The Balance of Concessions in Trade Agreements*

Mostafa Beshkar† Pao-Li Chang‡ Shenxi Song§

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Abstract

This paper introduces a quantitative framework to analyze the WTO's reciprocity principle. Utilizing two polar bargaining environments, we measure terms-of-trade concessions among WTO members and examine how shifts in applied tariffs and economic fundamentals affect bilateral and multilateral balance of concessions. We find significant disparities in concessions, largely driven by the rise in trade imbalances since the early 1990s. Notably, although US-China bilateral tariffs suggest considerable terms-of-trade benefits for China, under a hypothetical balanced trade scenario, their relationship evolves towards near reciprocity following China's accession to the WTO. Furthermore, in contrast to the significant gains in its relationship with the US, China experiences a terms-of-trade loss in its bilateral relationships with other WTO members. Lastly, we offer insights into the magnitude of concessions exchanged by countries at different levels of development.

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†Associate Professor of Economics, Department of Economics, Indiana University, 100 S. Woodlawn Ave., Bloomington, IN 47405, USA. mbeshkar@iu.edu.

‡Associate Professor of Economics, School of Economics, Singapore Management University, 90 Stamford Road, Singapore 178903. plchang@smu.edu.sg.

§Data Scientist Economist, Lazada South East Asia, Lazada One 51 Bras Basah Road #01-21 Singapore 189554, email: shenxi.song@alibaba-inc.com.

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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 Introduction

The principle of reciprocity, which underpins negotiations in the GATT/WTO agreement, requires a balance of concessions among WTO members. In recent years, however, politicians from various parts of the world have expressed concerns about their countries' disproportionate obligations under the WTO and a perceived lack of reciprocity from their trading partners. Notably, high-level U.S. politicians have proposed reassessing the nation's commitments under the WTO, with some even advocating withdrawal from the organization.[1] Chinese authorities have also expressed their dissatisfaction with the organization and indicated that they are prepared to reassess their partnership with the organization.

Amidst these political rumblings, our study seeks to empirically evaluate these claims of imbalanced concessions within the WTO framework. Although reciprocity has been identified in the economics literature as one of the core principles of the WTO (Bagwell and Staiger, 1999, 2004), little has been done to quantify it and, therefore, it is hard to assess the claims regarding substantial deviations from reciprocity.

In this paper, we propose a framework to quantitatively evaluate the extent of deviation from reciprocity in a setting that allows for trade imbalances and an arbitrary number of countries and sectors. Our framework is based on terms of trade theory, under which the unilateral choice of import tariffs is globally inefficient due to the negative externality it imposes on other countries. Accordingly, we define concessions associated with a tariff cut as the resulting change in the terms of trade, weighted by the quantity of affected trade. We then provide a bargaining framework for multilateral tariff cut negotiations and quantify this model using trade and tariff data from WTO members. Our analysis generates a dataset of bilateral concessions exchanged among 38 WTO member countries each year from 1995 to 2018.

A key step in measuring concessions is to characterize a disagreement (or, non-cooperative) scenario that will be used as the benchmark to calculate exchanged concessions. Given the multilateral nature of the WTO, disagreements could take several forms involving different subsets of countries. For example, an extreme case of disagreement is

[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."

a complete dissolution of the WTO and its associated trade agreements. However, more likely scenarios of non-cooperation include bilateral trade wars and a country's unilateral departure from the WTO's "grand coalition". We explore the latter two alternative approaches to determine the non-cooperative outcomes under the WTO.

The main difference between these two approaches is related to their implicit treatment of the non-discrimination clause. In the bilateral trade war approach, the non-cooperative outcomes are unconstrained by the non-discrimination clause. In the grand coalition approach, by contrast, non-discrimination is assumed to be non-negotiable within the agreement and, therefore, the non-cooperative outcome for a country involves leaving the multilateral agreement altogether.

The first approach, which we refer to as the nexus of bilateral trade agreements, posits that 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 non-cooperative outcomes is generally consistent with the rules and procedures of the WTO.

Our second approach to quantifying trade concessions operates under the assumption that the WTO is an effective multilateral system capable of enforcing its non-discrimination clause.[2] Therefore, the threat point in the relationship between two parties is no longer represented by a bilateral trade war (as in the first approach). Instead, a country that threatens to terminate cooperation with one (or more) countries risks being excluded from the WTO altogether. In this approach, each country is essentially in bargaining with a grand coalition and its non-cooperative outcome is its departure from the agreement.

We present and analyze the two bargaining environments outlined above because we believe they each illuminate distinct facets of the global trading system. The first environment, focusing on bilateral relations, reflects the realities of direct country-to-country negotiations and disputes, highlighting how power dynamics between larger and smaller countries can shape trade policies and concessions. This approach brings into focus the tactical aspects of implementing trade agreements, where obligations are essentially enforced bilaterally. On the other hand, the grand coalition approach underscores the importance of multilateralism norms and the collective bargaining power they can confer on smaller nations, emphasizing the role of non-discrimination clause in determining the perceived balance of concessions. Together, these bargaining environments offer a fuller view of the mechanisms that underpin reciprocity in international trade.

We now briefly describe our main quantitative results. Under both bargaining frame-

[2] In quantification of the model, we allow for the usual exceptions to the non-discrimination clause, namely, the preferences granted under PTAs.

works, we observe significant variation in net terms-of-trade gains across countries, with the United States standing out as the country with the largest net contributions to the system. China emerges as a key player, in terms of the level of concessions exchanged, especially after its accession to the WTO in 2002. Perhaps unexpectedly, in the latter half of our period of study, China emerges as a large net contributor to the system, experiencing notable terms-of-trade losses compared to a scenario with reciprocal tariff cuts in all bilateral relationships.

