The Effects of China's Accession to the WTO on Nigeria and Other Developing Economies

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Abstract

I employ a computable general equilibrium (CGE) model to quantitatively examine the impact of China's accession into the WTO on developing economies, with a focus on Nigeria. My framework is a multi-country, multi-sector, Ricardian trade model with sectoral heterogeneity in several dimensions including the trade elasticity. I estimate the key trade elasticities and comparative advantage parameters using a gravity equation with cross country data on trade, tariff rates, and proxies for trade costs. The calibrated model has 29 sectors and 25 countries which includes advanced, middle income and emerging economies. I study the effects of bilateral tariff reductions for Nigeria and China only, as well as for the observed tariff reductions after China's WTO accession. I find that most gains accrue to low income countries. Nigeria's welfare gain is 1.20% but China gains 0.20%, United States gains 0.05% and India gains 1.49%. The primary source of these gains is increased volume of trade.

KEYWORDS: Trade policy and globalisation, Gains from trade, Gravity equation, Intermediate inputs, Sectoral interrelations, Africa economies, Computational general equilibrium

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1 Introduction

As part of the agreement to join the World Trade Organization (WTO), participating countries reduced bilateral tariff and non-tariff barriers on China, leading to increased trade flows. In 1995, China's share of global exports was 3.17%; but only about a decade later, that share had more than doubled to 7.25% by 2006. Top destination countries for China's exports includes the United States and emerging economies from Asia and Sub-Saharan Africa. As a group, developing countries have become more important in world trade, as they now account for one-third of world trade, up from about a quarter in the early 1970s.

There have been numerous studies, with several methodologies, examining the impact of China's WTO accession on welfare, employment, trade, and other variables. However, these studies have focused on China's effects on high and middle income countries, and have paid little attention to low income economies. In order to understand the complete impacts of tariff policies, "third party" effects, and more broadly, general equilibrium effects need to be included. Even bilateral tariff policies need to take into account general equilibrium effects. Nigeria as the largest economy in Africa; with a population size of 190 million as at 2017, a market where both China and United States are active, provides an interesting case study. In principle, to the extent international trade is driven by comparative advantage forces, countries considerably poorer than China should experience relatively higher gains from increased trade with China.

In this paper, I quantitatively study the effects of China's entry to the WTO on low income countries, with a focus on the experience of Nigeria. I employ a state-of-the art multi-country, multi-sector, general equilibrium model of international trade that incorporates sectoral linkages[1] to conduct the quantitative analysis. The model framework is based on Ricardian comparative advantage; thus, cross sector and within sector differences in relative productivities, together with tariffs and other barriers to trade, drive the direction and magnitude of international trade flows. The model draws from Caliendo and Parro (2015) (CP henceforth) model, which itself draws on the seminal work of Eaton and Kortum (2002). In these models, the key parameter that governs the variance of distribution of productivities across goods turns out to also be the trade elasticity.

When tariffs are lowered, several forces come into play. First, households import more final goods, as their relative prices have declined. Second, firms import more own-sector intermediate goods for the same reason. Both of these forces imply more trade, as well as

[1] A reduction in tariffs that China applies to Nigeria's agricultural products for instance, does not only affect the prices in that sector but also on other industry like-textile that purchase cotton (material) from that sector. Moreover, trade liberalization affects prices in non-tradable sectors that are using inputs from tradable sectors.

welfare gains. But third, owing to both tariff reductions and general equilibrium effects, the use of imported intermediate goods from other sectors, may or may not increase depending on how the relative prices of these goods change. This means welfare may be lower or higher. Finally, there is the loss of tariff revenue. All together, while there is a presumption of welfare gains from lower trade costs, it need not be the case. Using a calibrated version of my model, I am able to quantify these different effects.

Regardless of the number of sectors and complex input-output (IO) networks among sectors, the model calibration depends on the estimates of the sectoral trade elasticity. Using the same structure as Eaton and Kortum (2002), the trade elasticity is equal to the parameter governing the distribution of productivities within a sector. A great deal of effort has been devoted to estimating and calibrating this elasticity. Two of the most prominent methods involve a two-step procedure developed by Eaton and Kortum (2002), which uses micro price data to estimate a structural gravity equation, and a triple difference methodology developed by Caliendo and Parro (2015). Because I have detailed tariffs data, I am able to estimate the sectoral trade elasticities in one-step from the structural gravity model. I estimate the sectoral trade elasticity using generalized least square for 15 tradable sectors with data from 24 countries in 2000.

My elasticity estimates range from 0.19 (food sector) to 15.66 (petro-chemicals); the median estimate is 6.50 (textile products). My results show there is high productivity dispersion in food industry while petro-chemical industry is less dispersed. With the Caliendo and Parro (2015) gravity estimation method, my trade elasticity estimates are larger but similar to literature. The estimates are significant and range from 1.03 (agriculture) to 43.24 (petro-chemicals) showing productivity gaps across sectors.

Based on my understanding, My sectoral structural gravity estimation is one of the first to include several developing economies from Africa. Waugh (2010) documents that fitting gravity model when rich and poor countries are included is non trivial, as productivity dispersion varies with income. Lagakos (2009) provides evidence that the coexistence of high productive firms and low productive firms in developing countries suggest why the variance in productivity is higher for poor economies. Even within a narrowly defined sector, there are large evidence that productivity vary significantly, explaining why the sectoral trade elasticity estimates is smaller than result from existing literature.

The remaining model parameters are calibrated to data for 25 countries and 29 sectors in 2000. For instance, value added in agriculture sector is the value that is obtained from data as at 2000. I use data on sectoral bilateral trade flows, sectoral bilateral tariffs, sectoral production, country specific input-output (I-O) tables and my estimate of the sectoral trade elasticity. Similar to Dekle, Eaton and Kortum (2008), I express the model in relative changes reducing the number of parameter to be calibrated. Quantifying the welfare effects of trade is computed by changing the tariff regime and evaluating the impact on wages and prices.

With my calibrated framework, I perform two main quantitative exercises modeled as tariff changes from 2000 to 2006. In the first exercise, I use only Nigeria and China tariff reductions to assess the narrow effects of China's WTO accession on one country. In the second exercise, I quantify the welfare effects from all the bilateral and multilateral agreements implemented around this time. In addition to evaluating the welfare effects, I decompose these effects, as well as compute the impacts on real wages and trade at the aggregate and sectoral levels.

In the first exercise, the model implies that Nigeria's imports from China rises by 113%, while China's import from Nigeria increases by only 2.63%. Nigeria's increased trade with China impacts countries from Europe and developing economies, who are facing competition from China in Nigeria's market. The sectoral composition of trade changes slightly for Nigeria while it is unchanged for China. Nigeria's welfare rises by 0.09%, because of increased trade in non-oil manufacturing industry. China loses 0.04% in welfare because of deterioration in terms of trade. Cote d'Ivoire gains 0.18%, South Africa gains 0.06% and there is no significant impact on other countries in my sample.

A tariff reduction between two countries opens them up for more trade, and the larger country offers more goods. Since the smaller country's increase in supply of the goods she specializes on does not change the world price substantially, the small country gains more. Nigeria gains more than China because, as the smaller economy, she is able to specialize more, following tariff reductions. The welfare gain in Nigeria, as well as the welfare loss in China, are modest because having only bilateral tariff reductions, while it leads to increased bilateral trade, leads to reduced trade and trade diversion from their other trading partners. China's loss results from a deterioration in its terms of trade. By contrast, Nigeria experiences an improvement in its terms of trade. A closer look at the terms of trade changes show that Nigeria's real wage rises, and China's falls. In addition, I obtain the familiar result that small countries tend to gain more from trade, because there are more opportunities to specialize.

In the second experiment, I use the observed global tariff reductions and assess the impact on trade and welfare. Patterns of technology and geography in determining comparative advantage emerge. Smaller countries have larger gains from tariff reductions.[2] Compared to the first experiment, the larger tariff reductions in the second experiment imply a much larger role for comparative advantage, and larger effect coming from country's size. In this

[2] As noted by Eaton and Kortum (2002), as geographic barriers falls, manufacturing worker shrinks in smaller country as production shift to larger country. As geographic barrier continue to diminish, the forces of technology prevails and the fraction of labor in manufacturing increases and rises above autarky in smaller country.

experiment, the gains to most countries are positive with Cote d'Ivoire having the largest positive gain of 8.09% due to improvements in terms of trade. Nigeria gains 1.2%, mostly driven by trade in the non-oil manufacturing sector like basic metals and textiles, while China gains 0.20%. Still, real wages are higher for both China and Nigeria.[3] Model yields evidence of displacements effects, low income countries, who are competing with China are being displaced and replaced. Among Asian economies, India has the highest gain of 1.49%, mostly due to increase in trade flows. Portugal suffers a mild welfare loss of 0.01%. Global tariff reductions led to more trade and higher positive gains from volume of trade effects. Looking at sectoral contributions, textiles, office, electrical, communication and medical (OECM) industry, and machinery account for 57% of China's positive gains from volume of trade.[4] As we will see in the next section, these industries had high import barriers before China's accession.

The rest of the paper is structured as follows: section 2 reviews related literature. Section 3 gives background information and motivate the importance of modeling trade in intermediate inputs, multiple sectors with sectoral linkages. Section 4 provides the model set up and calibration algorithm. In section 5, I present the trade elasticity estimation methodologies. Section 6 uses the quantified model to explore the counter factual scenarios listed above. The last section concludes.

2 Literature Review

This paper is most closely related to Caliendo and Parro (2015) who studies the effects of NAFTA on United States, Canada and Mexico. The framework I employ builds on the model in that paper. Two key differences are the application of the model, and the estimation of the trade elasticities. More broadly, there is now a large literature employing multi-country, multi-sector extensions of the celebrated Eaton and Kortum (2002) Ricardian trade model to study quantitatively the gains from trade. The key distinction between this literature and my paper is that I focus on the particular impacts of China's WTO accession on low-income countries, as opposed to general decline in trade costs.

A related paper is Lai, Riezman, and Wang (2016). This paper uses a CGE model to evaluate the effects of WTO accession on China itself. Their framework draws from Arkolakis, Costinot and Rodgruez-Claire (2010). This model shows the welfare effect can be captured by the share of own consumption and the trade elasticity with respect to trade

[3]Textile, basic metals, and chemicals account for 60% of Nigeria's gains from volume of trade, whereas mining (oil) is only 0.068% of Nigeria's total welfare effects.

[4]These are industries identified as import sector by Lai, Riezman, and Wang (2016).

costs. Both terms can be directly estimated from data. Similar to my finding, their results indicate that there are positive large gains to China's import sectors and the effects are heterogeneous across sectors. My paper differs in that I look at the effects on other countries beyond China.

My approach has less in common with literature like Zhi Wang (2002), Martin and Lanchovina (2003)or Ghosh and Rao (2010) that have used a recursive dynamic CGE model with GTAP data to simulate the gains from China's accession on some countries and regions. In contrast to their results, I find that China welfare gain is not as large as predicted and that most gains accrues to low income economies from Sub Sahara Africa and Asia.

On the empirical sides, there are studies that have looked at the effect of WTO accession on employment as in Autor Dorn, and Hanson (2016) and structural change, and poverty reduction in Sub Saharan African as in Dani Rodrik (2014). Autor, Dorn, and Hanson (2016) employ a difference in differences strategy to identify the impact of China's accession on regional employment across the United States. Rodrik (2014), employing a standard growth model with regression of income growth on macro fundamentals evaluates the performance of 18 African economies. His results show that there are positive improvements in economic fundamentals but structural change and industrialization seems to be underutilized.[5]

In regards to determinants of growth in Africa economies, Busse, Erdogan and Mühlen (2014) find that trade, rather than foreign direct investments or aids, have significant impact on growth rate. They employed a regression model to identify three channels of China's activities in Africa. Their results show that African economies that export natural resources have benefited from positive terms-of-trade effects but still there is evidence for displacement as a result of Chinese competition.[6] Their empirical work is based on traditional Heckscher-Ohlin-type trade patterns and do not account for spillover effects as a result of trade with a third country.

3 Overview of Trade, Tariffs, and production pattern

In this section, I present a broad overview of tariffs and trade at the aggregate and sectoral level in 2000 and 2006 for Nigeria and some selected countries. I show the IO table to

[5] Macro fundamentals are defined as conditions that determine long term growths such as levels of investment, human capital, and the quality of policies

[6] A Solow type growth model is employed to evaluate Africa performance from 2000 to 2011 using an empirical model that includes three main China's activities in Africa: trade, foreign direct investment (FDI) and aids. Their result shows that Africa economies that export natural resources have benefited from positive terms-of-trade, and non resource imports from China has a negative impact on growth.

motivate the need for modeling trade in intermediates and sectoral linkages. Finally, I show the implications of home bias and relative tariffs between developed and poor economies on the trade elasticity estimate with the Caliendo and Parro (2015) method.[7] Throughout the paper, a sector (industry) is a 2-digit ISIC Rev. 3 industrial classification. The sectoral classification is in table A.1 in the appendix.[8]

Table 1 presents the observed import weighted tariff rates that Nigeria imposed on China and Unites States in 2000 and 2006. There was a substantial drop in the tariffs that Nigeria imposed on China, and the reduction in tariffs is heterogeneous across sectors. For example, agriculture products had about 58% drop in tariffs while petro-chemicals had only 19% reduction in tariffs.[9]

Table 1: Nigeria's tariff rates on China and Nigeria in 2000 and 2006

	China		United States	
Sectors	2000	2006	2000	2006
Agriculture	17%	7.13%	26%	5.07%
Mining	13.57%	5.12%	15%	5.62%
Food	41.39%	22.24%	36.69%	27.29%
Textile	39.41%	15.09%	42.24%	13.98%
Wood	50%	19.31%	34.58%	21.41%
Paper	21.17%	10.70%	21.27%	8.63%
Petro-chemicals	30%	24.58%	7.60%	16.39%
Chemicals	19.65%	7.47%	19.88%	5.94%
Plastic	31.85%	15.15%	30.96%	18.03%
Minerals	33.63%	18.35%	32.87%	15.08%
Basic Metals	29.19%	13.68%	29.21%	12.38%
Machinery	16.92%	13.66%	15.94%	3.97%
OECM	19.92%	7.66%	18.16%	6.19%
Auto	20.31%	9.43%	18.20%	9.04%
Other	31.21%	18.96	31.13%	17.16%

Source: UNCTAD TRAINS import weighted average tariffs at 2 digit ISIC. Columns 2 and 3 is Nigeria's bilateral tariffs on China and columns 4 and 5 are the Nigeria's tariff rates on United States.

[7]Though this summary statistics focuses on Nigeria's trade relation with China and the United States, effect is similar across developing economies. When countries with differing incomes are included in the trade elasticity estimation, taking the ratios of trade and tariffs generates outliers observations that can bias the trade elasticity coefficients.

[8]In the appendix section on data sources and procedure, I describe in details the data sources I use and how the data is set up for estimation purpose. Sectors are at 2 digit ISIC Rev. 3 and the sectoral categories are provided in the appendix.

[9]Between 2000 and 2006, the effective tariff Nigeria imposes on China dropped from (import weighted average of) 21.53% to 12.11%.

Nigeria not only reduced its tariffs on China but she also reduced tariffs on countries who are already a member of the WTO. In columns 4 and 5 of Table 1, I present Nigeria's tariff rates on United states in 2000 and 2006. The same pattern emerges. Nigeria reduced the tariffs imposed on United States and the reduction differs across sectors. The tariff reductions was due to the Trade and Foreign Investment Agreement (TIFA) between Nigeria and United States, implemented in 2000.

Chinese WTO accession also coincided with other bilateral and multilateral trade agreements. For example, there was a gradual elimination of quotas on textile and apparel imports by OECD countries. Also, the African growth and opportunity act (AGOA) was signed to promote trade integration for Africa economies.

After WTO accession and the corresponding tariff reductions, China became a major player in global trade. Most countries increased their imports from China, even with global reduction in tariffs on other countries. Figure 1 below, presents the imports share of China for six countries. There is a huge growth in China's import share, particularly for emerging economies like Nigeria, Thailand and India. Nigeria's share of imports from China rose from 4% to 13.3% between 2000 and 2006; while Nigeria's share of imports from advanced economies dropped from 62% to 52%.[10]

Focusing on Nigeria, in Figure 2, I report the import share of top 10 partners. While the share of China and the United States rose sharply between 2000 and 2006, Nigeria imports from Japan, Germany and other European countries fell substantially, showing evidence of displacement by China.

Most imported products from China are intermediates inputs, which are used for further production of tradable and non-tradable goods. Nigeria's share of intermediate inputs in total import is 65% in 2001 and increase to 70% by 2006 as shown in figure 3. Focusing on Nigeria's import from China, in 2001, the share of intermediates import from China was 56% and rose to 63% in 2006.[11]

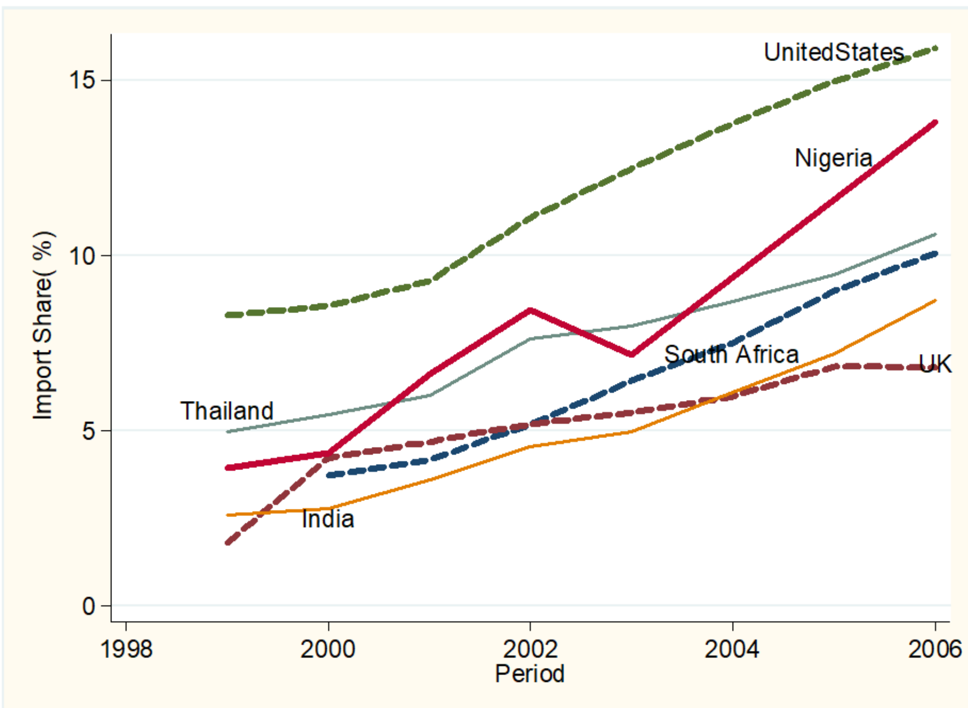
Heterogenous reduction in tariffs have huge implication for prices within that sector and in other sectors that purchase materials from the directly affected sector. The extent of interrelationship among sectors is observed from the input-output (IO) table.

Figures 14 and 15 in the appendix present the IO table for United States and Nigeria. Each cell in the I-O table represents the share of output from the column sector used in

[10]The steep jump in Chinese import share is evident when plotted as a share of GDP. By 2012, Nigeria had risen to the position of 11th port destination for Chinese export following Asian economies closely.

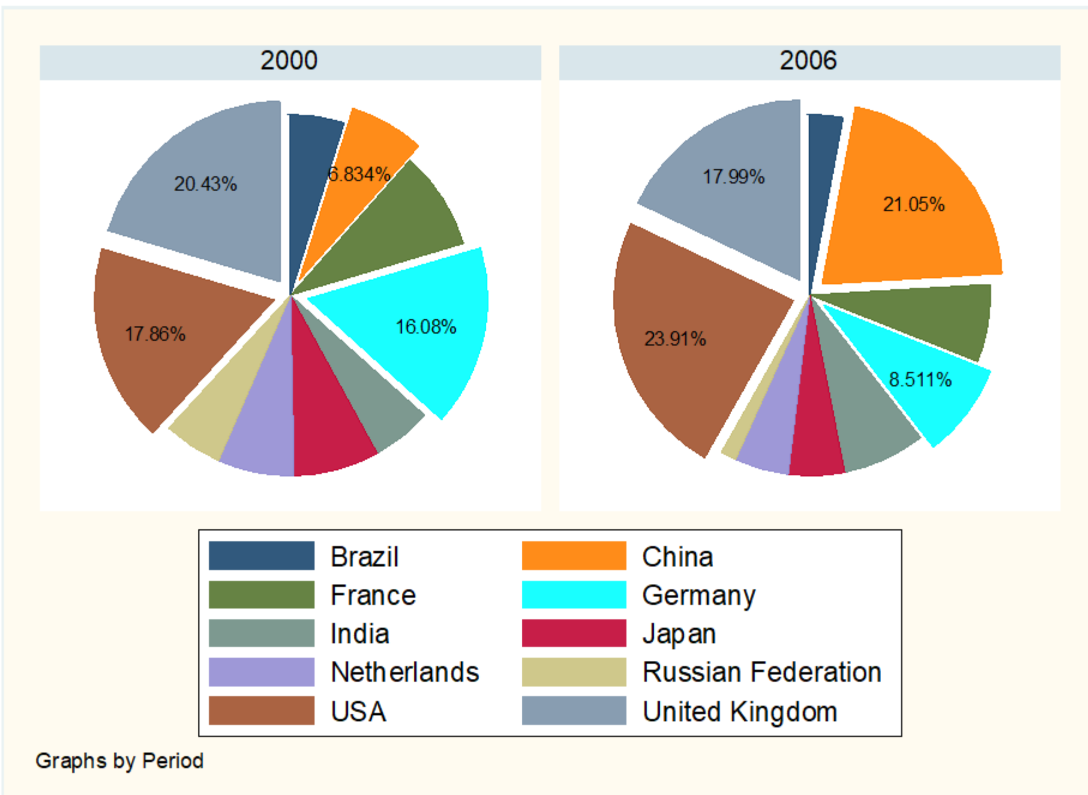
[11]For the descriptive statistics presented in this section, I use the bilateral trade value of reported imports from COMTRADE. The product categories are the HS 1996 standard products groups. The product are categorized as intermediates using the UNCTAD-SoP2, for intermediates goods and UNCTAD SoP4, for capital goods. The intermediates goods I present are mapped to these two categories

Figure 1: China's import share for selected countries (2000-2006)



Source: Author constructed based on UNCOMTRADE database. Import share is imports of a given country from China divided by total imports of the country.

Figure 2: Nigeria's Imports from Selected Countries (2000-2006)



Source: Author constructed based on UNCOMTRADE data. The figure includes countries for which Nigeria's imports share is above 4%. Values on the chart is the share among the selected countries.

