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Essays on international trade

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By

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ESSAYS ON INTERNATIONAL TRADE

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ABSTRACT

Reciprocity is a key principle governing the negotiations under the GATT/WTO agreement, which calls for a balance of concessions among the WTO members. In recent years, however, various politicians across the world have voiced concerns about their country's excessive obligations under the WTO and a lack of reciprocation by their trading partners. The objective in the first chapter is to evaluate the degree to which the pattern of applied tariffs across WTO members deviates from a balanced-concession condition. To this end, we employ a quantitative trade model and use alternative definitions of reciprocity (based on market access or welfare) to measure the concessions received and given by each country during 1995–2011 for a large set of 64 economies and 20 sectors, relative to the counterfactual of unilateral optimal tariffs. We characterize how the balance of bilateral and multilateral concessions have shifted over time due to changes in applied tariffs and in market sizes, and how they systematically differ across developed WTO members, old developing members, and new developing members.

The World Trade Organization disciplines regulatory protectionism by the principle of national treatment, which prohibits discrimination between imported and domestic "like" products. In the second chapter, we provide the first empirical analysis on how product likeness, approximated by elasticity of substitution, affects trade frictions associated with non-tariff barriers that are subject to national treatment. Regression results using both product- and firm-level trade data are consistent with the hypothesis that technical barriers to trade create more frictions when the corresponding market and product have a smaller elasticity of substitution. We also construct a model that features heterogeneous firms and production relocation to illustrate the role of product likeness under national treatment.

In the third chapter, we demonstrate that treating trade imbalance as gifts (discrepancies between local income and expenditure, as a fixed share of world output or as contributions in excess of receipts to and from a global portfolio) leads to unintended implications on optimal tariff policy analysis. In particular, there arises a negative association between the optimal tariff rate and the trade-deficit-to-GDP ratio across countries. By purging away trade imbalances before conducting optimal tariff analysis, although circumventing the caveat above, leads to optimal tariffs that are distorted and compressed toward zeros and hence underestimated welfare gains (and exchanges of market access concessions) of tariff cooperation. We then show that the reputable negotiating rule of the GATT/WTO — the principle of reciprocity — cannot keep the world prices fixed in the presence of trade imbalances (and neutralize the terms-of-trade externality, a function critical in facilitating reciprocal trade liberalization). We propose methodologies toward endogenizing trade imbalances in general equilibrium trade models by calibrating the discount factor (that are country-specific and time-varying for a large set of economies), such that the model matches the pattern of borrowing and lending across countries. The framework can then be used to conduct counterfactual analysis of tariff reductions, where the world interest rate and trade imbalances respond endogenously to changes in tariffs, and to assess how the quantitative implications on trade and welfare are distorted by shutting down the mechanism of endogenous trade imbalances.

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The Balance of Concessions in the World Trade Organization

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"We believe that trade must be fair and reciprocal. The United States will not be taken advantage of any longer." — Donald Trump, Address to the UN General Assembly, September 25, 2018.

1.1 Introduction

Reciprocity is a key principle governing the negotiations under the GATT/WTO agreement, which calls for a balance of concessions among the WTO members. In recent years, however, various politicians across the world have voiced concerns about their country's excessive obligations under the WTO and a lack of reciprocation by their trading partners. Notably, based on similar grounds, high-level politicians in the United States have argued for reconsidering the obligations of the U.S. under the WTO agreement. Some have even argued that the U.S. should pull out of the WTO altogether.[1] These widespread anti-WTO sentiments in the United States government, which was one of the organization's principal sponsors from the beginning, has put the future of the organization in doubt.

Our objective in this paper is to map the structure of the balance of concessions in the WTO and evaluate the resilience of the organization to the departure or downgraded cooperation of its principal members such as the United States. To this end, we employ a quantitative trade model and use alternative definitions of reciprocity (based on market access or welfare) to measure the concessions received and given by each country under the WTO during 1995–2011 for a large set of 64 economies and 20 sectors, compared to a world without trade policy cooperation (where individual countries retreat to their unilateral optimal tariffs). We also measure the amounts of market access (welfare gains) that are

[1] In a New York Times article, U.S. Senator Josh Hawley calls for the abolition of the WTO, arguing that "its mandate was to promote free trade, but the organization instead allowed some nations to maintain trade barriers and protectionist workarounds, like China, while preventing others from defending themselves, like the United States."

withheld due to the remaining tariffs. We characterize how the balance of bilateral and multilateral concessions have shifted over time due to changes in applied tariffs and in market sizes, and how they systematically differ across industrial WTO members, old developing members (which join the GATT/WTO before 1995), and new developing members (which join the GATT/WTO after 1995).

A first step in depicting the structure of concessions in the WTO is to develop a meaningful measure of concessions that reflects the objectives and motivations of governments in international trade cooperations. We follow Bagwell and Staiger (1999) by defining the level of concessions associated with a tariff cut as the resulting change in the trade volume at original prices. Specifically, the concession (in terms of market access) given by a country is the increase in its imports from each of its trading partners by restraining from levying its unilateral optimal tariff. Vice versa, the concession received by a country from a trading partner is the additional market access the country enjoys if the trading partner maintains its applied tariffs instead of withdrawing from the WTO (and all other trade agreements) and levying its unilateral optimal tariffs.

In addition to the measure based on market access, we also evaluate concessions based on welfare (i.e., real income). That is, the concession (in terms of welfare) given by a country is the welfare gain enjoyed by each of its trading partners when the country restrains from levying its optimal tariff. This concept is closely related to the welfare analysis of trade war and trade talks by Ossa (2014) in a static game and Mei (2020) in a repeated game. In particular, Mei (2020) evaluates the self-enforceability of trade agreements (given each country's one-period gain from deviation and the future loss as a result of the deviation). One may argue that the minimum discount factor Mei (2020) finds is related to the balance of concessions. Nonetheless, both studies conduct the analysis with a relatively small set of individual countries (less than 10) and a year of data (2007). Hence, they do not address the issue of changes in the balance of concessions over the years and on a bilateral basis for many developing trading economies of policy interest. Given that the market size and trade policies of developing countries have shifted significantly since 1995, it is useful to characterise the balance of concession under the WTO along both cross-sectional and temporal dimensions.

Given the measured concessions, we evaluate whether the level of bilateral exchange of concessions differ systematically across the development status (and the vintage of WTO membership) of bilateral country pairs, and whether any asymmetry pattern identified change over the years. The analysis is motivated by the observations that tariff commitments under the GATT/WTO vary substantially across countries: while advanced industrial countries engaged in substantial tariff cuts across many sectors, most developing countries have retained various degrees of flexibility to set their import tariffs unilaterally. The substantial asymmetry in the level of tariffs across countries may indicate that developing countries received more market access concessions from industrial countries than they gave. In fact, a favorable treatment of developing countries would be consistent with the spirit of *special and differential treatment provisions* in the WTO.[2]

Subramanian and Wei (2007), however, find that, holding other factors constant, industrial countries import about 40% less from developing countries than from other industrial countries. They interpret this result as indicating higher tariffs on the products of interest to developing countries. By simulating the bilateral exchange of market access that WTO tariff cuts confer (relative to the counterfactual of unilateral optimal tariffs), we complement their ex-post analysis and provide a direct evaluation of whether industrial WTO members receive more concessions than developing WTO members do, and whether old developing members receive more concession relative to new members (or vice versa). These concessions (measured against the counterfactual of optimal tariffs) take into account potential productivity and market size changes over time, and hence offers a more precise depiction of the

[2]The WTO Agreements contain special provisions which give developing countries special rights and which give developed countries the possibility to treat developing countries more favorably than other WTO members. This includes provisions requiring all WTO members to safeguard the trade interests of developing countries.

market power and outside option of member countries at each given point in time, relative to mere comparisons based on trade volumes.

The remainder of this paper is organized as follows. In Section 1.2, we lay out the general equilibrium model that we use to simulate counterfactual equilibria. In Section 1.3, we formally define the alternative measures of concessions (based on market access or welfare) and discuss their merits and limitations. Section 1.4 presents the anatomy of concessions in the WTO across years bilaterally and multilaterally. In Section 1.5, we analyze how the level of bilateral exchange of concessions differ across the development status (and the vintage of WTO membership) of bilateral country pairs. Section 1.6 concludes.

1.2 Model

Consider a multi-country and multi-sector setup. The goods are differentiated by the origin of production i, destination of consumption j, and sector, in terms of both production technology and preferences. We take the activities in the service sectors as exogenous (whose quantities of production, consumption, and trade flows remain fixed in counterfactual exercises) and group them into one aggregate sector s. The set M of non-service sectors (including agriculture, mining, and manufacturing) are indexed by $k \in \{1, 2, ..., K\}$.

1.2.1 Setup

Let U_j^M denote utility obtained from non-service sectors in country j, with a nested Cobb-Douglas CES structure such that:

$$U_j^M = \prod_{k \in M} (\sum_{i=1}^{N} b_{ij,k}\, \tilde{q}_{ij,k}^{\rho_k})^{\frac{\mu_{j,k}^M}{\rho_k}}, \tag{1.1}$$

where $\tilde{q}_{ij,k}$ is the quantity consumed in country j of variety i in sector k, $b_{ij,k} \in \mathbb{R}_+$ is a constant taste shifter, $\sigma_k \equiv 1/(1-\rho_k)$ corresponds to the elasticity of substitution across varieties in sector k, and $\mu_{j,k}^M \equiv \frac{\mu_{j,k}}{\mu_j^M}$ represents the share of expenditure on sector k among non-service sectors (where $\mu_{j,k}$ is country j's share of expenditure on sector k, and $\mu_j^M \equiv \sum_{l \in M} \mu_{j,l}$ is the total share of expenditure on non-service sectors in country j).

Production technology follows the Ricardian structure, with labour as the only factor of production. Let $\bar{a}_{ij,k}$ denote the exogenous unit labour requirement to produce a good of sector k in country i for consumption in country j. Given perfectly competitive markets, the producer price $p_{ij,k}$ equals:

$$p_{ij,k} = \bar{a}_{ij,k}\, \omega_i^M,$$

where ω_i^M is the wage rate in country i (for non-service sectors). The consumer price $\tilde{p}_{ij,k}$ at the destination equals:

$$\tilde{p}_{ij,k} = (1 + t_{ij,k})(1 + \tau_{ij,k}) p_{ij,k}, \quad t_{ii,k} = 0, \tag{1.2}$$

where $t_{ij,k}$ and $\tau_{ij,k}$ are respectively the ad valorem tariff rate and trade cost factor faced by goods shipped from country i to country j in sector k.

Given the CES structure within each sector, the share of expenditure allocated to varieties of origin i is:

$$\lambda_{ij,k} = b_{ij,k}^{\sigma_k} \left(\frac{\tilde{p}_{ij,k}}{P_{j,k}} \right)^{1-\sigma_k} \tag{1.3}$$

with the price index $P_{j,k}$ for sector k in country j equal to:

$$P_{j,k} = \left(\sum_n b_{nj,k}^{\sigma_k}\, \tilde{p}_{nj,k}^{1-\sigma_k} \right)^{\frac{1}{1-\sigma_k}}. \tag{1.4}$$

It follows that wage income of country i (for non-service sectors) is:

$$\begin{aligned} \omega_i^M L_i^M &= \sum_j \sum_{k \in M} \frac{\tilde{p}_{ij,k}\, \tilde{q}_{ij,k}}{1 + t_{ij,k}} \\ &= \sum_j \sum_{k \in M} \frac{\lambda_{ij,k}\, \mu_{j,k}^M\, Y_j^M}{1 + t_{ij,k}}, \end{aligned} \tag{1.5}$$

where the aggregate expenditure Y_j^M of country j on non-service sectors, by budget constraint, is equal to the sum of wage income, tariff revenues, and trade deficit TD_j^M of these sectors:

$$\begin{aligned} Y_j^M &= \omega_j^M L_j^M + \sum_{k\in M}\sum_i \frac{t_{ij,k}}{1+t_{ij,k}} \tilde{p}_{ij,k}\tilde{q}_{ij,k} + TD_j^M \\ &= \omega_j^M L_j^M + \sum_{k\in M}\sum_i \frac{t_{ij,k}}{1+t_{ij,k}} \lambda_{ij,k}\, \mu_{j,k}^M\, Y_j^M + TD_j^M. \end{aligned} \tag{1.6}$$

Given the tariffs $\{t_{ij,k}\}$, an equilibrium is a vector of variables $\left\{\omega_j^M, Y_j^M, \lambda_{ij,k}, P_{j,k}^M\right\}$ that satisfies conditions (1.2)–(1.6) for all ij, k, conditional on the set of parameters $\{\tau_{ij,k}, b_{ij,k}, \bar{a}_{ij,k}, \sigma_k\}$ and observables $\{\mu_{j,k}^M, \mu_j^M, TD_j^M\}$.

Given (1.1), we have the welfare of country j (derived from non-service sectors) as:

$$W_j = \left(\frac{Y_j^M}{\prod_{k\in M} P_{j,k}^{\mu_{j,k}^M}}\right)^{\mu_j^M}. \tag{1.7}$$

1.2.2 Counterfactual Changes

In counterfactual exercises, we introduce changes in the tariff into the system. Applying the hat-algebra approach popularized by Dekle et al. (2008), the system of equilibrium conditions can be re-written in terms of changes as:

$$\hat{\lambda}_{ij,k} = \left(\frac{1+t'_{ij,k}}{1+t_{ij,k}}\hat{\omega}_i^M\right)^{1-\sigma_k} (\hat{P}_{j,k})^{\sigma_k-1}, \tag{1.8}$$

$$(\hat{P}_{j,k})^{1-\sigma_k} = \sum_i \lambda_{ij,k}\left(\frac{1+t'_{ij,k}}{1+t_{ij,k}}\hat{\omega}_i^M\right)^{1-\sigma_k}, \tag{1.9}$$

$$\hat{\omega}_i^M \omega_i^M L_i^M = \sum_j \sum_{k\in M} \frac{\hat{\lambda}_{ij,k}\, \hat{Y}_j^M\, \lambda_{ij,k}\, \mu_{j,k}^M\, Y_j^M}{1+t'_{ij,k}}, \tag{1.10}$$

$$\hat{Y}_j^M Y_j^M = \hat{\omega}_j^M \omega_j^M L_j^M + \sum_{k\in M}\sum_i \left(\frac{t'_{ij,k}}{1+t'_{ij,k}}\hat{\lambda}_{ij,k}\, \hat{Y}_j^M\, \lambda_{ij,k}\mu_{j,k}^M Y_j^M\right) + TD_j^{M\prime}, \tag{1.11}$$

where $\hat{x} \equiv x'/x$ indicates the ratio of the counterfactual value x' to the factual value x of an endogenous variable. This implies changes in welfare to be:

$$\hat{W}_j = \left(\frac{\hat{Y}_j^M}{\prod_{k\in M} \hat{P}_{j,k}^{\mu_{j,k}^M}}\right)^{\mu_j^M}. \tag{1.12}$$

We start the analysis by allowing trade deficits in the model. Following the literature (see, e.g., Caliendo and Parro, 2015), we assume the trade deficit of each country to be a constant share of world output. This implies that $TD_j^{M\prime} = \delta_j \sum_i \hat{\omega}_i^M \omega_i^M L_i^M$, where $\delta_j \equiv TD_j^M / \sum_i \omega_i^M L_i^M$. Note that $\sum_j TD_j^{M\prime} = -\sum_j TD_j^{S\prime} = -\sum_j TD_j^S$ by trade balance at the world level (in the first equality) and by keeping the service sector activities fixed (in the second equality where TD_j^S indicates country j's trade deficit in the service sector), while at the same time, $\sum_j TD_j^{M\prime} = \sum_i \hat{\omega}_i^M \omega_i^M L_i^M$. Thus, the structure effectively keep the world output fixed (or equivalently, normalizes the changes in variables relative to changes in the world output). As an alternative, we also consider a balanced trade scenario in which trade deficits are purged from the data as in Ossa (2014). More details are to be discussed in Section 1.4.

1.2.3 Map the Model to the Data

Given data on trade flows $x_{ij,k}$ and applied tariff rates $t_{ij,k}$, we measure the parameters and variables required in the counterfactual analysis (1.8)–(1.11) as follows:

$$\lambda_{ij,k} = \frac{x_{ij,k}}{\sum_i x_{ij,k}}; \quad \mu_j^M = \frac{\sum_{k \in M} \sum_i x_{ij,k}}{\sum_{k \in M} \sum_i x_{ij,k} + \sum_i x_{ij}^S}; \quad \mu_{j,k}^M = \frac{\sum_i x_{ij,k}}{\sum_{k' \in M} \sum_i x_{ij,k'}};$$

$$\omega_i^M L_i^M = \sum_{k \in M} \sum_j \frac{x_{ij,k}}{1 + t_{ij,k}}; \quad Y_j^M = \sum_{k \in M} \sum_i x_{ij,k};$$

$$TD_j^M = \sum_{k \in M} \sum_i \left(\frac{x_{ij,k}}{1 + t_{ij,k}} - \frac{x_{ji,k}}{1 + t_{ji,k}} \right); \quad \delta_j = \frac{TD_j^M}{\sum_i \omega_i^M L_i^M}.$$

We obtain production and bilateral trade data (in intermediate and final goods combined) from the OECD-WTO Trade in Value Added (TiVA) database. The 2016 edition records trade flows for 63 economies (and a residual Rest of the World) in 34 sectors (based on ISIC Rev. 3) for years 1995–2011. The methodology and assumptions underlying the construction of the TiVA database can be found in OECD-WTO (2012).[3] See Tables 1.1 and 1.2 for the list of economies and sectors. We aggregate service sectors into one combined sector. This amounts to a total of 20 individual sectors to be used in the subsequent analysis. In the optimal tariff analysis and measure of concession, we consider countries in the European Union (EU) as one combined entity in setting trade policy. The membership size of the EU increased from 15 to 27 during the period 1995–2011. Correspondingly, the set of individual economy entities analyzed reduced from 50 (in the period 1995–2003), to 40 (in 2004–2006), and to 38 (in 2007–2011). The data on tariffs are sourced from the TRAINS database, downloaded via the World Integrated Trade Solution (WITS) interface.[4]

We estimate the trade elasticity ($\sigma_k - 1$) following the approach in Caliendo and Parro (2015). In particular, the trade structure in the current model implies that:

$$\ln \frac{x_{in,k} x_{nj,k} x_{ji,k}}{x_{ni,k} x_{jn,k} x_{ij,k}} = (1 - \sigma_k) \ln \frac{\tilde{t}_{in,k} \tilde{t}_{nj,k} \tilde{t}_{ji,k}}{\tilde{t}_{ni,k} \tilde{t}_{jn,k} \tilde{t}_{ij,k}} + \varepsilon_{inj,k} \tag{1.13}$$

where $\tilde{t}_{ij,k} = 1 + t_{ij,k}$. We implement the regression using the panel of country pairs in the period 1995–2011 for each sector $k \in M$. The estimates of $\sigma_k - 1$ are reported in Table 1.2. See the footnote therein for further details of the implementation.

1.3 Measure of Concessions

We define concession given by a country as the gain (in terms of market access or welfare) of its trading partners when the country restrains from levying its unilateral optimal tariffs. In other words, we measure the difference in each trading partner's market access to the country (or correspondingly, difference in welfare) under the applied tariff structure relative to the counterfactual scenario in which the importing country imposes its unilaterally-optimal

[3]More details about the dataset are provided at http://www.oecd.org/sti/ind/measuring-trade-in-value-added.htm. Tables are available from https://www.oecd.org/sti/ind/inter-country-input-output-tables.htm.

[4] https://wits.worldbank.org/.

tariff rates. The optimal tariff rates are endogenously calculated given the factual trade flows, production, and tariff structures across countries and sectors. We find country j's unilaterally optimal tariffs by searching for the set of tariffs that maximize the increase in country j's welfare, namely:

$$\max_{t'_{ij,k}} \hat{W}_j \tag{1.14}$$

given (1.12) subject to the counterfactual equilibrium conditions (1.8)–(1.11), within the parameter space:

$$t'_{ij,k} = \begin{cases} t'_{j,k}, & \text{if } i \neq j; \\ 0, & \text{if } i = j. \end{cases}$$

The optimal tariff vector $\{t'^{o}_{j,k}\}_k$ is simulated for one economy at a time, given the other economies' factual trade policies.

1.3.1 Market Access Concession

We follow Bagwell and Staiger (1999) by defining the level of concessions associated with a tariff cut as the resulting change in the trade volume at original prices. Specifically, the concession (in terms of market access) given by a country is the increase in its imports from each of its trading partners by restraining from levying its unilateral optimal tariff. In other words, the concession given by an importing country j to its trading partner i in terms of market access is the gain in i's export value to market j under the factual tariffs (with trade agreements in place) relative to the counterfactual value, measured at initial prices, if country j levies its optimal tariffs:

$$\begin{aligned} Concession^{MA}_{ij} &\equiv P_{ij}(Q_{ij} - Q'_{ij}) \\ &\equiv \sum_{k \in M} \frac{\tilde{p}_{ij,k}\, \tilde{q}_{ij,k}}{1 + t_{ij,k}} - \frac{1}{\hat{\omega}^M_j} \sum_{k \in M} \frac{\tilde{p}'_{ij,k}\, \tilde{q}'_{ij,k}}{1 + t'^{o}_{ij,k}}. \end{aligned} \tag{1.15}$$

Since market access is measured at initial prices and quantity traded in the service sector is kept unchanged under counterfactuals, the formula above reflects changes in the market access in non-service sectors only. Balance of concession can then be measured for a country pair as follows:

$$BoC_{ij}^{MA} = \frac{Concession_{ij}^{MA} - Concession_{ji}^{MA}}{Concession_{ij}^{MA} + Concession_{ji}^{MA}}, \tag{1.16}$$

which indicates how much more country j's concession to i is compared to country i's concession to j, as a fraction of the total exchange of market access. An index closer to zero corresponds to a more balanced exchange of concession. Similarly, we can measure a country's total concession offered and received relative to its trading partners as:

$$BoC_{j}^{MA} = \frac{\sum_{i \neq j} \left(Concession_{ij}^{MA} - Concession_{ji}^{MA}\right)}{\sum_{i \neq j} \left(Concession_{ij}^{MA} + Concession_{ji}^{MA}\right)}. \tag{1.17}$$

A larger positive index value indicates that country j has provided more concessions to the rest of the world than it has received in return, and vice versa with a more negative index value.

1.3.2 Welfare Concession

In addition to market access, we may also measure concessions in terms of welfare changes. The concession rendered by an importing country j to its trading partner i in terms of welfare is the gain in i's welfare under the factual tariffs (with trade agreements in place) relative to the counterfactual value, should country j impose its unilateral optimal tariffs. In other words,

$$Concession_{ij}^{W} = \left[1 - \hat{W}_i(\{t_{j,k}^{\prime o}\})\right] \times \mu_i^M \times GDP_i, \tag{1.18}$$

where $\hat{W}_i(\{t_{j,k}^{\prime o}\})$ indicates country i's counterfactual welfare (relative to the status quo) should country j impose its optimal tariffs; and GDP_i denotes real GDPs of country i (data on which were extracted from the Penn World Table). Given (1.18), we can define bilateral and multilateral balance of concessions, BoC_{ij}^{W} and BoC_{j}^{W}, in terms of welfare in similar manners as for the market access.

We now discuss the merits and limitations of the proposed measures. If trading partners were symmetric in size, measuring concessions by market access or welfare changes would lead to identical conclusions. However, when countries are asymmetric, these two measures would generate different levels of bilateral concessions and hence yardsticks of evaluations.

Concessions as measured by market access is the closest definition to the language used in the GATT/WTO agreements. Moreover, as pointed out by Bagwell and Staiger (1999), under various models of international trade, the exchange of market access reflects the core objective of trade negotiations, namely, eliminating the terms of trade externality of unilateral trade policy. On the other hand, using welfare effects as a measure of concessions may be more aligned with a bargaining model of tariff cuts such as Nash bargaining used in Ossa (2014). For practical matters, however, it is unlikely that trade negotiators use a direct measure of welfare effect: For one, it is difficult to come up with a universally-accepted measure of welfare effect.

Another practical way to measure the balance of concessions is to compare the amount of taxes that countries surrender/collect on their bilateral imports (relative to optimal tariffs and free trade, respectively). Tariff revenues, however, do not have a solid theoretical foundation as a measure of granted/withheld trade concessions. An obvious problem with this measure is that low import tariff revenues could be the result of very high tariffs (that result in small import volumes) or low tariffs on imports. This problem may be avoided by using the trade volume under free trade multiplied by the levied ad valorem tariffs as a measure of withheld concessions. Although this variable lacks a theoretical foundation as a measure of concession, it is frequently used to describe the extent of a trade skirmish (such as the recent US-China tariff adjustments).

1.4 Anatomy of WTO Concessions

To understand the cross-country and temporal patterns of concessions, it is useful to decompose them into the variation due to trade balances, applied tariffs, and market size.

The effects of trade imbalance on concessions could be inferred by comparing the concessions under the factual world (with trade imbalances) and those in a world purged of trade imbalances. In the latter case, we first purge trade imbalances from the data following the methodology in Costinot and Rodríguez-Clare (2014). Effectively, the equilibrium is recalculated by setting trade deficits to zeros. Under the counterfactual world with trade balance, the optimal tariffs and concessions (in market access and welfare) are re-simulated following the formulas in Section 1.3. Countries such as China and the United States operated with large trade imbalances during the period of the study. This could potentially amplify the extent of concessions received and granted, given a setup where trade deficits are modelled as fixed proportions of world output. Intuitively, countries with large trade deficits have more room to raise import tariffs and hence more potential concessions to offer; on the other hand, exporting countries with large trade surplus benefit more from any given tariff reductions by their trading partners. Removing the trade imbalances from the data will thus tend to reduce the imbalance of concessions between countries with trade deficits and those with trade surpluses in general.

Next, given the counterfactual world equilibrium with trade balance (call this world equilibrium II), we further isolate the effects on concessions due to changes in applied tariffs. This is accomplished by simulating yet another parallel world equilibrium across years where applied tariffs are kept at their levels in 1995 (call this world equilibrium III). The optimal tariffs and concessions (in market access and welfare) are re-simulated across years given this alternative pseudo world. The difference in concessions under the pseudo world II and the pseudo world III can be regarded as the effect on concessions due to changes in applied tariffs. The change in concessions across years computed under the pseudo world III can then be attributed to the effects of market size changes over time. Since the formation of the WTO in 1995, tariffs have reduced by different extents among the members. Meanwhile, market sizes of some economies (such as China and India) have experienced substantial growth. For countries with small drops in applied tariffs since 1995, market size effects will play a predominant role. On the other hand, for countries with considerable cuts in applied tariffs since 1995, their concessions will embody proportionally more the tariff effects.

1.4.1 Overall Patterns and Trade Imbalance Effects

Figure 1.1 and Figure 1.2 summarize each economy's net concession index BoC_j^{MA} (concessions offered net of concessions received as a fraction of total concessions exchanged), given trade deficits and with trade deficits purged respectively. The effects on concessions due to trade imbalance can be inferred from comparison of the measure under these two scenarios.

We have grouped countries by their geographical regions into six sub-plots. Figure 1.1 shows that in East Asia, Pacific & South Asia, Australia, New Zealand, and Hong Kong are the three economies with positive balance of concessions in market access. This indicates that they granted more concessions to their trading partners than they received in 1995–2011. The reverse is true with economies such as Japan, Korea and Taiwan, which provided net negative concessions. Over the years, the balance of concessions of India increased, and turned from negative to positive in 2005. This was partly driven by large reductions in import tariffs by India in the year. China's net concessions saw a jump in 2002 when it joined WTO. However, its concessions have trended downward since then and turned negative in 2006. Compared with Figure 1.2, we see that the decrease in its net concessions was largely due to its growing export volumes and trade surplus. With its trade surplus purged, China was more or less in balance in terms of total concessions it granted and received to and from its trading partners. The same applies to the case of Japan, Korea, and Taiwan. These countries generally ran large trade surpluses with respect to their trading partners. With trade surplus purged, their negative net concessions in market access are reduced and close to being zeros. Overall for the economies in East Asia, the degrees of deviations from the balance of concessions were small once trade imbalance is purged; most economies were either hovering around or converging toward the reciprocity condition. Hong Kong was in an opposite situation from the East Asian economies discussed above. Its net concessions were positive with trade imbalance, but became largely negative (and increasingly so) once trade imbalance was purged. Indeed, Hong Kong ran huge trade deficits during the period of study, which correspond to large concessions in market access. When trade imbalance is eliminated, the amount of concessions Hong Kong granted was reduced.

Southeast Asian economies in general were net receivers of market access concessions, even after trade imbalance is purged. The exceptions are Vietnam, Indonesia and Brunei. While in the case of Vietnam, it was a net giver of market access concessions with or without trade imbalance purged, Indonesia's concession index became positive (or more positive) with trade imbalance purged. The effect of trade surplus was especially pronounced for Brunei, having a large negative concession index with trade imbalance in place and a positive concession index instead when trade imbalance is purged.