In our quantitative analysis, we decompose the cross-country and intertemporal variation in the balance of concessions into changes due to the shift in economic fundamentals and changes in applied tariffs over time. Two salient changes in the global economic landscape since the early 1990s are the rapid economic expansion in parts of the developing world, and the increase in trade imbalances across the world, both of which have the potential to shift the balance of concessions. Trade imbalances prove to be a significant factor in the balance of concessions.[3] Specifically, eliminating trade imbalances worldwide reduces the log-difference between granted and received concessions for the United States by 40-50%, thereby rendering the trade agreements more reciprocal for the United States.[4]

Both bargaining environments generate similar intertemporal patterns in the evolution of the Balance of Concessions (henceforth, BoC). Notably, there is a discernible decline in the Terms-of-Trade (henceforth, ToT) gains of prominent developing nations (China, India, Indonesia, and the Philippines), whereas major industrial countries/regions (USA, Japan, EU) see a rise in their ToT gains. The primary distinction between the outcomes of these two models lies in the scale of terms-of-trade benefits exchanged. Specifically, through the lens of the Grand Coalition model, apart from the United States during 1998 to 2006, all nations experienced an improvement in their ToT due to their membership in the WTO and its associated FTAs. However, using bilateral trade wars as a benchmark, the United States, and later China, experience a large ToT loss due to their WTO membership.

Our analysis, therefore, shows that both the United States and China extend net concessions to their trade partners. In their bilateral relationships, however, the United States has given more ToT concessions to China than it has received in return. This discrepancy in bilateral concessions is largely attributable to trade imbalances. Specifically, in a hypothetical balanced-trade scenario, the relationship between China and the US approaches a state of near reciprocity in years after China's accession to the WTO. Another implication of this observation is that China must undertake substantial tariff cuts against the United States to move towards bilateral reciprocity.

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

[4] We model trade imbalances as arising from foreign ownership of factors of production, which implies that a country that runs a trade deficit in equilibrium has a net ownership of foreign factors of production.

Finally, we evaluate the effect of development status of countries on their exchange of concessions. Specifically, we evaluate two common hypotheses: i) Industrial countries have liberalized their trade more aggressively than developing countries, and ii) Tariff cuts under the auspices of the WTO tend to favor exports from developed countries.[5] The previous literature has evaluated the effect of member countries' development status based on the effect of WTO membership on their level of imports and exports (e.g., Subramanian and Wei 2007) or the size of tariff cuts implemented by countries of different development status. We provide a complementary perspective by considering a country's ToT concessions to its trading partners as a fraction of the total possible concessions that it could grant by adopting a full free trade regime. We find that the developed countries have indeed granted a greater fraction of their total possible concessions to other countries. However, we find no evidence that tariff cuts under the WTO have a bias in favor of exports from developed countries.

Our methodology generates a dataset of bilateral concessions covering 38 countries over 24 years, with the potential for extension to additional years and countries. This dataset may be utilized to explore a wide range of trade policy questions, including the resilience of the WTO agreement, the effects of preferential trade agreements on the balance of concessions, and the interplay between reciprocity and geopolitical interactions, among other issues.[6]

The remainder of this paper is organized as follows. In Section 2, we discuss the relevance of our work to the existing literature. In Section 3, we formally define the alternative measures of concessions and discuss their merits and limitations. In Section 4, we present alternative bargaining environments to evaluate tariff cut concessions. In Section 5, we lay out the general equilibrium trade model that we use to simulate counterfactual equilibria. Section 6 contains our quantitative results, which portrays the anatomy of concessions in the WTO across years for bilateral and multilateral relationships. Section 7 concludes.

2 Related literature

This paper contributes to a nascent literature that utilizes the advances in quantitative analysis of trade flows (Eaton and Kortum, 2002; Caliendo and Parro, 2015) 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

[5] Despite apparent advantages that the WTO rules afford the developing nations, early critics of the GATT/WTO argued that the trading system was primarily developed through negotiations among industrial countries, with developing members of the WTO often sidelined in discussions on tariff reductions.

[6] Further discussion of potential uses of this dataset is provided in our concluding remarks (Section 7).

(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 hinges critically on the inclusion of the MFN clause in the agreement.

Our nexus of bilateral agreement model is inspired by Bagwell et al.'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 theoretical non-cooperative tariffs to WTO-implemented tariffs.

Bown, Caliendo, Parro, Staiger, and Sykes (2023) provide a quantitative framework to investigate 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 different 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 non-cooperative 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-a-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.[7] 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.

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 right pro-

[7] 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 changes in country's market power, recurring rounds of negotiations under the WTO will be helpful to keep commitments at mutually accepted level.

tection, product standards, labor laws, etc, or broader geopolitical cooperations such as security alliances.[8] 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.[9] Our quantitative framework provides a starting point for such analysis by mapping out tariff concessions exchanged among countries.

3 Measuring Trade Concessions

In this section, we propose a metric for measuring *deviation* from reciprocity in a two-country-two-good model featuring trade imbalances. To achieve this, we first define concessions that are implied by tariff cuts. We then compute the deviations from reciprocity as the difference between the concessions a country grants and those it receives as a result of bilateral or multilateral tariff cuts.

As detailed in Definition 1 below, we define concessions associated with a tariff cut as the change in terms of trade, weighted by the corresponding post-liberalization traded quantities. We often refer to these concessions as ToT gains/losses or ToT concessions. As we will discuss below, ToT concessions are related to, but distinct from, "market access" concessions, which is typically defined as the change in import volumes evaluated at pre-liberalization prices.

Finally, we make a key observation regarding the effect of a trade balance shock on the level of reciprocity in an agreement. Subsequent sections of the paper extend and apply the proposed metric of ToT concessions to a broader setting involving multiple countries and sectors.

3.1 Basic model

Consider a pair of countries, home (h) and foreign (f), that are endowed with Q_h and Q_f units of nationally differentiated goods, which may be exchanged in a competitive market. Letting q_{ij} denote the quantity of exports from country i to j $(i, j \in \{h, f\})$, consumer

[8] 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."

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

preferences are given by:

$$U_i = u\left(q_{ji}\right) + u\left(q_{ii}\right). \tag{1}$$

We assume that the home country owns a fraction α of the foreign country's endowment, which leads to a trade deficit at home if $\alpha > 0$. Moreover, we let t_i denote ad valorem import tariffs applied by country i on its imports. Using the foreign good as the numeraire and letting p denote the world price of the home good, home country's consumer budget constraint is:

$$pq_{hh} + (1 + t_h) q_{fh} = pQ_h + \alpha Q_f + T_h, \tag{2}$$

where tariff revenues, $T_h \equiv t_h q_{fh}$, are assumed to be distributed back to home consumers in a lump sum fashion. Similarly, the foreign country's consumer budget constraint is given by:

$$q_{ff} + p\left(1 + t_f\right) q_{hf} = (1 - \alpha) Q_f + T_f, \tag{3}$$

where, $T_f \equiv p t_f q_{hf}$.