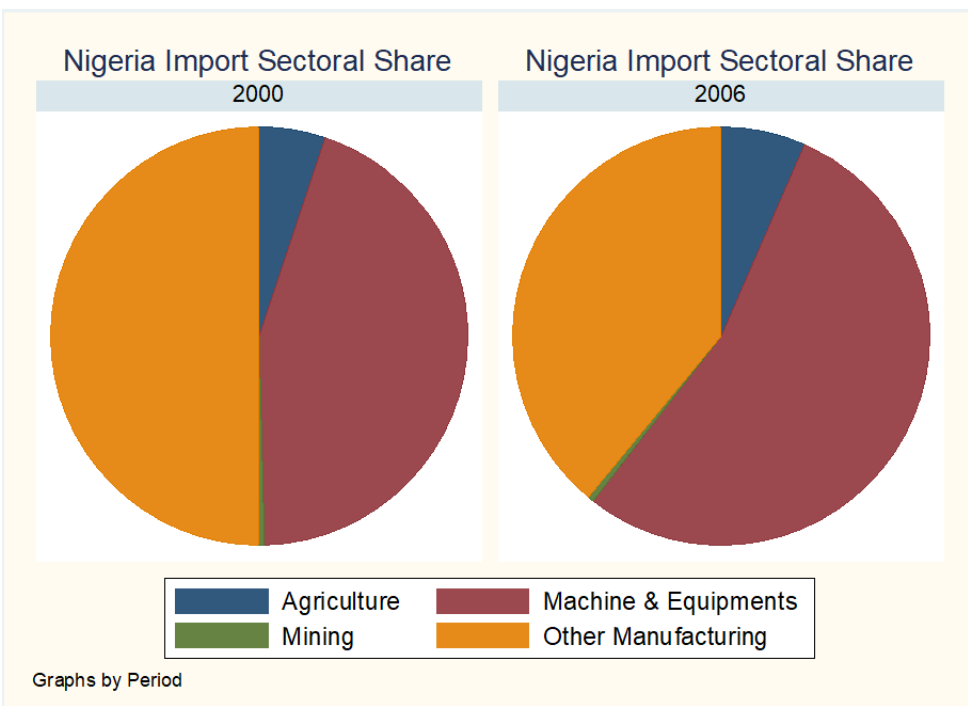
producing one unit of the row sector. The diagonal represents the share of own industry used in production. There is a huge difference in the sectoral production structure of the United States and Nigeria. For the case of Nigeria, chemicals products constitute about 25% of inputs in mining production. The mean diagonal share for Nigeria is about 17% while the standard deviation is 8.3%. The[12]

3.1 Sectoral composition of Nigeria's Import and export

After China's WTO accession, there was a large change in sectoral composition of Nigeria's exports. Figures 3 and 4 present the share of Nigeria imports and exports from the rest of the world in four broad industries: agriculture, mining, machinery and equipment and other manufacturing products.[13]

Figures 3 and 4 show that following 2000, machinery and equipment share of imports expanded 12% points by 2006. On the exports side, Nigeria's manufacturing share of exports rose from (under 1%)to 8% between 2000 and 2006. In other words Nigeria's imports became more capital-intensive and her exports became more manufacturing intensive.

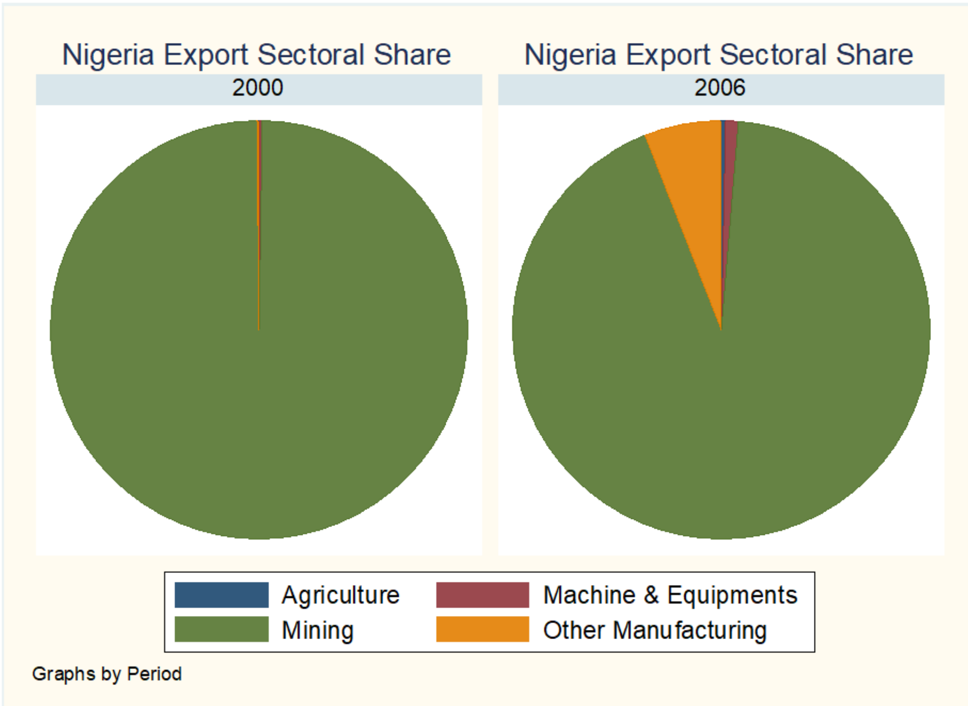
Figure 3: Sectoral composition of Nigeria's total Import



[12]Nigeria's IO is the median value for the remaining non-Africa countries

[13]Detailed HS1996 product are aggregated into four sectors: agriculture, mining, machines and equipment and other manufacturing. I use the World integrated trade solution (WITS) United nation trade and development (UNCTAD) SOP-2 and SOP-4 concordance to classify HS6 commodity into four sectors.

Figure 4: Sectoral composition of Nigeria's total Import



4 Structure of the model

As the model draws from Caliendo and Parro (2015), in this section, I provide a brief summary of the model, equilibrium conditions and calibration methods.

Consider a world with N countries indexed by n (importer) and i (exporter). Each country has J sectors indexed by j (user) and k (source). Sectors are tradable or non-tradable (final goods). Labor is the only factor of production. Labor is mobile across sectors and immobile across countries. Each consumer supplying one unit of labor inelastically, earns a wage w and receives lump sum transfers from the government (coming from the tariff revenues). Furthermore, each consumer maximizes preferences over the sectoral final good, which is non traded. There is perfect competition in all markets.

As in Dornbusch, Fisher and Samuelson (1977), in each sector j, there is a continuum of goods $\omega^j \in [0,1]$. To produce a good ω^j in sector j of country n, labor (l_n^j) is combined with composite intermediates inputs $(m_n^{k,j})$ from all sectors and countries. The Cobb Douglas production function is given by:

$$q_n^j(\omega^j) = z_n^j(\omega^j)[l_n^j(\omega^j)]^{\gamma_n^j} \prod_{k=1}^{J} [m_n^{k,j}(\omega^j)]^{\gamma_n^{kj}}, \tag{1}$$

where $\gamma_n^{kj} \geq 0$ captures the sectoral input-output linkages and denotes the share of materials from sector k used in the production of intermediate goods in sector j, with $\sum_{k=1}^{J} \gamma_n^{k,j} = 1 - \gamma_n^j$.[14] γ_n^j is the value added share and differs across countries and sectors. The representative firm's problem is to minimize cost of supplying ω^j by choosing labor and the aggregate tradable goods, given factor prices w_n and p_n^k

Producers differ in efficiency across country and sectors. The Ricardian motive is introduced following Eaton and Kortum (2002) probability representation of technology. In particular, efficiency of producing good ω^j is a random draw from Frech*ét* distribution with a location parameter λ_n^j that varies by countries and sectors, and dispersion parameter that varies by sector, θ^j. The fraction of goods for which the efficiency is lower than z is expressed as:

$$F_n^j(z) = \exp(-\lambda_n^j z^{-\theta^j}),$$

where λ_n^j governs country n's sectoral average productivity. A relatively larger λ_n^j implies a higher efficiency in producing tradable goods. θ^j is the dispersion in productivity levels. A larger dispersion yields more variation in efficiency levels relative to the mean and translates to a larger gain from trade, essentially because producers are dissimilar in their productivities. A higher value of θ^j implies less heterogeneity and gain from lower trade cost is small because producers are identical. EK (2002) show that θ^j is also the sectoral trade elasticity. I present the estimation method of θ^j more formally in section 5.

Individual goods ω^j are combined, via a CES aggregator to produce a sectoral composite good. A firm producing the composite good buys each good from the lowest cost supplier across all countries. There are three factors that determine which country has the lowest cost: (i) factor prices and inputs cost (w, p), (ii) trade costs between countries (see below) and (iii) level of productivity $z_n^j(\omega^j)$. Factor prices are determined in equilibrium, and the trade cost is exogenous. Removing tariff distortions leads to further realization of comparative advantage.[15]

Trade in goods is costly. There are two types of trade costs: observed ad valorem tariffs τ_{ni}^j and iceberg trade costs d_{ni}^j. $\tilde{\tau}_{ni}^j = 1 + \tau_{ni}^j/100$. Iceberg costs are defined in physical units according to Samuelson (1969) where by one unit of a tradable intermediates good in sector j from country i requires producing $d_{ni}^j \geq 1$ units in i with $d_{nn}^j = 1$. Non tradable goods are assumed to attract infinite tariffs. Combining both trade costs yields:

$$\kappa_{ni}^j = \tilde{\tau}_{ni}^j d_{ni}^j \quad , \tag{2}$$

[14] γ_n^{kj} captures the heterogeneity in bilateral tariff reductions.

[15] Modeling productivity this manner is suitable. Consider two identical countries. Ex ante, there is no reason for trade, however after the random draw, one country is relative efficient in producing a good hence creating room for trade.

Each country n faces the following aggregate price of tradable goods:

$$P_n^j = A^j \left[\sum_{i=1}^{N} \lambda_i^j (c_i^j \kappa_{ni}^j)^{-\theta^j} \right]^{-\frac{1}{\theta^j}} \quad . \tag{3}$$

The properties of the Frech$\acute{e}t$ distribution imply the prices and the trade share π_{ni}^j; which is country n's expenditure share on goods from country i as a share of country n's total expenditure. This is also the fraction of all goods that country n imports from country i.[16].

$$\pi_{ni}^j = \frac{X_{ni}^j}{X_n^j} = \frac{\lambda_i^j [c_i^j \kappa_{ni}^j]^{-\theta^j}}{\sum_{h=1}^{N} \lambda_h^j [c_h^j \kappa_{nh}^j]^{-\theta^j}} \quad , \tag{4}$$

where X_{ni}^j is the import of country n from country $i$of sector j goods. X_n^j is the total expenditure on sector j goods in country n and is given by $X_n^j = P_n^j Q_n^j$. Q_n^j is gross sectoral output and aggregated across final goods and intermediate goods consumers. Specifically, total expenditure X_n^j is given by:

$$X_n^j = \sum_{k=1}^{J} \gamma_n^{j,k} \sum_{i=1}^{N} X_i^k \frac{\pi_{in}^j}{1 + \tau_{in}^j} + \alpha_n^j I_n \quad , \tag{5}$$

where $I_n = W_n L_n + R_n$. $W_n L_n$ is labor income and R_n is tariffs revenue.

The trade share equation forms the foundation for structural gravity model used in estimating the dispersion in productivity parameter. A higher λ_i^j corresponds to higher market share of country i in country n, because country i has a higher productivity relative to the rest of the world. Changes in tariffs affect trade shares π_{ni}^j through κ_{ni}^j and an indirect effects coming through the cost of an input bundle c_n^j since it contains all the information about the inter sectoral relations from the I-O tables.[17]

Using the definition of sectoral total expenditure X_n^j, the trade balance condition is defined as follows:

$$\sum_{j=1}^{J} \sum_{i=1}^{N} X_n^j \frac{\pi_{ni}^j}{1 + \tau_{ni}^j} - D_n = \sum_{j=1}^{J} \sum_{i=1}^{N} X_i^j \frac{\pi_{in}^j}{1 + \tau_{in}^j} \quad . \tag{6}$$

Country n's imports of all sectors j goods from all countries is equals the sum of country n's exports of sector j goods to all country i excluding tariff payments.[18]

[16]With continuum of goods, this probability is calculated by finding the fraction of goods for which i is the lowest cost supplier to country i given the joint distribution of efficiency levels, prices and geographic barriers for any good

[17]Trade share represents the market share of country i in country n and it relates trade flows to technology, deviation from the purchasing power parity and geographic features.

[18]Aggregate trade deficit D_n are exogenous and assumed to be zero while sectoral deficits D_n^j are endoge-

4.1 Gains from Trade and Welfare Effects Decomposition

Welfare gain is calculated from the equilibrium real wage per capita and the tariff revenues. Since the real wage equation provides more intuition, I will focus my discussion on that.

As stated in the introduction section, there are three sources of gains from trade: (i) Final goods consumers who are paying lower relative prices and consuming more varieties (ii) Intermediates users who are purchasing materials at a lower price and (iii) Inter-sectoral linkages effect.[19] As in Caliendo and Parro (2015), the real wage is defined as:

$$\ln \frac{\hat{w}_n}{\hat{P}_n} = \underbrace{-\sum_{j=1}^{J} \frac{\alpha_n^j}{\theta^j} \ln \hat{\pi}_{nn}^j}_{\text{Final goods}} \underbrace{-\sum_{j=1}^{J} \frac{\alpha_n^j}{\theta^j} \frac{1-\gamma_n^j}{\gamma_n^j} \ln \hat{\pi_{nn}^j}}_{\text{Intermediate goods}} \underbrace{-\sum_{j=1}^{J} \frac{\alpha_n^j}{\gamma_n^j} \ln \prod_{k=1}^{J} \left(\frac{\hat{P}_n^k}{\hat{P}_n^j} \right)^{\gamma_n^{k,j}}}_{\text{Sectoral linkages}} , \tag{7}$$

where a variable $\hat{X}$ denotes the changes in X. This equation shows that all the general equilibrium effect on real wages can be identified from the change in the share of own spending on domestic goods produced in sector j, $\hat{\pi}_{nn}^j$, the changes in aggregate consumption prices $\hat{P}_n^k / \hat{P}_n^j$ and they all depend on the consumption expenditure share, α_n^j and the trade elasticity, θ^j.[20]

A reduction in trade barriers raises countries' imports from the rest of the world leading to a decline in sectoral expenditure on home goods (π_{nn}^j) and $\ln \hat{\pi_{nn}}^j < 0$. This leads to an increase in welfare for both final goods consumer and intermediates inputs users. Welfare gain is larger if α_n^j / θ^j is large. The sectoral linkages effects capture the I-O relations. Reduction in materials price index $\prod_{k=1}^{J} \left(\frac{\hat{P_n^k}}{\hat{P_n^j}} \right)^{\gamma_n^{k,j}}$ yields more gains to a sector that use a larger share of materials from sector k in production.

I decompose the welfare effects into terms of trade (ToT) effects and volume of trade (VoT) effects.[21] Total differentiation of W_n and the equilibrium conditions of the model

nously determined.

[19]Both the final goods consumers and intermediate goods users results in increase volume of trade while sectoral linkages capture trade diversion where by domestic exporter are hedged out in a market because relative prices are higher in the third country.

[20]Sectoral prices is a function of productivity, tariff and the shape parameter-(θ^j)

[21]The welfare effects from final goods consumers and intermediates users are captured by the volume of trade effects, while the change in relative prices, resulting from sectoral linkages is the terms of trade effects.

yields a change in welfare given by:

$$d\ \ln W_n = \frac{1}{I_n}\sum_{j=1}^{J}\sum_{i=1}^{N}\underbrace{\left(E_{ni}^j d\ln c_n^j - M_{ni}^j d\ln c_i^j\right)}_{\text{Terms of Trade}} + \frac{1}{I_n}\sum_{j=1}^{J}\sum_{i=1}^{N}\underbrace{\boldsymbol{\tau}_{ni}^j M_{ni}^j\left(d\ln M_{ni}^j - d\ln c_i^j\right)}_{\text{Volume of Trade}} \quad . \tag{8}$$

4.2 Solving the Model in Relative Changes

The policy evaluation comes from comparing the equilibrium under policy $\boldsymbol{\tau}'$ with the equilibrium under policy $\boldsymbol{\tau}$. I follow the Dekle, Eaton, and Kortum (2008) approach to solve the model in changes. This approach has an advantage because I do not need to calibrate the initial equilibrium by taking a stand on the average productivity and trade cost. Rather, I use the actual data from 2000 and compare it with the counter factual equilibrium.

I solve the model for the change in tariff policy from τ and τ' captured by $\hat{\kappa}_{ni}^j$ in relative changes.[22] To do so, I rewrite the key equations of the model in 'hat' form where a $\hat{X}$ denotes X'/X, and X' is the new counter factual variable, and X is the existing variable from the data. All together, I solve for N wage equation in N unknown, the trade share and price are $J \times N \times N$ equations in $J \times N \times N$ unknown.

4.3 Taking the Model to Data

Solving the model in relative changes reduces the data required to calibrate the model. The data needed to quantify the effect of China joining the WTO are two sets of tariffs ($\boldsymbol{\tau}$ and $\boldsymbol{\tau}'$), bilateral trade shares (π_{ni}^j), value added ($w_n L_n$), share of intermediate consumption ($\gamma_n^{k,j}$) and sectoral dispersion of productivity (θ^j) otherwise called trade elasticity. The estimation method for the trade elasticity (θ^j) and result is shown in section 5. With these data, I calculate the values for π_{ni}^j, γ_n^j, $\gamma_n^{j,k}$ and α_n^j to year 2000.

For tractability and analytical convenience, I aggregate the model to 24 countries including a constructed rest of the world (ROW) and 29 major industries. Model is calibrated to the benchmark data for 2000.[23]

Before I compute the bilateral trade share, first I calculate the domestic consumption of own goods in each country, M_{nn}^j. Domestic sales is computed as the difference between

[22] These are the equilibrium conditions Equations 21-25 in the appendix

[23] The appendix contains the list of countries and the sectors. There are 15 tradable industry and 14 non tradable sectors. I assign each detailed product to two digit industry using the World integrated trade solution (WITS) Harmonized system (HS6) to industrial classification concordance.

sectoral gross production and sectoral total exports: $M_{nn}^{j}= Y_{n}^{j} - \sum_{i=1,i\neq n}^{N} M_{in}^{j}$. Expenditure by country n on sector j goods imported from country i is X_{ni}^{j}. X_{ni}^{j} and can be calculated by multiplying trade value with tariffs : $X_{ni}^{j} = M_{ni}^{j}(1+\tau_{ni}^{j})$. The trade share π_{ni}^{j} for each sector j and country pair n, i are obtained as follows $\pi_{ni}^{j} = X_{ni}^{j}/\sum_{i=1}^{N} X_{ni}^{j}$.

The share of sector j's spending on sector k's goods $\gamma_{n}^{k,j}$ is calculated from the IO matrix as the share of intermediate goods from sector k used in producing one unit of sector j's goods.[24] The share of value added is given as $\gamma_{n}^{j} = V_{n}^{j}/Y_{n}^{j}$. To calculate the final consumption expenditure share α_{n}^{j}, I take the sectoral total expenditure after subtracting intermediate goods expenditure purchased from both domestic and foreign consumers, and then divide it by total final absorption (Income). Specifically, $\alpha_{n}^{j}= (Y_{n}^{j} + D_{n}^{j} - \sum_{k=1} \gamma_{n}^{j,k} Y_{n}^{k})/\ I_{n}$. Sectoral trade deficit in each country is given by $D_{n}^{j} =\sum_{i=1}^{N} M_{ni}^{j}$ - $\sum_{i=1}^{N} M_{in}^{j}$. The only remaining parameter is the sectoral dispersion of productivity θ^{j}. In the next section, I present the estimation method and the result for the trade elasticity parameter.

5 Trade elasticity Estimation and Calibration of other parameters

5.1 Trade, Tariffs and Geography

Equation (6) can be rewritten to yield the following expression in Equation (9), which relates trade shares to technology, deviations from purchasing power parity, and geographic features, and can be interpreted as a structural gravity equation.

$$\frac{X_{ni}^{j}/X_{n}^{j}}{X_{ii}^{j}/X_{i}^{j}} = \frac{\Phi_{i}^{j}\kappa_{ni}^{j}}{\Phi_{n}^{j}}^{-\theta^{j}} = \left(\frac{P_{i}^{j}\kappa_{ni}^{j}}{P_{n}^{j}}\right)^{-\theta^{j}} \quad . \tag{9}$$

I refer to the left hand side variable as country n's normalized input share from country i and is positively related to the real exchange rate P_i/P_n, and negatively related to all the trade costs κ_{ni}. As prices rises in n, as a result of an increase in trade costs (κ_{ni}) from shipping goods from country i to n, i's normalized share in market n declines. In a symmetric world the term on the left hand side equals one always. However deviation from the symmetric occurs because of two reasons: (i) differences in aggregate tradable prices and (ii) differences in trade cost between two countries. As documented by Waugh (2010),

[24]From a typical IO table, the sum of the column items is the total input used in production while the sum of the row items is the total output for that given sector. The $\gamma_{n}^{j,k}$ is obtained by dividing the value of sector k goods used in producing one unit of sector j goods by the total input used in producing one unit of sector j's goods

aggregate tradable prices are not significantly different across countries because of the law of one price. Therefore, deviation from the symmetric world is mostly driven by asymmetric bilateral trade cost (κ_{ni}).

The relationship between the normalized trade share and prices in Equation (9) is a structural one, whose slope yields the estimate of the trade elasticity parameter, θ^j. A lower θ^j (high dispersion) corresponds to small trade elasticity: changes in trade cost is associated with small change in trade flow. However, the gain from trade is large because producers' relative efficiencies are very different across goods. On the other hand, when productivities are less dispersed, trade elasticity is large and the gain from trade is small. The reason is that goods are more substitutable essentially because producers are similar in their productivities.[25]

Equation (9) is the sectoral gravity type expression for trade. The slope of the relationship between trade share and prices yields the value of the comparative advantage parameter, θ^j. Unlike Eaton and Kortum (2002), which uses a two-step, estimation procedure i.e. first using micro price data to estimate θ, then using the gravity equation to estimate all other parameters, I can estimate all the parameter from the structural gravity equation. I use the observed sectoral bilateral tariffs on imported products as part of the estimate of trade costs. To my knowledge, this is the first application of the Eaton and Kortum (2002) methods with observed bilateral tariff rates. With this method, θ^j is identified in a single step estimation procedure.

Trade share is negatively proportional to trade costs- κ_{ni} which can be decomposed into observed bilateral tariff rates, τ_{ni} and unobserved bilateral trade costs, d_{ni}. Following Eaton and Kortum (2002), I capture all unobserved time invariant geographic features d_{ni} by adding country's fixed effects such as importer, exporter, distance, border, and common currency to the model. Taking the logs of Equation (9) yields:

$$\log\Big(\frac{X^j_{ni}}{X^j_{nn}}\Big) = S_i - S_n - \theta^j \log \tau^j_{ni} - \theta^j m_n - \theta^j (d_k + b_{ni} + comcur_{ni} + \epsilon^j_{ni}) \quad . \tag{10}$$

The S_i's are recovered as the coefficients on source country (exporter) specific dummy variable. Think of it as a measure of country i's relative competitiveness and her state of technology. τ_{ni} is asymmetric bilateral tariffs that country n imposes on goods from country i. d_k is the effect of the distance between n and i lying in the kth interval with k= 1, 2,...., 6. I use the same distance (in miles) interval as Eaton and Kortum (2002): [0,375), [375,750), [750,1500), [1500,3000), [3000,6000) and [6000,max]. b_{ni} is the effect of country n and i sharing a common border in which $b_{ni} = 1$ if n and i have a shared border and

[25] Equation (6) framework nests the structural gravity equation. Steps involve are included in the appendix

zero otherwise. Comcur measures the effect of having a common currency and equals one if n and i have common currency and zero otherwise. I assume that ϵ_{ni} is orthogonal to the regressors and measures barrier to trade resulting from all other factors. Theory implies a zero intercept.[26]

Before showing the result, let me describe the data and examine the relationship between trade share and geography. I measure the left hand side of equation (10) with data on sectoral bilateral trade share in 15 tradable manufacturing sectors for 24 countries using data for year 2000, the year before China entered the WTO. Normalized import share does not exceeds one at the aggregate level.[27]

In order to compute the normalized trade share, I start with:

$$X^j_{nn} = Y^j_n - \sum_{i \neq n}^{N} X^j_{in} \quad .$$

This yields the value of domestic purchase of own goods in each sector X^j_{nn}. Then to compute X^j_n, I add all imports in a given sector from all countries in the world, including domestic purchase X^j_{nn}. Because the world is included in the calculation of total expenditure, this bilateral trade equation allows us to ignore the rest of the world in the estimation.[28] Normalizing home purchase and imports of an importing country n from its trading partner i by the importer's total expenditure creates the trade share -π_{ni} used in estimating the gravity equation. When n=i there is no observation. All together, I have $N^2 - N$ observations in each sector, and 8280 total number of observations.

