0.798***	-0.597**	-0.732***
	(0.241)	(0.246)	(0.239)	(0.243)	(0.232)	(0.234)
ΔDuty $\times HOMOGENEOUS$		1.574***		1.620***		1.601***
		(0.393)		(0.380)		(0.365)
Observations	9394	9394	10126	10126	11029	11029
R-squared	.005	.007	.005	.007	.005	.006
Panel B: dependent variable = $\Delta\ln(\hat{q}_{fhc})$						
ΔDuty	-4.368***	-4.968***	-4.718***	-5.326***	-4.240***	-4.830***
	(1.183)	(1.260)	(1.185)	(1.252)	(1.112)	(1.159)
ΔDuty $\times HOMOGENEOUS$		6.520***		6.947***		7.023***
		(2.218)		(2.167)		(2.061)
Observations	9394	9394	10126	10126	11029	11029
R-squared	.007	.008	.008	.009	.008	.010
Panels A and B:						
Firm-level Controls	yes	yes	yes	yes	yes	yes
Industry-level Competition Control	yes	yes	yes	yes	yes	yes

Notes: ***, **, and * indicate significance at the 1%, 5%, and 10% level. Robust standard errors corrected for clustering at the firm level in parentheses. All regressions include a constant term, firm-level controls, and industry-level competition control. Firm-level controls include the changes between 2006 and 2001 in the following variables: TFP, the number of imported varieties, capital intensity, average wage, and firm size (measured by total employment). Industry-level Competition Control refers to Herfindahl index (HHI), which is computed in the initial year (2001) at the 4-digit CIC industry in China. Using ΔHHI as industry-level competition control does not alter the main results. Quality estimates are based on elasticities of substitution from Broda and Weinstein (2006).

8.2 Other Potential Mechanisms

There may exist other mechanisms through which tariff changes could potentially affect quality choice. These include reduced uncertainty about the ability to export to high-income markets (the policy uncertainty effect), currency appreciation (exchange rate effect), and fending off stronger competition from abroad (the product market competition effect). We conduct the sensitivity tests for these potential mechanisms and discuss each in turn.

Policy Uncertainty

Prior to its accession to the WTO, China was vulnerable to the sudden loss of MFN status in its trade relations with the United States, where such status required annual congressional action to maintain. Pierce and Schott (2013) have shown that this vulnerability depressed Chinese exports to the U.S., particularly in industries where non-MFN tariffs were very high. To remove the potential for this mechanism to drive our results, we remove the U.S. from our sample and reestimated our main equations. The resulting estimates are shown in Columns 1 and 2 in Table 14. All coefficients on tariff

Table 14: Sensitivity to Other Potential Mechanisms

	policy uncertainty		currency appreciation		competition effect	
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: dependent variable = $\Delta \ln(p_{fhc})$						
ΔDuty	-0.487**	-0.658***	-0.114	-0.157	-0.480**	-0.661***
	(0.235)	(0.246)	(0.118)	(0.124)	(0.225)	(0.234)
$\Delta\text{Duty}^{output}$					-0.256	-0.238
					(0.304)	(0.301)
ΔDuty $\times HOMOGENEOUS$		1.308***		0.483*		1.460***
		(0.326)		(0.279)		(0.315)
Observations	12911	12911	18809	18809	14439	14439
R-squared	.005	.006	.001	.001	.004	.005
Panel B: dependent variable = $\Delta \ln(p_{fh})$						
ΔDuty	-0.689**	-1.004***	-0.422**	-0.511***	-0.692**	-0.991***
	(0.285)	(0.298)	(0.179)	(0.192)	(0.278)	(0.289)
$\Delta\text{Duty}^{output}$					-0.097	-0.118
					(0.353)	(0.350)
ΔDuty $\times HOMOGENEOUS$		1.841***		0.660**		1.844***
		(0.395)		(0.293)		(0.378)
Observations	6883	6883	9253	9253	7595	7595
R-squared	.005	.007	.001	.001	.005	.008
Panels A and B:						
Firm-level Controls	yes	yes	yes	yes	yes	yes
Industry-level Competition Control	yes	yes	yes	yes	yes	yes

Notes: ***, **, and * indicate significance at the 1%, 5%, and 10% level. Robust standard errors corrected for clustering at the firm level in parentheses. We use the concordance between HS6 products and Chinese input-output sector to compute industry output tariffs. All regressions include a constant term, firm-level controls, and industry-level competition controls. Firm-level controls include the changes between 2006 and 2001 in the following variables: TFP, the number of imported varieties, capital intensity, average wage, and firm size (measured by total employment). Industry-level competition control refers to Herfindahl index (HHI), which is computed in the initial year (2001) at the 4-digit CIC industry in China. Using ΔHHI as industry-level competition control does not alter the main results.

reductions are virtually unchanged.

Currency Appreciation

Note that our export price is denominated in US dollars. One may be concerned that the price increase is partially due to the appreciation of *Renminbi* (Chinese currency, hereafter RMB). It is possible that a stronger RMB reduces firms' costs to purchase imported inputs with local currency, and thus provides firms more incentive to switch to better inputs.

To test the sensitivity of our results to RMB appreciation, we use the data during the period before the appreciation to test whether export prices indeed increase without currency appreciation. As the RMB appreciated in late 2005, we dropped data of 2005 and 2006, and conduct the long-difference estimation for the period 2004-2001 in columns 3 and 4 in Table 14. At firm-product level, all coefficients on $\Delta Duty$ are significantly negative at the (at least) 5 percent level. At firm-product-country level, the effect of tariff reduction is less significant, but remains its negative signs. The insignificance at firm-product-country level is perhaps due to two reasons: First, the difference estimation for currency appreciation is based on a 3-year difference which is shorter than our main estimation period (5-year difference) and thus the quality adjustment may not be sufficient. Second, a compositional effect may play a role here such that the effect of tariff reduction at more aggregated levels is more significant, which is also consistent with our previous discussion of a modest compositional effect in the baseline results in Table 4. The coefficients on the interaction term are also significantly positive, consistent with previous discussion. The test confirms that export prices indeed increase even without currency appreciation.

