The Balance of Concessions in Trade Agreements*

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This Version: February 22, 2025

Abstract

We develop a quantitative framework to analyze the WTO's reciprocity principle. Our approach defines a consistent measure of bilateral reciprocity in a multilateral setting based on the terms-of-trade effects of tariff cuts. We demonstrate that trade-balance shocks can disrupt negotiated reciprocity, causing deficit countries to make excessive terms-of-trade concessions. By quantifying the concessions exchanged among WTO members, we identify significant deviations from reciprocity across countries, with the U.S. standing out as the largest net granter of concessions. The rise in trade imbalances since the early 1990s has exacerbated these deviations, approximately accounting for two-thirds of the U.S.'s excess concessions.

*We are grateful for the helpful comments and suggestions from Enakshi Bera, Emily Blanchard, Eric Bond, Kristy Buzard, Mario Crucini, David DeRemer, Fatemeh Fatemi, David Hummels, Doug Irwin, Bilgehan Karabay, Sung Eun Kim, Phillip McCalman, Helen Milner, Luca Opromolla, Kamal Saggi, Anson Soderbery, Robert Staiger, Mohammad Vesal, Ben Zissimos, and seminar participants at various institutions. We acknowledge excellent research assistance by Fangfang Gong and Guilherme Pinto. Chang acknowledges the financial support of Lee Kong Chian Fund for Research Excellence. Beshkar acknowledges financial support from the Center for Applied Economics and Policy Research.

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1 Introduction

Reciprocity is a fundamental principle in international trade agreements, particularly within the World Trade Organization, where negotiations are expected to result in a balanced exchange of market access concessions. However, whether trade agreements truly adhere to this principle remains an open question, as there has been no established quantitative methodology to measure reciprocity in a multilateral setting. Most existing studies analyze reciprocity in a two-country setting, leaving multilateral contexts largely unexplored. This gap in understanding has become increasingly urgent as major WTO members have raised concerns about perceived imbalances in trade commitments, with some even questioning their continued participation in the WTO. The rising dissatisfaction with the fairness of existing agreements presents a significant challenge to the stability of the global trading system.[1]

We address these concerns by developing a theoretical framework that extends the notion of reciprocity to a multilateral setting and provides a quantitative approach to measure the balance of concessions exchanged through various agreements under the WTO. We build on Bagwell and Staiger (1999), who define bilateral tariff cuts as reciprocal if they lead to equal changes in import and export volumes for both countries.[2] This definition aligns with the language and practice of GATT/WTO, which emphasizes *enhancing international market access* in a reciprocal manner. While some critics have dismissed this emphasis on enhanced market access as

[1]For instance, in his 2018 address to the United Nations General Assembly, the U.S. president Stated that *"We believe that trade must be fair and reciprocal. The United States will not be taken advantage of any longer."* This statement was followed by calls from some U.S. senators advocating for the abolition of the WTO.

[2]The subsequent literature, including Zissimos (2009), Blanchard (2010), Ossa (2011), Mrázová (2023), Bagwell and Staiger (2012), DeRemer (2016), and Cole et al. (2021), has evaluated this definition of reciprocity in various contexts, such as different numbers of countries, market structures, policy spaces, political preferences, and cross-border asset ownership. While some of these papers identify conditions under which this notion of reciprocity fails to deliver an efficient outcome, it is consistently shown to have useful efficiency properties.

"illiterate mercantilism," Bagwell and Staiger argue that requiring an equal exchange of market access serves an important purpose by discouraging governments from using trade policy to manipulate their terms of trade with trading partners.

Building on this foundation, we extend the concept of reciprocity that is suitable for use in a setting with multiple countries. Specifically, we define a set of bilateral tariff cuts as reciprocally balanced if it leads to equal changes in each country's *terms-of-trade gains*—or, equivalently, net imports when evaluated at fixed prices. Unlike in a two-country framework, where one country's terms-of-trade gain necessarily comes at the expense of its partner, in a multi-country setting, bilateral tariff cuts can simultaneously improve the terms-of-trade gains (or net imports) for both trading partners. Accordingly, we measure deviations from bilateral reciprocity—termed net bilateral concessions—as the difference between a country's terms-of-trade gains and the average terms-of-trade gains of the two trading partners.

With this notion of reciprocity at hand, we theoretically examine how an exogenous trade-balance shock affects the balance of concessions in a previously negotiated trade agreement. We model trade imbalances as arising from foreign ownership of domestic factors of production, where a country with net foreign asset ownership runs a trade deficit. An increase in trade deficit is thus interpreted as an exogenous shock to foreign asset ownership. We demonstrate that such a shock can disrupt the reciprocity of previously negotiated tariff cuts. Specifically, as a country's trade deficit expands, it derives a smaller terms-of-trade gain from tariff cuts that were initially structured to be reciprocal, effectively increasing its net concessions relative to its trading partners.

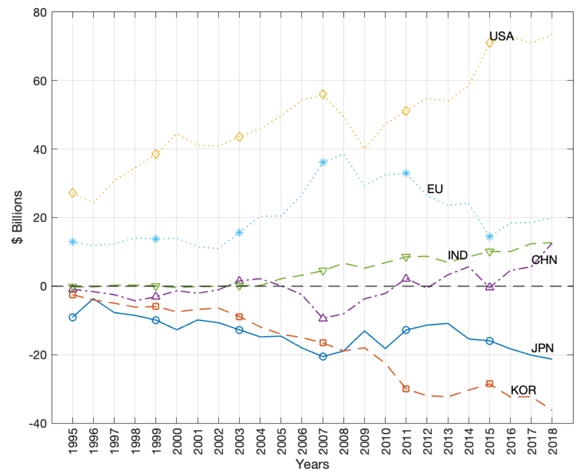
At the time of the Uruguay Round negotiations in the early 1990s, the U.S. had a balanced trade position and did not anticipate the emergence of a large and persistent trade deficit (Kehoe, Ruhl, and Steinberg, 2018). It is, therefore, likely that the U.S. negotiators structured bilateral tariff cuts under the assumption that trade balances would remain stable over time. Our findings suggest that the subsequent rise in trade deficits may have disrupted the intended reciprocity in these agreements, offering a potential explanation for the growing dissatisfaction with trade agreements in the United States. Our finding also underscores the importance of incorporating flexibility mechanisms into trade agreements to mitigate deviations from reciprocity caused by unforeseen and persistent shifts in trade balances.

A key step in measuring concessions is to characterize a noncooperative scenario that will be used as the benchmark. We assume tariff cut negotiations take place bilaterally and, therefore, disagreement scenarios involve bilateral trade wars. This choice of bargaining environment is inspired by Bagwell, Staiger, and Yurukoglu's (2021) Nash-in-Nash model of trade agreements. However, we remain agnostic about the bargaining protocol that governs bilateral negotiations and, instead, we concern ourselves with calculating each country's terms-of-trade gains/losses from moving from bilateral noncooperative tariffs to WTO-implemented tariffs.

Quantitative Results We conduct our quantitative analysis using a competitive, multi-sector, multi-country trade model with exogenous trade imbalances. To characterize noncooperative tariffs in bilateral trade wars, we compute bilateral best-response (Nash) tariffs, using applied tariffs as a lower bound for optimal tariffs. To assess the sensitivity of our results to different tariff rates, we also examine a scenario where countries apply equal, uniform tariffs on imports. Specifically, we report results using a 50% noncooperative tariff rate, which is within the historically observed range during high-tariff periods and consistent with computational estimates from previous studies.

Our quantitative analysis generates a matrix of bilateral concessions among 38 economies for each year and several counterfactual scenarios between 1995 and 2018, with potential extensions to additional years and economies. As depicted in Figure 1, we observe significant variation in net terms-of-trade gains across countries and years. The United States stands out as the country with the largest net concessions to the rest of the world

Figure 1: Net Multilateral Concessions Granted by Selected Countries



This graph depicts the net terms-of-trade concessions granted by selected countries to the rest of the world in each year from 1995 to 2018. For more details see Section 4.

ranging from $25 billion in 1996 to more than $70 billion in 2018.[3] The United States is followed by the European Union and China with each granting a net terms-of-trade concession close to $20 billion in 2018. Conversely, the largest recipients of net terms-of-trade concessions in 2018 are South Korea (~$40 billion) and Japan ($20 billion).

While the United States, China, and the European Union are the largest net granters of concessions to the world, their bilateral relationship features a substantial imbalance of concessions. Specifically, the US made $17 billion of net concessions to each of China and EU in 2018. This discrepancy in bilateral concessions is largely attributable to differences in bilateral tariffs and trade imbalances.

Our quantitative results indicate a growing disparity of concessions made by different economies over time, making the agreement increasingly asymmetric for certain countries. While various factors may account for the intertemporal variation in the balance of concessions—including the rapid economic expansion of developing countries and changes in applied

[3] For comparison, note that the total foreign aid budget of the United States in 2018 was $47 billion.

tariffs—the sharp increase in global trade imbalances stand out as the most likely cause. Specifically, our quantitative results suggest that if trade imbalances had remained as small as they were during the Uruguay Round negotiations, trade agreements would have been significantly more reciprocal for the United States. Under this counterfactual scenario, the net concessions granted by the U.S. would have been more than 60% lower, indicating that much of the observed asymmetry stems from the structural effects of trade imbalances rather than from the negotiated tariff cuts themselves. These results confirm the significance of our theoretical finding that trade imbalances systematically distort the intended reciprocity of negotiated tariff concessions, forcing deficit countries to grant disproportionately large net concessions.[4]

Related Literature This paper contributes to a nascent literature that utilizes the advances in quantitative analysis of trade flows to provide an empirical evaluation of theoretical models of trade agreements. Notably, Bagwell, Staiger, and Yurukoglu (2020, 2021) provide a theoretical foundation to evaluate bilateral tariff negotiations in a multilateral setting where negotiations are governed by a Most-Favored Nation (MFN) clause. Employing a Nash-in-Nash equilibrium concept, Bagwell et al. (2021) calibrate bargaining power of countries in their respective bilateral relationships. A key quantitative finding of their paper is that global efficiency gains under the WTO depends critically on the inclusion of the MFN clause in the agreement.

Bown, Caliendo, Parro, Staiger, and Sykes (2023) provide a quantitative framework to examine the effect of reciprocal tariff cuts on labor reallocation across industries in each country. They also use this framework to evaluate the degree of reciprocity that is implied by tariff cuts under the WTO from 1990 to 2007. Our paper, developed independently, adopts a dif-

[4] Delpeuch, Fize, and Martin (2021) demonstrate that trade imbalances are a crucial predictor of protectionism. Our finding that the scale of terms-of-trade concessions is also significantly influenced by trade imbalances may offer fresh insights into the the link between trade imbalances and protectionism.

ferent approach in measuring concessions exchanged among countries and reaches significantly different conclusions. Both papers define reciprocity as maintaining terms of trade at a specific benchmark level, with a key distinction lying in the choice of that benchmark. Specifically, while Bown et al. (2023) anchor their analysis to a historical benchmark to assess reciprocity, our methodology uses the noncooperative equilibrium as the reference point. Consequently, we find that China's tariff cuts failed to reciprocate the tariff cuts by the United States, whereas Bown et al. (2023) find that China's tariff cuts *exceeded* the reciprocity norm vis-á-vis the United States.

Our choice of the benchmark for terms of trade is based on the understanding that an equitable agreement should reflect the outside options available to the parties, namely, the outcomes they could secure in the absence of collaboration. For instance, an increase in import market power of a country amplifies the terms-of-trade effect of its tariff cuts.[5] Therefore, maintaining a reciprocal relation would require adjusting tariffs to achieve a balance that reflects contemporary conditions, rather than striving to revert to a historical ToT baseline. The difference in our ToT benchmark leads to different implications about the effect of changes in economic fundamentals on the balance of concessions. Notably, our framework suggests that to restore the balance of concessions after the growth in China's trade surplus, China must undertake more aggressive tariff cuts against the United States. In Bown et al.'s (2023) framework, restoring reciprocity requires a tariff increase in China because its growing trade surplus has deteriorated its terms of trade compared to the early 1990s.

The remainder of this paper is structured as follows. Section 2 presents our theoretical framework. Section 3 lays out the quantitative trade model employed to simulate counterfactual scenarios. Section 4 discusses our quantitative findings, and Section 5 concludes with final remarks.

[5] Jakubik, Keck, and Piermartini (2023) make the point that as trade patterns and relative economic size of countries change over time, the relative market power of countries change as well. They suggest that due to changes in country's market power, recurring rounds of negotiations under the WTO will be helpful to keep commitments at mutually accepted level.

2 Measurement of Trade Concessions and Reciprocity

In this section, we define reciprocity and propose a metric for measuring deviations from it in a multi-country trade model with multilateral trade imbalances. We then use a two-country version of the model (home vs. the rest of the world) to illustrate the key results graphically and derive a theoretical result on how a shock to a country's trade balance with the rest of the world affects its balance of concessions.