To measure κ_{ni} in Equation (10), I use the weighted average bilateral tariffs in 2000 as a measure of τ_{ni} and the distance, common currency and border fixed effects. Also, I use the simple average bilateral tariffs for the estimation of θ^j. Identifying θ^j using bilateral tariffs requires that all unobserved importer, exporter and bilateral effects are fully controlled for to reduce omitted variable bias.

[26]All fixed effects are constructed using the Head and Ries gravity cookbook websites:https://sites.google.com/site/hiegravity/. Bilateral trade data are from United Nations Commodity trade (UN-COMTRADE) database. Sectoral bilateral tariff rates are from United Nations, Trade analysis Information system (TRAINS)

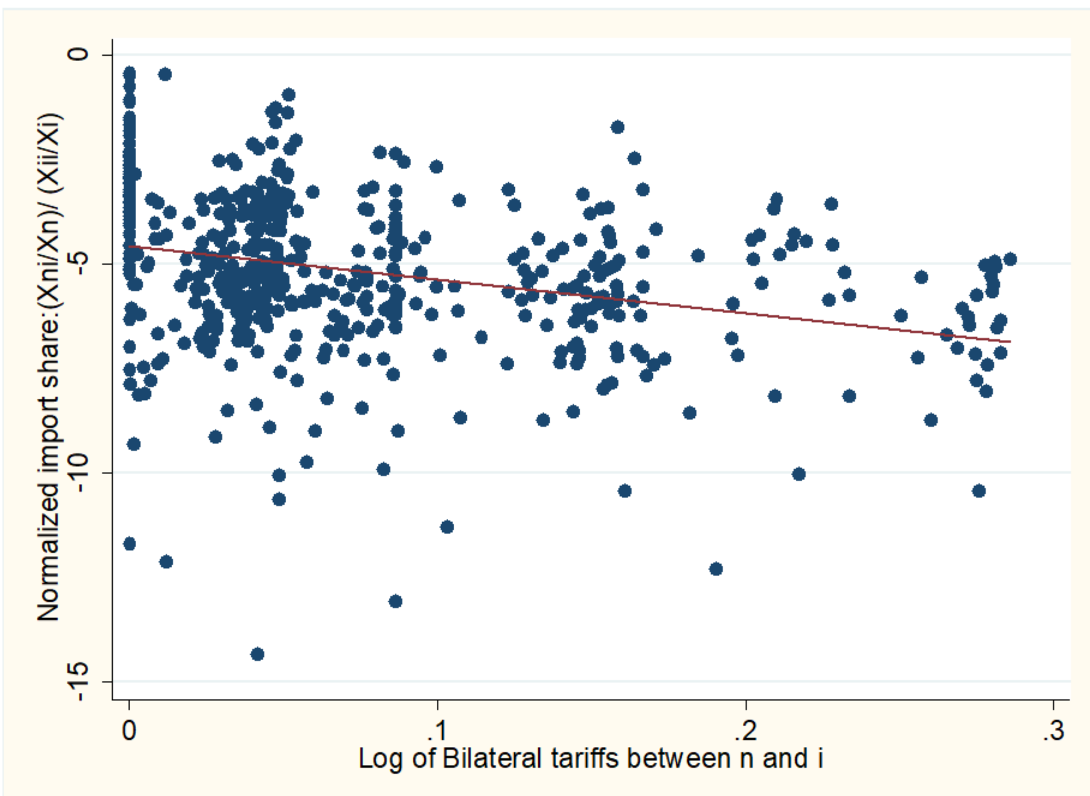
[27]Because of triangular inequality, normalized trade share in country n does not exceed one. However, at the sectoral level, it is larger than 1 for some countries in my sample like Belgium, Netherlands, and Cote d'Ivoire, who do not produce some products within a sector domestically. Having both low and high income economies in the sample of countries makes fitting the model to data difficult. Standard approaches to modeling trade costs usually assume that they are symmetric.

[28]Even though the rest of the world (ROW) is included in calculating domestic share on own good, similar to Eaton and Kortum (2002), I excluded ROW from the estimation. ROW accounts for less than 10% of the world trade for my sample. Also, getting bilateral fixed effect when the ROW is partner may be difficult since the rest of the world is made up of countries not included in my sample

For the aggregate trade elasticity, I sum all tradable products to one sector and the tariffs is the import weighted average bilateral tariffs across all goods in a 2 digit sector. The highest normalized import share is 0.8, which is the share of Canada's import from the United States; Belgium and Netherlands does not exceed 0.5 and far below the level of one that exist in a zero gravity world.

Figure 5 plots the log of the normalized trade share against the log of bilateral tariffs between the 24 country pairs. The fitted line shows a negative relationship between the resistance effect of trade cost on normalized trade share. The slope of the relationship provides an aggregate estimate of the value of the trade elasticity θ^j.

Figure 5: Trade and bilateral tariffs



I use generalized least squares (GLS) with zero intercept to estimate the trade elasticity parameter sector by sector using the proposed specification in equation (10).[29] Table 2 reports the (negative of the) comparative advantage estimates θ^j and heteroskedastic robust standard errors. Columns (2) to (4) shows the results from using weighted bilateral tariffs data and columns (5) to (7) are the results from using simple average tariffs data. The

[29] I estimate equation (10) by dropping observations with zeros and missing values. Although, zeros are frequent at the dissagregated product level, but very infrequent at the 2 digit sectoral level, which reduces the number of data point trimmed out of the sample

aggregate elasticity is reported in the first row.[30]

Sectoral productivity dispersion have the correct sign in all sectors and ranges from 0.19 in the food industry and 15.66 in the petro-chemicals industry. Productivity in the food industry is largely dispersed while producers have similar relative productivity in petro-chemicals industry.[31] With smple mean bilateral tariffs, the trade elasticity estimates are larger in most sector beside paper and chemicals.[32]

Table 2: Trade Elasticity estimates by Sector

	Weighted Mean (τ_{ni})			Simple mean (τ_{ni})		
Sector	θ^j	se	N	θ^j	se	N
Aggregate Elasticity	3.17	(2.69)	551	3.17	(2.69)	551
Agriculture	1.41	(2.89)	347	3.43	(6.29)	286
Mining	4.19	(3.45)	422	15.37	(9.35)	433
Food	0.19	(0.52)	543	1.16	(1.16)	544
Textile	6.50	(1.57)	513	7.88	(2.23)	514
Wood	9.78	(2.18)	491	15.65	(4.48)	495
Paper	6.46	(2.32)	528	4.87	(4.39)	530
Petro-Chemicals	15.66	(7.09)	410	42.58	(11.45)	414
Chemicals	11.22	(2.70)	517	4.26	(3.97)	516
Plastic	2.22	(2.59)	513	18.37	(3.87)	505
Minerals	11.45	(1.82)	525	25.19	(3.07)	526
Basic Metals & Metal Products	11.34	(2.45)	535	21.45	(4.23)	536
Machinery n.e.c	10.12	(2.89)	496	21.27	(4.23)	491
Office Elec Comm. Med.	6.16	(3.08)	449	10.98	(5.08)	449
Auto & Other Transport	2.51	(1.31)	414	4.32	(2.85)	404
Other	7.62	(2.42)	444	11.25	(4.01)	443
Prob > chi2	0.0000					

Notes: Estimated by generalized least squares using 2000 data. The specification is given in equation (10) of the paper. Standard errors are robust and are in parentheses. In the case of agriculture, I keep observations within 0.9 standard deviation from the mean to remove outliers skewing the estimate. I report the estimates after trimming the data for agricultural sector only. The mean elasticity for the manufacturing sector using estimate weighted average tariffs is 7.79.

[30] As in Waugh (2010), I divide the sample into two group based on income and re-estimated the trade elasticity. When non OECD countries and OECD countries are considered separately, the estimates are 4.03 and 11.43 respectively. Estimates for the non OECD group is similar to the aggregate elasticity. My aggregate elasticity estimate is similar to the literature. Waugh (2010) founds an estimate of 5.5 and 7.9 for non-OECD and OECD respectively. I include countries in the OECD, if they are in the group in 2000. Chile is excluded from OECD. Estimates of non OECD without China is 2.09.

[31] Compare to Giri et al (2018), who used the price based method Of Eaton and Kortum (2002), my estimates are smaller and consistent with gravity estimation literature. Giri, Yi and Yilmazkuday (2016) employing Simonovska and Waugh (2015) simulated method of moments, finds trade elasticity estimates that ranges from 4.26 to 35.55

[32] I use both trade elasticity reported in Table 2 for the numerical analysis.

Table 4 presents the distance effect, shared border effect and the effect of common currency for the aggregate elasticity. As we can see, geographic barriers inhibit trade, and the effects are diluted by the shared border and common currency effect. Table 5 summarizes the aggregate estimates on the exporter (S_i) and importer's (θm_n) effects respectively. All countries faces intense competition, with the United States as the most competitive country as at 2000 closely followed by Germany. The source and destination countries effects depends on the comparison country and may not be comparable to results from literature. However, the estimates and standard errors are similar to Eaton and Kortum (2002) and Waugh (2010). Both find the United States and an European country, Belgium to be the most productive exporter and importer respectively.[33]

Table 3: Estimation Results: Fixed Effects (Aggregate Elasticity)

Observations	552	
Geographic barriers	Parameter estimates	standard error
$[0, 375]$	-1.04	.65
$[375, 750]$	-2.00	.34
$[750, 1500]$	-1.88	.30
$[1500, 3000]$	-2.10	.31
$[3000, 6000]$	-2.65	.29
$[6000, Maximum]$	-3.56	.27
Shared border	.15	.23
Common currency	-.03	.22

Notes: Aggregate estimates of distance, shared border and common currency effects from equation (17). Standard errors are in parentheses.

5.2 Calibration of Other Parameters

To measure the trade and welfare impact of China's WTO accession, my data draws from many sources. The required data are trade flows, tariffs for 2000: our base year and 2006 the counter factual year, sectoral gross output for all countries, sectoral value added and IO tables for all countries in my sample. I have a sample of N=25 and J= 29 sectors: 15 tradable and 14 non-tradable. Here, I provide a short list of data sources. A detailed description of

[33]My estimate for most industry in particular the Petro-chemicals sector is similar to Caliendo and Parro (2015). A linear fit of the scatter in figure 1 yields a slope of -9.67 and an intercept of -4.34 (the standard errors are 1.0 and 0.11 respectively. R^2 is 12.6%. Having a negative intercept signals errors in variable which implies that the estimates are biased towards zero. With no intercept, OLS yields a significant estimate of -40.24. and R^2 is 60%. The generalized least square methods yields a similar estimates of θ^j. Belgium is the country of comparison, therefore each effect is relative to Belgium.

Table 4: COUNTRY SPECIFIC ESTIMATES-AGGREGATE ELASTICITY

Country list	S_i	s.e.	θm_n	s.e.
Brazil	-0.04	(0.25)	0.63	(0.40)
Canada	-0.03	(0.25)	0.63	(0.24)
Chile	-1.69	(0.25)	1.93	(0.29)
China	1.09	(0.25)	0.27	(0.42)
Cote d'Ivoire	-3.94	(0.25)	4.17	(0.25)
France	0.89	(0.24)	-0.43	(0.24)
Germany	1.48	(0.24)	-1.02	(0.24)
India	-0.44	(0.25)	1.28	(0.70)
Indonesia	-0.52	(0.25)	1.44	(0.27)
Italy	0.54	(0.24)	0.25	(0.24)
Japan	1.64	(0.25)	-0.19	(0.25)
Korea, Rep.	0.41	(0.25)	0.66	(0.29)
Netherlands	0.15	(0.24)	-0.01	(0.24)
Nigeria	-1.69	(0.25)	1.90	(0.56)
Portugal	-2.28	(0.25)	2.86	(0.25)
Russian Federation	-0.38	(0.25)	1.51	(0.36)
South Africa	-0.71	(0.24)	1.16	(0.27)
Spain	-0.31	(0.24)	0.82	(0.24)
Sweden	-0.46	(0.25)	1.38	(0.25)
Switzerland	0.18	(0.25)	-0.37	(0.25)
Thailand	-0.32	(0.25)	0.58	(0.42)
United Kingdom	0.81	(0.25)	-0.46	(0.24)
United States	2.45	(0.25)	-1.99	(0.25)

Notes: Estimated equation 10 by generalized lest squares using 2000 data. The fixed effect parameter are normalized so that $\sum_{i=1}^{24} S_i = 0$ and $\sum_{i=1}^{24} m_n = 0$. θm_n is derived as importer's effect less exporter's effects. Mean elasticity for manufacturing sector is 7.79. Standard errors are in parentheses.

Table 5: SUMMARY OF PARAMETERS

Parameter	Definition	Average Value	Source
θ^j	Comparative advantage	Table 2	Section 5.1
α_n^j	Final goods expenditure share	0.23	From production and trade Section 4.3
β_n^j	Value added share	0.25	From IO table section 4.3
$\gamma_n^{j,k}$	Sectoral linkages	IO tables	From IO table section 4.3

sectoral and aggregate data used in this paper is provided in the appendix section titled: data and sources.

Bilateral trade flow data are from United Nations Statistical Division (UNSD) commodity Trade (COMTRADE) database. Values are reported in US dollars at current prices which include cost, insurance and freight (CIF). Effective advalorem tariffs data for the years 2000 and 2006 (and other years in this study) are obtained from the United Nations Statistical Division-Trade Analysis and Information System (UNCTAD-TRAINS). Gross output and value added come from five different sources. The sources are OECD STAN database for industry structural analysis; UNIDO INDTAT2 database; WIOD (World input-output) database; OECD Input-Output database; and the EORA MRIO (multi region Input-Output) database. Input-Output (IO) tables are sourced from WIOT, EORA multi region IO tables and the OECD IO tables. Table 5 summarizes the model parameter value and sources.

After calibrating the model parameter to base year (2000) using the trade elasticity estimates in the previous section, I then quantify the effect of Chinese accession and tariff reduction by performing two intuitive counterfactual exercises. The results of these numerical analysis are presented in the next section.

6 Counterfactual Results

In the first exercise, I introduce into the model a tariff reduction on China and Nigeria between 2000 and 2006 while fixing the tariff structure for the rest of the world to the base year. This counter factual exercises measures the economic importance of China in Nigeria conditional on no other changes in tariffs for other countries. With this exercise, I can directly measure the narrow effects of China WTO accession on Nigeria, China and other countries.

In the second exercise, I numerically explore the effects of global tariff reduction to capture all the bilateral and multilateral agreements signed around that time. This exercise quantify the gains to all countries from bilateral and multilateral tariffs agreement. To do this, I feed into the model the observed change in global tariffs structure between 2000 and 2006.

Tariff changes lead to further realization of productivity draws and changes the distribution of prices and trade share. Then, I use the model implied result to compute the welfare and trade effects given observed world tariff changes.

Before presenting my results, note that my calibration strategy is to match the model to the base year, then simulate the change in trade and welfare after tariffs reduction. Meaning that if countries have an aggregate trade deficit the model also accounts for the trade deficit in the base year but counter factual changes to trade policy are not going to adjust the aggregate trade deficit since they are not endogenous.

To deal with this, first, I calibrate the model to the base year with trade deficits and then solve the model imposing a zero aggregate deficit: $D_n' = 0$. Then, I use the simulated no deficit world as my base year. Secondly, I calibrate the model with aggregate deficit to year 2000 and then calculate all counterfactuals holding the countries aggregate trade deficit constant as a share of world GDP. I compute all counterfactuals using both methods but I report the no trade deficit result in the main text.

6.1 The effects of China joining the WTO and tariff reduction on China and Nigeria

The trade elasticity estimates in column 2 of table 3 provides the comparative advantage parameter values that I use to quantify the model and perform policy analysis. Given that the model is static, these counterfactual results should not be seen as the ultimate policy on sustainable growth or for any policy analysis. Regardless, the magnitude of the effect do provide insights into how the model works.

With a model calibrated to the base year 2000 for 25 countries, first, I consider the trade and welfare impact from tariff reduction on Nigeria and China only, while fixing the tariff to and from the rest of the world to the base year 2000. Welfare effects are calculated from Equation (8), and changes in real wages are from Equation (7). Since labor supplies and population is held fixed, there is no difference between GDP or GDP per worker or GDP per capita.

Table 6 shows the results. The effect is modest for both countries. As seen from the table, Nigeria's welfare increases by 0.09% while China has a welfare loss of 0.04%. Moreover, the real wage increases for Nigeria and decreases for China. China's real wage decreased because of deterioration in terms of trade.

Decomposing the welfare effects into volume of trade and terms of trade emphasize the sources of these gains. The volume of trade effect captures the gain to final goods consumers and domestic firms who import more because of tariff reductions. The second source of

Table 6: Welfare Effects from tariff reduction on Nigeria-China only

	Welfare Effects			
Countries	Total	Terms of Trade	Volume of Trade	Real Wages
China	-0.04%	-0.1%	0.09%	-0.10%
Nigeria	0.09%	0.02%	0.07%	0.14%

Notes: Welfare effects are calculated from Equations (7) and (8).

welfare effects is the terms of trade. The term of trade is the price of export relative to the price of imports. The term of trade accounts for the effect of lower tariffs on the relative price of a country's export goods. If that price declines, then the terms of trade effect is negative. The third column in Table 6 shows that the substantial source of gains are increases in volume of trade. The welfare gains from volume of trade as a result of trade creation is 0.09% for China and 0.07% for Nigeria.[34] The welfare effects are largely driven by trade created as a result of tariff reduction on China and the rest of the world.

From column 2 in Table 6, Chinese term of trade deteriorates and improves for Nigeria. The term of trade effect is driven by how export prices change in each country as a result of tariff reductions. The cost of a unit bundle is an increasing function of wages and the prices of materials. From column 4 in Table 6, notice that wages increase in Nigeria and decreases in China, hence the increase in wages raises export prices in Nigeria and lowers export prices in China. However, from Equation (3) note that, all else equal, the price of materials falls with reduction in import tariffs. Therefore, export prices change according to how large is the increase in wages relative to the fall in the price of materials. It turns out that Nigeria's tariffs on China's export falls significantly relative to China's tariffs on Nigeria exports.

A tariff reduction on Nigeria and China impacts other countries in my sample. Cote d' Ivoire gains 0.27%, most of these gains are from improvements in the term of trade. South Africa gains 0.17% and the rest of the world gains about 0.10%. The gain is modest in all countries. This is essentially because other countries have their tariffs fixed to the higher tariffs regime as at 2000. A higher tariff regime accounts for the modest change in volume of trade and worsened term of trade for most countries.

Table 7 presents the sectoral contribution to welfare as a result of bilateral tariff reductions on China and Nigeria for Nigeria and China.[35] There is substantial heterogeneity in the sectoral contribution to the welfare effects in all countries. Still, few sectors account

[34]This decomposition is done using Equation (8) defined in structure of the model section of this paper.

[35]These are calculated for each sector j using $d\ln TOT_n^j / \sum_{j=1}^J d\ln T_n^j$: that is sectoral changes in term of trade as a share of aggregate changes in term of trade. And the sectoral Volume of trade effect is calculated as in $d\ln VOT_n^j / \sum_{j=1}^J d\ln VOT_n^j$.

for the change in aggregate term of trade in both countries. For China, textile, mining, others and OECM (office, electrical communication and medical products) contributes 65% to deterioration of Chinese term of trade. The three sectors that contributes the most to Nigeria's term of trade improvement are mining, machinery and auto products accounting for more than 80% of Nigeria's improvement in terms of trade.[36]

Table 7: Sectoral contribution to welfare(%) from China-Nigeria Tariff Reduction

	China			Nigeria
Sectors	Terms of Trade	Volume of trade	Terms of Trade	Volume of Trade
Agriculture	3.41%	-0.376%	1.13%	-25.2%
Mining	9.77%	-1.59%	104%	11.5%
Food	4.13%	16.6%	-5.36%	-24.7%
Textile	21.6%	21.6%	-2.43%	23.2%
Wood	1.07%	0.0514%	-0.571%	0.137%
Paper	0.972%	4.91%	-0.308%	-4.34%
Petroleum	2.56%	-3.83%	-6.49%	47.2%
Chemicals	5.16%	-1.38%	1.77%	13.9%
Plastic	2.99%	2.14%	-0.211%	5.31%
Minerals	1.36%	-1.22%	-3.68%	13%
Basic Metals	5.88%	-6.41%	-0.468%	28.9%
Machinery	4.18%	2.51%	5.18%	16.9%
OECM	25.2%	38%	2%	0.436%
Auto	2.82%	18.4%	5.55%	-7.08%
Other	8.93	10.6%	0.261%	0.776%

Table 8 shows the aggregate trade effects resulting from tariffs reduction on Nigeria and China only. As you can see, Nigeria's import from China increased by more than 113% while China only increased imports from Nigeria by 2.63%.

Table 8: Trade Effects from Tariff Reduction on China and Nigeria

	China	Nigeria
China's Imports		2.63%
Nigeria's Imports	113%	

Notes: Table shows the trade effects from Nigeria and China bilateral tariff reduction. I use θ estimates with weighted average tariffs.

China's impact on global trade also had an effect on sectoral specialization in trade across countries. Table 9 presents the sectoral export share for China and Nigeria and the

[36] OECM is composed of office, electrical, communication and medical industries

Herfindahl index to measure the export concentration in the top three sectors. In the year 2000, for China, three sectors:textile, OECM and other account for 68.2% of total exports and the model implied result shows that export is still concentrated in these sectors.[37] For the case of Nigeria, the three sectors with the largest share are mining, food and agriculture, accounting for 99% of Nigeria's total exports. Nigeria had modest increase in export share in mining, still there is a slight decrease in export concentration.

Table 9: Export shares by sector before and after China-Nigeria tariff reductions

	China		Nigeria	
Sectors	Before	After	Before	After
Agriculture	2.15%	2.16%	0.444%	0.403%
Mining	2.19%	2.24%	97.9%	98%
Food	3.9%	3.74%	0.766%	0.721%
Textile	27.1%	26.7%	0.25%	0.244%
Wood	0.993%	1.03%	0.128%	0.131%
Paper	0.878%	0.891%	0.00928%	0.00906%
Petroleum	1.25%	1.37%	0.332%	0.329%
Chemicals	3.07%	3.22%	0.0265%	0.026%
Plastic	3.48%	3.43%	0.00566%	0.00575%
Minerals	1.51%	1.59%	0.00924%	0.00951%
Basic Metals	4.79%	5.04%	0.00443%	0.0043%
Machinery	4.16%	4.23%	0.012%	0.0113%
OECM	30.4%	30.3%	0.0303%	0.0301%
Auto	3.36%	3.26%	0.113%	0.107%
Other	10.7%	10.8%	0.00255%	0.00249%
Normalized HHI	0.159	0.156	0.96	0.96

In the next section, I look at the impact of China entering the WTO in the presence of global tariff reduction.

6.2 The effects of China joining the WTO given world tariff changes

China's WTO accession coincided with many other trade agreements. There were trade alliances signed to encourage foreign direct investment and growth opportunities for Africa economies like the AGOA agreement, Multi-Fibre Arrangement and others. For instance, Nigeria signed the Trade, Investment and Foreign Direct Investment Agreement (TIFA) with the United States in 2001. Between 2000 and 2006, there were substantial bilateral tariffs reduction between Nigeria and other top partners like the United States. All these agreements

[37] Chinese has comparative advantage in labor intensive industries which explains why these sectors:textile, OECM and other manufacturing industries account for half of the welfare gains.

led to reductions in global tariffs. In this section, I capture the effects of multilateral and bilateral trade agreement enforced around 2001 using observed changes in tariffs. I quantify the global effects from world tariff reductions including the changes in tariff rates between China and Nigeria.

Table 10 presents the aggregate welfare effects of global bilateral tariff reductions on all countries in my sample. These effects capture the gains to countries from reduction in barriers that occurred between 2000 and 2006 due to China's WTO accession and other multilateral and bilateral arrangements. Beside Portugal, all countries gain from world tariff reduction with Cote d'Ivoire getting the largest gain of 8.09%.