The effect of trade imbalance on concessions is most evident in the case of the US, whose trade deficits have increased over the years and who has topped the nations in terms of trade deficits incurred. While it was a large net granter of market access concessions with trade deficits in place, it was a net receiver of market access concessions with the trade imbalance excluded. Canada and Mexico were overall net receivers of concessions in market access, although the gap closed up momentarily during 2005–2010.

Most of the Latin American economies granted more concessions than they received from their trading partners, with the exceptions of Chile and Costa Rica. Although both countries' concessions granted to trading partners have increased over the years, the amount of concessions received grew at an even faster rate.

Turning to Europe, the EU (being one of the largest trading bloc) has granted concessions in amounts very close to what it received. In contrast, Iceland and Norway were net grantors, while Switzerland and Russia were net receivers, of concessions in market access. In the case of Russia, the conclusion reversed if we purge the trade imbalance, with the amount of concessions granted surpassing the concessions received in the 2000s. This again reflects the effect of its trade surplus in this period of study. With trade surplus removed, it leads to smaller amounts of market access concessions received by Russia and hence a less negative (or more positive) position in its balance of concession.

The set of Middle Eastern and African countries were in general net receivers of market access concessions. No significant difference is observed when comparing the concessions with and without trade imbalance. The exception was Saudi Arabia, which ran trade surpluses. When trade imbalance is purged from the data, Saudi Arabia's net concession index turned from being negative to positive.

The net concessions in terms of welfare are summarized in Figure 1.3 and Figure 1.4 for the scenario with and without trade imbalance respectively. The net concessions across countries are found to be more dispersed in terms of welfare than market access. With some major exceptions (including China, Japan, the US and the EU), the qualitative patterns are in general consistent with those discussed above based on market access. Importantly, in terms of welfare concessions, China is found to be a large net beneficiary (even with trade imbalance purged). In contrast, Japan, the US and the EU were found to be large net benefactors. Japan and the EU, who were found to be in either negative or balanced positions in terms of market access concessions, are shown to be in large positive positions in terms of welfare concessions. In similar spirits, the US's position in net welfare concession tended to be higher than its position in terms of market access concession, and remained to be positive even after trade imbalance is purged. Nonetheless, it is worthwhile noting that China's net welfare concessions have increased over the years (turning from negative toward balance); in contrast, the US's net welfare concessions have trended downward (if excluding the effects of its large trade deficits).

1.4.2 Applied Tariff Effects versus Market Size Effects

Next, we decompose the concessions granted by each economy into effects driven by applied tariffs and effects driven by market size, in the way suggested in the introduction of Section 1.4. The results are summarized in Figure 1.5. We note that concessions in market access are predominantly driven by changes in market size. That is, when economies grow and vary in their sizes, optimal tariffs and hence implied concessions change. This effect tends to overwhelm potential changes in concessions due to changes in applied tariff rates.

China and India are two notable exceptions, with sizable applied tariff effects. In the case of China, it started to reduce its unilateral tariffs in the 1990s and with its negotiated accession packages for joining the WTO in 2001, its general tariffs were further lowered. This is reflected in the increasing role of applied tariff effects in the decomposition of market access concessions by China (from 24% in 1996 to nearly 40% in 2002). The share of applied tariff effects remained high for the next few years. However, China's economies grew rapidly in the 2000s and the market size effect started to push back, thereby reducing the relative importance of applied tariff effects to below 40% after 2007.

India is one of the developing countries that have been a member of GATT/WTO since 1948, but import barrier set by India remained high until recent decades, with noticeable reductions starting 2005. This change in tariff structures is well captured in the decomposition diagram of India. In the initial years of the period, a large share of market access granted by India is due to market size effect. In 2005, India halved its tariff rates from the level of 32% in 1995, and further reduced them to 12% in 2011. Correspondingly, the contribution of changes in the applied tariffs to market concessions increased from under 20% to 34% and 43% in 2005 and 2011, respectively.

Among the set of economies studied, Morocco stood out in terms of the importance of applied tariff effects in its market access concessions (on average 81% across years). This is due to the fact that Morocco had an extremely high import tariff rate (59%) to begin with in 1995. It underwent substantial liberalization subsequently, and slashed the tariff rate to 20% in 1996, followed by consecutive reductions of tariffs in the following years. Although its market size has increased over the years, its market access concession remained predominantly determined by changes in its applied tariff rates.

Note that the applied tariff effects could be negative as shown in Figure 1.5. This could happen if the applied tariffs in a year were more restrictive than in 1995. In this case, the concessions in market access calculated conditional on the applied tariff rates is smaller than conditional on the 1995 tariff rates. In this case, the difference of the two scenarios, which corresponds to the applied tariff effects, is negative. This happened, for example, during the Asian Financial Crisis to Thailand, Vietnam, and Brazil. The import restrictions were tightened post 1998 in these countries to reduce trade deficits and foreign reserve loss, and resulted in negative applied tariff effects on market access concessions. The situation improved after the recovery period, when the import tariffs were reverted and further reduced in subsequent years, reflected in the switch of the sign and the increased magnitude of the applied tariff effects.

Figure 1.6 provides the corresponding decomposition of welfare concessions (granted to trading partners) for the same set of economies. Noticeable differences from the market access concessions are the negative applied tariff effects on welfare concession in the cases of Japan, Korea, Singapore and the US, for example. This suggests that although these economies' applied tariffs might not have become more restrictive in terms of market access concessions, they have altered across sectors in a way that exerted more negative welfare impacts (on trading partners) given the world economy structure in the current year. This leads to smaller welfare concessions given the current applied tariffs relative to the 1995 tariff structures, and hence negative applied tariff effects on welfare concessions. Thus, for these countries, the growing market size of their economies contributes to the major brunt of their welfare concessions.

1.4.3 Ranking in Market Access Concessions

We now compare the dollar amounts of concessions in market access granted and received by major economies (Australia, Brazil, Canada, China, the EU, Japan, Korea, Mexico and the US). These are illustrated in panel (a) and (b) of Figure 1.7 for 1995, and (c) and (d) for 2011. Market size played a crucial role in determining a country's ranking in terms of the size of concessions. Economies with large domestic markets have more capacity in terms of market access concessions. Similarly, economies with large export volumes have more to benefit given trading partners' reduction of tariffs.

Unsurprisingly, the EU topped the list given its economic size, followed by the US, in terms of market access granted and received. During this period, China climbed up the ladder substantially and replaced Japan by 2011 as the third largest important players in exchange of market access. Korea also overtook Canada and became a key player next to China and Japan. The ranking of concessions granted follows almost the same order as the ranking of concessions received, suggesting the influence of country size.

For the concessions granted by each economy, we further disaggregate them by the major recipients and the remainder. Similarly, for the concessions received by each economy, we disaggregate them by the major grantors and the residual. The complete decompositions are indicated in Figure 1.7 for each of the major economies, with beneficiaries (benefactors) sorted in ascending orders according to the size of bilateral market access concessions. The residual entity (excluding the nine economies) given its collective size, however, obscures the ranking of bilateral concessions. To facilitate discussions, we thus illustrate by radial network diagrams (Holtz and Healy, 2018) the decompositions for each bilateral relationship of the nine economies in Figure 1.8. To read the diagram, each economy's size (in terms concessions granted and received) is indicated by the length it occupies on the circumference of the circle. An arrow pointing outward from the arc indicates the amount of concessions granted by the economy to a trading partner; while an arrow pointing inward represents the concessions received from a trading partner. The width of an arrow indicates the magnitude of concessions exchanged. The arrows for each economy are sorted in a descending order by the size of concession.

In 1995, the market access concessions received by the nine economies were mainly contributed by the US, the EU and Japan (Canada, the EU and Japan were respectively the top three beneficiary of the US's market access concessions). By 2011, China had replaced Japan as the second largest recipient of the US's market access concession. China had similarly replaced the US and became the largest beneficiary of the EU's and Japan's market access concessions. In return, China became the largest contributor of market access concessions received by Japan, and respectively the second and the third largest contributor of market access concessions received by the EU and the US.

Large asymmetry in bilateral exchange of concessions was evident for the US and Canada. The market access granted by the US to Canada was much larger than the concessions Canada gave to the US in 1995. The asymmetry was still observed in 2011, although the extent of imbalance had reduced. The opposite is the case between the US and Mexico; the imbalance between them appeared to have increased between 1995–2011.

The gap between Korea and Japan closed up during the period, with respect to the total size of market concessions granted and received, indicating Korea's large growth in trade volumes. Over time, China had replaced the US as among the top three beneficiaries of Korea's market access concessions. On the other hand, China overtook Japan as among the top three benefactors of the concessions received by Korea.

1.4.4 Bilateral Concessions

Finally, we look into the bilateral exchange of market access concessions in detail for a selective set of country pairs. These are illustrated in Figures 1.9–1.10.

The US has consistently received more market access concession from the EU than the EU from the US, and the magnitude exchanged has increased steadily over the years but for a setback in 2009 following the financial crisis. The increasing amounts of market access exchanged reflect the growing market size of these economies, as their applied tariff rates were relatively stable since 1995. The US was similarly a net recipient of market access concession from Brazil since 2003. Before then, the exchange of concession was nearly balanced. In particular, Brazil went through substantial tariff cuts following 2003; as a result, the amount of market access concessions given by Brazil to the US expanded. In contrast, the US has granted more market access concessions than it received with respect to the Asian economies such as Japan, India, and Vietnam. In particular, with the Generalized System of Preferences (GSP) program granted by the US to India, the US has constantly offered higher levels of of concessions to India than the amount it received. In the case of Vietnam, we observe a discrete jump in the amount of concessions it received from the US in 2003 when it joined the WTO. This likely reflects eased import restrictions by the US against Vietnam with the latter's entry into the WTO. Prior to this, in fact, Vietnam received net negative concessions from the US. The net amounts of bilateral exchange between the US and Taiwan saw a change of sign around 2003 (after Taiwan joined the WTO), with Taiwan offering an increasingly larger amount of market access concessions above those offered by the US. In fact, the concessions granted by the US to Taiwan has trended downward in general.

India and Brazil both joined the GATT/WTO in 1948, and had participated in trade liberalization to different extents. In particular, India tended to receive more market concessions than it granted, e.g., with respect to the EU and Brazil. In contrast, Brazil granted more concessions than it received with respect to the EU and Korea. The exchange of market access between these two old developing members (India and Brazil) and new developing members (such as Taiwan and Vietnam, respectively) appeared to be more or less in balance.

As the largest emerging economy, China's concessions to its trading partners have increased over time. Nonetheless, the concessions it received from the US and EU grew even faster and exceeded what it granted in return. Meanwhile, China and Japan's exchange of market access went nearly hand in hand, and remained close to balance. The opposite is the case in its exchange with Taiwan. China has granted substantially more market access concessions to Taiwan than it received from Taiwan, and the gap has grown over the years. China also maintained a close-to-balance condition in its exchange of market access with respect to India and Brazil, although in recent years, it started to receive net concessions from India and vice versa with respect to Brazil.

1.5 Asymmetries in Concession across Development Status and Membership Vintage

Given the measured concessions, we evaluate whether the level of bilateral exchange of concessions differ systematically across the development status (and the vintage of WTO membership) of bilateral country pairs, and whether any asymmetry pattern identified change over the years. Toward this end, we construct a normalized index of bilateral concession. Specifically:

$$Concession_{ij}^{MA,n} \equiv \frac{Concession_{ij}^{MA}}{\max Concession_{ij}^{MA}}, \tag{1.19}$$

where $\max Concession_{ij}^{MA}$ denotes the amount of concession that country j could potentially offer to country i by reducing its tariffs from the unilaterally optimal level to zero. This corresponds to the sum of realized concessions $Concession_{ij}^{MA}$ calculated in (1.15), from reducing optimal tariffs to factual rates, and potential concessions via further reduction of the factual tariffs to zero. The latter is calculated by setting $t'_{ij,k} = 0$ in (1.15) for an importing economy j at a time, and simulate the changes in market access for all i, k given j. Label the corresponding concession $Concession_{ij}^{MA,0}$. It measures the amount of market access that could be further extended if country j's remaining tariffs were removed; it could also be interpreted as the concession withheld by j. The measure $Concession_{ij}^{MA,n}$ provides an index of the degree to which country j has conceded its market access to country i relative to its maximum capacity to do so.

We regress this measure on the development status of the country pair, controlling for exporter and importer FEs and pertinent trade flows determinants:

$$Concession_{ij}^{MA,n} = \beta_1 * Ind\_Ind_{ij} + \beta_2 * Dev\_Ind_{ij} + \beta_3 * Ind\_Dev_{ij} + \beta_4 * Dev\_Dev_{ij} + \gamma' Z_{ij} + FE_i + FE_j + \epsilon_{ij}, \quad (1.20)$$

where Z_{ij} denotes a list of trade costs proxies including: bilateral distance, common language, common currency, colonial relationship and contiguity indicators.[5] Countries are classified into two development status: industrial countries (IND) and developing countries (Dev), following Subramanian and Wei (2007). For each of the bilateral development status variable $I^{exp}\_I^{imp}$, the indicator equals one if the exporter's status is I^{exp} and the importer's status is I^{imp}, and zero otherwise. For example, Ind_Dev_{ij} equals one if the exporter is an industrial country and the importer is a developing country. Following Subramanian and Wei (2007), the list of industrial countries includes Australia, Canada, Switzerland, Iceland, Japan, Norway, New Zealand and USA. Note that all industrial economies in the sample are members and joined the GATT/WTO before 1995. On the other hand, all individual developing economies in the sample became members by the end of the sample period (except Russia in 2012).

Table 1.3 reports the estimation results of (1.20) for each year in 1995–2011. We find that the coefficient on Ind_Ind is larger than Dev_Ind, and the difference is statistically significant for all years except in the initial year 1995. Similarly, the coefficient on Ind_Dev is larger than Dev_Dev except in 1995. This suggests that a systematic bias in the applied tariff structure under the GATT/WTO (and other trade agreements) in favor of industrial countries' exports. At the same time, the coefficient on Ind_Ind is found to be larger than Ind_Dev and that of Dev_Ind to be larger than Dev_Dev (except in 1996 and 1997). Thus, the industrial economies also provide relatively larger extents of concessions than the developing economies do (relative to their respective maximum capacities).

[5]The EU and the residual Rest of the World are not included in this set of analysis, as Z_{ij} is not available when i, j involves a group of economies.

This asymmetry may reflect two empirical observations: that the developing economies were given more exemptions from liberalizing their import sectors despite their membership in the GATT/WTO and that their sectors of key export interest (e.g., agriculture) still face heavy protectionism. This pattern of heterogeneity in concessions across development status could be explained by existing theories of trade agreements; see, for example, Bagwell and Staiger (2010, pp. 245–247) for a review. Basically, the two GATT/WTO principles of MFN and reciprocity actually facilitate this outcome, whereby if countries do not actively participate in trade negotiations/tariff reductions, other active players can engineer tariff bargains among themselves that minimize free-riding by third countries. Thus, by retaining domestic market access, the developing economies may also face more resistance expanding their export volumes.

We now evaluate whether the exchange of concessions further differ by the vintage of GATT/WTO membership. In particular, we split developing economies into those that joined the GATT/WTO before 1995 (OldDev) and those that joined the GATT/WTO after 1995 (NewDev). As the Uruguay Round (1986–1995) negotiation outcome imposed more disciplines on the developing economies, and new members' accession packages are subject to more scrutiny and demand from existing members, we may expect the extent of concessions given by the new members to be higher than the old developing members. In particular, we estimate the following alternative specification:

$$\begin{aligned} Concession_{ij}^{MA,n} =& \beta_1 * Ind\_Ind_{ij} + \beta_2 * OldDev\_Ind_{ij} + \beta_3 * NewDev\_Ind_{ij} \\ &+ \beta_4 * Ind\_OldDev_{ij} + \beta_5 * OldDev\_OldDev_{ij} + \beta_6 * NewDev\_OldDev_{ij} \\ &+ \beta_7 * Ind\_NewDev_{ij} + \beta_8 * OldDev\_NewDev_{ij} + \beta_9 * NewDev\_NewDev_{ij} \\ &+ \boldsymbol{\gamma}' Z_{ij} + FE_i + FE_j + \epsilon_{ij}, \end{aligned} \tag{1.21}$$

For each of the bilateral status variable $I^{exp}\_I^{imp}$, the indicator equals one if the exporter's status is I^{exp} and the importer's status is I^{imp}, and zero otherwise. For example,

$NewDev\_Ind_{ij}$ equals one if the exporter is a new developing member and the importer is an industrial member. The set of new developing members include: Bulgaria (1996), Latvia (1999), Estonia (1999), Croatia (2000), Lithuania (2001), China (2001), Taiwan (2002), Cambodia (2004), Vietnam (2007) and Russia (2012) with the year of joining the WTO in the parentheses.

Table 1.4 reports the estimation results of (1.21) for each year in 1995–2011. Consistent with the previous set of regression results, we find that industrial members provide more concessions to fellow industrial members than to old developing members throughout 1996–2011. Although we also observe this bias between industrial and new developing members in early years, the difference becomes statistically insignificant after 2003. That is, industrial members gave out just as much concessions to new developing members as to fellow industrial members in recent years since 2003. In contrast, old developing members' concessions given to the industrial members continue to dominate those given to fellow developing members (old or new), without significant difference between their concessions given to old and new developing members (except in 1999, 2003 and 2004). Similarly, new developing members' concessions given to the industrial members tend to dominate those given to fellow developing members (old or new), without systematic difference between their concessions given to old and new developing members.

Next, given the exporter's development status, we find that industrial members granted significantly more concessions than new developing members to old and new developing members (2001 and 2003 onwards, respectively). The difference in their concessions granted is not significant, however, with respect to industrial trading partners (except in 2006 and 2007). This in some sense implies that new developing members are almost on par with industrial members in the extent of their concessions, especially with respect to the export interest of industrial members. Furthermore, comparing the normalized concession granted by old and new developing members, we find new developing members to provide more concessions than old developing members (to all three categories of exporters, although the difference is not always significant across years). For example, estimation results show that coefficient of Ind_NewDev is larger than that of Ind_OldDev typically. This aligns with the notion that new developing members have participated more actively in tariff cut negotiations than old developing members. In reciprocity, new developing members have received more concessions from industrial members as discussed in the previous paragraph.

1.6 Conclusion

Despite its initial success, the WTO's efficacy to sustain cooperation in multilateral trade liberalization has been increasingly questioned by academics, politicians, and policy makers alike. Concerns have been raised as to whether the exchange of concessions among members continue to be balanced, when the world economic structure has undergone significant changes in the last few decades. In particular, developing economies' weight in the world trade has grown substantially. Tariff structures deemed appropriate by participating members in 1995 might have become grotesquely out of line decades later when the relative market size of trading partners switched in proportions.

In this paper, we characterize the concession of WTO members across years during 1995–2011, and decompose the concessions into variations due to changes in trade imbalance, applied tariff rates, and market size. We show that the overall concessions across all economies have increased in general over the years, and largely due to the expansion in market size. Although initially the industrialized economies as a whole granted more concessions to the rest of the world, by 2002, the balance has tilted such that the developing economies now offered more concessions than they received in return and remained to be the case afterwards. In addition to the growth in developing economies' market size, more tariff reductions undertaken by developing economies (especially the new members) after 2000 have contributed to this switch in the balance of concessions in market access.

Among the industrialized economies, the US indeed was a net benefactor of concessions (more so in terms of welfare than market access) during the period of study, although a large part of these were due to its large trade deficits. Absent the trade deficits, its net concessions have decreased over the years. China, on the other hand, has remained more or less in balance of the concessions it offered and received (but for the increasing trade surplus effect in recent years that reduced its net concession position). In terms of welfare concession, China's net position has improved steadily. Starting out as a net welfare beneficiary of the world trade system, China has closed up its negative position substantially by 2011. Although overall China's concessions have increased over time, the concessions it received from the US and EU grew even faster and exceeded what it granted in return. This might help to explain the growing tensions between China and these two major economies in recent years.

By adopting estimation specifications that account for country (market) size, we find that the normalized degree of market access concessions aligns well with the pattern of trade negotiations under the GATT/WTO. In particular, the developing economies have been given more exemptions in liberalizing their import restrictions despite their membership in the GATT/WTO. This is notably the case for developing members that were part of the regime prior to 1995. In return, the pattern of negotiated trade liberalization has systematically biased toward industrial economies, which provided more concessions than developing economies to either industrial or developing economies, but also received more concessions from either types of trading partners. A further decomposition by the vintage of the GATT/WTO membership among the developing economies, however, shows that the extent of concessions given by new members were higher than old members and matched nearly those of industrial economies, especially after 2002. In reciprocity, they also have received more concessions than old developing members from industrial member economies.

Some remarks are in order. In this paper, we have abstracted away from the endogeneity of trade imbalance and adopted draconian assumptions about its behavior as the tariffs change (such as proportionality with respect to world output). This is less than ideal and a dynamic trade model that takes into account inter-temporal consumption choice might help address potential distortions to the quantitative evaluations. Second, in calculating optimal tariffs, we have assumed national governments to behave benevolently and maximize aggregate welfare. The presence of political economy could very well alter the endogenous optimal tariffs and the perceived concessions by each national government. Nonetheless, it is debatable whether we should adopt the optimal tariffs or the politically endogenous tariffs as the benchmark in measuring a country's market access concessions, because domestic political economy (and hence the politically endogenous tariff) is not always observable and credible to trading partners, when the nations compare the exchange of concessions in trade negotiations.

1.7 Tables

Table 1.1: Country List

OECD Economies			Non-OECD Economies		
ISO	Country Name	Region	ISO	Country Name	Region
AUS	Australia	East Asia and Pacific	ARG	Argentina	Latin America
AUT	Austria	Europe and Central Asia	BGR	Bulgaria	Europe and Central Asia
BEL	Belgium	Europe and Central Asia	BRA	Brazil	Latin America
CAN	Canada	North America	BRN	Brunei Darussalam	East Asia and Pacific
CHL	Chile	Latin America	CHN	China	East Asia and Pacific
CZE	Czech Republic	Europe and Central Asia	COL	Colombia	Latin America
DNK	Denmark	Europe and Central Asia	CRI	Costa Rica	Latin America
EST	Estonia	Europe and Central Asia	CYP	Cyprus	Europe and Central Asia
FIN	Finland	Europe and Central Asia	HKG	Hong Kong SAR	East Asia and Pacific
FRA	France	Europe and Central Asia	HRV	Croatia	Europe and Central Asia
DEU	Germany	Europe and Central Asia	IDN	Indonesia	East Asia and Pacific
GRC	Greece	Europe and Central Asia	IND	India	South Asia†
HUN	Hungary	Europe and Central Asia	KHM	Cambodia	East Asia and Pacific
ISL	Iceland	Europe and Central Asia	LTU	Lithuania	Europe and Central Asia
IRL	Ireland	Europe and Central Asia	MLT	Malta	Middle East and North Africa
ISR	Israel	Middle East and North Africa	MYS	Malaysia	East Asia and Pacific
ITA	Italy	Europe and Central Asia	MAR	Morocco	Middle East and North Africa
JPN	Japan	East Asia and Pacific	PER	Peru	Latin America
KOR	Korea	East Asia and Pacific	PHL	Philippines	East Asia and Pacific
LVA	Latvia	Europe and Central Asia	ROU	Romania	Europe and Central Asia
LUX	Luxembourg	Europe and Central Asia	RUS	Russian Federation	Europe and Central Asia
MEX	Mexico	North America	SAU	Saudi Arabia	Middle East and North Africa
NLD	Netherlands	Europe and Central Asia	SGP	Singapore	East Asia and Pacific
NZL	New Zealand	East Asia and Pacific	THA	Thailand	East Asia and Pacific
NOR	Norway	Europe and Central Asia	TUN	Tunisia	Middle East and North Africa
POL	Poland	Europe and Central Asia	TWN	Taiwan	East Asia and Pacific
PRT	Portugal	Europe and Central Asia	VNM	Vietnam	East Asia and Pacific
SVK	Slovak Republic	Europe and Central Asia	ZAF	South Africa	Sub-Saharan Africa
SVN	Slovenia	Europe and Central Asia	ROW	Rest of the world	Rest of the World
ESP	Spain	Europe and Central Asia			
SWE	Sweden	Europe and Central Asia			
CHE	Switzerland	Europe and Central Asia			
TUR	Turkey	Europe and Central Asia			
GBR	United Kingdom	Europe and Central Asia			
USA	United States	North America			

Note: †India is the only economy in South Asia that is separately reported in TiVA.

Table 1.2: Sector classification and trade elasticity estimate

Sector	TiVA Industry Code	ISIC Rev 3	Sector Description	Trade Elasticity
1	C01T05AGR	01-05	Agriculture, hunting, forestry and fishing	0.45
2	C10T14MIN	10-14	Mining and quarrying	0.80
3	C15T16FOD	15-16	Food products, beverages and tobacco	0.68
4	C17T19TEX	17-19	Textiles, textile products, leather and footwear	1.18
5	C20WOD	20	Wood and products of wood and cork	4.57
6	C21T22PAP	21-22	Pulp, paper, paper products, printing and publishing	5.15
7	C23PET	23	Coke, refined petroleum products and nuclear fuel	0.32
8	C24CHM	24	Chemicals and chemical products	2.89
9	C25RBP	25	Rubber and plastics products	2.02
10	C26NMM	26	Other non-metallic mineral products	2.13
11	C27MET	27	Basic metals	2.38
12	C28FBM	28	Fabricated metal products	0.49
13	C29MEQ	29	Machinery and equipment, nec	1.98†
14	C30T33XCEQ	30-33	Computer, Electronic and optical equipment	1.98†
15	C31ELQ	31	Electrical machinery and apparatus, nec	1.98†
16	C34MTR	34	Motor vehicles, trailers and semi-trailers	1.98†
17	C35TRQ	35	Other transport equipment	2.68
18	C36T37OTM	36-37	Manufacturing nec; recycling	1.98†
19	C40T41EGW	40-41	Electricity, gas and water supply	10.00‡
20	C45CON	45	Construction	NA§
	C50T52WRT	50-52	Wholesale and retail trade; repairs	
	C55HTR	55	Hotels and restaurants	
	C60T63TRN	60-63	Transport and storage	
	C64PTL	64	Post and telecommunications	
	C65T67FIN	65-67	Financial intermediation	
	C70REA	70	Real estate activities	
	C71RMQ	71	Renting of machinery and equipment	
	C72ITS	72	Computer and related activities	
	C73T74OBZ	73-74	R&D and other business activities	
	C75GOV	75	Public admin. and defence; compulsory social security	
	C80EDU	80	Education	
	C85HTH	85	Health and social work	
	C90T93OTS	90-93	Other community, social and personal services	
	C95PVH	95	Private households with employed persons	

Note: The table reports the classification of sectors used in the study. The trade elasticity is estimated based on the approach of Caliendo and Parro (2015), corresponding to the regression coefficient of trade flows (in ratios) to tariff variations (in ratios). †The elasticity estimates for these sectors are negative, and are replaced by the mean across sectors with positive elasticity estimates. ‡The elasticity estimate for this sector is negative, and is replaced by a large number (10). The choice is based on the consideration that trade flows and tariffs are sparse in this sector. Using a large elasticity value mutes the optimal tariff consideration in this sector and neutralizes its role in the analysis. §Tariffs (which are required for the elasticity estimation) are not observed for these sectors.