3.2 A metric for measuring deviation from reciprocity

As shown by Bagwell and Staiger (1999), under a vast range of international trade models, ToT externality is the only source of inefficiency in unilateral tariff choices that may be corrected with trade agreements.[10] Given that under these models, the role of trade agreements is to internalize the ToT externality of trade policy, we define concessions received by a country as the change in its relative export price times its export quantity after liberalization. Formally:

Definition 1. Consider a set of bilateral tariff cuts between countries h and f that changes the relative world price of h's exports from p to p'. The net concessions granted by f to h is:

$$NC_{hf} \equiv \left(p' - p\right).q'_{hf}.$$

The net concessions defined above may be understood as trade-weighted terms-of-trade effect. As stated earlier, this definition is related to, but distinct from, the notion of market access concessions that is commonly used in the literature. To see the similarity, note that our definition of net concession may be equivalently stated as $NC_{hf} \equiv$

[10] Bagwell and Staiger (1999) call a set of mutual tariff cuts reciprocal if it brings about equal changes in import volumes (i.e., market access) across trading partners. They show that reciprocal tariff cuts leave the ToT unchanged. 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 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.

$\left(q'_{fh} - q_{fh}\right) - p\left(q'_{hf} - q_{hf}\right)$, where $q'_{fh} - q_{fh}$ and $p\left(q'_{hf} - q_{hf}\right)$ reflect, respectively, the increased market access of the foreign and home countries at pre-liberalization relative price, p. However, using the market access terminology would require labeling the increase in imports as concessions *received* by an importing country, which is contrary to the intended use of this language in negotiations, where governments consider the increase in their imports as concessions that they *give to*, rather than *receive from*, other countries. In contrast, using ToT gains to measure concessions, offers a terminology that is more congruent with the language typically used in the context of trade negotiations.

Given Definition 1, a set of bilateral tariff cuts between countries h and f conforms to the principle of reciprocity if and only if $NC_{hf} = 0$. In a two-country world, an equal exchange of concessions between countries keeps the relative world price constant. To illustrate, consider mutual tariff cuts that increases trade volumes from an initial *non-cooperative* equilibrium (NN) to the *Factual* equilibrium (FF) under currently applied tariffs. Figure 1 depicts the equilibria of hypothetical NN and FF scenarios, which are the intersection of the trade offer curves of the two countries before and after tariff cuts.[11] The trade offer curve of the home country under its non-cooperative tariff is depicted by the red curve passing through NN and NF. Similarly, the trade offer curve of the foreign country under its non-cooperative tariff is depicted by the blue curve that passes through NN and FN. The point D^{NN} on the vertical axis depicts the amount of foreign endowment that is owned by the home country, which leads to a trade deficit (surplus) for the home (foreign) country. The intersection of the offer curves at NN indicates the equilibrium under non-cooperative tariffs. Trade liberalization by home and foreign countries expands their respective trade offer curves outwardly, and shifts the equilibrium trade quantities from NN to FF.

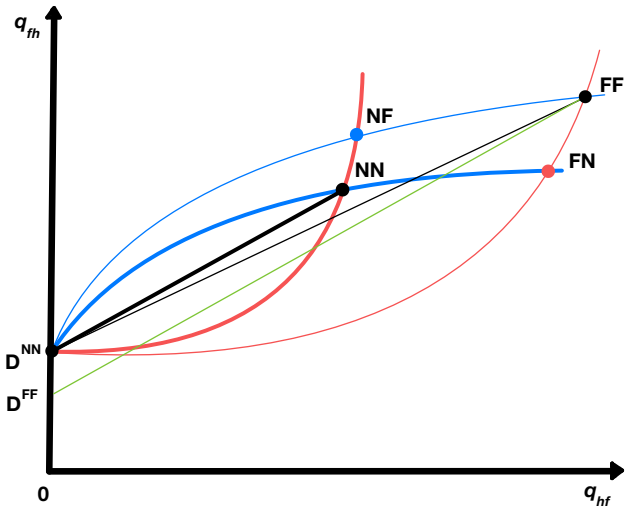
The bilateral tariff cuts that leads to a shift from NN to FF, depicted in Figure 1, do not conform to the principle of reciprocity because they result in a deterioration of home country's ToT. To see this, note that the slope of the line connecting the equilibrium point with $\left(0, D^{NN}\right)$ indicates the ToT of the home country (i.e., p^w), which is lower for the FF equilibrium compared to the NN equilibrium. Based on Definition 1, the degree of deviation from reciprocity is captured by the change in the home country's trade-weighted ToT, or equivalently, the change in home country's real deficit when trade volumes are evaluated at the initial price. In particular, in Figure 1, mutual tariff cuts causes the home country a ToT loss equal to $\left(p^{NN} - p^{FF}\right) q^{FF}_{hf} \equiv D^{NN} - D^{FF}$.[12]

The net concessions exchanged between two countries may be decomposed into concessions given by each country. This decomposition is useful in measuring the amount of concessions that tariff cuts of a country imparts on its partners. To this end, we decompose the total effect of mutual tariff cuts (i.e., $D^{NN} - D^{FF}$) into the marginal effect of each

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

[12] This confirms Blanchard's (2010) theoretical result that with cross-border ownership of factors of production, a reciprocal tariff cut "leaves net remittances unchanged," namely, $D^{NN} - D^{FF} = 0$.