Table 10: Welfare Effects from global tariff reductions

Country	Welfare Effect	Term of trade	Volume of trade	Real Wages
Belgium	0.362%	0.324%	0.0381%	0.372%
Brazil	0.0714%	-0.117%	0.189%	0.23%
Canada	0.309%	0.275%	0.0342%	0.331%
Chile	0.248%	-0.211%	0.459%	1.29%
China	0.204%	-0.529%	0.734%	0.812%
Cote dIvoire	8.09%	6.8%	1.29%	8.21%
France	0.0582%	0.0414%	0.0168%	0.0625%
Germany	0.144%	0.119%	0.0256%	0.152%
India	1.49%	-0.655%	2.15%	1.15%
Indonesia	0.2%	-0.0151%	0.215%	0.491%
Italy	0.0726%	0.0512%	0.0214%	0.0768%
Japan	0.0399%	0.0204%	0.0196%	0.028%
Korea, Rep.	0.0184%	0.00977%	0.00863%	0.123%
Netherlands	0.253%	0.218%	0.0354%	0.265%
Nigeria	1.2%	0.147%	1.05%	2.41%
Portugal	-0.00707%	-0.0179%	0.0108%	-0.00193%
Russia	0.0727%	-0.0921%	0.165%	0.25%
South Africa	0.371%	0.357%	0.0141%	0.726%
Spain	0.0599%	0.0453%	0.0147%	0.062%
Sweden	0.144%	0.118%	0.0258%	0.16%
Switzerland	0.33%	0.174%	0.156%	0.229%
Thailand	0.926%	-0.785%	1.71%	2.39%
United Kingdom	0.162%	0.136%	0.0257%	0.172%
United States	0.0541%	0.0373%	0.0168%	0.062%
ROW	0.726%	-0.0882%	0.814%	2.7%

The welfare effects are computed using Equation (8). The result is from comparing the effect at the counter factual with 2000, the benchmark year.

Focusing on China and Nigeria, both countries gain more compared to the case where only China and Nigeria experience tariff changes. Nigeria's aggregate welfare increases by 1.20%. China gains 0.2% in welfare. Real wages increase for both countries. The fourth column in Table 10 shows that the major source of gains for Nigeria and China are increases in the volume of trade. The terms of trade deteriorate for China and contributes -0.53% to the total welfare effects. In Nigeria, the terms of trade improves and contributes positively, 0.15%, to the total welfare effect. The volume of trade effect is also positive in Nigeria, and adds 1.05% to the welfare gain. The welfare gain from volume of trade as a result of trade creation is 0.73% for China.

The welfare gain in India are 1.49%. Thailand gains 0.93% and Indonesia gains 0.2%. Compare to Ianchovina et al. (2003) and Ghosh and Rao (2010), the welfare effect to these Asian countries, particularly India, are positive and large. OECD countries have modest positive gains, Canada gains 0.31% while United States gains 0.05%. Welfare gains are within the context of the literature that have used the CP (2015) trade model.

Studies that have ignored the third country effects like Ianchovina et al. (2003) and Reizman et al. (2016) find most gains accrue to China. Contrary to their results, I found that gain to China is modest while the low income economies, particularly from Sub Sahara Africa, get the most gain. These positive growth in real wages have been tagged "Africa Growth Miracle" by Dani Rodrik (2014). My results suggest that trade openness is a key source of these gains. A framework that ignores the third country effects understates the total effects.[38]

Figure 6 is the plot of growth in imports (in percent), of the country on the row entry from the country on the column entry. The vertical axis represents the importer and the horizontal axis denotes the exporter. From this image, it is clear there are substantial changes in imports for many countries. However, countries with large positive welfare gains have huge growth in imports and sometimes exports. For instance, Cote d'Ivoire and India had a large positive welfare gains. The model indicates Cote d'Ivoire's import from Nigeria rises by 593% while the rest of the world (ROW) imports from Cote d'Ivoire rises by 574%, shown by the yellow colored rectangles in Figure 6. Cote d'Ivoire trades in commodities such as mineral fuels, pharmaceutical products and foods (rice, wheat, cocoa and processed vegetables).

Table 11 shows the effects of global tariff reductions on trade between China, Nigeria, United Kingdom and United States.[39] Global tariffs reduction led to an increase in Nigeria's imports from China by 64%, which is smaller than when only China and Nigeria had tariff

[38] These results are based on a static Ricardian trade model calibration and focus on a short window: 2000 to 2006.

[39] Result in Table 11 is plotted in Figure 6

Table 11: Trade Effects and Import Growth from World Tariff Reduction for Selected Countries

	China	Nigeria	United Kingdom	United States
China's Imports	NaN	-5.62	13%	19.2%
Nigeria's Imports	64%	NaN	4.58%	12.9%
United kingdom's Import	7.85%	-1.08%	NaN	1.27%
United States' Import	21%	3.23%	-1.57%	NaN

Model implied import growth between 2000 and 2006. Result for all 24 countries is plotted in Figure 6.

reductions. The smaller percentage increase in Nigeria's imports can be explained by the presence of partner countries that both China and Nigeria trade with. Nigeria's imports from the United Kingdom and the United States grows by 4.58% and 12.9% respectively. Nigeria imports from Cote d' Ivoire, Korea Rep., Russia and South Africa fell by 33.64%, 10.06%, 32.41% and 3.46% respectively. From these result, we can see that China's accession creates some displacement effects in the third markets and heavily impacts developing economies.

Table 12: Sectoral contribution to welfare(%) from world Tariff Reduction

	China		Nigeria	
Sectors	Terms of Trade	Volume of trade	Terms of Trade	Volume of Trade
Agriculture	2.15%	9.64%	0.379%	5.18%
Mining	3.48%	-0.383%	45.8%	3.54%
Food	3.62%	2.13%	-2.06%	0.2%
Textile	33.7%	22.8%	2.98%	18.8%
Wood	0.929%	1.73%	-0.0382%	0.373%
Paper	0.636%	5.21%	2.64%	3.8%
Petroleum	1.03%	-0.433%	-0.738%	7.41%
Chemicals	0.0291%	10.3%	13.2%	13.3%
Plastic	3.34%	0.804%	1.52%	3.21%
Minerals	1.38%	1.48%	1.73%	5.24%
Basic Metals	2.62%	3.15%	13.1%	28.8%
Machinery	2.51%	12.8%	7.42%	4.76%
OECM	30.7%	22.1%	6.53%	2.88%
Auto	3.29%	7.4%	6.36%	1.21%
Other	10.6%	1.3%	1.1%	1.22%

Sectoral terms of trade an volume of trade is computed from equation in the appendix.Each column sums up to 100%. The table reports only tradable sectors.

In addition to computing the broad welfare effect, I measure the sectoral contribution to

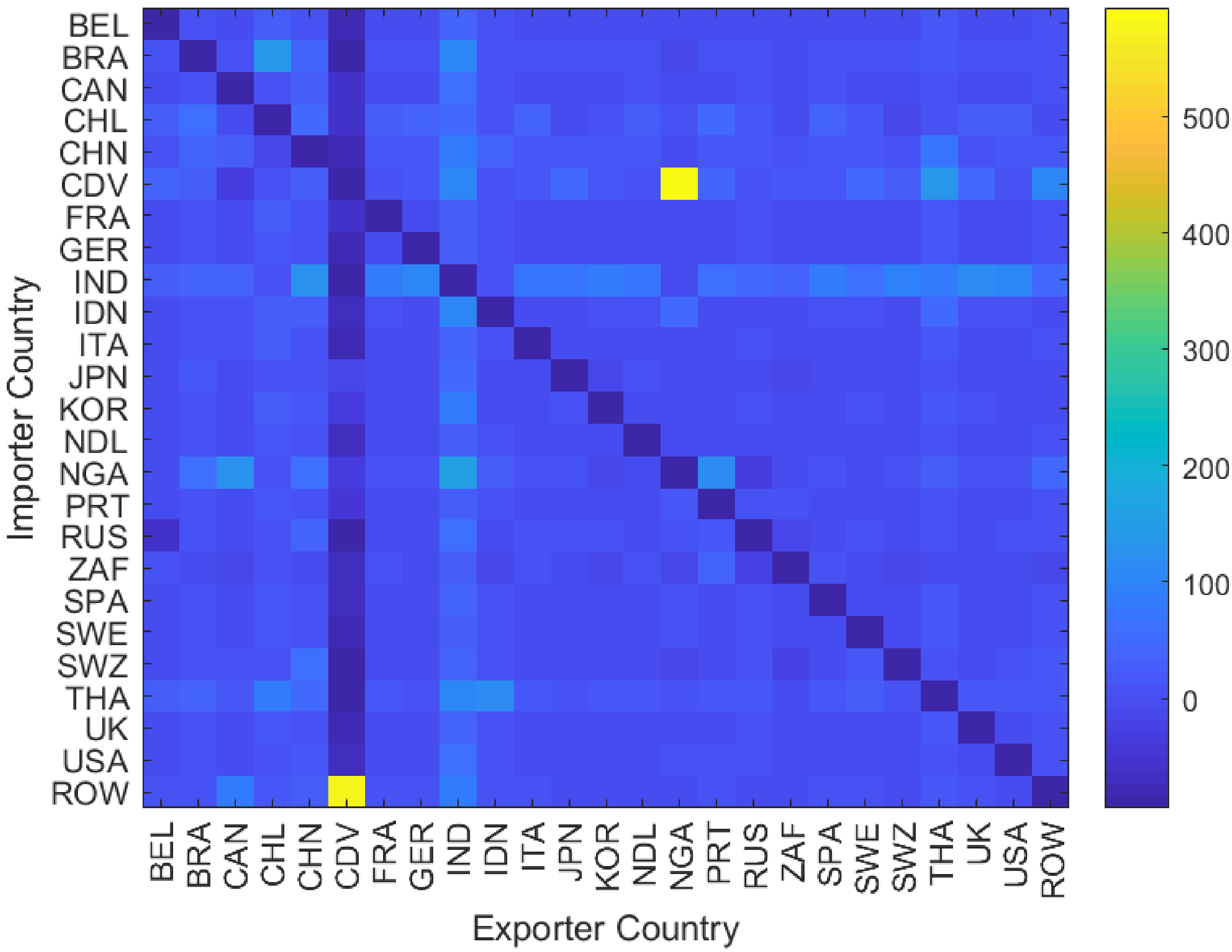


Figure 6: Growth in Import from Model

the aggregate terms of trade and volume of trade effects for Nigeria and China. I report the sectoral contribution in Table 12. The key difference compared to the case with only bilateral tariffs reductions on Nigeria and China is that, for Nigeria, the volume of trade contribution to welfare are positive in all sectors. Textile, chemicals, and basic metals account for 60% of total gain. In China, the volume of trade contributions are also positive for most sectors. Textiles, machinery and OECM account for 65% of China's welfare gain from trade creation. From column 2 and 4 in Table 12, it can be seen that China's terms of trade deterioration are mainly because of lower prices in textiles, OECM and other, which are sectors with large tariff reductions. For Nigeria, mining accounts for 45.8% of Nigeria's terms of trade contributions to total welfare effect.

Table 13 presents the sectoral contributions for United States, Cote d'Ivoire and South Africa. textiles, office and electrical, communication and medical (OECM), auto and other manufacturing products account for most of the terms of trade contributions to the welfare gain. These same sectors contribute 77% to gains from trade creation for the United States. For Cote d'Ivoire, agriculture, food and wood industries accounts for 83% of the terms of trade contribution to the welfare gain. This is consistent with data in that there was positive growth in the prices of primary resource commodities during this period. Mining and minerals account for 93.7% of Cote d'Ivoire gain from trade creation. Many sectors account for terms of trade improvement in South Africa; however, the gain from trade creation comes largely from textile, paper, petroleum and basic metals.

Regarding the sectoral composition of export shares, qualitatively, the result is similar to the bilateral tariffs reductions case. Both China and Nigeria's exports commodities are still concentrated in a few sectors. Still, there is evidence of positive export growth in wood, petro-chemicals and OECM in both countries.

In the Appendix, I explore the effects of changes in the comparative advantage parameter θ^j by using an alternative estimates of the trade elasticity.

7 Conclusion

Chinese accession to the WTO and reduction in bilateral tariffs on member country creates a potential gains from trade. I employed a general equilibrium model to quantify the trade and welfare effects of tariff changes. Model yields a gravity equation that links bilateral trade for all countries in the world to technology, bilateral tariffs and geography. I use data on bilateral trade flows, bilateral tariffs and proxies for geographic barriers to estimate the comparative advantage parameter. Unlike other gravity model literature, I include sample of developing economies in the estimation and also in the calibration.

Table 13: Sectoral contribution to welfare(%) from Global Tariff Reduction

	United States		Cote d'Ivoire		South Africa	
Sectors	ToT	VoT	ToT	VoT	ToT	VoT
Agriculture	-3.8%	-0.558%	47.5%	-7.09%	2.69%	-6.02%
Mining	-19.7%	-0.282%	4.81%	83.7%	8.96%	-14.5%
Food	-2.59%	0.353%	29.3%	0.0156%	5.95%	-56.8%
Textile	31.7%	51.1%	2.44%	1.17%	6.11%	101%
Wood	-0.989%	0.279%	7%	-1.49%	1.06%	21.6%
Paper	-2.63%	0.243%	0.454%	2.41%	2.27%	32.5%
Petroleum	-0.625%	0.941%	2.82%	4.97%	2.76%	55.9%
Chemicals	-2.59%	9.95%	1.72%	1.79%	5.61%	4.46%
Plastic	3.09%	1.03%	1.12%	-0.0812%	1.48%	-11.1%
Minerals	0.26%	0.986%	0.736%	10%	0.554%	29.6%
Basic Metals	1.72%	7.08%	0.872%	0.786%	22.4%	39.7%
Machinery	-0.762%	1.39%	0.216%	0.724%	4.58%	-12.4%
OECM	61.1%	16.7%	0.221%	1.34%	9.37%	-42.7%
Auto	18.8%	2.02%	0.551%	1.67%	21.9%	-85%
Other	17.1%	8.76%	0.183%	0.00776%	4.32%	43.9%

Sectoral terms of trade an volume of trade is computed from equation in the appendix.Each column sums up to 100%. Table reports only tradable sectors.

Many studies on the impact of China paid little attention to china's impact on developing economies. The empirical strategy employed in these studies ignore the impacts on exporting sectors in the third country market. With my model, I capture all the channels through which reduction in tariffs can spread gains across sectors and countries. I show that using a general equilibrium model with sectoral interrelations is quantitatively and economically useful. However, my study does not account for the effects of technological change and capital accumulation which are possible sources of growth. China's investment in Africa's infrastructure has grown substantially in recent years, the impacts of these FDI is outside the scope of my study. My study investigate the impact of China's WTO accession, modelled as tariff reductions. I find that welfare effects is amplified for low income economies, who also suffer some displacement effects in third market. With this results, I hope to show that modelling the bilateral impacts of trade is not enough, even the bilateral outcome depend on the general equilibrium effects.

Appendix

This appendix describes the data sources and data construction I use in the article. The list of countries and the year country joined the WTO is in table A9. My analysis uses data in 2000 and 2006 for the 24 countries plus the rest of the world. The list of sectors is reported in table A1.

A Data Sources and description

Bilateral Trade flows:

I use the bilateral trade flows for the 15 tradable sectors described in table A1 and my sample of 24 countries plus a constructed rest of the world for the year 2000. The bilateral trade flows is from United Nations Statistical Division (UNSD) commodity Trade (COMTRADE) database. Values are reported in US dollars at current prices and include cost, insurance and freight (CIF). Products are defined using the Harmonized system for 1996 (HS1996) at the 6 digit level of aggregation and were mapped to 2-digit ISIC Rev. 3.1 using the World Integrated Trade solution (WITS) concordance table. Import data for each country in our sample is used for the trade elasticity estimation where X_{ni}^{j} is the imports of country n from country i in sector j. Country i's imports from home are gross manufacturing less maufacturing exports. Its total expenditure are home purchase plus imports from everywhere else.

To construct imports from the rest of the world, I use data of each country n in my sample from the world and subtract the total imports of that country n from the rest of the countries in my sample. Similarly , to construct exports to the rest of the world (imports

Table A1: Tradable and non-Tradable Sectors

Serial No	Industry	Product Description	ISIC rev 3
1	Agriculture	Agriculture forestry and fishing	1-5
2	Mining	Mining and quarrying	10-14
3	Food	Food products, beverages and tobacco	15-16
4	Textile	Textiles, textile products, leather and footwear	17 -19
5	Wood	Wood and products of wood and cork	20
6	Paper	Pulp, paper, paper products, printing and publishing	21 -22
7	Petroleum	Coke refined petroleum and nuclear fuel	23
8	Chemicals	Chemicals	24
9	Plastic	Rubber and plastics products	25
10	Minerals	Other nonmetallic mineral products	26
11	Basic metals	Basic metals & Fabricated Metal Products 27-28	
12	Machinery	n.e.c Machinery and equipment n.e.c	29
13	OECM	Office, Electrical, Communication & Medical(OECM)	30-33
14	Auto& Transport	Auto, Motor vehicles trailers and semi-trailers	34-35
15	Other Manufacturing	n.e.c and recycling	36 -37
16	Electricity	Electricity Gas and Water Supply	40 -41
17	Construction	Construction	45
18	Retail	Wholesale and retail trade repairs	50 -52
19	Hotels	Hotels and restaurants	55
20	Transport	Land, Air, Water & Aux transport transport via pipelines	60 - 63
21	Post	Post and telecommunications	64
22	Finance	Financial Intermediation	65 -67
23	Real Estates	Real Estate Activities	70
24	RRCB	Renting & Computer, R& D& Other business (RRCB)	71-74
25	Public	Public admin. and defense compulsory social security	75
26	Education	Education	80
27	Health	Health and social work	85
28	Other services	Other community social and personal services	90 -93
29	Private	Private households with employed persons	95

of the rest of the world), I use data on exports of each country n in my sample to the rest of the world and subtract total exports to the rest of the countries included in our sample from that country n.

From the bilateral trade flow, observations where reporter is the partner are dropped. Matching the products to ISIC rev 3.1 leaves 2475 products unmatched. The downloaded data contains total trade flows across sample countries which I dropped from the data set. Products 999999- Division: 99 - Extra-territorial organizations and bodies (described as: Commodities not specified according to kind) does not concord to iSIC Rev 3.1. There are 1076 products which are not assigned to sectors. I use the products code to concord these products to 'Others' sector classification.

I refer to intermediates goods as categopries UNCTAD-SoP4 and UNCTAD-SoP2 to classify products into capital goods and intermediate goods respectively. Capital goods and intermediate goods are considered intermediate goods. First, I combine the two data set and then merge with the bilateral trade flows data to assign each commodity to a category. The share for these two products represent intermediate share in total imports.

In Table 2, I provide a summary trade matrix across the eight selected countries whose tariffs rate were shown in Table 1. There are two features to note here: (i) Both rich and poor countries display preferences for home goods. Home bias is shown by the large values in the diagonal of table 2 relative to off diagonal. (ii) Systematic correlation between bilateral trade shares and relative level of development is evident with China as outlier. Value in the lower left quadrant representing poor countries purchase of developed countries is larger relative to rich economies' purchase from poor economies display in the upper right quadrant.[40]

Tariffs

Bilateral tariffs data for the years 2000 and 2006 are obtained from the United Nations Statistical Division-Trade Analysis and Information System (UNCTAD-TRAINS). Effective applied rates refer to the actual tariffs applied, taking into account whether there is any trade agreement between the countries. The tariffs measures are tariff lines and are reported in two ways; simple and weighted effective applied rates at HS6 level of aggregation. I use weighted average tariffs in most part of the paper. Bilateral tariff rates at 2 digit ISIC Rev. 3 industries are calculated by using import weighted average tariffs where the weights are the import values at the diaggregated level. A member of the world Trade Organization (WTO) members cannot discriminate between their trading partners; therefore each country grants other members same favorable treatment. Tariff rate vary across bilateral pairs because actual tariffs is based on the value of the goods imported. The tariffs that considers this

[40]Observations have implication for the triple (even double) difference gravity estimation methodology of Caliendo and Parro (2015) particularly in sector like food and agriculture where products are necessity. Observations from trade share matrix in table 1 are documented in the literature. Waugh (2010) find a positive slope (2.4) by regressing relative trade flow (X_{ni}/X_{in}) on relative income (Y_i/Y_n) per worker in 2000

Table A2: 2000 BILATERAL TRADE SHARE (π_{ni}) IN PERCENT FOR SELECTED COUNTRIES

	US	Canada	Japan	UK	Brazil	China	India	Nigeria
US	75.81	4.44	2.92	0.84	0.28	2.08	0.22	0.21
Canada	32.26	49.78	2.36	1.83	0.21	1.60	0.17	0.07
Japan	2.57	0.31	86.46	0.23	0.11	1.98	0.09	.008
UK	5.76	0.81	2.57	53.94	0.25	1.97	0.36	.02
Brazil	3.11	0.26	0.71	0.30	86.67	0.29	0.06	0.18
China	1.19	0.21	2.29	0.20	0.09	87.63	0.08	0.02
India	0.57	0.08	0.46	0.64	0.04	0.31	89.06	0.16
Nigeria	2.26	0.09	0.98	2.58	0.62	0.87	0.68	80.04

Source: Trade data is from UNCOMTRADE and gross output is from OECD, WIOD, INDSTAT2 and EORA-MRIO. Entry in row and column i is the share of total expenditure of country n on i's goods.

rule is the Most Favored Nations (MFN) tariffs. I use both import weighted and simple average in the trade elasticity estimation, however, the import weighted average is used for the counter factuals.

When the tariffs data for year 2000 was missing, I input the value with the closest value available from four previous year. That is from year 1996, 1997, 1998 and 1999. When tariffs data are not available for year 2006, I input the missing tariff with the tariff data from year 2004 and 2005. Cases where there is missing trade and missing tariffs are dropped out of the observations. There are few missing bilateral tariffs at the 2 digit Rev 3 industry. All missing tariffs are dropped out of estimation. In Figures 1-12, I present the effective tariffs that Nigeria, China and the United States imposes on one another. Tariff rates seems to have dropped significantly across bilateral pairs after China's WTO accession in 2001.