A key step in measuring concessions is to characterize a disagreement (or, noncooperative) scenario that will be used as the benchmark to calculate exchanged concessions. Given the multilateral nature of the WTO, trade disputes can take various forms, ranging from purely bilateral disputes without multilateral enforcement to a fully multilateral system where a violation against one country is treated as a violation against all. However, while a multilateral agreement may be more efficient than a web of bilateral agreements (Maggi, 1999), WTO enforcement mechanisms primarily rely on affected members retaliating rather than imposing broad multilateral sanctions. Therefore, we designate bilateral trade wars as the relevant noncooperative outcome.

Basic Model

Consider a world with N countries where each country i is endowed with Q_i units of a nationally-differentiated good. Letting q_{ji} denote the quantity of exports from country j to i, consumer preferences in country i are given by:

$$U_i = \sum_{j=1}^{N} u\left(q_{ji}\right). \tag{1}$$

To allow for trade imbalances, we assume that countries could hold overseas assets. Specifically, we assume that country i owns a fraction α_{ij} of country j's endowment, where $\sum_{k=1}^{N} \alpha_{kj} = 1$ for all j. Moreover, country i

draws income from tariffs, t_{ji}, that it imposes on imports from each country j. Therefore, letting p_{ji} denote the price of country j's good at country i's border, country i's disposable income is given by:

$$Y_i \equiv \sum_{j=1}^{N} \alpha_{ij} p_{jj} Q_j + \sum_{j=1}^{N} t_{ji} p_{ji} q_{ji}, \tag{2}$$

where the first term is country i's income from its worldwide asset holding, and the second term is its tariff revenues. Finally, county i's expenditure is given by $\sum_{j=1}^{N} \tilde{p}_{ji} q_{ji}$, where $\tilde{p}_{ji} = \left(1 + t_{ji}\right) p_{ji}$. Balanced budget requires $Y_i = \sum_{j=1}^{N} \tilde{p}_{ji} q_{ji}$ for all i.

To define concessions, consider a multilateral trade agreement, A, that determines tariff obligations of each country j with respect to country i, denoted by t_{ij}^{A}. Moreover, let t_{ij}^{N} denote the *noncooperative* tariff that country j would apply on imports from country i under a bilateral trade war. We let $\mathcal{D}_{ij}$ represent a scenario in which country j defects from its tariff obligations to country i by increasing its tariffs on i from t_{ij}^{A} to t_{ij}^{N}. Further, let $\mathcal{D}$ denote the set of all defections in a counterfactual scenario. For example, $\mathcal{D} = \left\{\mathcal{D}_{ij}, \mathcal{D}_{ji}\right\}$ represents a counterfactual in which country i and country j engage in a bilateral trade war, while all other bilateral relationships in the world maintain the agreement tariffs. The empty set, $\mathcal{A} \equiv \emptyset$, represents the equilibrium under the agreement, i.e., when there is no defection.

Let $T_i^{\mathcal{D}}$ denote the terms-of-trade gains of country i as a result of a change in equilibrium from $\mathcal{D}$ to $\mathcal{A}$, namely:

$$T_i^{\mathcal{D}} \equiv \sum_{\forall l \neq i} \left[\left(p_{il}^{\mathcal{A}} - p_{il}^{\mathcal{D}} \right) q_{il}^{\mathcal{D}} - \left(p_{li}^{\mathcal{A}} - p_{li}^{\mathcal{D}} \right) q_{li}^{\mathcal{D}} \right].$$

Note that $T_i^{\mathcal{D}}$ is also equivalent to the change in the net imports of country i evaluated at equilibrium prices under $\mathcal{A}$. We first establish that:

Proposition 1. *For any pair of countries, i and j, the sum of the two country's* *terms-of-trade gains from their bilateral cooperation is non-negative, namely:*

$$T_i^{\{\mathcal{D}_{ij},\mathcal{D}_{ji}\}} + T_j^{\{\mathcal{D}_{ij},\mathcal{D}_{ji}\}} \geq 0.$$

Moreover, this sum is strictly positive if either country trades with the rest of the world, and it is zero otherwise.

The above proposition implies that bilateral tariff reductions increase the joint terms of trade of the two countries, at the expense of the terms of trade of the rest of the world. However, it is possible for one (and only one) of the two countries in the bilateral pair to suffer a terms-of-trade loss from this cooperation.

We define the relationship between two countries as reciprocal if a bilateral trade war between them, while holding all other tariffs in the world constant, results in equal terms-of-trade effects for both countries. Specifically,

Definition 1. The relationship between h and f is reciprocal iff $T_h^{\{\mathcal{D}_{hf},\mathcal{D}_{fh}\}} = T_f^{\{\mathcal{D}_{hf},\mathcal{D}_{fh}\}}$.

This definition extends the concept of reciprocity in a two-country setting proposed by Bagwell and Staiger (1999) to a multi-country setting.[6] In a two-country setting, they define a set of bilateral tariff cuts as reciprocal if they leave the net imports (evaluated at initial prices) unchanged for both countries. However, as Proposition 1 demonstrates, in a multi-country setting, bilateral tariff cuts will necessarily increase the net imports for at least

[6]Note that our definition of bilateral reciprocity in a multi-country setting differs from the one introduced in Section III of Bagwell and Staiger (1999). They define a set of tariff cuts between a home country and a foreign country as reciprocal if it keeps the net imports of the foreign country constant at initial prices. Proposition 1 shows that such tariff cuts would necessarily result in an increase in the net imports of the home country. To adapt this concept for our purposes, we use Definition 1, which offers a symmetric measure of reciprocity by ensuring it does not depend on which country in the bilateral pair is designated as foreign. This symmetry is essential for our quantitative analysis, where we evaluate the balance of concessions in real-world trade agreements.

one of the two countries involved. Therefore, in a multi-country setting, bilateral-reciprocity cannot be defined as holding net imports constant.

To address this issue, Definition 1 characterizes bilateral tariff cuts as reciprocal when they result in equal terms-of-trade gains for the two countries involved. For the special case of a two-country world, this definition implies constant terms of trade under reciprocal tariff cuts.

To measure deviations from reciprocity in a bilateral relationship, we define *net concessions* that country h gives to country f as

$$NC_{hf} \equiv \frac{1}{2}\left[T_f^{\{\mathcal{D}_{hf},\mathcal{D}_{fh}\}} - T_h^{\{\mathcal{D}_{hf},\mathcal{D}_{fh}\}}\right], \tag{3}$$

which represents the deviation from an equal split of the joint terms-of-trade gains achieved through bilateral cooperation.

Following the above definition of reciprocity in bilateral relationships, we define the agreement multilaterally-reciprocal for a country if the sum of its bilateral net concessions is zero. While halting cooperation with another member country violates the WTO's non-discrimination clause, the WTO law specifies that a violation by one member country against another can only be addressed through retaliation by the affected member, precluding multilateral sanctions. Therefore, designating bilateral trade wars as non-cooperative outcomes is generally consistent with the rules and procedures of the WTO.

Trade Imbalances and Reciprocity

To illustrate deviations from reciprocity when trade is unbalanced, consider the two-country version of the above model, comprising a home country, h, and the rest of the world combined into a single region, r. Furthermore, let the home country to have a trade deficit by assuming that it owns its domestic endowment as well as a fraction $\alpha = \sum_{j\neq h}\alpha_{hj}$ of productive assets in the rest of the world. Within this framework, we first establish that:

Proposition 2. *If a country's real trade imbalance is unaffected by tariffs, i.e., if* α

is exogenously given, a reciprocal tariff cut between the home country and the rest of the world leaves the terms of trade unchanged.

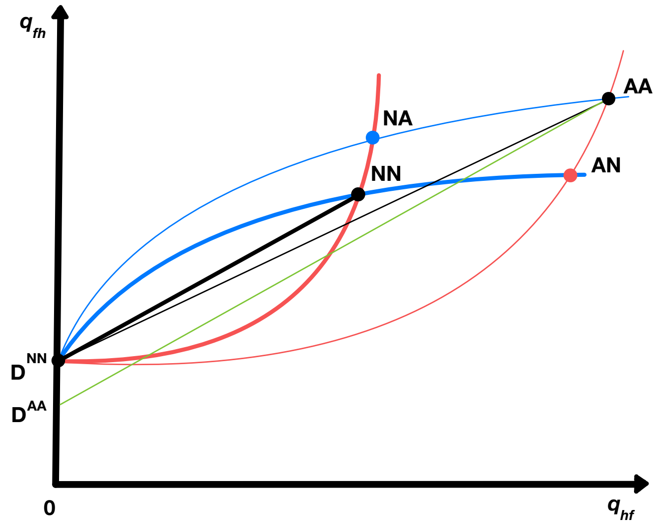
This proposition implies that even when trade is unbalanced, a reciprocal exchange of market access leaves the world prices unchanged. As we will discuss below, this proposition confirms Blanchard's (2010) finding that net remittances from foreign assets are unaffected by reciprocal tariff cuts.

Figure 2 depicts the effect of a set of mutual tariff cuts on quantity of imports and exports for the home country. The noncooperative (NN) and agreement (AA) equilibria correspond to the intersection of the trade offer curves of the two countries before and after tariff cuts, respectively.[7] The trade offer curve of the home country under its noncooperative tariff is depicted by the red curve passing through NN and NA. Similarly, the trade offer curve of the foreign country under its noncooperative tariff is depicted by the blue curve that passes through NN and AN. The point D^{NN} on the vertical axis depicts the home country's trade deficit, which is equal to the value of foreign endowment that is owned by the home country. The intersection of the offer curves at NN indicates the equilibrium under noncooperative tariffs. Trade liberalization by home and foreign countries expands their respective trade offer curves outwardly, and shifts the equilibrium trade quantities from NN to AA.

The bilateral tariff cuts that cause a shift from NN to AA, depicted in Figure 2, do not conform to the principle of reciprocity because they result in a deterioration of home country's ToT. To see this, note that the slope of the line connecting the equilibrium point with $\left(0, D^{NN}\right)$ indicates the ToT of the home country, which is lower under the agreement than noncooperation. The degree of deviation from reciprocity in this two-country setting is captured by the change in the home country's net imports. In particular, in Figure 2, mutual tariff cuts causes the home country a ToT loss equivalent to $\left(p^{AA} - p^{NN}\right) q_{hf}^{AA} \equiv D^{AA} - D^{NN} < 0$. This confirms Blanchard's (2010) theoretical result that with cross-border ownership of factors of pro-

[7] The trade offer curve of a country illustrates the import and export quantities it is willing to trade at various relative world prices.

Figure 2: Deviation from Reciprocity



This figure uses trade offer curves—red for the home country and blue for the foreign country—to illustrate the equilibrium trade flows under noncooperative tariffs, NN, and the factual (cooperative) tariffs, AA. These tariff cuts are not reciprocal as they have caused a terms-of-trade loss, equivalent to $D^{NN} - D^{AA}$, for the home country.

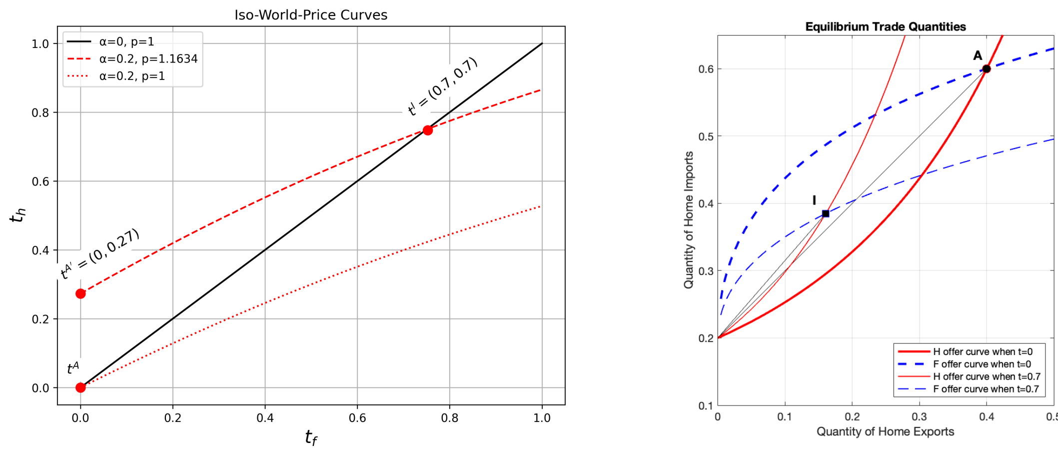
duction, a reciprocal tariff cut "leaves net remittances unchanged," namely, $D^{AA} = D^{NN}$.

