Cross-Country Heterogeneous Response to Competition: Theory and Evidence from Trade Data*

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Abstract

We document that in response to intensified competition from China in the U.S., poor countries reduce their export prices relative to rich countries, consistent with conventional wisdom. Interestingly, however, the opposite is true for export quantities. To reconcile these facts, we develop and estimate a general equilibrium model of trade featuring (i) cross-country heterogeneity in the ability to produce high-quality goods and (ii) a two-dimensional Bertrand competition on price and quality. Our model explains the empirical facts by showing that rich countries have a comparative advantage in quality upgrading, whereas a nested model without quality cannot do so.

JEL codes: F12, F14, F15, F61.

Keywords: International trade, product market competition, quality, heterogeneous response, China.

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1 Introduction

How do different countries respond to intensified product market competition from China? Are poorer countries affected more than richer economies? These are traditional questions with important implications. This paper documents that when faced with heightened competition from China in the U.S. market, countries on average reduce their export prices, with poor countries lowering their export prices relative to rich countries. This aligns with the conventional wisdom that competition from China induces a stronger inward shift in the residual demand that poor countries face. The same inward shift in demand is expected to reduce quantities exported by other countries on average, with poor countries reducing their export quantities relative to rich economies.

Intriguingly, however, our empirical findings reveal a contrary pattern on the quantity margin: in response to intensified competition from China, countries on average *increase* their export quantities, with poor countries *raising* their export quantities relative to rich countries. To explain these empirical facts, we develop and estimate a general equilibrium Ricardian model of international trade featuring Bertrand competition and cross-country heterogeneity in the ability to produce high-quality goods.

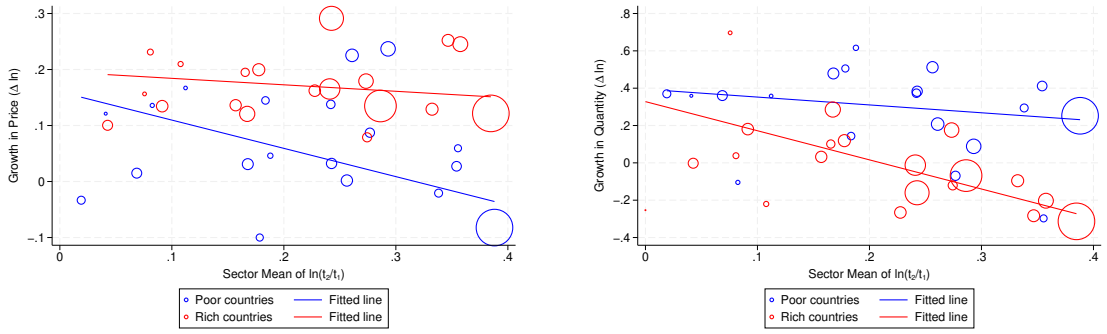
Using the U.S. import data at the most disaggregated level (i.e., 10-digit HS codes), we first explore how other exporting countries to the U.S. market responded to China's penetration in the U.S. market after China joined the World Trade Organization (WTO) in 2001. Following the difference-in-difference identification strategy proposed by Pierce and Schott (2016), we use variation in the gap between the most favored nation (MFN, hereafter) and non-MFN tariff rates across product categories to identify the effects of intensified competition from China on the responses of other exporting countries to the U.S. market. The larger the initial gap in tariff rates, the

more uncertainty was eliminated for Chinese producers, leading to more entry by China and thereby increasing competition (Handley and Limão, 2017). We interact the difference-in-difference term by the GDP per capita of exporting countries to document cross-country heterogeneous responses to intensified competition from China in the U.S. market.

Figure 1 provides suggestive evidence on how rich and poor countries respond differently to competition from China. Panel 1a graphs the average growth rate in export prices (i.e., unit values) of products exported by different countries to the U.S. market from 2000 to 2005 against the log difference between MFN and non-MFN tariff rates in each two-digit HS sector. Panel 1b repeats the same exercise but for export quantities. A general pattern that emerges on the price margin is that rich countries responded less than poor countries in terms of export prices. Section 2 will verify this pattern by employing a triple-difference identification strategy (in the spirit of Pierce and Schott, 2016) controlling for various fixed effects. Our regression results show that increasing the tariff gap from the 25th percentile of its distribution (22.9%) to the 75th percentile (46.4%) causes export prices from Indonesia to fall by 0.074 log points more than prices from Germany (within the same HS10).

This empirical pattern can be explained by existing theories in different ways. For example, in the spirit of Holmes and Stevens (2014), competition from China mostly affects products originating from poor countries because they produce similar, standardized goods. Hence, the market for products imported from rich countries would be affected less by Chinese competition, making these products less responsive in terms of price adjustments. Alternatively, one can argue that China's import penetration makes competition in the U.S. market tougher for other exporting countries, leading competing firms to differentiate their products by catering to domestic tastes or upgrading quality in order to escape competition (e.g., Khandelwal, 2010; Medina, 2017; Fieler and Harrison, 2018). If rich countries are more capa-

Figure 1: Differential Response of Countries to Intensified Competition from China



(a) Price Response (b) Quantity Response

Notes: The horizontal axis measures the log difference between MFN and non-MFN tariff rates in 1999 averaged across HS8 product categories within each HS2. The vertical axes measure the average growth in export prices (left) and quantities (right) from 2000 to 2005. Countries are categorized as poor versus rich according to the median GDP per capita in our sample. Each circle corresponds to an HS2 sector with its size being proportional to the number of observations in that sector.

ble of differentiating their products or quality upgrading, they would more easily escape the competition without reducing their market prices.

These explanations imply that poor countries are more impacted by Chinese competition, and hence the residual demand curve that firms from these countries face shifts inward to a greater extent, which explains why their prices fall relative to rich economies. Based on these explanations, this inward shift in the residual demand would imply that not only prices but also quantities exported to the U.S. by poor countries should fall relative to those by rich economies. In other words, a shift in the residual demand curve would imply that prices and quantities move in the same direction.

An examination of the average growth of quantities exported to the U.S. in Figure 1b, however, reveals an intriguing observation: rich countries *reduce* their export quantities to the U.S. market relative to poor countries after facing competition from China. Section 2 confirms this pattern by employing a triple-difference identification strategy. Our results show that moving from the 25th to 75th percentile of the tariff gap distribution, quantities exported from Germany to the U.S. *decreased* by

0.383 log points relative to those exported by Indonesia. This is in contrast with the existing theories emphasizing either that rich countries are less affected by competition from China because of the type of goods they produce or that rich countries can escape the competition more easily.

To rationalize these empirical facts, we develop a general equilibrium model of international trade. Specifically, we introduce cross-country heterogeneity in the ability to produce high-quality goods into the seminal work by Bernard et al. (2003) (BEJK, henceforth). The model therefore features tractably two-dimensional Bertrand competition on both margins of price and quality. In the model, countries are heterogeneous in two aspects: their physical efficiency, reflecting the amount of output that a country can make using a bundle of inputs, and their quality capability, reflecting the ability of a country to produce high-quality products. We show that having both aspects of heterogeneity is important to rationalize the empirical facts. Firms choose both the price and quality of their outputs when they sell in a destination market. Firms engage in head-to-head competition with each other in the sense that the firm that can provide the lowest quality-adjusted price will be the only seller of a given product in that market.

Using data on gravity variables, bilateral trade flows, and the average export price of countries in the year 2000, we estimate the model and back out country-level physical efficiency and quality capability simultaneously. Our estimated model indicates that rich countries are not only more efficient in physical production but also more capable of producing high-quality goods. We employ our estimated model to simulate the effects of China's intensified competition in the U.S. economy. We show that our model is able to produce the heterogeneous response on price and quantity margins of richer versus poorer countries to this intensified competition, whereas a nested model without quality adjustment is not able to do so. We further demonstrate that the quality upgrading channel plays a quantitatively significant role in

explaining these empirical facts.

Through the lens of our model, firms adjust both price and quality in response to product market competition. Since firms from poorer countries are less capable of producing high-quality products, in order to survive in the market, they mainly respond to head-to-head intensified competition by cutting export prices, which results in increased export quantities, rather than upgrading quality. As a result, in response to competition from China, export prices from poorer countries fall relative to richer economies, whereas the opposite is true for export quantities. We note that employing a BEJK-type framework is crucial for rationalizing our empirical facts, whereas most Melitz (2003)-Chaney (2008)-type models in this literature would not be fully consistent with our documented facts. To elaborate, within the Melitz-Chaney class of models, intensified product market competition operates by reducing the (industry- or country-level) price index in the U.S., thus leading to an inward shift in the residual demand faced by other countries. This shift in the demand curve would imply that export prices and quantities would move in the same direction. In this paper, however, the head-to-head nature of competition would induce a firm to reduce its price and increase its quantity in order to survive in the market, implying that prices and quantities move in the opposite direction in response to product market competition.[1]

In addition to the head-to-head competition, the main mechanism in the model that enables us to explain our empirical findings is that in response to intensified competition from China in the U.S. market, firms from other countries increase the quality of their exports to the U.S., with rich countries raising their quality relative to poor countries. We directly test and confirm this mechanism in the data by estimating the quality of all products exported to the U.S. following Khandelwal (2010)'s

[1]Notice that an alternative framework along the lines of Atkeson and Burstein (2008) and Edmond, Midrigan and Xu (2015) with a large enough lower-tier elasticity would be very similar to BEJK and would therefore be able to rationalize our empirical facts.

methodology.

Related Literature. This paper is related to two broad strands in the literature studying the effects of import competition. The first strand considers the response to competition on prices and markups and shows that import competition leads to firms losing their market share and thus reducing their prices and markups. This fact has been theoretically rationalized with different market structures (Melitz and Ottaviano, 2008; De Blas and Russ, 2015; Arkolakis et al., 2019) and verified quantitatively by several firm-level studies (see, e.g., Levinsohn, 1993; Krishna and Mitra, 1998; Edmond, Midrigan and Xu, 2015; Brandt et al., 2017; Feenstra and Weinstein, 2017; Hsu, Lu and Wu, 2017; Firooz, 2022).

The second strand investigates the impact of import competition on the innovation activity of firms or quality upgrading. Theoretical models on this margin of response stem from the pioneering studies by Sutton (1989, 1991), Boone (2000), and Aghion et al. (2005). Several studies examine the effect of international trade on either general innovation activity or the technological progress of firms (see, e.g., Bertschek, 1995; Bustos, 2011; Hombert and Matray, 2015; Bloom, Draca and Van Reenen, 2016; Autor et al., 2017; Aghion et al., 2018), or, more specifically, on the quality-upgrading behavior of firms (see, e.g., Verhoogen, 2008; Amiti and Khandelwal, 2013; Fernandes and Paunov, 2013; Smeets, Traiberman and Warzynski, 2016; Medina, 2017; Heins, 2019).

Our contribution to this literature is threefold. First, while most studies in this literature focus on a single country, we document a new empirical pattern that in response to Chinese competition in the U.S., poor countries reduce their export prices relative to rich countries, whereas the opposite is true for export quantities. Second, we develop a two-dimensional Bertrand competition framework featuring margins of adjustment on both price and quality to show how cross-country heterogeneity

in quality-upgrading capability can rationalize these facts. As mentioned above, the head-to-head nature of Bertrand competition is important for rationalizing our empirical findings. Lastly, we show that the quality upgrading channel is quantitatively important in explaining the empirical facts.

Within the narrower part of this literature that focuses on the effect of globalization on quality upgrading, there are three groups of studies that consider different channels through which globalization triggers quality upgrading. The first group (e.g., Fan, Li and Yeaple, 2015; Bas and Strauss-Kahn, 2015; Eslava, Fieler and Xu, 2018) shows that globalization reduces the price of high-quality inputs and thus makes it more profitable for firms to produce high-quality outputs. The second group (e.g., Bustos, 2011; Antoniades, 2015; Eslava, Fieler and Xu, 2018) focuses on the role of economies of scale for quality enhancement: international trade enlarges the market in which firms can sell their products, and hence the expanded revenue justifies paying the fixed costs of quality improvements. The third group (e.g., Medina, 2017; Bloom et al., 2018) focuses on factor reallocation within firms: import competition decreases the return to fixed factors that cannot be adjusted instantaneously, and therefore firms reassign these factors to produce products that are differentiated from imported products in an attempt to escape competition.

In this paper, quality improvement is due to neither cheaper intermediates nor the interaction of fixed costs and market size. It is rather due to the direct effect of competition in the output market. In fact, firms engage in head-to-head competition with foreign firms, which forces incumbent firms to increase quality in order to survive. Firms, therefore, provide higher-quality products in the same market in which competition is intensified, rather than redirecting their sales toward other markets (as in, e.g., Medina, 2017).

This paper is also related to the literature on cross-country differences in the quality of products that countries produce. In many studies, the well-known fact

that rich countries charge higher prices for their exports is attributed to the quality of their products. Rich countries endogenously produce higher-quality products either because of their geographic proximity to the markets demanding high-quality goods (e.g., Hallak, 2006), which is known as the "Linder hypothesis," or because they are more productive in producing high-quality goods (e.g., Feenstra and Romalis, 2014). Our paper departs from the standard tradition in the literature and differentiates between physical productivity and quality productivity. In this sense, our model is similar to Hallak and Sivadasan (2013), who consider two types of productivity for *firms*: process productivity (i.e., the ability of a firm to transform input to physical units of output) and product productivity (i.e., the ability of a firm to produce high-quality goods). Our paper also distinguishes between these two types of productivity but at the *country level*. We show that distinguishing between physical and quality productivity is crucial in capturing differential responses of countries to Chinese competition.

2 Empirical Regularities

This section presents the empirical facts. We document that in response to intensified competition from China in the U.S. market, poor countries reduce their export prices relative to rich countries, which is consistent with conventional wisdom. However, we show that the exact opposite pattern holds for export quantities. Several robustness exercises confirm these empirical regularities.

To assess the heterogeneous response of countries to intensified competition, we use China's accession to the WTO as a quasi-natural experiment. The Tariff Act of 1930 made the U.S. imports from non-market economies (including China) subject to high tariff rates known as "non-MFN" or "column 2" rates. The Trade Act of 1974, however, allowed the U.S. president, conditional on congressional approval,

to temporarily extend low tariff rates, known as "MFN" or "column 1" rates, on Chinese products on an annual basis. From 1980 until 2002, the U.S. government kept approving low MFN tariff rates for China, but the problem was that this approval had to be certified by Congress every year, a process that was politically uncertain. Consequently, the uncertainty of this process deterred Chinese firms from incurring the cost of entry into the U.S. market. In 2002 and after China joined the WTO, the U.S. Congress passed a bill and granted permanent MFN rates to China. With this uncertainty removed, China's exports to the U.S. market surged.

To identify the effects of Chinese intensified competition in the U.S., we follow Pierce and Schott (2016) and use the cross-product variation in the gap between MFN and non-MFN tariff rates. The gap between MFN and non-MFN rates can serve as an indicator of the size of the barriers that Chinese firms faced before China joined the WTO. The greater the gap, the more uncertainty that has been eliminated, and therefore more Chinese firms would be expected to enter the U.S. market after permanent MFN rates were granted (Handley and Limão, 2017). Labeling the U.S. as the destination market, we examine the rise in Chinese penetration after 2002 to explore how other exporting countries to the U.S. reacted to this intensified competition.

We use the U.S. import data from the U.S. Census Bureau and as prepared by Schott (2008) to measure the annual value and physical quantity of 10-digit HS product categories that are exported by all countries to the U.S. from 1992 to 2005. There are 197 distinct countries in the data. We denote the value, quantity, and unit value (price, hereafter) of 10-digit HS product h exported by country c to the U.S. at time t as v_{cht}, x_{cht}, and p_{cht}, respectively.[2] The variables v_{cht} and x_{cht} are directly recorded in the data, and we construct the price data by dividing the value by the quantity:

[2]In order to reduce measurement error, we drop all observations with a total value of imports less than $7,500 in 1989 dollars.

$p_{cht} = v_{cht}/x_{cht}$. The gap between the two tariff schedules (tariff gap, hereafter) is defined as

$$Gap_g = Non\ MFNRate_g - MFNRate_g\ , \tag{1}$$

where g stands for eight-digit HS product categories. We use ad valorem equivalents of MFN and non-MFN tariff rates in 1999 from Feenstra, Romalis and Schott (2002). Table C.1 presents the summary statistics.

We employ the following triple-difference specification to measure the cross-country heterogeneous impact of intensified competition from China:

$$\ln p_{cht} = \alpha_1 D_t^{2002} \times Gap_{g(h)} + \alpha_2 \ln GDP_c \times D_t^{2002} \times Gap_{g(h)} + D_{ch} + D_{ct} + \varepsilon_{cht}, \quad c \neq China, \tag{2}$$

where c denotes exporting countries to the U.S. (except China), h denotes 10-digit HS product categories, and t is time. The dummy variable D_t^{2002} takes the value of 1 for years $t \geq 2002$ and 0 otherwise, $Gap_{g(h)}$ is the gap between MFN and non-MFN tariff rates in eight-digit HS category g (in which product h lies), GDP_c is the GDP per capita for exporting country c in 2001, and D_{ch} and D_{ct} are country-product and country-time fixed effects, respectively.[3]

Table 1 reports different specifications that we run for regression (2). Column 1 is the baseline specification in which we do not include the triple-difference term. This baseline specification investigates how competition from China affects the pricing decisions of other exporting countries on average. The specification in column 2 allows for cross-country heterogeneity by introducing a triple-difference term that interacts the DID term $D_t^{2002} \times Gap_{g(h)}$ with the log GDP per capita of the exporting country. The main coefficient of interest is the triple-difference coefficient α_2, which

[3]Including detailed HS10-country fixed effects helps us deal with that different products may have different units. In the years that quantity units are available in Schott (2008)'s data, while quantity units may differ across countries (still not rare at the HS10 level), the units remain consistent *within HS10-country pairs* over time.

Table 1: The Effects of China's Accession to the WTO

	$\ln p_{cht}$	$\ln p_{cht}$	$\ln x_{cht}$	$\ln x_{cht}$
$D_t^{2002} \times Gap_{g(h)}$	-0.099***	-0.212***	0.066***	0.888***
	(0.008)	(0.048)	(0.017)	(0.111)
$\ln GDP_c \times D_t^{2002} \times Gap_{g(h)}$		0.012**		-0.091***
		(0.006)		(0.012)
Observations	1,704,760	1,702,241	1,704,760	1,702,241
R^2	0.92	0.92	0.87	0.87

Notes: This table reports the effect of intensified competition from China on the price and quantity of products exported to the U.S. by all countries except China. The left-hand side variables in columns 1-2 and 3-4 are the log unit value and the log quantity of products imported by the U.S., respectively. Right-hand side variables are the interaction of tariff gap and post-2002 dummy, and the triple interaction of tariff gap, post-2002 dummy, and log of the exporting country's GDP per capita in 2001. Data cover 1992 to 2005. All columns include country×product and country×year fixed effects. Standard errors are clustered at the country×product level and reported in parentheses. $^{***}p < 0.01$ $^{**}p < 0.05$ $^{*}p < 0.1$

captures the cross-country heterogeneous effect of Chinese competition on export prices to the U.S. market. We use GDP per capita as an indicator of the country's economic development. In all specifications, we include country-product as well as country-time fixed effects. Country-product fixed effects D_{ch} control for the fact that different countries self-select to export different types of products to the U.S. and also to control for different measurement units. Moreover, country-time fixed effects D_{ct} control for aggregate shocks that hit country c in year t.

We first show in Table C.2 that, as expected, Chinese penetration in the U.S. market after its accession to the WTO increases more for products with larger tariff gaps. We now present the main empirical regularities.

Fact 1. *In response to competition from China, poor countries reduce their export prices relative to rich countries.*

We document in column 1 of Table 1 that, on average, countries exporting to the U.S. respond to competition from China by cutting their prices. The DID coefficient is negative and highly significant, indicating that, on average, countries exporting product categories with a higher tariff gap tend to reduce their export prices in re-

sponse to China's easier access to the U.S. market. To put the magnitude of the coefficient into context, prices of products that experienced a tariff gap removal of 0.464 (the 75th percentile of the tariff gap distribution) fall by 0.023 log points (=0.099 $\times$ (0.464-0.229)) relative to the products associated with 0.229 gap removal (the 25th percentile of the gap distribution).