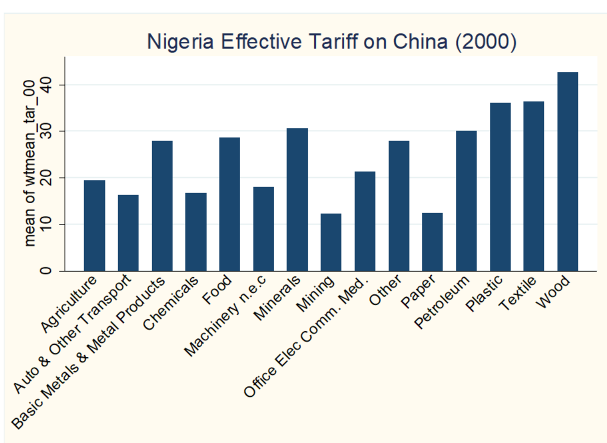


Figure .1: Applied Tariff rates Nigeria on China (2000)

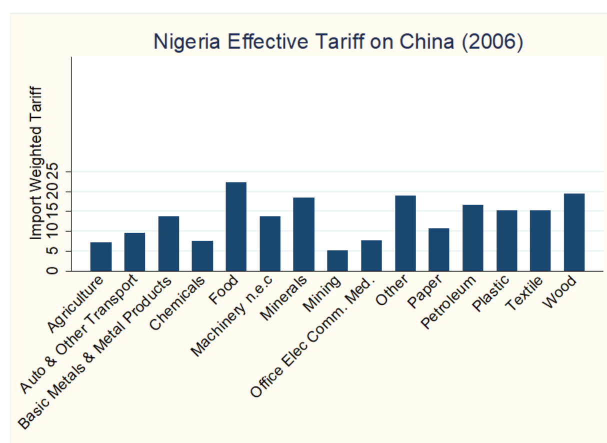


Figure .2: Applied Tariff rates Nigeria on China (2006)

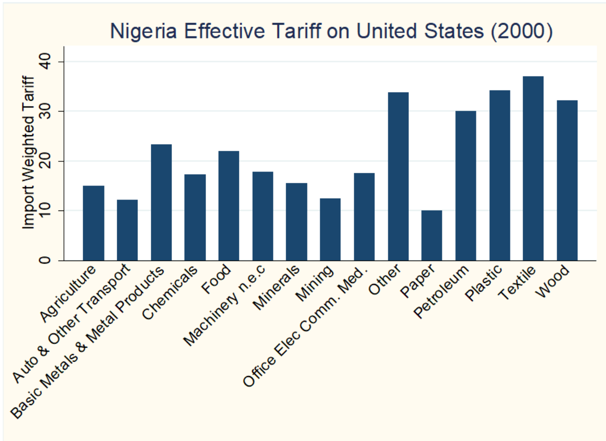


Figure .3: Applied Tariff rates Nigeria on United States (2000)

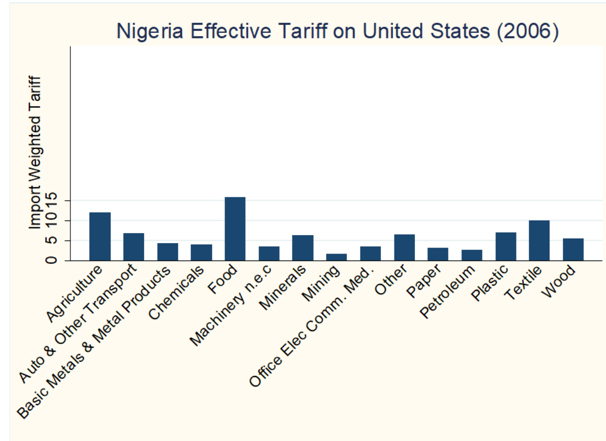


Figure .4: Applied Tariff rates Nigeria on United States (2006)

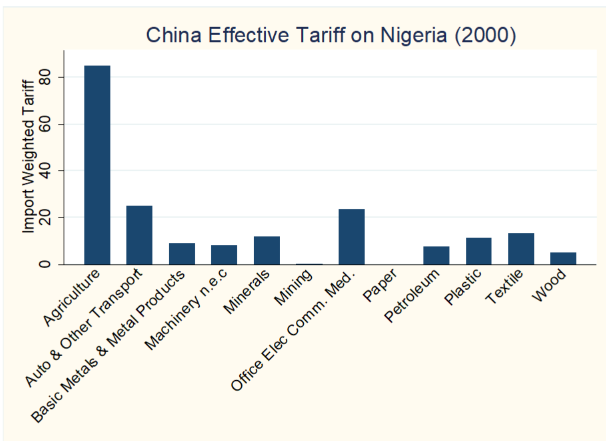


Figure .5: Applied Tariff rates China on Nigeria (2000)

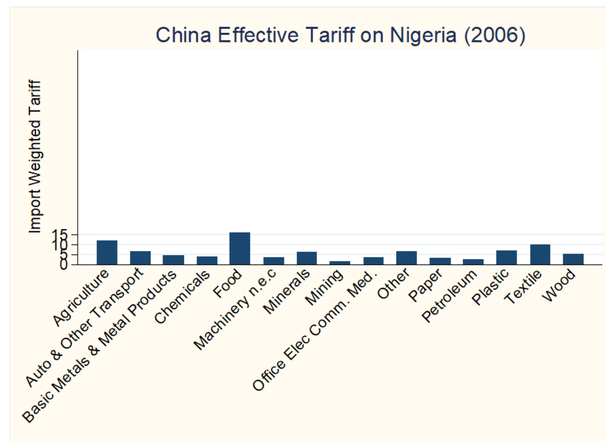


Figure .6: Applied Tariff rates China on Nigeria (2006)

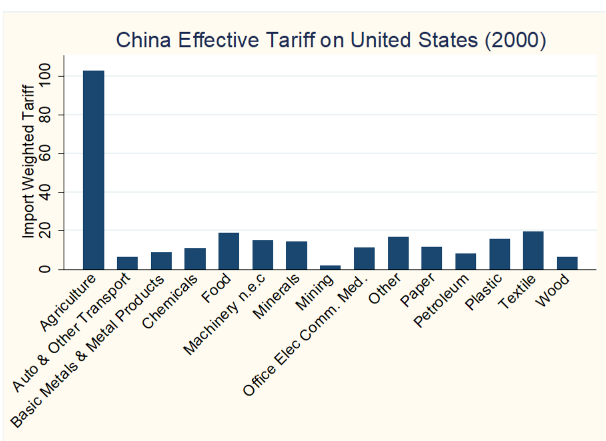


Figure .7: Applied Tariff rates China on United States (2000)

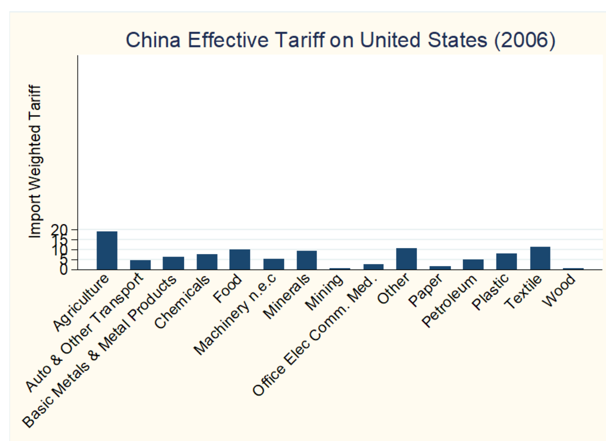


Figure .8: Applied Tariff rates China on United States (2006)

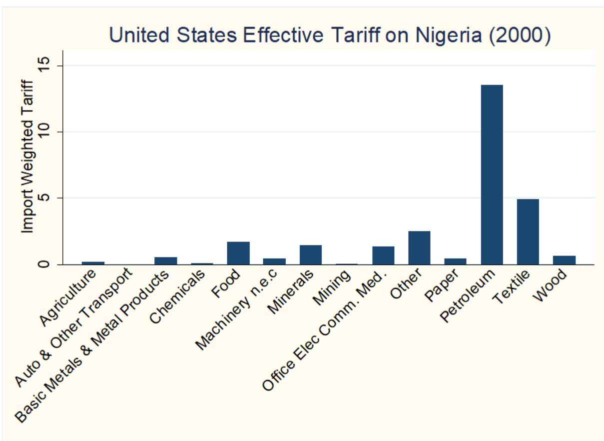


Figure .9: Applied Tariff rates United States on Nigeria (2000)

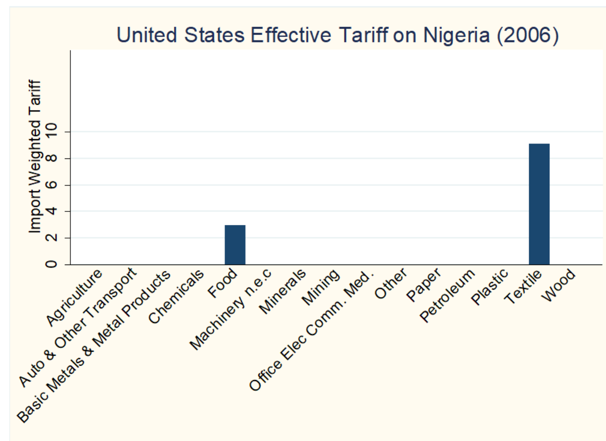


Figure .10: Applied Tariff rates United States on Nigeria (2006)

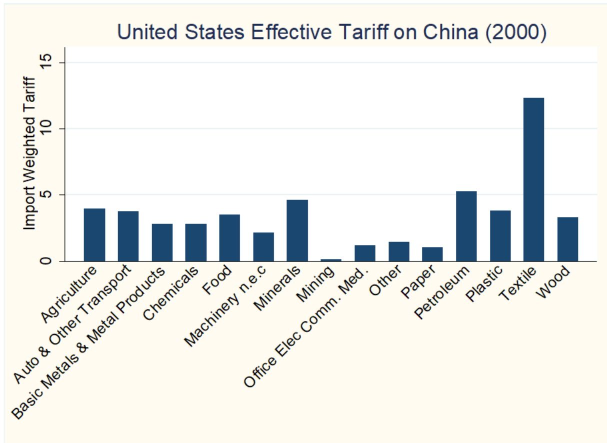


Figure .11: Applied Tariff rates United States on China (2000)

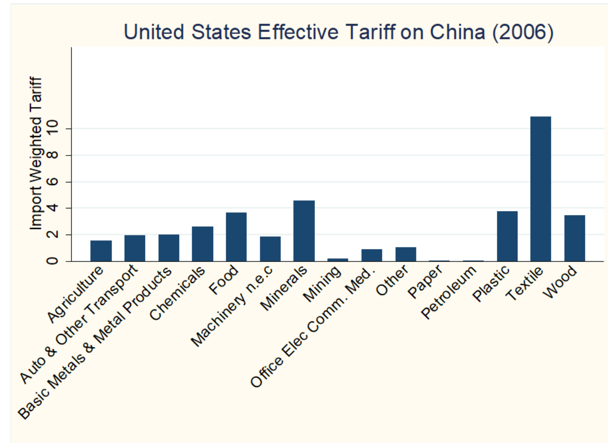


Figure .12: Applied Tariff rates United States on China (2006)

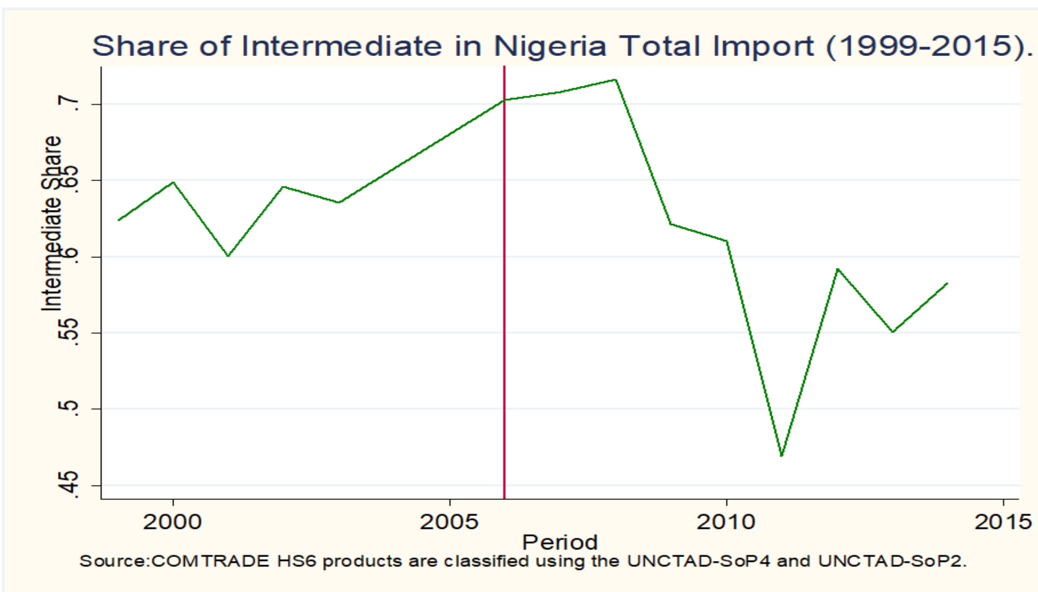


Figure .13: Share of Intermediates in Nigeria's Total Imports from 1999-2015.

In table A3, I summarize the tariff rates across income group for 8 selected countries in 2000. A row denote the importing country and a column represents the exporting country.[41] A key feature stands out:

OBSERVATION 1: *Negative correlation between bilateral tariffs and level of development*- While high income economies impose lower tariffs, emerging economies rely on tariffs as source of revenue. To see this correlation, notice the tariff values in the upper right quadrant (comprising of tariffs rich economies impose on poor economies) are small relative to

[41]The tariffs are calculated as import weighted average bilateral tariffs across all goods aggregated into one sector.

those in the lower left quadrant of table 1 (encompassing the tariffs poor economies impose on rich countries).[42]

Table A3: 2000 BILATERAL TARIFFS (τ_{ni}) IN PERCENT FOR SELECTED COUNTRIES

	US	Canada	Japan	UK	Brazil	China	India	Nigeria
US	0	0.11	1.89	2.01	2.86	4.08	3.64	0.59
Canada	0.52	0	2.51	1.38	2.01	4.70	7.74	0.00
Japan	6.25	15.37	0	2.36	3.33	4.56	1.48	0.00
UK	2.16	2.04	4.05	0	10.99	2.84	5.45	0.06
Brazil	12.89	11.35	15.52	12.79	0	14.73	11.08	3.22
China	17.72	17.62	14.56	11.89	40.01	0	9.03	2.48
India	25.63	16.98	27.91	36.10	37.96	27.49	0	9.84
Nigeria	16.91	15.44	19.50	20.11	16.44	21.53	23.34	0

Source: Author constructed based on UNCOMTRADE database. Entry in row n, column i is the import weighted average tariffs that country n imposes on country i. Diagonal elements are replaced with zero since no country imposes tariff on its own goods

Value added and gross production:

I obtain data on gross output and value added data at the sectoral level for the year 2000 from different sources. First, I collect data from the OECD STAN Rev. 3 database for industrial analysis for OECD countries at the sectoral level, based on ISIC rev 3 at current prices, and in national currency. The OECD database provides I-O tables for 48 countries for the year 2000 and contain information for 37 ISIC Rev. 3 industries. I use OECD STAN exchange rate data to convert values to US dollars. STAN data are expressed in national currency for current price data (PROD, VALU, GFCF, LABR, EXPO etc.) i.e. in Euros for EMU countries ; in terms of the current price value in the reference year (usually 2000) for volume data (PRDK, VALK, GFCK etc.) ; as indices (reference year = 1) for implicit deflators ; in number of persons or jobs for employment data. From the OECD STAN database, I construct sectoral value added, gross output, and input output table for only Switzerland, Chile and Thailand. Secondly, value added and gross output for some other 19 countries are sourced from the World Input Output database (WIOT) for year 2000. WIOT contains IO tables across 35 sectors for 42 countries. Values are in million of dollars at current prices. Gross production includes exports and domestic consumption. Total intermediates consumption includes materials purchased domestically and from other country. The row sum represents the gross output in each sector, while the column sum is the total cost of

[42] This observation has implication for the productivity dispersion parameter. When developing economies are included in the sample, relative trade and tariffs between low income and developed countries are larger and the gravity equation yields a counter intuitive positive slope.

intermediates. Value added is gross output less the cost of intermediates inputs. To get the value added share, I divide the sectoral value added by the sectoral gross output. The IO table of the rest of the world, Nigeria, Cote d'Ivoire and South Africa is the median values of the input output tables for all the 21 countries.

Value added and gross output for Nigeria, Cote d'Ivoire and South Africa are taken from the Industrial Statistics Database INDSTAT2 for 1996 which is the most recent year available. This database contains data at current prices in US dollars for 23 ISIC rev 3 manufacturing sector at 2 digit level of aggregation. These two databases combined to complete all the observation for the gross output and value added for all the sample countries. The sectoral gross output and value added for remaining sectors are from the EORA multi region analysis input output (MRIO) table.

B Sectoral Importer and Exporter's Effects Results

Table A2 reports the estimates of geographic fixed effects for sectoral elasticity estimation. Result is similar to the aggregate fixed effects coefficients. Table A3 and A4 report the exporters' effects for all 24 countries in 15 sectors. The importers effects are reported in tables A5 and A6. Fixed effects coefficients are similar to literature and are within the magnitude of estimated country specific effects.

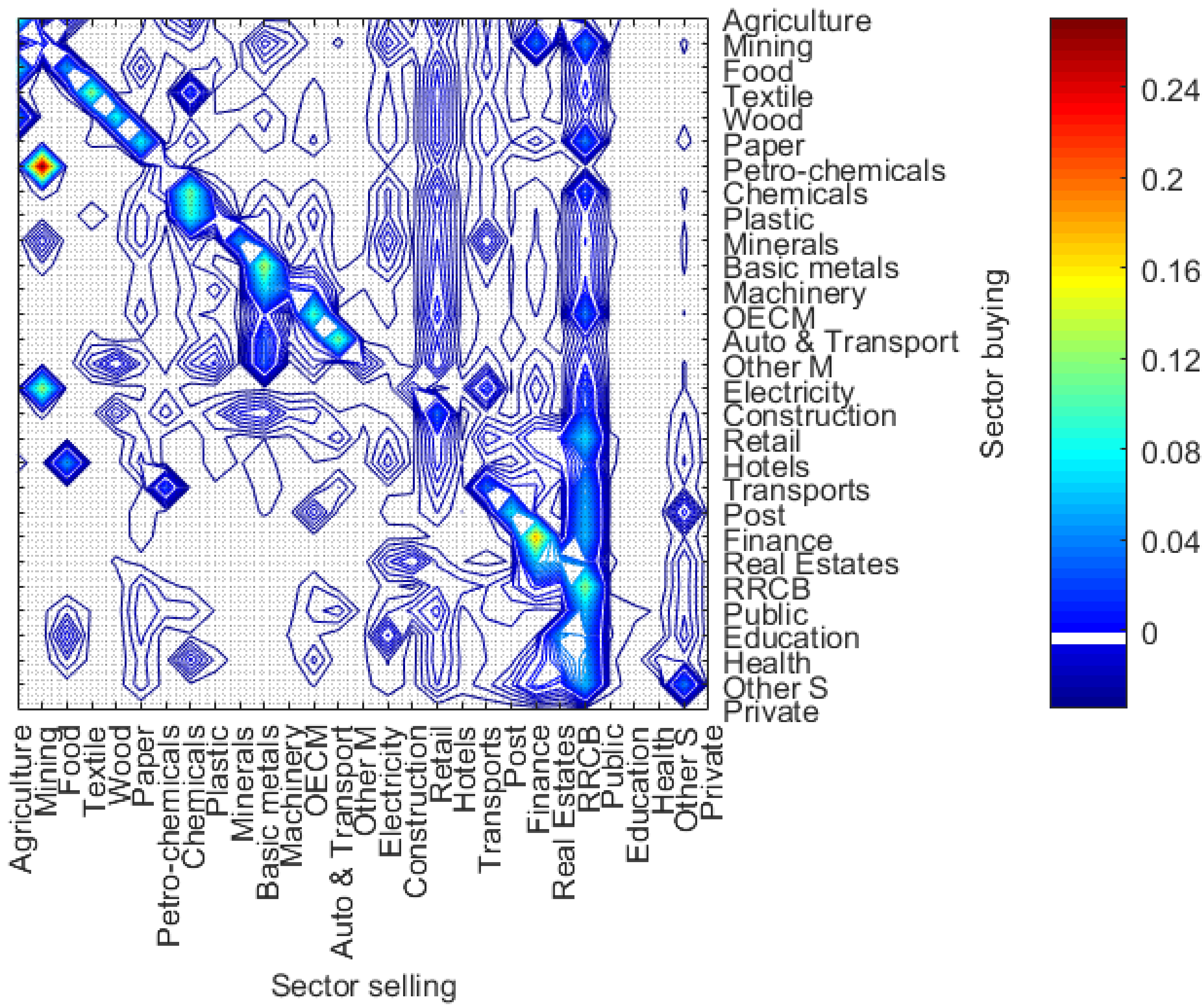


Figure .14: Input-Output Table - United States (ISIC Rev.3)

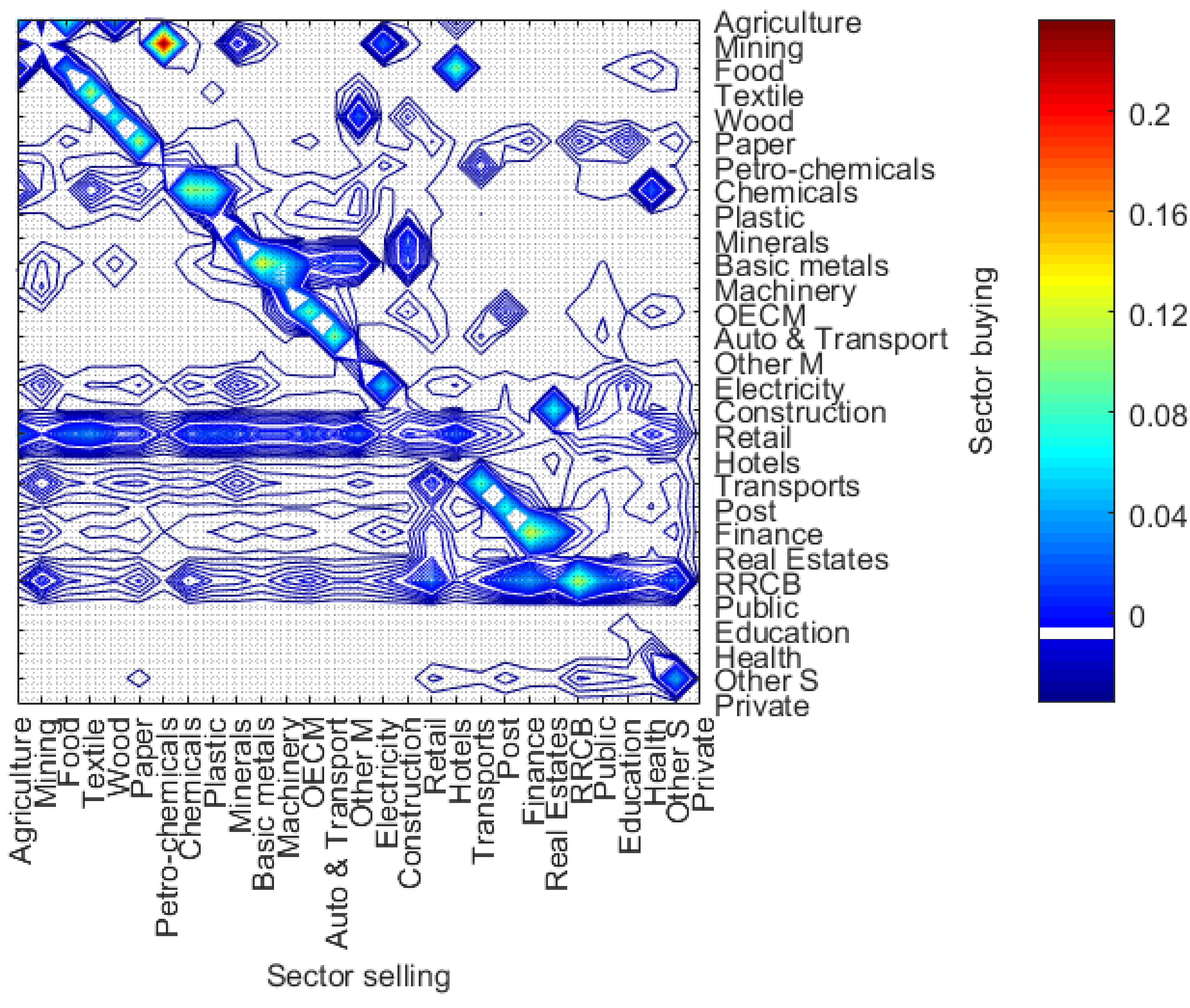


Figure .15: Input-Output Table - " Nigeria" (ISIC Rev.3)