Effect of a Trade Balance Shock on Reciprocity A key idea we will evaluate quantitatively in the subsequent sections is that a trade balance shock can alter the balance of concessions under an existing trade agreement. To gain theoretical insights into this effect, we conduct comparative statics on α, which uniquely determines trade imbalances. Assuming CES preferences, we show in Appendix A.3 that:

Lemma 1. *In the (t_f, t_h) space, the iso-world-price curves satisfy the uniform single crossing property with respect to the trade-imbalance parameter, α. Furthermore, as α increases, the iso-world price curve passing through a given tariff pair undergoes a clockwise rotation.*

The left panel in Figure 3 illustrates this property by depicting the iso-world-price curves that passes through an initial tariff pair, t^I, under two

Figure 3: Reciprocal Tariff Cuts under Different Trade-Balance Scenarios



Left Panel: Schedule of reciprocal tariff cuts from initial tariffs, $t^I = (0.7, 0.7)$ under balanced trade (represented by the solid line, $(\alpha = 0)$), and trade deficit for home (represented by the dashed-line, $\alpha = 0.2$.)
Right Panel: Equilibrium traded quantities under the initial tariffs t^I and free trde t^A. Figures drawn assuming CES preferences with $\sigma = 2$, and $\alpha = 0.2$, $Q_h = Q_f = 1$.

trade balance scenarios: $\alpha = 0$, and $\alpha = 0.2$. When trade is balanced $(\alpha = 0)$, a set of tariff cuts from t^I to agreement tariffs t^A is reciprocal, as it preserves the world price. However, an increase in α from 0 to 0.2 disrupts this reciprocity. Under the new trade-balance scenario, the maximum reciprocal tariff cuts would result in a zero tariff in the surplus country while the deficit country maintains a positive tariff.

A corresponding representation of this result in import-export quantity space is shown in the right panel of Figure 3. Point I in this figure shows the traded quantities under the initial equilibrium before tariff cuts, while point A represents traded quantities after tariff cuts. The slope of the lines passing through each equilibrium point indicates the world price of the home country's exports in the respective equilibrium. The deterioration of the deficit country's terms of trade due to tariff cuts is reflected in the decrease in the slope of this line. Formally,

Proposition 3. *Under a given set of mutual tariff cuts, an increase in trade imbalances, represented by an increase in α, moves the balance of concessions in favor of the trade-surplus country.*

Therefore, tariff cuts considered reciprocal under trade imbalance require relatively smaller tariff reductions by the home country compared to reciprocal tariff cuts under balanced trade.

3 The Quantitative Model

To quantify the effect of tariffs on terms-of-trade gains, which is our main measure of tariff concessions, we use a multi-country and multi-sector setup in which goods are differentiated by the origin of production, i, destination of consumption, j, and sector, k, 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 $k \in \{1, 2, ..., K\}$.

3.1 Setup

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

$$U_j = \prod_k (\sum_{i=1}^{N} b_{ij,k} \tilde{q}_{ij,k}^{\rho_k})^{\frac{\mu_{j,k}}{\rho_k}}, \tag{4}$$

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, $\sigma_k \equiv 1/(1 - \rho_k)$ is the elasticity of substitution across varieties in sector k, and $\mu_{j,k}$ represents the share of expenditure on sector k relative to the total expenditure of country j on non-service sectors.

Production technology follows the Ricardian structure, with labor as the only factor of production. Let $\bar{a}_{ij,k}$ denote the exogenous unit labor 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:

$$p_{ij,k} = \bar{a}_{ij,k}\,\omega_i, \tag{5}$$

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

$$\tilde{p}_{ij,k} = (1 + t_{ij,k})(1 + \kappa_{ij,k})p_{ij,k}, \quad t_{ii,k} = 0, \tag{6}$$

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

By budget constraint, the aggregate expenditure, Y_j, of country j is equal to the sum of wage income, tariff revenues, and trade deficit D_j, i.e.,

$$Y_j = \omega_j L_j + \sum_k \sum_i \frac{t_{ij,k}}{1 + t_{ij,k}} \tilde{p}_{ij,k} \tilde{q}_{ij,k} + D_j \tag{7}$$

We assume that trade deficit (or, surplus) of country j is a fixed fraction, δ_j, of the world income, i.e.,[8]

$$D_j = \delta_j \sum_i \omega_i L_i.$$

Furthermore, given that the sum of trade deficits in the world should be zero, we must have:

$$\sum_i \delta_i = 0.$$

Finally, the welfare of country j driven from non-service sectors may be written as:

$$W_j = \left(\frac{Y_j}{\prod_k P_{j,k}^{\mu_{j,k}}} \right)^{\mu_j}, \tag{8}$$

[8] This is a variation of the assumption, stated in Section 2, about cross-border ownership of factors of production.

where, $P_{j,k}$ is the price index in country-sector j,k. [9]

3.2 Computing Concessions

The procedure to compute concessions involves two steps. First, we compute the counterfactual equilibrium under a bilateral trade war for each pair of countries, holding all other tariffs in the world constant. We then use equation (3) to measure the net concessions exchanged between each pair of countries as a result of moving from bilateral trade war to the factual equilibrium.

The bilateral trade war approach is akin to, yet distinct from, the Nash-in-Nash approach of Horn and Wolinsky (1988). In evaluating the bilateral relationship for each pair of countries, we consider the bilateral tariffs of all other country-pairs as given. In this bargaining environment, bilateral concessions are computed using the outcome of the bilateral trade war as the noncooperative outcome, with multilateral concessions calculated as the sum of bilateral concessions.

A noteworthy departure from the Nash-in-Nash methodology is that our approach remains agnostic about the bargaining protocol generating observed cooperative tariffs. To elaborate, consider Bagwell et al. (2021), who use Horn and Wolinsky's approach to analyze tariff bargaining under the WTO. They calibrate a Nash-in-Nash bargaining model by finding bargaining power parameters that rationalize the observed tariff concessions under the WTO. In contrast, we do not take any stance on the bargaining protocol and we do not attempt to calibrate the corresponding bargaining parameters of the model. Instead, we quantify concessions by computing the ToT gains for each country as a result of bilateral tariff cuts from noncooperative tariffs to the observed tariffs under the WTO.

This framework reflects a core aspect of the negotiation process within the GATT/WTO where tariff concessions are often negotiated bilaterally.

[9] See Section 5 for a discussion of the limitations of this framework, and Appendix E for details of our calibration exercise.

This framework also reflects the fact that trade agreements are mostly enforced on a bilateral basis. Specifically, any member country has the option to terminate its trade policy cooperation with another member, leading to a bilateral trade war. While halting cooperation with another member country violates the WTO's non-discrimination clause, the WTO law specifies that a violation by one member country against another can only be addressed through retaliation by the affected member, precluding multilateral sanctions. Therefore, designating bilateral trade wars as noncooperative outcomes is generally consistent with the rules and procedures of the WTO.

Determining Noncooperative Outcomes An important challenge in calculating concessions within this framework is the difficulty of predicting noncooperative tariffs in each bilateral trade war. As expected, the magnitude of computed concessions are sensitive to the choice of the noncooperative tariffs. We employ multiple benchmarks for noncooperative tariffs to evaluate the sensitivity of our quantitative results to different assumptions about noncooperative tariff levels.

As our primary noncooperative benchmark, we compute bilateral best-response "Nash" tariffs within our trade model. For robustness check, we also consider bilateral trade war scenarios in which countries raise their tariffs to a predetermined level. Specifically, to suppress the impact of noncooperative tariff variation on the Balance of Concessions (BoC), we adopt a uniform noncooperative tariff of 50% across all countries, which is within the range of estimated average tariffs in the previous literature as well as tariffs applied prior to the implementation of GATT/WTO.

Drawing on the observations of Beshkar, Bond, and Rho (2015) and Beshkar and Lee (2022), we argue that applied tariffs under the WTO contain information about political-economy preferences. This assertion is based on the notion that variations in applied tariffs, beyond what can be explained by differences in import market power, reflect variations in government preferences across sectors.[10] One direct implication of the above

[10] Ossa (2014) proposes an alternative method for calculating noncooperative tariffs by

argument is that a country's applied tariff on a product can be considered a lower bound for its noncooperative tariff. Moreover, in sectors without a negotiated tariff binding, the applied tariff rates must indicate the government's optimal tariffs. This observation is particularly important for commodities such as crude oil, where applied tariffs are virtually unbound.[11]

The above discussion suggests that the set of sectoral best-response tariffs of country h on imports from country f in each sector k, denoted by $\left\{t^N_{fh,k}\right\}_k$, are the solution to the following maximization problem:

$$\left\{t^N_{fh,k}\right\}_k \equiv \max_{\left\{t_{fh,k}\right\}_k} W_h\left(\left\{t_{fh,k}\right\}_k, \left\{t^N_{hf,k}\right\}_k\right), \tag{9}$$

such that applied tariffs are a lower bound for optimal tariffs:

$$t_{fh,k} \geq \max_i \{t^A_{ih,k}\}, \tag{10}$$

and optimal tariffs are equal to applied tariffs in unbound sectors, $k \in U$:

$$t_{fh,k} = t^A_{fh,k}, \forall k \in U, \tag{11}$$

and national budget constraints are satisfied. In this optimization problem, we hold all other tariffs in the world fixed at the rates that are currently applied by governments.[12]

Table 1 presents the summary statistics of the noncooperative tariffs computed using the above method for year 2018.[13]

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using existing measures of noncooperative tariffs (if available) to calibrate the political-economy weights in the government's optimization problem. This method requires observing a measure of noncooperative tariffs (such as column-2 tariffs) in order to uncover the distribution of political preferences across sectors. In a recent paper, Adão et al. (2023) propose a new method to estimate political-economy weights of industries using a revealed preference approach.

[11] For example, despite the fact that the United States has no tariff binding obligation for crude oil under the WTO, its applied tariff on imported crude oil is nearly zero.

[12] In implementing this optimization problem, we cap the lower bound of optimal tariffs

3.3 Mapping the Model to Data

We obtain production and bilateral trade data (in intermediate and final goods combined) from the OECD-WTO Trade in Value Added (TiVA, 2021) database. The 2021 edition records trade flows for 66 economies (and a residual Rest of the World) in 45 sectors (based on ISIC Rev. 4) for years 1995–2018.

We aggregate service sectors into one combined sector, and consider countries in the European Union (EU) as one combined entity in setting trade policy.[14] This amounts to a total of 22 individual sectors (excluding the service sectors) and 40 economies/regions to be used in the equilibrium analysis. In presenting the anatomy of concessions below, we exclude concessions granted to and received from the residual Rest of the World (ROW) and Kazakhstan, because the former is a mix pool of members and non-members, while the latter's applied tariff data are missing or inconsistent in some years. Tables E.2 and E.3 provide the list of economies and sectors used in the study.

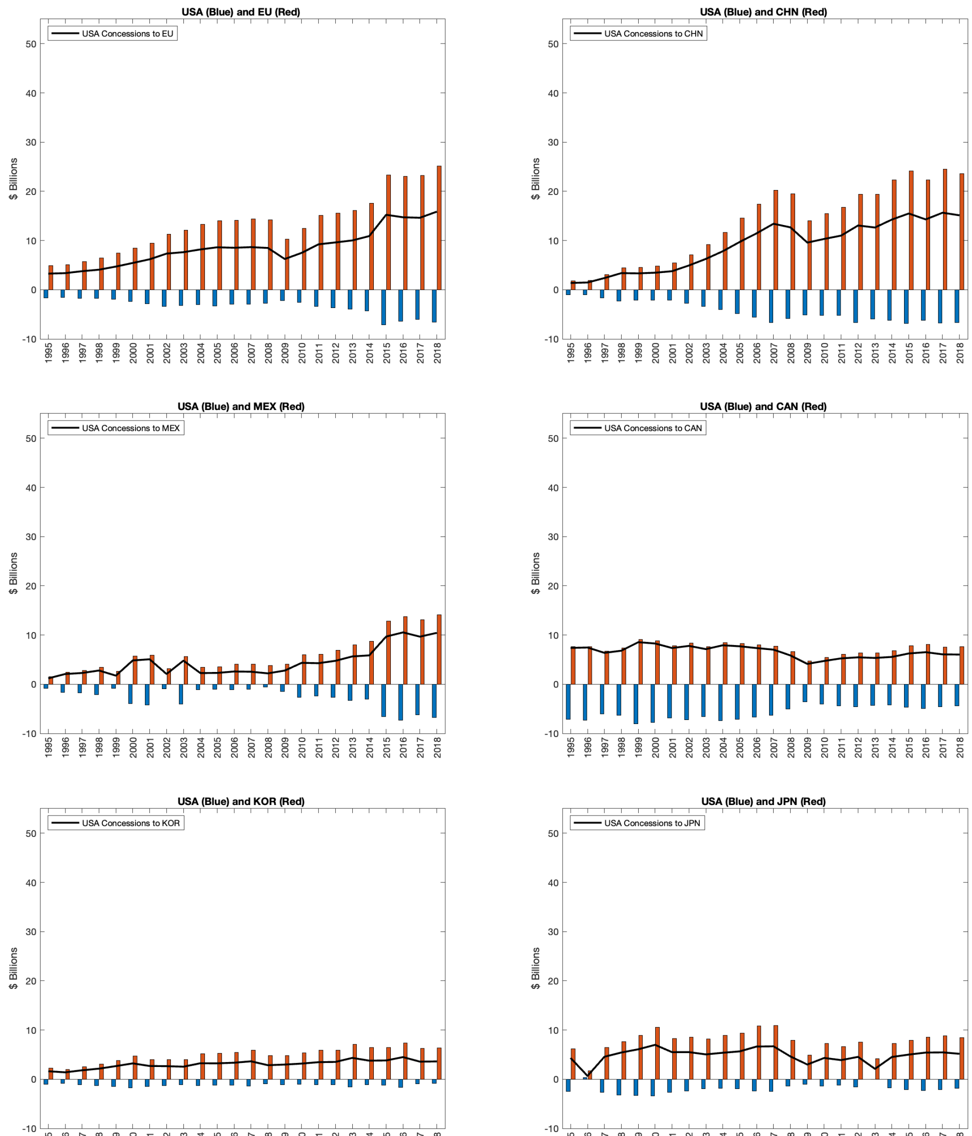
The data on tariffs are sourced from the TRAINS database, downloaded via the World Integrated Trade Solution (WITS) interface. Table E.1 summarizes the list of the parameters and variables that are constructed using the data on trade flows, $x_{ij,k}$, and applied tariff rates, $t_{ij,k}$. Finally, we estimate the trade elasticities ($\sigma_k - 1$) following the approach in Caliendo and Parro (2015).

to 100% to prevent the outliers from playing an outsized role. Moreover, the tariffs in Sector 3, which comprises mainly of crude oil, are the only tariff rates that are designated as unbound. While the 100% cap on the lower bound does not significantly affect the quantitative results, designating crude oil tariffs as unbound has a significant influence on the computed size of tariff concessions exchanged between key oil-exporting and oil-importing nations.