Competition Effect

Increased competition from imports has been linked in existing studies to quality upgrading (Amiti and Khandelwal, 2013). If reduction in tariffs on Chinese firms' output are correlated with reductions in tariffs of inputs, then we might misattribute the mechanism that drives quality upgrading. Here, we add industry-level output tariffs to our main specification in order to dispel any concerns about this possibility.[42] Columns 5 and 6 in Table 14 report results of sensitivity tests for competition effect. The coefficients on output tariff reduction are in general negative, but including output tariff to control for competition effect does not alter our main results.[43]

8.3 Comparison Group: Processing Exporters

We use processing exporters as comparison group to show that processing firms do not significantly increase export prices, probably because they never pay tariffs to begin with. As some firms are "hybrid" exporters, i.e., they do both ordinary trade and processing trade transactions, we only select those pure processing exporters as comparison. Table 15 reports the results of equation (14) for those pure processing firms, which can be compared with the baseline regressions for ordinary exporters in Table 4. There is no evidence that pure processing exporters increase their export prices in response to tariff reductions. Nevertheless, one may be concerned that import tariffs have potential impacts on the export processing margin for firms. We conduct further tests for shifting processors (i.e., firms that switched trade regimes) in Table A.10 in the Appendix and all our main results remain robust to the changes in the margins of trade regimes.

9 Conclusion

In this paper, we uncover patterns of price and quantity adjustments in the wake of trade liberalization that strongly suggest that access to imported intermediate inputs can substantially increase the ability of firms to deliver high quality goods to foreign markets. We first uncover interesting price adjustments across firms that can clearly be documented in a series of figures. We then devised an econometric

[42] Note that in section 7.2 we presented a similar specification. The difference here is that we are using our main measure of tariff reductions rather than a measure based on IO tables.

[43] Another control variable related with competition effect is the industry-level competition control based on either the initial HHI or the change in HHI. Using either one does not alter the robustness of our main results.

Table 15: Comparison Group: Processing Exporters

	Dependent Variable							
	$\Delta \ln(\text{Export Price}_{fhc})$				$\Delta \ln(\text{Export Price}_{fh})$			
Regressor:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
ΔDuty	0.265	0.264	0.256	0.259	0.420	0.427*	0.357	0.363
	(0.261)	(0.261)	(0.233)	(0.234)	(0.258)	(0.259)	(0.224)	(0.224)
ΔDuty $\times HOMOGENEOUS$		1.137**		0.722		0.537		0.403
		(0.530)		(0.684)		(0.847)		(0.913)
Industry-level Competition Control			yes	yes			yes	yes
Firm-level Controls			yes	yes			yes	yes
Observations	1771	1771	1771	1771	1036	1036	1036	1036
R-squared	.002	.003	.010	.011	.003	.003	.009	.010

Notes: ***, **, and * indicate significance at the 1%, 5%, and 10% level. Robust standard errors corrected for clustering at the firm level in parentheses. All regressions include a constant term. Industry-level Competition Control refers to Herfindahl index (HHI), which is computed in the initial year at the 4-digit CIC industry in China. Using ΔHHI as industry-level competition control does not alter the main results. Firm-level controls include the changes in the following variables: TFP, the number of imported varieties, capital intensity, average wage, and firm size (measured by total employment).

model from a simple analytical framework of quality choice and access to imported intermediates. Estimating this model on Chinese data in the post WTO accession period, we find strong and robust evidence that those firms in industries where quality heterogeneity is substantial that experienced the largest tariff reductions on their imported inputs increase the price and quality of their outputs.

Our study has imposed relatively little structure on the data. While this allows us to take a diverse set of cuts of the data to establish the existence and robustness of our results, it does come at the cost of limiting a complete assessment of magnitudes that a more structural approach would allow. Such a structural approach would incorporate a number of important elements. First, formally modeling the decisions to export would allow us to more thoroughly trace out the complementarities between imported intermediates and exports. Second, while we argued that our results are not primarily driven by markup adjustments, a more structural approach would allow the actual contributions of our mechanism and markup adjustments to be quantified. Finally, a more structural model would allow the relative contributions of the extensive and intensive margins to be separately identified. We hope that our paper will provide the impetus for an expansion in research along these lines.

References

Ackerberg, Daniel, Kevin Caves, and Garth Frazer, "Structural identification of production functions," MPRA Paper 38349, University Library of Munich, Germany December 2006.

Ahn, JaeBin, Amit K. Khandelwal, and Shang-Jin Wei, "The role of intermediaries in facilitating trade," *Journal of International Economics*, May 2011, *84* (1), 73–85.

Amiti, Mary and Amit K. Khandelwal, "Import Competition and Quality Upgrading," *The Review of Economics and Statistics*, May 2013, *95* (2), 476–490.

_ and Jozef Konings, "Trade Liberalization, Intermediate Inputs, and Productivity: Evidence from Indonesia," *American Economic Review*, December 2007, *97* (5), 1611–1638.

_ , Oleg Itskhoki, and Jozef Konings, "Importers, Exporters, and Exchange Rate Disconnect," *American Economic Review*, forthcoming.

Anderson, James E. and Eric van Wincoop, "Trade Costs," *Journal of Economic Literature*, September 2004, *42* (3), 691–751.

Anderson, T. W., *An introduction to multivariate statistical analysis* Wiley series in probability and mathematical statistics, 2 ed., New York: Wiley, 1984. T.W. Anderson; ;25 cm; Includes index; Bibliography: p. 643-665.