Furthermore, column 2 of Table 1 shows that the response of export prices to Chinese competition documented above is quite heterogeneous across countries. In fact, the coefficient of the triple-difference term $\log GDP_c \times D_t^{2002} \times Gap_{g(h)}$ is positive and significant, indicating that in response to competition from China, poor countries reduce their export prices relative to rich countries. The triple-difference coefficient is also economically significant: moving from the 25th to the 75th percentile of the tariff gap distribution leads to a fall in export prices from Indonesia to the U.S. of 0.074 log points more than those from Germany.[4]

This cross-country heterogeneous response in export prices to Chinese competition can be explained by the existing theories in the literature in at least two ways. First, one can rationalize this fact in the spirit of Holmes and Stevens (2014) by arguing that Chinese firms and those from poor countries produce similar, standardized products, whereas products exported by rich countries are more differentiated. This would imply that poor countries are more subject to competition from China and need to reduce their prices more than rich countries. Second, incumbent firms facing increased competition from China try to escape competition by differentiating their products or by quality upgrading (Khandelwal, 2010; Medina, 2017; Fieler and Harrison, 2018). If rich countries are more capable of differentiating their products or quality upgrading, they can more easily escape the competition compared to

[4]We note that the difference-in-difference and triple-difference coefficients capture the effects of one group *relative to* another one, not the absolute effects on prices. In particular, the difference-in-difference coefficient captures the response of prices for products with higher tariff gaps relative to those with lower tariff gaps, and the triple-difference coefficient identifies the differential effects on richer economies relative to poorer countries.

poor countries, and they are therefore affected less by Chinese competition.

These theories imply that poor countries are more impacted by Chinese competition either because they are more subject to competition from China as a result of the type of products they produce or because they are less able to differentiate their products or upgrade quality in order to escape competition. As a result, the residual demand curve that firms in poor countries face shifts inward to a greater extent compared to rich countries, which explains why their prices fall relative to rich economies. Based on these explanations, this inward shift in the demand curve would imply that not only prices but also quantities exported to the U.S. by poor countries should fall relative to those by rich economies. In other words, a shift in the residual demand curve would imply that prices and quantities move in the same direction.

Surprisingly, however, our next empirical fact documents that the exact opposite is true on the quantity margin.

Fact 2. *In response to competition from China, rich countries reduce their export quantities relative to poor countries.*

To establish this fact, we run the same regression 2, but we replace export prices p_{cht} with export quantities x_{cht}. The last two columns in Table 1 present the results. Column 3 of this table shows that countries exporting to the U.S. on average respond to competition from China by *increasing* their export quantities. The difference-in-difference coefficient is positive and highly significant, indicating that, on average, countries exporting products with a higher tariff gap tend to increase their export quantities in response to China's easier access to the U.S. market. To put the magnitude of the coefficient into context, export quantities of products that experienced a tariff gap removal of 0.464 (the 75th percentile of the tariff gap distribution) rise by 0.016 log points (=0.066 $\times$ (0.464-0.229)) relative to the products associated with

0.229 gap removal (the 25th percentile of the gap distribution).

Interestingly, the last column of Table 1 indicates that in contrast to Fact 1, rich countries *reduce* their export quantities relative to poor countries in response to competition from China: moving from the 25th to the 75th percentile of the tariff gap distribution, shipments from Germany to the U.S. *decreased* by 0.383 log points relative to those from Indonesia.

To reconcile these two empirical facts, Section 3 develops a Ricardian model of international trade with Bertrand competition and endogenous choice of quality in which firms react to tougher competition on both price and quality margins simultaneously. The main mechanism in the model that reconciles these two evidence is that, in response to intensified competition from China, rich countries increase the quality of their products relative to poor countries. We will also empirically support this mechanism by estimating the quality of exported products to the U.S. following Khandelwal (2010)'s methodology.

2.1 Robustness and Additional Results

We perform several robustness exercises explained briefly in what follows.

Pre-trends, U.S. duties, export reallocation, and changes in competition. Appendix A.1 performs four robustness exercises. We show that i) all effects *relative to* a potential pre-trend are both qualitatively and quantitatively very similar to what we documented in this section, suggesting that pre-trends are not deriving our results; ii) the results are not driven by changes in duties imposed by the U.S. on different origin countries; iii) an alternative story that rich countries might be more capable than poor countries in reallocating their exports to other destinations does not find support in the data; and iv) our results are robust to controlling for the Herfindahl index as a proxy for industry-level competition among exporters from a given

origin.

The U.S. regional trade agreements (RTAs). The U.S. has signed several RTAs with different countries over time. These RTAs might contaminate the effects we identified in this section to the extent that they correlate with tariff gaps. Appendix A.2 explores the universe of U.S. RTAs, identifies the ones that fall within our sample period, drops these countries from the sample, and shows that our results are not driven by these countries.

The case of Vietnam's accession to the WTO. The case of Vietnam's accession to the WTO was similar to that of China, but with a different timing: The U.S. and Vietnam signed a bilateral trade agreement in 2001 which granted conditional access to MFN rates to Vietnam, subject to annual approval by the congress. Later, in December 2006, Vietnam joined the WTO and accessed the MFN rates permanently. Appendix A.3 shows that patterns similar to what we documented in this section also hold around the time that Vietnam joined the WTO.

Imported inputs from China. A potential explanation for the empirical patterns documented in this section is that countries get access to cheaper imported inputs from China after its accession to the WTO. If this channel is stronger for poor countries compared to rich economies, this would explain why poor countries reduce their export prices relative to rich countries and can therefore sell more in the U.S. market. To analyze this explanation, Appendix A.4 performs two robustness checks. First, we do not find evidence that after China's accession to the WTO, poor countries imported disproportionately more from China relative to rich countries. Second, we focus on the textile industry (the inputs of which are arguably easier to identify), control for input tariffs, and show that our main results still hold.[5] While we do not claim to have systematically ruled out this alternative explanation, as doing so would require a detailed input-output table at the HS10 level, our model aims

[5]We thank one of the referees for this thoughtful suggestion.

to explore the quantitative importance of the quality-upgrading channel proposed in this paper.

Weighted regressions. The results reported in this section were based on unweighted regressions. To ensure that our results are not driven by products with small initial trade values, Appendix A.5 performs two robustness checks using contemporaneous as well as pre-2002 trade values as weights. Moreover, another potential concern is that tariff gaps alone may not correctly capture the intensity of Chinese competition, especially when Chinese penetration in the U.S. before its accession to the WTO varies substantially across products. To address this concern, Appendix A.5 performs another robustness check using pre-2002 Chinese exports (in terms of quantities) relative to total exports to the U.S. as weights. Appendix A.5 shows that our results using all these weighted regressions are not only qualitatively but also quantitatively similar to our unweighted regressions.

Heterogeneous Chinese penetration. Since the results reported in this section are attributed to China's accession to the WTO, we would expect these effects to be stronger for the products in which China appeared to have a comparative advantage. To explore this idea, we divide the whole sample into two subsamples based on Chinese penetration in the U.S. market. We then run the same regression (2) for each subsample separately. Appendix A.6 reports the results. As expected, all effects are stronger in the subsample with greater Chinese penetration.

3 The Model

The model is an extension of BEJK, which incorporates quality as an endogenous firm choice. There are N countries, indexed by $i, j \in \{1, ..., N\}$. Consumers buy goods to maximize their utility and supply their labor inelastically. Producers use labor as the only factor of production.

3.1 Consumers

The representative consumer in country n has a utility function that is a CES aggregate of a continuum of goods indexed by $\omega \in [0,1]$ (e.g., Hallak, 2006; Fan, Li and Yeaple, 2015; Eaton and Fieler, 2019):[6]

$$U_n = \left[\int_0^1 (z_n(\omega)x_n(\omega))^{\frac{\sigma-1}{\sigma}} d\omega\right]^{\frac{\sigma}{\sigma-1}}, \tag{3}$$

where $\sigma > 1$ is the elasticity of substitution, $z_n(\omega)$ and $x_n(\omega)$ are the quality and quantity of good ω in country n, respectively. The optimal consumption of good ω by the representative consumer in country n is given by

$$x_n(\omega) = E_n P_n^{\sigma-1} z_n(\omega)^{\sigma-1} p_n(\omega)^{-\sigma}, \tag{4}$$

where $p_n(\omega)$ is the price of good ω in country n, E_n is the total expenditure in country n, and P_n is country n's quality-adjusted aggregate price index:

$$P_n = \left[\int_0^1 (p_n(\omega)/z_n(\omega))^{1-\sigma} d\omega\right]^{\frac{1}{1-\sigma}}. \tag{5}$$

The indirect utility of the representative consumer is given by

$$U_n = E_n/P_n. \tag{6}$$

For future reference, it proves useful to substitute the optimal consumption $x_n(\omega)$ back into the utility function, and rewrite the utility function (3) as

$$U_n = E_n P_n^{\sigma-1} \left[\int_0^1 U_n(\omega)^{\sigma-1} d\omega\right]^{\frac{\sigma}{\sigma-1}}, \tag{7}$$

[6]The notion of quality in this paper resembles the horizontal quality in Eaton and Fieler (2019).

where $U_n(\omega)$ is the utility that the consumer in country n derives from good ω:

$$U_n(\omega) = \frac{z_n(\omega)}{p_n(\omega)} \,. \tag{8}$$

3.2 Producers

The production side of the model departs from the current standard in the literature and assumes two dimensions for the comparative advantage of countries: countries are heterogeneous not only in technology frontiers for physical production but also in their capability of making high-quality goods.[7]

In terms of physical production, we follow BEJK and assume that the joint efficiency distribution of the best and second-best producer (φ_1 and φ_2, respectively) in country i follows a bivariate Fréchet distribution:[8]

$$F_i(\varphi_1, \varphi_2) = [1 + T_i(\varphi_2^{-\theta} - \varphi_1^{-\theta})] \exp(-T_i \varphi_2^{-\theta}) \,, \tag{9}$$

where $0 < \varphi_2 < \varphi_1$. The parameter $T_i > 0$ captures the absolute advantage of country i in physical production, and $\theta > 1$ governs the heterogeneity of efficiencies.

Producing higher-quality goods can increase production costs in two ways. First, a firm needs to employ more production inputs (here, labor) to produce the same amount of output but at a higher level of quality. Therefore, quality raises the marginal cost of production. Several studies (e.g., Feenstra and Romalis, 2014; Fan et al., 2017; Eaton and Fieler, 2019; Bloom et al., 2021) use this approach to account for the role of quality in the cost structure. Second, in line with Kugler and Verhoogen (2012), Fan, Li and Yeaple (2015), and Eslava, Fieler and Xu (2018), a fixed

[7] As mentioned before, Hallak and Sivadasan (2013) also differentiate between two types of abilities, but at the firm level: the ability to produce goods at a lower marginal cost (process productivity) and the ability to produce goods at a higher quality level (product productivity).

[8] See chapter 4 of Eaton and Kortum (2005) for the micro-foundation of this distribution.

cost is associated with quality upgrading, reflecting the fact that higher quality demands factors such as more advanced technology, more product design services, a better distribution network, more advertisement, and so on.

In this paper, we incorporate both approaches—that is, both marginal and fixed costs are increasing in quality. Specifically, the total production cost that a firm with efficiency φ in country i incurs in order to deliver x units of output with quality z to country n is given by

$$C_{in}(x, z; \varphi) = \frac{w_i d_{in} z^{\gamma}}{\varphi} x + w_i z^{\beta_i} \ , \tag{10}$$

where w_i is the prevalent wage in country i and d_{in} is the iceberg trade cost (i.e., the amount of output that needs to be shipped from source i in order to deliver one unit to destination n). Parameter β_i reflects the production cost of quality in country i and governs the comparative advantage of country i in producing high-quality goods. This parameter can be interpreted as the capability of country i in upgrading quality: the higher β_i, the more costly it is for firms in country i to make high-quality goods. Our cost structure resembles that in Fan, Li and Yeaple (2015) with one difference: our focus is on *cross-country* heterogeneity in quality capability β_i, whereas they consider *cross-industry* heterogeneity in this parameter.

We will discuss later that the presence of a fixed cost of quality upgrading is essential to explain our empirical facts. In particular, we will explore three alternative cost structures and show that those specifications would not generate our empirical regularities.

3.3 Market Structure

For each product ω, there are many potential producers from all over the world who are perfect substitutes. They engage in two-dimensional Bertrand competition in

which they choose not only the price but also the quality of output. The firm that can provide the consumer in country n with the highest utility $U_n(\omega)$ (see equation (8)) will be the only seller of that good in that market.

3.4 Solving Producers' Problem

In this section, for ease of notation, we fix the product ω and the destination country, which we call Home, and solve the problem of potential producers of product ω across the world that try to sell this product in the Home market (hence, we drop ω in what follows). The goal is to (i) analyze export price, quantity, and quality decisions of the firm selling in Home and (ii) investigate competition effects in Home and explore how firms react if the Home market becomes more competitive. Since we fix the destination country, in what follows we drop the destination subscript while noting that all bilateral variables are denoted by the origin country. For example, d_i shows the iceberg cost of shipping goods from country i to Home.

Characterizing the Bertrand equilibrium requires two steps. First, we need to identify the winner of the competition. Second, given the identity of the winner, we need to determine the winner's optimal price, quantity, and quality. We discuss these steps in turn.

3.4.1 Step 1: Identifying the Winner

Since producers are perfect substitutes, there will be one active seller for each good on the market, and the consumer buys the good solely from the firm that can offer the highest utility, as indicated in (8). The winner of Bertrand competition is therefore the firm providing the highest utility, subject to earning a non-negative profit.

To identify the winner, consider a producer with efficiency φ from country i. The highest utility $U_i(\varphi)$ that this producer can deliver to Home's consumers subject to

earning a non-negative profit solves the following maximization problem:

$$\begin{aligned} \max_{z,p} \quad & U_i(\varphi) = \frac{z}{p} \\ \text{s.t.} \quad & \Pi = B(z/p)^{\sigma-1} - (\frac{w_i d_i z^{\gamma}}{\varphi} B z^{\sigma-1} p^{-\sigma} + w_i z^{\beta_i}) \geq 0 \,, \end{aligned} \tag{11}$$

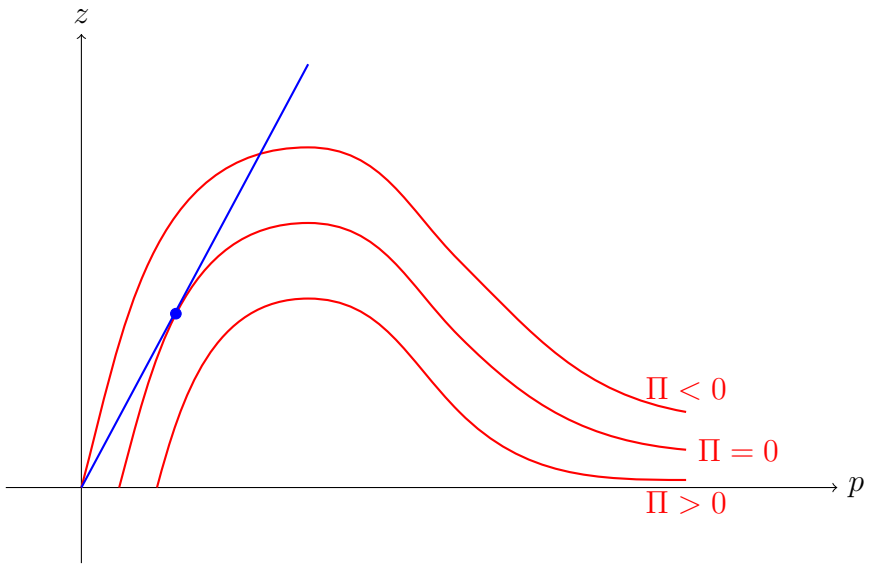
where $B = EP^{\sigma-1}$ is Home's aggregate demand shifter, and profit Π is the total revenue of the firm minus its total cost. Figure 2 shows a graphical illustration of this maximization problem. It shows the decision space of a firm where quality is on the vertical axis and price is on the horizontal axis. The objective function is the slope of the blue ray emanating from the origin, which indicates the level of utility delivered to consumers. The iso-profit curves of the firm are shown in red. Shifting the iso-profit curves downward and to the right increases the firm's profit (as a result of higher price, lower quality, or both). Therefore, as the firm increases the utility of the consumer by offering higher quality and lower price (i.e., rotating the blue ray counterclockwise), its profit decreases. Therefore, the maximum utility that the firm can afford is attained at the point where the blue ray becomes tangent to the zero-profit curve.

The first-order conditions of this optimization problem imply that the maximum utility that this firm can deliver equals

$$U_i(\varphi) = A_i \varphi^{\frac{1}{1-(\sigma-1)\lambda_i}} \,, \tag{12}$$

where $\lambda_i = \frac{1-\gamma}{\beta_i}$ and $A_i = (\lambda_i B)^{\frac{\lambda_i}{1-(\sigma-1)\lambda_i}} \left((1+\lambda_i) w_i\right)^{\frac{-1-\lambda_i}{1-(\sigma-1)\lambda_i}} d_i^{\frac{-1}{1-(\sigma-1)\lambda_i}}$. There are two components contributing to $U_i(\varphi)$: country-specific components w_i, λ_i and d_i, which are collected into A_i, and a firm-specific component φ. Sufficient conditions for

Figure 2: Maximum Utility that a Firm Can Deliver



Notes: This figure is a graphical illustration of the optimization problem (11). The curved lines are iso-profit curves, and the straight line is the maximum utility that the firm can deliver subject to earning a non-negative profit.

solution (12) to maximize problem (11) are

$$\beta_i > \sigma - 1 + \gamma \,, \tag{13}$$
$$\gamma < 1 \,.$$

We assume these conditions hold throughout the paper. Note that given conditions (13), $U_i(\varphi)$ is increasing in φ.

Denoting the highest and second-highest efficiencies from country i by φ_i^1 and φ_i^2, the highest and second-highest utility that country i can provide to Home will be $U_i^1 = U_i(\varphi_i^1)$ and $U_i^2 = U_i(\varphi_i^2)$, respectively. Since φ_i^1 and φ_i^2 are drawn from the bivariate Fréchet distribution (9), we can derive the joint distribution of U_i^1 and U_i^2 as

$$G_i(u_1, u_2) = \Pr(U_i^1 \leq u_1, U_i^2 \leq u_2) = [1 + \Phi_i(u_2^{-\theta_i} - u_1^{-\theta_i})] \exp(-\Phi_i u_2^{-\theta_i}) \,, \tag{14}$$

where $\Phi_i = T_i A_i^{\theta_i}$ governs the average utility coming from i and $\theta_i = \theta(1-\lambda_i(\sigma-1))$ governs its heterogeneity. Consequently, the distribution of the highest utility that can be sourced from i is

$$J_i(u) = \Pr(U_i^1 \leq u) = \exp(-\Phi_i u^{-\theta_i}) \ . \tag{15}$$

Now, denote the highest and second-highest utility that can be delivered to Home from all over the world by $U_i^{*(1)}$ and $U_j^{*(2)}$, where i and j are the nationalities of the best and second-best producers, respectively. Then

$$\begin{aligned} U_i^{*(1)} &= \max_k U_k^1 \ , \\ U_j^{*(2)} &= \max\{U_i^2, \max_{k \neq i} U_k^1\} \ , \end{aligned} \tag{16}$$

where country $i = \arg\max_k U_k^1$ is the nationality of the winner of Bertrand competition. Using the probabilistic formulation of the highest utility from each source country, we derive the probability that a firm from a given country is the active seller of any good in the Home market.