Figure 1: Deviation from Reciprocity



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

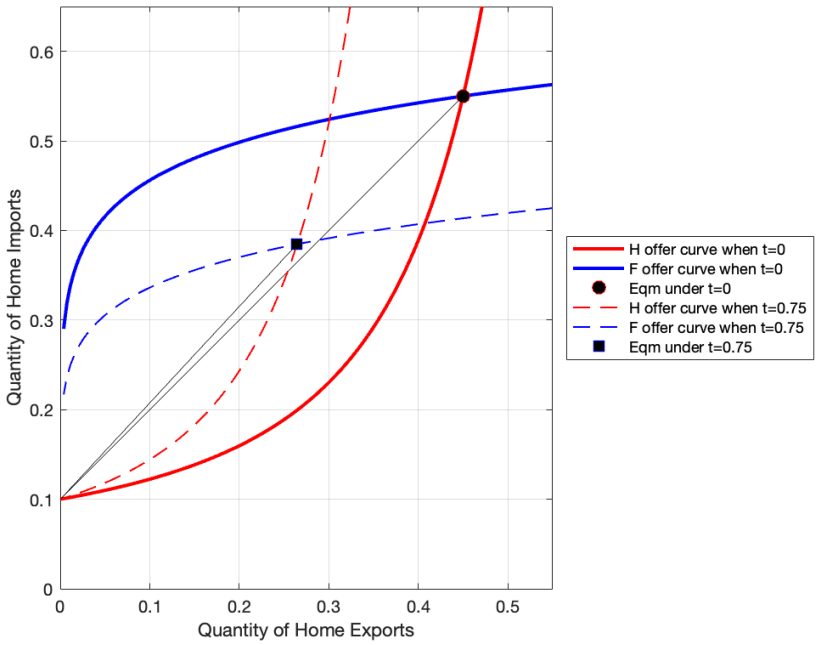
country's tariff cut. The change in equilibrium variables due to mutual tariff cuts may be decomposed into sequential unilateral liberalization by the two countries. There are two liberalization routes, given by $NN \to FN \to FF$ and $NN \to NF \to FF$, where the first and second letter in each pair denote the liberalization status of home and foreign countries, respectively. We measure the marginal effect of home country's tariff cut on foreign country's ToT gains by taking the average change in ToT gains by moving from $NN \to FN$ and $NF \to FF$ on ToT gains of the foreign country. Similarly, the effect of foreign country's tariff cut is measured by the average effect of tariff cuts represented by $NN \to NF$ and $FN \to FF$.

Formally, the *marginal* ToT concessions granted to home by the foreign country in the above scenario is given by:

$$C_{hf} \equiv \frac{1}{2}\left[\left(p^{NF} - p^{NN}\right) q_{hf}^{NF} + \left(p^{FF} - p^{FN}\right) q_{hf}^{FF}\right]. \tag{4}$$

The two terms inside the bracket illustrate the effect of the foreign country's liberalization on the home country's ToT gains under different initial points: The first term shows the home's ToT gains as a result of unilateral liberalization by the foreign country, while home keeps its tariffs at the non-cooperative level (i.e., $NN \to NF$). The second term is related to $FN \to FF$, which captures the effect of foreign country's liberalization on the home country's ToT gains when home has already liberalized its trade. The average of these effects is used as our measure of ToT gains granted. A similar equation as (4) may be written for

Figure 2: Simulation of Mutual Tariff Cuts under Trade Imbalance



*Notes:*The impact of reducing tariffs mutually from 75% to zero, when the home country owns 10% of the foreign endowment and, thus, runs a trade deficit. Model parameters: $\alpha = 0.1, u(x) = x^{\rho}, \rho = 0.25, Q_h = Q_f = 1$.

C_{fh}, which measures the concessions granted to the foreign country by the home country.

3.3 The effect of a trade balance shock on reciprocity

A key premise of this paper is that an increase in trade imbalances over time has upset the BoC under the existing trade agreements. In particular, we hypothesize that countries that have experienced a substantial surge in trade deficits will in turn witness an increase in the concessions they grant to other nations relative to the concessions they receive.

This point is most succinctly illustrated for a pair of symmetric countries that have a balanced trade at the time of negotiating a reciprocal tariff cut arrangement but subsequently face an unexpected trade balance shock while the agreement is in effect. In the case of symmetric countries with balanced trade, reciprocity entails equal tariff cuts for both nations. Yet, if these countries encounter a trade balance shock, resulting in one running a deficit and the other a surplus, equal tariff cuts cease to be reciprocal. Specifically, for symmetric countries with equal tariffs, mutual tariff reductions worsen the terms of trade for the country running a trade deficit.

Figure 2 simulates this for a pair of symmetric countries that jointly reduce their tariffs from an initial level of 75% to zero. Given the symmetry of the countries, if trade is balanced (i.e., if $\alpha = 0$) such symmetric tariff cuts are *reciprocal* as they do not alter the world price. However, with $\alpha = 10\%$, the same tariff cuts lead to a deterioration of the ToT of the deficit country (i.e., the home country). The slope of the lines passing through each equilibrium point represents the world price of the home country's exports under the corresponding equilibrium. As depicted in this figure, when home has a trade deficit, a joint tariff cut from 75% to zero deteriorates home's ToT.

4 Bargaining Environment: The Non-Cooperative Counterfactuals

Given the multilateral nature of the WTO, disagreements could take several different forms involving different subsets of countries. For example, an extreme case of disagreement is a complete dissolution of the WTO and its associated trade agreements. However, more likely scenarios of non-cooperation include bilateral trade wars and a country's unilateral departure from the WTO's "grand coalition". We explore the latter two alternative approaches to determine the non-cooperative outcomes under the WTO.

The main difference between these two approaches is related to their implicit treatment of the non-discrimination clause. In the bilateral trade war approach, the non-cooperative outcomes are unconstrained by the non-discrimination clause. In the grand coalition approach, by contrast, non-discrimination is assumed to be non-negotiable within the agreement and, therefore, the non-cooperative outcome for a country involves leaving the multilateral agreement altogether.

The choice of the bargaining environment affects the implied bargaining position of each country, which can have significant implications for the calculated BoC in the WTO. In particular, the bilateral trade war approach implies that larger countries can leverage their power to pressure smaller member countries more effectively. In contrast, the grand coalition approach implies an enhanced bargaining position for smaller countries, as their position is strengthened by the support of all other members in case of infringement of their rights by any member.

4.1 Framework 1: WTO as a Nexus of Bilateral Agreements

The first approach, which we refer to as bilateral trade wars, posits that 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 mem-

ber, precluding multilateral sanctions. Therefore, designating bilateral trade wars as non-cooperative outcomes is generally consistent with the rules and procedures of the WTO.

The procedure to compute concessions under the Bilateral Relationship framework involves three steps:

i. Compute the counterfactual of a bilateral trade war for each pair of countries, holding all other tariffs in the world constant.[13]

ii. Using equation (4), measure the concessions exchanged, C_{ij} and C_{ji}, between each pair of countries as a result of moving from bilateral trade war to the factual equilibrium.

iii. Determine country j's total concessions received from the world (C_{jW}), and granted to the world (C_{Wj}), as the sum of concessions received/granted in each of its bilateral relationships:

$$C_{jW} \equiv \sum_{i \neq j} C_{ji}, \tag{5}$$
$$C_{Wj} \equiv \sum_{i \neq j} C_{ij}.$$

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 non-cooperative 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 computed non-cooperative tariffs to the observed tariffs under the WTO.