[13] Appendix B provides additional summary statistics for applied and noncooperative tariffs.

[14] The membership size of the EU increased from 15 to 27 during our period of study. In order to have a consistent definition of "EU" over time, we consider all the eventual 27 members as part of one trade policy authority from the beginning.

Figure 4: The ToT Effect of Tariff Cooperation between the United States and its Major Trading Partners



Each panel illustrates the terms-of-trade effects of bilateral cooperation between the US and one of its major trading partners. Blue (red) bars depict the magnitude of the effect on the US (its partner). The line depicts the net concessions granted by the US, computed using equation (3).

Table 1: Computed Disagreement Tariffs in 2018

Country	Min	Median	Average	Max	Country	Min	Median	Average	Max
ARG	8	20	21	34	LAO	2	10	12	31
AUS	5	6	17	51	MAR	15	50	72	58
BRA	5	19	19	33	MEX	12	21	22	42
BRN	2	8	17	43	MMR	3	9	10	23
CAN	0	8	12	59	MYS	1	24	22	60
CHE	0	10	21	85	NOR	0	6	12	71
CHL	10	10	12	10	NZL	8	11	19	51
CHN	1	17	42	52	PER	13	13	17	21
COL	5	17	19	28	PHL	9	24	26	31
CRI	6	16	18	43	RUS	5	12	14	18
EU	7	23	25	59	SAU	5	7	13	21
HKG	0	2	7	5	SGP	1	11	11	53
IDN	6	24	30	58	THA	9	38	41	59
IND	11	37	42	68	TUN	15	34	37	68
ISL	5	13	16	53	TUR	2	12	18	68
ISR	0	12	13	56	TWN	0	9	10	34
JPN	0	4	16	65	USA	4	20	23	65
KHM	7	29	30	30	VNM	0	24	26	61
KOR	1	8	13	72	ZAF	7	17	21	57

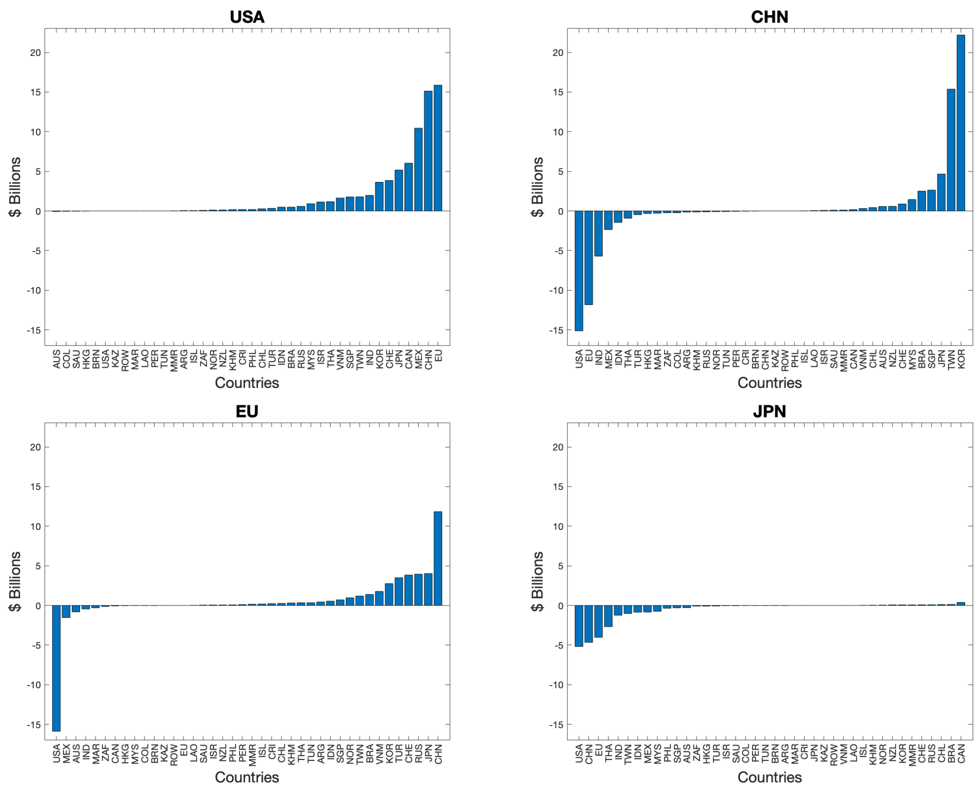
Note: This table provides the summary statistics of the disagreement tariffs in 2018 across sectors, which are computed using the optimization problem 9-11.

4 Anatomy of WTO Concessions

In this section, we present findings on the bilateral and multilateral balance of concessions among WTO members from 1995 to 2018. We also evaluate the effect of trade imbalances on the magnitude of concessions exchanged among countries. Finally, we use an alternative trade war benchmark to shed light on the sensitivity of our quantitative results to the choice of tariff benchmarks.

To start, recall that we measure bilateral concessions based on the terms-of-trade effect of bilateral cooperation between each pair of countries. Figure 4 depicts the terms-of-trade effect of the bilateral cooperation between the United States and its major trading partners. Specifically, the blue bars indicate the effect on the US terms of trade and the red bars indicate the effect on the terms of trade of the partner. As is depicted in this figure, the effect of each of these cooperations is negative (positive) on the terms of trade of the US (the partner country).

Figure 5: Net Bilateral Concessions Granted by Selected Countries in 2018

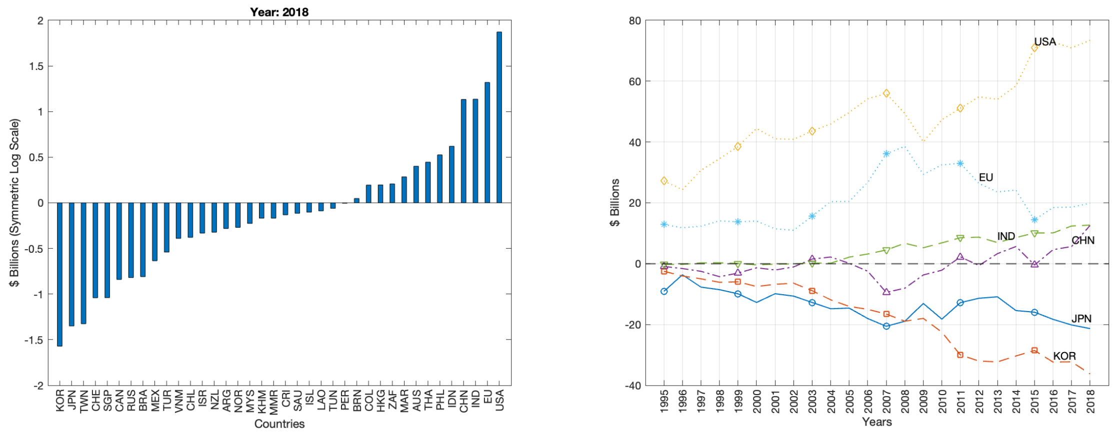


The net concessions of the US, which is calculated using equation (3), is depicted by the black line in Figure 4. It indicates that the net concessions of the US to EU, China, and Mexico have increased over time, while its concessions to Canada, Korea, and Japan, are relatively stable over time.

Bilateral Balance of Concessions An investigation of bilateral concessions over years reveals that the United States consistently acts as a net granter in almost all of its bilateral relationships throughout the years. After its accession to the WTO, China also becomes a net granter to most of its trading partners except a few economies, including the United States, European Union and India.

Figure 5 demonstrates the net bilateral concessions made by key WTO

Figure 6: Net Multilateral Concessions Granted (Selected Countries)



The left panel depicts the net multilateral concessions granted by each country on a symlog scale in 2018. The right panel depicts the same measure for selected countries from 1995 to 2018.

members in year 2018.[15] In this year, the United States is a net granter of concessions to nearly all other countries, with the European Union ($16 billion), China ($15 billion), Mexico ($10 billion), and Canada ($6 billion) as the largest recipients of net concessions from the United States. The European Union grants net concessions to various other countries, including China ($10 billion) and Japan ($4.5 billion).[16]

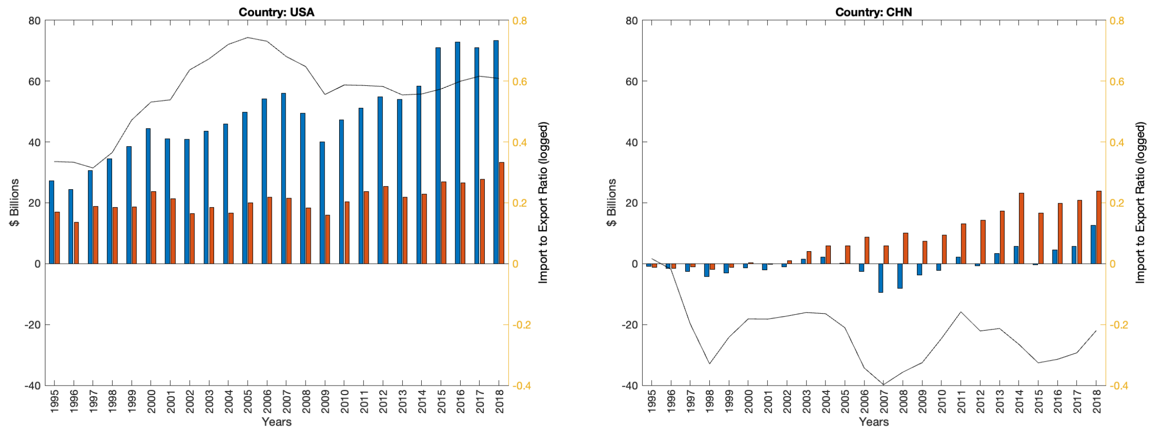
Multilateral Balance of Concessions The left panel of Figure 6 shows the net multilateral concessions of each country in 2018, calculated as the sum of its bilateral concessions. The figure highlights substantial variation in net concessions across countries, with the United States standing out as the largest net contributor to the system and the South Korea as the largest recipient.

The right panel of Figure 6 tracks net multilateral concessions over time for selected countries. Following its accession to the WTO in 2001, China

[15]Table C.1 in the Appendix shows the concessions granted/received by top net recipients and granters in year 2018.

[16]To attain some comparability over time, we group all eventual members of the European Union into one region (EU) for the entire period of study.

Figure 7: The Role of Trade Imbalances on Net Multilateral Concessions



The net concessions granted by the United States and China under the balanced-trade scenario (represented by red bars) and factual trade flows (blue bars). The line graph, aligned with the right axis, displays the logarithmic ratio of the country's imports to exports. Similar charts for other countries are provided in Figure C.2 in the appendix.

initially receives net concessions before transitioning into a net granter. Meanwhile, Korea and Japan consistently remain the largest net recipients of concessions over time.

4.1 The Effect of Trade Imbalances on Reciprocity

In Section 3, we introduced the hypothesis that an increase in trade imbalance will shift the BoC in favor of trade-surplus countries. To evaluate this hypothesis, we compute the BoC under a counterfactual scenario with balanced trade and compare it to the BoC under the observed (factual) scenario. To construct the balanced-trade counterfactual scenario, we set $\delta_i = 0$ for all countries in our quantitative model, and employ the hat-algebra method to compute trade volumes under the new equilibrium.[17] We then compute ToT effects of cooperation under this counterfactual equilibrium.

Figure 7 compares the net multilateral concessions granted by the

[17] Recall that the product of δ_i and the world income represents the trade deficit of country i. Setting $\delta_i = 0$ for all i implies balanced trade across all countries.

United States and China under the factual scenario (blue bars) and the balanced trade scenario (red bars) over time. This figure shows that removing multilateral trade imbalances reduces the multilateral concessions granted by the United States from \$73 billion to \$30 billion, making trade agreements more reciprocal for the United States.[18] Conversely, eliminating multilateral trade imbalances has the opposite effect on the balance of concessions of China, increasing its net multilateral concessions from around \$13 billion to \$25 billion.