Table 1.3: Asymmetry in Bilateral Market Access Concession across Development Status

Year	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Panel A: Estimation Results (Dependent Variable — $Concession_{ij}^{MA,n}$)																	
Ind_Ind	0.984***	0.892***	0.928***	0.967***	1.038***	0.944***	1.021***	1.223***	1.443***	1.434***	1.539***	2.022***	1.898***	1.926***	1.967***	1.561***	1.646***
	(0.102)	(0.0998)	(0.0989)	(0.101)	(0.0968)	(0.0857)	(0.0899)	(0.0877)	(0.0973)	(0.120)	(0.115)	(0.127)	(0.132)	(0.124)	(0.123)	(0.128)	(0.122)
Dev_Ind	0.887***	0.755***	0.714***	0.815***	0.860***	0.758***	0.816***	1.006***	1.146***	1.185***	1.386***	1.845***	1.663***	1.774***	1.812***	1.392***	1.464***
	(0.104)	(0.104)	(0.105)	(0.104)	(0.101)	(0.0901)	(0.0928)	(0.0899)	(0.0975)	(0.125)	(0.117)	(0.129)	(0.136)	(0.129)	(0.126)	(0.136)	(0.127)
Ind_Dev	0.781***	0.850***	0.852***	0.828***	0.866***	0.762***	0.854***	1.048***	1.260***	1.255***	1.411***	1.871***	1.748***	1.780***	1.749***	1.356***	1.448***
	(0.0957)	(0.0933)	(0.0937)	(0.0972)	(0.0923)	(0.0804)	(0.0860)	(0.0830)	(0.0925)	(0.122)	(0.116)	(0.125)	(0.136)	(0.126)	(0.122)	(0.129)	(0.119)
Dev_Dev	0.737***	0.706***	0.660***	0.685***	0.649***	0.532***	0.619***	0.797***	0.935***	0.914***	1.143***	1.581***	1.382***	1.494***	1.479***	1.123***	1.197***
	(0.102)	(0.101)	(0.103)	(0.104)	(0.101)	(0.0896)	(0.0949)	(0.0891)	(0.0987)	(0.131)	(0.123)	(0.134)	(0.143)	(0.134)	(0.129)	(0.140)	(0.129)
Method	Tobit	Tobit	Tobit	Tobit	Tobit	Tobit	Tobit	Tobit	Tobit	Tobit	Tobit	Tobit	Tobit	Tobit	Tobit	Tobit	Tobit
Exporter FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Importer FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Trade Cost Variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,256	2,256	2,256	2,256	2,256	2,256	2,256	2,256	2,256	1,406	1,406	1,406	1,260	1,260	1,260	1,260	1,260
Panel B: Hypothesis Test of H_0																	
Ind_Ind = Dev_Ind	0.140	0.028	0.001	0.019	0.007	0.002	0.001	0.000	0.000	0.000	0.020	0.009	0.001	0.021	0.021	0.020	0.007
Ind_Dev = Dev_Dev	0.395	0.005	0.001	0.007	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Ind_Ind = Ind_Dev	0.000	0.429	0.134	0.005	0.001	0.000	0.001	0.000	0.000	0.000	0.016	0.004	0.008	0.007	0.000	0.001	0.000
Dev_Ind = Dev_Dev	0.001	0.231	0.157	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Notes for Panel A: Tobit estimation of equation (1.20). The dependent variable $Concession_{ij}^{MA,n} \equiv Concession_{ij}^{MA} / \max Concession_{ij}^{MA}$ indicates the extent of concession importing country j grants to exporting country i, as a fraction of its maximum possible concession. Countries are classified into two development status: industrial countries (IND) and developing countries (Dev). For each of the bilateral development status variable $I^{exp}\_I^{imp}$, the indicator equals one if the exporter's status is I^{exp} and the importer's status is I^{imp}, and zero otherwise. The list of trade cost proxy variables included are: bilateral distance, common language, common currency, colonial relationship and contiguity. Significance: *** (1%), ** (5%), and * (10%). Note for Panel B: The p-value statistics for the tests are shown in Panel B.

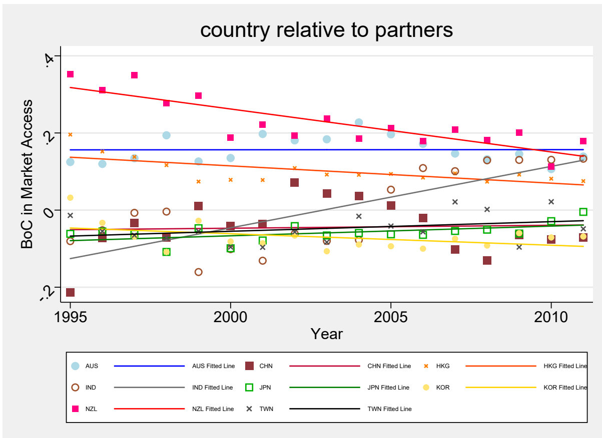
Table 1.4: Asymmetry in Bilateral Market Access Concession across Development Status and GATT/WTO Membership Vintage

Year	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Panel A: Estimation Results (Dependent Variable — $Concession_{ij}^{MA,n}$)																	
Ind_Ind	0.989***	0.898***	0.933***	0.968***	1.040***	0.943***	1.024***	1.224***	1.440***	1.436***	1.539***	2.017***	1.892***	1.913***	1.959***	1.554***	1.641***
	(0.101)	(0.0993)	(0.0986)	(0.101)	(0.0966)	(0.0850)	(0.0894)	(0.0874)	(0.0972)	(0.121)	(0.115)	(0.127)	(0.132)	(0.124)	(0.122)	(0.129)	(0.123)
OldDev_Ind	0.906***	0.779***	0.728***	0.828***	0.867***	0.773***	0.831***	1.016***	1.145***	1.171***	1.367***	1.813***	1.634***	1.739***	1.772***	1.361***	1.442***
	(0.104)	(0.103)	(0.105)	(0.104)	(0.101)	(0.0903)	(0.0925)	(0.0902)	(0.0985)	(0.126)	(0.118)	(0.130)	(0.137)	(0.129)	(0.126)	(0.137)	(0.128)
NewDev_Ind	0.800***	0.761***	0.795***	0.807***	0.952***	0.775***	0.873***	1.057***	1.316***	1.382***	1.517***	1.970***	1.854***	1.886***	1.997***	1.600***	1.614***
	(0.105)	(0.106)	(0.106)	(0.108)	(0.0999)	(0.0902)	(0.0965)	(0.0928)	(0.0966)	(0.120)	(0.112)	(0.125)	(0.130)	(0.122)	(0.122)	(0.130)	(0.119)
Ind_OldDev	0.793***	0.859***	0.855***	0.833***	0.869***	0.756***	0.848***	1.041***	1.250***	1.255***	1.414***	1.868***	1.755***	1.786***	1.751***	1.361***	1.449***
	(0.0955)	(0.0931)	(0.0937)	(0.0974)	(0.0927)	(0.0806)	(0.0863)	(0.0836)	(0.0921)	(0.122)	(0.116)	(0.125)	(0.136)	(0.126)	(0.122)	(0.129)	(0.119)
OldDev_OldDev	0.738***	0.706***	0.666***	0.682***	0.650***	0.526***	0.622***	0.798***	0.933***	0.925***	1.152***	1.582***	1.384***	1.480***	1.482***	1.120***	1.197***
	(0.103)	(0.101)	(0.104)	(0.104)	(0.101)	(0.0893)	(0.0947)	(0.0890)	(0.0986)	(0.131)	(0.123)	(0.134)	(0.143)	(0.134)	(0.128)	(0.139)	(0.129)
NewDev_OldDev	0.688***	0.769***	0.763***	0.716***	0.757***	0.608***	0.711***	0.875***	1.114***	1.044***	1.199***	1.621***	1.478***	1.531***	1.533***	1.235***	1.284***
	(0.0948)	(0.0932)	(0.0974)	(0.102)	(0.0909)	(0.0827)	(0.0900)	(0.0837)	(0.0964)	(0.122)	(0.113)	(0.126)	(0.131)	(0.122)	(0.119)	(0.128)	(0.117)
Ind_NewDev	0.920***	0.897***	0.940***	0.937***	1.042***	0.968***	0.975***	1.176***	1.340***	1.406***	1.497***	1.910***	1.678***	1.847***	1.901***	1.471***	1.586***
	(0.0978)	(0.101)	(0.0974)	(0.0991)	(0.0932)	(0.0867)	(0.0874)	(0.0831)	(0.102)	(0.124)	(0.110)	(0.118)	(0.133)	(0.117)	(0.116)	(0.123)	(0.116)
OldDev_NewDev	0.888***	0.758***	0.730***	0.806***	0.828***	0.726***	0.706***	0.901***	0.994***	1.058***	1.233***	1.639***	1.357***	1.640***	1.666***	1.289***	1.361***
	(0.104)	(0.106)	(0.107)	(0.106)	(0.103)	(0.0974)	(0.0959)	(0.0882)	(0.102)	(0.127)	(0.118)	(0.127)	(0.140)	(0.124)	(0.122)	(0.131)	(0.123)
NewDev_NewDev	0.886***	0.862***	0.890***	0.847***	0.957***	0.778***	0.820***	0.979***	1.146***	1.203***	1.304***	1.598***	1.418***	1.580***	1.660***	1.365***	1.397***
	(0.0995)	(0.101)	(0.103)	(0.105)	(0.0955)	(0.0915)	(0.0930)	(0.0852)	(0.101)	(0.121)	(0.111)	(0.122)	(0.132)	(0.118)	(0.115)	(0.124)	(0.114)
Method	Tobit	Tobit	Tobit	Tobit	Tobit	Tobit	Tobit	Tobit	Tobit	Tobit	Tobit	Tobit	Tobit	Tobit	Tobit	Tobit	Tobit
Exporter FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Importer FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Trade Cost Variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,256	2,256	2,256	2,256	2,256	2,256	2,256	2,256	2,256	1,406	1,406	1,406	1,260	1,260	1,260	1,260	1,260
Panel B: Hypothesis Test of H_0																	
Ind_Ind = OldDev_Ind	0.210	0.060	0.003	0.033	0.010	0.005	0.002	0.001	0.000	0.000	0.009	0.003	0.000	0.008	0.005	0.008	0.003
Ind_Ind = NewDev_Ind	0.008	0.044	0.042	0.021	0.171	0.005	0.022	0.009	0.067	0.437	0.730	0.495	0.562	0.621	0.538	0.507	0.628
OldDev_Ind = NewDev_Ind	0.152	0.806	0.381	0.775	0.247	0.976	0.551	0.549	0.010	0.007	0.033	0.038	0.006	0.030	0.002	0.004	0.012
Ind_OldDev = OldDev_OldDev	0.302	0.004	0.001	0.005	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Ind_OldDev = NewDev_OldDev	0.038	0.057	0.071	0.025	0.021	0.000	0.002	0.000	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.013	0.000
OldDev_OldDev = NewDev_OldDev	0.412	0.298	0.156	0.585	0.089	0.139	0.140	0.182	0.002	0.086	0.446	0.561	0.177	0.414	0.440	0.112	0.155
Ind_NewDev = OldDev_NewDev	0.585	0.017	0.001	0.023	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.000	0.008	0.000
Ind_NewDev = NewDev_NewDev	0.565	0.539	0.398	0.128	0.126	0.000	0.002	0.000	0.000	0.003	0.000	0.000	0.000	0.000	0.000	0.105	0.001
OldDev_NewDev = NewDev_NewDev	0.973	0.118	0.027	0.549	0.058	0.373	0.068	0.190	0.012	0.053	0.287	0.573	0.452	0.415	0.939	0.354	0.610
Ind_Ind = Ind_NewDev	0.366	0.994	0.925	0.656	0.972	0.714	0.444	0.389	0.156	0.643	0.480	0.082	0.000	0.251	0.281	0.171	0.352
OldDev_Ind = OldDev_NewDev	0.792	0.763	0.973	0.725	0.512	0.434	0.021	0.010	0.011	0.039	0.010	0.001	0.000	0.062	0.025	0.172	0.112
NewDev_Ind = NewDev_NewDev	0.262	0.191	0.171	0.572	0.944	0.968	0.406	0.168	0.010	0.006	0.001	0.000	0.000	0.000	0.000	0.001	0.001
Ind_OldDev = Ind_NewDev	0.057	0.569	0.155	0.086	0.003	0.000	0.023	0.003	0.151	0.016	0.140	0.451	0.204	0.290	0.003	0.043	0.006
OldDev_OldDev = OldDev_NewDev	0.023	0.418	0.275	0.038	0.002	0.001	0.123	0.011	0.295	0.021	0.146	0.287	0.651	0.005	0.000	0.001	0.001
NewDev_OldDev = NewDev_NewDev	0.003	0.157	0.035	0.034	0.001	0.004	0.055	0.022	0.609	0.013	0.084	0.705	0.407	0.483	0.034	0.040	0.057

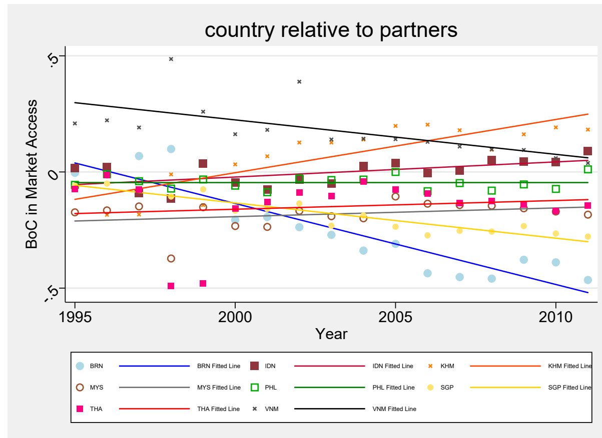
Note: See Table 1.3 footnote. Tobit estimation of equation (1.21). Countries are classified under three main categories: industrial countries (IND), developing countries that joined GATT/WTO before 1995 (OldDev) and developing countries that joined WTO after 1995 (NewDev). For each of the bilateral status variable $I^{exp}\_I^{imp}$, the indicator equals one if the exporter's status is I^{exp} and the importer's status is I^{imp}, and zero otherwise.

1.8 Figures

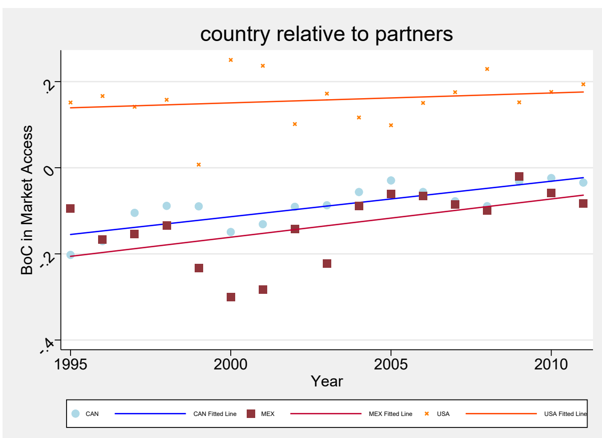
Figure 1.1: Balance of Market Access Concession (with trade imbalance)



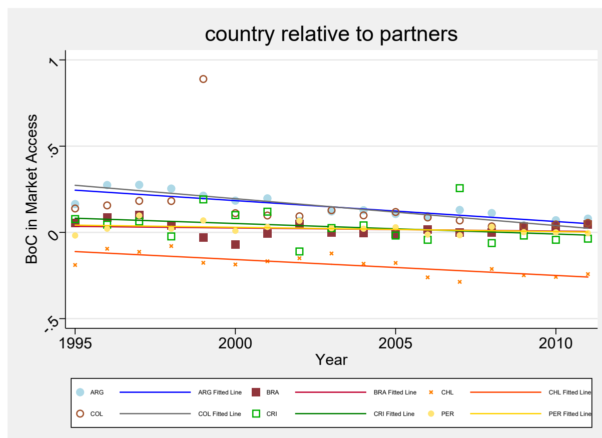
(a) East Asia and Pacific & South Asia



(b) Southeast Asia



(c) North America



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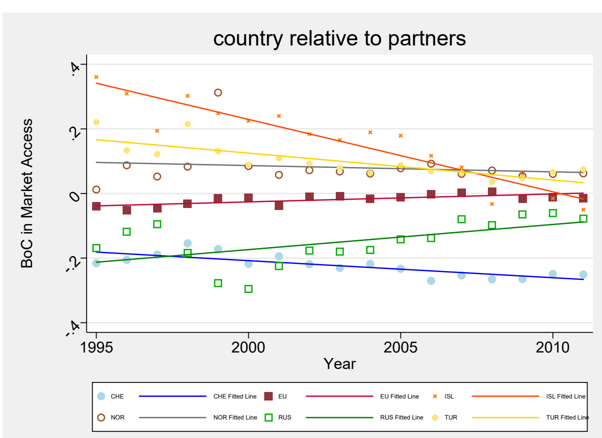
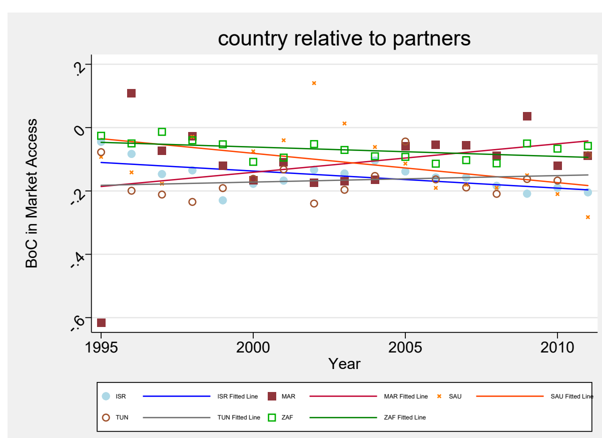
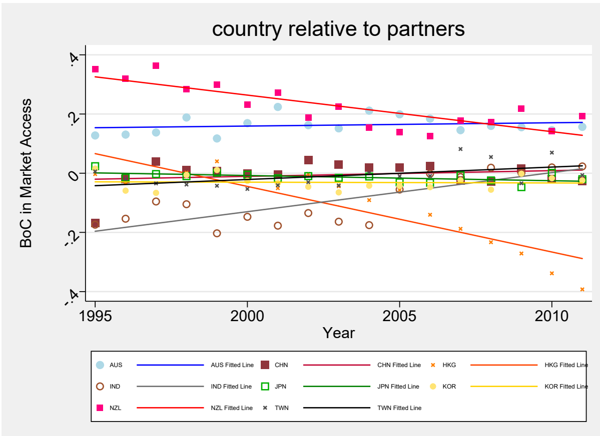


(e) Europe and Central Asia

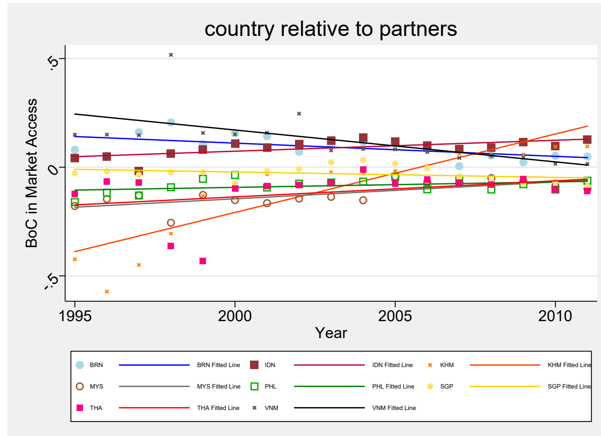


(f) Middle East and Africa

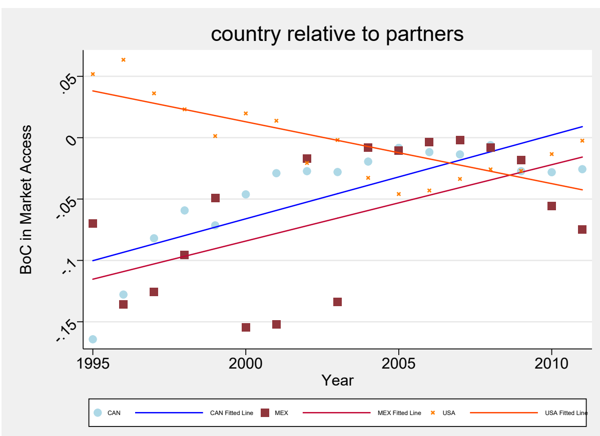
Figure 1.2: Balance of Market Access Concession



(a) East Asia and Pacific & South Asia



(b) Southeast Asia



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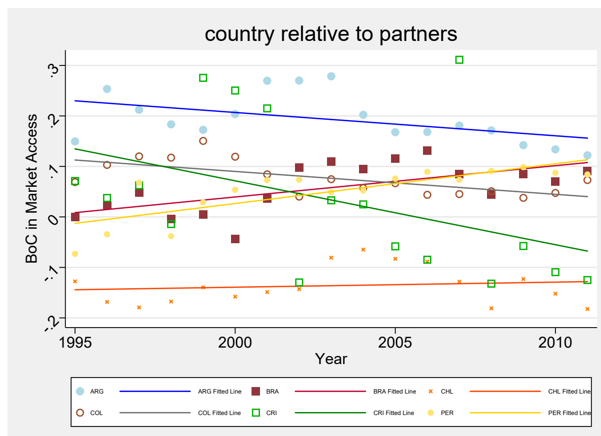
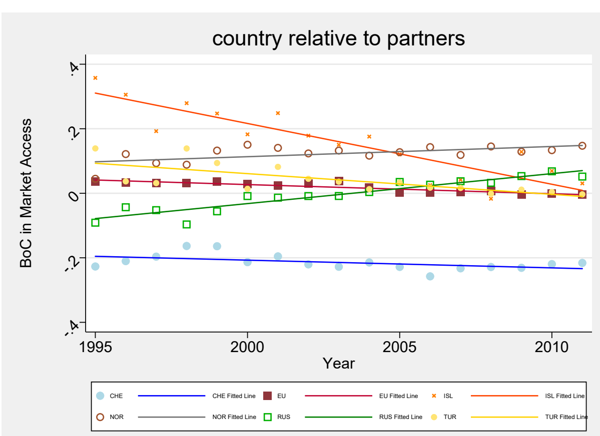
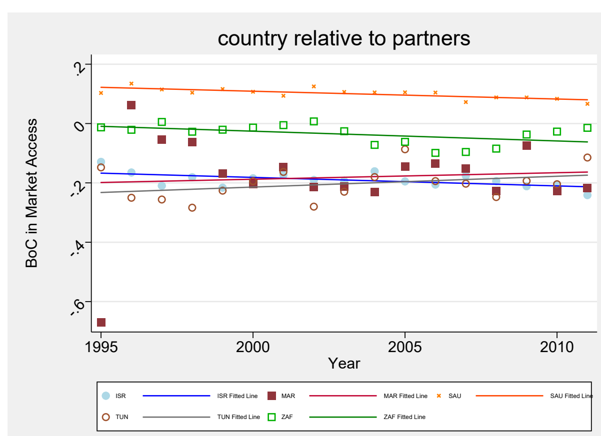


(d) Latin America

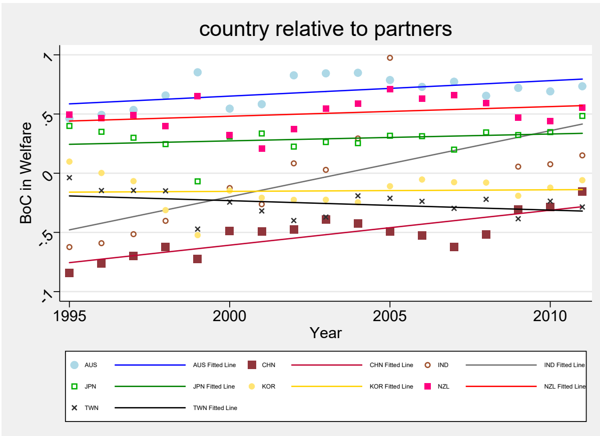


(e) Europe and Central Asia

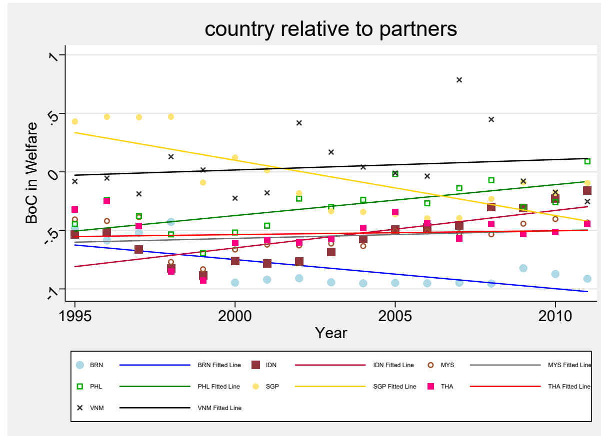


(f) Middle East and Africa

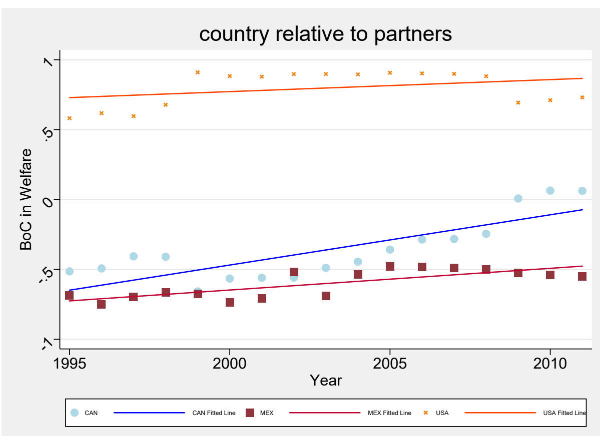
Figure 1.3: Balance of Welfare Concession (with trade imbalance)



(a) East Asia and Pacific & South Asia



(b) Southeast Asia



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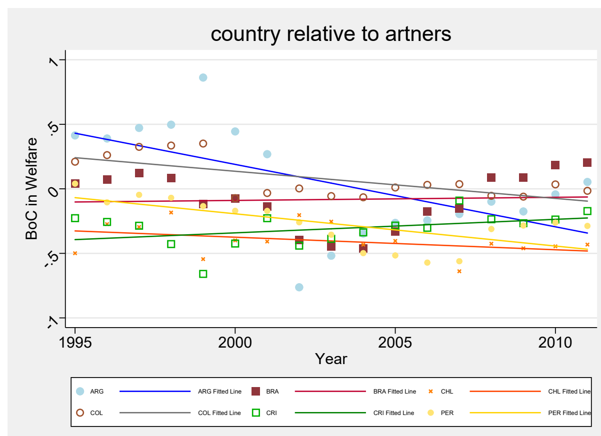
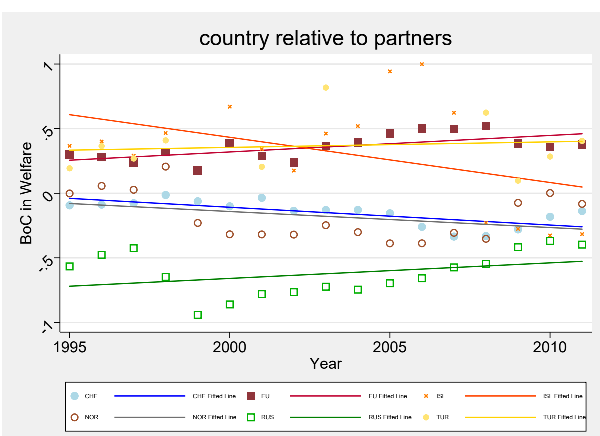
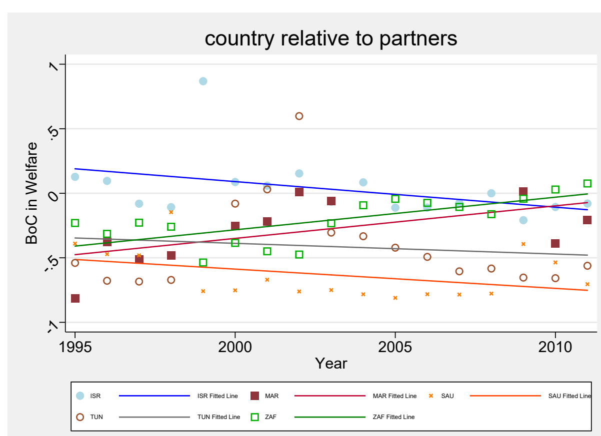


(d) Latin America

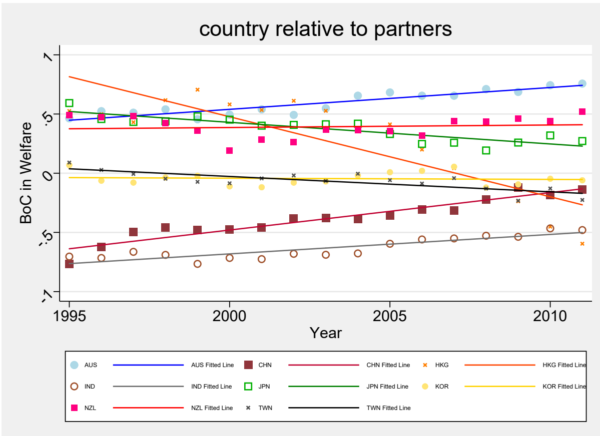


(e) Europe and Central Asia

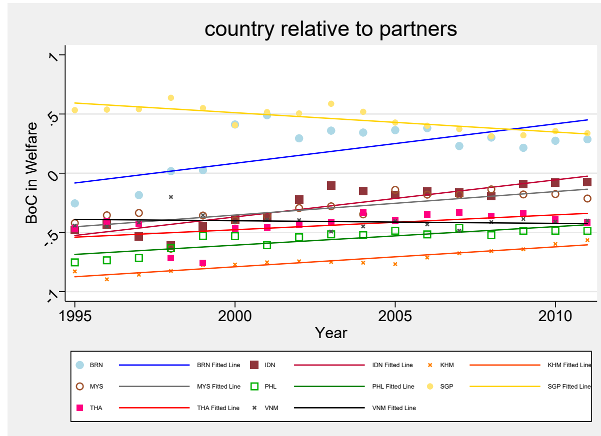


(f) Middle East and Africa

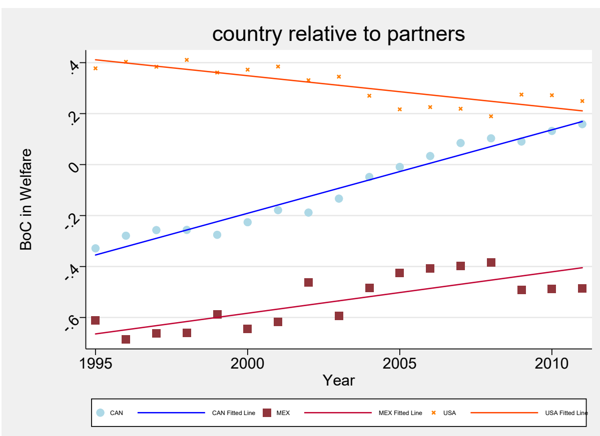
Figure 1.4: Balance of Welfare Concession