4.2 Framework 2: WTO as a Grand Coalition

Our second approach to quantifying trade concessions operates under the assumption that the WTO is an effective multilateral system capable of enforcing its non-discrimination

[13] Section 4.3 describes a procedure to compute the equilibrium under a counterfactual scenario.

clause.[14] Therefore, the threat point in the relationship between two parties is no longer represented by a bilateral trade war (as in the first framework). Instead, a country that threatens to terminate cooperation with one (or more) countries risks being excluded from the WTO altogether. In this approach, each country is essentially in bargaining with a *grand coalition* and its non-cooperative outcome is its departure from the agreement.

The procedure to compute concessions under the Grand Coalition framework involves three steps:

i. For each country i, compute the counterfactual scenario in which country i departs from the WTO, applying its optimal tariffs and facing retaliatory optimal tariffs from each country in the rest of the world.[15]

ii. Using equation (4), measure the concessions that country i grants to each member j of the WTO, C_{ji}, by joining the Grand Coalition.

iii. Determine country j's total concessions received from the world $(C_{jW} \equiv \sum_{i \neq j} C_{ji})$, and granted to the world $\left(C_{Wj} \equiv \sum_{i \neq j} C_{ij}\right)$, as the sum of concessions from/to each country.

Our second bargaining environment is akin to a coalition game: The contributions of each member to the agreement is measured by computing the amount of trade concessions that other members would lose if this country departed from the agreement. Similarly, a country's gain from participating in the agreement is measured by computing the sum of concessions that this country would lose due to the departure of each of the other member countries from the agreement.

4.3 Non-cooperative Tariffs

To calculate the level of concessions as outlined in equation (4), it is necessary first to determine the tariffs that countries would implement in a scenario where there is no cooperation. A significant hurdle in computing these non-cooperative tariffs is the absence of information about political-economy preferences of governments. 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.

One direct implication of the above argument is that a country's maximum applied tariff on a product can be considered a lower bound for its non-cooperative tariff. In computing non-cooperative tariffs, we will use the maximum applied tariff in a country-sector

[14] In quantification of the model, we allow for the usual exceptions to the non-discrimination clause, namely, the preferences granted under preferential trade agreements (PTAs).

[15] Section 4.3 describes a procedure to compute the equilibrium under a counterfactual scenario.

over the years as the lower bound for the optimal tariff in that country-sector. A second implication is that if MFN applied tariffs are below the negotiated binding rates, i.e., if there is tariff overhang in a sector, the applied tariff represents the unilaterally optimal tariff of the country. This observation is particularly important for commodities such as crude oil, where applied tariffs are virtually unbound. 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. As in Bagwell and Staiger (2005) and Beshkar, Bond, and Rho (2015), we take the view that these observed tariffs maximize the government's broad political and economic objectives.[16] Therefore, we require the optimal tariff in sectors that are virtually unbound to be equal to applied tariffs in those sectors.[17]

Adopting this perspective, we derive the set of sectoral best-response tariffs of country h on imports from country f in each sector k, denoted by $\left\{t^N_{fh,k}\right\}_k$, as the solution to the following maximization problem:[18]

$$\left\{t^N_{fh,k}\right\}_k \equiv \max_{\left\{t_{fh,k}\right\}_k} W_h\left(\left\{t_{fh,k}\right\}_k, \left\{t^N_{hf,k}\right\}_k\right), \tag{6}$$

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

$$t_{fh,k} \geq \max_i\{t^A_{ih,k}\}, \tag{7}$$

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

$$t_{fh,k} = t^A_{fh,k}, \forall k \in U, \tag{8}$$

and national budget constraints are satisfied.

In comparing our results with the existing literature, it is important to note the difference between our disagreement tariffs and the ones used in other papers, notably Bagwell, Staiger, and Yurukoglu (2021) and Bown, Caliendo, Parro, Staiger, and Sykes (2023): While we compute disagreement tariffs, these papers use observed pre-WTO tariffs as disagreement tariffs. Other papers, including Handley and Limão (2017), use the unilateral tariff schedules, such as "column-2" tariffs of the United States, that some governments publish and apply to non-WTO members. For the purpose of this paper, however, it is more appropriate to compute non-cooperative tariffs for each year in our period of study. Recall

[16] Ossa (2014) proposes an alternative method for calculating non-cooperative tariffs by using existing measures of non-cooperative tariffs (if available) to calibrate the political-economy weights in the government's optimization problem. In a recent paper, Adão et al. (2023) propose a new method to estimate political-economy weights of industries using a revealed preference approach. Both methods require observing a measure of non-cooperative tariffs (such as column-2 tariffs or Trump tariffs) in order to uncover the distribution of political preferences across sectors.

[17] In our quantification, the tariff on crude oil is the only tariff that is designated as unbound.

[18] In this optimization problem, we hold all other tariffs in the world fixed at the rates that are currently applied by governments.

that our objective is to evaluate the changes in the BoC for each country over time. Fixing non-cooperative tariffs at the pre-WTO levels would preclude evaluating the possibility that unilaterally optimal tariffs may change over time due to changes in the composition and volume of trade.

5 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 $k \in \{1, 2, ..., K\}$.

5.1 Setup

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

$$U_j = \prod_k \Big(\sum_{i=1}^{N} b_{ij,k}\, \tilde{q}_{ij,k}^{\rho_k}\Big)^{\frac{\mu_{j,k}}{\rho_k}}, \tag{9}$$

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 country j's share of expenditure on sector k.