4.2 The Effect of Asymmetric Tariffs on Reciprocity

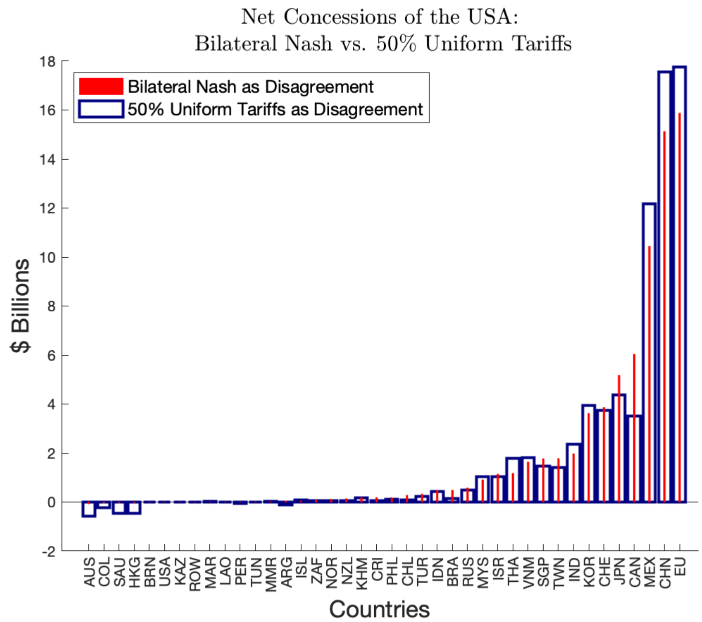
A well-documented feature of the WTO is that larger countries tend to impose lower tariffs and implement more aggressive tariff reductions than smaller countries. As Beshkar, Bond, and Rho (2015); Beshkar and Bond (2017) argue, this pattern can be explained as an effort to maximize global welfare in the presence of unverifiable political-economy shocks affecting government trade policy preferences.

However, this tendency—where larger, more powerful countries impose lower tariffs— contradicts the principle of reciprocity, as larger countries, with their greater international market power, should theoretically be able to secure larger tariff cuts from their trading partners in exchange for their own reductions. The United States exemplifies this pattern, applying lower tariffs on its imports than the tariffs it faces on its exports. In 2015, for instance, the U.S. imposed an average import tariff of less than 3%, while its exports were subject to an average tariff of nearly 7% (Figure B.2).

To assess the implications of this imbalance, we compute BoC for the U.S. in a counterfactual scenario where the United States applies to its imports the same tariff rates it faces in each of its bilateral relationships. We find that such an adjustment in the US tariffs reduces its net concessions by 1-10% in different years (Figure C.3).

[18] For a more detailed breakdown, Figure C.1 in the appendix illustrates how removing multilateral trade imbalances affects the U.S.'s bilateral concessions to selected countries.

Figure 8: Net Concessions Under Alternative Benchmarks for Noncooperative Tariffs



The hollow bars illustrate the net concessions made by the US to each of its partners in 2018 using 50% tariffs as disagreement benchmark for all countries. The thin bars show this measure under our baseline Nash tariffs.

4.3 Alternative Benchmarks for Noncooperative Tariffs

A potential source of measurement error in our calculations arises from estimating noncooperative tariffs in bilateral trade relationships. The calculation of bilateral Nash tariffs in (9-11) relies on estimated trade elasticities, which are known to be imprecise. Additionally, using a country's highest applied tariffs in each sector as a lower bound for its optimal tariff may introduce a downward bias in the estimated optimal tariffs for WTO members that pursued a more open trade policy during this period.

To mitigate this potential bias, we introduce an alternative trade war benchmark in which both countries impose an equal and uniform tariff on their imports. Specifically, we use a uniform tariff rate of 50% as noncooperative tariffs, which is within the range of estimated average tariffs in the previous literature as well as tariffs applied prior to the implementation of GATT/WTO.[19] For example, the United States imposed an average tariff of around 60% following the Smoot-Hawley Tariff Act. Similarly, China's average tariffs in mid-1990s were around 50%. Moreover, several papers in the literature have proposed model-based optimal tariff formulas, which deliver optimal tariffs in a range from 10% to 70% for various sectors/countries. For example, as pointed out by Costinot and Rodríguez-Clare (2014), assuming an aggregate trade elasticity of 5, the uniform optimal tariff rate for all countries is around 20%. Using a multi-sector Ricardian model, Beshkar and Lashkaripour (2020b) estimate the optimal tariffs for the United States and European Union to be in the range of 20-30%. Using a calibrated general equilibrium political-economy model with firm delocation and terms-of-trade effects, Ossa (2014) finds median optimal tariffs of around 60% for various countries. Finally, using a partial-equilibrium political-economy model, Beshkar and Lee (2022) find sectoral optimal tariffs for various countries. The median of their estimated tariffs ranges from 8% for Georgia and 16% for Norway to 64% for the United States and 73% for Bangladesh.

As illustrated in Figure 8, replacing Nash tariffs with a uniform tariff of 50% as noncooperative tariffs preserves the overall pattern of the US bilateral concessions. However, using this alternative trade war scenario has a more pronounced impact on smaller and more open economies such as Hong Kong, where Nash tariff rates are in single digits. Figures D.1-D.3 in the appendix illustrate the results for this alternative noncooperative scenario.

5 Concluding Remarks and Caveats

The most consistent observation across different scenarios is that the United States is the largest net granter of concessions under the WTO and its associated preferential trade agreements. This deviation from reciprocity is

[19] Results under a uniform tariff rate of 25% and 75% are available upon request.

partly due to lower U.S. import tariffs compared to the tariffs it faces on exports. However, the persistent and large trade deficits—presumably unanticipated during the Uruguay Round of negotiations in the early 1990s—appear to account for a greater share of the deviation from reciprocity. Specifically, we show that up to two-third of the U.S.'s net multilateral concessions can be attributed to its trade deficit.

Our results suggest that the long-term stability of trade agreements may hinge on their ability to mitigate the impact of trade imbalances on the balance of concessions. Notably, the WTO's dispute settlement mechanism—arguably designed to address "trade skirmishes" within a relatively balanced agreement (Beshkar 2010a,b)—could face mounting pressures if deviations from reciprocity become large and persistent. To ensure the resilience of trade agreements, policymakers should explore flexibility mechanisms that prevent sustained trade deficits from undermining reciprocity over time.

Limitations and Caveats

As with any quantitative trade model, our findings should be interpreted with caution. While these models sometimes provide useful insights, their numerical outputs depend heavily on underlying assumptions and modeling choices. In this section, we briefly discuss the key limitations and caveats of our analysis.

Measure of Concessions While our analysis uses terms-of-trade gains to measure trade concessions, one could argue that a more natural metric would be the impact of tariff changes on real consumption. However, evaluating trade agreements based on their effect on real consumption presents several challenges. Most notably, in the absence of policy constraints, governments tend to impose tariffs significantly higher than those that maximize real consumption. As a result, a significant portion of tariff cuts would be unilaterally optimal and cannot be interpreted as concessions to the exporting countries.

The tendency for noncooperative tariffs to exceed the levels that maximize real consumption likely reflects political-economy objectives beyond aggregate consumption, such as income distribution and domestic industry protection. Our framework does not explicitly model these considerations, but it builds on Bagwell and Staiger (1999), who show that mutual tariff reductions that maintain constant terms of trade neutralize the externality of unilateral tariff choices. This result provides a sufficient statistic for capturing political-economy considerations in trade negotiations.

Trade in Intermediate Inputs Intermediate input trade plays a significant role in global trade flows, yet our framework does not explicitly model input-output linkages. A key challenge is that standard competitive models fail to capture tariff escalation, the widely observed pattern where governments impose lower tariffs on intermediate inputs than on final goods. Because our model does not account for this pattern, it likely overestimates the actual concessions granted by importing countries on intermediate inputs.

While studies such as Caliendo and Parro (2015) provide tractable methods for incorporating input-output linkages into quantitative trade models, they do not resolve the counterfactual implication of competitive models regarding tariff escalation. In fact, as shown by Beshkar and Lashkaripour (2020a), under perfect competition, optimal tariffs on imported intermediate goods may be even higher if these inputs are essential for a country's exports.

Due to the counterfactual implications introduced by input-output linkages in competitive models, the quantitative predictions can become less reliable, as they obscure the mechanisms that drive government tariff decisions. For the sake of transparency, we have opted not to include input-output linkages in our quantitative analysis. However, recent papers have addressed this issue by incorporating monopolistic distortions (Caliendo, Feenstra, Romalis, and Taylor, 2023) and scale economies (Antràs, Fort, Gutiérrez, and Tintelnot, 2022), which generate lower optimal tariffs on intermediate inputs, aligning more closely with observed tariff escalation patterns.

Trade Imbalances Our analysis relies on a static trade model where trade imbalances are exogenous, meaning trade policy in one year does not affect past or future trade volumes or deficits. This assumption aligns with the idea that governments focus primarily on medium-term effects rather than long-term dynamics. However, defining reciprocity in a dynamic setting remains an open question. Prior theoretical works on trade and capital control policies (Costinot et al., 2014; Beshkar and Shourideh, 2020; Auray et al., 2024) provide a potential starting point for such an extension.

Issue Linkage While our focus is on reciprocity in tariff cuts, we recognize that tariff concessions may be linked to concessions in other trade-related areas such as intellectual property rights protection, product standards, labor laws, etc, or broader geopolitical cooperations such as security alliances.[20] A fuller study of the balance of concessions, therefore, requires quantifying the concessions that countries exchange in other issues that are linked to trade policy negotiations. The literature on issue linkage, reviewed by Maggi (2016), is mostly focused on theoretical and qualitative analysis (Limão, 2005; Conconi and Perroni, 2002; Hoekman, 1989; McGinnis, 1986). Quantifying the models of issue linkage remains an open field of research.[21] Our quantitative framework provides a starting point for such analysis by mapping out tariff concessions exchanged among countries.

[20] Goldstein and Gulotty (2022) provide an illustrative example of the connection between geopolitics and trade policy concessions by examining if the United States extended additional market access to European countries to facilitate post-war recovery, enhance the productive capabilities of nations impacted by the war, and support unstable regimes. Their findings indicate that during the initial negotiations under the GATT, the United States "was less a liberal warrior and more a seeker of stability."

[21] Suttner (2023) quantifies potential costs of issue linkage by considering policy uncertainty that is caused when other issues are linked to trade policy concessions.

References

Adão, R., A. Costinot, D. Donaldson, and J. A. Sturm (2023). Why is trade not free? A revealed preference approach. NBER Working Paper No. 31798.

Antràs, P., T. Fort, A. Gutiérrez, and F. Tintelnot (2022). Trade policy and global sourcing: a rationale for tariff escalation. *NBER Working Paper 30225*.

Auray, S., M. B. Devereux, and A. Eyquem (2024). Trade wars, nominal rigidities, and monetary policy. *Review of Economic Studies*.

Bagwell, K. and R. W. Staiger (1999). An Economic Theory of GATT. *American Economic Review 89*(1), 215–248.

Bagwell, K. and R. W. Staiger (2012). Profit shifting and trade agreements in imperfectly competitive markets. *International Economic Review 53*(4), 1067–1104.

Bagwell, K., R. W. Staiger, and A. Yurukoglu (2020). Nash-in-Nash tariff bargaining. *Journal of International Economics 122*, 103263.

Bagwell, K., R. W. Staiger, and A. Yurukoglu (2021). Quantitative Analysis of Multiparty Tariff Negotiations. *Econometrica 89*(4), 1595–1631.

Beshkar, M. (2010a). Optimal remedies in international trade agreements. *European Economic Review 54*(3), 455–466.

Beshkar, M. (2010b). Trade skirmishes and safeguards: A theory of the WTO dispute settlement process. *Journal of international Economics 82*(1), 35–48.

Beshkar, M. and E. W. Bond (2017). Cap and escape in trade agreements. *American Economic Journal: Microeconomics 9*(4), 171–202.

Beshkar, M., E. W. Bond, and Y. Rho (2015). Tariff binding and overhang: Theory and evidence. *Journal of International Economics 97*(1), 1–13.

Beshkar, M. and A. Lashkaripour (2020a). The cost of dissolving the wto: The role of global value chains.

Beshkar, M. and A. Lashkaripour (2020b). Interdependence of trade policies in general equilibrium. manuscript.

Beshkar, M. and R. Lee (2022). How does import market power matter for trade agreements? *Journal of International Economics 137*, 103580.

Beshkar, M. and A. Shourideh (2020). Optimal trade policy with trade imbalances. *Journal of Monetary Economics 109*, 65–82.

Blanchard, E. J. (2010). Reevaluating the role of trade agreements: Does investment globalization make the WTO obsolete? *Journal of International Economics 82*(1), 63–72.

Bown, C. P., L. Caliendo, F. Parro, R. W. Staiger, and A. O. Sykes (2023). Reciprocity and the China shock. manuscript.