Table A4: Sectoral Distance and Geography Fixed Effects

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Sectors	Agriculture	Mining	Food	Textile	Wood	Paper	Petro-chem	Chemicals	Plastic	Minerals	Basic Metals	Machinery	OECM	Auto	Other
$[0, 375]$	0	-2.33	-3.01	1.08	-0.84	-2.56	-1.27	0	0.59	-1.81	-2.05	0	0	0	
	(0)	(1.89)	(0.93)	(1.34)	(1.03)	(1.05)	(1.88)	(0)	(0.90)	(0.87)	(0.90)	(0)	(0)	(0)	
$[375, 750]$	-6.50	-2.19	-3.70	-0.60	-3.04	-3.93	-2.45	-0.36	-0.83	-3.54	-3.16	-0.64	-4.27	0	-1.17
	(1.68)	(0.85)	(0.48)	(0.53)	(0.55)	(0.55)	(1.03)	(1.04)	(0.47)	(0.46)	(0.47)	(1.09)	(0.56)	(0)	(1.29)
$[750, 1500]$	-2.75	-3.22	-3.78	-0.63	-3.46	-3.57	-2.83	-0.06	-0.69	-3.48	-2.93	-0.48	-4.21	0.29	-1.06
	(1.22)	(0.74)	(0.43)	(0.47)	(0.49)	(0.50)	(0.95)	(1.05)	(0.43)	(0.41)	(0.42)	(1.11)	(0.49)	(0.50)	(1.31)
$[1500, 3000]$	-4.81	-4.14	-3.91	-0.55	-3.58	-3.48	-3.05	-0.29	-0.77	-3.67	-3.16	-0.30	-4.08	0.39	-0.78
	(0.76)	(0.74)	(0.44)	(0.47)	(0.50)	(0.50)	(0.97)	(1.06)	(0.43)	(0.41)	(0.42)	(1.12)	(0.47)	(0.55)	(1.32)
$[3000, 6000]$	-5.78	-5.01	-4.33	-0.90	-3.56	-4.53	-4.14	-0.91	-1.73	-4.21	-3.95	-0.71	-4.30	-0.48	-1.33
	(0.64)	(0.63)	(0.40)	(0.43)	(0.48)	(0.47)	(0.94)	(1.07)	(0.41)	(0.38)	(0.39)	(1.12)	(0.45)	(0.53)	(1.33)
$[6000, max.]$	-7.09	-6.89	-5.69	-2.12	-5.11	-5.76	-7.23	-2.15	-2.58	-5.09	-4.88	-1.72	-5.60	-1.30	-1.96
	(0.59)	(0.66)	(0.38)	(0.41)	(0.43)	(0.44)	(0.85)	(1.07)	(0.38)	(0.36)	(0.36)	(1.12)	(0.46)	(0.51)	(1.32)
Shared border	0.04	0.11	0.40	0.02	0.30	0.24	0.06	0.11	0.10	0.58	0.44	0.09	-0.29	0.55	0.20
	(0.74)	(0.52)	(0.33)	(0.37)	(0.37)	(0.38)	(0.69)	(0.29)	(0.32)	(0.31)	(0.32)	(0.30)	(0.32)	(0.41)	(0.38)
Common curr.	0.35	-0.81	0.04	-0.27	-0.81	0.06	-0.71	-0.49	0.16	-0.47	-0.02	0.00	0.43	1.14	
	(0.34)	(0.49)	(0.31)	(0.35)	(0.35)	(0.35)	(0.65)	(0.27)	(0.30)	(0.29)	(0.30)	(0.29)	(0.31)	(0.42)	
N	347	427	544	514	492	530	411	517	514	526	536	498	449	397	445

Table A5: Secoral exporter's effects Result

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Sectors	Agriculture	Mining	Food	Textile	Wood	Paper	Petro-chem	Chemicals	Plastic	Minerals	Basic Metals	Machinery	OECM	Auto	Other
Brazil	2.84	2.21	1.19	-0.53	1.08	0.68	-2.45	-1.50	-1.57	-0.64	0.22	-1.17	-1.48	0.09	-1.3
	(0.42)	(0.57)	(0.36)	(0.38)	(0.41)	(0.40)	(0.77)	(0.30)	(0.35)	(0.33)	(0.34)	(0.33)	(0.34)	(0.44)	(0.40)
Canada	2.65	2.72	-0.18	-1.31	1.38	2.09	-0.13	-1.37	-0.78	-1.58	-0.23	-0.44	0.37	0.49	-1.09
	(0.42)	(0.57)	(0.35)	(0.38)	(0.41)	(0.41)	(0.75)	(0.30)	(0.35)	(0.33)	(0.34)	(0.33)	(0.34)	(0.44)	(0.41)
Chile	1.40	1.76	-0.54	-4.21	-0.59	0.03	-4.29	-3.23	-6.48	-6.24	-1.02	-5.53	-6.28	-5.52	-5.38
	(0.43)	(0.59)	(0.36)	(0.39)	(0.42)	(0.42)	(1.18)	(0.30)	(0.36)	(0.34)	(0.36)	(0.34)	(0.35)	(0.44)	(0.41)
China	1.84	1.57	0.31	2.95	1.76	0.35	1.12	-0.36	1.34	1.49	1.03	0.74	2.14	-0.03	2.61
	(0.42)	(0.57)	(0.35)	(0.39)	(0.41)	(0.40)	(0.75)	(0.30)	(0.35)	(0.33)	(0.34)	(0.33)	(0.34)	(0.44)	(0.40)
Cote d'Ivoire	0.23	-4.45	-3.51	-6.13	-2.29	-8.33	-5.22	-9.14	-7.77	-9.06	-8.35	-8.51	-8.51	-7.39	-6.40
	(0.42)	(0.87)	(0.37)	(0.44)	(0.45)	(0.51)	(1.12)	(0.33)	(0.43)	(0.41)	(0.38)	(0.37)	(0.38)	(0.56)	(0.44)
France	1.77	-1.15	1.12	0.72	0.89	1.34	1.22	0.66	0.94	1.04	0.80	0.97	1.49	1.81	0.64
	(0.41)	(0.55)	(0.35)	(0.38)	(0.40)	(0.39)	(0.73)	(0.30)	(0.34)	(0.32)	(0.33)	(0.32)	(0.34)	(0.43)	(0.40)
Germany	1.43	-0.01	0.77	0.78	1.84	2.02	0.63	1.10	1.66	1.47	1.55	2.35	2.16	2.75	1.23
	(0.41)	(0.55)	(0.35)	(0.38)	(0.40)	(0.39)	(0.73)	(0.30)	(0.34)	(0.32)	(0.33)	(0.32)	(0.34)	(0.43)	(0.40)
India	1.41	0.17	-0.28	1.35	-1.45	-2.24	-1.92	-1.01	-1.32	-0.73	-0.57	-2.07	-1.48	-1.09	0.10
	(0.42)	(0.56)	(0.35)	(0.38)	(0.41)	(0.40)	(0.80)	(0.30)	(0.35)	(0.33)	(0.34)	(0.33)	(0.34)	(0.44)	(0.40)
Indonesia	1.67	1.58	-0.14	1.01	1.54	0.01	-1.83	-1.93	-1.01	-0.49	-1.82	-3.50	-0.51	-2.20	-0.06
	(0.42)	(0.57)	(0.35)	(0.38)	(0.41)	(0.40)	(0.84)	(0.30)	(0.35)	(0.33)	(0.34)	(0.33)	(0.34)	(0.44)	(0.40)
Italy	0.55	-0.81	0.38	1.82	0.96	0.70	-0.21	-0.21	0.92	1.47	0.51	1.64	0.70	0.65	1.44
	(0.41)	(0.55)	(0.35)	(0.38)	(0.41)	(0.39)	(0.74)	(0.30)	(0.34)	(0.33)	(0.34)	(0.32)	(0.34)	(0.43)	(0.40)
Japan	-0.42	-1.05	-1.48	-0.04	-1.85	0.67	-0.64	0.66	1.89	1.35	1.36	2.09	2.63	3.37	1.30
	(0.42)	(0.57)	(0.35)	(0.38)	(0.41)	(0.40)	(0.75)	(0.30)	(0.35)	(0.33)	(0.34)	(0.33)	(0.34)	(0.44)	(0.41)
N	517	431	543	513	492	528	413	516	504	525	535	490	447	398	443

Table A6: Secoral exporter's effects Result- Continued

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Sectors	Agriculture	Mining	Food	Textile	Wood	Paper	Petro-chem	Chemicals	Plastic	Minerals	Basic Metals	Machinery	OECM	Auto	Other
Korea, Rep	-1.91	-4.31	-1.56	1.42	-2.26	-0.65	-0.50	-0.33	0.87	-0.37	0.42	0.38	1.57	1.27	-0.15
	(0.42)	(0.58)	(0.35)	(0.38)	(0.41)	(0.40)	(0.79)	(0.30)	(0.35)	(0.33)	(0.34)	(0.33)	(0.34)	(0.45)	(0.41)
Netherlands	1.80	-1.05	1.10	-0.46	-0.78	0.61	0.66	0.02	-0.23	-0.62	-0.28	0.04	0.70	0.23	-0.74
	(0.41)	(0.55)	(0.34)	(0.37)	(0.40)	(0.39)	(0.72)	(0.30)	(0.34)	(0.32)	(0.33)	(0.32)	(0.33)	(0.42)	(0.40)
Nigeria	-2.09	3.35	-4.87	-6.17	-4.09	-8.69	-2.93	-8.08	-8.61	-9.85	-8.55	-9.03	-8.75	-6.53	-8.03
	(0.43)	(0.57)	(0.38)	(0.41)	(0.45)	(0.45)	(0.90)	(0.33)	(0.42)	(0.40)	(0.37)	(0.36)	(0.36)	(0.47)	(0.44)
Portugal	-1.93	-3.06	-2.80	-0.71	0.59	-2.03	-4.74	-3.62	-2.69	-1.60	-2.78	-2.79	-2.33	-2.71	-2.96
	(0.42)	(0.56)	(0.35)	(0.38)	(0.41)	(0.40)	(0.82)	(0.30)	(0.35)	(0.33)	(0.34)	(0.32)	(0.34)	(0.43)	(0.41)
Russia	-0.23	1.56	-1.20	-3.37	-0.60	-1.27	0.89	-1.73	-5.12	-3.36	1.01	-3.95	-4.09	-2.46	-3.25
	(0.44)	(0.57)	(0.36)	(0.39)	(0.43)	(0.41)	(0.76)	(0.30)	(0.35)	(0.33)	(0.34)	(0.33)	(0.35)	(0.44)	(0.42)
South Africa	0.99	2.52	-0.78	-1.74	-1.57	-0.54	-0.94	-2.20	-2.54	-2.59	0.58	-2.01	-2.88	-0.84	-2.56
	(0.42)	(0.56)	(0.35)	(0.38)	(0.41)	(0.40)	(0.76)	(0.30)	(0.35)	(0.33)	(0.34)	(0.32)	(0.34)	(0.43)	(0.41)
Spain	1.23	-0.50	0.11	-0.03	0.13	0.06	-0.29	-0.69	0.13	0.81	-0.25	-0.37	-0.41	0.19	-0.25
	(0.42)	(0.55)	(0.35)	(0.37)	(0.40)	(0.39)	(0.73)	(0.30)	(0.34)	(0.33)	(0.34)	(0.32)	(0.33)	(0.43)	(0.40)
Sweden	-2.79	-2.42	-2.08	-2.22	0.55	1.35	-1.19	-1.76	-0.97	-1.69	-0.36	0.18	0.64	0.16	-1.38
	(0.43)	(0.57)	(0.36)	(0.39)	(0.42)	(0.40)	(0.75)	(0.30)	(0.35)	(0.33)	(0.34) (0.33)	(0.34)	(0.44)	(0.41)	
Switzerland	-0.57	-1.20	-0.80	-0.90	-0.78	0.31	-1.70	0.23	-0.19	-0.73	0.34	0.84	0.88	-0.78	-0.05
	(0.42)	(0.55)	(0.35)	(0.38)	(0.41)	(0.40)	(0.74)	(0.30)	(0.35)	(0.33)	(0.34)	(0.32)	(0.34)	(0.42)	(0.40)
Thailand	1.38	-2.06	0.50	0.52	0.22	-1.24	-3.30	-2.19	-0.23	0.10	-1.65	-1.20	0.30	-0.81	0.18
	(0.43)	(0.58)	(0.35)	(0.38)	(0.41)	(0.40)	(0.86)	(0.30)	(0.35)	(0.33)	(0.34)	(0.33)	(0.34)	(0.44)	(0.40)
United kingdom	0.58	1.79	0.81	0.35	-1.03	1.39	0.92	0.31	0.81	0.54	0.83	1.04	1.61	1.77	0.45
	(0.41)	(0.56)	(0.35)	(0.38)	(0.41)	(0.40)	(0.75)	(0.30)	(0.35)	(0.33)	(0.34)	(0.33)	(0.34)	(0.43)	(0.41)
United States	4.42	3.04	2.13	1.46	2.57	3.30	3.49	1.95	2.34	1.72	1.95	2.71	3.49	3.38	2.01
	(0.42)	(0.56)	(0.36)	(0.38)	(0.41)	(0.40)	(0.75)	(0.30)	(0.35)	(0.33)	(0.33)	(0.33)	(0.34)	(0.44)	(0.41)
N	517	431	543	513	492	528	413	516	504	525	535	490	447	398	443

Table A7: Secoral Importer's effects Result

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Sectors	Agriculture	Mining	Food	Textile	Wood	Paper	Petro-chem	Chemicals	Plastic	Minerals	Basic Metals	Machinery	OECM	Auto	Other
Brazil	5.28	3.39	3.63	3.62	3.74	2.01	-2.97	0.03	1.71	-0.29	0.35	0.56	-2.47	4.52	2.88
	(0.03)	(0.06)	(0.00)	(0.04)	(0.06)	(0.07)	(0.02)	(0.79)	(0.15)	(0.0)	(0.12)	(0.88)	(0.02)	(0.20)	(0.98)
Canada	3.74	3.60	0.34	0.72	3.36	3.78	0.49	0.59	2.35	-1.35	0.37	1.49	-2.12	2.86	1.99
	(0.04)	(0.08)	(0.00)	(0.00)	(0.03)	(0.00)	0.03)	0.76)	-0.00)	0.00)	(0.01)	(0.79)	(0.00)	(0.17)	(0.91)
Chile	4.19	2.67	1.63	-1.22	1.33	0.37	-4.23	-2.48	-4.19	-6.24	-1.04	-4.95	-10.83	-5.52	-2.88
	(0.04)	(0.06)	(0.01)	(0.01)	(0.01)	0.02)	-(0.23)	(0.78)	(0.02)	(0.02)	(0.03)	(0.80)	(0.02)	(0.44)	(0.92)
China	5.36	2.66	2.91	7.56	4.05	1.43	2.10	1.78	7.04	3.86	2.74	4.21	2.46	6.30	2.61
	(0.03)	(0.06)	(0.01)	(0.03)	(0.01)	(0.05)	(0.17)	(0.80)	(0.12)	(0.09)	(0.05)	(0.85)	(0.01)	(0.21)	(0.40)
Cote d'Ivoire	0.63	-4.45	-4.03	-1.46	-2.29	-8.69	-5.97	-8.31	-7.77	-6.69	-9.01	-8.51	-11.48	-3.80	-6.40
	(0.59)	(0.87)	(0.00)	(0.06)	(0.45)	(0.09)	(0.27)	(0.73)	(0.43)	(0.06)	(0.03)	(0.37)	(0.03)	(0.05)	(0.44)
France	3.20	-1.57	1.79	2.85	1.86	2.20	2.15	2.59	3.84	1.78	1.71	3.73	0.79	6.34	3.53
	(0.06)	(0.10)	(0.00)	(0.01)	(0.03)	(0.01)	(0.03)	(0.77)	(0.01)	(0.00)	(0.80)	(0.09)	(0.16)	(0.92)	
Germany	2.24	-0.53	1.73	2.66	3.32	3.62	1.76	2.85	4.95	2.55	2.73	5.65	1.45	7.24	4.34
	(0.08)	(0.11)	(0.00)	(0.01)	(0.02)	(0.01)	(0.05)	(0.77)	(0.01)		(0.00)	(0.80)	(0.09)	(0.17)	(0.92)
India	5.65	-0.47	3.03	6.44	0.79	-2.36	-1.55	-1.00	2.68	-1.04	-2.27	-0.19	-2.30	4.28	3.07
	(0.01)	(0.31)	(0.01)	(0.07)	(0.31)	(0.21)	(0.60)	(1.00)	(0.50)	(0.30)	(0.44)	(0.99)	(0.14)	(0.23)	(1.08)
Indonesia	4.46	2.34	2.52	5.72	4.49	-0.09	-0.82	0.14	3.30	0.86	-2.83	-1.64	-0.51	3.68	-0.06
	(0.04)	(0.05)	(0.01)	(0.00)	(0.02)	(0.02)	(0.03)	(0.76)	(0.12)	(0.01)	(0.02)	(0.79)	(0.34)	(0.19)	(0.40)
Italy	1.43	-1.02	1.53	5.20	2.66	2.01	1.16	2.13	4.71	2.96	1.91	4.99	0.51	4.71	5.46
	(0.06)	(0.10)	(0.00)	(0.01)	(0.02)	(0.01)	(0.03)	(0.77)	(0.01)	(0.00)	(0.01)	(0.80)	(0.09)	(0.19)	(0.91)
Japan	0.85	-1.10	-0.25	3.71	0.50	3.37	0.70	4.17	7.52	3.56	4.08	7.44	4.19	9.41	5.03
	(0.01)	(0.08)	(0.01)	0	(0.03)	(0.01)	(0.04)	(0.76)	(0.00)	(0.00)	(0.00)	(0.79)	(0.09)	(0.16)	(0.90)
N	347	431	543	513	492	528	413	516	504	525	535	490	447	398	443

Table A8: Secoral Importer's effects Result- Continued

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Sectors	Agriculture	Mining	Food	Textile	Wood	Paper	Petro-chem	Chemicals	Plastic	Minerals	Basic Metals	Machinery	OECM	Auto	Other
Korea Rep.	0.85	-5.43	-0.48	5.38	-1.57	0.91	0.54	2.23	5.53	0.97	1.12	4.20	1.96	7.54	4.24
	0.09	0.04	(0.00)		(0.00)	(0.00)	(0.01)	(0.04)	(0.77)	(0.02)	(0.02)	(0.01)	(0.80)	(0.03)	(0.15)
Netherlands	1.20	-0.69	0.86	-0.46	-0.63	1.40	-0.4	-1.9	1.40	-0.20	-0.18	2.05	0.70	0.23	2.40
	(0.04)	(0.12)	(0.00)	(0.37)	(0.03)	(0.01)	(0.02)	(0.72)	(0.01)	(0.01)	0	(0.75)	(0.33)	(0.42)	(0.87)
Nigeria	0.64	3.35	-3.90	-0.70	-4.09	-9.36	-2.93	-7.30	-3.94	-12.09	-9.12	-7.68	-9.67	-3.52	-4.53
	(0.05)	(0.57)	(0.03)	(0.14)	(0.45)	(0.05)	(0.90)	(0.81)	(0.31)	(0.13)	(0.20)	(0.84)	(0.06)	(0.16)	(1.02)
Portugal	0.11	-3.25	-1.99	2.50	2.11	0.15	-3.57	-1.72	0.32	0.16	-1.64	0.09	-3.41	-2.71	1.45
	(0.06)	(0.11)	(0.00)	(0.01)	(0.03)	(0.01)	0	(0.77)	0	(0.01)	(0.00)	(0.80)	(0.08)	(0.43)	(0.91)
Russia	2.35	1.56	0.24	0.31	1.57	-0.21	0.89	-0.19	-1.72	-2.52	1.04	-0.74	-4.09	-2.46	1.39
	(0.07)	(0.57)	(0.00)	(0.03)	(0.12)	(0.05)	(0.76)	(0.77)	(0.12)	(0.11)	(0.14)	(0.83)	(0.35)	(0.44)	(0.96)
South Africa	3.14	4.65	0.55	1.82	0.00	0.43	0.78	-0.61	-0.09	-2.65	-0.08	0.06	-4.23	2.56	1.30
	(0.05)	(0.09)	(0.00)	(0.00)	(0.02)	(0.01)	(0.06)	(0.76)	(0.09)	(0.01)	(0.00)	(0.80)	(0.04)	(0.18)	(0.92)
Spain	1.82	-0.93	1.01	3.03	1.54	1.53	0.96	1.24	3.19	2.12	0.94	2.34	-1.48	4.58	3.78
	(0.07)	(0.10)	(0.01)	(0.01)	(0.02)	(0.01)	(0.05)	(0.77)	(0.01)	(0.01)	(0.01)	(0.80)	(0.08)	(0.18)	(0.92)
Sweden	-1.20	-2.32	-1.13	-2.90	3.50	4.36	0.51	0.53	1.59	-0.81	1.09	3.22	-0.62	4.14	1.68
	(0.07)	(0.09)	(0.01)	(0.01)	(0.03)	(0.01)	(0.07)	(0.75)	(0.00)	(0.01)	(0.00)	(0.78)	(0.08)	(0.15)	(0.89)
Switzerland	0.85	-1.20	-0.14	0.37	1.38	0.84	-1.70	1.84	2.15	0.03	-0.90	3.76	0.24	-0.78	0.28
	(0.01)	(0.55)	(0.00)	(0.01)	(0.02)	(0.00)	(0.74)	(0.76)	(0.00)	(0.00)	(0.01)	(0.79)	(0.10)	(0.42)	(0.92)
Thailand	4.47	-1.87	1.40	4.35	1.84	-1.70	-2.25	-2.03	2.53	-0.42	-3.37	1.82	0.30	3.09	3.45
	(0.16)	(0.05)	(0.01)	(0.04)	(0.04)	(0.06)	(0.03)	(0.78)	(0.11)	(0.08)	(0.06)	(0.81)	(0.34)	(0.23)	(0.92)
United Kingdom	1.78	3.46	1.37	2.28	-0.23	2.36	2.40	2.12	3.94	1.20	1.11	3.53	-0.16	4.26	2.90
	(0.08)	(0.09)	(0.00)	(0.01)	(0.03)	(0.00)	(0.04)	(0.75)	(0.01)	(0)	(0.01)	(0.77)	(0.08)	(0.11)	(0.89)
United States	5.57	3.83	3.11	3.40	4.31	5.34	0.63	4.33	5.59	1.94	2.71	5.95	3.10	7.54	4.74
	(0.0)	(0.09)	(0.00)	(0.00)	(0.03)	(0.01)	(0.16)	(0.76)	(0.01)	(0.00)	(0.00)	(0.79)	(0.08)	(0.17)	(0.91)
N	347	431	543	513	492	528	413	516	504	525	535	490	447	398	443

C Caliendo-Parro Estimation Methodology

The trade elasticities (θ^j) are the key parameters for trade policy evaluation exercise because it determines the world trading equilibrium after feeding in tariff changes. As documented by Eaton and Kortum (2002) and Yi, Giri and Yilmazkuday (2016), different estimation methodologies yield varying results even at the sectoral level. To show this, I employ the triple difference Caliendo and Parro (2015) multiplicative gravity method. Estimation requires bilateral tariffs and bilateral trade data. The trade elasticities are related to the dispersion in productivity. I now present the alternative estimates to the one from section 5.1.

A large trade elasticity corresponds to less dispersion in productivity. Tariffs reduction leads to substantial changes in the share of tradable goods however, the gain from trade is small because traded goods are identical. When there is high dispersion in productivity, changes in tariffs translates to small change in the share of traded goods, still the gain from trade is large essentially because goods are more substitutable and producers of the composites differs in productivity.

Table A9: Trade Elasticity Parameter and Implication

Size	Implication	Trade Force(CA)	Welfare Gain
Low (θ)	High Dispersion	Strong	Large
High (θ)	Low Dispersion	Weak	Small

Note: CA means Comparative Advantage.