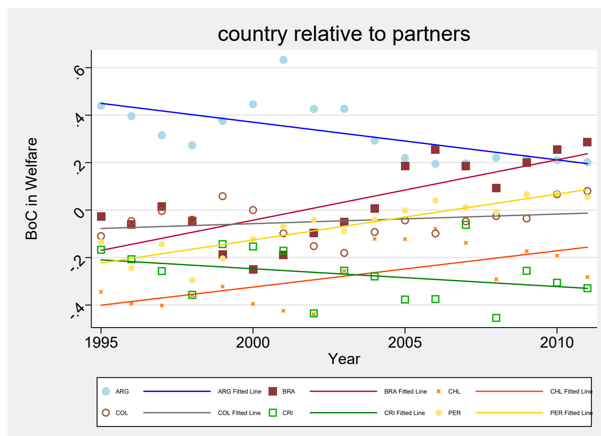
(a) East Asia and Pacific & South Asia



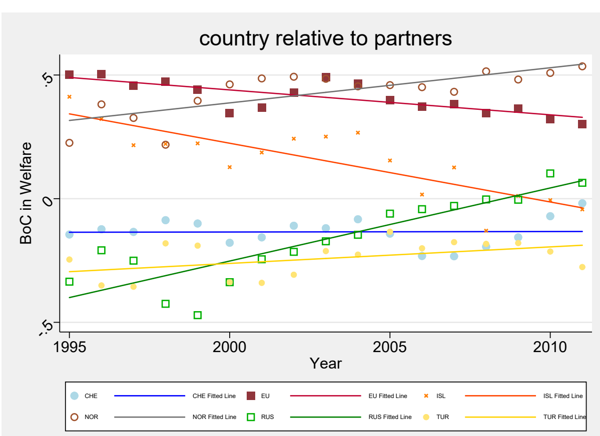
(b) Southeast Asia



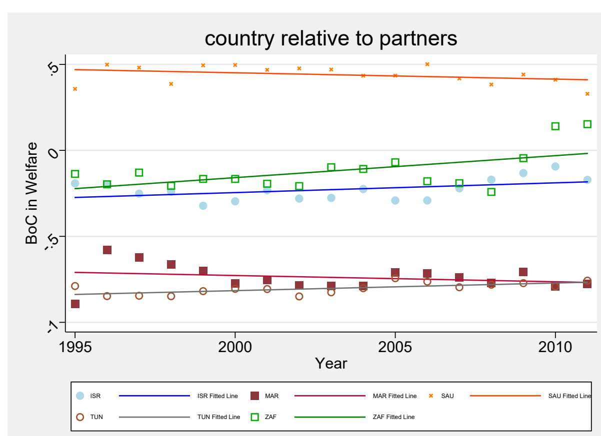
(c) North America



(d) Latin America

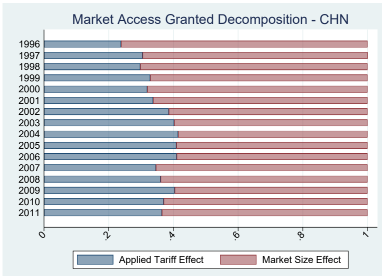


(e) Europe and Central Asia

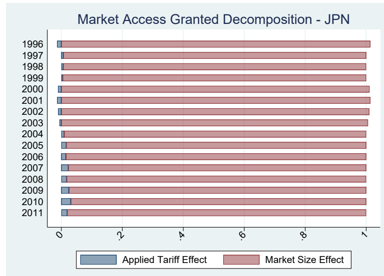


(f) Middle East and Africa

Figure 1.5: Decomposition of Market Access Concession



China



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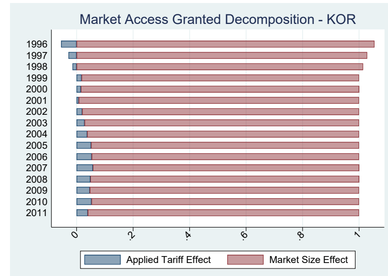
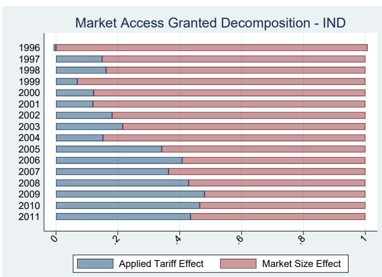


Korea



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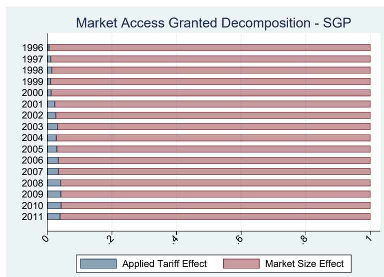
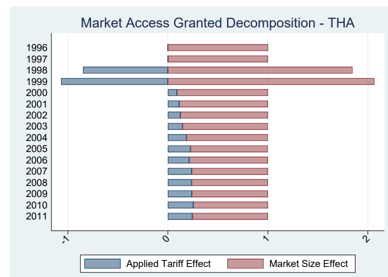
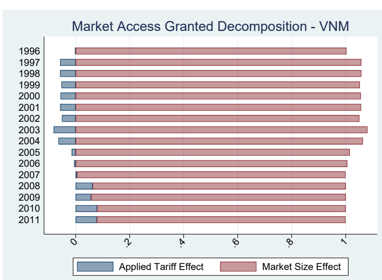


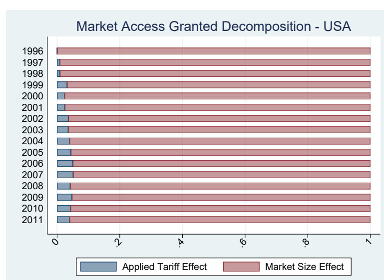
Singapore



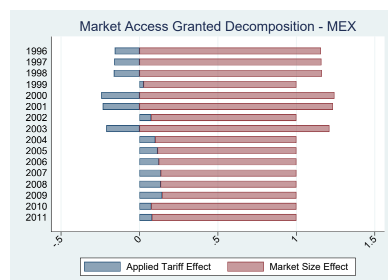
Thailand



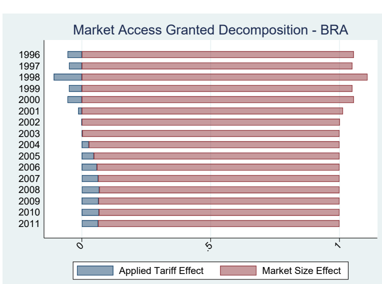
Vietnam



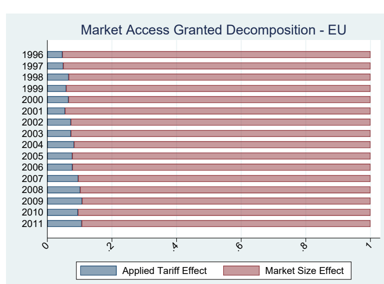
United States



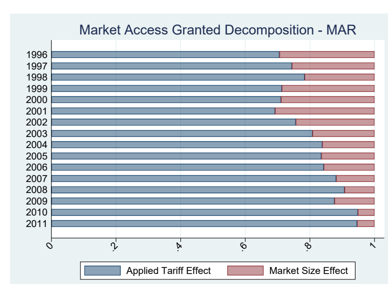
Mexico



Brazil

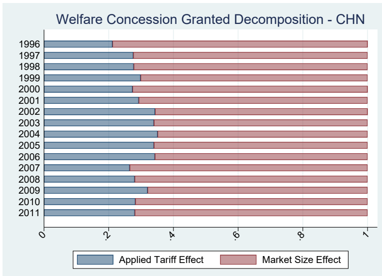


European Union

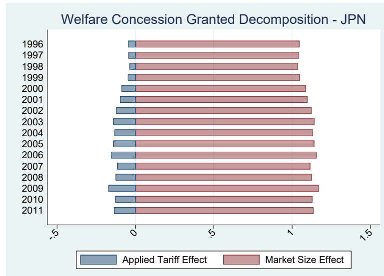


Morocco

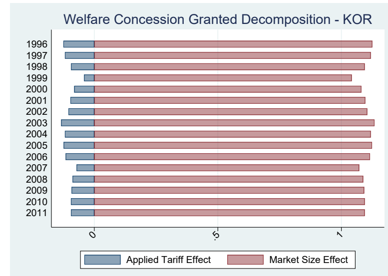
Figure 1.6: Decomposition of Welfare Concession



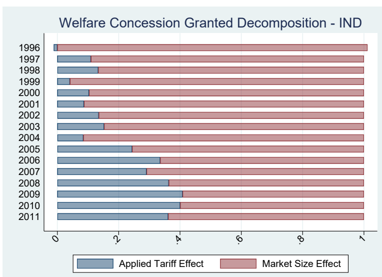
China



Japan



Korea



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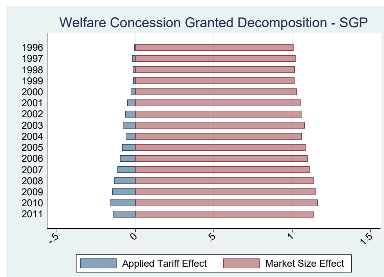
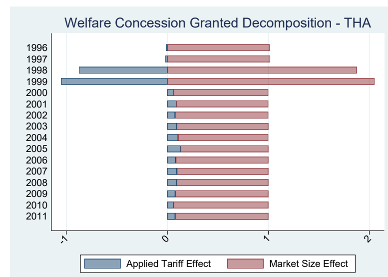
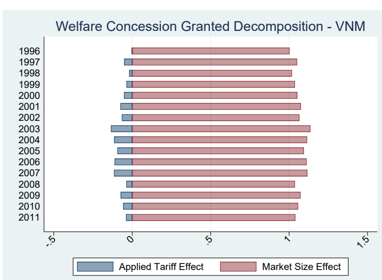


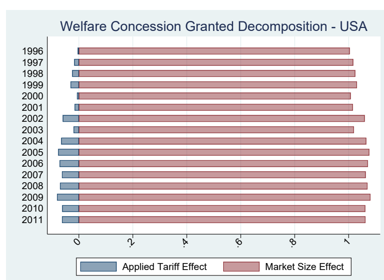
Singapore



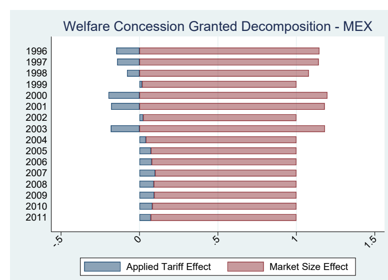
Thailand



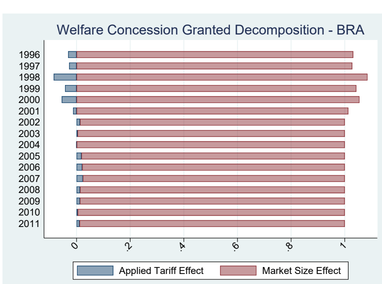
Vietnam



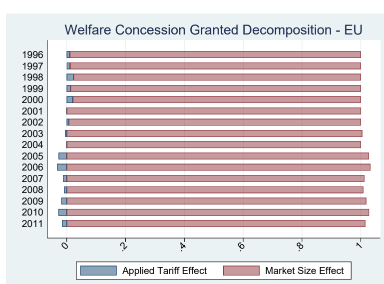
United States



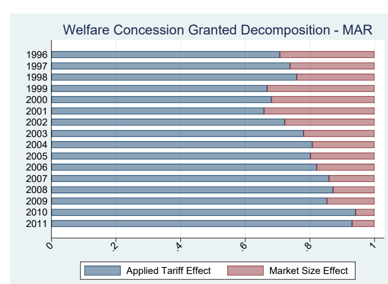
Mexico



Brazil

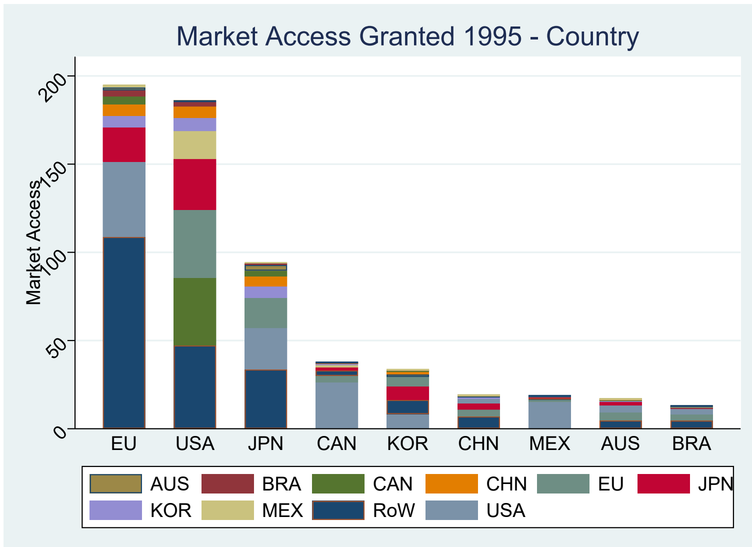


European Union

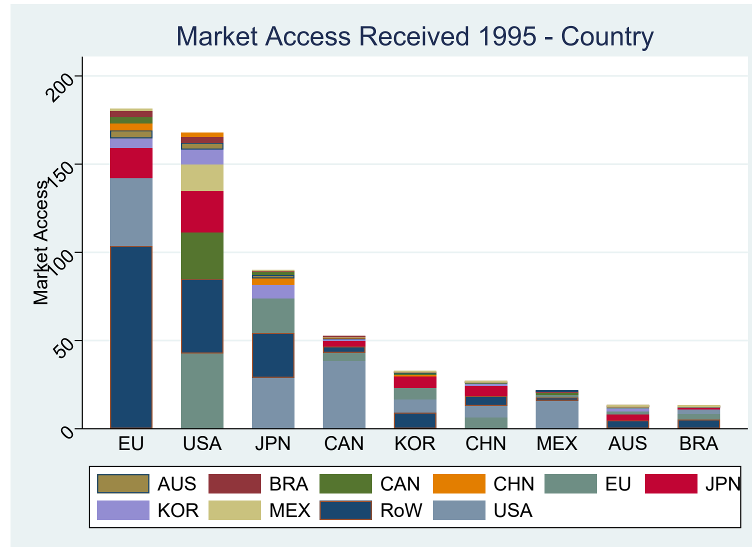


Morocco

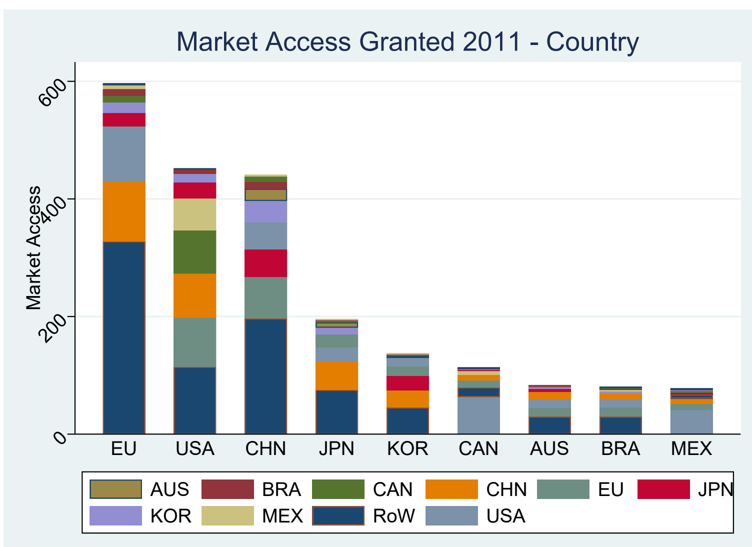
Figure 1.7: Market Access Granted and Received — Ranking



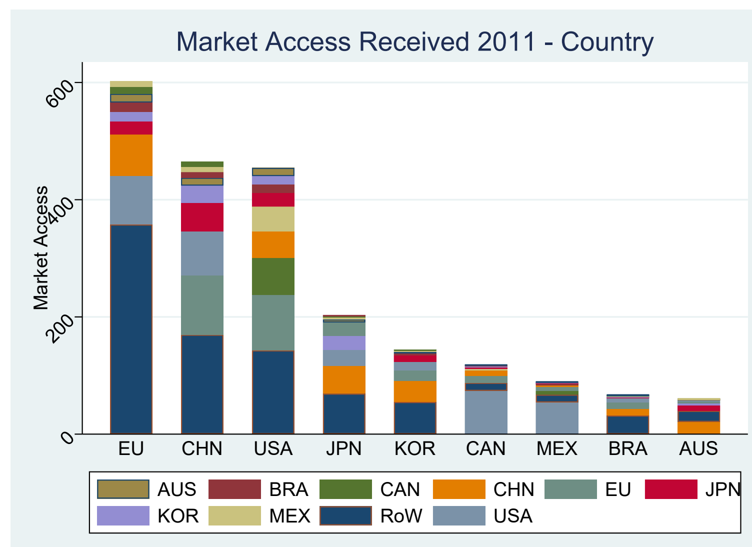
(a)



(b)



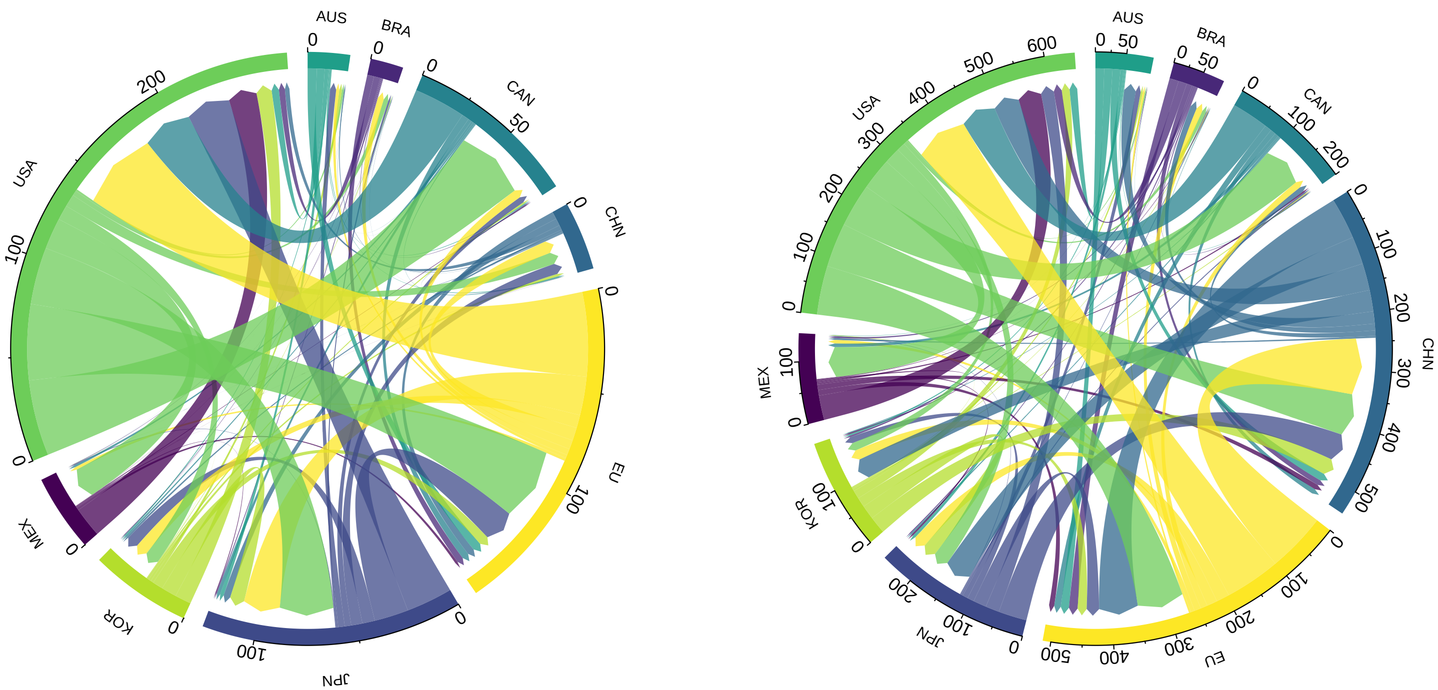
(c)



(d)

Note: The concessions are in billion US$.

Figure 1.8: Market Access Granted and Received — Network

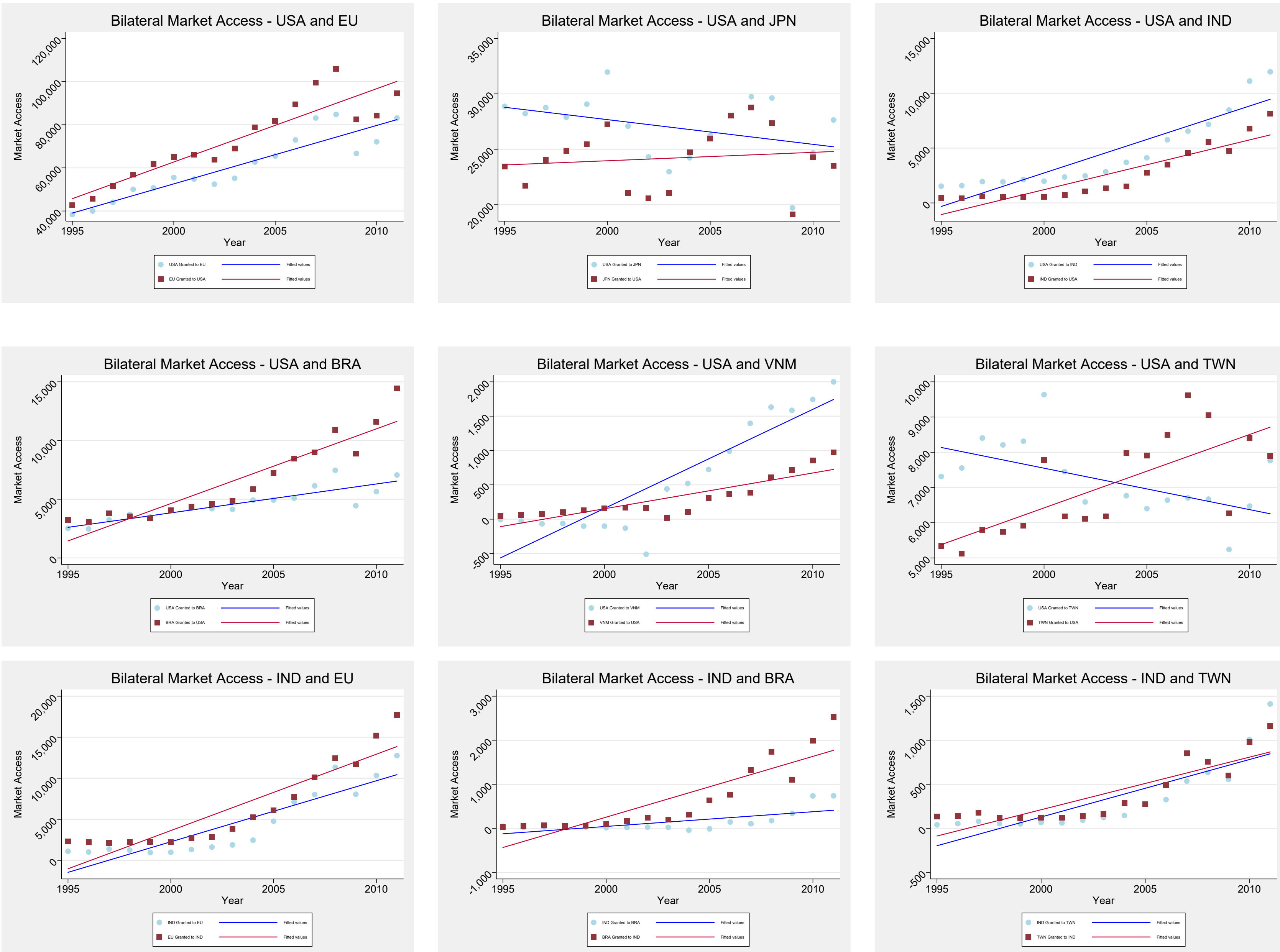


(a) 1995

(b) 2011

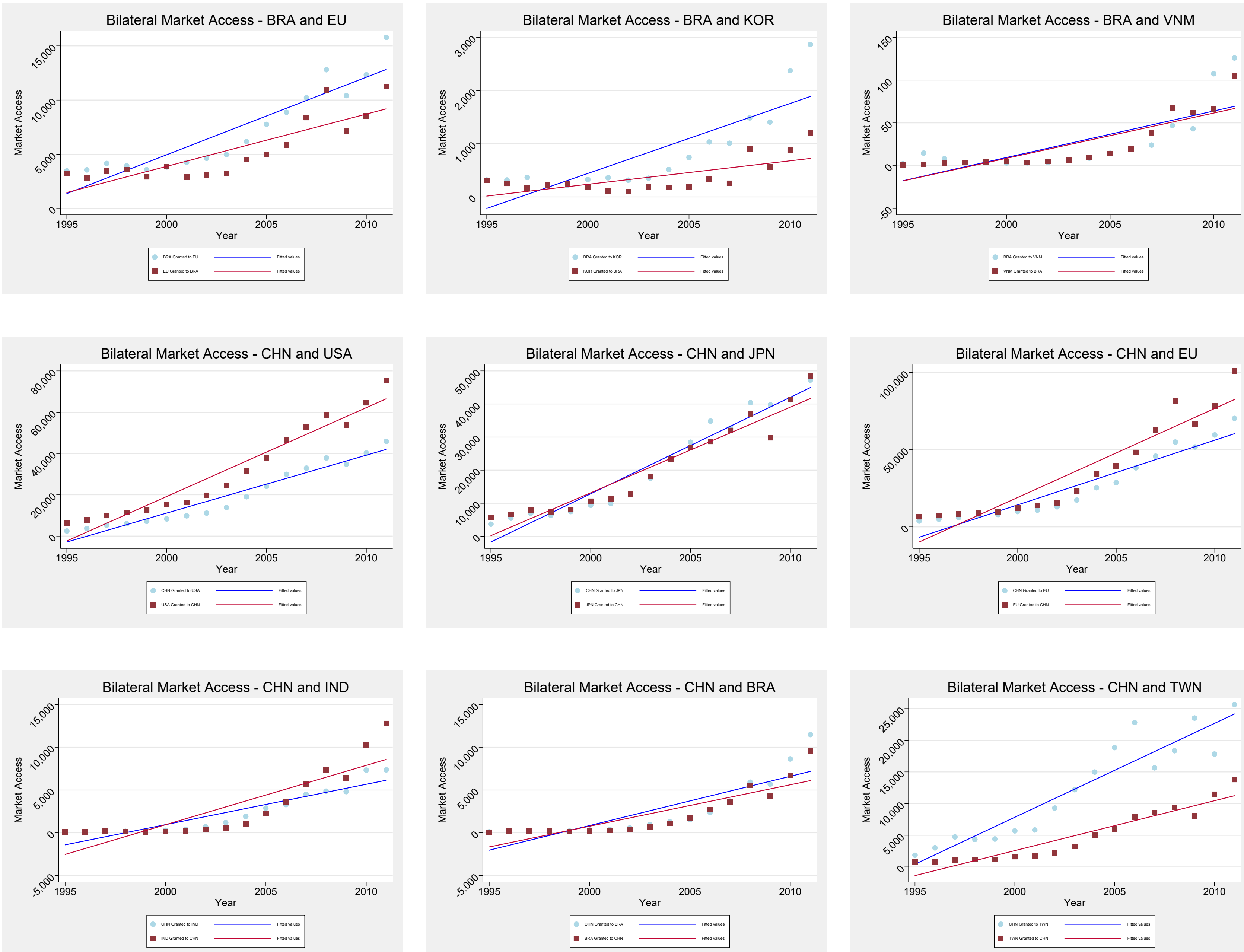
Note: The concessions are in billion US$.

Figure 1.9: Bilateral Market Access Concession — Part I



Note: The concessions are in million US$.

Figure 1.10: Bilateral Market Access Concession — Part II



Chapter Two

National Treatment, Product Likeness, and Trade Restrictiveness of Product Standards

Author: Renjing Chen, Yuan Mei, Shenxi Song

2.1 Introduction

Despite the on-going trade war between the United States and China, the world has observed substantial tariff reductions in the past decades due to successful multilateral and bilateral negotiations. The focus of modern trade negotiations has shifted toward reducing trade barriers associated with domestic regulations on products. The General Agreement on Tariffs and Trade (GATT) and its successor the World Trade Organization (WTO) discipline regulatory barriers to trade by the non-discrimination principle of national treatment. National treatment requires that, once imports have cleared customs and applicable tariffs have been collected, they must be treated the same as domestic products (Matsushita et al., 2006). Since the beginning of the GATT/WTO system, national treatment has been the baseline for regulatory integration among the majority of GATT/WTO members (Mavroidis, 2016).