Caliendo, L., R. C. Feenstra, J. Romalis, and A. M. Taylor (2023). A second-best argument for low optimal tariffs on intermediate inputs. *Journal of International Economics 145*, 103824.

Caliendo, L. and F. Parro (2015). Estimates of the trade and welfare effects of NAFTA. *Review of Economic Studies 82*(1), 1–44.

Cole, M. T., J. Lake, and B. Zissimos (2021). Contesting an international trade agreement. *Journal of International Economics 128*, 103410.

Conconi, P. and C. Perroni (2002). Issue linkage and issue tie-in in multilateral negotiations. *Journal of International Economics 57*(2), 423–447.

Costinot, A., G. Lorenzoni, and I. Werning (2014). A theory of capital controls as dynamic terms-of-trade manipulation. *Journal of Political Economy 122*(1), 77–128.

Costinot, A. and A. Rodríguez-Clare (2014). Trade theory with numbers: Quantifying the consequences of globalization. In G. Gopinath, E. Helpman, and K. Rogoff (Eds.), *Handbook of international economics*, Volume 4, Chapter 4, pp. 197–261. Elsevier.

Delpeuch, S., E. Fize, and P. Martin (2021). Trade imbalances and the rise of protectionism. CEPR Discussion Paper DP15742.

DeRemer, D. R. (2016). The principle of reciprocity in the 21st century. IEHAS Discussion Papers, No. MT-DP - 2016/13.

Goldstein, J. and R. Gulotty (2022). Trading away tariffs: The operations of the GATT system. *World Trade Review 21*(2), 135–158.

Hoekman, B. M. (1989). Determining the need for issue linkages in multilateral trade negotiations. *International Organization 43*(4), 693–714.

Horn, H. and A. Wolinsky (1988). Bilateral monopolies and incentives for merger. *The RAND Journal of Economics*, 408–419.

Jakubik, A., A. Keck, and R. Piermartini (2023). Trade policy implications of a changing world: Tariffs and import market power. IMF Working Paper No. 2023/005.

Kehoe, T. J., K. J. Ruhl, and J. B. Steinberg (2018). Global imbalances and structural change in the united states. *Journal of Political Economy 126*(2), 761–796.

Limão, N. (2005). Trade policy, cross-border externalities and lobbies: Do linked agreements enforce more cooperative outcomes? *Journal of International Economics 67*(1), 175–199.

Maggi, G. (1999). The role of multilateral institutions in international trade cooperation. *American Economic Review 89*(1), 190–214.

Maggi, G. (2016). Issue linkage. In *Handbook of Commercial Policy*, Volume 1, pp. 513–564. Elsevier.

McGinnis, M. D. (1986). Issue linkage and the evolution of international cooperation. *Journal of Conflict Resolution 30*(1), 141–170.

Mrázová, M. (2023). Trade agreements when profits matter. manuscript.

Ossa, R. (2011). A "new trade" theory of GATT/WTO negotiations. *Journal of Political Economy 119*(1), 122–152.

Ossa, R. (2014). Trade wars and trade talks with data. *American Economic Review 104*(12), 4104–46.

Ossa, R. (2016). Quantitative models of commercial policy. In *Handbook of Commercial Policy*, Volume 1, pp. 207–259. Elsevier.

Suttner, S. (2023). Issue linkage and trade policy uncertainty: Evidence from trade preferences for developing countries. FAU Discussion Papers in Economics 07/2023.

TiVA (2021). Trade in value added database. *Organisation for Economic Co-operation and Development (OECD).*

Zissimos, B. (2009). Optimum tariffs and retaliation: How country numbers matter. *Journal of International Economics 78*(2), 276–286.

Appendix

A Proofs of Propositions

A.1 Proof of Proposition 1

Consider a bilateral tariff reduction between countries i and j, while they maintain their tariffs on all third countries $l \neq i, j$ unchanged. This reduction induces trade diversion, leading both countries to decrease their demand for imports from third countries. Consequently, country $k \in \{i, j\}$ experiences an improvement in its terms of trade with the rest of the world, namely,

$$\sum_{\forall l \neq i,j} \left[\left(p_{kl}^{\mathcal{A}} - p_{kl}^{\mathcal{D}} \right) q_{il}^{\mathcal{D}} - \left(p_{li}^{\mathcal{A}} - p_{lk}^{\mathcal{D}} \right) q_{lk}^{\mathcal{D}} \right] \geq 0,$$

where, the inequality is satisfied strictly if k trades with any country $l \neq i, j$. Therefore, it immediately follows that

$$T_i^{\left\{\mathcal{D}_{ij}, \mathcal{D}_{ji}\right\}} + T_j^{\left\{\mathcal{D}_{ij}, \mathcal{D}_{ji}\right\}} \geq 0,$$

with strict inequality if either i or j trade with any country in the rest of the world.

A.2 Proof of Proposition 2

By definition, tariff cuts from N to A are reciprocal if it leaves the net imports, evaluated at fixed prices, unchanged. Letting p^z denote the relative world price of home exports under equilibrium z, the net import of the home country under the agreement (A) is given by $q_{fh}^A - p^A q_{hf}^A$. Similarly, the net imports under the noncooperative equilibrium (N), evaluated at prices under agreement, is given by $q_{fh}^N - p^A q_{hf}^N$. Therefore, reciprocity requires

$$q_{fh}^A - p^A q_{hf}^A = q_{fh}^N - p^A q_{hf}^N.$$

Moreover, the budget constraints under the relevant equilibria require $q_{fh}^{A} - p^{A}q_{hf}^{A} \equiv \alpha Q_N$, and $q_{fh}^{N} - p^{N}q_{hf}^{N} \equiv \alpha Q_N$. The above three conditions can be satisfied simultaneously if and only if $p^A = p^N$.

A.3 Proof of Lemma 1

Suppose consumer preferences in country j are given by $u\left(q_{ij}, q_{jj}\right) \equiv q_{ij}^{\frac{\sigma-1}{\sigma}} + q_{jj}^{\frac{\sigma-1}{\sigma}}$ and import taxes are $\tau_h - 1$ and $\tau_f - 1$. Home demand function for the two goods will be

$$q_{fh} = \frac{1}{2}\frac{I_h}{\tau_h^{1-\sigma} + p^{1-\sigma}}\tau_h^{-\sigma},$$

and

$$q_{hh} = \frac{1}{2}\frac{I_h}{\tau_h^{1-\sigma} + p^{1-\sigma}}p^{-\sigma},$$

which implies

$$q_{fh} = \left(\frac{p}{\tau_h}\right)^{\sigma} q_{hh}. \tag{12}$$

Substituting for q_{fh} from (12) in the home budget constraint ($pq_{hh} + q_{fh} = pQ_h + \alpha Q_f$) yields

$$pq_{hh} + \left(\frac{p}{\tau_h}\right)^{\sigma} q_{hh} = pQ_h + \alpha Q_f.$$

Solving for q_{hh} and q_{fh} yields

$$q_{hh} = \frac{pQ_h + \alpha Q_f}{p + \left(\frac{p}{\tau_h}\right)^{\sigma}},$$
$$q_{fh} = \frac{pQ_h + \alpha Q_f}{p\left(\frac{p}{\tau_h}\right)^{-\sigma} + 1}.$$

Similarly, home consumption bundle is given by

$$q_{hf} = \frac{(1-\alpha)\,Q_f}{p + (\tau_f p)^{\sigma}},$$
$$q_{ff} = \frac{(1-\alpha)\,Q_f}{p\,(\tau_f p)^{-\sigma} + 1}.$$

World Equilibrium

Finally, using the world clearing condition $q_{hf} + q_{hh} = Q_h$, equilibrium world price, p, is implicitly given by

$$\frac{(1-\alpha)\,Q_f}{p + (\tau_f p)^{\sigma}} = \frac{\left(\frac{p}{\tau_h}\right)^{\sigma} Q_h - \alpha Q_f}{p + \left(\frac{p}{\tau_h}\right)^{\sigma}}.$$

Solving for τ_h yields

$$\tau_h = p\left(\frac{-(1-\alpha) + \left(p + (\tau_f p)^{\sigma}\right)\frac{Q_h}{Q_f}}{\alpha\,(\tau_f p)^{\sigma} + p}\right)^{\frac{1}{\sigma}}. \tag{13}$$

Single Crossing Property

Rearranging the right-hand side of (13) yields

$$\tau_h = p\left(\frac{(1-\alpha)}{\alpha\,(\tau_f p)^{\sigma} + p}\left((\tau_f p)^{\sigma} - \frac{Q_f}{Q_h}\right) + 1\right)^{\frac{1}{\sigma}}\left(\frac{Q_h}{Q_f}\right)^{\frac{1}{\sigma}}. \tag{14}$$

This equation is independent of α if and only if

$$(\tau_f p)^{\sigma} - \frac{Q_f}{Q_h} = 0.$$

For any p, define $\bar{\tau}_f$ and $\bar{\tau}_h$ such that

$$\bar{\tau}_f \equiv \frac{1}{\bar{\tau}_h} \equiv \left(\frac{Q_f}{Q_h}\right)^{\frac{1}{\sigma}} \frac{1}{p}.$$

Substituting $\tau_f = \bar{\tau}_f$ in (14) yields $\tau_h = \bar{\tau}_h$ for all values of α. Furthermore, since

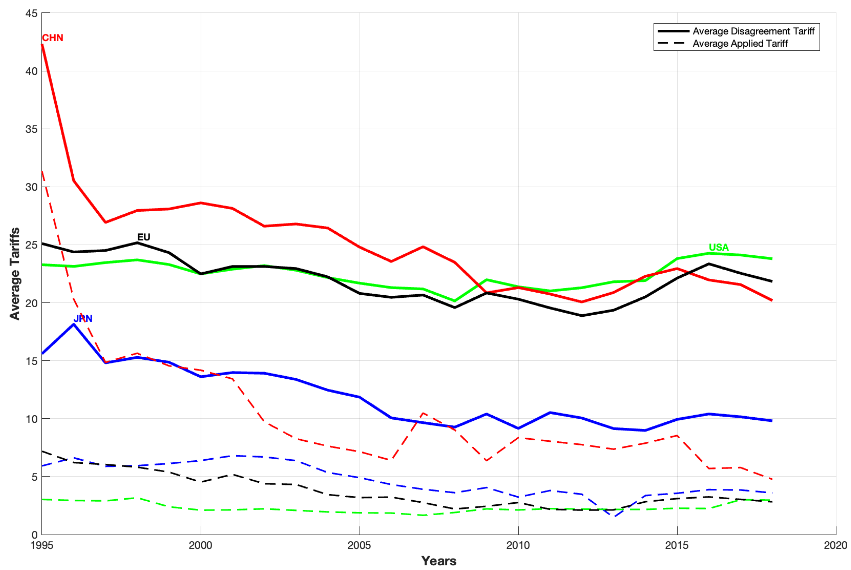
$$\frac{d}{d\alpha} \frac{(1-\alpha)}{\alpha \left(\tau_f p\right)^{\sigma} + p} < 0,$$

it follows that if $\alpha_2 > \alpha_1$ then $\tau_h \left(\tau_f, \alpha_2, p\right) - \tau_h \left(\tau_f, \alpha_1, p\right) > 0$ if and only if $\tau_f < \bar{\tau}_f$. In words, for any world price, p, there exist a unique pair $\left(\bar{\tau}_f, \bar{\tau}_h\right)$ such that an increase in α rotates the iso-world price curve clockwise around $\left(\bar{\tau}_f, \bar{\tau}_h\right)$.

Finally, since for a given α, iso-world prices do not intersect, an increase in α decreases the slope of the iso-world price curve that goes through any pair of $\left(\tau_f, \tau_h\right)$. This proves that for any world price, p, the reciprocity function that maps τ_f to τ_h satisfies a uniform single crossing property with respect to α.