Bernard, Andrew B and J. Bradford Jensen, "Firm Structure, Multinationals, and Manufacturing Plant Deaths," *The Review of Economics and Statistics*, May 2007, *89* (2), 193–204.

Brandt, Loren, Johannes Van Biesebroeck, and Yifan Zhang, "Creative Accounting or Creative Destruction? Firm-level Productivity Growth in Chinese Manufacturing," *Journal of Development Economics*, 2012, *97* (2), 339–351.

Broda, Christian and David E. Weinstein, "Globalization and the Gains From Variety," *The Quarterly Journal of Economics*, 2006, *121* (2), 541–585.

Cai, Hongbin and Qiao Liu, "Competition and Corporate Tax Avoidance: Evidence from Chinese Industrial Firms," *Economic Journal*, 04 2009, *119* (537), 764–795.

Fan, Haichao, Edwin L.-C. Lai, and Yao Amber Li, "Credit Constraints, Quality, and Export Prices: Theory and Evidence from China," MPRA Paper 40857, University Library of Munich, Germany August 2012.

Feenstra, Robert C. and John Romalis, "International Prices and Endogenous Quality," *Quarterly Journal of Economics*, forthcoming.

Ge, Ying, Huiwen Lai, and Susan Zhu, "Intermediates Import and Gains from Trade Liberalization," Technical Report, mimeo, University of International Business and Economics 2011.

Goldberg, Pinelopi Koujianou, Amit Kumar Khandelwal, Nina Pavcnik, and Petia Topalova, "Imported Intermediate Inputs and Domestic Product Growth: Evidence from India," *The Quarterly Journal of Economics*, November 2010, *125* (4), 1727–1767.

_ and Nina Pavcnik, "Trade, wages, and the political economy of trade protection: evidence from the Colombian trade reforms," *Journal of International Economics*, May 2005, *66* (1), 75–105.

Gopinath, Gita and Brent Neiman, "Trade Adjustment and Productivity in Large Crises," NBER Working Papers 16958, National Bureau of Economic Research, Inc April 2011.

Halpern, László and Miklós Koren, "Pricing to Firm: an Analysis of Firm- and Product-level Import Prices," *Review of International Economics*, 08 2007, *15* (3), 574–591.

_ , _ , and Adam Szeidl, "Imported Inputs and Productivity," CeFiG Working Papers 8, Center for Firms in the Global Economy September 2011.

Head, Keith and John Ries, "Increasing Returns versus National Product Differentiation as an Explanation for the Pattern of U.S.-Canada Trade," *American Economic Review*, September 2001, *91* (4), 858–876.

Kasahara, Hiroyuki and Joel Rodrigue, "Does the use of imported intermediates increase productivity? Plant-level evidence," *Journal of Development Economics*, August 2008, *87* (1), 106–118.

Khandelwal, Amit, "The Long and Short (of) Quality Ladders," *Review of Economic Studies*, 2010, *77* (4), 1450–1476.

Khandelwal, Amit K., Peter K. Schott, and Shang-Jin Wei, "Trade Liberalization and Embedded Institutional Reform: Evidence from Chinese Exporters," *American Economic Review*, forthcoming.

Kleibergen, Frank and Richard Paap, "Generalized reduced rank tests using the singular value decomposition," *Journal of Econometrics*, July 2006, *133* (1), 97–126.

Kugler, Maurice and Eric Verhoogen, "Plants and Imported Inputs: New Facts and an Interpretation," *The American Economic Review*, 2009, *99* (2), pp. 501–507.

_ and _ , "Prices, Plant Size, and Product Quality," *Review of Economic Studies*, 2012, *79* (1), 307–339.

Levinsohn, James and Amil Petrin, "Estimating Production Functions Using Inputs to Control for Unobservables," *The Review of Economic Studies*, 2003, *70* (2), pp. 317–341.

Manova, Kalina and Zhiwei Zhang, “Export Prices Across Firms and Destinations,” *The Quarterly Journal of Economics*, 2012, *127*, 379–436.

_ and _ , “Multi-Product Firms and Product Quality,” NBER Working Papers 18637, National Bureau of Economic Research, Inc December 2012.

Melitz, Marc J. and Gianmarco I. P. Ottaviano, “Market Size, Trade, and Productivity,” *Review of Economic Studies*, 2008, *75* (1), 295–316.

Olley, G. Steven and Ariel Pakes, “The Dynamics of Productivity in the Telecommunications Equipment Industry,” *Econometrica*, 1996, *64* (6), pp. 1263–1297.

Pierce, Justin and Peter Schott, “The Surprisingly Swift Decline of U.S. Manufacturing Employment,” Working Papers 13-59, Center for Economic Studies, U.S. Census Bureau December 2013.

Rauch, James E., “Networks versus markets in international trade,” *Journal of International Economics*, June 1999, *48* (1), 7–35.

Schott, Peter K., “Across-product Versus Within-product Specialization in International Trade,” *The Quarterly Journal of Economics*, May 2004, *119* (2), 646–677.

Smeets, Valerie and Frederic Warzynski, “Estimating productivity with multi-product firms, pricing heterogeneity and the role of international trade,” *Journal of International Economics*, 2013, *90* (2), 237 – 244.

Stock, James H. and Motohiro Yogo, “Testing for Weak Instruments in Linear IV Regression,” in Donald W. K. Andrews and James H. Stock, eds., *Identification and Inference for Econometric Models: Essays in Honor of Thomas Rothenberg*, New York: Cambridge University Press., 2005, pp. 80–108.

Tang, Heiwai and Yifan Zhang, “Quality Differentiation and Trade Intermediation,” Technical Report 2012.

Trefler, Daniel, “The Long and Short of the Canada-U. S. Free Trade Agreement,” *American Economic Review*, September 2004, *94* (4), 870–895.