The national treatment obligation is set forth in Article III of the GATT, which prohibit discrimination between imported and domestic "like" products. The term "like" does not require products to be identical. In fact, the Panel and Appellate Body of the GATT/WTO have routinely stated that determinations as to whether products are "like" should be made on a case-by-case basis. The importance of the determination of "like" products in the implementation of national treatment can be illustrated by a dispute case in WTO: *EC-Asbestos* (WT/DS135). Asbestos fibers had been widely used in the construction industry but inhalation of such fibers can lead to serious lung conditions. The French government banned the sale and importation of all asbestos-related products in 1996. However, Canada as a major producer and exporter of asbestos challenged the ban as a national treatment violation under Article III.4 of the GATT, despite the fact that both domestic and imported asbestos were both banned in France. Canada claimed that imported Canadian asbestos were banned whereas domestic French alternative fibers were permitted, and this differentiation between "like" products violates national treatment (Pauwelyn et al., 2016).

From the case of *EC-Asbestos*, we can see that the determination of "like" products is central to the administration of national treatment in order to discipline *de facto* discrimination using domestic regulations. The determination of "like" products and its role in the implementation of national treatment have attracted substantial attention from the international trade law literature and is considered "one of the thorniest in GATT/WTO jurisprudence" (Matsushita et al., 2006). However, we are not aware of any existing economic study that empirically examines the role of product likeness in regulatory barriers to trade.

In this paper, we provide the first empirical analysis that examines the relationship between product likeness and trade frictions arisen from non-tariff barriers. We hypothesize that, because of the way GATT/WTO disciplines regulatory protectionism, the determination of "like" products for more heterogeneous products leaves regulators more room for argument and interpretation. As a result, technical regulations on these products are more susceptible to become discriminatory policy tools against imports, hence creating more trade frictions. The empirical part of this paper is devoted to test this hypothesis.

We start by using the estimated elasticity of substitution in Soderbery (2018) to approximate product likeness at importer–four-digit Harmonized System (HS) level. Despite its novelty, our approach is actually consistent with existing policy and legal analysis on the role of "like" products. GATT/WTO and related legal studies have repeatedly emphasized the importance of competitive relationships in the determination of "like products" even though the dictionary definition of "like" is about similar characteristics and qualities. In the case of *EC-Asbestos*, for example, the report from the WTO's appellate body explicitly states that "..., the decisive criterion in order to determine whether two products are directly competitive or substitutable is whether they have common end-uses, *inter alia*, as shown by elasticity of substitution".

Next, using trade data from the World Integrated Trade Solution (WITS) database and non-tariff measures (NTMs) data from UNCTAD's TRAINS, we estimate the trade restrictiveness associated with technical barriers following the approach introduced in Kee et al. (2009). We find that larger trade restrictiveness associated with technical barriers, measured in terms of ad-valorem equivalents (AVEs), is observed in products and markets with smaller elasticity of substitution. In other words, technical regulations on more heterogeneous products create larger trade frictions, which is consistent with our hypothesis. This result is robust when different combinations of fixed effects and other trade policy controls are incorporated in the regressions.

Additional reduced-form analysis using more disaggregated firm-level data from China Customs Database provide similar results. In particular, we find that Chinese firms export less to destinations imposing NTMs, and these frictions associated with NTMs are stronger in destinations and products with lower elasticity of substitution. In addition, we find a similar effect in the extensive margin when we regress the number of exporting Chinese firms on NTMs and the interaction of NTMs and elasticity of substitution. These findings are robust even after we control for fixed effects at very disaggregated level.

Lastly, we also construct a two-country, two-sector model with firm heterogeneity to illustrate the role of product likeness under national treatment. In our model, product standards of the heterogeneous good are purely protectionist and raising standards can increase the marginal and fixed costs of production. Higher standards on imports reduce the sales of foreign firms, triggering entry of domestic firms and exit of foreign firms. Due to the presence of trade costs, this production relocation effect reduces the domestic price index but raises the price index in foreign countries, hence creating an international efficiency.[1] Even under national treatment, discrimination is possible due to the difficulty of determining "like" products. We show that, in the Nash equilibrium under national treatment, both countries will discriminate against foreign product using standards to the maximum extent, which depends on the elasticity of substitution of the heterogeneous product.

This paper complements existing works on WTO's non-discrimination principle national

[1]This effect was first systematically analyzed in the study of cooperative and non-cooperative tariffs in Ossa (2011). The term "production relocation" follows Ossa (2011) and Mei (2021), although Bagwell and Staiger (2015) and Grossman et al. (2021) use "delocation" to describe the same effect. These works all use a Krugman (1980)-style framework, but Ossa (2011) in the online appendix illustrates that production relocation of tariffs also exists in a model of firm heterogeneity.

treatment by providing the first empirical and theoretical analysis of regulatory protection that incorporates product likeness. The welfare effects of national treatment have been analyzed from a theoretical perspective in both partial equilibrium environment (Horn, 2006; Costinot, 2008; Geng, 2019) and in models featuring monopolistic competition (Grossman et al., 2021; Mei, 2021). Mei (2021) also quantitatively examines the welfare consequence of removing national treatment in a reasonably comprehensive multi-country, multi-sector trade model. Unlike our paper, these studies typically assume that product standards on imports and domestic products are equalized under national treatment, hence abstracting from the role of product likeness when analyzing the effects of NTMs.

Our work speaks to the growing empirical literature that examines the effects of NTMs on international trade using either publicly available product-level data (Essaji, 2008; Chen and Mattoo, 2008; Portugal-Perez et al., 2010; Yue, 2019) or more disaggregated firm-level data (Fontagne et al., 2015; Fontagné and Orefice, 2018; Schimidt and Steingress, 2019; Mei and Xu, 2021). In this strand of literature, our work is closely related to Kee et al. (2009) who measures ad-valorem equivalents (AVEs) of non-tariff barriers at six-digit HS level. Using the same approach, we further estimate AVEs of NTMs at importer–four-digit HS level and find that the estimated AVEs are higher in products and markets with lower elasticity of substitution. By doing so, our analysis links trade frictions associated with NTMs to WTO's non-discriminating principle of national treatment, which is a novel contribution.

This paper also contributes to a modest body of works that empirically tests predictions from theoretical analysis of trade policy. For example, several studies empirically confirm predictions from the terms-of-trade theory on non-cooperative tariffs (Broda et al., 2008), tariff reductions of WTO accession countries (Bagwell and Staiger, 2011), and most-favored-nation (MFN) tariff schedules Ludema and Mayda (2013). Goldberg and Maggi (1999) find that the pattern of trade protection in the United States is broadly consistent with predictions from the political economy model in Grossman and Helpman (1994). Whereas these studies all focus on tariffs, we focus on NTMs by constructing a trade model with product standards and providing consistent evidence using both product- and firm-level data.

Despite the novelty of our research, we acknowledge the limitations in our exercise. Firstly, all existing works on the estimation of elasticity of substitution generate results that are only cross sectional.[2] Combined with the fact that NTMs data from UNCTAD TRAINS also lacks variation over time, our analysis thus only exploits the cross-sectional variation of product likeness and frictions associated with NTMs. In addition, even the latest work on estimating the elasticity of substitution (Soderbery, 2018) only provides estimates at destination–four-digit HS level. As a result, we cannot quantify trade restrictiveness of NTMs at finer level, which prevents us from fully utilizing the more disaggregated data from China Customs Database.

The rest of the paper is structured as follows: in Section 2.2, we describe the data and summarizes the method introduced in Kee et al. (2009) to compute AVEs of technical barriers to trade. Section 2.3 discusses our empirical strategy and presents the results. In Section 2.4, we construct a simple model to illustrate how product likeness affect governments' decisions on product standards under the constraint of national treatment. The last section concludes.

2.2 Data and AVEs of Non-Tariff Measures

In this section, we first introduce the sources of the data used in the main analysis and in estimating AVEs associated with NTMs. We then briefly describe the AVE estimation procedure, which strictly follows the approach introduced in Kee et al. (2009).

2.2.1 Data

In the main empirical analysis, we use estimated elasticity of substitution to approximate product likeness. The destination–four-digit HS level substitution elasticity is taken directly from Soderbery (2018). On the other hand, the substitution elasticity at six-digit HS level

[2]See Feenstra (1994), Broda and Weinstein (2006), Soderbery (2015), and Soderbery (2018), for example.

is estimated using the Soderbery (2015) methodology which adopts a hybrid estimator of Leamer (1981) and Feenstra (1994)/ Broda and Weinstein (2006). The hybrid estimator deals with bias resulted from over-weighing of the outlier observations. Instead of using two-stage least squares, Soderbery (2015) proposed to use limited information maximum likelihood (LIML) to address small sample bias. If this produces infeasible estimates, a constrained non-linear LIML routine is adopted. The estimation procedure is further elaborated in Section 2.2.2.

NTMs data used in the empirical analysis are from two sources. Firstly, the core NTM data is from UNCTAD TRAINS: The Global Database on Non-tariff Measures (NTMs TRAINS researcher file). This data set provides comprehensive official mandatory NTMs at six-digit HS level with the start and end dates. The data set also records whether a particular NTM is considered a technical or non-technical measure. Trade frictions from non-technical measures like quota or non-automatic import licensing should not be related to national treatment in theory. Nevertheless, we include them as controls when estimating the AVEs of technical measures. In addition, we also follow Kee et al. (2009) and include another type of NTMs— agriculture domestic support to control for the supply side effects. Countries' domestic agricultural subsidies data are from WTO Online document: G/AG/NG/S/1.[3]

The supplementary firm-level analysis relies on year 2013 exporting data from China Custom Database (CCD). This data set records every exporting and import transaction between Chinese firms and foreign countries at eight-digit HS level. We further aggregate the data into six-digit HS level in order to match with the level of aggregation of NTMs. In the estimation of AVEs associated with technical barriers, the bilateral trade flows from 2010 to 2016 and applied tariff rates (both at six-digit HS level) are from the WITS data base. Details of other datasets used in the AVE estimation are discussed in Section A.2 of

[3]The original document is available on: https://docs.wto.org/dol2fe/Pages/FE_DownloadDocument.aspx?Symbol=G/AG/NG/S/1&Language=English&CatalogueId=46353&Context=ShowParts. Currencies of the domestic support have been deflated to US Dollars in the base year for each country.

the Appendix.

2.2.2 Estimation of AVE

Before studying the impact of technical NTMs, we need to estimate the AVEs of technical barriers to trade. Our approach closely follow the method introduced in Kee et al. (2009). Hence, we only briefly discuss the estimation procedure in this section. Let j denote the importing country and s for the sector or product. The estimation equation of destination-four-digit HS level AVE of NTMs is given by:

$$\log x_{js} - \varepsilon_{js} \log(\tau_{js} + 1) = \sum_k \alpha_{jk} C_j^k + \beta_{js}^T T_{js} + \beta_{js}^{NT} NT_{js} + \beta_{js}^{DS} \log DS_{js} + \epsilon_{js}, \tag{2.1}$$

where

$$\begin{cases} \beta_{js}^T = -e^{\left(\beta_s^T + \sum_k \beta_{sk}^T C_j^k\right)} \\ \beta_{js}^{NT} = -e^{\left(\beta_s^{NT} + \sum_k \beta_{sk}^{NT} C_j^k\right)} \\ \beta_{js}^{DS} = -e^{\left(\beta_s^{DS} + \sum_k \beta_{sk}^{DS} C_j^k\right)}, \end{cases} \tag{2.2}$$

and x_{js} is the average import volume at destination–four-digit HS level across the 2010 to 2016 period, ε_{js} is the corresponding import demand elasticity, and τ_{js} is the tariff rate. In addition, $C_j^k,\ k \in \{1, 2, 3, 4\}$ refer to GDP and country level relative factor endowments variables, including agricultural land over GDP, capital over GDP, and labor over GDP. Lastly, technical core NTMs, non-technical NTMs, and domestic support are included separately as T_{js}, NT_{js} and DS_{js} at destination-four-digit HS level. That is because we want to identify the AVE of technical NTMs and still control for the other two types of NTMs. Non-technical NTMs and domestic support are not the focus of this study since these measures are not subject to the non-discrimination principle of national treatment.

Following Kee et al. (2009), we ignore the number of measures when defining technical and non-technical NTMs variables. Specifically, dummies T_{js} and NT_{js} take the value of one if at least one technical or non-technical NTM on product s from all exporters was always implemented by the importing country j during 2010 to 2016.[4] In addition, to address the

[4]We do not consider the NTMs that being implemented on selected countries by the importers nor those

endogeneity concern of NTMs, we use exports, the past changes in imports and the GDP-weighted average of the NTM variables of the nearest five countries as the instrumental variables of NTMs.

Intuitively, NTMs' effect on trade flow should be negative. Thus, in equation (2.2), the coefficients of technical NTMs, non-technical NTMs and domestic support (in log) are expressed in an exponential form with a negative sign sign to guarantee their negativity. After getting estimates of β_{js}^T, the AVE of core technical NTMs can be obtained by:

$$AVE_{js}^T = \frac{e^{\beta_{js}^T} - 1}{\varepsilon_{js}}. \quad (2.3)$$

The summary statistics of the variables needed in the estimation of AVEs in shown in Table A.1. Including those destination–sector observations with no NTMs, the mean of AVE_{js} is 19.93 percent, which is close to the average value (12 percent) in Kee et al. (2009).

Table 2.1: Summary Statistics: Product Likeness and the Effects of Non-Tariff Measures

Variable	Obs.	Mean	Std. Dev.	Min	Max
AVE_{js}	124,530	19.93	45.22	0	244.03
σ_{js}	124,530	231.36	18063.09	1.02	2166897
Tariff_{js}	124,530	0.05	0.13	0	15.15
Tariff Water_{js}	124,530	0.07	0.17	0	5.97

2.3 Empirical Analysis

This section empirically examines the effect of product likeness on trade frictions associated with NTMs. We first present regression results using the WITS database and then turn to the more disaggregated China Customs Database.

being terminated during 2010 to 2016.

2.3.1 Sector–Destination Level Analysis Using WITS Data

We first use trade data from the WITS database. In particular, we start by running the following regression equation at destination–four-digit HS level:

$$\log AVE_{js} = \beta_0 + \beta_1 \log \sigma_{js} + FE_j + FE_{HS2} + \epsilon_{js}. \tag{2.4}$$

In this regression equation, the dependent variable is the estimated log AVE of technical NTMs. σ_{is} denotes the measure of product likeness which is approximated by substitution elasticity from Soderbery (2018), FE_j is the destination country fixed effects, and FE_{HS2} refers to the two-digit HS level fixed effects.[5] We expect β_1 to have a negative sign. In other words, technical barriers in markets and products with larger elasticity of substitution should create less trade frictions on average.

Table 2.2 shows the regression results. In addition to ordinary least squares (OLS), we also run (2.4) using Poisson Pseudo-Maximum Likelihood (PPML) to address potential issues of zero trade flows and heteroskedasticity. Columns (1) and (2) report the regression results by using OLS and the dependent variable is $\log AVE_{js}$. Column (3) and (4) report the regression results by using PPML and the corresponding dependent variable is AVE_{js}. Column (1) and (3) include two-digit HS sector level fixed effects, whereas column (3) and (4) include additional destination country fixed effects. For all regressions, the top 1% outliers of the estimated AVE_{js} have been replaced by the 99% largest value.

We can see that the estimated coefficient β_1 is negative all four specifications. In column (1) where two-digit HS sector fixed effects are included, the coefficient is significant 5%. When destination fixed effects are added in column (2), β_1 has a larger magnitude and becomes significant at 1%. In column (3) and (4) where PPML is used, the coefficient is still significant at 5% but with a smaller magnitude. The result from PPML regressions show that a 1 percent increase in elasticity of substitution leads a 0.023 percent decrease in the AVEs of corresponding technical barriers. This is consistent with our hypothesis that technical

[5] Table 2.1 in the Appendix displays the summary statistics of the variables we used in the regressions.

Table 2.2: Product Likeness and the Effects of Non-tariff Measures: Benchmark

	(1)	(2)	(3)	(4)
Dependent Variable	$\log(AVE_{js})$		AVE_{js}	
$\log\sigma_{js}$	-0.148^b	-0.157^a	-0.023^b	-0.023^b
	(0.058)	(0.058)	(0.010)	(0.010)
HS2 FE	✓	✓	✓	✓
Destination FE		✓		✓
Method	OLS	OLS	PPML	PPML
Observations	41,844	41,844	66,686	66,685
R^2	0.086	0.099		

Note: In Columns (1) and (2), the dependent variable is $\log(AVE_{js})$ and OLS is used. In Columns (3) and (4), the dependent variable is AVE_{js} and PPML is used. Destination country fixed effects are included from Columns (1)-(4).HS2 sector fixed effects are included in Columns (2) and (4). Standard errors are clustered at the HS2 sector level. Significance: a (1%), b (5%), and c (10%)

regulations on more heterogeneous products are more susceptible to become discriminatory against imports, hence creating more trade frictions.

Table 2.3 shows the results of robustness checks using PPML. Both destination country fixed effects and two-digit HS sector fixed effects are included in all regressions. We run regressions shown in column (1) and (2) to address the concern that the effect of NTMs may correlate with other policy instruments. According to Limão and Tovar (2011); Niu et al. (2020), for example, tariff may determine the trade frictions arisen from NTMs.[6] In addition, members of the WTO are also constrained by bound tariffs, the maximum Most-Favored Nation tariff rate committed by individual WTO member governments. Therefore, tariff water which is defined as the difference between applied and bound tariff rate can be considered as a measure of alternative policy constraints. From column (1) and column (2), we can see that the coefficient of $\log\sigma_{js}$ remains negative and significant at 1% when tariff or tariff water is included in the regression.

In columns (3) and (4) of Table 2.3, we further examine the heterogeneity in the effect

[6]Niu et al. (2020) shows that tariffs and NTMs are substitutes. Limão and Tovar (2011) shows that tariff commitments in trade agreements increase the likelihood and restrictiveness of NTBs.

of product likeness. In particular, we divide the observations into two groups of equal size according to the value of substitution elasticity σ_{js}. For each group, we run a PPML with the same setup as in column (4) in Table 2.2. Comparing column (3) and (4), we can see that the effect of product likeness on trade frictions associated with NTMs mostly exists in the more heterogeneous group.

Table 2.3: Product Likeness and the Effects of Non-Tariff Measures: Robustness Checks

Dependent Variable: AVE_{js}	(1)	(2)	(3)	(4)
$\log \sigma_{js}$	-0.157^{a}	-0.157^{a}	0.006	-0.144^{a}
	(0.058)	(0.058)	(0.010)	(0.052)
Tariff_{js}	-0.337^{c}			
	(0.176)			
Tariff Water_{js}		-0.108		
		(0.246)		
Destination FE	✓	✓	✓	✓
HS2 FE	✓	✓	✓	✓
Sample	Full	Full	Less Heterogeneous	More Heterogeneous
Observations	41,844	41,844	33,028	33,657

Note: The top 1% outliers of the estimated AVE_{js} have been replaced by the 99% largest value. Destination country fixed effects and HS2 sector fixed effects are included from Columns (1)-(4). In Columns (1) and (2), we control the tariff and tariff water, respectively. In Columns (3) and (4), the sample has been divided into the more homogeneous and more heterogeneous groups according to the value of substitution elasticity σ_{js}. Standard errors are clustered at the HS2 sector level. Significance: a (1%), b (5%), and c (10%)

In addition to regressions shown in Table 2.2 and 2.3 which are at destination–four-digit HS level, we also perform a robustness check at six-digit HS level. As discussed in greater details in Section A.1 in the Appendix, we first estimate trade frictions associated with NTMs at six-digit HS level using the method in Kee et al. (2009). We then follow the approach introduced in Soderbery (2015) to estimate elasticity of substitution at six-digit HS level using limited information maximum likelihood (LIML). Given these estimates, we run the following regression using PPML:

$$\log AVE_s = \beta_0 + \beta_1 \log \sigma_s + FE_{HS4} + \epsilon_s, \tag{2.5}$$

where FE_{HS4} refers to four-digit HS level fixed effects. Note that the subscript s in (2.5) is at six-digit HS level. Compared to regressions shown in Table 2.2 and 2.3, this specification sacrifices the destination dimension in exchange for a more disaggregated product-level variation. Since product likeness is approximated by elasticity of substitution at product level, regression equation (2.5) is consistent with the "naive" interpretation of product likeness that only focuses on product characteristics. Nevertheless, this empirical setup is less preferred since the number of observations is an order of magnitude less than regressions at destination–six-digit HS level.

Table 2.4 presents the PPML regression results at six-digit HS level. Column (1) represents the benchmark regression in which only the four-digit HS fixed effects are included. Tariff and tariff water are included in column (2) and column (3) as controls, respectively. In all three regression, the coefficient of $\log \sigma_s$ has a negative coefficient and is significant at 10%. The less significant result is expected since the number of of observations is an order of magnitude less and we only can exploit variations at product level.

Table 2.4: Product Likeness and the Effects of Non-tariff Measures: Sector Level Analysis

Dependent Variable: AVE_s	(1)	(2)	(3)
$\log \sigma_s$	-0.078^c	-0.080^c	-0.077^c
	(0.046)	(0.046)	(0.046)
Tariff_s		3.185	
		(3.045)	
Tariff Water_s			-0.841
			(1.009)
HS4 FE	✓	✓	✓
Observations	4,768	4,768	4,768

Note: PPML is used in all three regressions. The top 5% outliers of the estimated AVE_s have been replaced by the 95% largest value. Standard errors are clustered at the HS2 sector level. Significance: a (1%), b (5%), and c (10%)

2.3.2 Firm Level Analysis

Next, we use the more disaggregated data from the China Customs Database to analyze the role of product likeness. Since the observations in this data set is at firm–HS-8–destination level, we cannot use the method in Kee et al. (2009) to estimate the AVEs at the same level of aggregation. Hence, our approach in the previous analysis using WITS data no longer applies. To examine the effect of product likeness on the intensive margin of trade, the estimation equation we run is as follows:

$$\log x_{fjs} = \beta_0 + \beta_1 \tau_{js} + \beta_2 T_{js} + \beta_3 (\log \sigma_{js} \times T_{js}) + \mathbf{\Psi} + \varepsilon_{fjs}. \tag{2.6}$$

In this equation, $\log x_{fjs}$ denotes the logged value of a HS six-digit product s exported from Chinese firm f to destination country j. τ_{js} and T_{js} are the applied tariff rate and a dummy indicating the presence of technical NTMs. σ is the estimated elasticity of substitution at destination–four-digit HS level. Lastly, Ψ denotes a vector of fixed effects at firm-product, firm-destination, and product-destination level. Similar to the procedure that estimates the AVEs of technical barriers described in Section 2.2.2, we use exports, the past changes in imports and the GDP-weighted average of the NTM variables of the nearest five countries as the instrumental variables of NTMs.

Parameters $\{\beta_1, \beta_2, \beta_3\}$ denote the coefficients of interest. Since we expect that technical regulations on more heterogeneous products create more trade frictions, β_3 as the coefficient of $(\log \sigma_{js} \times T_{js})$ should have a positive sign. In addition, β_1 and β_2 as coefficients of tariff and technical barriers to trade should carry a negative sign. Table A.2 in the Appendix shows the summary statistics of the variables we used in the firm level regressions.

Table 2.5 presents the estimation results of Equation (2.6) using the 2013 export data from the China Customs Database. We experiment with different combinations of fixed effects, with increasing level of disaggregation from column (1) to column (3). In our preferred specification in column (3), we include HS-4–destination and HS-6–firm fixed effect to control for multilateral resistance at product level. In addition, the firm-destination fixed effect is also included to control for trade frictions specific to each firm–destination.

In all three regressions, the coefficient of the interaction of $\log \sigma_{js}$ and T_{js} is positive and significant at 1%. Combining with the negative coefficient of T_{ij}, the positive coefficient of the interaction implies that trade frictions associated with technical NTMs are weaker when the product and destination market are more homogeneous. This results is consistent with our hypothesis that standards on more homogeneous products are less discriminating under national treatment. Moreover, the coefficient of τ_{js} is also negative and significant at 5% or less in all three regressions.

Table 2.5: Firm Level Analysis (Intensive Margin)

Dependent variable: $log(Value_{fjs})$	(1)	(2)	(3)
τ_{js}	-0.251^a	-0.329^a	-0.153^b
	(0.040)	(0.051)	(0.060)
T_{js}	-1.356^a	-1.804^a	-0.869^c
	(0.39)	(0.43)	(0.49)
$\log \sigma_{js} \times T_{js}$	0.132^a	0.200^a	0.253^a
	(0.051)	(0.055)	(0.064)
HS6 FE	✓	✓	
Firm FE	✓		
HS4–Destination FE	✓	✓	✓
Firm–Destination FE		✓	✓
HS6–Firm FE			✓
Observations	5,477,391	4,697,220	3,270,451
R^2	0.382	0.502	0.753

Note: The dependent variable is the $Value_{fjs}$ in logarithm term. T_{js} is the IV estimate obtained from Section 2.2.2. Significance: a (1%), b (5%), and c (10%)

We then move on to analyze the role of product likeness in the extensive margin. The regression equation we run is as follows:

$$\log(Count_{js}) = \beta_0 + \beta_1 \tau_{js} + \beta_2 T_{js} + \beta_3 (\log \sigma_{js} \times T_{js}) + \mathbf{\Psi} + \epsilon_{js}, \tag{2.7}$$

which is very similar to regression equation (2.6). We measure extensive margin by $Count_{js}$, the number of firms that export product s to destination j. $\mathbf{\Psi}$ represents product and country fixed effects since this regression only exploits variations at product-destination level. Similar to regression equation (2.6), we include τ_{js} to control for tariff barriers and use exports, the past changes in imports and the GDP-weighted average of the NTM variables of the nearest five countries as the instrumental variables of T_{js}. Table A.3 in the Appendix presents the summary statistics of the extensive margin regression.

Table 2.6 presents the regression results. Regressions using PPML are shown in column (1) and (2) whereas those using OLS are shown in column (3) and (4). All regressions include destination fixed effects. Column (1) and (3) include product fixed effects at four-digit HS level, whereas the product fixed effects in column (2) and (4) are at six-digit HS level. In all four regressions, the coefficient of the $(\log \sigma_{js} \times T_{js})$ has a positive coefficient but is only significant at 1% in column (2). The noisy results may be because we can only exploit variations at product-destination level, contrast to the intensive margin analysis that incorporates an additional firm dimension. In addition, firms' entry to foreign markets is usually dynamic and path dependent (Morales et al., 2019), which is not captured in our cross-sectional analysis.

2.4 Model

In this section, we construct a two-country, two-sector Melitz model to illustrate the role of product likeness under national treatment. In the model, product standards affect the marginal and fixed costs of heterogeneous varieties. In the non-cooperative equilibrium without national treatment, countries set discriminatingly high standards on imports to improve welfare through production relation. The degree of discrimination is independent of product likeness. When national treatment is imposed, on the other hand, the degree of discrimination decreases and is negatively related to the product's elasticity of substitution.

Table 2.6: Firm Level Analysis (Extensive Margin)

	(1)	(2)	(3)	(4)
Dependent variable	$Count_{fs}$		$\log(Count_{fs})$	
τ_{js}	-0.136	-0.148^a	-0.137^b	-0.258^b
	(0.11)	(0.056)	(0.054)	(0.085)
T_{js}	-0.366	3.183^a	-0.441	2.071^a
	(2.16)	(0.78)	(0.50)	(0.41)
$\log \sigma_{js} \times T_{js}$	0.0999	0.0982^a	0.0234	0.0250
	(0.072)	(0.028)	(0.033)	(0.027)
Method	PPML	PPML	OLS	OLS
HS4 FE	✓		✓	
HS6 FE		✓		✓
Destination FE	✓	✓	✓	✓
Observations	134,322	134,198	134,322	134,198
R^2			0.553	0.788

Note: In Columns (1) and (2), PPML is used and the dependent variable is $Count_{js}$. In Columns (3) and (4), OLS is used and the dependent variable is $\log(Count_{fs})$. T_{js} is the IV estimate obtained from Section 2.2.2. Destination fixed effects are included in all Columns. HS4 fixed effects are included in Columns (1) and (3) while HS6 fixed effects are included to Columns (2) and (4). Significance: a (1%), b (5%), and c (10%)

2.4.1 Setup

The economy consists of two countries represented by i and j. Each country has one sector producing heterogeneous goods and one sector producing a homogeneous good. Representative households in country j has the following utility:

$$U_j = \left(\sum_{i=1}^{2} \int_0^{n_{ij}} x_{ij}(\omega_i)^{\frac{\sigma-1}{\sigma}} d\omega_i \right)^{\frac{\sigma}{\sigma-1}\mu} (y_j)^{1-\mu} .$$

ω_i indexes heterogeneous varieties produced in country i. x_{ij} is the quantity of a heterogeneous variety from country i consumed in country j, whereas y_j is country j's consumption of the homogeneous good. n_{ij} is the number of country i firms exporting heterogeneous varieties to country j. μ is the Cobb-Douglas consumption share of the heterogeneous sector and σ is the elasticity of substitution.