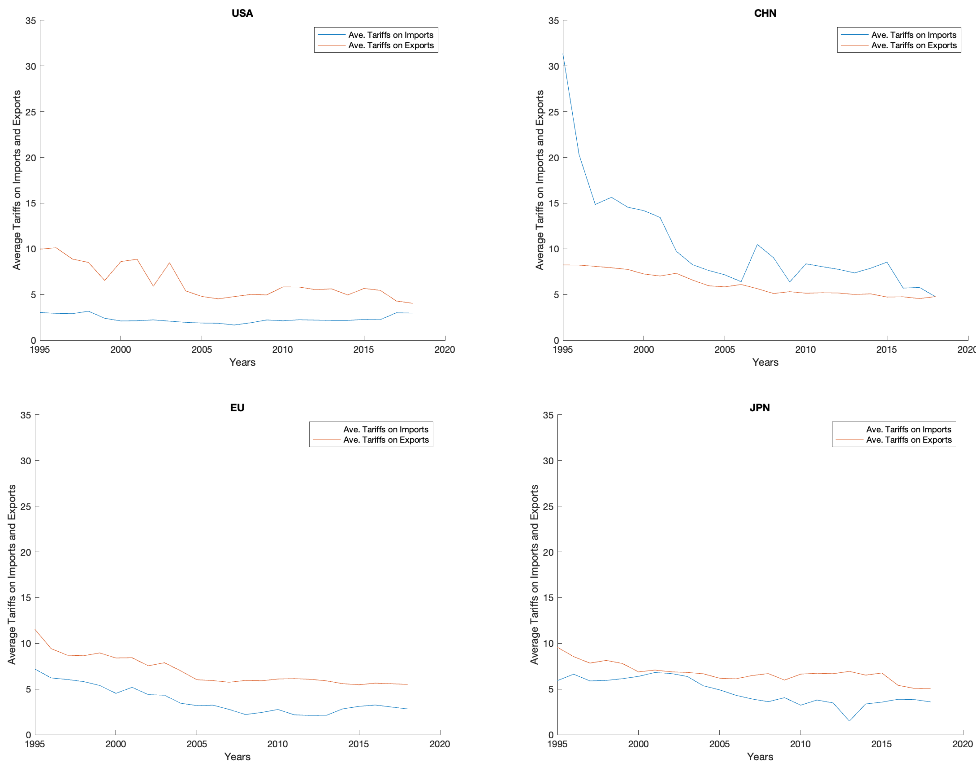
B Tariff Summary Statistics

Figure B.1: Trade-Weighted Average Noncooperative and Applied Tariffs for Selected Countries



This graph illustrates the trade-weighted average of noncooperative and applied tariffs (in percentage points), using current-year trade flows as weights.

Figure B.2: Average Applied Tariffs on imports and exports of Selected Countries



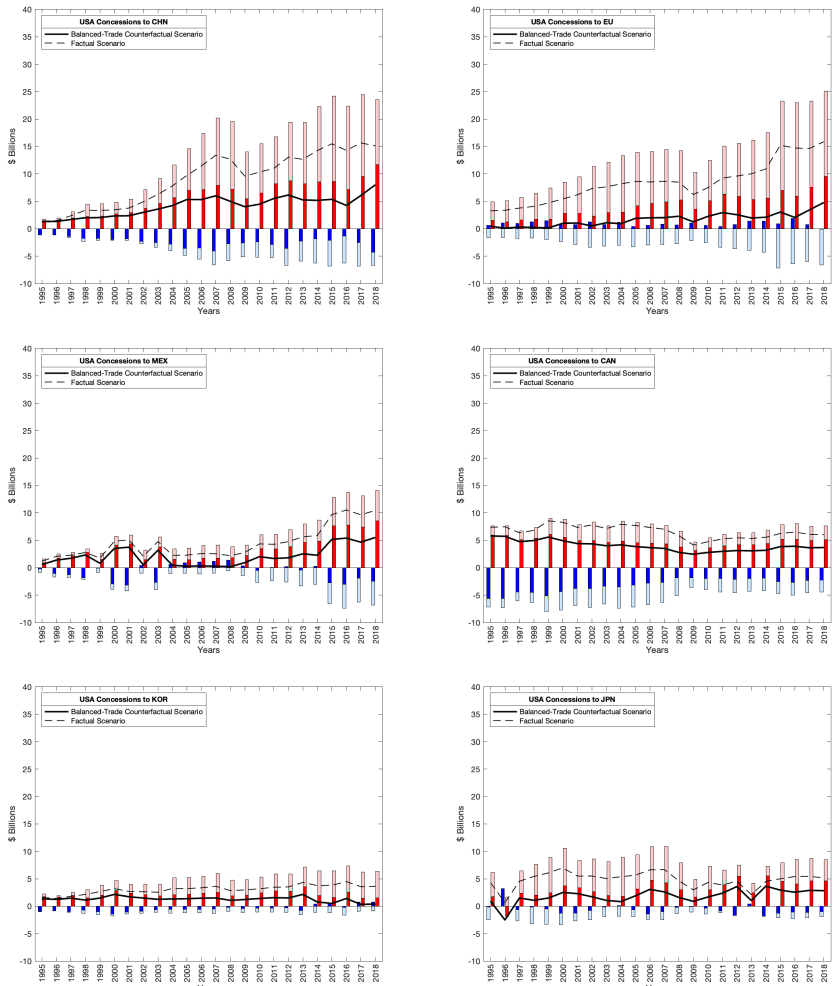
Trade-weighted average of applied tariffs on imports and exports of several countries.

C Bilateral Trade Wars: Additional Graphs and Tables

Table C.1: Net Bilateral Concessions for selected countries

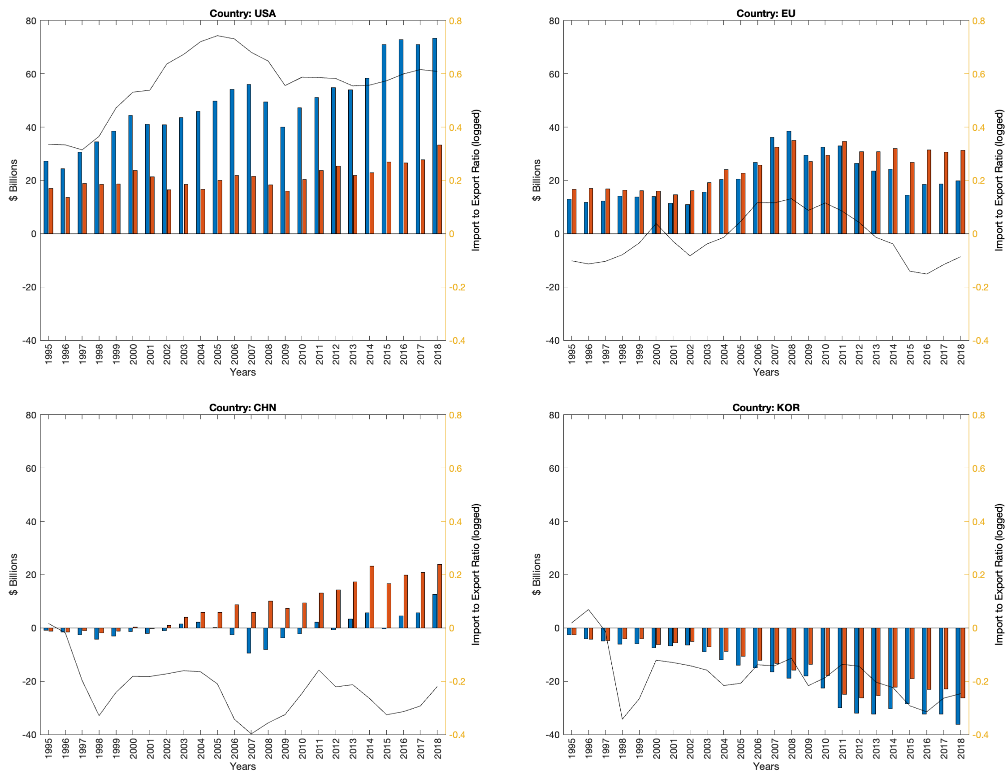
		Top Receivers of Net Concessions										
		KOR	**JPN**	**TWN**	**CHE**	**SGP**	**CAN**	**RUS**	**BRA**	**MEX**	**TUR**	Total
Top Granters of Net Concessions	**USA**	3,620	5,170	1,777	3,853	1,773	6,031	579	485	10,440	320	**73,430**
	EU	2,762	4,013	1,188	3,838	714	-57	3,949	1,385	-1,533	3,500	**19,883**
	IND	2,419	1,233	453	294	1,530	-9	176	155	-103	-149	**12,679**
	CHN	22,198	4,655	15,359	881	2,634	174	-114	2,509	-2,353	-471	**12,574**
	IDN	534	853	138	29	1,072	52	40	68	-42	-47	**3,172**
	PHL	579	359	249	20	402	9	60	21	-57	7	**2,354**
	THA	774	2,677	737	148	728	-46	28	126	-254	-23	**1,793**
	AUS	73	276	2	66	172	-4	-1	16	108	12	**1,521**
	MAR	38	4	6	16	13	17	53	17	-25	140	**926**
	ZAF	35	79	24	26	21	-7	6	21	15	17	**615**
	HKG	54	79	43	8	143	4	0	8	-1	0	**573**
	COL	30	14	12	13	3	10	4	41	118	8	**569**
	Total	**36,231**	**21,339**	**20,129**	**9,991**	**9,940**	**5,922**	**5,596**	**5,450**	**3,318**	**2,471**	

Figure C.1: The ToT effect of Tariff Cooperation between the United States (Blue) and its Major Trading Partners (Red)



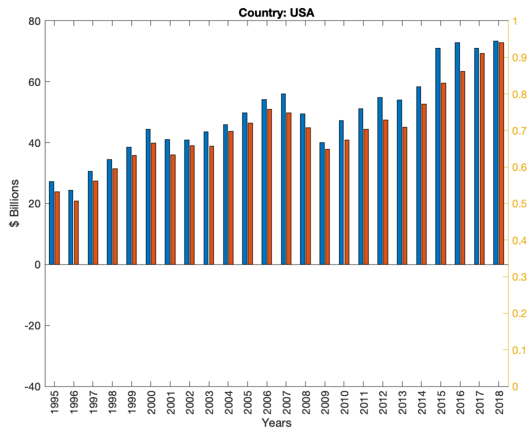
The bars illustrate the terms-of-trade effects of bilateral cooperation between the US (blue) and its partner (red) under two scenarios: the balanced-trade counterfactual scenario (represented by solid colors) and the factual scenario (represented by light colors). The net concessions granted by the US to its partner are shown with a solid line for the balanced-trade scenario and a dashed line for the factual scenario.

Figure C.2: The Role of Trade Imbalances on Net Multilateral Concessions



See Figure 7 in the main text.

Figure C.3: The Impact of Matching the Partner's Tariffs on U.S. Multilateral Concessions

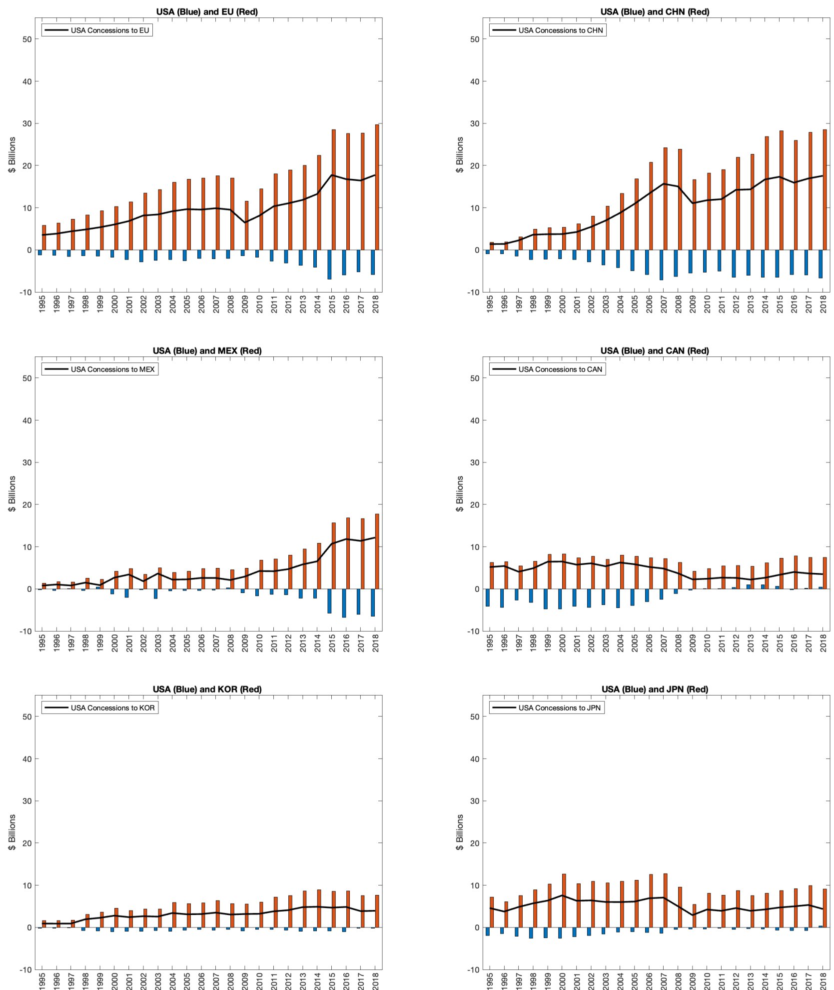


The red bars represents the net concessions granted by the United States under a scenario where the U.S. applies to imports from each country the same sectoral tariff rates that it faces in that country. The blue bars are the U.S.'s net concessions under the factual scenario.

D Alternative Noncooperative Benchmark: Uniform 50% Tariffs

The following graphs illustrate different concession variables for the noncooperative scenario where in each bilateral trade wars both countries apply a tariff of 50% on their imports. In the oil sector and sectors with applied tariffs above 50%, the noncooperative tariff is set equal to applied tariffs. These figures correspond to Figures 4-7 in the main text that presented the results under the bilateral Nash scenario.