Proposition 1. *The probability that a firm from country i is the supplier of a given good in the Home market is*

$$\pi_i = \Phi_i \theta_i \int_0^\infty u^{-\theta_i - 1} \exp(-\sum_j \Phi_j u^{-\theta_j}) du \ . \tag{17}$$

Proof. See Appendix B.1. □

3.4.2 Step 2: Solving the Winner's Problem

Given the identity of the winner (i.e., the best producer), the second step in characterizing the Bertrand equilibrium is to determine what price and quality the winner

offers in the market. Suppose that the best producer that sells a particular product in the Home market is a firm with productivity φ from country i. It proves useful to first solve the profit-maximization problem if this firm was a monopolist. This monopolist would maximize its profit to find price p_i^{mon} and quality z_i^{mon} (where mon stands for "monopolist"):

$$\max_{p_i^{mon}, z_i^{mon}} \quad \Pi_i^{mon}(\varphi) = B(z_i^{mon}/p_i^{mon})^{\sigma-1} - \left(\frac{w_i d_i (z_i^{mon})^{\gamma}}{\varphi} B(z_i^{mon})^{\sigma-1} (p_i^{mon})^{-\sigma} + w_i (z_i^{mon})^{\beta_i} \right). \quad (18)$$

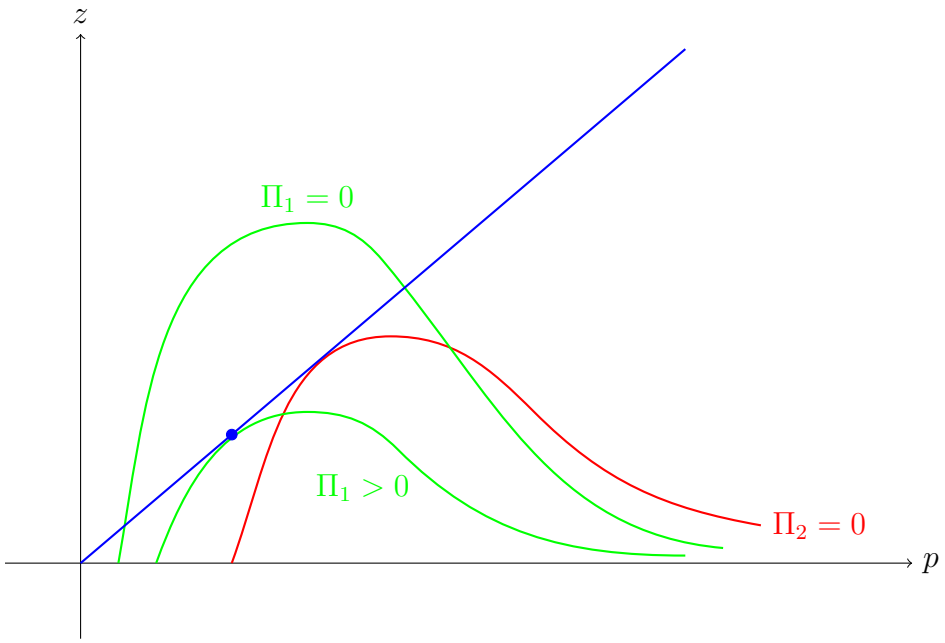
The first-order conditions of this profit-maximization problem deliver

$$\begin{aligned} z_i^{mon} &= \left[B(\frac{w_i \sigma}{\sigma - 1})^{-\sigma} (\frac{d_i}{\varphi})^{1-\sigma} (\frac{1-\gamma}{\beta_i}) \right]^{\frac{1}{\beta_i - (1-\gamma)(\sigma-1)}}, \\ p_i^{mon} &= (\frac{\sigma}{\sigma - 1}) \frac{w_i d_i}{\varphi} (z_i^{mon})^{\gamma}. \end{aligned} \quad (19)$$

This monopolist can therefore deliver the utility $U_i^{mon} = z_i^{mon}/p_i^{mon}$ to consumers in the Home country.

In the Bertrand competition, the best producer is limited by the second-best producer from country j if the second-best producer provides a utility that is greater than the utility provided by the monopolist (i.e., $U_j^{*(2)} > U_i^{mon}$). In this case, the objective of the best producer is to maximize its profit conditional on providing the utility that is weakly greater than $U_j^{*(2)}$ in order to remain the active seller in the market. This means that the best producer needs to lower the price and raise the quality relative to the monopolist's choice, up to the point where the second-best producer is kept out of the market. In other words, the best producer solves the

Figure 3: Profit Maximization Problem



Notes: This figure is a graphical illustration of the optimization problem (20).

following profit-maximization problem:

$$\begin{aligned} \max_{p_i, z_i} \quad & \Pi_{i(1)}(\varphi) = B(z_i/p_i)^{\sigma-1} - \left(\frac{w_i d_i z_i^{\gamma}}{\varphi} B z_i^{\sigma-1} p_i^{-\sigma} + w_i z_i^{\beta_i}\right) \\ \text{s.t.} \quad & \frac{z_i}{p_i} \geq U_j^{*(2)} \ . \end{aligned} \tag{20}$$

It can be verified that the monopolist-delivered utility U_i^{mon} is a fraction $\delta_i = [(\frac{\sigma-1}{\sigma})(1+\lambda_i)]^{\frac{1+\lambda_i}{1-\lambda_i(\sigma-1)}}$ of $U_i^{*(1)}$, where conditions (13) imply $\delta_i < 1$. So if $U_j^{*(2)} > \delta_i U_i^{*(1)}$, then the best producer is bounded by the second-best producer and needs to solve the problem (20). Otherwise, it will be a monopolist in the market and decide about its price and quality according to the problem (18).

Figure 3 illustrates the graphical representation of problem (20). The green and red curves represent the iso-profit curves of the best and second-best producers, respectively. The slope of the blue ray is equal to the maximum utility that the

second-best firm can deliver subject to earning non-negative profit. This is the utility that the best producer is bounded to provide. So the optimal point is where the best producer's iso-profit curve becomes tangent to the blue ray. Solving problem (20) delivers the following optimal price, quality, and quantity:

$$p_i = \begin{cases} \left[\dfrac{B(1-\gamma)}{w_i(\beta_i+1-\gamma)}\right]^{\frac{1}{\beta_i}} (U_j^{*(2)})^{\xi_i^p} (U_i^{*(1)})^{\psi_i} & \text{if} \quad U_j^{*(2)} > \delta_i U_i^{*(1)} \\ p_i^{mon} & \text{if} \quad U_j^{*(2)} \leq \delta_i U_i^{*(1)} \end{cases} \tag{21}$$

$$z_i = \begin{cases} \left[\dfrac{B(1-\gamma)}{w_i(\beta_i+1-\gamma)}\right]^{\frac{1}{\beta_i}} (U_j^{*(2)})^{\xi_i^z} (U_i^{*(1)})^{\psi_i} & \text{if} \quad U_j^{*(2)} > \delta_i U_i^{*(1)} \\ z_i^{mon} & \text{if} \quad U_j^{*(2)} \leq \delta_i U_i^{*(1)} \end{cases} \tag{22}$$

$$x_i = \begin{cases} B^{1-\frac{1}{\beta_i}} \left[\dfrac{(1-\gamma)}{w_i(\beta_i+1-\gamma)}\right]^{\frac{-1}{\beta_i}} (U_j^{*(2)})^{\xi_i^x} (U_i^{*(1)})^{-\psi_i} & \text{if} \quad U_j^{*(2)} > \delta_i U_i^{*(1)} \\ x_i^{mon} & \text{if} \quad U_j^{*(2)} \leq \delta_i U_i^{*(1)} \end{cases} \tag{23}$$

where

$$\begin{aligned} \xi_i^p &= -\frac{\beta_i + 1 - \gamma - \sigma}{\beta_i + 1 - \gamma}\,, \\ \xi_i^z &= \frac{\sigma}{\beta_i + 1 - \gamma}\,, \\ \xi_i^x &= \frac{\sigma(\beta_i - \gamma)}{\beta_i + 1 - \gamma}\,, \\ \psi_i &= -\frac{\beta_i - (\sigma - 1)(1-\gamma)}{\beta_i(\beta_i + 1 - \gamma)}\,. \end{aligned} \tag{24}$$

Table 2 specifies the sign and partial derivatives of these elasticities, which will prove useful below.[9]

[9] Note that the signs of these elasticities follow from conditions (13).

Table 2: Elasticities of price, quality, and quantity with respect to competition

	ξ_i^p	ξ_i^z	ξ_i^x	ψ_i
Sign	< 0	> 0	> 0	< 0
Derivative w.r.t. β_i	$\partial\lvert\xi_i^p\rvert/\partial\beta_i > 0$	$\partial\xi_i^z/\partial\beta_i < 0$	$\partial\xi_i^x/\partial\beta_i > 0$	$\partial\lvert\psi_i\rvert/\partial\beta_i < 0$

3.5 Investigating Model Mechanisms

Now that we have solved the winner's problem, we investigate how an increase in competition influences the equilibrium price, quality, and quantity. Assume that the U.S. is the Home market and, to simulate the intensified competition from China in the U.S., consider a reduction in the trade cost from China to the U.S. Similar to what we did in reporting the empirical patterns, we focus on the goods exported to the U.S. market from all sources except China. Our goal here is to explain intuitively how the model mechanisms are able to generate the empirical patterns documented in Section 2. Section 5 will employ our estimated model, run regressions analogous to those reported in Section 2, and examine the quantitative importance of the quality upgrading channel in explaining the empirical facts.

In the model, this intensified competition acts through two channels. The first channel works through the aggregate price index P (which is inside B). A reduction in trade cost would reduce the aggregate price index, thereby affecting exporting firms' optimal price, quality, and quantity. This is the standard general equilibrium effect of competition, and we call it the *indirect* competition effect in what follows.

The second channel works through the head-to-head competition that firms are engaged in, which implies that a non-Chinese incumbent firm (i.e., the best producer) is directly responding to the competition induced by a second-best Chinese firm. To elaborate, facing a reduction in trade cost from China to the U.S., Chinese firms would be able to deliver a higher utility to U.S. consumers than before (see

equation (12)). As a result, the second-highest utility $U_j^{*(2)}$ that threatens an incumbent firm would increase since either a second-best Chinese firm can now provide a higher utility than before or a Chinese firm can replace a non-Chinese second-best producer. We call this channel the *direct* effect of competition, and it is acting through $U_j^{*(2)}$. The elasticities of optimal price, quality, and quantity with respect to this direct competition are ξ_i^p, ξ_i^z, and ξ_i^x, respectively, derived in equation (24).

As for the indirect effect, the reduction in the aggregate price index shifts down the demand curve for a firm, which makes the firm reduce its price and quantity (i.e., price and quantity would move in the same direction).[10] Moreover, the firm will also downgrade its quality because a fall in demand reduces the marginal benefit of increasing product quality.[11] This resembles the Schumpeterian effect (Aghion et al., 2005), in which competition discourages innovation (here, quality upgrading). Notice that this indirect effect of competition is *not* reflected in the difference-in-difference term in the empirical regularities reported in Section 2, since this effect is captured by the country-time fixed effects.[12] Hence, to explain how countries respond differently to intensified competition (as shown in Section 2), we will focus on how the *direct* competition effect influences optimal price, quantity, and quality.

As for the direct effect of competition, the incumbent firm (i.e., the best producer) now faces a stronger rival and therefore must provide higher utility to the consumer in order to survive in the market. An inspection of equations (21)-(23) reveals that the incumbent firm does so by adjusting on both margins of price and quality in response to the direct competition (i.e., higher $U_j^{*(2)}$): it will both upgrade the quality

[10] Given conditions (13), a sufficient condition for quantities to fall with a fall in the price index is to have $\sigma \geq 2$.

[11] Note that the aggregate price index in equations (21)-(23) also appears in $U_i^{*(1)}$. Taking this fact into account, one can still confirm that the indirect effect of competition reduces optimal price, quantity, and quality.

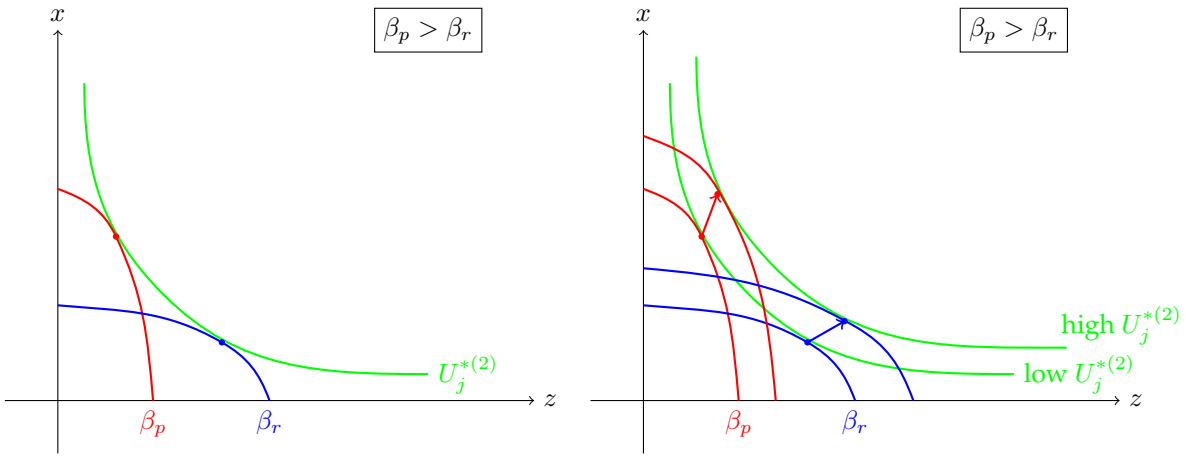
[12] In other words, the difference-in-difference terms in our regressions measure the heterogenous response of products with different exposures to the China shock (i.e., products with different tariff gaps). The change in the price index P is the same for all products and it does not therefore affect the difference-in-difference coefficients.

and reduce the price, which would raise the equilibrium quantity. How much of this response is on the price, quality, and quantity margins depends on the elasticities ξ_i^p, ξ_i^z, and ξ_i^x, respectively, which in turn depend on the capability of the exporting country in producing high-quality goods (i.e., β_i).

As our estimation in Section 4 will show, rich countries are more capable of producing high-quality products (i.e., they have lower β_i). Therefore, incumbent firms from rich countries (compared to those from poor countries) respond to competition mainly by upgrading quality rather than responding on the price margin. This is the escaping competition channel that tends to raise quality. To elaborate, as we move from poorer to richer countries, β_i decreases, causing the competition elasticity of price ξ_i^p (in absolute terms) and that of quantity ξ_i^x to fall and the competition elasticity of quality ξ_i^z to rise (see Table 2). This means that incumbent firms from poor countries (compared to those from rich countries) respond to direct competition mainly by cutting their prices, which results in increased export quantities, rather than upgrading their quality. Therefore, consistent with the empirical patterns in Section 2, poor countries reduce their export prices relative to rich countries, whereas export quantities by poor countries rise relative to those by rich economies. Notice that the cross-country heterogeneity in β_i is essential for explaining these empirical facts. In other words, having heterogeneity in only physical efficiency would not be sufficient to explain our empirical regularities.

Figure 4 graphically illustrates cross-country differential responses to competition. To this end, we first rewrite the optimization problem (20) as a cost minimization problem in quality-quantity space, as shown in Appendix B.2. The left panel in Figure 4 illustrates this cost minimization problem for an incumbent firm in a rich (β_r) versus a poor (β_p) country. The red and blue curves are iso-cost curves. The rich country is more efficient in quality production, which results in the red curve being steeper than the blue one. Moving the iso-cost curve outward means pro-

Figure 4: Cross-Country Differential Response to Competition



Notes: This figure is a graphical illustration of the optimization problem (20) in quality-quantity space for two different quality capability parameters, β.

viding more of both quantity and quality, which increases the total cost of a firm. The iso-utility curve $U_j^{*(2)}$ demonstrates all combinations of quality and quantity that deliver utility $U_j^{*(2)}$. Therefore, a firm's cost-minimizing choice of quantity and quality, conditional on providing the utility $U_j^{*(2)}$, is obtained by making the iso-cost curve tangent to the iso-utility curve. Now suppose that intensified competition raises $U_j^{*(2)}$. Firms have to re-optimize in order to deliver a higher utility level. This re-optimization is illustrated in the right panel of Figure 4. The firm in the poor country adjusts more on the quantity margin, while the firm in the rich country mainly increases its quality.

It is worth emphasizing that the head-to-head nature of competition is crucial for explaining why export prices and quantities for rich relative to poor countries move in the opposite direction in response to intensified competition. This is because in the absence of head-to-head competition, the *direct* effect of competition acting through $U_j^{*(2)}$ would disappear. Moreover, the presence of a fixed cost of quality upgrading is essential to explain our empirical facts. In particular, Appendix B.3 employs three alternative cost structures and shows that those specifications would

not generate our empirical regularities.

To summarize, both direct and indirect effects push the firm to reduce its price, but their impact on quality is opposing. In relation to the literature on competition and innovation, this model provides a tractable framework that nests both types of firm innovation responses (i.e., resembling escaping competition and Schumpeterian effects (Aghion et al., 2005)).

Other implications of the model. Our model also implies two other results consistent with what has been documented in the literature. First, all else being equal, firms export higher-quality goods to more distant markets. In the literature, this fact is usually rationalized by assuming specific trade costs. In this model, however, it is the head-to-head competition and fixed cost of quality upgrading that drive the result: As Appendix B.2 shows, the total revenue of the best firm under Bertrand competition is completely disciplined by the second-best firm. Therefore, the profit maximization problem faced by a firm reduces to a pure cost minimization problem. Given the trade costs for each unit of exports, firms try to save on shipping costs by shifting the production cost toward the fixed component of the cost structure, thereby increasing the quality of exports rather than the physical volume.

Second, our model implies that, all else being equal, firms export higher-quality goods to larger economies. The fixed cost of quality upgrading generates an economy of scale in quality provision. If the destination market is larger, any investment in upgrading quality will result in more revenue, giving the firm more incentive to incur the fixed cost of quality improvement.[13]

[13]This result is also consistent with the fact that Chinese firms charge higher prices in larger markets, as documented by Manova and Zhang (2012).

3.6 Testing Model Mechanisms in the Data

The response of quality to China's accession to the WTO. Our model implies that in response to intensified competition from China in the U.S. market, firms from other countries increase the quality of their exports to the U.S., with rich countries raising their quality relative to poor countries. In addition to the head-to-head competition, this is the main mechanism explaining our empirical facts. It is therefore crucial to test this mechanism directly in the data. To this end, we estimate the quality of all 10-digit HS products exported by all countries to the U.S. from 1992 to 2005, following Khandelwal (2010)'s methodology. We then run a regression analogous to equation (2), with the left-hand side replaced by the quality of exports. Table C.3 presents the results, which confirm the model mechanism: countries, on average, increase the quality of their exports in response to intensified Chinese competition in the U.S. market (column 1), with rich countries increasing their quality relative to poor countries.[14]

China's response to its WTO accession. Thus far, we have examined the responses of other countries to China's accession to the WTO. Investigating China's own response and comparing it with the data provide additional validation of the model. As Appendix C.1 shows, our model suggests that after China's accession to the WTO, Chinese prices fall while their quantities rise. We then test these predictions using a specification analogous to equation (2), restricting the exporting country to China and dropping the triple-difference term accordingly. Appendix Table C.4

[14]Our result that in response to competition rich countries increase their quality *relative to* poor countries is consistent with Amiti and Khandelwal (2013). To elaborate, Amiti and Khandelwal (2013) focus on the *absolute* quality upgrading of countries exporting to the U.S. and document that in response to competition (proxied by tariffs), countries that are close to the quality frontier increase their quality while those that are far from the quality frontier reduce their quality. Amiti and Khandelwal (2013) find that rich countries are on average quality leaders and therefore in response to competition, rich countries increase their quality *relative* to poor countries. Notice that what matters to rationalize our empirical facts on cross-country heterogeneous response to competition is the *relative* quality upgrading of rich versus poor countries.

confirms our model predictions.

Extensive margin. Thus far, we have focused on the effects of China's accession to the WTO on the intensive margin, examining changes in prices and quantities within HS10-country pairs. Appendix C.2 investigates the cross-country heterogeneous response to China's accession to the WTO on the extensive margin, both in the model and the data. In particular, we first show that, in the model, a reduction in Chinese trade costs to the U.S. reduces the number of products exported by other countries to the U.S., with this reduction being more pronounced for poorer countries. We then demonstrate that these model predictions align with the data.

3.7 A Special Case: Cobb-Douglas Utility

Although the main mechanisms of the model are described in Section 3.4, it is still useful to consider a special case in which we can derive closed-form solutions and analytically investigate firms' responses to an intensified competition shock in the Home market. This special case is constructed by setting the elasticity of substitution σ to one, which means assuming a Cobb-Douglas utility function.

In this case, the location parameter of the distribution of the highest utility that can be sourced from country i (equation (15)) becomes $\Phi_i = T_i A_i^{\theta}$ where $A_i = (\lambda_i E)^{\lambda_i} \left((1+\lambda_i) w_i\right)^{-1-\lambda_i} d_i^{-1}$. Notice that in this case with $\sigma = 1$, the dispersion of these highest utilities would be identical for all source countries (i.e., $\forall i : \theta_i = \theta$). While this assumption ($\sigma = 1$) removes the heterogeneity in the dispersion of utilities across source countries, it makes the model more tractable since we can derive closed-form solutions for trade shares and the distribution of equilibrium quality. We derive these expressions below.