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:

$$p_{ij,k} = \bar{a}_{ij,k}\, \omega_i, \tag{10}$$

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:

$$\tilde{p}_{ij,k} = (1 + t_{ij,k})(1 + \tau_{ij,k}) p_{ij,k}, \quad t_{ii,k} = 0, \tag{11}$$

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 in sector k is:

$$\lambda_{ij,k} \tag{12}$$

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

$$P_{j,k} \equiv \left(\sum_n b_{nj,k}^{\sigma_k} \tilde{p}_{nj,k}^{1-\sigma_k} \right)^{\frac{1}{1-\sigma_k}}. \tag{13}$$

It follows that wage income of country i is:

$$\begin{aligned} \omega_i L_i &= \sum_j \sum_k \frac{\tilde{p}_{ij,k} \tilde{q}_{ij,k}}{1 + t_{ij,k}} \\ &= \sum_j \sum_k \frac{\lambda_{ij,k} \mu_{j,k} Y_j}{1 + t_{ij,k}}. \end{aligned} \tag{14}$$

Due to 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.,

$$\begin{aligned} Y_j &= \omega_j L_j + \sum_k \sum_i \frac{t_{ij,k}}{1 + t_{ij,k}} \tilde{p}_{ij,k} \tilde{q}_{ij,k} + D_j \\ &= \omega_j L_j + \sum_k \sum_i \frac{t_{ij,k}}{1 + t_{ij,k}} \lambda_{ij,k} \mu_{j,k} Y_j + D_j. \end{aligned} \tag{15}$$

We assume that trade deficit (or, surplus) of country j is a fixed fraction, δ_j, of the world income, i.e.,[19]

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

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 $\left\{ \omega_j, Y_j, \lambda_{ij,k}, P_{j,k} \right\}$ that satisfies conditions (11)–(15) for all ijk, conditional on the set of parameters $\{\tau_{ij,k}, b_{ij,k}, \bar{a}_{ij,k}, \sigma_k\}$ and observables $\{\mu_{j,k}, \mu_j, D_j\}$, where μ_j is share of expenditure on non-service goods.

[19] This is a variation of the assumption, stated in Section 3.1, about cross-border ownership of factors of production.

Table 1: Summary of Variables and their Descriptions

Variables	Description
$\mu_{j,k} = \frac{\sum_i x_{ij,k}}{\sum_{k'} \sum_i x_{ij,k'}}$	Within-sector share of expenditure on each non-service industry, k.
$\lambda_{ij,k} = \frac{x_{ij,k}}{\sum_i x_{ij,k}}$	Within-industry share of expenditure on different exporters, i.
$\mu_j = \frac{\sum_k \sum_i x_{ij,k}}{\sum_k \sum_i x_{ij,k} + \sum_i x_{ij}^S}$	Share of total expenditure on all non-service industries, where the superscript S denotes service sector variables.
$\omega_i L_i = \sum_k \sum_j \frac{x_{ij,k}}{1+t_{ij,k}}$; $\quad Y_j = \sum_k \sum_i x_{ij,k}$	Wage and total expenditure.
$D_j = \sum_k \sum_i \left(\frac{x_{ij,k}}{1+t_{ij,k}} - \frac{x_{ji,k}}{1+t_{ji,k}} \right)$; $\quad \delta_j = \frac{D_j}{\sum_i \omega_i L_i}$	Trade deficits (D_j) and Deficit to world GDP ratio (δ_j).

Given (9), the welfare of country j driven from non-service sectors may be written as:

$$W_j = \left(\frac{Y_j}{\prod_k P_{j,k}^{\mu_{j,k}}} \right)^{\mu_j}. \tag{16}$$

5.2 Counterfactual Changes

We use the hat-algebra approach to compute changes in the endogenous variables given counterfactual scenarios for tariff rates and trade imbalances.[20] For any variable or parameter x, we let x' denote the value in the counterfactual and define $\hat{x} \equiv \frac{x'}{x}$ as the ratio of the counterfactual to factual values.

In the case of a change in tariffs, the system of equilibrium conditions can be re-written in terms of changes as follows (see Table 1 for a description of the variables in these equations):

$$\hat{\lambda}_{ij,k} = \left(\frac{1 + t'_{ij,k}}{1 + t_{ij,k}} \hat{\omega}_i \right)^{1-\sigma_k} (\hat{P}_{j,k})^{\sigma_k - 1}, \tag{17}$$

$$(\hat{P}_{j,k})^{1-\sigma_k} = \sum_i \lambda_{ij,k} \left(\frac{1 + t'_{ij,k}}{1 + t_{ij,k}} \hat{\omega}_i \right)^{1-\sigma_k}, \tag{18}$$

$$\hat{\omega}_i \omega_i L_i = \sum_j \sum_k \frac{\hat{\lambda}_{ij,k} \hat{Y}_j \lambda_{ij,k} \mu_{j,k} Y_j}{1 + t'_{ij,k}}, \tag{19}$$

[20] Costinot and Rodríguez-Clare (2014) provide a detailed description of this method. For insights into its application to trade negotiations, see Ossa (2014, 2016). Our quantitative analysis incorporates aspects derived from or influenced by the codes shared by these authors.

$$\hat{Y}_j Y_j = \hat{\omega}_j \omega_j L_j + \sum_k \sum_i \left(\frac{t'_{ij,k}}{1 + t'_{ij,k}} \hat{\lambda}_{ij,k} \hat{Y}_j \lambda_{ij,k} \mu_{j,k} Y_j \right) + D'_j, \tag{20}$$

where the trade balance condition will be given as:

$$D'_i = \delta_i \sum_j \hat{\omega}_i \omega_i L_j.$$

The changes in welfare can then be written as:

$$\hat{W}_j = \left(\frac{\hat{Y}_j}{\prod_k \hat{P}_{j,k}^{\mu_{j,k}}} \right)^{\mu_j}. \tag{21}$$

5.3 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.[21] 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 nonmembers, while the latter's applied tariff data are missing or inconsistent in some years. Tables A.1 and A.2 provide the list of economies and sectors used in the study.

Finally, the data on tariffs are sourced from the TRAINS database, downloaded via the World Integrated Trade Solution (WITS) interface. Table 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, $t_{ij,k}$.

Trade elasticities 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:

$$\ln \frac{x_{in,k} x_{nj,k} x_{ji,k}}{x_{ni,k} x_{jn,k} x_{ij,k}} = (1 - \sigma_k) \ln \frac{\tilde{t}_{in,k} \tilde{t}_{nj,k} \tilde{t}_{ji,k}}{\tilde{t}_{ni,k} \tilde{t}_{jn,k} \tilde{t}_{ij,k}} + \varepsilon_{inj,k}, \tag{22}$$

[21] 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.