The Caliendo Parro (2015) triple difference multiplicative gravity method uses the ratio of bilateral trade going in both direction for possible choices of three selected countries. This method cleverly captures unobserved within importers and exporters differences by using the ratios of asymmetric iceberg trade cost and introducing a third country as an identification strategy. The advantage of using this methodology is that all unobservables resistance terms cancel out and I am able to identify the effect of reduction in tariffs on bilateral trade without adding any fixed effects to the model.[43]

Consider three countries indexed by n, i and h. First, I multiply the goods from sector j shipped in one direction between the three countries from n to i, i to h and from h to n. Then the product of the same good shipped in opposite direction from i to n, n to h and h

[43] This gravity equation is similar to the model of Eaton Kortum (2002), Melitz (2003), Krugman (1981) and all the models in Akolakis et al (2012). It is also related to the tetrad method of Head and Ries (2001) with a third country effect. The multiplicative gravity type is similar to a triple difference in differences in which you evaluate the differences in outcomes across individual, group and time. Whereas, the multiplicative type gravity equation consider the difference across bilateral pairs, trade flows: exporter and importer and in relation to the rest of the world.

to i. Finally, I take the ratio of bilateral trade and trade costs terms.[44]

From the expenditure share equation (6), calculating each expression and taking the ratio yields the following estimable equation:

$$\frac{X^j_{ni}X^j_{ih}X^j_{hn}}{X^j_{nh}X^j_{hi}X^j_{in}} = \left(\frac{\kappa^j_{ni}\kappa^j_{ih}\kappa^j_{hn}}{\kappa^j_{nh}\kappa^j_{hi}\kappa^j_{in}}\right)^{-\theta^j} \quad . \tag{11}$$

The prices and parameters cancel out and all that remains is a relation between bilateral trade and trade costs. Trade costs are composed of non symmetric tariffs (τ_{ni}) and non symmetric iceberg costs (d_{ni}) and given as:

$$\ln \kappa^j_{ni} = \ln \tilde{\tau}^j_{ni} + \ln d^j_{ni} \quad .$$

In particular, iceberg trade cost can be generally modeled as a linear functions of cross country characteristics (observed and unobserved differences) and specified as:

$$\ln \kappa^j_{ni} = \ln \tilde{\tau}^j_{ni} + \ln d^j_{ni} = \ln \tilde{\tau}^j_{ni} + \upsilon^j_{ni} + \mu^j_n + \delta^j_i + \varepsilon^j_{ni} \quad , \tag{12}$$

where $\upsilon^j_{ni} = \upsilon^j_{in}$ picks up symmetric bilateral trade costs like language, distance and common border. For instance the distance between Nigeria and Ghana is the same as the distance between Ghana and Nigeria. The parameter μ^j_n captures the importer sectoral fixed effect and it is common to all trading partner of country n. The parameter δ^j_i is an exporter fixed effect and also capture non tariff trade resistance and it is assumed to be common to all trading partner of country i. The ε^j_{ni} is a random disturbance term and does not correlate with tariffs.[45]

Taking the logarithmic ratio by differencing yields:

$$\ln\left(\frac{X^j_{ni}X^j_{ih}X^j_{hn}}{X^j_{nh}X^j_{hi}X^j_{in}}\right) = -\theta^j \ln\left(\frac{\tilde{\tau}^j_{ni}\tilde{\tau}^j_{ih}\tilde{\tau}^j_{hn}}{\tilde{\tau}^j_{nh}\tilde{\tau}^j_{hi}\tilde{\tau}^j_{in}}\right) + \tilde{\varepsilon}^j \quad . \tag{13}$$

[44]The number of cross products term is defined by:

$$\sum_{n=1}^{n-2} n(n+1)/2$$

where N is the number of countries in the sample. For instance, a sample with 16 countries has a maximum of 560 observations.

[45]Bearing the above equation in mind, the RHS terms in equation (17) can be generally written as:

$$\ln\left(\kappa^j_{ni}\kappa^j_{ih}\kappa^j_{hn}\right) = \ln \tilde{\tau}^j_{ni} + \upsilon^j_{ni} + \mu^j_n + \delta^j_i + \varepsilon^j_{ni} + \ln \tilde{\tau}^j_{ih} + \upsilon^j_{ih} + \mu^j_i + \delta^j_h + \varepsilon^j_{ih} + \ln \tilde{\tau}^j_{hn} + \upsilon^j_{hn} + \mu^j_h + \delta^j_n + \varepsilon^j_{hn}$$

$$\ln\left(\kappa^j_{in}\kappa^j_{hi}\kappa^j_{nh}\right) = \ln \tilde{\tau}^j_{in} + \upsilon^j_{in} + \mu^j_i + \delta^j_n + \varepsilon^j_{in} + \ln \tilde{\tau}^j_{hi} + \upsilon^j_{hi} + \mu^j_h + \delta^j_i + \varepsilon^j_{hi} + \ln \tilde{\tau}^j_{nh} + \upsilon^j_{nh} + \mu^j_n + \delta^j_h + \varepsilon^j_{nh}$$

Where $\tilde{\varepsilon}^j = \varepsilon_{in} - \varepsilon_{ni} + \varepsilon_{nh} - \varepsilon_{hn} + \varepsilon_{hi} - \varepsilon_{ih}$. By taking the ratio of the multiplicative term, all the symmetric and asymmetric components of iceberg trade costs cancel out. The term $\kappa^j_{ni}/\kappa^j_{in}$, $\kappa^j_{ih}/\kappa^j_{hi}$ and $\kappa^j_{hn}/\kappa^j_{nh}$ will cancel the symmetric bilateral trade costs (υ^j_{ni} , υ^j_{ih} and υ^j_{hn}). The terms $\kappa^j_{ni}/\kappa^j_{nh}$, $\kappa^j_{ih}/\kappa^j_{in}$ and $\kappa^j_{hn}/\kappa^j_{hi}$ cancels out (μ^j_n , μ^j_i and μ^j_h), the common importers' fixed effects. The terms $\kappa^j_{ni}/\kappa^j_{hi}$, $\kappa^j_{in}/\kappa^j_{hi}$ and $\kappa^j_{nh}/\kappa^j_{ih}$ cancels out (δ^j_i , δ^j_n and δ^j_h), common exporters' fixed effects.

The advantage of using equation (18) is that unobservables components of trade costs is eliminated and concern for measurement error and omitted variable bias is reduced. The only identification restriction is that $\tilde{\varepsilon}^j$ is assumed to be orthogonal to tariffs. I estimate (20) with simple method of moments sector by sector with no constant and robust standard errors.

From ***observation 1*** in section 2, relative trade share is larger for low income relative to rich economies. Similarly in table 1, relative tariffs is larger for developing economies because poor countries rely on tariffs as revenue sources. Taking the ratio of trade and tariffs when countries have differing income generates extreme values, possibly skewing the comparative advantage parameter and yielding estimates with incorrect sign. To correct this, I drop extreme observations within the mahalanobis distance away from the mean using the box plot detection method.

Table 12 presents the (negative of the) estimates of θ^j and heteroskedastic robust standard error using bilateral trade data and weighted average tariffs data in 2000. I include the aggregate elasticity at the bottom of the table. As we can see, the coefficients have the correct sign and the magnitudes of the estimates ranges from 1.03 (Agriculture) to 43.24 (Petro-chemical). Compare to Caliendo and Parro (2015), my coefficients are smaller but larger in auto and other transport sector. There are 16 countries in my sample and each country has an equal weight. [46]

C.1 Estimation of dispersion in productivity with Caliendo Parro Method

To estimate the dispersion of productivity, I collect data on trade flows and effective tariff rates for 16 economies: Brazil, Canada, Chile, China, Côte d'Ivoire, European Union (EU-9)France, Germany, India, Indonesia, Japan, Nigeria, Portugal, Rep. of Korea, Russian Federation, South Africa, Switzerland, Thailand, United Kingdom, United States. Countries are included in the sample provided they have reliable tariffs data and cross trade with many countries. European union composes of the 9 member (Belgium, France, Germany, Italy, Netherlands, Portugal, Spain, Sweden, United Kingdom.) countries in my sample. As

[46] My estimates are in the range of the trade elasticities estimated in the literature.There is a 90% correlation between Caliendo and Parro estimates and mine. The magnitudes of the sectoral trade elasticities are within the range of the coefficients estimated by Caliendo-Parro (2014) for the manufacturing sector as a whole. Their aggregate elasticity was 4.55. Yi (2003) compares several model and find that to match the bilateral trade flows in the data, the Armington type models need a trade elasticity value of 15. This is still a preliminary result. The next iteration controls for outliers in the sectors with negative trade elasticity. All 9 European union countries are represents as one.

Table A10: Trade elasticity estimates with CP methodology

Sector	θ^j	se	N
Agriculture	1.03	(1.77)	309
Mining	9.10	(4.99)	314
Food	2.16	(1.20)	373
Textile	3.64	(1.42)	424
Wood	9.02	(2.42)	376
Paper	3.50	(1.92)	391
Petro-Chemicals	43.24	(6.91)	254
Chemicals	5.08	(2.44)	435
Plastic	1.50	(4.66)	354
Minerals	8.73	(1.88)	385
Basic Metals & Metal Products	8.49	(2.32)	429
Machinery n.e.c	1.73	(3.97)	394
Office Elec Comm. Med.	6.87	(2.89)	443
Auto & Other Transport	7.87	(1.30)	342
Other	7.75	(2.64)	402
Aggregate Elasticity	4.11	(0.51)	5784

Notes: Result is estimated by ordinary least square using 2000 data. Specification is given by equation (20) of the paper. Standard errors are in parenthesis. For agriculture, mining, food, and plastic, I trimmed extreme observations within 0.7, 1, 1 and 1.5 standard deviation above the mean respectively. These outlier ratios are created by trade among countries with differing income for instance Brazil, Canada and United States are outliers in the agriculture sector.

stated in the paper, developing economies are added to capture the role of these countries in current global trade. The sample of countries represented more than 85% of world trade in 2000 and at least 80% in each sector. Bilateral trade data for 2000 are from United Nations commodity trade database (UNCOMTRADE). Values are recorded in US dollars for commodities defined using HS 1996 at six digit aggregation that corresponds to ISIC-rev 3.1 The reporter is the importer and imports are at CIF values. I aggregated trade flow to 15 sectors using the WITS HS-ISIC rev3 concordance. Trade within EU-9 are dropped.

Bilateral tariffs data is from UNCTAD TRAINS for 1996 - 2000. Tariffs represents the effective tariff rate applied by each country. Tariffs are available at HS-1996 product description and reported in percentage. Tariffs data includes both simple and (import share) weighted average value. Result from using both tariffs data are similar. To increase the sample size, when tariffs are missing, I input the values with the closest value available up until four previous years that is 1996. First, I merge the bilateral tariff values with sectoral bilateral trade flow. To get the two digits sectoral bilateral tariffs rate, I use the import weighted average tariffs for each 15 sectors. Missing tariffs with non missing trade are dropped out of estimation and vice versa.

D THE QUANTITATIVE MODEL FOR TRADE POLICY EVALUATION

My model draws closely from Caliendo-Parro model: a quantitative general equilibrium model of Eaton Kortum (2002) with trade in intermediate goods, sectoral interconnections and input-output linkages. This model accounts for the facts that Nigeria relationship with China after she joined the WTO did not only induce a change in trade with China but also impact the rest of the world as shown in the previous section. Also, intermediates is important for this model because, in year 2000, intermediates import constitutes 65% of total import to Nigeria.

The model builds on the Ricardian trade model of Eaton-Kortum (2002). There are N countries and J sectors.[47] I denote the countries by i and n and sectors by j and k. There are two sectors: tradable and non tradable. Labor is the only factor of production. I assume market to be perfectly competitive and labor is mobile across sectors and not mobile across countries.

D.1 Households

In each country, there are a number of L_n representative household that consumes final goods C_n^j and maximizes utility. The preferences of the households are given by:

$$u(C_n) = \prod_{j=1}^{J} C_n^{j\alpha_n^j}, where \sum_{j=1} \alpha_n^j = 1 \tag{14}$$

[47]This are made up of 15 tradable and 14 non tradable sectors.

The household earns income I_n. Income is derived from two sources; wage income from supplying labor L_n and they also receive transfers on a lump sum basis. The transfer amount comes from the tariff revenues and transfers from the rest of the world.

D.2 Intermediate Goods

There is a continuum of intermediate goods $\omega^j \in$ [0,1] produced in each sector j.

The production technology of a good ω^j is a Cobb Douglas production function and given as:

$$q_n^j(\omega^j) = z_n^j(\omega^j)[l_n^j(\omega^j)]^{\gamma_n^j} \prod_{k=1}^{j} [m_n^{kj}(\omega^j)]^{\gamma_n^{kj}} \tag{15}$$

For the production of intermediate goods ω^j, two types of inputs are used, which are : labor (l_n^j) and composite material (m_n^{kj}) also referred to as materials. The parameter $\gamma_n^{j,k} \geq 0$ is the share of materials (output) from sector k used in producing one unit of intermediate good ω^j where by $\sum_{k=1}^{J} \gamma_n^{j,k} = 1 - \gamma_n^j$. $\gamma_n^j \geq 0$ is the share of value added. Both value added shares and intermediate goods shares vary across countries and sectors. [48]

Producers of intermediate goods across countries differ in the efficiency of production. I denote the efficiency in producing intermediate good ω^j in country n as $z_n^j(\ \omega^j)$. Similar to Eaton-Kortum (2002), I assume that the productivity in producing ω^j has a Fr$\acute{e}$chet distribution (also called the Type II extreme value distribution or the inverse Wiebull distribution)

$$F_n^j(z) = \exp(-\lambda_n^j z^{-\theta^j})$$

Where $\lambda_n^j > 0$ and $\theta^j > 1$. λ_n^j is the location parameter and it varies by countries and sectors. A high λ_n^j is a notion of high average productivity and it denotes that a high productivity draw for producing ω^j is likely. A high λ_n^j represents the notion of absolute advantage. The parameter θ^j, which is common to all countries is the shape parameter. A low θ^j implies a higher dispersion in productivity across goods ω^j in sector j and it represents a notion of comparative advantage. A small θ^j means that productivity is dispersed across producers. A change in tariff when λ_n^j is low means that comparative advantage exerts a stronger force and the gain from tariff reduction is large. Whereas, a large $theta^j$ means that trade exerts a weaker force and the gain from tariff reduction is smaller.

Since production of intermediate goods is a Cobb Douglas with constant return to scale and markets are perfectly competitive, firms charge unit price cost $c_n^j/z_n^j(\omega_n^j)$. c_n^j denotes

[48] Borrowing from Caliendo-Parro (2014), I assume a unit elasticity of substitution across materials because value added and I-O shares are fairly constant over time. They used the I-O tables for 1995 and 2005 at the two digit ISIC rev 2 from 26 countries and they found the shares to be constant over time. Their result shows that for all countries, the correlation between input shares was higher than 0.91.

the cost of an input bundle and can be specified as:

$$c_n^j = \Upsilon_n^j w_n^{\gamma_n^j} \prod_{k=1}^{J} P_n^{k\gamma_n^{kj}} \tag{16}$$

where w_n is wages, P_n^k is the price of composite intermediate goods from sector k used in production of ω_n^j and Υ_n^j is a constant. [49]

From equation (2), cost of an input bundle is a function of the labor wage and the price of composite intermediate inputs from other sector k (tradable and non tradables). This captures the key difference compared to the one sector model or the multi-sector without sectoral interrelation. For instance, a change in tariff policy affects the price of a single tradable intermediates which in turn affects the price of all the sectors in the economy through the tradable input bundle embodied in production. This interrelationship across sectors plays a large role in evaluating the trade and welfare gain from Nigeria's trade openness to China.

D.3 Composite Intermediate Goods

Producers of composite intermediate goods in sector j and country n, supply Q_n^j at minimum cost by purchasing intermediate goods ω^j from the lowest cost suppliers around the world. The CES production technology of Q_n^j is a Dixit and stiglitz [50] aggregator specified as:

$$Q_n^j = \left[\int r_n^j(\omega^j)^{\frac{\sigma^j-1}{\sigma^j}} d\omega^j \right]^{\frac{\sigma^j}{(\sigma^j-1)}}$$

where $\sigma^j > 0$ is the elasticity of substitution across intermediate goods available to sector j and $r_n^j(\omega^j)$ is the demand for intermediate goods ω^j from the lowest cost supplier. The solution to the composite producers' problem yields the following demand for good ω^j

$$r_n^j(\omega^j) = \left(\frac{p_n^j(\omega^j)}{P_n^j} \right)^{-\sigma^j} Q_n^j$$

where $p_n^j(\omega^j)$ is the lowest price of intermediate goods ω^j across all countries n and P_n^j is the unit price of composite intermediate goods denoted by:

$$P_n^j = \left[\int p_n^j(\omega^j)^{1-\sigma^j} d\omega^j \right]^{\frac{1}{(1-\sigma^j)}}$$

[49]Specifically

$$\Upsilon_n^j \equiv \prod_{k=1}^{J} (\gamma_n^{k,j})^{-\gamma_n^{k,j}} (\gamma_n^j)^{-\gamma_n^j}$$

[50]This is similar to the Ethier (1982) aggregator

Composite intermediates goods from sector j (Q_j^n) are used as final goods in consumption and materials for production of intermediates good in other sector (ω^k) in the amount of $m_n^{j,k}(\omega^k)$. The market clearing condition for the composite intermediate good in sector j is

$$Q_n^j = C_n^j + \sum_{k=1}^{J} \int m_n^{j,k}(\omega^k) d\omega^k$$

D.4 Trade Cost and Prices

For this study, I assume trade in intermediate goods to be costly. There are two kind of trade costs: iceberg trade costs and an ad-valorem flat-rate tariffs. Iceberg trade costs are defined according to Samuelson (1954). That is, to get one unit of intermediate goods from sector j in country n, requires shipping $d_{ni} \geq 1$ from country i to country n. Also, country n imposes an advalorem tariff (τ_{ni}^j) on goods imported by country n from country i. Effective tariffs can be observed from the data but iceberg trade cost is unobserved. Combining both the iceberg trade cost and the tariffs yields:

$$\kappa_{ni}^j = \tilde{\tau}_{ni}^j d_{ni}^j \tag{17}$$

where $\tilde{\tau}_{ni}^j = (1 + \tau_{ni}^j)$ and the triangular inequality holds $\kappa_{nh}\kappa_{hi} \geq \kappa_{ni}$. Accounting for trade cost raises the unit cost of tradable good ω^j produced in country i and available in country n market at unit prices of $c_i^j \kappa_{ni}^j / z_i^j(\omega^j)$. The price of intermediate good ω^j in country n is given by:

$$p_n^j(\omega^j) = \min_i \left\{ \frac{c_i^j \kappa_{ni}^j}{z_i^j(\omega^j)} \right\}$$

From the above price equation,note that a producer with high efficiency charges lower price and an increase in trade cost κ_{ni}^jb raises the available price of good ω^j in country n while a reduction in trade cost lowers the price in country n. Therefore, producers of intermediate goods buys tradable input from the lowest cost supplier from all over the world. This is a stark difference from the Armington model where goods are purchased from all countries regardless of the prices because of the love of variety and because goods differ by origin.

Non tradable is modelled in the same manner as tradable sectors but $\kappa_{in}^j = \infty$. Therefore non tradable goods are not traded because it is cheaper to buy them domestically. The price in non tradable sector is $p_n^j(\omega^j) = c_i^j / z_i^j(\omega^j)$and the demand for intermediate goods is $r_n^j(\omega^j) = q_n^j(\omega^j)$

Since the producer buys from the lowest cost supplier whose productivity is coming from a Fréchet distribution, the distribution of price is also Fréchet.[51] With these assumption on the distribution of efficiency, the distribution of prices of the composite intermediate goods

[51] In the Armington model the elasticity of substitution σ is the same as the trade elasticity θ^j. Here trade elasticity is measured at both the intensive and extensive margin

is given by

$$P_n^j = A^j \left[\sum_{i=1}^{N} \lambda_i^j (c_i^j \kappa_{ni}^j)^{-\theta^j} \right]^{-\frac{1}{\theta^j}} \tag{18}$$

for all sectors j and countries n. A^j is a constant. A reduction in trade cost results in a drop in the composite intermediate goods. Equation (4) is also the price index for the non tradable goods. Since $\kappa_{in} = \infty$ the price index is specified as $P_n^j = A^j \lambda_n^{j-1/\theta^j} c_n^j$.

Consumer purchase final goods at prices P_n^j and with Cobb-Douglas preferences from equation (1), consumer price index is given by

$$P_n = \prod_{j=1}^{J} (P_n^j / \alpha_n^j)^{\alpha_n^j} \tag{19}$$

D.5 Expenditure Shares and Trade Balance

Country n's expenditure on sector j's goods is given by $X_n^j = P_n^j Q_n^j$. Where X_{ni}^j is expenditure of country n on sector j goods from country i. The expenditure share represents the market share of country i in country n. Since the price has a Fréchet distribution, it follows that the probability that country n buys from i is the expenditure share of country n on sector j goods from country i and it is given by $\pi_{ni}^j = X_{ni}^j / X_n^j$. The expenditure share can be derived as a function of prices, technologies and trade cost.

$$\pi_{ni}^j = \frac{\lambda_i^j [c_i^j \kappa_{ni}^j]^{-\theta^j}}{\sum_{h=1}^{N} \lambda_h^j [c_h^j \kappa_{nh}^j]^{-\theta^j}} \tag{20}$$

The bilateral expenditure share acquires the form of a multi sector gravity equation relating expenditure share to importer and exporter's characteristics. A change in tariff affects the market size of country i through κ_{ni}. For instance, a reduction in the tariff that Nigeria imposes on China increases the market size of country China relative to other countries including Nigeria itself. Therefore, a reduction in tariff on tradable induces Nigeria to buy more from China and less from other countries and even itself. The changes in tariff also have indirect effect on welfare through the input output linkages.

Total expenditures on sector j goods is the sum of the expenditure by the households and composite intermediate goods purchased by firms after deducting the tariffs payment. In particular, total expenditure is specified as

$$X_n^j = \sum_{k=1}^{J} \gamma_n^{j,k} \sum_{i=1}^{N} X_i^k \frac{\pi_{in}^j}{1 + \tau_{in}^j} + \alpha_n^j I_n \tag{21}$$

where

$$I_n = W_n L_n + R_n + D_n \tag{22}$$

I_n is the final absorption in country n and it is the sum of labor income, trade deficits and tariff revenue. R_n are the tariffs revenue from imports represented as $\sum_{j=1}^{j}\sum_{j=1}^{j}\tau_{ni}^{j}M_{ni}^{j}$ and $M_{ni}^{j} = X_n^j\frac{\pi_{ni}^j}{1+\tau_{ni]^j}}$ are country n's import of sector j's goods from country i. Country n's deficits are the sum of sectoral deficit and are given by $D_n^j = \sum_{k=1}^{J} D_n^k$. Sectoral deficits are endogeneously determined and are given as $D_n^j = \sum_{i=1}^{J} M_{ni}^j - \sum_{i=1}^{J} E_{ni}^j$ where E_{ni}^j are country n's exports of sector j goods to country i. Aggregate trade deficits D_n are assumed exogenous in the model while sectoral deficits are endogenously determined.

Using the assumption on trade deficits and the definition of expenditure share, I assume that trade is balance.

$$\sum_{j=1}^{J}\sum_{i=1}^{N} X_n^j \frac{\pi_{ni}^j}{1+\tau_{ni}^j} - D_n = \sum_{j=1}^{J}\sum_{i=1}^{N} X_i^j \frac{\pi_{in}^j}{1+\tau_{in}^j} \tag{23}$$

where by total expenditure excluding tariff payments in country n minus trade deficit equals the sum of other country's total expenditure on country n's goods after deducting tariff payment. The non tradable sector appear on both sides and cancels out.

D.6 Equilibrium in Relative Changes

Definition 1. Given L_n, D_n, λ_n^j and d_{ni}^j, an equilibrium is defined under tariff τ as a wage vector $\mathbf{w} \in \mathbb{R}_{++}$ and prices $\{P_n^j\}_{j=1,n=1}^{J,N}$ that satisfies the condition in equations (3), (5), (7), (8) and (10).

The policy evaluation outcomes is from comparing the equilibrium under policy τ with the equilibrium under policy τ'. Since parameters like productivity λ_n^j and d_{ni}^j are not readily observed in the data, the equilibrium is solved for in relative changes: where by we solve for changes in prices and wages after changing from policy τ (2000 effective tariffs) to policy τ' (2006 effective tariffs).