Corollary 1. *With Cobb-Douglas utility, the price and quality that the source country i*

provides in the Home market for a given product is

$$p_i = \bar{p}_i (U_j^{*(2)})^{\frac{\gamma-\beta_i}{\beta_i+1-\gamma}} (U_i^{*(1)})^{\frac{-1}{\beta_i+1-\gamma}} , \quad z_i = \bar{z}_i \left(\frac{U_j^{*(2)}}{U_i^{*(1)}} \right)^{\frac{1}{\beta_i+1-\gamma}} , \tag{25}$$

where $\bar{p}_i = \left[\frac{E(1-\gamma)}{w_i(\beta_i+1-\gamma)} \right]^{\frac{1}{\beta_i}}$ *and* $\bar{z}_i = \left[\frac{E(1-\gamma)}{w_i(\beta_i+1-\gamma)} \right]^{\frac{1}{\beta_i}}$ *can be interpreted as the average price and quality of goods sourced from country* i*, respectively.*

Proof. Equations can be derived by plugging $\sigma = 1$ into equations (21) and (22). □

Notice that in this special case, the best producer is always bounded by the second-best producer because the utility it delivers as a monopolist would be zero (by choosing $p = \infty$ and $z = 0$), which is always less than the second-highest utility. Moreover, the equations above show that, in line with the general case in the previous section, firms from poor countries (i.e., with high β_i) respond to direct competition (i.e., higher $U_j^{*(2)}$) mainly by cutting their prices, whereas firms from rich countries mostly upgrade their quality.

Proposition 2. *With Cobb-Douglas utility, the trade share of country* i *in the Home market,* s_i*, is equal to the probability that a firm from country* i *will be the supplier for a given good in the Home market, which is equal to:*[15]

$$s_i = \pi_i = \frac{\Phi_i}{\Phi} , \quad \Phi = \sum_j \Phi_j . \tag{26}$$

Proof. See Appendix B.4. □

Proposition 3. *With Cobb-Douglas utility, the distribution of the ratio of the second-*

[15] As we will discuss below, in the case in which $\sigma \neq 1$, there would be no closed-form solution for the trade shares.

highest to the highest utility for a good sourced from country i is

$$\Pr\left(\frac{U_j^{*(2)}}{U_i^{*(1)}} \leq x \mid i \text{ source}\right) = x^{\theta}, \qquad 0 < x < 1\,. \tag{27}$$

Proof. See Appendix B.5. □

Now we can easily derive the quality distribution using Proposition 3 and the quality expression (25), which we state below.

Proposition 4. *With Cobb-Douglas utility:*

(i) The quality distribution of products exported by country i to the Home market is

$$H_i(\zeta) = \Pr(z_i \leq \zeta | i \text{ source}) = \left(\frac{\zeta}{\bar{z}_i}\right)^{\theta(\beta_i+1-\gamma)}. \tag{28}$$

(ii) The quality distribution of all products sold in the Home market is

$$H(\zeta) = \Pr(z \leq \zeta) = \sum_{i=1}^{n} \pi_i \left(\frac{\zeta}{\bar{z}_i}\right)^{\theta(\beta_i+1-\gamma)}. \tag{29}$$

Proof. Combine the quality expression (25) and Proposition 3. □

One implication of equation (28) is that conditional on the source country, the quality distribution does not vary by trade costs. This result is similar to the unresponsiveness of markup distribution to trade costs in BEJK.

The next proposition summarizes the effect of intensified competition on the quality of goods in the Home market.

Proposition 5. *Denote the quality distribution of goods in the Home market before and after a reduction in trade cost d_i by $H_b(\zeta)$ and $H_a(\zeta)$, respectively. Moreover, denote the distribution function of quality provided by a surviving firm φ before and after this change in trade cost by $h_b(\zeta|\varphi)$ and $h_a(\zeta|\varphi)$, respectively. With a Cobb-Douglas utility function:*

(i) The surviving firm φ stochastically raises its quality, that is, $h_a(\zeta|\varphi) \succsim h_b(\zeta|\varphi)$.

(ii) If country i's quality is stochastically inferior to the average quality in the Home market (i.e., $H(\zeta) \succsim H_i(\zeta)$), then the quality distribution of goods will be stochastically downgraded after the fall in the trade cost, that is, $H_b(\zeta) \succsim H_a(\zeta)$, and vice versa.

Proof. See Appendix B.6. □

The intuition for part (i) is straightforward and has been explained before: it is the intensified competition effect in the Home market that makes firm φ upgrade its quality in order to survive the competition. The intuition for part (ii), however, merits further explanation. Consider a particular good produced by country $j \neq i$ before the fall in d_i. If country j remains the source of this good after the fall in d_i, then its quality will not change, as implied by Proposition 4. However, when a firm from country i replaces a firm from country j, it provides the good on average at a lower-quality level because country i's technology in quality production is inferior to the world's average technology. This implies that the quality of goods, on average, decreases. In a nutshell, if any policy shifts trade shares toward a country whose quality is on average below (above) the world's quality, then the quality distribution of goods sold in the Home market will be downgraded (upgraded).

3.8 Equilibrium

An economy is defined by a set of N countries. Each country i is populated with L_i units of individuals who supply one unit of labor inelastically. Each country i is endowed with physical technology and quality capability parameters T_i and β_i, respectively. We now expand the notation used in Section 3.4 to capture the bilateral nature of variables. That is, for any variable Y_{in}, i is the source and n is the destination country.

Before we define the equilibrium of the model, we first characterize the international flow of goods in the following corollary.

Corollary 2 (Gravity). *Trade flow from country i to n, X_{in}, is given by*

$$X_{in} = \frac{(1-\delta_i^{\theta_i})\Phi_{in}\int_0^\infty u^{\sigma-\theta_i-1}(\sum_j \Phi_{jn}\theta_j u^{-\theta_j-1})\exp(-\sum_j \Phi_{jn}u^{-\theta_j})du}{P_n^{1-\sigma}}E_n + \frac{\delta_i^{\theta_i}\Phi_{in}\theta_i\int_0^\infty u^{\sigma-\theta_i-2}\exp(-\sum_j \Phi_{jn}u^{-\theta_j})du}{P_n^{1-\sigma}}E_n \,, \tag{30}$$

where E_n is total expenditure in destination n, Φ_{in} is the average utility sourced from i and delivered to n

$$\Phi_{in} = T_i A_{in}^{\theta_i} \,, \quad \theta_i = \theta(1-\lambda_i(\sigma-1)) \,, \tag{31}$$

$$A_{in} = (\lambda_i E_n P_n^{\sigma-1})^{\frac{\lambda_i}{1-(\sigma-1)\lambda_i}} ((1+\lambda_i)w_i)^{\frac{-1-\lambda_i}{1-(\sigma-1)\lambda_i}} d_{in}^{\frac{-1}{1-(\sigma-1)\lambda_i}} \,, \tag{32}$$

and P_n is the quality-adjusted price index in country n:

$$P_n^{1-\sigma} = \int_0^\infty (\sum_j (1-\delta_j^{\theta_j})\Phi_{jn}u^{\sigma-\theta_i-1})(\sum_j \Phi_{jn}\theta_j u^{-\theta_j-1})\exp(-\sum_j \Phi_{jn}u^{-\theta_j})du + \int_0^\infty (\sum_j \delta_j^{\theta_j}\Phi_{jn}\theta_j u^{\sigma-\theta_i-2})\exp(-\sum_j \Phi_{jn}u^{-\theta_j})du \,, \tag{33}$$

where $\delta_i^{\theta_i} = [(\frac{\sigma-1}{\sigma})(1+\lambda_i)]^{\theta(1+\lambda_i)}$.[16]

The expressions for X_{in} and P_n have two parts because, under Bertrand competition, the threat of the second-best firm may not be binding for the best firm. Accordingly, the first part of the expressions relates to the case in which the best firm is bounded by the second-best firm, and the second part relates to the case in

[16] For the price index to be finite, we require that $\underline{\beta} > \frac{\theta(1-\gamma)(\sigma-1)}{\theta+1-\sigma}$, where $\underline{\beta} \equiv \min_j \beta_j$.

which the best firm is a monopolist. Note that the gravity equation (30) doesn't deliver a closed-form solution as in BEJK, because θ_j is country-specific. However, as we showed above, in the special case of a Cobb-Douglas utility (i.e., $\sigma = 1$), θ_j would equal to θ for all countries, and we can therefore derive the closed-form gravity equation (26).

An equilibrium is a set of expenditures $\{E_i\}_{i=1}^N$ and wages $\{w_i\}_{i=1}^N$ that satisfy the income-expenditure identity, $E_i = \sum_{n=1}^N X_{in}$, $\forall\, i = 1, 2, ..., N$, where X_{in} is given in equation (30), as well as the labor market clearing condition

$$L_i = \sum_{n=1}^{N} \Bigg[\int_{u_1=0}^{\infty} \frac{B_n}{w_i} \theta_i \Phi_{in} \delta_i^{\sigma/(1+\lambda_i)} u_1^{\sigma-\theta_i-2} exp(-\sum_{j=1}^{N} \Phi_{jn} (\delta_i u_1)^{-\theta_j}) du_1 + \int_{u_1=0}^{\infty} \int_{u_2=\delta_i u_1}^{u_1} \frac{B_n}{w_i} u_2^{\sigma/(1+\lambda_i)} u_1^{(\lambda_i(\sigma-1)-1)/(1+\lambda_i)} \theta_i \Phi_{in} u_1^{-\theta_i-1} (\sum_{j=1}^{N} \theta_j \Phi_{jn} u_2^{-\theta_j-1}) exp(-\sum_{j=1}^{N} \Phi_{jn} u_2^{-\theta_j}) du_1 du_2 \Bigg], \tag{34}$$

where the right side is country i's labor demand, derived in Appendix B.7.

4 Estimation

To estimate the model, we assume the following functional form for iceberg trade costs, $d_{in} = 1 + a_l \,.\, a_b \,.\, a_a \,.\, (a_0 . Dist_{in} + a_1 . Dist_{in}^{a_d})$, where $Dist_{in}$ is the distance (in thousands of kilometers) between countries i and n.[17] The parameters a_l, a_b, and a_a are one if countries i and n do not have a common official language, common border, and trade agreement, respectively, and to be estimated otherwise. Therefore, the set of parameters that we estimate is $\Omega = \{\{T_i\}_{i=1}^n, \{\beta_i\}_{i=1}^n, a_0, a_1, a_d, a_l, a_b, a_a\}$.

Values for the rest of the parameters (γ, σ, and θ) are borrowed from the literature and we will show that our main results are robust to alternative choices. Specifically,

[17] This is a slightly modified functional form considered by Lashkaripour (2020) to achieve a better fit.

following Bernard et al. (2003), we calibrate the Fréchet shape parameter to $\theta = 3.6$ and the elasticity of substitution to $\sigma = 3.79$.[18] As for the variable cost of quality upgrading, γ, Feenstra and Romalis (2014) find that the cross-country median of γ is close to the respective statistic for the importance (i.e., exponent) of quality in the utility function (which is one in our model). Since our theoretical model requires $\gamma < 1$ (see condition (13)), we set $\gamma = 0.7$ in the baseline and conduct a sensitivity analysis using $\gamma = 0.9$.

Data. To estimate the model, we use data on bilateral trade flows, export prices (unit values), and GDP for 39 countries in the year 2000, which account for the vast majority of global trade and represent a mix of rich and poor economies.[19] Bilateral trade flow data are based on UN Comtrade. Export price data are from the Trade Unit Value (TUV) database compiled by Berthou and Emlinger (2011) and are accessible through CEPII. We use CIF unit values at the six-digit HS product level. We use the gravity variables—the distance between countries, common official languages, common borders, and trade agreements—compiled by Head, Mayer and Ries (2010). Finally, we use data on country-level wages and GDP from World Input-Output Database Socio-Economic Accounts (SEA) provided by Erumban et al. (2012).[20]

Estimation Procedure. The parameters that we estimate are $\boldsymbol{T} = \{T_i\}$, $\boldsymbol{\beta} = \{\beta_i\}$ and $\boldsymbol{a} = \{a_0, a_1, a_d, a_l, a_b, a_a\}$. We use countries' GDP, the average export price of each country, and bilateral trade flows between countries to estimate $\boldsymbol{T}$, $\boldsymbol{\beta}$, and $\boldsymbol{a}$,

[18] The Fréchet shape parameter in Bernard et al. (2003) is equal to the trade elasticity. While our model does not deliver a closed-form solution for the gravity equation and trade elasticity, our simulations below show that trade elasticity in our model is also close to θ. This justifies our choice of using Bernard et al. (2003)'s trade elasticity. As a robustness check, Section 5.2 sets the trade elasticity and elasticity of substitution to $\theta = 4$ and $\sigma = 2.25$, as estimated by Simonovska and Waugh (2014*a*) and Simonovska and Waugh (2014*b*), respectively.

[19] For the list of countries, see Appendix Table C.6.

[20] Since imperfect competition between firms implies that firms can earn profits, we do not use GDP per capita as a proxy for wages.

respectively. The estimation procedure, inspired by Fieler (2011), is composed of three steps.

First, given trade cost parameters $\boldsymbol{a}$ and quality capability parameters $\boldsymbol{\beta}$, we back out technology parameters $\boldsymbol{T}$ to match countries' GDP. That is, we solve the system of equations $\sum_{n=1}^{N} X_{in} = GDP_i, \ \forall \ i = 1, 2, ..., N,$ where X_{in} is the model-implied trade flow from country i to n, and the right-hand side is country i's GDP in the data.[21]

Second, given trade cost parameters $\boldsymbol{a}$ and technology parameters $\boldsymbol{T}$, we back out quality capability parameters $\boldsymbol{\beta}$ by matching average export prices for each country. That is, we first derive the model-implied average export price of each country across all destinations and products, and then set it equal to its data counterpart:

$$E(\ln p_i) = \frac{\sum_{n \neq i} \pi_{in} E(\ln p_{in} | i \ source)}{\sum_{n \neq i} \pi_{in}} = \frac{\sum_{n \neq i} \sum_{\omega} \ln p_{in}^{data}(\omega)}{M_i^{data}} \quad \forall i = 1, ..., N, \qquad (35)$$

where π_{in} is the probability that country i serves country n for a given variety. The average price of country i's exports to n, $E(\ln p_{in} | i \ source)$, is obtained using equilibrium prices in equation (21).[22] The last part of equation (35) is the data counterpart of average export prices, with M_i^{data} being the total number of six-digit HS products that country i exported to other countries in 2000. We note that products are symmetric in the model, but not in the data. To account for this product asymmetry in the data, we first regress log prices on product fixed effects and then take the residual to obtain $\ln p_{in}^{data}(\omega)$ for each product ω.

[21] Note that in steps 1 and 2, the model-based expressions are evaluated using numerical methods. For example, in step 1, X_{in} is obtained by using the numerical evaluation of integrals in equation (30), then adding all X_{in}'s across destinations and equating it to GDP_i.

[22] To compute average export prices, we need to calculate the conditional mean of the highest and second-highest utilities delivered to country n, which we obtain by employing the appendix equation (60).

Figure 5: Technology and Production Cost of Quality Parameters across Countries



Notes: This figure plots the estimated technology parameters $\boldsymbol{T}$ (left panel, in log) as well as the production cost of quality $\boldsymbol{\beta}$ (right panel) against countries' wages (in log).

Lastly, given a set of trade cost parameters $\boldsymbol{a}$, we iterate over steps 1 and 2 to converge to a solution for $\boldsymbol{T}$ and $\boldsymbol{\beta}$. Using this solution, trade cost parameters $\boldsymbol{a} = \{\hat{a}_0, \hat{a}_1, \hat{a}_d, \hat{a}_l, \hat{a}_b, \hat{a}_a\}$ are estimated by NLLS estimation of gravity equation (30). Then, the updated values of trade cost parameters are fed back into the first and second steps. We repeat this procedure until the estimated values for the whole set of parameters converge to a solution.

The intuition behind the estimation of $\{T_i\}_{i=1}^n$ and $\{\beta_i\}_{i=1}^n$ is straightforward. A higher value for physical technology parameter T_i makes country i more productive, and therefore country i would export more. This drives up the total income of country i. Therefore, holding other factors such as trade costs and quality capability fixed, country i's GDP would be increasing in T_i. Moreover, firms in a country with a lower value for the quality cost parameter β_i have a comparative advantage in producing higher-quality products. Since quality is costly to produce, these firms would charge higher prices. Therefore, a lower β_i results in higher export prices.

5 Estimation Results and Counterfactual Analysis

5.1 Estimation Results

Figure 5 summarizes the estimation results for technology as well as quality capability parameters. Detailed estimation results are reported in Appendix Table C.7. The left and right panels show the technology parameters $\boldsymbol{T}$ as well as the production cost of quality parameters $\boldsymbol{\beta}$, respectively, against countries' wages. Each circle in the graph represents a country. The general pattern in Figure 5 indicates a strong relationship between the economic development of a country (in terms of wages) and its efficiency in physical and quality production, which is intuitive: rich countries are more advanced in physical technology (higher T) and more efficient in quality production (lower β). Our result that rich countries are more efficient in quality production is in line with the literature (e.g., Schott, 2004; Amiti and Khandelwal, 2013; Feenstra and Romalis, 2014). Based on our estimates, China (Japan) is the country with the lowest (highest) efficiency in quality production. To estimate these parameters, the model exactly matches countries' GDP as well as their average export prices.

Table 3 reports the NLLS estimation of trade cost parameters $\boldsymbol{a}$. The estimated parameters are in line with what we expect: a positive a_d implies that trade costs increase with distance, and the fact that $a_l, a_b,$ and a_a are less than one implies that trade costs fall with a common language, a common border, and having a free trade agreement. Moreover, the estimated model explains 44% of trade flows between countries. Appendix Figure C.2 shows the fit of the estimated model with respect to trade flows.

Table 3: Estimated Trade Cost Parameters

Parameter	a_0	a_1	a_d	a_b	a_l	a_a	R^2
Estimated value	-0.356	4.283	0.368	0.517	0.696	0.877	0.44
	(0.105)	(0.196)	(0.045)	(0.033)	(0.056)	(0.036)	

Notes: This table reports the NLLS estimates of trade cost parameters. Standard errors are reported in parentheses.

5.2 Heterogeneous Response to Intensified Competition

We now employ our estimated model to investigate the quantitative importance of the quality upgrading channel in explaining the empirical regularities presented in Section 2. To this end, we first solve for the general equilibrium and then simulate the model. To examine the response of other countries to intensified competition from China, we simulate one million products using our estimated model for two periods. In the first period, trade costs are equal to those estimated in the model. In the second period, to simulate the cross-product heterogeneity in intensified competition from China, we reduce the trade cost from China to the U.S., $d_{China-U.S.}$, only for half of the products. In each period, we identify the winning country in each product and record the price and quantity of products exported by the winner to the U.S. This produces a panel data set of export prices and quantities for two periods, allowing us to run similar triple-difference regressions as in Section 2. As in the empirical specifications in Section 2, we drop the products sourced by China or the U.S.[23]

The BEJK Model. To show the importance of the quality channel in generating the differential response of countries to intensified competition from China, we do the same exercise as above for a nested model in which the quality channel is missing. Specifically, by setting $\beta_i = \infty$ for all countries, we shut down the quality channel, which reduces the model to that in BEJK. We set the same parameters $\theta = 3.6$ and

[23]Note that the products sourced by the U.S. are not observable in our trade data in Section 2.

Table 4: Cross-Country Differential Response to Competition in Simulated Data

	Model with quality				Model without quality			
	$\ln p_{cht}$	$\ln p_{cht}$	$\ln x_{cht}$	$\ln x_{cht}$	$\ln p_{cht}$	$\ln p_{cht}$	$\ln x_{cht}$	$\ln x_{cht}$
$D_t \times \text{ChinaShare}_{g(h)t}$	-0.097***	-3.486***	0.419***	3.459***	-0.077***	-0.083*	0.214***	0.237
	(0.006)	(0.056)	(0.019)	(0.175)	(0.005)	(0.047)	(0.018)	(0.179)
$D_t \times \text{ChinaShare}_{g(h)t} \times \ln GDP_c$		0.333***		-0.299***		0.001		-0.002
		(0.005)		(0.017)		(0.005)		(0.017)
Observations	33,952	33,952	33,952	33,952	28,294	28,294	28,294	28,294

Notes: This table reports the effects of intensified competition from China on simulated export prices and quantities to the U.S. market, as described in the text. Standard errors are reported in parentheses. Numbers are rounded to the nearest thousandth. $^{***}p < 0.01$ $^{**}p < 0.05$ $^{*}p < 0.1$

$\sigma = 3.79$ as in our baseline model, and then reestimate the technology parameters $\boldsymbol{T}$ as well as the trade cost parameters $\boldsymbol{a}$ in this model using steps 1 and 3 of the estimation procedure outlined in Section 4.[24] Using these estimated parameters, we simulate this model for two periods in the identical way explained above and run the regressions similar to those in Section 2 using the simulated data.