Labor is the only factor of production. The homogeneous good is produced with a single unit of labor and is freely traded between two countries. The homogeneous sector in both countries is assumed to be perfectly competitive and always active. Choosing the price of the homogeneous good to be the numeraire, the wage in both countries hence always equals to one. Firms in the heterogeneous sector need to pay a fixed entry cost f^e in advance to enter the market and draw a productivity. Given the CES preference, the demand for any heterogeneous good from a country i firm with productivity ϕ charging price $p_{ij}(\phi)$ in country j is:

$$x_{ij}(\phi) = \frac{p_{ij}(\phi)^{-\sigma}}{P_j^{1-\sigma}} \mu L_j, \tag{2.8}$$

where L_j is the measure of consumers in country j and

$$P_j = \left(\sum_{i=1}^{2} \int_0^{n_{ij}} p_{ij}(\omega_i)^{1-\sigma} d\omega_i \right)^{1/(1-\sigma)}$$

is the ideal price index of sector s in country j.

Product standards affect both the variable cost of production and fixed market entry costs. Let s_{ij} denote the standard on country i's heterogeneous product imposed by country

j. We assume that the standards set by the governments within an interval $s \in [0, s^{max}]$ are the only policy instruments available. Let $l_{ij}(\phi)$ denote the variable labor requirement of producing x_{ij} in a firm from country i with productivity ϕ. The (inverse) production function is

$$l_{ij}(\phi) = \frac{\tau_{ij} c(s_{ij}) x_{ij}(\phi)}{\phi}, \tag{2.9}$$

where $c(\cdot)$ is a function of standards. τ_{ij} is the iceberg trade cost and $\tau_{jj} = 1$. For simplicity we assume $\tau_{ij} = \tau_{ji} = \tau > 1$. Given (2.8) and (2.9), the firm's profit-maximizing price is a constant mark-up over marginal costs:

$$p_{ij}(\phi) = \frac{\sigma}{\sigma - 1} \frac{\tau_{ij} c(s_{ij})}{\phi}.$$

Entrants in country i wishing to sell their products in country j need to hire f_j units of labor in country j. We further assume that $f_j = f(s_{ij})$, where $f(\cdot)$ is a function of country j's standard with $f' > 0$ and $f'' > 0$. Given s_{ij}, the cut-off exporting productivity of country i firms ϕ^* is

$$\phi^*_{ij} = \frac{\sigma}{\sigma - 1} \frac{\tau c(s_{ij})}{P_j} \left(\frac{\sigma f(s_{ij})}{\mu L_j} \right)^{1/(\sigma - 1)}. \tag{2.10}$$

We can define average productivity $\tilde{\phi}_{ij}$ as

$$\tilde{\phi}_{ij} = \left(\int_0^\infty \phi^{\sigma - 1} g(\phi | \phi > \phi^*_{ij}) d\phi \right)^{\frac{1}{\sigma - 1}}$$

such that $P_j = \left[n_{jj} p_{jj} (\tilde{\phi}_{jj})^{1-\sigma} + n_{ij} p_{ij} (\tilde{\phi}_{ij})^{1-\sigma} \right]^{1/(1-\sigma)}$. Assume that firm productivity in country i is drawn from a Pareto distribution $G_i(\phi) = 1 - (b/\phi)^\theta$ and $\theta > \sigma - 1$. Then we can write $\tilde{\phi}_{ij}$ in close form:

$$\tilde{\phi}_{ij} = \left(\frac{\theta}{\theta - \sigma + 1} \right)^{\frac{1}{\sigma - 1}} \phi^*_{ij}. \tag{2.11}$$

Let $\pi_{ij}(\phi) = \frac{p_{ij}(\phi)^{1-\sigma} \mu L_j}{P_j^{1-\sigma} \sigma} - f(s_{ij})$ denote the profit of a country i firm exporting to country j. Using (2.11) and $\pi_{ij}(\phi^*) = 0$, we have

$$\pi_{ij}(\tilde{\phi}) = \frac{\sigma - 1}{\theta - \sigma + 1} f(s_{ij}). \tag{2.12}$$

Free entry requires that the expected profits of a country i firm from drawing a productivity are equal to the fixed entry costs:

$$f^e = \text{prob}\left(\phi > \phi_{ii}^*\right)\pi_{ii}\left(\tilde{\phi}_{ii}\right) + \text{prob}\left(\phi > \phi_{ij}^*\right)\pi_{ij}\left(\tilde{\phi}_{ij}\right). \tag{2.13}$$

Substituting (2.12) and $\text{prob}(\phi > \phi_{ij}^*) = (b/\phi_{ij}^*)^\theta$ into (2.13) gives

$$\kappa = \frac{f(s_{ii})}{(\phi_{ii}^*)^\theta} + \frac{f(s_{ij})}{(\phi_{ij}^*)^\theta}, \tag{2.14}$$

where $\kappa \equiv \frac{(\theta-\sigma+1)f^e}{(\sigma-1)b^\theta} > 0$ is a constant.

Given standards $\{s_{ii}, s_{ij}, s_{ji}, s_{jj}\}$, the equilibrium can be described by two equations of the ideal price index. In particular, substituting (2.10) into (2.14) gives:

$$P_j = \frac{\sigma}{\sigma-1}\left(\frac{\sigma}{\mu L_j}\right)^{\frac{1}{\sigma-1}}\left(\frac{\gamma_{jj}\gamma_{ii} - \tau^{-2\theta}\gamma_{ij}\gamma_{ji}}{\kappa(\gamma_{ii} - \tau^{-\theta}\gamma_{ji})}\right)^{-\frac{1}{\theta}}, \tag{2.15}$$

where $\gamma_{ij} \equiv c(s_{ij})^{-\theta} f(s_{ij})^{\frac{\sigma-1-\theta}{\sigma-1}}$ to simplify the notation.[7]

Before analyzing the two countries' equilibrium behavior, we further introducing the following assumptions on marginal and fixed cost functions.

Assumption 1. *For* $s \in [0, s^{max}]$:

1. $c(0) > 0$ *and* $f(0) > 0$.

2. $c'(\cdot) \geq 0$, $f'(\cdot) \geq 0$, *and* $c'(\cdot)f'(\cdot) > 0$.

3. $c''(\cdot) > 0$ *and* $f''(\cdot) > 0$.

Assumption 1 allows us to capture different forms of protectionist product standards. For example, when $c(\cdot) = 0$, the standard can be interpreted as the extent of procedural barriers on imports, which is does not depend on the quantity imported. On the other hand, $c(\cdot) > 0$ incorporates the possibility that a protectionist standard could also involve unnecessary requirements that increase the variable cost of production. Similar assumptions are also imposed in Grossman et al. (2021).

[7] A positive P_j requires $\gamma_{jj}\gamma_{ii} - \tau^{-2\theta}\gamma_{ij}\gamma_{ji} > 0$ and $\gamma_{ii} - \tau^{-\theta}\gamma_{ji} > 0$. One sufficient condition for this to hold is a large trade cost τ or large Pareto shape parameter θ. We assume that these two inequalities always hold for all s in the range $[0, s^{max}]$.

2.4.2 No National Treatment

We first analyze the equilibrium outcome when the welfare-maximizing governments are not constrained by national treatment. In this case, country j's government freely chooses $\{s_{ij}, s_{jj}\}$ to maximize real expenditure $W_j \equiv \frac{L_j}{P_j}$ in the non-cooperative Nash equilibrium. Since wage and hence total income are fixed, country j government uses standards to minimize the ideal price index P_j.

Taking partial derivatives of P_j with respect to the standards gives us the following lemma:[8]

Lemma 1. *If Assumption 1 is satisfied, then* $\frac{\partial P_j}{\partial s_{jj}} > 0$, $\frac{\partial P_j}{\partial s_{ji}} > 0$, $\frac{\partial P_j}{\partial s_{ii}} < 0$, *and* $\frac{\partial P_j}{\partial s_{ij}} < 0$ *in equilibrium.*

Changing standards in this model leads to a partial equilibrium effect and a general equilibrium effect on welfare. Firstly, raising standard s_{ij} directly increases the cost of production and consequently the domestic price index P_j. On the other hand, higher cost and hence price of country i products lead to exit of country i firms and entry of country j firms in country j. Since products supplied by domestic firms do not bear the trade cost, this relocation of firms reduces the price index of country j. Lemma 1 shows that the production relocation effect always dominates the partial equilibrium effect when national treatment is not in place. As a result, both countries will impose extremely high standards on imports and minimum standards on domestic products.[9] Similar results are also derived in Mei (2021) and Grossman et al. (2021) although the setup of their models are not exactly the same. The above analysis is formally stated in the following proposition:

[8] See Section A.3.1 in the Appendix for the algebraic details.

[9] Notice that in the model of this paper, standards act like cost shifters and do not address any consumption externality. These standards are only for protectionist purposes and have been previously analyzed in Fischer and Serra (2000) and Mei (2021). When a negative consumption externality is included, $s_{jj} > 0$ in equilibrium but the main results of the theoretical analysis still holds.

Proposition 1. *When Assumption 1 is satisfied, both countries will impose maximum standard on imported heterogeneous goods and minimum standard on domestically produced heterogeneous goods. In other words,* $s_{ii} = s_{jj} = 0$ *and* $s_{ij} = s_{ji} = s^{max}$*.*

Proof. Follows immediately from Lemma 1. □

2.4.3 With National Treatment

Next, we consider the scenario in which national treatment is imperfectly enforced. In this case, countries in theory cannot discriminate against imports using product standards. In reality, however, there is no general definition of "like product" when national treatment is applied. As a result, the extent to which discriminatory standards can operate should depend on the level of difficulty in determining "like products". Following this rationale, we assume that country j still can impose discriminatingly high standards on imports from country i under national treatment. However, the degree of discrimination depends on the elasticity of substitution of the heterogeneous good σ. In other words, for any standard $s_{jj} \in [0, s^{max}]$ imposed by country j, we assume the following for s_{ij} under national treatment:

$$s_{ij} \in [s_{jj}, min\{s^{max}, s_{jj} + \psi(\sigma)\}], \tag{2.16}$$

where $\psi(\sigma) > 0$, $\psi(\sigma) < s^{max}$, and $\psi(\sigma)' < 0$ for any $\sigma > 1$.[10]

In the Nash equilibrium under national treatment, country j maximizes W_j using $\{s_{jj}, s_{ij}\}$ subject to the additional constraint described by (2.16). Note that even with the additional constraint, the results in Lemma 1 still hold under national treatment. Therefore, for any $s_{jj} \in [0, s^{max}]$, country j still imposes the maximum standard allowed $min\{s^{max}, s_{jj} + \psi(\sigma)\}$ on imports from country i. However, unlike the scenario without national treatment in which reducing the standard on domestic products always improves domestic welfare, country j now

[10]In theory, country j can impose a lower standard on imports. However, given $\frac{\partial P_j}{\partial s_{ij}} < 0$ as shown in Lemma 1, country j does not have any incentive to impose $s_{ij} < s_{jj}$ under national treatment. To simplify our analysis, we ignore this possibility when modeling the role of product likeness.

faces a trade-off when choosing s_{jj}. To see this, we can totally differentiate W_j with respect to s_{jj}:

$$\frac{dW_j}{ds_{jj}} = -\frac{L_j}{P_j^2}\left(\frac{\partial P_j}{\partial s_{jj}} + \frac{\partial P_j}{\partial s_{ij}}\frac{\partial s_{ij}}{\partial s_{jj}}\right). \tag{2.17}$$

As long as $s_{jj} < s^{max} - \psi(\sigma)$, we have $\frac{\partial s_{ij}}{\partial s_{jj}} = 1$. We already know that $\frac{\partial P_j}{\partial s_{jj}} > 0$ and $\frac{\partial P_j}{\partial s_{ij}} < 0$ from Lemma 1. Hence, it is possible to have $s_{jj} > 0$ in the Nash equilibrium if the benefit of loosing the constraint on s_{ij} is larger than the cost of raising P_j.

Regardless of the optimal standard imposed on the domestic product, we can show that $s_{ij} = s_{jj} + \psi(\sigma)$ in the Nash equilibrium. In addition, since we assume $\psi'(\sigma) < 0$, the difference between s_{ij} and s_{jj} will be larger for a smaller σ. If we interpret $s_{ij} - s_{jj}$ as the degree of discrimination of product standards in country j, then this result is equivalent to saying that the standard imposed on more heterogeneous imports (smaller σ) will be more discriminating in the Nash equilibrium under national treatment.

We can formally summarize the above analysis in the following proposition:

Proposition 2. *Assume Assumption 1 is satisfied. Then in the Nash equilibrium under national treatment,* $s_{ij} = s_{jj} + \psi(\sigma)$ *and* $\frac{d(s_{ij}-s_{jj})}{d\sigma} < 0$.

Proof. See Section A.3.2 in the Appendix. □

2.5 Conclusion

The non-discrimination principle of national treatment has been WTO's most powerful weapon in dealing with regulatory protection. The role of product likeness, one important feature in WTO's articles related to national treatment, has been emphasized in WTO arbitration and attracted substantial attention in the international trade law literature. In this paper, we provide the first empirical analysis on the role of product likeness in trade restrictiveness of product standards. We hypothesize that technical regulations on more heterogeneous products are more susceptible to become discriminatory against imports, hence creating more trade frictions. Using trade data from the WITS database and NTMs data from UNCTAD's TRAINS, we estimate the trade restrictiveness associated with technical barriers following the approach introduced in Kee et al. (2009). We find that, as expected, larger AVEs of technical barriers are observed in products and markets with smaller elasticity of substitution. Additional analysis using firm-level data from China Customs Database corroborates this finding. We also construct a model that features heterogeneous firms and production relocation to illustrate the role of product likeness under national treatment.

By providing the first empirical analysis on the effect of product likeness in NTMs, this paper complements existing works on WTO's non-discrimination principle national treatment. These studies typically assume that product standards on imports and domestic products are equalized under national treatment, hence abstracting from the role of product likeness when analyzing the effects of NTMs. Moreover, we construct a Melitz (2003)-style model to analyze how product likeness determines the degree of discriminating product standards, which is a novel contribution compared to existing studies on regulatory protection.

Chapter Three

The Robustness of Principle of Reciprocity under Trade Imbalances?

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3.1 Introduction

Trade imbalances are a prevalent feature of the world economy, a key issue addressed by the international macroeconomic literature, yet which often simplifies on the microeconomic allocations across sectors and labor markets. On the other hand, quantitative trade models have developed sophisticated algorithms to accommodate highly disaggregated data on allocations of expenditures and of productive factors across countries and sectors in general equilibrium setups. See, for example, Eaton and Kortum (2002), Ossa (2014), Caliendo and Parro (2015), Caliendo, Dvorkin and Parro (2019), and Caliendo, Parro, Opromolla and Sforza (2021). Yet, trade imbalance is often taken to be exogenous in this literature; it is often purged away, kept at its observed share of world output, or mechanically accommodated by a discrepancy between the contributions to and receipts from a global portfolio.

In this paper, we demonstrate potential caveats of treating trade deficits as gifts in conducting quantitative welfare analysis in general equilibrium trade models. The choice of purging away trade imbalances in the data before conducting welfare analysis, although circumvents these caveats, might be analysing a counterfactual world economy structure that is far from the factual world for its conclusions to be representative for policy purposes.

As an example of the potential caveats of ignoring trade imbalances, we show that the reputable negotiating rule of the GATT/WTO — the principle of reciprocity as emphasized by Bagwell and Staiger (1999) — will break down in the presence of trade imbalances. In particular, the principle fails to serve its purpose of maintaining the world prices at the pre-existing level after members exchange tariff reductions and market access, and hence cannot neutralize the terms-of-trade externality that inhibits trade liberalization.

We take a first step toward endogenizing trade imbalances in the general equilibrium trade models by calibrating the discount factor in preferences (that are country-specific and time-varying for a large set of economies) and the prevailing world interest rate, such that the model matches the pattern of borrowing and lending across countries at each point in time of the calibration. In the framework, trade imbalance of each country reflects its income-expenditure difference, where income includes not only current income from production of goods and services, tariff revenues, but also net interest income from past international lending (negative in the case of borrowing). The framework can then be used to conduct counterfactual analysis of tariff reductions, where the world interest rate and trade imbalances respond endogenously to changes in tariffs. This then can be used to assess how the quantitative implications on trade and welfare, of past tariff negotiation outcomes, are distorted by shutting down the mechanism of endogenous trade imbalances. We leave this final step for future research.

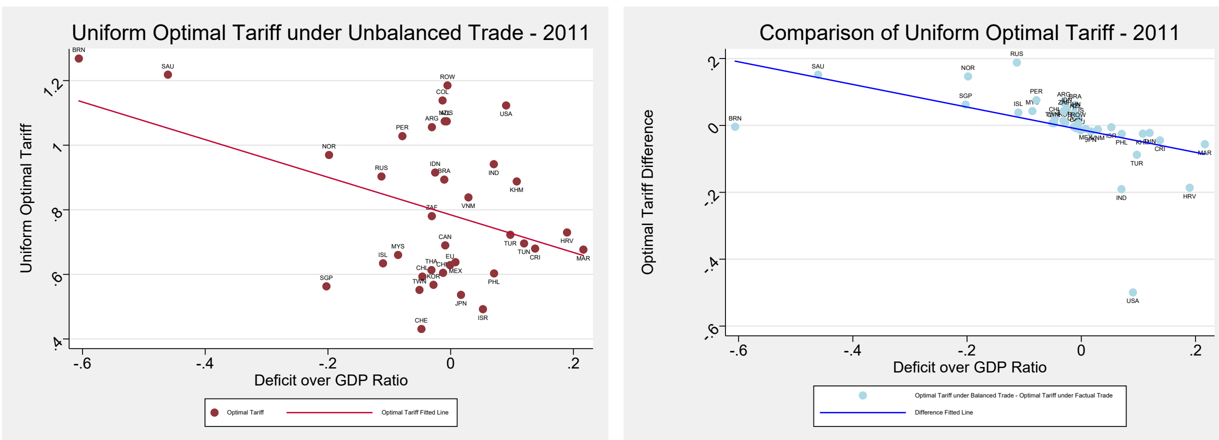
Our paper is related to several studies that highlight the role of endogenous trade imbalances in general equilibrium quantitative trade models. First, Reyes-Heroles (2016) constructs a dynamic Eaton and Kortum (2002) framework in which trade imbalances arise endogenously as a result of consumption-saving decisions. He shows that the decline in trade cost has notably contributed to the rise in net trade imbalances across countries over the past four decades. Next, Dix-Carneiro, Pessoa, Reyes-Heroles and Traiberman (2021) study how endogenizing trade imbalances changes the quantitative implications of globalization on labour market adjustments. They find that the "China shock" accounted for 25% of the decline in US manufacturing between 2000 and 2014 – twice the magnitude predicted by a model imposing balanced trade. Third, Kehoe, Ruhl and Steinberg (2018) model the US trade deficit as a result of the increased demand for savings in the rest of the world and assess the importance of the increase in the US trade deficit in accounting for the secular decline in the manufacturing sector over the last four decades. They show that this mechanism accounted for 15.1% of the fall in the US manufacturing employment share.

3.2 Deficit as a Gift

As discussed in the introduction, trade imbalance is often taken to be exogenous in the literature of quantitative trade models. If it is not purged away, it is often kept at its observed *share* of world output (Costinot and Rodríguez-Clare, 2014), or mechanically accommodated by a discrepancy between a country's contributions to and receipts from a global portfolio (Caliendo, Dvorkin and Parro, 2019) . In either approach, trade deficit is modelled as a gift. This is equivalent to assuming that the deficit country owns a fraction of the world production abroad. This implies that the deficit country, if levying an import tariff, is equivalent to taxing its own productive factors overseas. The more trade deficit a country has, the weaker its incentive is to impose import tariffs.

We verify this hypothesis based on the quantitative setup of Beshkar, Chang and Song (2022). We compute the optimal tariff (uniform across sectors as a simplification) for a large set of economies, under the scenario with trade imbalance, where the trade imbalance is modelled as a fixed share of world gross output. The results are summarized in the left panel of Figure 3.1. It indicates a negative correlation between the optimal tariff rate and the deficit-GDP ratio across countries. In other words, a country with a higher deficit-to-GDP ratio tends to levy a lower optimal tariff rate, consistent with the hypothesis proposed above.

Next, we then consider purging trade imbalances from the data, e.g., as in Ossa (2014), and compare the optimal tariffs under balanced trade versus those under factual trade imbalances. The right panel of Figure 3.1 indicates a downward bias in the simulated optimal tariff rates if trade imbalances are purged for the deficit countries and an upward bias for the surplus countries. To understand this finding, note that by removing trade deficits, the deficit countries import less (and become smaller buyers in the world market); as a result, their optimal tariffs are lower due to the reduced market power. The reverse is true for the surplus economies. The surplus economies will have to import more when surplus is purged. This will increase the market power of the surplus economies, and thus, its optimal tariff rate. Thus, by purging trade imbalances, the quantitative magnitudes of the optimal tariffs are distorted and compressed toward zeros, which leads to under-estimated welfare gains of tariff cooperation. Similarly, Beshkar, Chang and Song (2022) show that the concession granted by an importing country in terms of market access (measured in terms of the market access an importing country offers under factual tariffs versus under unilateral optimal tariffs) is reduced by purging away the trade imbalance. Hence, by abstracting away from trade imbalances, we incur the risk of under-estimating the impacts of trade cooperation on exchanges of market access and on welfare.



Note: The number on the vertical axis indicate the simulated optimal tariff rate (e.g., 0.8 corresponds to 80% tariff rate).

Figure 3.1: Optimal Tariffs and Deficit-to-GDP Ratios – 2011

3.3 The Principle of Reciprocity

Bagwell and Staiger (1999) show that under balanced trade, a set of tariff cuts that results in a reciprocal exchange of market access will leave the world price, i.e., the terms of trade, unaffected. In this section, we examine this proposition under a model with trade imbalances, and find that a reciprocal market access exchange does not keep the terms of trade fixed. In particular, we find that an equal exchange of market access will cause a deterioration in the terms of trade of the country with a trade deficit. Moreover, to keep the terms of trade fixed, the country with trade surplus must commit to a deeper tariff cut than needed for an equal market access exchange.

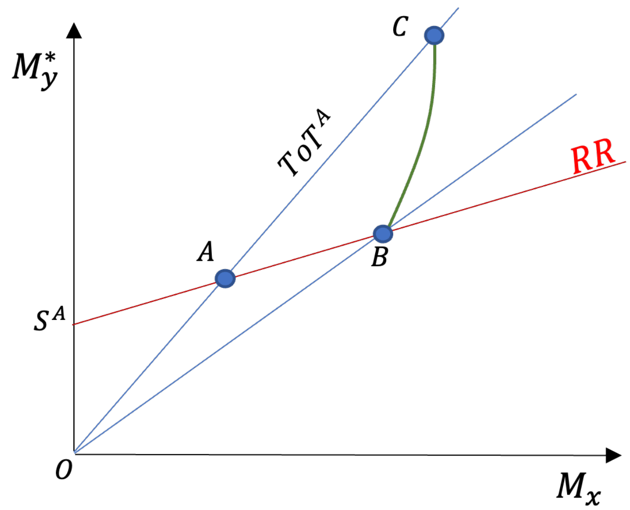


Figure 3.2: Reciprocal Market Access Exchange and Terms of Trade

As in Bagwell and Staiger (1999), we consider a two-good-two-country model in which Home imports good x and exports good y, and let $M_x\left(p\left(\tau, \tilde{p}^w\right), \tilde{p}^w\right)$ denote Home's demand for imports of x as a function of local and world relative prices, p and $\tilde{p}^w$, and $M_y^*\left(p^*\left(\tau^*, \tilde{p}^w\right), \tilde{p}^w\right)$ the Foreign's demand for imports of y as a function of local and world relative prices, p^* and $\tilde{p}^w$. A set of tariff changes, $\Delta\tau \equiv \tau^B - \tau^A$ and $\Delta\tau^* \equiv \tau^{*B} - \tau^{*A}$, results in equal market access exchange if and only if:

$$\begin{aligned}&\tilde{p}^{wA}\left[M_x\left(p\left(\tau^B, \tilde{p}^{wB}\right), \tilde{p}^{wB}\right) - M_x\left(p\left(\tau^A, \tilde{p}^{wA}\right), \tilde{p}^{wA}\right)\right]\\ &= \left[M_y^*\left(p^*\left(\tau^{*B}, \tilde{p}^{wB}\right), \tilde{p}^{wB}\right) - M_y^*\left(p^*\left(\tau^{*A}, \tilde{p}^{wA}\right), \tilde{p}^{wA}\right)\right]\end{aligned}$$

or

$$\begin{aligned}S^A \equiv& M_y^*\left(p^*\left(\tau^{*A}, \tilde{p}^{wA}\right), \tilde{p}^{wA}\right) - \tilde{p}^{wA} M_x\left(p\left(\tau^A, \tilde{p}^{wA}\right), \tilde{p}^{wA}\right)\\ =& M_y^*\left(p^*\left(\tau^{*B}, \tilde{p}^{wB}\right), \tilde{p}^{wB}\right) - \tilde{p}^{wA} M_x\left(p\left(\tau^B, \tilde{p}^{wB}\right), \tilde{p}^{wB}\right),\end{aligned} \tag{3.1}$$

where the expression in the first line is the trade surplus of Home under the initial tariff pair $\left(\tau^A, \tau^{*A}\right)$, and the expression in the second line is the trade surplus of Home under the new tariffs evaluated at initial price.

Figure 1 depicts the effect of "reciprocal tariff changes" on terms of trade in the presence of trade imbalances. Point A on this graph represents the quantity of Home and Foreign imports under the initial tariff pair $\left(\tau^A, \tau^{*A}\right)$. Line ToT^A is the set of import quantity pairs that are associated with the initial terms of trade, $\tilde{p}^{wA}$ under balanced trade and, more generally, under a model in which trade imbalances are proportional to total trade volumes.

Line RR, which goes through point A and has a slope representing the initial relative price of home imports, $\tilde{p}^{wA}$, is the set of import quantity pairs that conform to the principle of reciprocity relative to the initial point A. The intercept of the reciprocity line is equal to S^A, i.e., to the trade surplus of Home at the initial tariff pair. Note that the equation of line RR is simply given by the first line of equation (3.1).

The pair of import quantities represented by point B is obtained by tariff cuts from $\left(\tau^A, \tau^{*A}\right)$ to $\left(\tau^B, \tau^{*B}\right)$. The ratio of Home export quantity to its import quantity is lower at point B compared to point A, indicating a terms of trade improvement for Home as a result of this reciprocal market access exchange. Therefore,

Proposition 3. *A set of tariff cuts that conform to the principle of reciprocity keeps the level of trade imbalance–evaluated at initial prices–constant. Moreover, it improves the terms of trade of the country with trade surplus.*

The above proposition also implies that after a reciprocal tariff cut, in order to revert the terms of trade to its initial value, the country with a trade surplus must undertake further unilateral tariff cuts. To see this, consider once again the reciprocal tariff cuts that change import quantities from point A to point B. Unilateral tariff cuts by Home (the surplus country in this example), will increase import quantities along the green curve until it reaches point C, at which point the initial terms of trade is restored. In summary,

Proposition 4. *To maintain a constant terms of trade, the country with trade surplus must commit to a deeper tariff cut than suggested by the principle of reciprocity. Moreover, tariff cuts that keep the terms of trade constant will expand the level of trade imbalance (evaluated at initial prices).*

The second part of Proposition 4 follows from the first part and the fact that unilateral tariff cuts by a country will increase its net exports at initial prices.

3.4 Dynamic Quantitative Model

Considering a multi-country and multi-sector dynamic setup, the goods are differentiated by the origin of production i, destination of consumption j, and sector, in terms of both production technology and preferences. We take the activities in the service sectors as an aggregated sector s (whose quantities of production, consumption, and trade flows are independent of non-service sectors in counterfactual exercises). The set M of non-service sectors (including agriculture, mining, and manufacturing) are indexed by $k \in \{1, 2, ..., K\}$.

3.4.1 Setup

Let W_j denotes sum of the utility of country j across the horizon with a discount factor β_j

$$W_j = \sum_{t=0}^{\infty} \beta_j^t W_{j,t}^{\frac{\epsilon-1}{\epsilon}} \tag{3.2}$$

where $W_{j,t}$ denotes utility of country j at period t and the intertemporal utility function is governed by the intertemporal elasticity of substitution ϵ.