Solving the model in relative terms comes with benefits. First, the model can be easily matched to data for the base year; secondly, the effect on the equilibrium outcome is driven mainly by changes in tariffs which is my main argument for the changes in welfare; thirdly model can be solved without estimating productivity λ_n^j and bilateral resistance (iceberg trade costs $d_n i^j$). Below, I define the equilibrium of the model under policy τ' relative to a policy under tariff structure τ. [52]

Definition 2. Let ($\mathbf{w}$,p) be an equilibrium under τ and ($\mathbf{w}'$,$\mathbf{P}'$) be an equilibrium under τ'. Define ($\hat{w'}$,$\hat{P'}$) as an equilibrium under τ' relative to τ where a variable with a hat "$\hat{x}$" represents the relative change in the variable and generally given as $\hat{x} = x'/x$. Using equations (3), (5), (7), (8) and (10), the equilibrium conditions in relative changes is: Cost of Input bundles:

$$\hat{c_n^j} = \hat{w_n^{\gamma_n^j}} \prod_{k=1}^{J} \hat{P_n^k}^{\gamma_n^{k,j}} \tag{24}$$

[52] The idea of solving in relative changes follows Dekle et al. (2008)

Price Index:

$$\hat{P}_n^j = A^j \left[\sum_{i=1}^{N} \gamma_i^j (\hat{c}_i^j \hat{\kappa}_{ni}^j)^{-\theta^j} \right]^{-\frac{1}{\theta^j}} \tag{25}$$

Bilateral Trade Shares:

$$\hat{\pi}_{ni}^j = \left[\frac{\hat{c}_i^j \hat{\kappa}_{ni}^j}{\hat{P}_n^j} \right]^{-\theta^j} \tag{26}$$

Total Expenditure in each country n and sector j:

$$X_n^{j\prime} = \sum_{k=1}^{J} \gamma_n^{j,k} \sum_{i=1}^{N} X_i^{k\prime} \frac{\pi_{in}^{k\prime}}{1 + \tau_{in}^{k\prime}} + \alpha_n^j I_n^\prime \tag{27}$$

Trade Balance:

$$\sum_{j=1}^{J} \sum_{i=1}^{N} X_n^j \frac{{\pi^{j}}'_{ni}}{1 + {\tau^{j}}'_{ni}} - D_n = \sum_{j=1}^{J} \sum_{i=1}^{N} X_i^{j\prime} \frac{{\pi^{j}}'_{in}}{1 + {\tau^{j}}'_{in}} \tag{28}$$

where $\kappa_{ni}^j = (1+^{j'}_{ni})/(1+^{j}_{ni})$ and $I_n^\prime = \widehat{w_n} w_n L_n + \sum_{j=1}^{J} \sum_{i=1}^{N}$
$uptau_{ni}$ Looking at the equilibrium conditions in equations (11)to (15), one can see that a reduction in trade yields a negative change in unit cost of intermediates bundles, $\hat{c}_n^j$, a negative change in price index $\hat{P}_n^j$, a positive change in trade shares for country i and a positive change in total expenditure of country n on goods from country i.Focusing on the relative change allows us to perform counter factual without relying on the estimates of total factor productivity or transportation costs of goods. The data needed to quantify the effect of China joining the WTO are two sets of tariffs (τ and τ'), data on bilateral trade shares (π_{ni}^j), value added ($w_n L_n$), share of intermediate consumption ($\gamma_n^{k,j}$) and sectoral dispersion of productivity (θ^j) otherwise called trade elasticity. The estimation method for the trade elasticity (θ^j) and result is shown in section 4.

D.7 Relative Changes in real wages

Labor supply and population is held fixed throughout, therefore no need to distinguish beween GDP and GDP per worker. Welfare changes is measured as a weighted average of changes in real wages and tariff revenue. Given the micro approach of measuring changes in welfare, this section account for changes in real wages by capturing the welfare effect of prices on final goods and intermediates usage effects through multiple sector and sectoral linkages. Using equation (10)- changes in the cost of input bundles and equation (12)- the changes in bilateral shares one can solve for the counter factual changes in real wages $\hat{w}_n / \hat{P}_n^j$ in each sector j weighted by the consumption expenditure share on domestic goods and sectoral prices.[53]. This is then aggregated across sectors using consumption expenditure share as weight and by taking the logarithm, the changes in real wages can be expressed as:

To put an intuition to the final goods effect on changes in real wages, consider the case where $\gamma_n^j = 1$ for all j and n. This means that intermediate goods are produced with only labor input and they are used to produce only final goods. For this case, $\ln \hat{w}_n/\hat{P}_n^j$ = -(α_n^j/θ^j) $\ln \hat{\pi}_{nn}^j$.[54]. Aggregating across all sectors yields $\sum_{j=1}^J -(\alpha_n^j/\theta^j) \ln \hat{\pi}_{nn}^j$ which is the total effect from trade in final goods on aggregate change in real wages. The effect depends on the share of domestic spending on own goods π_{nn}^j and the ratio of expenditure share to trade cost elasticity (α_n^j/θ^j).

If θ^j is small-implying a large dispersion in productivity. A reduction in trade cost makes producers to buy more inexpensive imported inputs relative to domestically produced intermediates which means $\hat{\pi}_{nn}^j$ drops. The more negatively correlated is (α_n^j/θ^j) and $\ln \hat{\pi}_{nn}^j$, the larger the gain in real wage from a reduction in trade cost on final goods. Although, final good is non tradable but uses inexpensive tradable input bundles hence the gain from final goods consumption.

Looking at the model where $\gamma_n^j \neq 1$ and $\gamma_n^{j,j}$ = 1-γ_n^j for all j and n. For this case, there are no sectoral linkages since intermedate goods are produced with labor and intermediates input from the same sector. A drop in trade cost translates to a lower price of tradable intermediates goods. The lower unit price of tradable inputs lowers the price of composite intermediate good. This results in large gain to producers of intermediates due to a drop in the composite price. This effect is captured by the intermediate section of the changes in real wages.

Finally, consider the sectoral linkages effect. The material price index account for the changes in the trade cost's effect on the price of the composite intermediates from sector k on real wage in sector j. A drop in trade cost on the goods from sector k which constitutes a large share of sector j inputs yields an additional gain to sector j. The larger the share of material from sector k (whose price has dropped) used in the production in sector j the larger is the gain in welfare. The contribution of sectoral linkages to aggregate real wage is given by $-\sum_{j=1}^J \frac{\alpha_n^j}{\gamma_n^j} \ln \prod_{k=1}^J \left(\frac{\hat{P}_n^k}{\hat{P}_n^j}\right)^{\gamma_n^{k,j}}$.

D.8 Welfare Effects from tariff Changes

In this subsection, I decompose the welfare effects from changes in tariffs into term of trade (TOT) and volume of trade (VOT). This decomposition is used in the quantitative section to analyze the welfare effects of China-Nigeria tariff changes. This decomposition yields an

[53]Based on Arkolakis et al (2012), changes in each components of the consumer price index can be inferred from changes in relative prices. Secondly, changes in relative prices can be aggregated into changes in domestic share of expenditure and thirdly, small changes in expenditure share can be integrated into larger ones (because trade elasticity is constant across all equilibria)

[54]Here, I add the share of expenditure on sector j goods (α_n^j)

intuitive analysis of the effects of tariff changes across different countries and sectors. The welfare of a representative consumer in country n is denoted by Wn= In/Pn where In is from equation (8) and P_n is from equation (5). Totalling differentiating W_n and after using the equilibrium conditions of the model, the change in welfare is given by

$$d\ \ln W_n = \frac{1}{I_n}\sum_{j=1}^{J}\sum_{i=1}^{N}\underbrace{\left(E_{ni}^{j} d\ln c_n^j - M_{ni}^{j} d\ln c_i^j\right)}_{\text{Terms of Trade}} + \frac{1}{I_n}\sum_{j=1}^{J}\sum_{i=1}^{N}\underbrace{\tau_{ni}^{j} M_{ni}^{j}\left(d\ln M_{ni}^{j} - d\ln c_i^j\right)}_{\text{Volume of Trade}} \quad (29)$$

The change in welfare due to term of trade effects from tariff changes measures the gains from an increase in export prices relative to the change in importer's prices at the world prices. This term of trade measure is a multi lateral weighted change in exports and export prices at the sectoral and the weights are given by bilateral exports and imports respectively.The impacts of each sectors depends on sectoral deficit (the difference between export E_{ni}^{j} and M_{ni}^{j}) and also sectoral changes in importer and exporter prices.

This is the key difference from term of trade measurement in a one sector quantification. Without sectoral linkages and intermediate input, sectoral variation do not play any role in influencing aggregate terms of trade. To see this, consider a ,model where γ_n^j =1 for all j and n. Then, goods are produced with only labor and intermediate goods are not used in production. Input cost do not vary by sector since $c_n^j = w_n^j$ and aggregate term of trade is given by where M_{ni} are total imports by country n from i. Hence, conditional on changes in wages and aggregate trade, a one sector model yields the same term of trade as a multi sector model.

The volume of trade term in equation 17 measures the welfare gains from changes in the volume of trade as a consequence of the change in tariffs. If more trade is created, then the volume of trade surges. The volume of trade is measured by import values after deflating import prices. The initial tariffs and import volume are used to weigh the importance of this effects for all countries and sectors.

from equation (16), bilateral and sectoral measures of terms of trade and volume of trade between countries n and i can be specifically given by

$$d\ \ln tot_{ni} = \sum_{j=1}^{J}(E_{ni}^{j} d\ \ln c_n^j - M_{ni}^{j} d\ \ln c_i^j) \quad (30)$$

Also the change in the bilateral volume of trade is given by

$$d\ \ln vot_{ni} = \sum_{j=1}^{J}\tau_{ni}^{j} M_{ni}^{j}(d\ \ln M_{ni}^{j} - M_{ni}^{j} d\ \ln c_i^j) \quad (31)$$

Similarly, the change in sectoral terms of trade is given by

$$d \ \ln tot_n^j = \sum_{i=1}^{N} (E_{ni}^j d \ \ln c_n^j - M_{ni}^j d \ \ln c_i^j) \tag{32}$$

While the change in sectoral volume of trade is specified as

$$d \ \ln vot_n^j = \sum_{i=1}^{N} \tau_{ni}^j M_{ni}^j (d \ \ln M_{ni}^j - M_{ni}^j d \ \ln c_i^j) \tag{33}$$

Table A11: Year Countries became a Member

Country	Year
Belgium	1995
Brazil	1995
Canada	1995
Chile	1995
China	2001
Cote d'Ivoire	1995
France	1995
Germany	1995
India	1995
Indonesia	1995
Italy	1995
Japan	1995
Netherlands	1995
Nigeria	1995
Portugal	1995
Rep. of Korea	1995
Russian Federation	2012
South Africa	1995
Spain	1995
Sweden	1995
Switzerland	1995
Thailand	1995
United Kingdom	1995
USA	1995

E Calibration result using alternative θ estimates

In this section, I report the result from using an alternative comparative advantage parameter. I calibrate the model with simple mean (τ_{ni}) trade elasticity estimates reported in sub-column 2 of Table 3. Similar to previous scenarios, first I allow for tariff changes on Nigeria and China only while fixing the tariffs on remaining country in the sample to 2000. With China-Nigeria tariff reductions only, there is no significant effect on other countries while Nigeria gains 0.24% and contrary to previous result when I use the weighted average tariffs, China gains 0.03%. Gains to both countries are larger compare to using θ^j estimated from weighted average tariffs. Cote d'Ivoire, India and South Africa gain 0.18%, 0.08%, and 0.06% respectively. From the real wage Equation (7), welfare depends on domestic purchase of own goods $\hat{\pi}^j_{nn}$, relative prices, consumption expenditure share α^j_n and trade elasticity parameter θ^j. A negative $\hat{\pi}^j_{nn}$ linearly raises welfare however, real wages responds to comparative advantage term θ^j non monotonically. Result also shows that trade creation accounts for most of the gains.[55]

Table 18 presents the trade effects generated by tariff reduction on Nigeria and China only. Tariff reductions promote trade between the two countries. Nigeria's imports from China increased by more than 420% while China's import rises by only 12.63%. These figures shows how Nigeria adopted China as main trade partner after her ascension to the WTO. Nigeria sources for more goods from China whereas China purchases more goods from the rest of the world.

Table A12: Trade Effects from Tariff Reduction on China and Nigeria (simple average θ estimate)

	China	Nigeria
China's Imports		12.63%
Nigeria's Imports	420%	

Notes: Table shows the model implied change in imports from Nigeria and China bilateral tariff reduction only . I use θ estimates with simple average tariffs.

For the second experiment, I feed in global tariff reduction while using the simple average comparative advantage θ estimates. Table 19 reports the welfare effect. Beside United States and Russia, all countries gains positively from global tariff reduction and gain is larger for some countries compare to the weighted average θ estimate. Using different θ estimates yield differential results. Cote d'Ivoire, the smallest country in my sample, is still the largest winner from global tariff reduction while Russia and the United States had a welfare loss of 0.14% each. Most of the gains to Cote d'Ivoire results from improvements in term of trade. China gains 0.72% while Nigeria gains 2.44%. India gains 4.22% and Thailand has a positive gain of 2.11%. Compare to result from using weighted average θ^j estimate, magnitude differs across countries: some countries had a larger effects, while the effects is smaller for others. Among African economies, South Africa had the lowest gain of about 0.20%.

To see how the model performs compare to the data, I present the data (Table 20) and the

[55] The rest of the results are included in the 'additional Result from using alternative θ Estimates' in appendix

Table A13: Welfare Effects from global Tariff Reductions(simple average θ estimates)

Country	Welfare Effect	Term of trade	Volume of trade	Real Wage
Belgium	0.162%	0.113%	0.0494%	0.27%
Brazil	0.127%	-0.181%	0.308%	0.226%
Canada	5.64%	5.38%	0.266%	6.97%
Chile	0.59%	-0.209%	0.799%	1.54%
China	0.717%	-0.484%	1.2%	0.973%
Cote dIvoire	14.3%	11.3%	3%	15.2%
France	0.0503%	0.0237%	0.0266%	0.0779%
Germany	0.158%	0.114%	0.0443%	0.178%
India	4.2%	-0.486%	4.68%	1.76%
Indonesia	0.373%	0.014%	0.359%	0.609%
Italy	0.091%	0.0525%	0.0385%	0.117%
Japan	0.0106%	-0.00247%	0.0131%	0.0428%
Korea, Rep.	0.105%	-0.00513%	0.11%	0.234%
Netherlands	0.254%	0.193%	0.0612%	0.302%
Nigeria	2.44%	0.0885%	2.35%	2.48%
Portugal	0.0996%	0.0744%	0.0252%	0.116%
Russia	-0.141%	-0.308%	0.167%	0.0656%
South Africa	0.198%	0.127%	0.071%	0.337%
Spain	0.0556%	0.0315%	0.0241%	0.0735%
Sweden	0.202%	0.145%	0.057%	0.235%
Switzerland	1.49%	0.178%	1.31%	0.404%
Thailand	2.11%	-0.642%	2.75%	2.84%
United Kingdom	0.126%	0.0917%	0.0338%	0.176%
United States	-0.137%	-0.181%	0.0437%	-0.00684%
ROW	9.32%	-0.481%	9.8%	3.13%

Notes: Table shows the welfare effects from global tariff reduction. I use θ estimates with simple average tariffs.

model implied growth (Table 21) in imports for China and Nigeria. From Table 20, observed China's import from Nigeria falls by about 74.29% while the model captures one-third of these effect. In table 21, model simulates a 21.9% drop in imports from China. Nigeria's import from China rises by 217.67% and the model capture most of these effects, in that model implied growth in Nigeria's import from China is 153%.

Table A14: Import growth from Data

	China	Nigeria
China's Imports	NaN	-74.29%
Nigeria's Imports	217.67%	NaN

Notes: Table shows the growth in imports from data between 2000 and 2006 using the COMTRADE database. Reporter is the importer and values are in dollars.

Table A15: Import growth from model (simple average θ estimate)

	China	Nigeria
China's Imports	NaN	-21.9%
Nigeria's Imports	153%	NaN

Notes: Table shows the model implied change in imports from Nigeria and China given global tariff reductions. I use θ estimates with simple average tariffs.

Sectoral specialization of export shares is qualitatively similar to previous results. Table 22 reports export for China and Nigeria between 2000 and 2006. Although modest, Nigeria sectoral composition of exports changed after Chinese ascension in that export of wood, minerals and basic metals rose after 2000. Normalized Herfindahl Index (HHI) dropped significantly for China from 0.165 to 0.162, indicating a substantial change in sectoral composition of China's exports.

F Additional Results

Additional Result from using alternative θ Estimates

Nigeria-China bilateral tariff reduction also had implication for sectoral specialization. Table 19 presents the exports share by industry before and after reducing bilateral tariffs between Nigeria and China. Note that the sectoral concentration varies across sectors and countries. For China, textile, OECM and other manufacturing accounts for more than 68% of exports. For the case of Nigeria, agriculture and mining accounts for 97% of total exports which shows Nigeria has the highest degree of sectoral specialization while China is more diversified. To show this, I report the normalized Herfindahl index (HHI) in the last row. The drops in Chinese HHI from 0.165 to 0.161 shows that China is more diversified after tariff reduction on both, while Nigeria' export concentrates in few sectors.

Table A16: Export shares by sector before and after world tariff reductions

	China		Nigeria	
Sectors	Before	After	Before	After
Agriculture	2.23%	2.22%	1.26%	1.26%
Mining	2.04%	2.03%	96.2%	96.2%
Food	3.86%	3.83%	0.973%	0.962%
Textile	28.8%	28.5%	0.582%	0.58%
Wood	0.992%	0.989%	0.233%	0.254%
Paper	1.03%	1.02%	0.0315%	0.0313%
Petro-chemical	0.889%	1.4%	0.26%	0.266%
Chemicals	4.31%	4.29%	0.163%	0.162%
Plastic	2.28%	2.34%	0.00239%	0.00239%
Minerals	1.27%	1.31%	0.0134%	0.0136%
Basic Metals	4.39%	4.45%	0.00878%	0.00883%
Machinery	3.58%	3.6%	0.0185%	0.0187%
OECM	29.8%	29.6%	0.0488%	0.0494%
Auto	3.37%	3.34%	0.163%	0.163%
Other	11.1%	11%	0.00498%	0.00501%
Normalized HHI	0.165	0.162	0.924	0.924

Notes: Table shows the welfare effects from world tariff reduction for Nigeria and China be fore (2000) and after (2006)Chinese ascension. Export shares in 2000 is calibrated to match the data while the share of exports in 2006 is from model result. I use θ estimates with simple average tariffs.

Table A17: Welfare Effects of China's Entry and Tariff reductions One sector

Country (2000)	Welfare Gain	VoT Effect	ToT Effect
Belgium	0.61%	0.04%	0.57%
Brazil	0.067%	0.10%	-0.03%
Canada	0.09%	0.01%	0.08%
Chile	0.18%	0.25%	-0.07%
China	0.03%	0.4%	-0.36%
Côte d'Ivoire	0.53%	-0.07%	0.60%
France	0.18%	0.02%	0.16%
Germany	0.28%	0.03%	0.26%
India	0.29%	0.93%	-0.64%
Indonesia	0.22%	0.17%	0.05%
Italy	0.23%	0.02%	0.20%
Japan	0.09%	0.00%	0.09%
Korea, Rep.	0.23%	0.09%	0.14%
Netherlands	0.76%	0.06%	0.71%
Nigeria	0.13%	0.40%	-0.26%
Portugal	0.07%	0.01%	0.05%
Russian Federation	0.33%	0.17%	0.16%
South Africa	0.15%	0.04%	0.1%
Spain	0.14%	0.02%	0.12%
Sweden	0.27%	0.03	0.24%
Switzerland	0.2%	0.03%	0.17%
Thailand	0.50%	0.91%	-0.41%
United Kingdom	0.24%	0.02%	0.22%
United States	0.12%	0.01%	0.11%
World	-0.10%	0.63%	-0.73%

Table A18: Trade Effects from Tariff Reduction$_{o}nesector$

	China	Nigeria
China's Imports		16%
Nigeria's Imports	29%	

Table A19: Export shares by sector before and after Nigeria-China tariffs reduction (simple average θ estimate)

	China		Nigeria	
Sectors	Before	After	Before	After
Agriculture	2.23%	2.19%	1.26%	1.14%
Mining	2.04%	2.18%	96.2%	96.5%
Food	3.86%	3.71%	0.973%	0.889%
Textile	28.8%	28.2%	0.582%	0.558%
Wood	0.992%	1.03%	0.233%	0.248%
Paper	1.03%	1.02%	0.0315%	0.0303%
Petro-chemical	0.889%	1.17%	0.26%	0.26%
Chemicals	4.31%	4.3%	0.163%	0.158%
Plastic	2.28%	2.41%	0.00239%	0.00228%
Minerals	1.27%	1.38%	0.0134%	0.0144%
Basic Metals	4.39%	4.68%	0.00878%	0.00845%
Machinery	3.58%	3.71%	0.0185%	0.0174%
OECM	29.8%	29.7%	0.0488%	0.0482%
Auto	3.37%	3.26%	0.163%	0.152%
Other	11.1%	11.2%	0.00498%	0.00485%
Normalized HHI	0.165	0.161	0.92	0.93

Notes: Table shows the welfare effects from Nigeria and China bilateral tariff reduction in 2000 (before) and 2006, after Chinese ascension. Export shares in 2000 is calibrated to match the data while the share of exports in 2006 is from model. I use θ estimates with simple average tariffs.

Table A20: Sectoral contribution to welfare(%) from tariffs Reduction on Nigeria and China only

	China			Nigeria
Sectors	Terms of Trade	Volume of trade	Terms of Trade	Volume of Trade
Agriculture	3.53%	2.9%	1.11%	-4.71%
Mining	9.21%	-2.65%	95.3%	4.13%
Food	4.11%	14.3%	3.16%	-6.26%
Textile	22.9%	21.4%	1.11%	4.76%
Wood	1.09%	0.178%	0.733%	1.65%
Paper	1.17%	5.38%	0.469%	-0.783%
Petro-chemical	2.42%	-5.46%	2.28%	23.1%
Chemicals	6.24%	8.69%	0.919%	0.274%
Plastic	2.18%	-0.217%	-0.255%	39.9%
Minerals	1.17%	-1.69%	1.3%	8.39%
Basic Metals	5.58%	-5.66%	-0.143%	21.9%
Machinery	3.7%	1.44%	-2.51%	7.04%
OECM	24.6%	35.4%	-0.907%	1.68%
Auto	2.83%	16.5%	-2.43%	-1.55%
Other	9.28%	9.43%	-0.0928%	0.385%

Notes: Table shows the welfare effects from Nigeria and China bilateral tariff reduction only. Tariffs for the rest of the sample is fixed to 2000. I use θ estimates with simple average tariffs.

Table A21: Sectoral contribution to welfare(%) from global tariff reduction for China and Nigeria

	China		Nigeria	
Sectors	Terms of Trade	Volume of trade	Terms of Trade	Volume of Trade
Agriculture	3.34%	5.18%	-7.45%	1.24%
Mining	0.205%	-0.635%	-92.1%	3.11%
Food	4.25%	2.52%	7.68%	1.63%
Textile	41.2%	18.4%	5.18%	7.95%
Wood	0.973%	2.11%	1.39%	0.463%
Paper	2.23%	2.14%	8.04%	1.52%
Petro-chemical	-2.15%	4.42%	8.69%	6.44%
Chemicals	-0.648%	3.09%	39%	3.96%
Plastic	1.99%	4.69%	12.5%	39.1%
Minerals	1.05%	3.51%	9.75%	3.67%
Basic Metals	0.501%	5.73%	44.4%	23.5%
Machinery	-0.504%	18.2%	21.5%	3.4%
OECM	30.8%	23%	20.1%	2.31%
Auto	4.03%	6.71%	19.2%	0.956%
Other	12.7%	0.928%	2.13%	0.74%

Notes: Table shows the sectoral contribution to welfare effects of global tariff reduction. Sum of each column is 100%. I use θ estimates with simple average tariffs.

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