Table 4 presents the regression results. The term D_t equals 0 and 1 for the first and second periods, respectively, $\text{ChinaShare}_{g(h)t}$ measures the share of China in U.S. imports in category g (in which product h lies) where category g denotes whether products are exposed to Chinese competition (i.e., $d_{China-U.S.}$ is reduced) or not, and $\ln GDP_c$ denotes the model-implied log of GDP per capita of exporting country c in the first period.

The first columns in both models show that prices relatively fall for the products that face intensified competition from China. The second row in this table highlights the differential response of countries to intensified competition. In line with the empirical patterns in Section 2, the second column in the benchmark model with quality shows that rich countries reduce their prices by less than poor countries. The model without the quality channel, however, cannot explain this fact, as the

[24] In this nested model with $\beta_i = \infty$ for all countries, the quality-related parameter γ does not play any role and is therefore dropped from the model.

triple-difference term in this model is close to zero and statistically insignificant.[25]

Similarly, the third columns in both models show that quantities exported to the U.S. relatively *increase* for products facing intensified competition from China. Interestingly, in line with the empirical facts in Section 2, the benchmark model highlights that rich countries *reduce* their exported quantities relative to poor countries (column 4). The model without the quality channel, however, fails to explain this pattern and has an insignificant triple-difference coefficient close to zero, which emphasizes the importance of the quality channel in explaining our empirical regularities.

The magnitudes in Table 4 are not readily comparable to those in Table 1 since our model does not feature tariff gaps. To examine the quantitative importance of the quality channel in explaining our empirical facts, we slightly modify the empirical exercises in Table 1. In particular, in our data regressions, instead of using tariff gaps on the right-hand side we use the share of China in the U.S. instrumented by tariff gaps. Specifically, we first regress the share of China in total U.S. imports in HS8 category $g(h)$ at time t, $\text{ChinaShare}_{g(h)t}$, on tariff gaps $Gap_{g(h)}$. We then use the predicted shares, $\widehat{\text{ChinaShare}}_{g(h)t}$, and run regressions analogous to those in Table 1, where we replace tariff gaps with $\widehat{\text{ChinaShare}}_{g(h)t}$. Table C.8 presents the results. Comparing the triple-difference coefficients in Table C.8 to those in Table 4 shows that the quality upgrading channel in our model plays a quantitatively important role in explaining cross-country heterogeneous response to Chinese competition.

It is worth highlighting a few points regarding simulations in Table 4. First, these regressions were not targeted in the estimation procedure and should be therefore viewed as out-of-sample predictions of the model. While the model performs rea-

[25]Notice that the triple-difference coefficients in the model without quality are tiny and far from being statistically significant, but are not *exactly* equal to zero because of sampling errors. To elaborate, the triple-different coefficients would go to zero if the sample size goes to infinity, but not with a finite sample size.

sonably well in replicating the patterns in Table C.8 both qualitatively and quantitatively, it cannot replicate all coefficients perfectly. For example, the cross-country heterogeneous response in prices is larger in our quality-inclusive model compared to the data. This is because the quality upgrading process in the model is instantaneous, but it will presumably take time in the real world. Therefore, given quality upgrading by rich countries, the model implies a larger gap between the prices of rich versus poor countries in response to Chinese competition. Moreover, the difference-in-difference responses of prices in both models with and without quality (Columns 1 and 5) are small relative to the data. This is likely because of a high demand elasticity that we picked from the literature ($\sigma = 3.79$), whereas demand is likely less elastic in the short run in the data. We indeed show in Table C.10 that under lower elasticities, the difference-in-difference coefficients in the price regressions would be closer to that in the data.

Second, the quantitative importance of the quality channel in explaining cross-country heterogeneous response to competition is robust to different parameterizations of the model: In particular, we choose a different variable cost of quality $\gamma = 0.9$ (see Table C.9) and three different sets of θ and σ (see Tables C.10 to C.12). In all these robustness checks, we re-estimate both models with and without the quality channel and run the counterfactual exercise as explained above.

Finally, we would like to highlight that we employed a BEJK-type framework in this paper since most Melitz (2003)-Chaney (2008)-type models in the existing literature (e.g., Kugler and Verhoogen, 2012) cannot fully rationalize our empirical facts. To elaborate, in this class of models, intensified competition from China operates by reducing the (country- or industry-level) price index in the U.S. As a result, the demand curve that firms from other exporting countries face in the U.S. market would shift inward which would in turn *reduce* their export quantities.[26] As the third col-

[26]Notice that considering the extensive margin would imply an even larger decline in total export

umn of Table 1 in our empirical facts showed, however, countries on average *increase* their export quantities in response to intensified competition from China in the U.S. market. Because of the head-to-head nature of competition, both models with and without quality presented in this paper are indeed consistent with this empirical fact, as reported in columns 3 and 7 of Table 4.[27]

6 Conclusion

We document that in response to intensified competition from China in the U.S., poor countries reduce their export prices relative to rich countries, but the opposite is true for export quantities. To explain these empirical patterns, we develop and estimate a general equilibrium Ricardian model of international trade by introducing cross-country heterogeneity in the ability to produce high-quality goods into the seminal work by Bernard et al. (2003).

The focus of this paper has been on documenting novel cross-country empirical facts and demonstrating the quantitative significance of the quality upgrading channel in explaining these microeconomic patterns. However, we believe that this channel has potentially important implications for various aggregate variables. For example, it could affect labor productivity by influencing the type and quality of capital and equipment used in the production process. Additionally, it may impact wage inequality by affecting the demand for skilled labor. A potentially interesting avenue for future research would be to investigate the macroeconomic implications of this channel in a model incorporating investment, skill heterogeneity, or unemployment.

quantities since some firms exit in response to Chinese competition.

[27] As we emphasized in the introduction, an alternative framework along the lines of Atkeson and Burstein (2008) and Edmond, Midrigan and Xu (2015) with a large enough lower-tier elasticity would be very similar to BEJK and would therefore be able to rationalize our empirical facts.

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Appendices

A Robustness and Additional Results

In this section, we investigate the robustness of our empirical results presented in Section 2 by performing several robustness exercises.

A.1 Pre-trends, U.S. duties, export reallocation, and changes in competition

Pre-trends. A key identifying assumption in difference-in-difference specifications is that control and treatment groups experienced identical time trends prior to the implementation of intervention. Therefore, here we adopt different strategies to support that our results are not contaminated by a potential pre-trend for products of different groups $g(h)$.

First, we follow Felix (2021) and measure the effects of interest *relative to* a potential pre-trend. We show below that all effects *relative to* potential pre-trends are both qualitatively and quantitatively very similar to what we have documented in the text, suggesting that pre-trends are not driving our results.

To this end, we first predict our outcome variables (i.e., prices and quantities) by employing the following regression using the data before the China shock (i.e., before 2002):

$$\ln p_{cht} = \eta \, Gap_{g(h)} \times t + D_{ch} + D_{ct} + \varepsilon_{cht}, \quad c \neq China, \quad t < 2002, \tag{36}$$

where D_{ch} and D_{ct} are country-product and country-time fixed effects, respectively. We estimate $\hat{\eta}$ from this regression and then measure our outcome variables relative

Table A.1: Effects Relative to a Potential Pre-Trend

	$\ln \tilde{p}_{cht}$	$\ln \tilde{p}_{cht}$	$\ln \tilde{x}_{cht}$	$\ln \tilde{x}_{cht}$
$D_t^{2002} \times Gap_{g(h)}$	-0.128***	-0.128***	0.707***	0.690***
	(0.049)	(0.049)	(0.111)	(0.111)
$\ln GDP_c \times D_t^{2002} \times Gap_{g(h)}$	0.014***	0.014***	-0.095***	-0.094***
	(0.006)	(0.006)	(0.012)	(0.012)
$HI_{cs(h)t}$		0.023		-0.567***
		(0.018)		(0.036)
Observations	1,702,241	1,700,639	1,702,241	1,700,639
R^2	0.99	0.99	0.99	0.99

Notes: This table reports the effects of Chinese intensified competition relative to a potential pre-trend. The left-hand side variable in columns 1 and 2 is the price (relative to pre-trends) of products exported to the U.S. by all countries except China, while columns 3 and 4 have quantities (relative to pre-trends) on the left-hand side. The right-hand side variables are the same as those defined in Table 1. Data cover 1992 to 2005. All columns include country×product and country×year fixed effects. Standard errors are clustered at the country×product level and reported in parentheses. $^{***}p < 0.01$ $^{**}p < 0.05$ $^{*}p < 0.1$

to potential pre-trends using $\ln \tilde{p}_{cht} = \ln p_{cht} - \hat{\eta} \times Gap_{g(h)} \times t$. We then use this constructed variable $\ln \tilde{p}_{cht}$ to run the same specifications as in the main text:

$$\ln \tilde{p}_{cht} = \alpha_1 D_t^{2002} \times Gap_{g(h)} + \alpha_2 \ln GDP_c \times D_t^{2002} \times Gap_{g(h)} + \alpha_3 HI_{cs(h)t} + D_{ch} + D_{ct} + \varepsilon_{cht}, \quad c \neq China. \tag{37}$$

We follow the same procedure for quantities to construct $\ln \tilde{x}_{cht}$. Table A.1 reports the results for prices (the first two columns) and quantities (the last two columns) and shows that our results still hold. In particular, all difference-in-difference and triple-difference coefficients are both statistically and economically significant.

Since our main focus in this paper is on the cross-country heterogeneous response to intensified competition, in the second robustness check, we show that our triple-difference coefficient of interest is not contaminated by HS8-time-specific factors. To this end, we add HS8-year fixed effects $D_{g(h)t}$ to both price and quantity

regressions. In this case, the price regression becomes

$$\ln p_{cht} = \alpha_2 \ln GDP_c \times D_t^{2002} \times Gap_{g(h)} + \alpha_3 HI_{cs(h)t} + D_{ch} + D_{g(h)t} + D_{ct} + \varepsilon_{cht}, \quad c \neq China, \tag{38}$$

and similarly for the quantity regression. In this specification, the DID effect $D_t^{2002} \times Gap_{g(h)}$ is clearly picked up by HS8-year fixed effects. The first two columns of Table A.2 present the results and show that the triple-difference terms in both price and quantity regressions exhibit the same pattern across different exporting countries as documented before.

Changes in U.S. duties. Another concern about the empirical facts is that the results, rather than being due to intensified competition from China, may be due to over-time changes in duties that the U.S. imposed on each exporting country. To control for potential changes in duties, we include in our regressions the ad valorem equivalent of duties charged by the U.S. in each 10-digit HS product h sourced from country c at time t, tar_{cht}. We construct this measure by dividing the duty value by the total value of imports. Columns 3 and 4 in Table A.2 report the regression results. The results show that while more duties increase export prices and decrease export quantities as expected, the heterogeneous response of countries to competition from China (i.e., the triple-difference term) remains almost unchanged.

Shifting exports toward other destinations. An alternative explanation for the quantity regression results presented in the last two columns of Table 1 is that when exporting firms faced intensified competition from China in the U.S. market after 2002, they tried to reallocate their exports away from the U.S. market and toward other potentially substitute destinations, such as the European Union (EU) and Canada. If rich countries are more capable than poor economies in reallocat-

ing their exports across different destinations, they would be more likely to reduce their quantity of shipments to the U.S. market and shift them toward other markets, thereby generating a negative triple-difference coefficient in our quantity regressions. To rule out this explanation, we use UN Comtrade bilateral trade data to construct the total export quantity of each exporting country c (except China) to EU countries and Canada in each six-digit HS product h, labeled as $\ln EU_CAN_Exp_{cht}$.[1] We test this hypothesis by regressing $\ln EU_CAN_Exp_{cht}$ on the difference-in-difference term $D_t^{2002} \times Gap_h$ and the triple-difference term $\ln GDP_c \times D_t^{2002} \times Gap_h$:

$$\begin{aligned} \ln EU_CAN_Exp_{cht} =& \alpha_1 D_t^{2002} \times Gap_h + \alpha_2 \ln GDP_c \times D_t^{2002} \times Gap_h \\ &+ D_{ch} + D_{ct} + \varepsilon_{cht}, \quad c \neq China, \end{aligned} \tag{39}$$

where Gap_h is the average MFN tariff gap for the six-digit HS product category h. If this alternative explanation is true, the estimate of α_2 that reflects the differential capability of rich countries in changing their export destinations should be positive and significant.

Column 5 in Table A.2 reports the results. The estimate of α_2 is negative and statistically insignificant, implying that we do not find any evidence for the differential capability of rich versus poor countries in switching export destinations. Column 6 is an extension of regression (39) in which we add HS6-year fixed effects D_{ht} to control for any HS6-time-specific variations. The triple-difference coefficient of interest remains negative, confirming that this alternative explanation is not supported by the data.

[1] The most detailed product categories at which UN Comtrade records bilateral trade data is the six-digit HS code. Since import data are generally more reliable, we use imports of the EU and Canada from each origin country.

Table A.2: Robustness Exercises

	$\ln p_{cht}$	$\ln x_{cht}$	$\ln p_{cht}$	$\ln x_{cht}$	$\ln EU_CAN_Exp_{cht}$	$\ln EU_CAN_Exp_{cht}$
$\ln GDP_c \times D_t^{2002} \times Gap_{g(h)}$	0.013**	-0.092***	0.013 **	-0.091***		
	(0.006)	(0.013)	(0.006)	(0.013)		
$HI_{cs(h)t}$	0.005	-0.334***	0.004	-0.333***		
	(0.018)	(0.036)	(0.018)	(0.036)		
tar_{cht}			0.045**	-0.106 *		
			(0.022)	(0.063)		
$D_t^{2002} \times Gap_h$					0.135	
					(0.124)	
$\ln GDP_c \times D_t^{2002} \times Gap_h$					-0.019	-0.030**
					(0.014)	(0.014)
Country × Product FE (ch)	✓	✓	✓	✓	✓	✓
Country × Year FE (ct)	✓	✓	✓	✓	✓	✓
HS8 × Year FE (gt)	✓	✓	✓	✓	×	×
HS6 × Year FE (ht)	×	×	×	×	×	✓
R^2	0.93	0.89	0.93	0.89	0.85	0.87
Observations	1,692,077	1,692,077	1,692,077	1,692,077	1,295,741	1,293,236

Notes: This table reports several robustness exercises for empirical regularities documented in Section 2. The first two columns report the results when we include HS8-product × year fixed effects. Columns 3 and 4 show the robustness exercise when we control for time-varying duties that the U.S. imposes on each exporting country for each product. Column 5 regresses the log of total quantities exported to the EU and Canada by all countries c except China ($\ln EU_CAN_Exp_{cht}$) on the interaction of tariff gap (averaged at the HS6-product level) and post-2002 dummy, and the triple interaction of tariff gap, post-2002 dummy, and log of exporting countries' GDP per capita. All regressions include country × product fixed effects. Column 6 is the same as column 5 but includes HS6-product × year fixed effects as well. Data cover 1992 to 2005. Clustered standard errors at country×product (country×HS6-product in columns 5 and 6) are reported in parentheses. $^{***}p < 0.01$ $^{**}p < 0.05$ $^{*}p < 0.1$

Table A.3: The Effects of China's Accession to the WTO: Controlling for HHI

	$\ln p_{cht}$	$\ln x_{cht}$
$D_t^{2002} \times Gap_{g(h)}$	-0.212***	0.871***
	(0.049)	(0.110)
$\ln GDP_c \times D_t^{2002} \times Gap_{g(h)}$	0.012**	-0.090***
	(0.006)	(0.012)
$HI_{cs(h)t}$	0.027	-0.576***
	(0.018)	(0.036)
Observations	1,700,639	1,700,639
R^2	0.92	0.87

Notes: This table reports the effect of intensified competition from China on the price and quantity of products exported to the U.S. by all countries except China. The variables are the same as those defined in Table 1. The other control variable is the Herfindahl index of each country's exporters to the U.S. in each HS4 product category and time. Data cover 1992 to 2005. Both columns include country×product and country×year fixed effects. Standard errors are clustered at the country×product level and reported in parentheses. $^{***}p < 0.01$ $^{**}p < 0.05$ $^{*}p < 0.1$

Changes in competition. In this section, we control for the Herfindahl index as a proxy for industry-level competition among exporters from a given origin (in a similar spirit to, e.g., Fan, Li and Yeaple, 2015). The Herfindahl indices are at the HS4 level and are provided by Feenstra and Weinstein (2017). In particular, we employ the following triple-difference specification

$$\ln p_{cht} = \alpha_1 D_t^{2002} \times Gap_{g(h)} + \alpha_2 \ln GDP_c \times D_t^{2002} \times Gap_{g(h)} + \alpha_3 HI_{cs(h)t} + D_{ch} + D_{ct} + \varepsilon_{cht}, \quad c \neq China, \tag{40}$$

where $HI_{cs(h)t}$ is the Herfindahl index of firms in country c that export four-digit HS product category s (in which product h lies) to the U.S. in year t.

Table A.3 reports the results and shows that all results are quite similar to what we reported in the main text.

A.2 The U.S. Regional Trade Agreements (RTAs)

As mentioned in the main text, to the extent that tariff changes in the U.S. RTAs are correlated with tariff gaps, these RTAs might contaminate our results. Since

RTAs usually include both tariff and non-tariff measures, examining whether they are correlated with tariff gaps is challenging. However, we perform two robustness checks to isolate from potential effects of these RTAs.

We explore the universe of U.S. RTAs using Mario Larch's Regional Trade Agreements Database from Egger and Larch (2008).[2] It turns out that RTAs signed by the U.S. with the following countries entered into force between 2001 and 2005 (with the year in parentheses): Australia (2005), Chile (2004), and Jordan (2001). To ensure that these RTAs are not driving our results, we exclude them from our sample and run the main regressions. Table A.4 reports the results and confirms that the main empirical results are qualitatively and quantitatively similar to our baseline results.

Since we rely on a difference-in-difference identification strategy, it seems sufficient to exclude the RTAs that were signed after China's accession to the WTO. However, as another robustness check, we exclude all countries with which the U.S. has had an RTA in our entire sample period; that is we exclude Australia (2005), Chile (2004), Jordan (2001), Canada (1992), Israel (1985), and Mexico (1994). Table A.5 reports the results and shows that the main empirical results are robust to excluding these RTAs.

A.3 The Case of Vietnam's Accession to the WTO

To explore the effects of Vietnam's accession to the WTO in 2007, we run the following specification

$$\ln p_{cht} = \alpha_1 D_t^{2007} \times Gap_{g(h)} + \alpha_2 \ln GDP_c \times D_t^{2007} \times Gap_{g(h)} + D_{ch} + D_{ct} + \varepsilon_{cht}, \quad c \neq Vietnam, \tag{41}$$

[2] See also Kuenzel and Sharma (2021).