The utility function follows a nested Cobb-Douglas CES structure.

$$W_{j,t} = \left[\prod_{k \in M} \left(\sum_{i=1}^{N} b_{ijk} \, \tilde{q}_{ijk,t}^{\rho_k} \right)^{\frac{\mu_{jk}^M}{\rho_k}} \right] \left(\sum_{i=1}^{N} b_{ijs} \, \tilde{q}_{ijs,t}^{\rho_s} \right)^{\frac{\mu_{js}}{\rho_s}}, \tag{3.3}$$

where $\tilde{q}_{ijk,t}$ is the quantity consumed in country j of variety i in sector k, $b_{ijk}, b_{ijs} \in \mathbb{R}_+$ is a constant taste shifter, $\sigma_k \equiv 1/(1-\rho_k)$ ($\sigma_s \equiv 1/(1-\rho_s)$) corresponds to the elasticity of substitution across varieties in sector k (s), and $\mu_{jk}^M \equiv \frac{\mu_{jk}}{\mu_j^M}$ represents the share of expenditure on sector k among non-service sectors (where μ_{jk} is country j's share of expenditure on sector

k, $\mu_j^M \equiv \sum_{l \in M} \mu_{jl}$ is the total share of expenditure on non-service sectors in country j, and $\mu_j^M + \mu_{js} = 1$).

Disposable income (the income that can be spent on consumption) within a period is given by:

$$Y_{j,t} \equiv \omega_{j,t}\, L_j + T_{j,t} - (1 + r_t)\, b_{j,t-1} + b_{j,t},$$

where $\omega_{j,t}\, L_j$ and $T_{j,t}$ denotes wage income and tariff revenue respectively. $(1 + r_t)\, b_{j,t-1}$ refers to the redemption of debt that is incurred from the last period with an interest r_t and $b_{j,t}$ is the amount of new borrowing made in period t.

Production technology follows the Ricardian structure, with labour as the only factor of production. Let $\bar{a}_{ijk}$ denote the exogenous unit labour requirement to produce a good of sector k in country i for consumption in country j. Given perfectly competitive markets, the producer price $p_{ijk,t}$ equals:

$$p_{ijk,t} = \bar{a}_{ijk}\, \omega_{i,t}^M,$$

where $\omega_{i,t}^M$ is the wage rate in country i (for non-service sectors). The consumer price $\tilde{p}_{ijk,t}$ at the destination equals:

$$\tilde{p}_{ijk,t} = (1 + t_{ijk,t})(1 + \tau_{ijk,t}) p_{ijk,t}, \quad t_{iik,t} = 0, \tag{3.4}$$

where $t_{ijk,t}$ and $\tau_{ijk,t}$ are respectively the ad valorem tariff rate and trade cost factor faced by goods shipped from country i to country j in sector k period t.

Service sector production follows the same Ricardian structure:

$$p_{ijs,st} = \bar{a}_{ijs}\, \omega_{i,t}^S,$$

The consumer $\tilde{p}_{ijs,t}$ at the destination equals:

$$\tilde{p}_{ijs,t} = (1 + \tau_{ijs,t}) p_{ijs,t}, \tag{3.5}$$

where no ad valorem tariff rate is applied.

Given the CES structure within each sector, the share of expenditure allocated to varieties of origin i is:

$$\lambda_{ijk,t} = b_{ijk}^{\sigma_k} \left(\frac{\tilde{p}_{ijk,t}}{P_{jk,t}} \right)^{1-\sigma_k} \tag{3.6}$$

with the price index $P_{jk,t}$ for sector k in country j equal to:

$$P_{jk,t} = \left(\sum_n b_{njk}^{\sigma_k} \, \tilde{p}_{njk,t}^{1-\sigma_k} \right)^{\frac{1}{1-\sigma_k}} . \tag{3.7}$$

The share of expenditure allocated to varieties of origin i in service sector is:

$$\lambda_{ijs,t} = b_{ijs}^{\sigma_s} \left(\frac{\tilde{p}_{ijs,t}}{P_{js,t}} \right)^{1-\sigma_s} \tag{3.8}$$

with the price index $P_{js,t}$ for sector s in country j equal to:

$$P_{js,t} = \left(\sum_n b_{njs}^{\sigma_s} \, \tilde{p}_{njs,t}^{1-\sigma_s} \right)^{\frac{1}{1-\sigma_s}} . \tag{3.9}$$

3.4.2 Equilibrium Conditions

It follows that wage income of country i for non-service sectors is:

$$\begin{aligned} \omega_{i,t}^M L_{i,t}^M &= \sum_j \sum_{k \in M} \frac{\tilde{p}_{ijk,t} \, \tilde{q}_{ijk,t}}{1 + t_{ijk,t}} \\ &= \sum_j \sum_{k \in M} \frac{\lambda_{ijk,t} \, \mu_{jk}^M \, Y_{j,t}^M}{1 + t_{ijk,t}} \\ &= \sum_j \sum_{k \in M} \frac{\lambda_{ijk,t} \, \mu_{jk}^M \, \mu_j^M \, Y_{j,t}}{1 + t_{ijk,t}}, \end{aligned} \tag{3.10}$$

where the aggregate expenditure $Y_{j,t}^M$ of country j on non-service sectors is μ_j^M fraction of the aggregate expenditure at period t, $Y_{j,t}$, and the wage income of country i for service sector is:

$$\begin{aligned}\omega_i^S L_i^S &= \sum_j \tilde{p}_{ij,s}\, \tilde{q}_{ij,s} \\ &= \sum_j \lambda_{ij,s}\ Y_{j,s} \\ &= \sum_j \lambda_{ij,s}\, \mu_{j,s}\, Y_j.\end{aligned} \tag{3.11}$$

The aggregate expenditure follows:

$$Y_{j,t} = \omega_{j,t}^M\, L_j^M + \omega_{j,t}^S\, L_j^S + \sum_k \sum_i \frac{t_{ijk,t}}{1+t_{ijk,t}} \lambda_{ijk,t}\, \mu_{jk,t}^M\, \mu_{j,t}^M\, Y_{j,t} - (1+r_t) b_{j,t-1} + b_{j,t}, \tag{3.12}$$

where $b_{j,t} - (1+r_t) b_{j,t-1}$ can be considered as the trade deficit of country j in period t, $TD_{j,t}$.

Solvency requirement ensures the clearing of country's lending and borrowing at the last period:

$$\begin{aligned}\lim_{t->\infty} \frac{b_{j,t}}{\prod_{t' \leq t}(1+r_{t'})} &= 0 \\ \lim_{T->\infty} \sum_{t=0}^{T} \frac{TD_{j,t}}{\prod_{t' \leq t}(1+r_{t'})} + b_{j,0} &= 0\end{aligned} \tag{3.13}$$

3.4.3 Euler Equation

For the purpose of analysing inter-temporal allocations, the budget constraint is simplified to be the sum of consumptions across sectors:

$$\sum_j \sum_k \tilde{p}_{ijk,t} \tilde{q}_{ijk,t} + \sum_j \tilde{p}_{ijs,t} \tilde{q}_{ijs,t} = Y_{j,t}$$

alternatively, it can be written as:

$$P_{j,t}\, W_{j,t} = Y_{j,t} = \omega_{j,t}^M\, L_j^M + \omega_{j,t}^S\, L_j^S + T_{j,t} - (1+r_t) b_{j,t-1} + b_{j,t},$$

where $P_{j,t}$ denotes the aggregate price index of country j in period t.

The Lagrangian follows:

$$\mathcal{L}_j \equiv \sum_{t=1}^{\infty} \beta_j^t W_{j,t}^{\frac{\epsilon-1}{\epsilon}} - \sum_{t=1}^{\infty} \gamma_{j,t} \left(P_{j,t} W_{j,t} - \omega_{j,t}^M L_j^M + \omega_{j,t}^S L_j^S - T_{j,t} - (1+r_t) b_{j,t-1} + b_{j,t} \right),$$

the first order condition with respect to $W_{j,t}$ may be written as:

$$\beta_j^t \frac{\epsilon - 1}{\epsilon} W_{j,t}^{-\frac{1}{\epsilon}} = \gamma_{j,t} P_{j,t}, \tag{3.14}$$

the first order condition with respect to $b_{j,t}$ may be written as:

$$\gamma_{j,t} = \gamma_{j,t+1} \left(1 + r_{t+1}\right). \tag{3.15}$$

Combining these two first order conditions yields the Euler equation:

$$\left(\frac{W_{j,t}}{W_{j,t+1}} \right)^{1-\frac{1}{\epsilon}} = \beta_j (1 + r_{t+1}) \frac{Y_{j,t}}{Y_{j,t+1}}$$

We assume that technology, trade costs, and tariffs are the same across periods. Therefore, the only reason for lending and borrowing, and therefore nonzero $b_{j,t}$, is the variation of β_j across countries. If all countries had the same β_j then there will be no trade imbalance.

3.4.4 Inter-temporal Changes

To understand the inter-temporal changes, we have conducted the counterfactual exercises by introducing change in the trade deficit into the system. Applying the hat-algebra approach popularized by Dekle et al. (2008), the system of equilibrium conditions can be re-written in terms of inter-temporal changes as:

$$\tilde{\lambda}_{ijk,t+1} = \left(\frac{\tilde{P}_{jk,t+1}}{\tilde{\omega}_{i,t+1}^M} \right)^{\sigma_k - 1}, \tag{3.16}$$

$$\tilde{\lambda}_{ijs,t+1} = \left(\frac{\tilde{P}_{js,t+1}}{\tilde{\omega}_{i,t+1}^S} \right)^{\sigma_s - 1}, \tag{3.17}$$

$$\tilde{P}_{jk,t+1}^{1-\sigma_k} = \sum_i \lambda_{ijk,t} \left(\tilde{\omega}_{i,t+1}^{M}\right)^{1-\sigma_k}, \tag{3.18}$$

$$\tilde{P}_{js,t+1}^{1-\sigma_s} = \sum_i \lambda_{ijs,t} \left(\tilde{\omega}_{i,t+1}^{S}\right)^{1-\sigma_s}, \tag{3.19}$$

$$\tilde{\omega}_{i,t+1}^{M}\omega_{i,t}^{M}L_i^M = \sum_k \sum_j \frac{1}{1+t_{ijk,t+1}}\tilde{\lambda}_{ijk,t+1}\tilde{Y}_{j,t+1}\lambda_{ijk,t}\mu_{jk}^{M}\mu_j^{M}Y_{j,t}, \tag{3.20}$$

$$\tilde{\omega}_{i,t+1}^{S}\omega_{i,t}^{S}L_i^S = \sum_j \tilde{\lambda}_{ijs,t+1}\tilde{Y}_{j,t+1}\mu_j^{S}\lambda_{ijs,t}Y_{j,t}, \tag{3.21}$$

$$\begin{aligned}\tilde{Y}_{j,t+1}Y_{j,t} &= \tilde{\omega}_{j,t+1}^{M}\omega_{j,t}^{M}L_j^M + \tilde{\omega}_{j,t+1}^{S}\omega_{j,t}^{S}L_j^S + b_{j,t+1} - (1+\tilde{r}_{t+1}r_t)b_{j,t} + \sum_k \sum_i \frac{t_{ijk,t+1}}{1+t_{ijk,t+1}}\tilde{\lambda}_{ijk,t}\tilde{Y}_{j,t}\lambda_{ijk,t}\mu_{jk}^{M}\mu_j^{M}Y_{j,t} \\ &= \tilde{\omega}_{j,t+1}^{M}\omega_{j,t}^{M}L_j^M + \tilde{\omega}_{j,t+1}^{S}\omega_{j,t}^{S}L_j^S + \widetilde{TD}_{j,t+1}TD_{j,t} + \sum_k \sum_i \frac{t_{ijk,t+1}}{1+t_{ijk,t+1}}\tilde{\lambda}_{ijk,t+1}\tilde{Y}_{j,t+1}\lambda_{ijk,t}\mu_{jk}^{M}\mu_j^{M}Y_{j,t},\end{aligned} \tag{3.22}$$

$$\begin{aligned}\sum_j b_{j,t+1} - (1+\tilde{r}_{t+1}r_t)b_{j,t} &= 0 \\ \sum_j \widetilde{TD}_{j,t+1}TD_{j,t} &= 0,\end{aligned} \tag{3.23}$$

where $\tilde{X}_{t+1} = \frac{X_{t+1}}{X_t}$ indicates the cross period ratio [1]. This implies the intertemporal ratio in welfare to be:

$$\tilde{W}_{j,t+1} = \frac{\tilde{Y}_{j,t+1}}{\left(\prod_k \tilde{P}_{jk,t+1}^{\mu_{jk}}\right)^{\mu_j^M} \tilde{P}_{js,t+1}^{\mu_j^S}} \tag{3.24}$$

The Euler equation [2] can be expressed as:

$$\left(\frac{1}{\tilde{W}_{j,t+1}}\right)^{1-\frac{1}{\epsilon}} = \beta_j(1+\tilde{r}_{t+1}r_t)\frac{1}{\tilde{Y}_{j,t+1}} \tag{3.25}$$

[1] Period 1 trade balance condition is $\sum_j \widetilde{TD}_{j,1}b_{j,0} = 0$.

[2] Period 1 Euler equation is $\left(\frac{1}{\tilde{W}_{j,1}}\right)^{1-\frac{1}{\epsilon}} = \beta_j(1+r_1)\frac{1}{\tilde{Y}_{j,1}}$.

3.4.5 Counterfactual Analysis

In counterfactual exercises, we introduce changes to the tariffs in the initial period 0 and the tariff will be uniform henceforth across the periods. Applying the hat-algebra approach popularized by Dekle et al. (2008), the system of equilibrium conditions in period 0 can be re-written in terms of changes as:

$$\hat{\lambda}_{ijk,0} = \left(\frac{1+t'_{ijk,0}}{1+t_{ijk,0}} \frac{\hat{\omega}^M_{i,0}}{\hat{P}_{jk,0}} \right)^{1-\sigma_k}, \tag{3.26}$$

$$\hat{\lambda}_{ijs,0} = \left(\frac{\hat{\omega}^S_{i,0}}{\hat{P}_{js,0}} \right)^{1-\sigma_s}, \tag{3.27}$$

$$\hat{P}^{1-\sigma_k}_{jk,0} = \sum_i \lambda_{ijk,0} \left(\frac{1+t'_{ijk,0}}{1+t_{ijk,0}} \hat{\omega}^M_{i,0} \right)^{1-\sigma_k}, \tag{3.28}$$

$$\hat{P}^{1-\sigma_s}_{js,0} = \sum_i \lambda_{ijs,0} \left(\hat{\omega}^S_{i,0} \right)^{1-\sigma_s}, \tag{3.29}$$

$$\hat{\omega}^M_{i,0} \omega^M_{i,0} L^M_i = \sum_k \sum_j \frac{\hat{\lambda}_{ijk,0} \hat{Y}_{j,0} \lambda_{ijk,0} \mu^M_{jk} \mu^M_j Y_{j,0}}{1+t'_{ijk,0}}, \tag{3.30}$$

$$\hat{\omega}^S_{i,0} \omega^S_{i,0} L^S_i = \sum_j \hat{\lambda}_{ijs,0} \hat{Y}_{j,0} \mu^S_j \lambda_{ijs} Y_{j,0}, \tag{3.31}$$

$$\hat{Y}_{j,0} Y_{j,0} = \hat{\omega}^M_{j,0} \omega^M_{j,0} L^M_j + \hat{\omega}^S_{j,0} \omega^S_{j,0} L^S_j + \widehat{TD}_{j,0} TD_{j,0} + \sum_k \sum_i \frac{t'_{ijk,0}}{1+t'_{ijk,0}} \hat{\lambda}_{ijk,0} \hat{Y}_{j,0} \lambda_{ijk,0} \mu^M_{jk} \mu^M_j Y_{j,0}, \tag{3.32}$$

$$\sum_j \widehat{TD}_{j,0} b_{j,0} = 0, \tag{3.33}$$

where $\hat{X} = \frac{X'}{X}$ indicates the ratio of the counterfactual value x' to the factual value x of an endogenous variable. This implies the changes in welfare to be:

$$\hat{W}_{j,0} = \frac{\hat{Y}_{j,0}}{\left(\prod_k \hat{P}_{jk,0}^{\mu_{jk}}\right)^{\mu_j^M} \hat{P}_{js,0}^{\mu_j^S}} \tag{3.34}$$

Present value of trade deficit is zero.

$$\widehat{TD}_{j,0} b_{j,0} + \sum_t \frac{\widetilde{TD}_{j,t+1} TD_{j,t}}{\prod_{t' \le t}(1 + \tilde{r}_{t'+1} r_{t'})} = 0 \tag{3.35}$$

3.4.6 Map the Model to the Data

Given data on the initial period trade flow $x_{ijk,0}$, applied tariff rates $t_{ijk,0}$ and the initial net international investment $-b_{j,0}$[3], we measure the parameters and variables required in the counterfactual analysis (3.16) - (3.23) as follows:

$$\lambda_{ijk,0} = \frac{x_{ijk,0}}{\sum_i x_{ijk,0}}; \quad \lambda_{ijs,0} = \frac{x_{ij,0}^S}{\sum_i x_{ijs,0}};$$

$$\mu_j^M = \frac{\sum_{k \in M} \sum_i x_{ijk,0}}{\sum_{k \in M} \sum_i x_{ijk,0} + \sum_i x_{ijs,0}}; \quad \mu_j^S = 1 - \mu_j^M; \quad \mu_{jk}^M = \frac{\sum_i x_{ijk,0}}{\sum_{k' \in M} \sum_i x_{ijk',0}};$$

$$\omega_{i,0}^M L_i^M = \sum_{k \in M} \sum_j \frac{x_{ijk,0}}{1 + t_{ijk,0}}; \quad \omega_{i,0}^S L_i^S = \sum_j x_{ijs,0};$$

$$Y_{j,0}^M = \sum_{k \in M} \sum_i x_{ijk,0}; \quad Y_{j,0}^S = \sum_i x_{ijs,0}; \quad Y_{j,0} = Y_{j,0}^M + Y_{j,0}^S;$$

We obtain production and bilateral trade data (in intermediate and final goods combined) from the OECD-WTO Trade in Value Added (TiVA) database. The 2016 edition records

[3]To calibrate the parameters, we assume the initial debt is zero $b_{j,-1} = 0$ as a starting point. In another word, $b_{j,0} = TD_{j,0} + (1 + r_0) b_{j,-1} = TD_{j,0} = TD_{j,0}^M + TD_{j,0}^S$, where $TD_{j,0}^M = \sum_{k \in M} \sum_i \left(\frac{x_{ijk,0}}{1+t_{ijk,0}} - \frac{x_{jik,0}}{1+t_{jik,0}}\right)$; $TD_{j,0}^S = \sum_i (x_{ijs,0} - x_{jis,0})$. More information on the initial net international investment can be found at https://data.imf.org/?sk=7A51304B-6426-40C0-83DD-CA473CA1FD52

trade flows for 63 economies (and a residual Rest of the World) in 34 sectors (based on ISIC Rev. 3) for years 1995–2011. The methodology and assumptions underlying the construction of the TiVA database can be found in OECD-WTO (2012).[4] See Tables 3.1 and 3.2 for the list of economies and sectors. We aggregate service sectors into one combined sector. This amounts to a total of 20 individual sectors to be used in the subsequent analysis. We consider countries in the European Union (EU) as one combined entity in setting trade policy. The membership size of the EU increased from 15 to 27 during the period 1995–2011. Correspondingly, the set of individual economy entities analyzed reduced from 50 (in the period 1995–2003), to 40 (in 2004–2006), and to 38 (in 2007–2011).

The data on tariffs are sourced from the TRAINS database, downloaded via the World Integrated Trade Solution (WITS) interface.[5]

We estimate the trade elasticity ($\sigma_k - 1$) following the approach in Caliendo and Parro (2015). In particular, the trade structure in the current model implies that:

$$\ln \frac{x_{in,k}x_{nj,k}x_{ji,k}}{x_{ni,k}x_{jn,k}x_{ij,k}} = (1-\sigma_k)\ln \frac{\tilde{t}_{in,k}\tilde{t}_{nj,k}\tilde{t}_{ji,k}}{\tilde{t}_{ni,k}\tilde{t}_{jn,k}\tilde{t}_{ij,k}} + \varepsilon_{inj,k} \tag{3.36}$$

where $\tilde{t}_{ij,k} = 1 + t_{ij,k}$. We implement the regression using the panel of country pairs in the period 1995–2011 for each sector $k \in M$. The estimates of $\sigma_k - 1$ are reported in Table 3.2. See the footnote therein for further details of the implementation.

3.5 Calibration of Discount Factors

We propose the following algorithms to calibrate (country-specific and time-varying) discount factors that map the model and the data on the path of trade imbalances across time and countries. In particular, at each point in time, we take the current year as the base year

[4]More details about the dataset are provided at http://www.oecd.org/sti/ind/measuring-trade-in-value-added.htm. Tables are available from https://www.oecd.org/sti/ind/inter-country-input-output-tables.htm.

[5] https://wits.worldbank.org/.

and calibrate $\{\beta_j\}$ for the set of economies included and the associated world interest rate $\{r_t\}$, given the current year's trade imbalances across countries and the pre-existing bond balances $\{b_{j,0}\}$. For the benchmark, we allow the international borrowing and lending to clear in 10 periods (years). We repeat the process for each year in the sample (1995, 1996, ...) and obtain the discount factors across countries specific to the year, conditional on that year's observed trade imbalances and the beginning bond balances.

1. Start with an initial guess of $\widetilde{TD}_{j,1} = \frac{TD_{j,1}}{b_{j,0}}$ and compute for equilibrium $(\tilde{\omega}^M_{i,1}, \tilde{\omega}^S_{i,1}, \tilde{Y}_{j,1})$ and $(\tilde{\lambda}_{ijk,1}, \tilde{\lambda}_{ijs,1}, \tilde{P}_{jk,1}, \tilde{P}_{js,1})$, using equations (3.16)–(3.22). This is substituted into equation (3.24) to derive $\widetilde{W}_{j,1}$.

2. Fix one of the β_j's. In particular, we set β_{USA} to be 0.9. Using equation (3.25) to compute for $r_1 = \tilde{r}_1 r_0$ and the rest of β_j's. We set the inter-temporal elasticity of substitution ϵ to be 0.5.

3. Given r_1, β_j's, and period 1 variables that are computed in Step 1, calibrate $(\tilde{\omega}^M_{i,2}, \tilde{\omega}^S_{i,2}, \tilde{Y}_{j,2}, \widetilde{TD}_{j,2}, \tilde{r}_2)$ and $(\tilde{\lambda}_{ijk,2}, \tilde{\lambda}_{ijs,2}, \tilde{P}_{jk,2}, \tilde{P}_{js,2})$, using equations (3.16)–(3.25).

4. Iterate Step 3 for the subsequent periods until a large T. We set T to be 10 in the benchmark.

5. Verify that the present value sum of borrowing and lending across periods is $-b_{j,0}$,[6]; and the world trade balance condition in equation (3.23) is satisfied for the first period. Otherwise, adjust the initial guess of $\widetilde{TD}_{j,1}$ and repeat Steps 1–4 until the conditions are met.

The calibrated discount factors and interest rates are reported in Tables 3.3 and 3.4, respectively. We characterise the calibrated discount factors in Figure 3.3. The left panel plots the key percentiles (the 25%, the mean, and the 75%) of the discount factors across countries in each year. The mean values of the calibrated discount factors were relatively

[6]This is mathematically equivalent to $b_T = 0$, whereby there is no debt at the end of period T.

similar across years, but their dispersions increased in later years. For example, $\{\beta_j\}$ ranges from 0.858 to 0.943 in 1995, but from 0.870 to 1.141 in 2011. Note that the discount factor is determined by the deficit-to-GDP ratio of the respective country at each point in time, the increase in the range of discount factors over the years could be explained by correspondingly larger variations in the deficit-to-GDP ratios. For example, the ratios varied in the range of $[-29\%, 44\%]$ in 1995, in comparison with $[-61\%, 143\%]$ in 2011. Next, the right panel of Figure 3.3 indicates that economies with higher deficit-GDP ratios than the US have lower calibrated discount factors and the reverse is true for economies with lower deficit-GDP ratios (or higher surplus-GDP ratios). A very large trade surplus to GDP ratio could potentially lead to a discount factor that is greater than one. This was the case for economies such as Brunei and Saudi Arabia in 2011. A value of β_j greater than unity indicates that the economy values future consumptions more than the current-period consumptions.

Finally, recall that the calibrated interest rates are determined such that the international lending and borrowing implied by the current-period trade imbalances and pre-existing bonds clear within T periods. The gradual reduction in r_t over the periods corresponds to the diminution of borrowing and lending over the periods toward zeros.

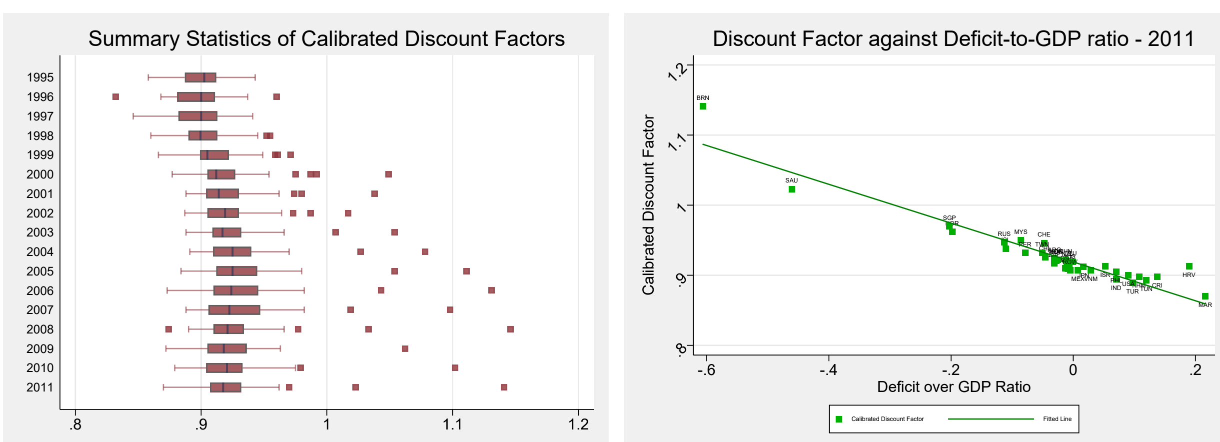


Figure 3.3: Calibrated Discount Factor and Deficit-to-GDP Ratios – 2011.

3.6 Conclusion

This paper highlights the role of trade imbalances in optimal tariff analysis and the downward bias in predicted optimal tariff rates based on a counterfactual world where trade imbalances are purged. This distorts downward the implied quantitative welfare benefits of reciprocal tariff reductions and the associated exchanges of market access concessions, relative to conclusions that would be drawn in the presence of trade imbalances. Relatedly, we show that in the presence of trade imbalances, exchanges of market access concessions by the same values in reciprocal tariff cooperation, summarized by the rule of reciprocity for the GATT/WTO negotiations, cannot maintain the pre-negotiation terms of trade and hence lose the rule's main function of guiding countries toward efficiency frontiers by neutralizing the terms-of-trade externality of trade policy making. In particular, the countries with trade surplus would be required to liberalize more than the rule of reciprocity for the terms-of-trade to be kept at the status quo. This may help explain the difficulty for the WTO members to reach further progress on trade liberalization in the recent decades with rising trade imbalances across countries.

The paper then proposes algorithms to endogenize trade imbalances and world lending/borrowing interest rates that respond to changes in tariff rates, by calibrating time-varying and country-specific discount factors that map the model to the data on the pattern of trade imbalances across countries and time. The proposed framework can then be used to address the caveats highlighted above and to re-assess the optimal tariff analysis. In particular, the rule of reciprocity can be generalized to allow for trade imbalances, and be modified to address the endogenous changes in the world interest rate and trade imbalances as a consequence of reciprocal tariff reductions. The quantitative results obtained will help guide the design of multilateral trade talks in the new era of prevalent trade imbalances.