Verhoogen, Eric A., “Trade, Quality Upgrading, and Wage Inequality in the Mexican Manufacturing Sector,” *The Quarterly Journal of Economics*, 05 2008, *123* (2), 489–530.

Appendix

A Data Description

The process of our sample construction can be summarized by five steps:

1. We organize the export data from the Chinese Customs Database by the following procedure:

   1.1 We delete all trade intermediaries from exporting firms. Similar to Ahn et al. (2011) and Tang and Zhang (2012), we identify trade intermediaries by finding the presence of phrases (such as "trading", "exporting", and "importing") in their company names.[44] We further drop all exports under processing trade regime and only keep ordinary trade in our sample.[45]

   1.2 We drop all observations with no destination information or destination country reported as PRC China. We further drop all observations with zero or missing quantity or value.

   1.3 We use the conversion table from the UN Comtrade to convert the HS 2002 codes into the HS 1996 codes at HS 6-digit level. Then we aggregate the export value and export quantity for each product at either HS6 or HS6-destination.

   1.4 We deflate the export value using output deflators from Brandt et al. (2012).[46] Note that the deflators in Brandt et al. (2012) are by 4-digit CIC industry in China, while there is no information about CIC industry code in the Customs Data. Therefore, we use the concordance between the Input-Output (I-O) sectors and the HS codes and the concordance between the I-O sectors and the CIC industries by the NBSC to merge each HS code with a CIC industry. Eventually, we are able to compute the deflated value at HS6 level.

   1.5 We estimate product quality and quality-adjusted price by following Khandelwal et al. (forthcoming). See Section 6.2 for details.

   1.6 We merge the above sample with Rauch's product classification (Rauch, 1999) to divide sample into differentiated goods and homogeneous goods.

2. We organize the import data from the Chinese Customs Database by the following procedure:

   2.1-2.3 are similar with 1.1-1.3.

   2.4 We deflate the import value using input deflators from Brandt et al. (2012). The process is similar to Step 1.4.

   2.5 We merge import data with import tariff at HS6 level and compute different measures of the effective import tariff reduction faced by each firm. See Section 5.2 for more details of each tariff measure.

[44] As company names in the Customs Database are written in Chinese, we search for "mao yi", "wai mao", "wai jing", "jin chu kou", "jing mao", "gong mao", and "ke mao" in firm names.

[45] Move 1.1 after 1.5 does not alter our estimation results.

[46] The deflator data are downloaded from http://www.econ.kuleuven.be/public/N07057/China/.

3. We merge the export data (based on Step 1) and the import data (based on Step 2) together to obtain a large sample based on the Customs Database solely. This sample serves as the basis for the robustness check when we use the whole customs data.

4. To obtain firm-level characteristics and industry-level competition control, we merge the above sample based on customs data with the NBSC manufacturing firm survey data. Our matching procedure is done in three steps: (1) by company name, (2) by telephone number and zip code, and (3) by telephone number and contact person name together (see detailed description of the matching process in Fan et al., 2012). The matching rates are reported in Section 2.

5. We further delete some unsatisfactory observations and outliers according to the following criteria in Cai and Liu (2009) and the General Accepted Accounting Principles, due to mis-reporting by some firms in the NBSC database: (i) the total assets must be higher than the liquid assets; (ii) the total assets must be larger than the total fixed assets; (iii) the total assets must be larger than the net value of the fixed assets; (iv) a firm's identification number cannot be missing and must be unique; and (v) the established time must be valid.

B Measures of Quality Differentiation

- **Rauch's (1999) homogeneous-good dummy**. Source: Rauch (1999).
  At the 4-digit SITC Revision 2 level, Rauch (1999) categorizes industries into three categories: (1) "homogeneous" goods that are mainly traded on organized exchanges; (2) "reference-priced" goods; (3) goods that neither have reference prices nor are traded on organized exchanges. The dummy variable $HOMOGENEOUS$ equals one if the product falls into category (1) or (2) and zero otherwise. We concord the data into HS 6-digit level (2002 version) from SITC Rev.2. The concordance table is from the United Nations Statistics Division.

- **Gallop-Monahan Index** (based on US firms). Source: Kugler and Verhoogen (2012).
  The index is defined as follows:

$$GM_k = \sum_{j,k,t} w_{jt} \left(\sum_i \frac{|s_{ijkt} - \bar{s}_{ikt}|}{2} \right)^{1/2}$$

  where i, j, k, and t stand for inputs, plants, industries and years; s_{ijkt} is the expenditure share on input i of plant j in industry k in year t; $\bar{s}_{ikt}$ is the average expenditure share on input i by all plants in industry k in year t; w_{jt} is the share of revenues of plant j in year t in total revenues of all plants in all years in industry k. The term inside the brackets measures how dissimilar input mix of plant j is from other plants in its industry in the corresponding year. The measure then averages those plant-specific measures over plants and years, using revenues as weights. We adopt this measure already constructed by Kugler and Verhoogen (2012) since we do not have complete information on input mix at the firm level in our Chinese data. Their method is building upon Bernard and Jensen (2007). Their original data are available at the ISIC Rev.2. 4-digit level, and we concord to HS6 using the concordance from the UN Comtrade.