Table A.4: The Effects of China's Accession to the WTO (excluding U.S. RTAs between 2001 and 2005)

	$\ln p_{cht}$	$\ln p_{cht}$	$\ln x_{cht}$	$\ln x_{cht}$
$D_t^{2002} \times Gap_{g(h)}$	-0.099***	-0.215***	0.066***	0.874***
	(0.008)	(0.049)	(0.017)	(0.111)
$\ln GDP_c \times D_t^{2002} \times Gap_{g(h)}$		0.013**		-0.090***
		(0.006)		(0.012)
Observations	1,668,339	1,665,820	1,668,339	1,665,820
R^2	0.92	0.92	0.87	0.87

Notes: This table reports the effect of intensified competition from China on the price and quantity of products exported to the U.S. by all countries except China. We exclude countries with which the U.S. signed an RTA between 2001 and 2005. The variables are the same as those defined in Table 1. Data cover 1992 to 2005. All columns include country×product and country×year fixed effects. Standard errors are clustered at the country×product level and reported in parentheses. $^{***}p < 0.01$ $^{**}p < 0.05$ $^{*}p < 0.1$

Table A.5: The Effects of China's Accession to the WTO (excluding all U.S. RTAs in the sample)

	$\ln p_{cht}$	$\ln p_{cht}$	$\ln x_{cht}$	$\ln x_{cht}$
$D_t^{2002} \times Gap_{g(h)}$	-0.101***	-0.206***	0.045**	0.950***
	(0.009)	(0.050)	(0.018)	(0.113)
$\ln GDP_c \times D_t^{2002} \times Gap_{g(h)}$		0.012**		-0.101***
		(0.006)		(0.013)
Observations	1,463,155	1,460,636	1,463,155	1,460,636
R^2	0.92	0.92	0.87	0.87

Notes: This table reports the effect of intensified competition from China on the price and quantity of products exported to the U.S. by all countries except China. We exclude countries with which the U.S. signed an RTA in our entire sample period. The variables are the same as those defined in Table 1. Data cover 1992 to 2005. All columns include country×product and country×year fixed effects. Standard errors are clustered at the country×product level and reported in parentheses. $^{***}p < 0.01$ $^{**}p < 0.05$ $^{*}p < 0.1$

where we measure the tariff gap in 2006. The rest of the variables are similar to those defined in the main text. We also run an analogous regression for quantities. To isolate from the effects of Chinese accession to the WTO in 2001 and also from the financial crisis, we focus on the years from 2002 to 2008. All the reported results are, however, robust to expanding the sample to 1992-2010.

The first two columns in Table A.6 present the results and show that the triple-difference coefficients are positive for prices and negative for quantities, as expected.

Table A.6: The Effects of Vietnam's Accession to the WTO

	$\ln p_{cht}$	$\ln x_{cht}$	$\ln \tilde{p}_{cht}$	$\ln \tilde{x}_{cht}$
$D_t^{2007} \times Gap_{g(h)}$	-0.316***	0.146	-0.240***	0.436***
	(0.068)	(0.139)	(0.068)	(0.139)
$\ln GDP_c \times D_t^{2007} \times Gap_{g(h)}$	0.027***	-0.050***	0.028***	-0.047***
	(0.008)	(0.015)	(0.008)	(0.015)
Observations	423,225	423,225	423,225	423,225
R^2	0.93	0.91	0.99	0.99

Notes: This table reports the effects of Vietnam's accession to the WTO. The left-hand side variables in columns 1 and 2 are the price and quantity of products exported to the U.S. by all countries except Vietnam, respectively. The left-hand side variables in columns 3 and 4 are the price and quantity (relative to pre-trends) of products exported to the U.S. by all countries except Vietnam, respectively. Right-hand side variables are the interaction of tariff gap and post-2007 dummy, and the triple interaction of tariff gap, post-2007 dummy, and log of the exporting country's GDP per capita. Data cover 2002 to 2008. All columns include country×product and country×year fixed effects. Standard errors are clustered at the country×product level and reported in parentheses. $^{***}p < 0.01$ $^{**}p < 0.05$ $^{*}p < 0.1$

To ensure that the results are not driven by potential pre-trends, we employ a similar strategy as the one in Appendix A.1 and measure the effects of interest *relative to* a potential pre-trend. In particular, we first predict our outcome variables (i.e., prices and quantities) by employing the following regression using the data before Vietnam's accession to the WTO (i.e., before 2007):

$$\ln p_{cht} = \eta \, Gap_{g(h)} \times t + D_{ch} + D_{ct} + \varepsilon_{cht}, \quad c \neq Vietnam, \quad t < 2007. \tag{42}$$

We estimate $\hat{\eta}$ from this regression and then measure our outcome variables relative to potential pre-trends using $\ln \tilde{p}_{cht} = \ln p_{cht} - \hat{\eta} \times Gap_{g(h)} \times t$. We then use this constructed variable $\ln \tilde{p}_{cht}$ on the left-hand side of equation (41). The last two columns in Table A.6 show that our results still hold.

A.4 Imported Inputs from China

As explained in the main text, a potential explanation for the empirical patterns documented in this paper is that countries get access to cheaper imported inputs from

China after its accession to the WTO. If this channel is stronger for poor countries compared to rich economies, this would explain why poor countries reduce their export prices relative to rich countries and can therefore sell more in the U.S. market. To analyze this explanation, we perform two robustness checks.

First, we explore whether poor countries imported disproportionately more from China compared to rich countries after Chinese accession to the WTO. To this end, we use UN Comtrade bilateral trade data to construct the total imports of each country c from China in each six-digit HS product h, labeled as $\ln v_{cht}$. We test this hypothesis by regressing $\ln v_{cht}$ on the difference-in-difference term $D_t^{2002} \times Gap_h$ and the triple-difference term $\ln GDP_c \times D_t^{2002} \times Gap_h$:

$$\ln v_{cht} = \alpha_1 D_t^{2002} \times Gap_h + \alpha_2 \ln GDP_c \times D_t^{2002} \times Gap_h + D_{ch} + D_{ct} + \varepsilon_{cht},$$

where Gap_h is the average tariff gap for six-digit HS product h. If this alternative explanation is true, we would expect α_2 to be negative and significant.

Table A.7 presents the results. Column 1 shows that countries on average imported more from China after its accession to the WTO, as expected. The triple-difference coefficient in the second column is, however, very close to zero and also statistically insignificant. We therefore do not find evidence that poor countries imported disproportionately more from China relative to rich countries after China's accession to the WTO.

Second, we explicitly control for tariffs that each country imposes on Chinese inputs to see whether our empirical results will still hold. To this end, we focus on the textile industry since inputs of this industry are arguably easier to identify. In particular, we restrict our sample to all 10-digit HS products in "textiles," that is the two-digit HS categories from 50 through 63. We treat the following two-digit HS codes as inputs to textiles: 50 (silk), 51 (wool), 52 (cotton), 53 (vegetable textile

Table A.7: Imports from China

	$\ln v_{cht}$	$\ln v_{cht}$
$D_t^{2002} \times Gap_h$	0.347***	0.348***
	(0.015)	(0.087)
$\ln GDP_c \times D_t^{2002} \times Gap_h$		-0.0002
		(0.010)
Observations	2,284,393	2,173,199
R^2	0.81	0.80

Notes: This table reports the effect of intensified competition from China on total imports by all countries. The left-hand side variable is the log value of imports by each country. Right-hand side variables are the interaction of tariff gap and post-2002 dummy, and the triple interaction of tariff gap, post-2002 dummy, and log of the importing country's GDP per capita. Data cover 1992 to 2005. Both columns include country×product and country×year fixed effects. Standard errors are clustered at the country×product level and reported in parentheses. $^{***}p < 0.01$ $^{**}p < 0.05$ $^{*}p < 0.1$

fiber), 54 (man-made filaments), 55 (man-made staple fibers), and 56 (wadding, felt and nonwovens, special yarns). In our regressions, we control for average tariffs that each country imposes on these inputs imported from China.

Table A.8 presents the results. As columns 2 and 4 of this table show, the sign of tariff variables are mixed and small overall. Moreover, after controlling for input tariffs, the triple-difference coefficient of interest increases in the price regression and decreases in the quantity regression, pointing to a mixed effect of tariffs on the cross-country heterogeneous effect documented in this paper. Overall, the triple-difference coefficients remain sizeable and significant after controlling for input tariffs.

A.5 Weighted Regressions

The results reported in the main text are based on unweighted regressions. This section employs different weighting schemes to address some potential concerns. In particular, to ensure that our results are not driven by products with small initial trade values, we perform two robustness checks using contemporaneous as well as pre-2002 trade values as weights. Tables A.9 and A.10 present these results, respec-

Table A.8: The Effects of China's Accession to the WTO: Textiles

	$\ln p_{cht}$	$\ln p_{cht}$	$\ln x_{cht}$	$\ln x_{cht}$
$D_t^{2007} \times Gap_{g(h)}$	-0.355***	-0.451***	2.118***	1.312***
	(0.023)	(0.031)	(0.069)	(0.083)
$\ln GDP_c \times D_t^{2007} \times Gap_{g(h)}$	0.031***	0.051***	-0.202***	-0.137***
	(0.003)	(0.004)	(0.008)	(0.009)
$tariff_{ct}^{HS50}$		0.0008***		-0.001
		(0.0002)		(0.001)
$tariff_{ct}^{HS51}$		-0.001***		0.0002
		(0.0003)		(0.001)
$tariff_{ct}^{HS52}$		0.0002		0.001
		(0.0003)		(0.001)
$tariff_{ct}^{HS53}$		-0.000		0.005***
		(0.000)		(0.001)
$tariff_{ct}^{HS54}$		-0.006***		0.004***
		(0.001)		(0.002)
$tariff_{ct}^{HS55}$		0.006***		-0.010***
		(0.001)		(0.001)
$tariff_{ct}^{HS56}$		0.001*		-0.011***
		(0.0004)		(0.001)
Observations	410,627	187,832	410,627	187,832
R^2	0.95	0.96	0.85	0.88

Notes: This table reports the effects of China's accession to the WTO in the textile sector (two-digit HS codes 50 through 63). The left-hand side variables in columns 1 and 2 are the prices of 10-digit HS products exported to the U.S. by all countries except China, whereas columns 3 and 4 have quantities on the left-hand side. The right-hand side variables are the same as those defined in Table 1. Columns 2 and 4 include the average tariffs that each country c imposes on China in year t in two-digit HS categories 50 through 56. Data cover 1992 to 2005. All columns include country×product fixed effects. Standard errors are clustered at the country×product level and reported in parentheses. $^{***}p < 0.01$ $^{**}p < 0.05$ $^{*}p < 0.1$

Table A.9: The Effects of China's Accession to the WTO (weighted by contemporaneous trade values)

	$\ln p_{cht}$	$\ln p_{cht}$	$\ln x_{cht}$	$\ln x_{cht}$
$D_t^{2002} \times Gap_{g(h)}$	-0.103***	-0.204***	0.073***	0.934***
	(0.008)	(0.046)	(0.017)	(0.110)
$\ln GDP_c \times D_t^{2002} \times Gap_{g(h)}$		0.011**		-0.096***
		(0.005)		(0.012)
Observations	1,704,760	1,702,241	1,704,760	1,702,241
R^2	0.93	0.93	0.88	0.88

Notes: This table reports the effect of intensified competition from China on the price and quantity of products exported to the U.S. by all countries except China. The variables are the same as those defined in Table 1. Observations are weighted by contemporaneous log trade values. Data cover 1992 to 2005. All columns include country×product and country×year fixed effects. Standard errors are clustered at the country×product level and reported in parentheses. $^{***}p < 0.01$ $^{**}p < 0.05$ $^{*}p < 0.1$

Table A.10: The Effects of China's Accession to the WTO (weighted by pre-2002 trade values)

	$\ln p_{cht}$	$\ln p_{cht}$	$\ln x_{cht}$	$\ln x_{cht}$
$D_t^{2002} \times Gap_{g(h)}$	-0.102***	-0.199***	0.078***	0.899***
	(0.008)	(0.046)	(0.017)	(0.113)
$\ln GDP_c \times D_t^{2002} \times Gap_{g(h)}$		0.011**		-0.091***
		(0.005)		(0.012)
Observations	1,676,930	1,674,611	1,676,930	1,674,611
R^2	0.93	0.93	0.88	0.88

Notes: This table reports the effect of intensified competition from China on the price and quantity of products exported to the U.S. by all countries except China. The variables are the same as those defined in Table 1. Observations are weighted by log trade values before 2002. Data cover 1992 to 2005. All columns include country×product and country×year fixed effects. Standard errors are clustered at the country×product level and reported in parentheses. $^{***}p < 0.01$ $^{**}p < 0.05$ $^{*}p < 0.1$

tively, and show that all results are qualitatively and quantitatively similar to our unweighted regressions.

Moreover, another potential concern is that tariff gaps alone may not correctly capture the intensity of Chinese competition, especially when Chinese penetration in the U.S. before its accession to the WTO varies substantially across products. To address this potential issue, Table A.11 reports the results using pre-2002 Chinese exports (in terms of quantities) relative to total exports to the U.S. in each HS10 as weights. We again confirm that our results are robust to this weighting scheme.

Table A.11: The Effects of China's Accession to the WTO (weighted by pre-2002 Chinese quantities)

	$\ln p_{cht}$	$\ln p_{cht}$	$\ln x_{cht}$	$\ln x_{cht}$
$D_t^{2002} \times Gap_{g(h)}$	-0.081***	-0.275***	0.117***	0.975***
	(0.018)	(0.092)	(0.033)	(0.204)
$\ln GDP_c \times D_t^{2002} \times Gap_{g(h)}$		0.021**		-0.094***
		(0.011)		(0.023)
Observations	1,559,441	1,557,260	1,559,441	1,557,260
R^2	0.89	0.89	0.85	0.85

Notes: This table reports the effect of intensified competition from China on the price and quantity of products exported to the U.S. by all countries except China. The variables are the same as those defined in Table 1. Observations are weighted by pre-2002 quantities exported by China relative to total quantities exported to the U.S. Data cover 1992 to 2005. All columns include country×product and country×year fixed effects. Standard errors are clustered at the country×product level and reported in parentheses. $^{***}p < 0.01$ $^{**}p < 0.05$ $^{*}p < 0.1$

A.6 Heterogeneous Chinese Penetration

We attribute our empirical results to China's accession to the WTO. Hence, we would expect these effects to be stronger for the products in which China appeared to have a comparative advantage. To explore this idea, we divide the whole sample into two subsamples based on Chinese penetration in the U.S. market. In particular, we compute changes in Chinese share in total U.S. imports in each HS6 sector from pre to post 2002 and divide the sample based on the median. We then run the same regression (2) for each subsample separately. Table A.12 presents the results. As expected, all effects in Panel B of this table are stronger than their counterpart in Panel A.

Table A.12: The Effects of China's Accession to the WTO (low versus high Chinese penetration)

{Panel A: Low Chinese Penetration}	$\ln p_{cht}$	$\ln p_{cht}$	$\ln x_{cht}$	$\ln x_{cht}$
$D_t^{2002} \times Gap_{g(h)}$	-0.075***	-0.129**	0.046**	0.887***
	(0.011)	(0.062)	(0.022)	(0.141)
$\ln GDP_c \times D_t^{2002} \times Gap_{g(h)}$		0.006		-0.094***
		(0.007)		(0.016)
Observations	1,704,760	1,702,241	1,704,760	1,702,241
R^2	0.93	0.93	0.88	0.88
{Panel B: High Chinese Penetration}	$\ln p_{cht}$	$\ln p_{cht}$	$\ln x_{cht}$	$\ln x_{cht}$
$D_t^{2002} \times Gap_{g(h)}$	-0.134***	-0.401***	0.131***	1.038***
	(0.013)	(0.081)	(0.026)	(0.181)
$\ln GDP_c \times D_t^{2002} \times Gap_{g(h)}$		0.029***		-0.099***
		(0.009)		(0.020)
Observations	1,704,760	1,702,241	1,704,760	1,702,241
R^2	0.93	0.93	0.88	0.88

Notes: This table reports the effect of intensified competition from China on the price and quantity of products exported to the U.S. by all countries except China. The variables are the same as those defined in Table 1. We divide the sample into two subsamples based on the median of changes in Chinese share in total U.S. imports in each HS6 sector from pre to post 2002. Data cover 1992 to 2005. All columns include country×product and country×year fixed effects. Standard errors are clustered at the country×product level and reported in parentheses. $^{***}p < 0.01$ $^{**}p < 0.05$ $^{*}p < 0.1$

B Proofs

B.1 Proof of Proposition 1

According to equation (15), the distribution of the highest utility that can be sourced from i equals

$$J_i(u_1) = \Pr(U_i^1 \leq u_1) = G_i(u_1, u_1) = \exp(\Phi_i u_1^{-\theta_i}). \tag{43}$$

The probability of country i being the supplier for a particular good is

$$\begin{aligned}\pi_i &= \Pr\{U_i^1 \geq U_j^1, \quad \forall\, j \neq i\} \\ &= \int_0^\infty \left(\prod_{j\neq i} J_j(u)\right) dJ_i(u) \\ &= \int_0^\infty \exp(-\sum_{j\neq i} \Phi_j u^{-\theta_j})\Phi_i\theta_i u^{-\theta_i-1}\exp(-\Phi_i u^{-\theta_i})du \\ &= \Phi_i\theta_i \int_0^\infty u^{-\theta_i-1}\exp(-\sum_{j} \Phi_j u^{-\theta_j})du.\end{aligned}$$

B.2 Rewriting Firms' Optimization Problem

Consider the profit-maximization problem (20):

$$\begin{aligned}\max_{p_i,z_i} \quad & \Pi_{i(1)}(\varphi) = B(z_i/p_i)^{\sigma-1} - (\frac{w_i d_i z_i^\gamma}{\varphi} B z_i^{\sigma-1} p_i^{-\sigma} + w_i z_i^{\beta_i}) \\ \text{s.t.} \quad & \frac{z_i}{p_i} \geq U_j^{*(2)}\ .\end{aligned}$$

We substitute for price using the demand function (4) and impose the fact that the constraint $\frac{z_i}{p_i} \geq U_j^{*(2)}$ is binding at the solution. This delivers the following optimization problem

$$\begin{aligned}\max_{x_i,z_i} \quad & \Pi_{i(1)}(\varphi) = B(U_j^{*(2)})^{\sigma-1} - (\frac{w_i d_i z_i^\gamma}{\varphi} x_i + w_i z_i^{\beta_i}) \\ \text{s.t.} \quad & z_i x_i \geq B(U_j^{*(2)})^{\sigma}\ .\end{aligned} \tag{44}$$

This problem shows that the revenue of an incumbent firm (i.e., the first term in the profit function) is determined by the second-best firm. This makes the best firm a cost-minimizer and its optimization problem can be rewritten as a cost-minimization

one

$$\begin{aligned} \min_{x_i, z_i} \quad & \frac{w_i d_i z_i^{\gamma}}{\varphi} x_i + w_i z_i^{\beta_i} \\ \text{s.t.} \quad & z_i x_i \geq B(U_j^{*(2)})^{\sigma} \ . \end{aligned} \tag{45}$$

Notice that for simplicity of exposition, Figure 4 expresses the constraint by $U_j^{*(2)}$ instead of the full term $B(U_j^{*(2)})^{\sigma}$.

B.3 Alternative Model Specifications

This section provides three alternative model specifications and shows why these alternative models could not rationalize our empirical facts or do not have well-defined solutions.

B.3.1 Alternative Specification 1

Consider the model in the text, but suppose the parameter γ is country-specific while the fixed-cost parameter β is the same across countries. Specifically, suppose the cost function in equation (10) takes the following form

$$C_{in}(x, z; \varphi) = \frac{w_i d_{in} z^{\gamma_i}}{\varphi} x + w_i z^{\beta}. \tag{46}$$

Consider a winner from country i selling to Home. Solving this firm's profit maximization problem analogous to (20) delivers the following optimal price, quality,

and quantity:

$$p_i = \begin{cases} \left[\frac{B(1-\gamma_i)}{w_i(\beta+1-\gamma_i)}\right]^{\frac{1}{\beta}} (U_j^{*(2)})^{\xi_i^p} (U_i^{*(1)})^{\psi_i} & \text{if} \quad U_j^{*(2)} > \delta_i U_i^{*(1)} \\ p_i^{mon} & \text{if} \quad U_j^{*(2)} \leq \delta_i U_i^{*(1)} \end{cases} \tag{47}$$

$$z_i = \begin{cases} \left[\frac{B(1-\gamma_i)}{w_i(\beta+1-\gamma_i)}\right]^{\frac{1}{\beta}} (U_j^{*(2)})^{\xi_i^z} (U_i^{*(1)})^{\psi_i} & \text{if} \quad U_j^{*(2)} > \delta_i U_i^{*(1)} \\ z_i^{mon} & \text{if} \quad U_j^{*(2)} \leq \delta_i U_i^{*(1)} \end{cases} \tag{48}$$

$$x_i = \begin{cases} B^{1-\frac{1}{\beta}} \left[\frac{(1-\gamma_i)}{w_i(\beta+1-\gamma_i)}\right]^{\frac{-1}{\beta}} (U_j^{*(2)})^{\xi_i^x} (U_i^{*(1)})^{-\psi_i} & \text{if} \quad U_j^{*(2)} > \delta_i U_i^{*(1)} \\ x_i^{mon} & \text{if} \quad U_j^{*(2)} \leq \delta_i U_i^{*(1)} \end{cases} \tag{49}$$

where

$$\begin{aligned} \xi_i^p &= -\frac{\beta+1-\gamma_i-\sigma}{\beta+1-\gamma_i} < 0\,, \\ \xi_i^z &= \frac{\sigma}{\beta+1-\gamma_i} > 0\,, \\ \xi_i^x &= \frac{\sigma(\beta-\gamma_i)}{\beta+1-\gamma_i} > 0\,, \\ \psi_i &= -\frac{\beta-(\sigma-1)(1-\gamma_i)}{\beta(\beta+1-\gamma_i)} < 0 \end{aligned} \tag{50}$$

and the monopolist's quality and price are given by

$$\begin{aligned} z_i^{mon} &= \left[B(\frac{w_i\sigma}{\sigma-1})^{-\sigma}(\frac{d_i}{\varphi})^{1-\sigma}(\frac{1-\gamma_i}{\beta})\right]^{\frac{1}{\beta-(1-\gamma_i)(\sigma-1)}}, \\ p_i^{mon} &= (\frac{\sigma}{\sigma-1})\frac{w_i d_i}{\varphi}(z_i^{mon})^{\gamma_i}. \end{aligned} \tag{51}$$

Similar to what we did in the text, we explore cross-country heterogeneity in the elasticities ξ_i^p, ξ_i^z, and ξ_i^x to evaluate firms' responses to competition. Rich countries are more capable of producing high-quality products (i.e., they have lower γ_i). As we move from poorer to richer countries, γ_i decreases, causing the competition

elasticity of price ξ_i^p (in absolute terms) and that of quantity ξ_i^x to rise. This implies that incumbent firms from poor countries (compared to those from rich countries) respond to direct competition mainly by increasing their prices and reducing their quantities. This is in contrast to our documented empirical facts.