3.7 Tables

Table 3.1: Country List

OECD Economies			Non-OECD Economies		
ISO	Country Name	Region	ISO	Country Name	Region
AUS	Australia	East Asia and Pacific	ARG	Argentina	Latin America
AUT	Austria	Europe and Central Asia	BGR	Bulgaria	Europe and Central Asia
BEL	Belgium	Europe and Central Asia	BRA	Brazil	Latin America
CAN	Canada	North America	BRN	Brunei Darussalam	East Asia and Pacific
CHL	Chile	Latin America	CHN	China	East Asia and Pacific
CZE	Czech Republic	Europe and Central Asia	COL	Colombia	Latin America
DNK	Denmark	Europe and Central Asia	CRI	Costa Rica	Latin America
EST	Estonia	Europe and Central Asia	CYP	Cyprus	Europe and Central Asia
FIN	Finland	Europe and Central Asia	HKG	Hong Kong SAR	East Asia and Pacific
FRA	France	Europe and Central Asia	HRV	Croatia	Europe and Central Asia
DEU	Germany	Europe and Central Asia	IDN	Indonesia	East Asia and Pacific
GRC	Greece	Europe and Central Asia	IND	India	South Asia†
HUN	Hungary	Europe and Central Asia	KHM	Cambodia	East Asia and Pacific
ISL	Iceland	Europe and Central Asia	LTU	Lithuania	Europe and Central Asia
IRL	Ireland	Europe and Central Asia	MLT	Malta	Middle East and North Africa
ISR	Israel	Middle East and North Africa	MYS	Malaysia	East Asia and Pacific
ITA	Italy	Europe and Central Asia	MAR	Morocco	Middle East and North Africa
JPN	Japan	East Asia and Pacific	PER	Peru	Latin America
KOR	Korea	East Asia and Pacific	PHL	Philippines	East Asia and Pacific
LVA	Latvia	Europe and Central Asia	ROU	Romania	Europe and Central Asia
LUX	Luxembourg	Europe and Central Asia	RUS	Russian Federation	Europe and Central Asia
MEX	Mexico	North America	SAU	Saudi Arabia	Middle East and North Africa
NLD	Netherlands	Europe and Central Asia	SGP	Singapore	East Asia and Pacific
NZL	New Zealand	East Asia and Pacific	THA	Thailand	East Asia and Pacific
NOR	Norway	Europe and Central Asia	TUN	Tunisia	Middle East and North Africa
POL	Poland	Europe and Central Asia	TWN	Taiwan	East Asia and Pacific
PRT	Portugal	Europe and Central Asia	VNM	Vietnam	East Asia and Pacific
SVK	Slovak Republic	Europe and Central Asia	ZAF	South Africa	Sub-Saharan Africa
SVN	Slovenia	Europe and Central Asia	ROW	Rest of the world	Rest of the World
ESP	Spain	Europe and Central Asia			
SWE	Sweden	Europe and Central Asia			
CHE	Switzerland	Europe and Central Asia			
TUR	Turkey	Europe and Central Asia			
GBR	United Kingdom	Europe and Central Asia			
USA	United States	North America			

Note: †India is the only economy in South Asia that is separately reported in TiVA.

Table 3.2: Sector Classification and Trade Elasticity Estimates

Sector	TiVA Industry Code	ISIC Rev 3	Sector Description	Trade Elasticity
1	C01T05AGR	01-05	Agriculture, hunting, forestry and fishing	0.45
2	C10T14MIN	10-14	Mining and quarrying	0.80
3	C15T16FOD	15-16	Food products, beverages and tobacco	0.68
4	C17T19TEX	17-19	Textiles, textile products, leather and footwear	1.18
5	C20WOD	20	Wood and products of wood and cork	4.57
6	C21T22PAP	21-22	Pulp, paper, paper products, printing and publishing	5.15
7	C23PET	23	Coke, refined petroleum products and nuclear fuel	0.32
8	C24CHM	24	Chemicals and chemical products	2.89
9	C25RBP	25	Rubber and plastics products	2.02
10	C26NMM	26	Other non-metallic mineral products	2.13
11	C27MET	27	Basic metals	2.38
12	C28FBM	28	Fabricated metal products	0.49
13	C29MEQ	29	Machinery and equipment, nec	1.98[†]
14	C30T33XCEQ	30-33	Computer, Electronic and optical equipment	1.98[†]
15	C31ELQ	31	Electrical machinery and apparatus, nec	1.98[†]
16	C34MTR	34	Motor vehicles, trailers and semi-trailers	1.98[†]
17	C35TRQ	35	Other transport equipment	2.68
18	C36T37OTM	36-37	Manufacturing nec; recycling	1.98[†]
19	C40T41EGW	40-41	Electricity, gas and water supply	10.00[‡]
20	C45CON	45	Construction	10.00[§]
	C50T52WRT	50-52	Wholesale and retail trade; repairs	
	C55HTR	55	Hotels and restaurants	
	C60T63TRN	60-63	Transport and storage	
	C64PTL	64	Post and telecommunications	
	C65T67FIN	65-67	Financial intermediation	
	C70REA	70	Real estate activities	
	C71RMQ	71	Renting of machinery and equipment	
	C72ITS	72	Computer and related activities	
	C73T74OBZ	73-74	R&D and other business activities	
	C75GOV	75	Public admin. and defence; compulsory social security	
	C80EDU	80	Education	
	C85HTH	85	Health and social work	
	C90T93OTS	90-93	Other community, social and personal services	
	C95PVH	95	Private households with employed persons	

Note: The table reports the classification of sectors used in the study. The trade elasticity is estimated based on the approach of Caliendo and Parro (2015), corresponding to the regression coefficient of trade flows (in ratios) to tariff variations (in ratios). [†]The elasticity estimates for these sectors are negative, and are replaced by the mean across sectors with positive elasticity estimates. [‡]The elasticity estimate for this sector is negative, and is replaced by a large number (10). The choice is based on the consideration that trade flows and tariffs are sparse in this sector. Using a large elasticity value mutes the optimal tariff consideration in this sector and neutralizes its role in the analysis. [§]Tariffs (which are required for the elasticity estimation) are not observed for these sectors; a large number (10) is adopted.

Table 3.3: Calibrated Discount Factor β_j

Country	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
AUS	0.904	0.907	0.905	0.902	0.906	0.918	0.917	0.912	0.912	0.914	0.919	0.920	0.916	0.921	0.910	0.919	0.915
EU	0.912	0.913	0.913	0.914	0.916	0.917	0.919	0.924	0.925	0.926	0.927	0.925	0.922	0.921	0.916	0.918	0.919
CAN	0.915	0.918	0.915	0.912	0.921	0.930	0.930	0.927	0.927	0.931	0.930	0.926	0.923	0.921	0.905	0.906	0.909
CHL	0.912	0.895	0.894	0.893	0.916	0.918	0.917	0.922	0.929	0.946	0.946	0.966	0.959	0.927	0.938	0.936	0.926
CZE	0.898	0.893	0.900	0.906	0.910	0.912	0.914	0.917	0.918								
EST	0.886	0.876	0.879	0.883	0.899	0.907	0.909	0.902	0.902								
HUN	0.905	0.906	0.904	0.903	0.904	0.905	0.912	0.912	0.909								
ISL	0.919	0.908	0.901	0.893	0.896	0.894	0.913	0.923	0.911	0.906	0.889	0.873	0.891	0.913	0.938	0.942	0.938
ISR	0.878	0.880	0.889	0.898	0.902	0.912	0.907	0.907	0.916	0.914	0.921	0.922	0.915	0.916	0.921	0.921	0.913
JPN	0.912	0.908	0.913	0.917	0.920	0.923	0.919	0.923	0.927	0.930	0.929	0.929	0.927	0.921	0.915	0.920	0.912
KOR	0.904	0.897	0.918	0.939	0.931	0.925	0.923	0.923	0.927	0.934	0.932	0.929	0.927	0.919	0.921	0.922	0.921
LVA	0.892	0.880	0.877	0.874	0.884	0.895	0.890	0.892	0.889								
MEX	0.914	0.911	0.905	0.898	0.903	0.905	0.904	0.907	0.909	0.909	0.912	0.913	0.910	0.907	0.905	0.907	0.907
NZL	0.911	0.911	0.912	0.913	0.914	0.925	0.927	0.926	0.925	0.922	0.919	0.922	0.921	0.920	0.920	0.922	0.918
NOR	0.927	0.937	0.926	0.914	0.936	0.975	0.974	0.964	0.965	0.969	0.980	0.982	0.965	0.977	0.956	0.956	0.962
POL	0.914	0.901	0.896	0.892	0.893	0.897	0.905	0.908	0.913								
SVK	0.908	0.879	0.879	0.880	0.898	0.908	0.898	0.902	0.916								
SVN	0.899	0.902	0.902	0.902	0.898	0.906	0.914	0.921	0.919								
CHE	0.919	0.920	0.920	0.921	0.926	0.931	0.930	0.937	0.939	0.942	0.943	0.946	0.948	0.951	0.945	0.946	0.946
TUR	0.904	0.899	0.906	0.912	0.913	0.906	0.931	0.921	0.916	0.913	0.912	0.908	0.904	0.906	0.908	0.896	0.889
USA	0.900	0.900	0.900	0.900	0.900	0.900	0.900	0.900	0.900	0.900	0.900	0.900	0.900	0.900	0.900	0.900	0.900
ARG	0.901	0.900	0.896	0.893	0.902	0.912	0.922	0.973	0.961	0.949	0.946	0.945	0.937	0.934	0.934	0.927	0.924
BGR	0.908	0.910	0.909	0.908	0.898	0.901	0.891	0.896	0.891	0.891	0.884	0.882					
BRA	0.895	0.894	0.894	0.895	0.903	0.906	0.909	0.924	0.932	0.938	0.939	0.936	0.927	0.921	0.912	0.910	0.912
BRN	0.917	0.903	0.897	0.892	0.943	1.049	1.038	1.017	1.054	1.078	1.111	1.131	1.098	1.146	1.062	1.102	1.141
CHN	0.916	0.919	0.922	0.925	0.922	0.924	0.923	0.926	0.926	0.929	0.938	0.942	0.943	0.940	0.926	0.925	0.922
COL	0.868	0.872	0.873	0.873	0.902	0.911	0.902	0.902	0.904	0.910	0.914	0.909	0.904	0.908	0.902	0.904	0.910
CRI	0.893	0.890	0.893	0.897	0.927	0.922	0.904	0.899	0.912	0.910	0.905	0.904	0.905	0.890	0.909	0.904	0.898
CYP	0.904	0.894	0.898	0.903	0.916	0.918	0.921	0.911	0.914								
HKG	0.891	0.901	0.906	0.910	0.929	0.931	0.931	0.945	0.949	0.949	0.962	0.958	0.953	0.950	0.936	0.931	0.926
HRV	0.874	0.878	0.879	0.881	0.887	0.902	0.899	0.887	0.891	0.899	0.902	0.901	0.895	0.894	0.900	0.911	0.913
IDN	0.910	0.912	0.929	0.945	0.939	0.951	0.943	0.939	0.944	0.937	0.938	0.943	0.936	0.925	0.924	0.923	0.922
IND	0.899	0.899	0.899	0.899	0.903	0.913	0.913	0.914	0.916	0.916	0.914	0.911	0.906	0.904	0.895	0.901	0.894
KHM	0.858	0.832	0.846	0.860	0.866	0.877	0.888	0.888	0.888	0.896	0.895	0.900	0.896	0.912	0.892	0.898	0.898
LTU	0.873	0.878	0.874	0.871	0.880	0.898	0.899	0.901	0.902								
MLT	0.868	0.871	0.879	0.888	0.891	0.894	0.908	0.926	0.913								
MYS	0.897	0.909	0.932	0.955	0.961	0.954	0.950	0.952	0.958	0.960	0.964	0.964	0.960	0.966	0.951	0.950	0.950
MAR	0.883	0.893	0.894	0.894	0.899	0.895	0.906	0.910	0.909	0.903	0.903	0.903	0.888	0.874	0.872	0.879	0.870
PER	0.879	0.882	0.882	0.883	0.900	0.906	0.907	0.914	0.920	0.936	0.946	0.956	0.947	0.924	0.930	0.928	0.932
PHL	0.876	0.874	0.878	0.883	0.900	0.908	0.896	0.893	0.899	0.907	0.909	0.919	0.922	0.915	0.911	0.911	0.905
ROU	0.889	0.881	0.881	0.880	0.896	0.899	0.893	0.901	0.897	0.895	0.892	0.886					
RUS	0.917	0.921	0.926	0.931	0.971	0.987	0.962	0.954	0.960	0.966	0.971	0.970	0.952	0.954	0.938	0.944	0.947
SAU	0.943	0.960	0.941	0.923	0.959	0.992	0.980	0.987	1.007	1.027	1.054	1.043	1.019	1.033	0.950	0.979	1.023
SGP	0.935	0.931	0.937	0.942	0.943	0.941	0.943	0.951	0.966	0.970	0.979	0.981	0.982	0.964	0.963	0.975	0.970
THA	0.887	0.888	0.920	0.952	0.949	0.938	0.933	0.935	0.938	0.935	0.922	0.933	0.941	0.927	0.936	0.930	0.921
TUN	0.893	0.901	0.899	0.897	0.904	0.905	0.903	0.905	0.909	0.914	0.923	0.917	0.914	0.910	0.900	0.895	0.893
TWN	0.910	0.914	0.914	0.913	0.920	0.922	0.931	0.938	0.939	0.931	0.936	0.940	0.942	0.934	0.936	0.933	0.932
VNM	0.878	0.873	0.881	0.890	0.906	0.911	0.911	0.905	0.900	0.904	0.916	0.916	0.891	0.890	0.890	0.897	0.907
ZAF	0.907	0.911	0.911	0.911	0.921	0.927	0.930	0.930	0.927	0.922	0.923	0.916	0.912	0.911	0.908	0.916	0.917
ROW	0.863	0.868	0.870	0.871	0.898	0.931	0.928	0.917	0.920	0.924	0.929	0.923	0.906	0.914	0.889	0.896	0.907

Note: USA's discount factor, β_{USA}, is fixed at 0.9 (as the numeraire against which the other countries' discount factors and the interest rates are calibrated). The calibration for year 1997 fails to converge; thus, we use the mean of the calibrated figures for years 1996 and 1998, for year 1997.

Table 3.4: Calibrated Interest Rate r

Period	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
1	10.4%	10.4%	10.3%	10.1%	9.7%	9.3%	9.3%	9.1%	8.8%	8.6%	8.4%	8.4%	8.7%	8.8%	9.5%	9.3%	9.3%
2	10.4%	10.4%	10.3%	10.1%	9.7%	9.3%	9.3%	9.1%	8.8%	8.6%	8.4%	8.4%	8.7%	8.7%	9.5%	9.3%	9.3%
3	10.4%	10.4%	10.3%	10.1%	9.7%	9.2%	9.3%	9.0%	8.8%	8.5%	8.3%	8.4%	8.6%	8.7%	9.5%	9.3%	9.2%
4	10.4%	10.4%	10.3%	10.1%	9.7%	9.2%	9.3%	9.0%	8.8%	8.5%	8.3%	8.3%	8.6%	8.7%	9.5%	9.3%	9.2%
5	10.4%	10.4%	10.2%	10.1%	9.7%	9.2%	9.2%	9.0%	8.8%	8.5%	8.3%	8.3%	8.6%	8.7%	9.5%	9.3%	9.2%
6	10.4%	10.4%	10.2%	10.1%	9.6%	9.2%	9.2%	9.0%	8.7%	8.5%	8.3%	8.3%	8.6%	8.6%	9.5%	9.2%	9.2%
7	10.3%	10.4%	10.2%	10.1%	9.6%	9.2%	9.2%	9.0%	8.7%	8.4%	8.2%	8.2%	8.5%	8.6%	9.5%	9.2%	9.2%
8	10.3%	10.4%	10.2%	10.0%	9.6%	9.2%	9.2%	9.0%	8.7%	8.4%	8.2%	8.2%	8.5%	8.6%	9.4%	9.2%	9.1%
9	10.3%	10.3%	10.2%	10.0%	9.6%	9.1%	9.2%	8.9%	8.7%	8.4%	8.2%	8.2%	8.5%	8.6%	9.4%	9.2%	9.1%
10	10.3%	10.3%	10.2%	10.0%	9.6%	9.1%	9.2%	8.9%	8.7%	8.4%	8.1%	8.1%	8.5%	8.5%	9.4%	9.2%	9.1%

Note: USA's discount factor, β_{USA}, is fixed at 0.9 (as the numeraire against which the other countries' discount factors and the interest rates are calibrated). The calibration for year 1997 fails to converge; thus, we use the mean of the calibrated figures for years 1996 and 1998, for year 1997.

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APPENDIX

Appendix A

Appendix for Chapter2

A.1 More Details on Analysis at HS 6 Level

A.1.1 Estimation of Sector Level AVE

The estimation procedure still closely follows Kee et al. (2009). The regression equation is:

$$\log(x_{js}+1) - \varepsilon_{js}\log(\tau_{js}+1) = \sum_k \alpha_{jk} C_j^k + \beta_s^T T_{js} + \beta_s^{NT} NT_{js} + \beta_s^{DS} \log DS_{js} + \epsilon_{js},$$

where

$$\begin{cases} \beta_s^T = -e^{\left(\gamma_s^T\right)}, \\ \beta_s^{NT} = -e^{\left(\gamma_s^{NT}\right)}, \\ \beta_s^{DS} = -e^{\left(\gamma_s^{DS}\right)}, \end{cases}$$

and x_{js} is the average import volume at destination-six-digit HS level across period 2010 to 2016, ε_{is} is the destination–six-digit HS level import demand elasticity, τ_{js} is the destination–six-digit HS level tariff rate. T_{js}, NT_{js} and DS_{js} are the NTMs indicators at destination–six-digit HS level. Then the AVE of core technical NTMs is given by:

$$AVE_s^T = \frac{e^{\beta_s^T} - 1}{\varepsilon_s},$$

where ε_s is the six-digit HS level substitution elasticity.

A.1.2 Estimation of Sector Level Substitution Elasticity

Following Soderbery (2015), assume a representative consumer faces CES preferences over varieties and across sectors and it yields the demand for a given variety in time t as

$$\zeta_{ist} = \frac{p_{ist}q_{ist}}{\sum_i p_{ist}q_{ist}} = \left(\frac{p_{ist}}{B_t(\boldsymbol{b_t})}\right)^{1-\sigma_g} b_{ist}.$$

Aggregate quantity of each variety i of sector s consumed in period t is denoted by q_{ist}, and σ_g is the sector specific elasticity of substitution. Trade share (ζ_{ist}) depends upon price (p_{ist}), the variety specific random taste parameter (b_{ist}) and a function of taste parameters ($B_t(\boldsymbol{b_t})$). Supply side is driven by monopolistically competitive market, so

$$p_{ist} = \left(\frac{\sigma_g}{\sigma - 1}\right) exp(\eta_{ist}) x_{ist}^{\rho_g}.$$

Random technology factors is given by η_{ist} and ρ_g represents the inverse supply elasticity of sector g.

Before preceding with the main estimation of elasticity of substitution, a reference country r is chosen for each sector s[1]. To eliminate time and good specific unobservables, price $\log p_{ist}$ and trade share $\log\zeta_{ist}$ are first subtracted by its lagged value and then by the reference country difference. The structural model's demand and supply curve is reflected in the following equations

$$\Delta^r \log\zeta_{ist} \equiv \Delta\log p_{ist} - \Delta\log p_{rst} = -(\sigma_g - 1)\Delta^r \log p_{ist} + \epsilon^r_{ist}$$
$$\Delta^r \log p_{ist} \equiv \Delta\log\zeta_{ist} - \Delta\log\zeta_{rst} = \left(\frac{\rho_g}{\rho + 1}\right) \Delta^r \log\zeta_{ist} + \delta^r_{ist}.$$

Assuming supply and demand disturbances vary independently across time and product space, we multiply the equations for the differenced supply and demand errors, ϵ^r_{ist} and δ^r_{ist}, and scale by $\frac{1}{1-\phi}$, we have

$$Y_{ist} = \theta_1 Z_{1ist} + \theta_2 Z_{2ist} + \mu_{ist},$$

where $Y_{ist} = (\Delta^r \log p_{ist})^2, Z_{1ist} = (\Delta^r \log\zeta_{ist})^2, Z_{2ist} = (\Delta^r \log\zeta_{ist})(\Delta^r \log p_{ist}),$ and $\mu_{ist} = \dfrac{\epsilon^r_{ist}\delta^r_{ist}}{1-\phi}.$ (A.1)

[1]Feenstra (1994) states that reference country should be the one that sells in every year. In the event of multiple potential reference countries, the one with highest sales is chosen.

With the advantage of panel nature of the dataset, following Soderbery (2015), LIML estimation on Equation (A.1) produces consistent estimates of θ_1 and θ_2 and using these two estimates, elasticity of substitution, σ, and supply elasticity, ρ, are obtained, as:

$$\phi = \frac{\rho(\sigma-1)}{1+\rho\sigma} \in \left[0, \frac{\sigma-1}{\sigma}\right]$$
$$\theta_1 = \frac{\phi}{(\sigma-1)^2(1-\phi)}$$
$$\theta_2 = \frac{2\phi-1}{(\sigma-1)(1-\phi)}.$$

If LIML estimation yields values of θ_1 and θ_2 that gives imaginary values of σ and ρ or values with the wrong sign, non-linear LIML search is adopted.

A.2 Data

Estimating the AVEs of technical measures also requires several other datasets. The bilateral trade flows from 2010 to 2016 and applied tariff rates, both at six-digit HS level, are from the WITS data base. To match with the estimated substitution elasticity from Soderbery (2018), we aggregate the trade flow data into destination-four-digit HS level. The destination–four-digit HS level MFN tariff rate is constructed by taking the average of the maximal and minimal value within each destination–four-digit HS group or six-digit HS group. In addition, we obtain data of tariff water, measured by the difference between bound tariff and MFN tariff, from Nicita et al. (2018).

The destination–six-digit HS import demand elasticity used in the estimation of AVEs is from Kee et al. (2008). Following Ossa (2015), assume $\varepsilon_{j,HS4}$ and $\varepsilon_{j,HS6}$ are the destination–four-digit HS and destination–six-digit HS level import demand elasticities, then the destination–six-digit HS level elasticity is given by $\frac{1}{\varepsilon_{j,HS4}} = E(\frac{1}{\varepsilon_{j,HS6}})$, where $E(\cdot)$ is an import-weighted average function. In addition, we obtain six-digit HS level import demand elasticity by using $\frac{1}{\varepsilon_{HS6}} = E(\frac{1}{\varepsilon_{j,HS6}})$. For those destination-sector observations that do not have import value record, we use the simple average to supplement the missing value.

The country level variables including GDP, exchange rate, GDP deflator, agricultural land, capital, and labor force during 2010 to 2016 are from WDI Data Bank.[2] The geographic distance data is from CEPII.[3] We use the GDP deflator to deflate GDP, capital to be in US Dollars in the base year. In the next step, we take the average across years. Table A.1 lists the summary statistics of the variables used in the estimation of AVEs.

[2]WDI Data Bank: https://databank.worldbank.org/source/world-development-indicators. For the missing values, we use the stata command *ipolate* (Linearly interpolate (extrapolate) values) to fill in the missing observations.

[3]CEPII: http://www.cepii.fr/cepii/en/bdd_modele/bdd.asp

Table A.1: Summary Statistics: Estimation of AVE_{js}

Variable	Obs	Mean	Std. Dev.	Min	Max
Tariff	109,833	0.07	0.17	0	30.00
Import Demand Elasticity	109,833	-2.27	10.84	-371.52	-0.0001
GDP (million USD)	109,833	493663.50	1462400	552.5	12947207
Agricultural Land (square kilometer)	109,833	355886.60	819867.10	6.93	5183326
Capital (million USD)	109,833	125985.50	406493.80	122.23	3284017
Labor (million)	109,833	109.36	404.75	0.03	4431.90
Import (million USD)	109,833	209.52	2688.10	0	375774.50
Domestic Agricultural Support (million USD)	109,833	38.29	6455.01	0	1948279
Technical NTM Dummy	109,833	0.14	0.35	0	1
Non-technical NTM Dummy	109,833	0.18	0.39	0	1

Table A.2: Summary Statistics: Firm Level Intensive Margin Analysis

Variable	Obs.	Mean	Std. Dev.	Min	Max
Value (million USD)	10,051,832	0.20	8.34	0	11,404
Tariff	10,051,832	0.05	0.08	0	15.03
Non-tariff Measure	5,527,095	0.18	0.15	0.01	0.95

Table A.3: Summary Statistics: Firm Level Extensive Margin Analysis

Variable	Obs.	Mean	Std. Dev.	Min	Max
Panel A. Full Sample					
Counts	298,040	33.73	115.34	1	12,413
Tariff	298,040	0.05	0.10	0	15.03
Non-tariff Measure	298,040	0.15	0.36	0	1
Panel B. Firms Exports to Destination j in Sector s from 2010-2015					
Counts	118,986	7.82	25.32	1	2629
Tariff	118,986	0.04	0.10	0	15.00
Non-tariff Measure	118,986	0.17	0.38	0	1

A.3 Discussions of Theoretical Analysis

A.3.1 Algebraic Details of Lemma 1

First note that for any $s \in \{s_{ii}, s_{ij}, s_{ji}, s_{jj}\}$, we have

$$\begin{aligned}\gamma'(s) &= -\theta c(s)^{-\theta-1} c'(s) f(s)^{\frac{\sigma-1-\theta}{\sigma-1}} + \frac{\sigma-1-\theta}{\sigma-1} c(s)^{\theta} f(s)^{\frac{-\theta}{\sigma-1}} f'(s) \\ &< 0 \qquad \forall s \in [0, s^{max}].\end{aligned}$$

Differentiating P_j accordingly gives

$$\frac{\partial P_j}{\partial s_{jj}} = -\frac{1}{\theta}\frac{\sigma}{\sigma-1}\left(\frac{\sigma}{\mu L_j}\right)^{\frac{1}{\sigma-1}}\left(\frac{\gamma_{jj}\gamma_{ii} - \tau^{-2\theta}\gamma_{ij}\gamma_{ji}}{\kappa(\gamma_{ii} - \tau^{-\theta}\gamma_{ji})}\right)^{-\frac{1+\theta}{\theta}} \frac{\gamma_{ii}\gamma'_{jj}}{\kappa(\gamma_{ii} - \tau^{-\theta}\gamma_{ji})} > 0$$

$$\frac{\partial P_j}{\partial s_{ij}} = -\frac{1}{\theta}\frac{\sigma}{\sigma-1}\left(\frac{\sigma}{\mu L_j}\right)^{\frac{1}{\sigma-1}}\left(\frac{\gamma_{jj}\gamma_{ii} - \tau^{-2\theta}\gamma_{ij}\gamma_{ji}}{\kappa(\gamma_{ii} - \tau^{-\theta}\gamma_{ji})}\right)^{-\frac{1+\theta}{\theta}} \frac{-\tau^{-2\theta}\gamma_{ji}\gamma'_{ij}}{\kappa(\gamma_{ii} - \tau^{-\theta}\gamma_{ji})} < 0$$

$$\frac{\partial P_j}{\partial s_{ii}} = -\frac{1}{\theta}\frac{\sigma}{\sigma-1}\left(\frac{\sigma}{\mu L_j}\right)^{\frac{1}{\sigma-1}}\left(\frac{\gamma_{jj}\gamma_{ii} - \tau^{-2\theta}\gamma_{ij}\gamma_{ji}}{\kappa(\gamma_{ii} - \tau^{-\theta}\gamma_{ji})}\right)^{-\frac{1+\theta}{\theta}} \frac{-\tau^{-\theta}\gamma_{ji}(\gamma_{jj} - \tau^{-\theta}\gamma_{ij})\gamma'_{ii}}{\kappa(\gamma_{ii} - \tau^{-\theta}\gamma_{ji})^2} < 0$$

$$\frac{\partial P_j}{\partial s_{ji}} = -\frac{1}{\theta}\frac{\sigma}{\sigma-1}\left(\frac{\sigma}{\mu L_j}\right)^{\frac{1}{\sigma-1}}\left(\frac{\gamma_{jj}\gamma_{ii} - \tau^{-2\theta}\gamma_{ij}\gamma_{ji}}{\kappa(\gamma_{ii} - \tau^{-\theta}\gamma_{ji})}\right)^{-\frac{1+\theta}{\theta}} \frac{\tau^{-\theta}\gamma_{ii}(\gamma_{jj} - \tau^{-\theta}\gamma_{ij})\gamma'_{ji}}{\kappa(\gamma_{ii} - \tau^{-\theta}\gamma_{ji})^2} > 0$$

A.3.2 Proof of Proposition 2

Note that the results shown in Lemma 1 still hold under national treatment. Since $\frac{P_j}{s_{ij}} < 0$, country j always chooses the highest standard possible under (2.16). In other words, $s_{ij} = \min\{s^{max}, s_{jj} + \psi(\sigma)\}$ in equilibrium. Hence $s_{ij} = s_{jj} + \psi(\sigma)$ does not hold only when $s_{jj} > s^{max} - \psi(\sigma)$. But if this is the case in the Nash equilibrium, $\frac{\partial s_{ij}}{\partial s_{jj}} = 0$ as raising s_{jj} cannot loosen the constraint on s_{ij} any more. From (2.17), we have $\frac{dW_j}{ds_{jj}} < 0$ since $\frac{\partial P_j}{\partial s_{jj}}$ from Lemma 1. Since reducing s_{jj} is possible and welfare-improving, it is impossible to have $s_{jj} > s^{max} - \psi(\sigma)$ in the Nash equilibrium under national treatment. Once we have $s_{ij} = s_{jj} + \psi(\sigma)$, $\frac{d(s_{ij} - s_{jj})}{d\sigma} < 0$ follows immediately given the assumption that $\psi' < 0$.