C More Figures and Tables

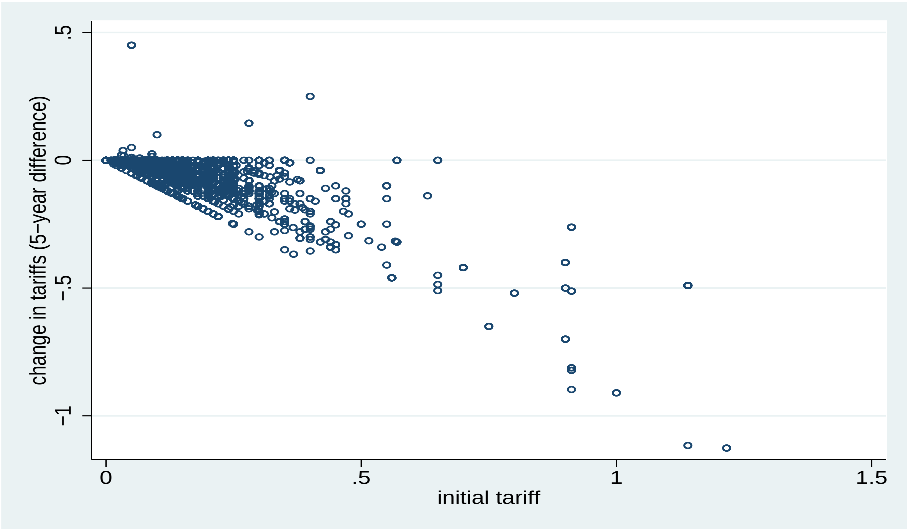

Figure A.1: Change in Tariffs for HS6 Products, 2001-2006, Relative to Initial Levels
Note: Some products experienced an increase in their tariff over the sample period.

Table A.1: Change in Export Prices year by year: Differentiated vs. Homogeneous Products

	(1) Whole Sample	(2) Differentiated Goods	(3) Homogeneous Goods
Panel A: 1-year difference			
Change in Export Prices (HS6):			
Per Firm-product, median	0.94%	1.31%	-0.46%
Per Firm-product, mean	2.64%	2.91%	0.89%
Change in Export Prices (HS6-country):			
Per Firm-product-country, median	0.24%	0.55%	-1.10%
Per Firm-product-country, mean	1.93%	2.22%	-0.34%
Panel B: 2-year difference			
Change in Export Prices (HS6):			
Per Firm-product, median	3.58%	4.41%	-0.44%
Per Firm-product, mean	5.98%	6.70%	1.20%
Change in Export Prices (HS6-country):			
Per Firm-product-country, median	2.11%	2.74%	-1.54%
Per Firm-product-country, mean	4.65%	5.25%	-0.04%
Panel C: 3-year difference			
Change in Export Prices (HS6):			
Per Firm-product, median	6.41%	7.61%	-0.44%
Per Firm-product, mean	9.50%	10.58%	2.38%
Change in Export Prices (HS6-country):			
Per Firm-product-country, median	4.62%	5.68%	-1.93%
Per Firm-product-country, mean	7.95%	8.84%	1.11%
Panel D: 4-year difference			
Change in Export Prices (HS6):			
Per Firm-product, median	9.74%	11.18%	0.12%
Per Firm-product, mean	12.60%	14.18%	2.10%
Change in Export Prices (HS6-country):			
Per Firm-product-country, median	6.82%	8.27%	-1.97%
Per Firm-product-country, mean	10.26%	11.64%	-0.58%
Panel E: 5-year difference			
Change in Export Prices (HS6):			
Per Firm-product, median	11.80%	14.10%	-1.19%
Per Firm-product, mean	15.72%	17.35%	3.43%
Change in Export Prices (HS6-country):			
Per Firm-product-country, median	9.14%	10.36%	-0.02%
Per Firm-product-country, mean	13.30%	14.68%	0.90%

Table A.2: Results with Different-period Difference

	Dependent Variable					
	$\Delta \ln(ExportPrice)_{fhct}$			$\Delta \ln(ExportPrice)_{fht}$		
	(1)	(2)	(3)	(4)	(5)	(6)
In 2 period difference: $\Delta Duty_{t-(t-2)}$	-0.180*			-0.255*		
	(0.108)			(0.137)		
In 3 period difference: $\Delta Duty_{t-(t-3)}$		-0.196*			-0.397**	
		(0.119)			(0.173)	
In 4 period difference: $\Delta Duty_{t-(t-4)}$			-0.271**			-0.468**
			(0.153)			(0.200)
Year fixed effects	yes	yes	yes	yes	yes	yes
Industry-level Competition Control	yes	yes	yes	yes	yes	yes
Firm-level Controls	yes	yes	yes	yes	yes	yes
Observations	158,616	79,777	37,427	69,040	37,203	18,483
R-squared	0.002	0.002	0.001	0.001	0.002	0.001

Notes: ***, **, and * indicate significance at the 1%, 5%, and 10% level. Robust standard errors corrected for clustering at the firm level in parentheses. All regressions include a constant term. Industry-level Competition Control refers to Herfindahl index (HHI), which is computed in the initial year of the difference period at the 4-digit CIC industry in China. Firm-level controls include the changes in the following variables: TFP, the number of imported varieties, capital intensity, average wage, and firm size (measured by total employment).

Table A.3: Effect of Tariff Reductions on Quality Upgrading with Bootstrapped Standard Errors

	Dependent Variable: $\Delta \ln(\hat{q}_{fhc})$					
	$\sigma = 5$		$\sigma = 10$		$\sigma = \sigma_i$ Broda and Weinstein (2006)	
	(1)	(2)	(3)	(4)	(5)	(6)
ΔDuty	-3.093**	-3.125**	-6.351***	-6.623***	-3.339***	-3.304***
	(1.262)	(1.253)	(2.331)	(2.340)	(1.063)	(1.054)
Δln(TFP)		0.301***		0.496***		0.236***
		(0.063)		(0.118)		(0.056)
Δln(Capital/Labor)		0.159*		0.230		0.0948
		(0.088)		(0.160)		(0.071)
Δln(Labor)		0.263***		0.210		0.278***
		(0.092)		(0.163)		(0.091)
Δln(Wage)		0.150		0.251		0.110
		(0.111)		(0.209)		(0.090)
Δln(Import Varieties)		0.118*		0.181		0.118**
		(0.064)		(0.125)		(0.051)
HHI		-1.690		-4.386		-1.227
		(1.501)		(2.903)		(1.209)
Observations	14439	14439	14439	14439	14439	14439
R-squared	.001	.007	.001	.006	.002	.008

Notes: ***, **, and * indicate significance at the 1%, 5%, and 10% level. Bootstrapped standard errors are in parentheses. All regressions include a constant term. Herfindahl index (HHI) is computed in the initial year (2001) at the 4-digit CIC industry in China.