B.3.2 Alternative Specification 2

We now consider a model specification without a fixed cost of quality production in which countries differ in their variable cost of producing quality. In particular, suppose the cost function takes the following form

$$C_{in}(x, z; \varphi) = \frac{w_i d_{in} z^{\gamma_i}}{\varphi} x. \tag{52}$$

Consider a producer from country i selling to Home. The highest utility $U_i(\varphi)$ that this producer can deliver to Home's consumers subject to earning a non-negative profit solves the following maximization problem:

$$\begin{aligned} \max_{z_i, p_i} \quad & U_i(\varphi) = \frac{z_i}{p_i} \\ \text{s.t.} \quad & \Pi = B(z_i/p_i)^{\sigma-1} - \frac{w_i d_i z_i^{\gamma_i}}{\varphi} B z_i^{\sigma-1} p_i^{-\sigma} \geq 0 \, . \end{aligned} \tag{53}$$

To deliver the highest utility, the constraint should hold with equality, which implies

$$p_i = \frac{w_i d_i z_i^{\gamma_i}}{\varphi}. \tag{54}$$

Therefore, the highest utility $U_i(\varphi)$ that this producer can deliver to Home is equal to

$$\max_{z_i} \quad U_i(\varphi) = \frac{z_i}{p_i} = \frac{\varphi}{w_i d_i} z_i^{1-\gamma_i}. \tag{55}$$

It is straightforward to show that this problem has a corner solution. In particular, if $\gamma_i > 1$, this producer could provide an infinitely large utility by providing a quality close to zero, $z_i \to 0$. If $\gamma_i < 1$, this producer could provide an infinitely large utility by setting $z_i \to \infty$.

B.3.3 Alternative Specification 3

Here we consider another model specification without a fixed cost of quality production. Suppose the cost function takes the following form

$$C_{in}(x, z; \varphi) = w_i d_{in} x(z^{\gamma_i} + \frac{z^{\beta}}{\varphi}). \tag{56}$$

Consider a producer from country i selling to Home. This firm solves the following profit-maximization problem

$$\begin{aligned} \max_{p_i, z_i} \quad & \Pi_{i(1)}(\varphi) = B(z_i/p_i)^{\sigma-1} - w_i d_{in}(z_i^{\gamma_i} + \frac{z_i^{\beta}}{\varphi}) B z_i^{\sigma-1} p_i^{-\sigma} \\ \text{s.t.} \quad & \frac{z_i}{p_i} \geq U_j^{*(2)} \ . \end{aligned}$$

Imposing the fact that the constraint is binding at the solution and solving this optimization problem delivers

$$\begin{aligned} p_i &= \frac{(\frac{1-\gamma_i}{\beta-1}\varphi)^{1/(\beta-\gamma_i)}}{U_j^{*(2)}}, \\ z_i &= (\frac{1-\gamma_i}{\beta-1}\varphi)^{1/(\beta-\gamma_i)}, \\ x_i &= (U_j^{*(2)})^{\sigma} B(\frac{1-\gamma_i}{\beta-1}\varphi)^{1/(\gamma_i-\beta)}. \end{aligned} \tag{57}$$

These optimal choices show that this model is not able to explain the empirical facts documented in this paper. In particular, there is no cross-country heterogeneity in

the responses of price and quantity to competition as the elasticities of p_i and x_i with respect to $U_j^{*(2)}$ are not country-specific. Furthermore, quality upgrading in response to competition is absent in this model, that is z_i does not change with $U_j^{*(2)}$.

B.4 Proof of Proposition 2

To prove this proposition, we make use of two lemmas.

Lemma. *The joint distribution of the highest ($U_i^{*(1)}$) and second-highest utility ($U_j^{*(2)}$) that can be delivered to the Home market is*

$$G(u_1, u_2) = exp(-\sum_{i=1}^{n} \Phi_i u_2^{-\theta_i})\{1 + \sum_{i=1}^{n} \Phi_i (u_2^{-\theta_i} - u_1^{-\theta_i})\}. \tag{58}$$

Proof.

$$\begin{aligned} G(u_1, u_2) &= \Pr\{U_i^{*(1)} \leq u_1, U_j^{*(2)} \leq u_2\} \\ &= \prod_{i=1}^{n} \exp(-\Phi_i u_2^{-\theta_i}) + \sum_{i=1}^{n} \Phi_i (u_2^{-\theta_i} - u_1^{-\theta_i}) \exp(-\Phi_i u_2^{-\theta_i}) \prod_{j \neq i} \exp(-\Phi_j u_2^{-\theta_j}) \\ &= \exp(-\sum_{i=1}^{n} \Phi_i u_2^{-\theta_i})\{1 + \sum_{i=1}^{n} \Phi_i (u_2^{-\theta_i} - u_1^{-\theta_i})\}. \end{aligned} \tag{59}$$

□

The second line in the proof breaks the probability into two parts. The first term is the probability that the highest utility from all source countries is less than u_2. The second term is the probability that the highest utility sourced from i is greater than u_2 but less than u_1, and the second-highest utility sourced from i and the highest utility sourced from the rest of the world is less than u_2, and then summing this probability across all countries.

Lemma. *The joint distribution of the highest ($U_i^{*(1)}$) and second-highest utility ($U_j^{*(2)}$) in*

the Home market conditional on country i being the source is

$$G(u_1, u_2|i \text{ source}) = \frac{\Phi_i \theta_i}{\pi_i} \int_0^{u_2} x^{-\theta_i - 1} \exp(-\sum_{j=1}^{n} \Phi_j x^{-\theta_j}) dx \; + \frac{\Phi_i}{\pi_i} (u_2^{-\theta_i} - u_1^{-\theta_i}) \exp(-\sum_{j=1}^{n} \Phi_j u_2^{-\theta_j}). \tag{60}$$

Proof.

$$\begin{aligned} G(u_1, u_2|i \text{ source}) =& \Pr\{U_i^{*(1)} \leq u_1, U_j^{*(2)} \leq u_2 | i \text{ source}\} \\ =& \frac{\Pr\{U_i^{*(1)} \leq u_1, U_j^{*(2)} \leq u_2, i \text{ source}\}}{\Pr\{i \text{ source}\}} \\ =& \frac{\int_0^{u_2} \exp(-\sum_{j \neq i} \Phi_j x^{-\theta_j}) \Phi_i \theta_i x^{-\theta_i - 1} \exp(-\Phi_i x^{-\theta_i}) dx}{\pi_i} \\ +& \frac{\Phi_i (u_2^{-\theta_i} - u_1^{-\theta_i}) \exp(-\Phi_i u_2^{-\theta_i}) \prod_{j \neq i} \exp(-\Phi_j u_2^{-\theta_j})}{\pi_i} \\ =& \frac{\Phi_i \theta_i}{\pi_i} \int_0^{u_2} x^{-\theta_i - 1} \exp(-\sum_{j=1}^{n} \Phi_j x^{-\theta_j}) dx \; + \frac{\Phi_i}{\pi_i} (u_2^{-\theta_i} - u_1^{-\theta_i}) \exp(-\sum_{j=1}^{n} \Phi_j u_2^{-\theta_j}). \end{aligned} \tag{61}$$

□

Now in the case of Cobb-Douglas utility, plugging $\sigma = 1$ into equations (58) and (60) yields the simple form

$$G^{cd}(u_1, u_2) = G^{cd}(u_1, u_2|i \text{ source}) = \exp(-\Phi u_2^{-\theta})\{1 + \Phi(u_2^{-\theta} - u_1^{-\theta})\}, \tag{62}$$

where $\Phi = \sum_{i=1}^{n} \Phi_i$ and superscript cd refers to Cobb-Douglas utility.

The total export value of country i to Home is equal to $V_i = M_i E(v_i|i \text{ source})$ where M_i is the measure of products exported by i and v_i is the export value of a typical product exported by i. Normalizing the measure of all products consumed in the Home market to one delivers $M_i = \pi_i$. Given that $v_i = EP^{\sigma-1}(U_j^{*(2)})^{\sigma-1}$, then

country i's trade share s_i would be

$$\begin{aligned} s_i &= \frac{\pi_i E(v_i|i \text{ source})}{\sum_k \pi_k E(v_i|k \text{ source})} \\ &= \frac{\pi_i E((U_j^{*(2)})^{\sigma-1}|i \text{ source})}{\sum_k \pi_k E((U_j^{*(2)})^{\sigma-1}|k \text{ source})} \\ &= \pi_i = \frac{\Phi_i}{\Phi}. \end{aligned}$$

The third equality comes from the fact that since $G^{cd}(u_1, u_2|i \text{ source})$ is identical for all $i = 1, ..., n$, hence: $\forall\ i, k\ :\ E((U_j^{*(2)})^{\sigma-1}|i \text{ source}) = E((U_j^{*(2)})^{\sigma-1}|k \text{ source})$. The fourth equality follows by substituting $\sigma = 1$ in equation (17). This proves Proposition 2.

B.5 Proof of Proposition 3

Let's first derive the distribution of $U_j^{*(2)}/U_i^{*(1)}$ conditional on $U_j^{*(2)} = u$:

$$\begin{aligned} \Pr\left(\frac{U_j^{*(2)}}{U_i^{*(1)}} \leq x\ |U_j^{*(2)} = u\right) &= \frac{\int_{\frac{u}{x}}^{\infty} g^{cd}(u_1, u)du_1}{\int_u^{\infty} g^{cd}(u_1, u)du_1} \\ &= x^{\theta}. \end{aligned}$$

Since the distribution of $U_j^{*(2)}/U_i^{*(1)}$ conditional on $U_j^{*(2)} = u$ doesn't depend on the value of u, then it will be equal to the unconditional distribution:

$$\Pr\left(\frac{U_j^{*(2)}}{U_i^{*(1)}} \leq x\right) = \Pr\left(\frac{U_j^{*(2)}}{U_i^{*(1)}} \leq x\ |U_j^{*(2)} = u\right) = x^{\theta}.$$

Since $G^{cd}(u_1, u_2) = G^{cd}(u_1, u_2|i \text{ source})$, then

$$\Pr\left(\frac{U_j^{*(2)}}{U_i^{*(1)}} \leq x \mid i \text{ source}\right) = \Pr\left(\frac{U_j^{*(2)}}{U_i^{*(1)}} \leq x\right) = x^{\theta}.$$

B.6 Proof of Proposition 5

Part (i)

We need to show that $h_a(\zeta|\varphi) \gtrsim h_b(\zeta|\varphi)$. So let's first derive $h_b(\zeta|\varphi)$:

$$h_b(\zeta|\varphi) = \Pr(z_i \leq \zeta|\varphi) = \Pr\left(\bar{z}_i \left(\frac{U_j^{*(2)}}{U_i^{*(1)}}\right)^{\frac{1}{\beta_i+1-\gamma}} \leq \zeta|\varphi\right),$$

where we assumed that country i is the nationality of firm φ. Since we conditioned on φ and according to equation (12), $U_i^{*(1)}$ is completely determined by φ ($U_i^{*(1)} = U_i(\varphi) = A_i\varphi^{\frac{1}{1-(\sigma-1)\lambda_i}}$), we can therefore write

$$\begin{aligned}
h_b(\zeta|\varphi) &= \Pr\left(U_j^{*(2)} \leq \left(\frac{\zeta}{\bar{z}_i}\right)^{\beta_i+1-\gamma} U_i^{*(1)} | U_i^{*(1)} = U_i(\varphi)\right) \\
&= \frac{\Pr\left(\left(U_j^{*(2)} \leq \left(\frac{\zeta}{\bar{z}_i}\right)^{\beta_i+1-\gamma} U_i(\varphi)\right) \cap (i \text{ source})\right)}{\Pr\left(\left(U_i^{*(1)} = U_i(\varphi)\right) \cap (i \text{ source})\right)} \\
&= \frac{\Phi_i\left(\left(\frac{\zeta}{\bar{z}_i}\right)^{\beta_i+1-\gamma} U_i(\varphi)\right)^{-\theta} \exp\left(-\Phi_H^b \left(\frac{\zeta}{\bar{z}_i}\right)^{-\theta(\beta_i+1-\gamma)} U_i(\varphi)^{-\theta}\right)}{\Phi_i\theta U_i(\varphi)^{-\theta-1}\exp\left(-\Phi_H^b U_i(\varphi)^{-\theta}\right)} \\
&= \frac{\left(\frac{\zeta}{\bar{z}_i}\right)^{-\theta(\beta_i+1-\gamma)} U_i(\varphi)}{\theta} \exp\left(-\Phi_H^b U_i(\varphi)^{-\theta}\left(\left(\frac{\zeta}{\bar{z}_i}\right)^{-\theta(\beta_i+1-\gamma)} - 1\right)\right),
\end{aligned}$$

where Φ_H^b captures the competitiveness of Home before the fall in the trade cost. It is clear that reducing trade barriers with any given country would increase the competitiveness of Home by increasing its Φ_H. So the expression for $h_a(\zeta|\varphi)$ can be obtained by replacing Φ_H^b by Φ_H^a where Φ_H^a captures the competitiveness of Home after the fall in the trade cost and $\Phi_H^a > \Phi_H^b$. Then we can conclude that $h_a(\zeta|\varphi) < h_b(\zeta|\varphi)$, which proves the claim.

Part (ii)

According to Proposition 2, the trade share of country i is equal to

$$\pi_i = \frac{\Phi_i}{\Phi}.$$

Reducing the trade cost d_i would change the trade shares of exporting countries according to

$$\frac{\partial \pi_j}{\partial d_i} = \begin{cases} \frac{\theta}{d_i}\pi_i\pi_j & \text{if} \quad j \neq i \\ \frac{-\theta}{d_i}\pi_i(1-\pi_i) & \text{if} \quad j = i \end{cases}$$

Now taking derivative of the quality distribution $H(\zeta)$ with respect to d_i delivers

$$\begin{aligned} \frac{\partial H(\zeta)}{\partial d_i} =& \sum_{i=1}^{n} \frac{\partial \pi_j}{\partial d_i} \left(\frac{\zeta}{\bar{z}_i}\right)^{\theta(\beta_i+1-\gamma)} \\ =& \frac{\theta\pi_i}{d_i} \sum_{j\neq i} \pi_j \bar{z}_j^{-\theta(\beta_j+1-\gamma)} \zeta^{\theta(\beta_j+1-\gamma)} - \frac{\theta\pi_i}{d_i}(1-\pi_i)\bar{z}_i^{-\theta(\beta_i+1-\gamma)}\zeta^{\theta(\beta_i+1-\gamma)} \\ =& \frac{\theta\pi_i}{d_i} \sum_{j\neq i} \pi_j \bar{z}_j^{-\theta(\beta_j+1-\gamma)} \zeta^{\theta(\beta_j+1-\gamma)} - \frac{\theta\pi_i}{d_i} \sum_{j\neq i} \pi_j \bar{z}_i^{-\theta(\beta_i+1-\gamma)}\zeta^{\theta(\beta_i+1-\gamma)} \\ =& \zeta^{\theta(1-\gamma)} \frac{\theta\pi_i}{d_i} \sum_{j\neq i} \pi_j \left(F_j \zeta^{\theta\beta_j} - F_i \zeta^{\theta\beta_i}\right), \end{aligned} \tag{63}$$

where $F_j = \bar{z}_j^{-\theta(\beta_j+1-\gamma)}$.

If country i's quality is stochastically inferior to the average quality in the Home

market, we can write

$$
\begin{aligned}
H_i(\zeta) \precsim H(\zeta) \Rightarrow \left(\frac{\zeta}{\bar{z}_i}\right)^{\theta(\beta_i+1-\gamma)} &\geq \sum_{j=1}^{n} \pi_j \left(\frac{\zeta}{\bar{z}_j}\right)^{\theta(\beta_j+1-\gamma)} \\
\Rightarrow F_i \zeta^{\theta\beta_i} &\geq \sum_{j=1}^{n} \pi_j F_j \zeta^{\theta\beta_j} \\
\Rightarrow \sum_{j=1}^{n} \pi_j F_i \zeta^{\theta\beta_i} &\geq \sum_{j=1}^{n} \pi_j F_j \zeta^{\theta\beta_j} \\
\Rightarrow \sum_{j=1}^{n} \pi_j \left(F_j \zeta^{\theta\beta_j} - F_i \zeta^{\theta\beta_i}\right) &\leq 0 \\
\Rightarrow \sum_{j\neq i} \pi_j \left(F_j \zeta^{\theta\beta_j} - F_i \zeta^{\theta\beta_i}\right) &\leq 0. \qquad (64)
\end{aligned}
$$

Combining equations (63) and (64) yields

$$
\frac{\partial H(\zeta)}{\partial d_i} \leq 0.
$$

This means that reducing the trade cost d_i would stochastically downgrade the quality distribution.

B.7 Labor Demand

Here we derive the total labor demand in country i. Given the cost function (10), the labor demand for a firm with productivity φ from country i serving country n equals $(d_{in} z^{\gamma}/\varphi) x_i + z_i^{\beta_i}$. Substituting for x_i and z_i from equations (22) and (23), we can write the labor demand for this firm in destination n as

$$
l_{in} = \begin{cases} \frac{B_n}{w_i} (U_j^{*(2)})^{\frac{\sigma}{1+\lambda_i}} (U_i^{*(1)})^{\frac{\lambda_i(\sigma-1)-1}{1+\lambda_i}} & \text{if} \quad U_j^{*(2)} > \delta_i U_i^{*(1)} \\ \frac{B_n}{w_i} \delta_i^{\frac{\sigma}{1+\lambda_i}} (U_i^{*(1)})^{\sigma-1} & \text{if} \quad U_j^{*(2)} \leq \delta_i U_i^{*(1)} \end{cases} \qquad (65)
$$

As proved in equation (60), we can write the joint distribution of the highest ($U_i^{*(1)}$) and second-highest utility ($U_j^{*(2)}$) in country n conditional on country i being the source as

$$G(u_1, u_2|i \text{ source}) = \frac{\Phi_{in}\theta_i}{\pi_{in}} \int_0^{u_2} x^{-\theta_i - 1} \exp(-\sum_{j=1}^{n} \Phi_{jn} x^{-\theta_j}) dx \; + \frac{\Phi_{in}}{\pi_{in}} (u_2^{-\theta_i} - u_1^{-\theta_i}) \exp(-\sum_{j=1}^{n} \Phi_{jn} u_2^{-\theta_j}). \tag{66}$$

We can then derive the associated conditional density function as

$$g(u_1, u_2|i \text{ source}) = \frac{\partial^2 G(u_1, u_2|i \text{ source})}{\partial u_1 \partial u_2} = \frac{\Phi_{in}\theta_i}{\pi_{in}} u_1^{-\theta_i - 1} (\sum_{j=1}^{n} \theta_j \Phi_{jn} u_2^{-\theta_j - 1}) \exp(-\sum_{j=1}^{n} \Phi_{jn} u_2^{-\theta_j}). \tag{67}$$

Given equations (65) and (67), we can write total labor demanded from origin i in destination n as

$$L_{in}^d = \pi_{in} \int_{u_1} \int_{u_2} l_{in} g(u_1, u_2|i \text{ source}) du_1 du_2. \tag{68}$$

Simplifying the equation above along with the fact that the total labor demand in country i equals $\sum_{n=1}^{N} L_{in}^d$ will deliver the result.