Figure D.1: The ToT Effect of Tariff Cooperation between the US and its Major Trading Partners (50% Noncooperative Tariffs)



Compare with Figure 4 for the bilateral Nash noncooperative scenario. Each panel illustrates the terms-of-trade effects of bilateral cooperation between the US and one of its major trading partners. Blue (red) bars depict the magnitude of the effect on the US (its partner). The line depicts the net concessions granted by the US, computed using equation (3).

Figure D.2: Net Bilateral Concessions Granted to Partners by Select Countries in 2018 (50% Noncooperative Tariffs)

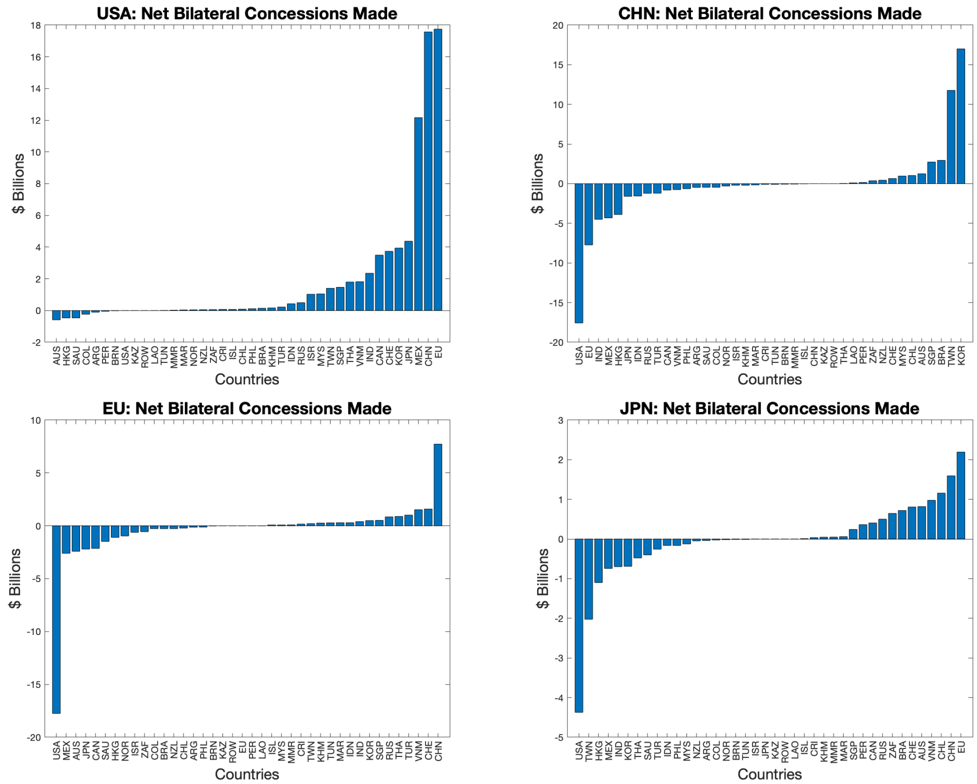
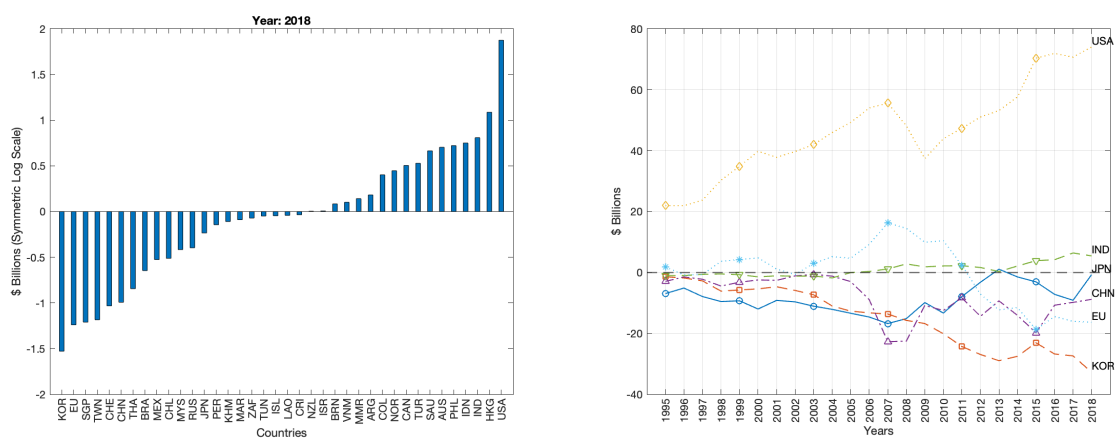
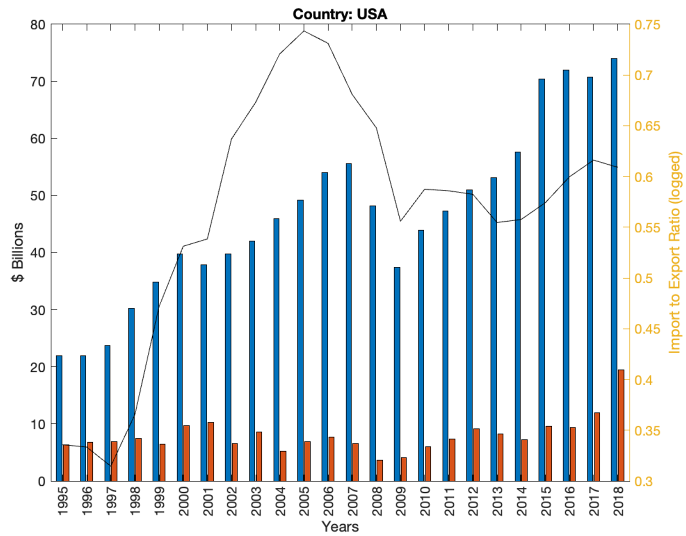


Figure D.3: Net Multilateral Concessions Granted (50% Noncooperative Tariffs)



Compare with Figure 1 for the bilateral Nash noncooperative scenario. The left panel depicts the net multilateral concessions granted by each country on a symlog scale in 2018. The right panel depicts the same measure for selected countries from 1995 to 2018.

Figure D.4: Net Multilateral Concessions of the United States (50% Disagreement Tariffs)
The Role of Trade Imbalances



Compare with Figure 7 for the bilateral Nash as noncooperative scenario. The net concessions granted by the United States under the balanced-trade scenario (represented by red bars) are significantly lower compared to those under the factual trade flows (blue bars). The line graph, aligned with the right axis, displays the logarithmic ratio of U.S. imports to exports. Additional charts for other countries are provided in the appendix.

E Calibration

Table E.1: List of Parameters and Variables

Parameters/Variables	Description
$\mu_{j,k} = \frac{\sum_i x_{ij,k}}{\sum_{k'} \sum_i x_{ij,k'}}$	share of expenditure on sector k in the total expenditure of country j on non-service sectors
$\lambda_{ij,k} = \frac{x_{ij,k}}{\sum_l x_{lj,k}}$	share of expenditure on goods from country i by country j in sector k
$\mu_j = \frac{\sum_k \sum_i x_{ij,k}}{\sum_k \sum_i x_{ij,k} + \sum_i x_{ij}^S}$	share of expenditure on all non-service sectors in the total expenditure of country j, where the superscript S denotes the service sectors
$\omega_i L_i = \sum_k \sum_j \frac{x_{ij,k}}{1+t_{ij,k}}; \quad Y_j = \sum_k \sum_i x_{ij,k}$	wage and total expenditure
$D_j = \sum_k \sum_i \left(\frac{x_{ij,k}}{1+t_{ij,k}} - \frac{x_{ji,k}}{1+t_{ji,k}} \right)$	Trade deficit of country j
$\delta_j = \frac{D_j}{\sum_i \omega_i L_i}$	The ratio of trade deficit to world GDP

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

$$\lambda_{ij,k} = \frac{x_{ij,k}}{\sum_l x_{lj,k}} \tag{15}$$

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

$$P_{j,k} \equiv \left(\sum_n b_{nj,k}^{\sigma_k} \tilde{p}_{nj,k}^{1-\sigma_k} \right)^{\frac{1}{1-\sigma_k}}. \tag{16}$$

It follows that wage income of country i is:

$$\begin{aligned}\omega_i L_i &= \sum_j \sum_k \frac{\tilde{p}_{ij,k}\tilde{q}_{ij,k}}{1+t_{ij,k}} \\ &= \sum_j \sum_k \frac{\lambda_{ij,k}\mu_{j,k}Y_j}{1+t_{ij,k}}.\end{aligned} \tag{17}$$

Therefore, the budget constraint (7) may be written as,

$$\begin{aligned}Y_j &= \omega_j L_j + \sum_k \sum_i \frac{t_{ij,k}}{1+t_{ij,k}}\tilde{p}_{ij,k}\tilde{q}_{ij,k} + D_j \\ &= \omega_j L_j + \sum_k \sum_i \frac{t_{ij,k}}{1+t_{ij,k}}\lambda_{ij,k}\mu_{j,k}Y_j + D_j.\end{aligned} \tag{18}$$

We assume that trade deficit (or, surplus) of country j is a fixed fraction, δ_j, of the world income, i.e.,

$$D_j = \delta_j \sum_i \omega_i L_i.$$

Furthermore, given that the sum of trade deficits in the world should be zero, we must have:

$$\sum_i \delta_i = 0.$$

Given tariffs $\{t_{ij,k}\}$, an equilibrium is a vector of variables $\{\omega_j, Y_j, \lambda_{ij,k}, P_{j,k}\}$ that satisfies conditions (6)–(18) for all ijk, conditional on the set of parameters $\{\kappa_{ij,k}, b_{ij,k}, \bar{a}_{ij,k}, \sigma_k\}$ and observables $\{\mu_{j,k}, \mu_j, D_j\}$, where μ_j is country j's share of total expenditure on non-service sectors. Given (4), the welfare of country j driven from non-service sectors may be written as:

$$W_j = \left(\frac{Y_j}{\prod_k P_{j,k}^{\mu_{j,k}}}\right)^{\mu_j}. \tag{19}$$

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

$$\ln \frac{x_{in,k} x_{nj,k} x_{ji,k}}{x_{ni,k} x_{jn,k} x_{ij,k}} = (1 - \sigma_k) \ln \frac{\tau_{in,k} \tau_{nj,k} \tau_{ji,k}}{\tau_{ni,k} \tau_{jn,k} \tau_{ij,k}} + \varepsilon_{inj,k}, \tag{20}$$

where $\tau_{ij,k} = 1 + t_{ij,k}$. We implement the regression using the panel of country pairs in the period 1995–2018 for each sector k. The estimates of $\sigma_k - 1$ are reported in Table E.3.

Finally, we use the hat-algebra approach to compute changes in the endogenous variables given counterfactual scenarios for tariff rates and trade imbalances. Costinot and Rodríguez-Clare (2014) provide a detailed description of this method. For insights into its application to trade negotiations, see Ossa (2014, 2016).

Table E.2: Country List

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

Table E.3: Sector Classification and Trade Elasticity Estimates

Sector	TiVA Industry Code	ISIC Rev 4	Sector Description	Trade Elasticity
1	D01T02	01-02	Agriculture, hunting, forestry	8.11^{*}
2	D03	03	Fishing and aquaculture	8.11^{*}
3	D05T06	05-06	Mining and quarrying, energy producing products	15.72^{*}
4	D07T08	07-08	Mining and quarrying, non-energy producing products	15.72^{*}
5	D09	09	Mining support service activities	15.72^{*}
6	D10T12	10-12	Food products, beverages and tobacco	$1.72^{\dagger}$
7	D13T15	13-15	Textiles, textile products, leather and footwear	1.26
8	D16	16	Wood and products of wood and cork	2.66
9	D17T18	17-18	Paper products and printing	2.29
10	D19	19	Coke and refined petroleum products	$1.72^{\dagger}$
11	D20 D21	20 21	Chemical and chemical products Pharmaceuticals, medicinal chemical and botanical products	2.59
12	D22	22	Rubber and plastics products	1.25
13	D23	23	Other non-metallic mineral products	0.48
14	D24	24	Basic metals	2.59
15	D25	25	Fabricated metal products	$1.72^{\dagger}$
16	D26	26	Computer, electronic and optical equipment	$1.72^{\dagger}$
17	D27	27	Electrical equipment	$1.72^{\dagger}$
18	D28	28	Machinery and equipment, nec	0.44
19	D29	29	Motor vehicles, trailers and semi-trailers	$1.72^{\dagger}$
20	D30	30	Other transport equipment	1.93
21	D31T33	31-33	Manufacturing nec; repair and installation of machinery and equipment	$1.72^{\dagger}$
22	D35	35	Electricity, gas, steam and air conditioning supply	$10.00^{\ddagger}$

Note: The table reports the list of non-service 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). While the trade flows from TiVA 2021 edition are based on ISIC Rev. 4, the tariff data given by WITS are available only in ISIC Rev. 3. In ISIC Rev. 3, D20 and D21 are grouped as one combined industry, reflected in Sector 11 in the table.

* The elasticity estimates for these agriculture and mining sectors are negative, and are replaced by the estimate from Caliendo and Parro (2015).

† The elasticity estimates for these manufacturing sectors are negative, and are replaced by the mean across the manufacturing 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.