Table A.4: Baseline Regressions with Only $\Delta \ln(TFP)$ as Firm Control

	Dependent Variable: Δprice			Dependent Variable: $\Delta \ln(\hat{q}_{fhc})$		
	(1)	(2)	(3)	(4)	(5)	(6)
	$\Delta \ln(p_{fhc})$	$\Delta \ln(p_{fh})$	$\Delta(p_f)$	σ=5	σ=10	$\sigma = \sigma_i$
ΔDuty	-0.487**	-0.669**	-0.638**	-3.133**	-6.419***	-3.370***
	(0.218)	(0.282)	(0.302)	(1.233)	(2.283)	(1.040)
Δ ln(TFP)	0.0448***	0.0449***	0.0507***	0.314***	0.526***	0.243***
	(0.011)	(0.016)	(0.017)	(0.062)	(0.116)	(0.055)
Observations	14439	7595	2368	14439	14439	14439
R-squared	.003	.003	.006	.005	.004	.005

Notes: ***, **, and * indicate significance at the 1%, 5%, and 10% level. Robust standard errors corrected for clustering at the firm level in parentheses. All regressions include a constant term.

Table A.5: Effect of Tariff Reductions on Export Prices and Quality with Industry Fixed Effects

	Dependent Variable							
	Δ ln(Price$_{fhc}$)		Δ ln(Quality$_{fhc}$)		Δ ln(Price$_{fh}$)		ΔPrice Index$_f$	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
ΔDuty	-0.467**	-0.531**	-6.602**	-6.997***	-0.666**	-0.728***	-0.701**	-0.694**
	(0.223)	(0.229)	(2.656)	(2.684)	(0.275)	(0.279)	(0.312)	(0.317)
Δln(TFP)		0.035***		0.320**		0.034**		0.043**
		(0.012)		(0.133)		(0.016)		(0.017)
Δln(Capital/Labor)		0.024		0.173		0.037		0.002
		(0.016)		(0.166)		(0.024)		(0.022)
Δln(Labor)		0.003		0.223		0.017		-0.006
		(0.017)		(0.175)		(0.025)		(0.027)
Δln(Wage)		0.016		0.073		0.029		0.045*
		(0.020)		(0.215)		(0.024)		(0.025)
Δln(Import Varieties)		0.005		0.151		0.013		0.004
		(0.013)		(0.135)		(0.015)		(0.018)
HHI		-0.548*		-5.517*		-0.699*		-0.159
		(0.284)		(3.157)		(0.390)		(0.274)
Industry fixed effects	yes	yes	yes	yes	yes	yes	yes	yes
Observations	14439	14439	14439	14439	7595	7595	2368	2368
R-squared	.013	.016	.012	.014	.015	.018	.026	.031

Notes: ***, **, and * indicate significance at the 1%, 5%, and 10% level. Robust standard errors corrected for clustering at the firm level in parentheses. All regressions include a constant term. Herfindahl index (HHI) is computed in the initial year (2001) at the 4-digit CIC industry in China. Quality estimates are based on elasticities of substitution from Broda and Weinstein (2006).

Table A.6: Effect of Tariff Reductions on the Change in Quality-Adjusted Prices

	Dependent Variable: the change in effective quality-adjusted price $\Delta\ln(\widetilde{p}_{fhct}) \equiv \Delta[\ln(p_{fhct}) - \ln(\hat{q}_{fhct})]$					
	$\sigma = 5$		$\sigma = 10$		$\sigma = \sigma_i$	
	(1)	(2)	(3)	(4)	(5)	(6)
ΔDuty	2.611**	2.608**	5.870***	6.106***	2.858***	2.787***
	(1.086)	(1.075)	(2.128)	(2.136)	(0.926)	(0.912)
Δln(TFP)		-0.260***		-0.454***		-0.194***
		(0.054)		(0.107)		(0.049)
Δln(Capital/Labor)		-0.136*		-0.208		-0.0720
		(0.075)		(0.145)		(0.061)
Δln(Labor)		-0.261***		-0.208		-0.276***
		(0.081)		(0.148)		(0.085)
Δln(Wage)		-0.131		-0.232		-0.0906
		(0.094)		(0.189)		(0.078)
Δln(Import Varieties)		-0.106**		-0.169		-0.106**
		(0.053)		(0.112)		(0.044)
HHI		1.249		3.945		0.785
		(1.234)		(2.607)		(0.992)
Observations	14439	14439	14439	14439	14439	14439
R-squared	.001	.008	.001	.006	.001	.008

Notes: ***, **, and * indicate significance at the 1%, 5%, and 10% level. Robust standard errors corrected for clustering at the firm level in parentheses. All regressions include a constant term. Herfindahl index (HHI) is computed in the initial year (2001) at the 4-digit CIC industry in China.

D Supplementary Discussions

D.1 Estimating Quality Using IV Estimation

To avoid parameterizing σ_i based on the values given in the existing literature, we also estimate quality using IV estimation. The method is as follows.