C Additional Tables and Figures

Table C.1: Summary Statistics

	Mean	Median	SD	Obs.
$\ln p_{cht}$	3.182	2.788	2.793	1,954,174
$\ln x_{cht}$	9.274	9.415	3.491	1,954,174
$Gap_{g(h)}$	0.345	0.330	0.226	1,803,168
$\ln GDP_c$	9.164	9.919	1.311	1,947,719

Notes: This table provides summary statistics for the variables defined in Table 1.

Table C.2: The Response of Chinese Penetration in the U.S. to its WTO Accession

	ChinaShare_{ht}
$D_t^{2002} \times Gap_{g(h)}$	0.051^{***}
	(0.008)
Observations	91,176
R^2	0.80

Notes: This table reports the effects of China's accession to the WTO on its market share in the U.S. ChinaShare_{ht} measures U.S. imports from China relative to total U.S. imports in product h at time t. The right-hand side variable is the interaction of tariff gap and post-2002 dummy. Data cover 1992 to 2005. Product and year fixed effects are included in the regression. Standard errors are clustered at the product level and reported in parentheses. $^{***}p < 0.01$ $^{**}p < 0.05$ $^{*}p < 0.1$

Table C.3: The Response of Quality to China's Accession to the WTO

	$\ln z_{cht}$	$\ln z_{cht}$
$D_t^{2002} \times Gap_{g(h)}$	0.392^{***}	0.144
	(0.017)	(0.111)
$\ln GDP_c \times D_t^{2002} \times Gap_{g(h)}$		0.027^{**}
		(0.012)
Observations	1,100,438	1,100,417
R^2	0.97	0.97

Notes: This table reports the effect of intensified competition from China on the quality of products exported to the U.S. by all countries except China. The left-hand side variable is our estimated log of all 10-digit HS product h exported by country c at time t to the U.S., following Khandelwal (2010)'s methodology. The right-hand side variables are the same as those defined in Table 1. Data cover 1992 to 2005. All columns include country×product and country×year fixed effects. Standard errors are clustered at the country×product level and reported in parentheses. $^{***}p < 0.01$ $^{**}p < 0.05$ $^{*}p < 0.1$

Table C.4: China's Response to its WTO Accession

	$\ln p_{ht}$	$\ln x_{ht}$
$D_t^{2002} \times Gap_{g(h)}$	-0.170***	0.232***
	(0.027)	(0.071)
Observations	91,176	91,176
R^2	0.93	0.88

Notes: This table reports the effects of China's accession to the WTO on its prices (column 1) and quantities (column 2) of all HS10 products h exported to the U.S. The right-hand side variable is the interaction of tariff gap and post-2002 dummy. Data cover 1992 to 2005. Both columns include product and year fixed effects. Standard errors are clustered at the product level and reported in parentheses. $^{***}p < 0.01$ $^{**}p < 0.05$ $^{*}p < 0.1$

C.1 China's Response to its WTO Accession.

This section investigates China's own response to its accession to the WTO and compares it with the data to provide additional validation of the model. To this end, we first describe what the model predicts regarding Chinese firms' responses to a reduction in their trade costs to the U.S. market. Consider a Chinese firm that is the first-best (winner) in a particular product in the U.S. market. In this case, the index i in equations (21) to (23) denotes China. A reduction in the iceberg cost from China to the U.S. would increase the maximum utility that this firm can deliver to U.S. consumers ($U_i^{*(1)}$), according to equation (12). This rise in $U_i^{*(1)}$ puts downward pressure on prices and upward pressure on quantities (since $\psi_i < 0$). Moreover, in the case that the second-best producer is also a Chinese firm, $U_j^{*(2)}$ rises as well, reinforcing the fall in prices and the rise in quantities (since $\xi_i^p < 0$ and $\xi_i^x > 0$). In sum, our model predicts that after China's accession to the WTO, Chinese prices fall and their quantities rise.[3] We test these predictions of the model using a similar specification to equation (2), where we restrict the exporting country to China and drop the triple-difference term accordingly. Table C.4 reports the results, which confirm our model predictions.

[3]Notice that our model has an ambiguous prediction regarding the quality of Chinese products: in equation (22), $\xi_i^z > 0$ while $\psi_i < 0$.

C.2 Extensive Margin

This section examines the cross-country heterogeneous response to China's accession to the WTO on the extensive margin, both in the model and the data.

In the model, the fraction of products exported by country i to Home (i.e., the U.S.) is given by equation (17) in the paper

$$\pi_i = \Phi_i \theta_i \int_0^\infty u^{-\theta_i - 1} \exp(-\sum_j \Phi_j u^{-\theta_j}) du \ .$$

To examine the elasticity of π_i with respect to a change in the trade cost from country $j \neq i$ to the U.S., d_j, we write

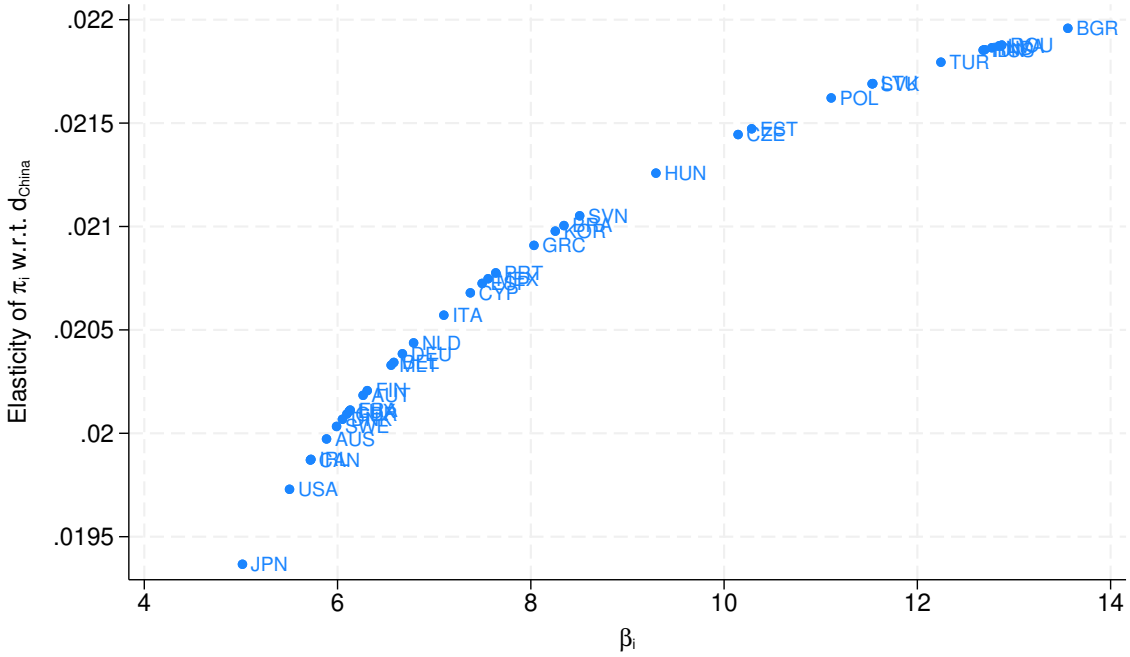
$$\frac{\partial \pi_i}{\partial d_j} \frac{d_j}{\pi_i} = \frac{-\Phi_i \theta_i d_j}{\pi_i} \frac{\partial \Phi_j}{\partial d_j} \int_0^\infty u^{-\theta_i - \theta_j - 1} \exp(-\sum_k \Phi_k u^{-\theta_k}) du. \tag{69}$$

Given the definition of Φ_i below equation (14), it is straightforward to verify that $\partial \Phi_j / \partial d_j < 0$ and therefore $\partial \pi_i / \partial d_j > 0$. Hence, the model predicts that a reduction in Chinese trade costs to the U.S. reduces the number of products exported by other countries to the U.S., which is intuitive.

We now investigate how this extensive margin effect in equation (69) varies across exporting countries. Given that this equation does not have a closed-form solution, we solve it numerically, employing the parameters estimated in Section 4. For each exporting country i to the U.S., Figure C.1 plots the elasticity of π_i with respect to the iceberg cost from China to the U.S. against the exporting country's efficiency in quality production, β_i. As this figure clearly shows, our model implies that this elasticity is larger for poor countries, indicating that the number of products exported by poor countries to the U.S. should decrease more than that of rich countries in response to China's accession to the WTO.

To examine whether these model predictions align with the data, we employ an

Figure C.1: The Response to China's Accession to the WTO on the Extensive Margin (Model)



analogous empirical specification to equation (2) but replace the left-hand side with the fraction of HS10 products that each country exports to the U.S. within each HS8 category, $\pi_{g(h)}$. Table C.5 presents the results and confirms both predictions of the model. In particular, the number of products exported to the U.S. by other countries decreases in response to China's accession to the WTO (the first column), with this reduction being more pronounced for poorer countries (the second column).

Table C.5: The Response to China's Accession to the WTO on the Extensive Margin (Data)

	$\ln \pi_{g(h)}$	$\ln \pi_{g(h)}$
$D_t^{2002} \times Gap_{g(h)}$	-0.710***	-1.162***
	(0.009)	(0.053)
$\ln GDP_c \times D_t^{2002} \times Gap_{g(h)}$		0.051***
		(0.006)
Observations	1,803,051	1,797,366

Notes: This table reports the effect of intensified competition from China on the fraction of HS10 products that each country (except China) exports to the U.S. within each HS8 category, $\pi_{g(h)}$. The right-hand side variables are the same as those defined in Table 1. Data cover 1992 to 2005. Both columns include country×year fixed effects. Standard errors are clustered at the country×product level and reported in parentheses. $^{***}p < 0.01$ $^{**}p < 0.05$ $^{*}p < 0.1$

Figure C.2: Fit of the Estimated Model

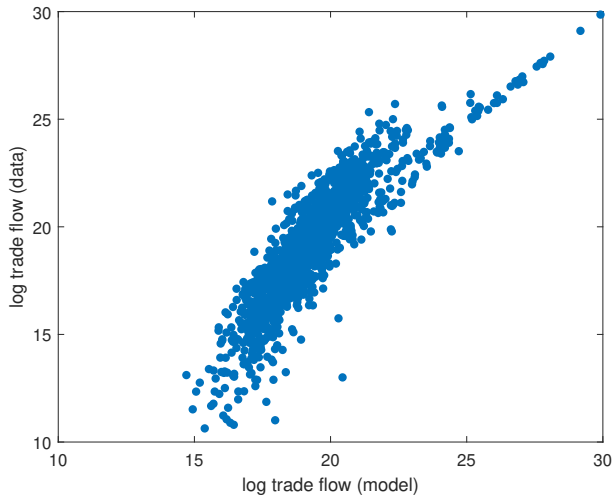


Table C.6: List of Countries

Country	ISO3 Code	Labor Force (thousands)	Wage (US$)	GDP (Million US$)
Australia	AUS	9012	25881	376634
Austria	AUT	3931	30821	178172
Belgium	BEL	4109	34997	214342
Bulgaria	BGR	3239	1560	10292
Brazil	BRA	78972	3577	567321
Canada	CAN	15048	25776	675314
China	CHN	720850	844	1199693
Cyprus	CYP	315	29548	15171
Czech Republic	CZE	4940	6150	53082
Germany	DEU	39144	30970	1772483
Denmark	DNK	2712	34814	142350
Spain	ESP	16412	21351	544827
Estonia	EST	573	5179	5257
Finland	FIN	2293	30381	109876
France	FRA	24332	31697	1232529
United Kingdom	GBR	29617	30829	1323724
Greece	GRC	4255	14619	114952
Hungary	HUN	4250	6186	42040
Indonesia	IDN	93321	880	164235
India	IND	416883	574	453137
Ireland	IRL	1697	28785	89437
Italy	ITA	22930	28205	1016047
Japan	JPN	65253	41780	4724855
South Korea	KOR	21136	17193	486734
Lithuania	LTU	1399	3741	10289
Luxembourg	LUX	264	39266	18738
Latvia	LVA	941	3890	7186
Mexico	MEX	39226	5352	585439
Malta	MLT	146	12949	3361
Netherlands	NLD	8115	29213	356573
Poland	POL	15018	7893	151266
Portugal	PRT	5030	13548	101738
Romania	ROU	10771	2086	34052
Russia	RUS	73726	1823	236179
Slovakia	SVK	2025	5248	26546
Slovenia	SVN	905	12513	15366
Sweden	SWE	4301	34965	225382
Turkey	TUR	21580	4677	239733
United States	USA	147717	41164	9950002

Table C.7: Estimated Parameters for Technology and Production Cost of Quality

Country	$\log(T)$	β	Country	$\log(T)$	β
Australia	7.04	5.89	Ireland	6.40	5.72
Austria	7.36	6.26	Italy	8.47	7.10
Belgium	7.96	6.58	Japan	9.37	5.02
Bulgaria	-3.68	13.56	South Korea	6.66	8.25
Brazil	0.91	8.34	Lithuania	-0.64	11.54
Canada	7.11	5.72	Luxembourg	6.31	6.12
China	-2.76	16.90	Latvia	-0.56	12.85
Cyprus	6.55	7.37	Mexico	2.14	7.56
Czech Republic	1.84	10.14	Malta	2.10	6.55
Germany	8.88	6.67	Netherlands	7.84	6.79
Denmark	7.69	6.05	Poland	3.62	11.11
Spain	7.25	7.50	Portugal	4.71	7.64
Estonia	0	10.29	Romania	-1.87	12.87
Finland	7.21	6.31	Russia	-1.24	12.70
France	8.50	6.13	Slovakia	1.09	11.53
United Kingdom	8.45	6.10	Slovenia	3.36	8.51
Greece	5.19	8.03	Sweden	7.96	5.99
Hungary	1.65	9.30	Turkey	2.16	12.24
Indonesia	-4.10	12.68	United States	10.13	5.50
India	-5.11	12.77			

Notes: This table reports the estimated values for technology parameters T and quality cost parameters β. The technology parameter for Estonia is normalized to one (this choice is arbitrary since only relative productivities matter).

Table C.8: The Effects of China's Accession to the WTO (using tariff gap as an IV for China Share)

	$\ln p_{cht}$	$\ln p_{cht}$	$\ln x_{cht}$	$\ln x_{cht}$
$D_t^{2002} \times \widehat{\text{ChinaShare}}_{g(h)t}$	-0.868***	-1.850***	0.582***	7.744***
	(0.071)	(0.423)	(0.148)	(0.965)
$D_t^{2002} \times \widehat{\text{ChinaShare}}_{g(h)t} \times \ln GDP_c$		0.109**		-0.794***
		(0.048)		(0.106)
Observations	1,704,760	1,702,241	1,704,760	1,702,241

Notes: This table reports the effect of intensified competition from China on the price and quantity of products exported to the U.S. by all countries except China, using an instrumental variable approach. In the first stage, we regress the share of China in each HS8 category in the U.S. on the associated tariff gap. $\widehat{\text{ChinaShare}}_{g(h)t}$ is the predicted value from the first stage, employed in the second stage. Other variables are the same as those defined in Table 1. $^{***}p < 0.01$ $^{**}p < 0.05$ $^{*}p < 0.1$

Table C.9: Cross-Country Differential Response to Competition in Simulated Data ($\gamma = 0.9$)

	Model with quality				Model without quality			
	$\ln p_{cht}$	$\ln p_{cht}$	$\ln x_{cht}$	$\ln x_{cht}$	$\ln p_{cht}$	$\ln p_{cht}$	$\ln x_{cht}$	$\ln x_{cht}$
$D_t \times \text{ChinaShare}_{g(h)t}$	-0.061***	-3.828***	0.236***	3.901***	-0.077***	-0.083*	0.214***	0.237
	(0.006)	(0.056)	(0.017)	(0.167)	(0.005)	(0.047)	(0.018)	(0.179)
$D_t \times \text{ChinaShare}_{g(h)t} \times \ln GDP_c$		0.368***		-0.358***		0.001		-0.002
		(0.005)		(0.016)		(0.005)		(0.017)
Observations	29,553	29,553	29,553	29,553	28,294	28,294	28,294	28,294

Notes: This table reports the effects of intensified competition from China on simulated export prices and quantities to the U.S. market, as described in the text. Standard errors are reported in parentheses. Numbers are rounded to the nearest thousandth. $^{***}p < 0.01$ $^{**}p < 0.05$ $^{*}p < 0.1$

Table C.10: Cross-Country Differential Response to Competition in Simulated Data ($\sigma = 1.5, \theta = 1.5$)

	Model with quality				Model without quality			
	$\ln p_{cht}$	$\ln p_{cht}$	$\ln x_{cht}$	$\ln x_{cht}$	$\ln p_{cht}$	$\ln p_{cht}$	$\ln x_{cht}$	$\ln x_{cht}$
$D_t \times \text{ChinaShare}_{g(h)t}$	-0.157***	-5.288***	0.215***	5.343***	-0.188***	-0.226**	0.248***	0.306*
	(0.011)	(0.121)	(0.016)	(0.174)	(0.010)	(0.107)	(0.015)	(0.161)
$D_t \times \text{ChinaShare}_{g(h)t} \times \ln GDP_c$		0.497***		-0.497***		0.004		-0.006
		(0.012)		(0.017)		(0.010)		(0.016)
Observations	28,146	28,146	28,146	28,146	30,961	30,961	30,961	30,961

Notes: This table reports the effects of intensified competition from China on simulated export prices and quantities to the U.S. market, as described in the text. Standard errors are reported in parentheses. Numbers are rounded to the nearest thousandth. $^{***}p < 0.01$ $^{**}p < 0.05$ $^{*}p < 0.1$

Table C.11: Cross-Country Differential Response to Competition in Simulated Data ($\sigma = 2.25, \theta = 2$)

	Model with quality				Model without quality			
	$\ln p_{cht}$	$\ln p_{cht}$	$\ln x_{cht}$	$\ln x_{cht}$	$\ln p_{cht}$	$\ln p_{cht}$	$\ln x_{cht}$	$\ln x_{cht}$
$D_t \times \text{ChinaShare}_{g(h)t}$	-0.125***	-4.256***	0.256***	4.281***	-0.140***	-0.146*	0.251***	0.265
	(0.009)	(0.089)	(0.019)	(0.199)	(0.008)	(0.087)	(0.019)	(0.196)
$D_t \times \text{ChinaShare}_{g(h)t} \times \ln GDP_c$		0.402***		-0.391***		0.001		-0.001
		(0.009)		(0.019)		(0.008)		(0.019)
Observations	28,881	28,881	28,881	28,881	27,575	27,575	27,575	27,575

Notes: This table reports the effects of intensified competition from China on simulated export prices and quantities to the U.S. market, as described in the text. Standard errors are reported in parentheses. Numbers are rounded to the nearest thousandth. $^{***}p < 0.01$ $^{**}p < 0.05$ $^{*}p < 0.1$

Table C.12: Cross-Country Differential Response to Competition in Simulated Data ($\sigma = 2.25, \theta = 4$)

	Model with quality				Model without quality			
	$\ln p_{cht}$	$\ln p_{cht}$	$\ln x_{cht}$	$\ln x_{cht}$	$\ln p_{cht}$	$\ln p_{cht}$	$\ln x_{cht}$	$\ln x_{cht}$
$D_t \times$ ChinaShare$_{g(h)t}$	-0.059***	-3.545***	0.107***	3.586***	-0.069***	-0.097***	0.124***	0.188**
	(0.006)	(0.058)	(0.009)	(0.095)	(0.004)	(0.035)	(0.008)	(0.079)
$D_t \times$ ChinaShare$_{g(h)t} \times$ $\ln GDP_c$		0.339***		-0.338***		0.003		-0.006
		(0.006)		(0.009)		(0.003)		(0.008)
Observations	29,205	29,205	29,205	29,205	28,314	28,314	28,314	28,314

Notes: This table reports the effects of intensified competition from China on simulated export prices and quantities to the U.S. market, as described in the text. Standard errors are reported in parentheses. Numbers are rounded to the nearest thousandth. $^{***}p < 0.01$ $^{**}p < 0.05$ $^{*}p < 0.1$