Table 2: Disagreement Tariffs in 1995

Country	Min	Median	Average	Max	Country	Min	Median	Average	Max
ARG	0	21	23	33	LAO	5	18	19	38
AUS	0	11	20	97	MAR	23	79	76	104
BRA	5	20	23	37	MEX	5	25	27	51
BRN	0	17	21	58	MMR	2	9	11	24
CAN	1	16	20	89	MYS	2	26	31	120
CHE	27	31	45	215	NOR	1	10	18	120
CHL	11	14	14	15	NZL	0	16	25	96
CHN	4	45	51	119	PER	15	15	17	24
COL	9	19	21	40	PHL	10	29	31	43
CRI	9	18	22	59	RUS	1	20	23	44
EU	1	20	22	64	SAU	12	16	16	62
HKG	0	7	7	11	SGP	0	10	11	83
IDN	3	29	39	91	THA	0	44	43	79
IND	22	47	48	91	TUN	11	39	42	90
ISL	0	16	20	86	TUR	9	18	22	70
ISR	2	17	22	92	TWN	7	22	24	93
JPN	0	22	33	109	USA	0	30	30	55
KHM	2	30	35	65	VNM	1	35	35	70
KOR	5	21	21	98	ZAF	0	18	22	69

Note: This table provides summary statistics of the disagreement tariffs in 1995 across industries, which are computed using the method described in Section 4.3.

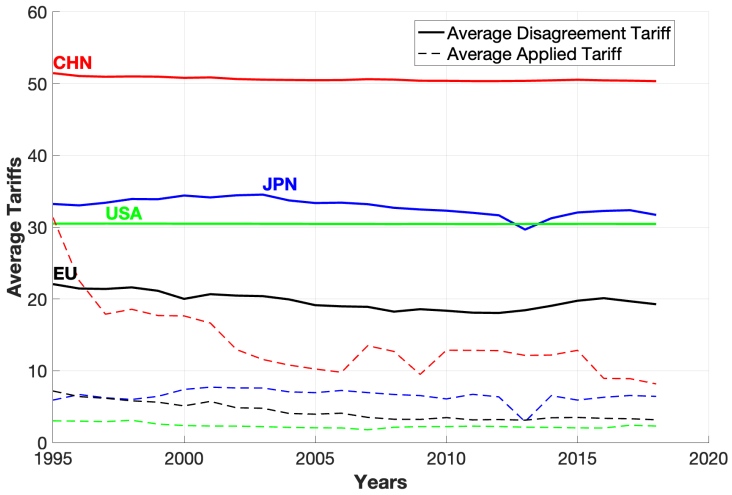
where $\tilde{t}_{ij,k} = 1 + t_{ij,k}$. We implement the regression using the panel of country pairs in the period 1995–2018 for each sector k. The estimates of $\sigma_k - 1$ are reported in Table A.2. See the footnote therein for further details of the implementation.

Non-Cooperative Tariffs Non-cooperative tariffs are computed for each bilateral trade war using the optimization program (6). This generates tariffs specific to each country-pair, sector, and year, which we will use as the disagreement point when calculating the effect of bilateral trade liberalizations. Table 2 presents the summary statistics of the computed disagreement tariffs across industries for each country in 1995. Moreover, Figure 3 presents the average disagreement tariffs (illustrated by solid lines) for various countries across years. For comparison, this figure also includes the average applied tariffs (depicted by dashed-lines) for these countries.

Measure of Concessions To compute the ToT gains exchanged among WTO members, we adapt equation (4)—originally formulated for a two-good two-country model—for an economic setting with multiple goods and countries. Specifically, to calculate the ToT gains of country i as a result of unilateral liberalization by country j, we sum i's terms of trade gains on its imports from and exports to country j in all sectors, excluding crude oil.[22] This results in a 38×38 matrix for each year from 1995 to 2018, where the entries represent C_{ij},

[22]We exclude the crude oil sector (Sector 3 as described in Table A.2) from the calculation of con-

Figure 3: 1995-Trade-Weighted Average Disagreement and Applied Tariffs for Selected Countries



Note: This figure illustrates trade-weighted average of disagreement and applied tariffs (in percentage points), using 1995 trade flows as weights. Disagreement and applied tariffs are depicted by solid and dashed lines, respectively. For comparison, Figure A.1 in the appendix reproduces this graph using current trade flows as weights.

namely, the concessions granted by country j to country i. Two versions of these matrices, corresponding to the two bargaining environments we analyze, are generated.

6 Anatomy of WTO Concessions

In this section, we present findings on the bilateral and multilateral balance of concessions, detailing how they have changed over time. Specifically, we focus on the consequences of trade imbalances and the influence of countries' development status on concessions.

In Section 6.1, we present results on multilateral balance of concessions under our two bargaining environments, namely, WTO viewed as a Grand Coalition or a Nexus of Bilateral Agreements. Under both frameworks, we observe significant variation in net ToT gains across countries, with the United States standing out as the country with the largest net contributions to the system. China emerges as a key player, in terms of the level of

cessions for the following reason: In reality, crude oil prices are virtually independent of wages. However, our one-factor economic model forces crude oil prices to change when wages change due to trade policy changes. Therefore, including crude oil in the calculation of concessions might create misleading results, particularly for major oil-exporting countries. A careful study of the balance of concessions for these countries requires a model that accounts for the fact that the labor value-added in crude oil production is minimal. We are grateful to Ben Zissimos for a conversion that led us to this conclusion.

concessions exchanged, especially after its accession to the WTO in 2002. Perhaps unexpectedly, in the latter half of our period of study, China emerges as a large net contributor to the system, experiencing notable ToT losses compared to bilateral trade war scenarios.

An investigation of bilateral concessions in Section 6.2 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 partner except a couple of countries, including the United States from which it extracts a large terms-of-trade gain.

Trade imbalances prove to be a significant factor in the balance of concessions (Section 6.3). Specifically, eliminating trade imbalances worldwide reduces the log-difference between received and granted concessions for the United States by 40-50%, thereby rendering the trade agreements more reciprocal for the United States. Similarly, reverting to balanced trade makes the agreement more balanced for EU. Eliminating trade imbalances has a more nuanced effect on the balance of concessions for China and Japan, which will be discussed in Section 6.3.