We first estimate σ_i sector by sector using Chinese data by transforming equation (17) to the following:

$$\ln(x_{fhct}) = -\sigma_{i_{(h)}} \ln(p_{fhct}) + \varphi_h + \varphi_{ct} + \epsilon_{fhct} \tag{21}$$

where $i_{(.)}$ refers to the industry that product h belongs to; $\sigma_{i_{(h)}}$, industry-specific elasticity of substitution, can be estimated by regressing export quantity $\ln(x_{fhct})$ on unit value price $\ln(p_{fhct})$, product fixed effects, and country-year fixed effects for each industry i. Since ϵ_{fhct} is potentially correlated with the product price $\ln(p_{fhct})$, instrumental variable estimation is needed to identify the parameters. We use local average wages as instruments for prices in the first stage of instrumental variable estimation of equation (21). The local average wage is computed as average wage per worker across all firms producing at the same location in China, which mainly captures common cost shocks at supply side.[47] Although the local wages obviously affect production costs of firms and, therefore, product

[47] We use average local wage in each province.

prices, one may be concerned that local wages may be correlated with product quality, if, for example, higher-wage workers produce better products. However, the exclusion restrictions remain valid as long as local wages do not affect *deviations* from average quality.[48] In other words, if a firm chooses to export higher quality products to a destination market because of shocks to local wages (which is less likely), the instruments remain valid as long as shocks to local average wages do not affect deviations from the firm's average quality choice. Hence, we are not concerned about the potential correlation between local average wages and quality. The instrumental variable estimations are conducted industry by industry. Here we define industry i by 2-digit HS2 sector. There are in total 91 HS2 industries, after dropping one industry with less than 10 observations.

Next, as in the approach described in Section 5.1.2 (Quality Equation) in the main text, we use an estimate of the residual $\hat{\epsilon}_{fhct}$ from equation (21) to infer quality and then to infer quality-adjusted price. We report estimation results when regressing quality and quality-adjusted price on tariff reductions based on σ_i recovered from Chinese data in Table A.7. All results here are consistent with the results reported in the main text, i.e. a reduction in import tariff induces an incumbent importer/exporter to raise the quality of its exports but to lower its quality-adjusted prices.

Table A.7: Changes in Quality and Quality-Adjusted Prices vs. Tariff Reductions

(Based on σ_i Recovered from Chinese Data)

	Dependent Variables					
	changes in quality $\Delta\ln(\hat{q}_{fhc})$			changes in quality-adjusted price $\Delta\ln(\widetilde{p}_{fhc})$		
	(1)	(2)	(3)	(4)	(5)	(6)
ΔDuty	-2.747**	-2.756**	-2.531**	2.082*	2.089*	1.833
	(1.253)	(1.239)	(1.243)	(1.166)	(1.159)	(1.161)
Firm-level controls	no	yes	yes	no	yes	yes
Industry-level competition control	no	no	yes	no	no	yes
Observations	12083	12083	12083	12083	12083	12083
R-squared	.001	.003	.005	.001	.002	.004

Notes: ***, **, and * indicate significance at the 1%, 5%, and 10% level. Robust standard errors corrected for clustering at the firm level in parentheses. All regressions include a constant term. Industry-level Competition Control refers to Herfindahl index (HHI), which is computed in the initial year (2001) at the 4-digit CIC industry in China. Firm-level controls include the changes between 2006 and 2001 in the following variables: TFP, the number of imported varieties, capital intensity, average wage, and firm size (measured by total employment). The number of observations in this table is smaller than that in Tables 5 and A.6 because we dropped a few sectors due to the estimated σ_i for those sectors were out of range when we estimated σ_i using Chinese data. The deleted observations in this process account for only 4.2% of the original sample.

[48] Here, our argument about the validity of instruments shares the similar spirit of Khandelwal (2010).

D.2 Effect of Tariff Reductions for Growing and Shrinking Product and Product-Country

We further present regression results for the effect of tariff reduction for growing and shrinking product or product-country categories in Table A.8. Panels A and B in Table A.8 report the change in price and quality, respectively, as the dependent variable, for growing and shrinking using all goods (see columns 1 and 2), differentiate goods (see columns 3 and 4), and homogeneous goods (see columns 5 and 6). For example, in column 1 we use the subsample of growing type only and regress the change in price on tariff reduction. The coefficients on tariff reduction for growing type are always significantly negative for all goods and differentiated goods (see columns 1 and 3), and the coefficients for shrinking type are also negative but less significant (see columns 2 and 4). The effect for homogeneous goods is less significant and sometimes ambiguous (see columns 5 and 6). This is consistent with Propositions 1 and 2.

Panel C of Table A.8 reports the results at the firm-product level. The effects of tariff reduction on the price change for continuing products (either growing or shrinking) are all significantly negative in the sample of all goods (see columns 1 and 2) and differentiated goods (see columns 3 and 4), indicating that firms improve quality and thus increase price for their continuing products, including both growing products and shrinking products. It is also worth noting that the effect of tariff reduction on shrinking type at fhc level in panel A is insignificant while becomes significant at fh level in panel C. This is due to a modest compositional effect: firms may redirect their exports to countries where higher prices can be charged for a continuing product, even though the total export sales for that product may be shrinking. This is also consistent with our previous discussion of the baseline results that the estimated effects of tariff reductions tend to be larger in the more aggregated measures of export prices (see Table 4). Lastly, in panel C the effect of tariff reduction on price change for homogeneous goods is, again, positive or less significant (see columns 5 and 6). This further corroborates our previous discussion of the role of quality differentiation.

Table A.8: Effect of Tariff Reductions for Different Types at Firm-Product-Country or Firm-Product Level

	all goods		differentiate goods		homogeneous goods	
	(1)	(2)	(3)	(4)	(5)	(6)
sample	growing	shrinking	growing	shrinking	growing	shrinking
Panel A: dependent variable $= \Delta \ln(p_{fhc})$						
ΔDuty	-0.669***	-0.390	-0.816***	-0.486	1.046*	-0.0492
	(0.259)	(0.329)	(0.278)	(0.386)	(0.633)	(0.425)
Observations	8807	5632	7823	4982	984	650
R-squared	.005	.007	.005	.007	.009	.020
Panel B: dependent variable $= \Delta \ln(\hat{q}_{fhc})$						
ΔDuty	-5.950***	-1.436	-6.706***	-2.383*	0.966	2.274
	(1.146)	(1.278)	(1.278)	(1.407)	(2.738)	(2.489)
Observations	8807	5632	7823	4982	984	650
R-squared	.009	.010	.009	.012	.018	.026
Panel C: dependent variable $= \Delta \ln(p_{fh})$						
ΔDuty	-0.760**	-0.792*	-1.055***	-1.146**	1.660**	-0.002
	(0.316)	(0.429)	(0.342)	(0.555)	(0.756)	(0.419)
Observations	4846	2749	4237	2383	609	366
R-squared	.004	.016	.005	.019	.011	.030
Panels A, B and C:						
Firm-level Controls	yes	yes	yes	yes	yes	yes
Industry-level Competition Control	yes	yes	yes	yes	yes	yes

Notes: ***, **, and * indicate significance at the 1%, 5%, and 10% level. Robust standard errors corrected for clustering at the firm level in parentheses. All regressions include a constant term, firm-level controls, and industry-level competition control. Industry-level competition control refers to Herfindahl index (HHI), which is computed in the initial year (2001) at the 4-digit CIC industry in China. Firm-level controls include the changes between 2006 and 2001 in the following variables: TFP, the number of imported varieties, capital intensity, average wage, and firm size (measured by total employment). Quality estimates are based on elasticities of substitution from Broda and Weinstein (2006).

D.3 Level Regressions with Industry Tariffs

To provide more evidence on the relationship between tariffs and export prices, we also conduct the baseline regression in levels (see equation (13)) with industry input/output tariffs in Table A.9.[49] Columns 1-3 and 4-6 present the results with export prices for HS6-country product and HS6 product, respectively. In separate regressions, the coefficients on output tariffs and on input tariffs are both significantly negative (see columns 1-2 and 4-5); in combined regressions, the effect of input tariffs are still significantly negative (see columns 3 and 6). This further provides evidence on the negative relationship between the levels of export prices and the levels of input tariffs, i.e., higher export prices are also associated with lower input tariffs.

Table A.9: Regressions in Levels with Industry Input/Output Tariffs

	Industry Input/Output Tariff					
	Dependent variable: $\ln(p_{fhct})$			Dependent variable: $\ln(p_{fht})$		
	(1)	(2)	(3)	(4)	(5)	(6)
$Duty^{output}$	-0.409***		0.344***	-0.738***		0.0457
	(0.087)		(0.115)	(0.145)		(0.196)
$Duty^{input}$		-1.457***	-1.814***		-1.633***	-1.678***
		(0.137)	(0.182)		(0.209)	(0.283)
Year fixed effects	yes	yes	yes	yes	yes	yes
Firm-product-country fixed effects	yes	yes	yes			
Firm-product fixed effects				yes	yes	yes
Industry-level Competition Control	yes	yes	yes	yes	yes	yes
Firm-level Controls	yes	yes	yes	yes	yes	yes
Observations	1161028	1161028	1161028	420034	420034	420034
R-squared	.981	.981	.981	.969	.969	.969

Notes: ***, **, and * indicate significance at the 1%, 5%, and 10% level. All regressions include a constant term. Industry-level Competition Control refers to Herfindahl index (HHI) at the 4-digit CIC industry in China. Firm-level controls include TFP, the number of imported varieties, capital intensity, average wage, and firm size (measured by total employment).

[49] We present the level regressions with industry- instead of firm-specific tariffs because we do not have theoretical justification of firm-specific tariffs in levels. Our theoretically derived firm-specific measures refer to tariff reductions at the firm level.

D.4 Shifting Processors

Though we use processing exporters to conduct a Placebo test in the main text and confirm the quality upgrading mechanism for ordinary exporters, one may concern that import tariffs have potential impacts on the export processing margin for firms. If in general ordinary exporters charge higher export prices, could changes in prices we observe be related to changes in which goods firms are exporting through processing arrangements? Our previous main results are based on the sample of all ordinary trade transactions, but it is possible that some firms in the sample switch their trade regimes. To show the robustness of our main results to the changes in the margins of trade regimes, we deleted firms that switched from hybrid to ordinary regime from the main sample and report results in Table A.10. Note that the firms who switch from ordinary trade to hybrid is not our concern, because they could only attenuate the effect of tariff reductions on price increase if any effect existed. All results here are consistent with our main results.

Table A.10: Robustness: Excluding Firms that Switched Trade Regimes

	Dependent Variable							
	$\Delta \ln(\text{Export Price}_{fhc})$				$\Delta \ln(\text{Export Price}_{fh})$			
Regressor:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
ΔDuty	-0.472**	-0.638***	-0.513**	-0.677***	-0.600**	-0.889***	-0.640**	-0.922***
	(0.234)	(0.244)	(0.233)	(0.242)	(0.300)	(0.316)	(0.288)	(0.301)
ΔDuty $\times HOMOGENEOUS$		1.375***		1.343***		1.730***		1.681***
		(0.331)		(0.326)		(0.398)		(0.384)
Industry-level Competition Control			yes	yes			yes	yes
Firm-level Controls			yes	yes			yes	yes
Observations	12825	12825	12825	12825	6795	6795	6795	6795
R-squared	.001	.002	.004	.005	.001	.003	.006	.008

Notes: ***, **, and * indicate significance at the 1%, 5%, and 10% level. Robust standard errors corrected for clustering at the firm level in parentheses. All regressions include a constant term. Industry-level Competition Control refers to Herfindahl index (HHI), which is computed in the initial year at the 4-digit CIC industry in China. Firm-level controls include the changes in the following variables: TFP, the number of imported varieties, capital intensity, average wage, and firm size (measured by total employment).