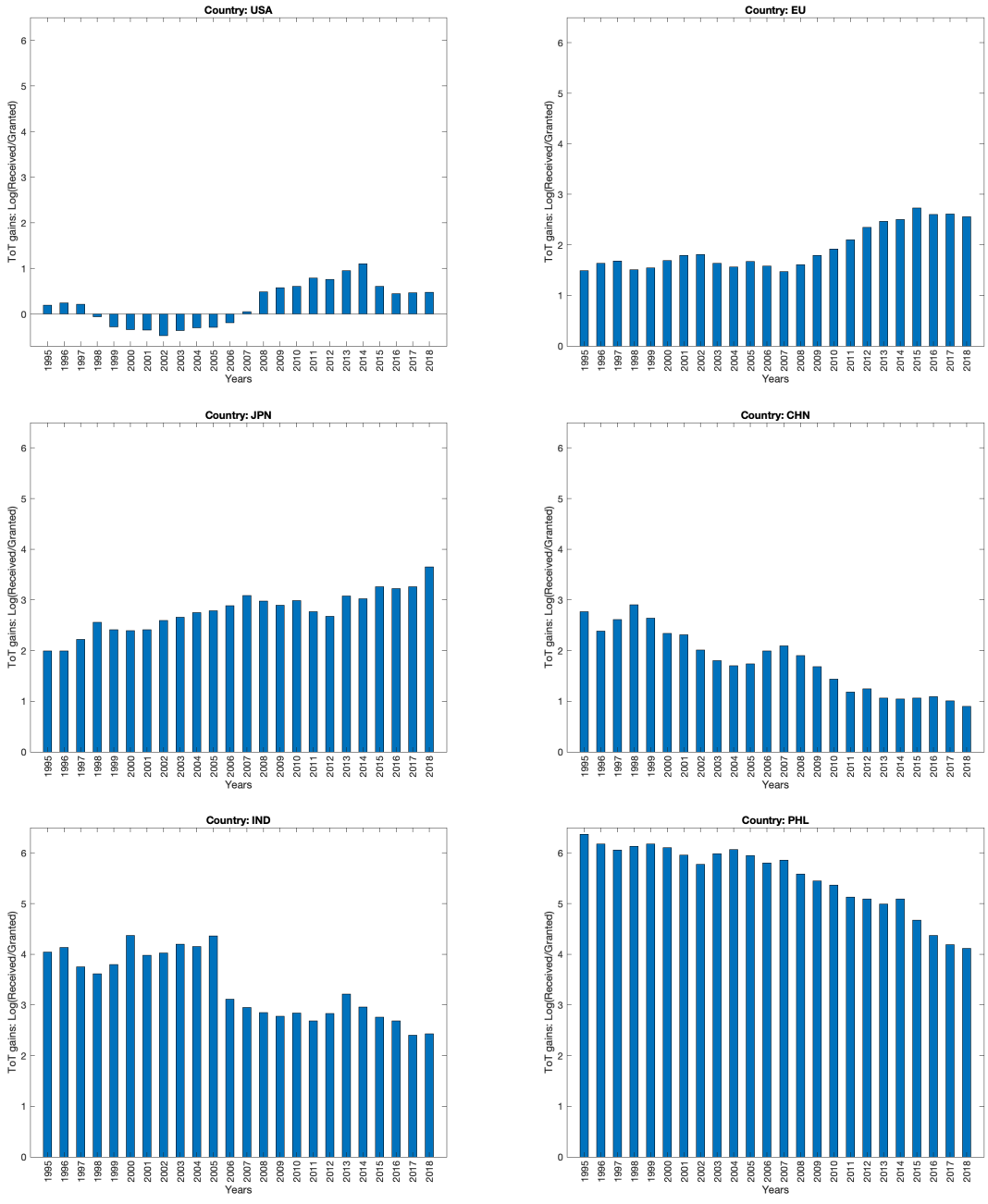
Finally, our analysis in Section 6.4 reveals that industrial countries have extended a larger portion of their total potential concessions to the rest of the world, aligning with Subramanian and Wei's (2007) finding that developing country members of the WTO did not increase their imports as much as industrial country members. Contrary to prevailing hypotheses, however, we do not find evidence that industrial countries, compared to developing countries, have secured a disproportionately larger share of concessions in their export destinations.

6.1 Multilateral BoC

We first present our findings on individual countries' BoC vis-a-vis the other members. A country's BoC with the other members depends on the bargaining framework governing its international relations. As outlined in Section 3, we consider two polar cases of bargaining relationships in a multilateral setting: (i) the Grand Coalition, where each country has to bargain with the rest of WTO members acting collectively, and (ii) Bilateral Agreements, where each pair of countries directly negotiate their bilateral tariffs. Under the Grand Coalition framework, each member country engages in bargaining with the WTO as an expansive entity that represents the rest of the world and, hence, even large countries are in a relatively weak bargaining position. Conversely, the Bilateral Agreement model tends to favor larger countries, providing them a stronger position in negotiations against smaller counterparts.

We analyze and juxtapose the ToT gains for nations under these two negotiation frameworks. Both frameworks generate similar intertemporal patterns in the evolution of BoC. Notably, there is a discernible decline in the net ToT gains of prominent developing nations, whereas major industrial countries/regions see a rise in their ToT gains. The pri-

Figure 4: WTO as a Grand Coalition
Log(Received Concessions/Granted Concessions)



Note: These graphs depict the log-ratio of ToT gains received and granted under the Grand Coalition framework, for each country across years. See equation (4) for the definition of ToT gains granted/received. Compare with Figure 5, which depicts the same variable generated under the Nexus of Bilateral Agreement framework.

mary distinction between the outcomes of these two models lies in the scale of ToT benefits exchanged. Specifically, through the lens of the Grand Coalition framework, WTO members have secured greater ToT gains for themselves, while contributing less towards the collective ToT benefits of the other members.

Figure 4 illustrates the net ToT gains (defined as the log difference of received and granted ToT gains) for a selection of countries through the lens of the Grand Coalition framework. These numbers should be understood as the net ToT gains that each country would lose if they leave the grand coalition of the WTO. A key insight is that, apart from the United States during 1998 to 2006, all nations experienced an improvement in their ToT due to their membership in the WTO and its associated FTAs. Additionally, the figure highlights a trend of increasing ToT gains for major industrialized nations (USA, Japan, and the EU) over time, contrasted with a decrease in ToT gains for some developing countries, including China, India, and the Philippines.

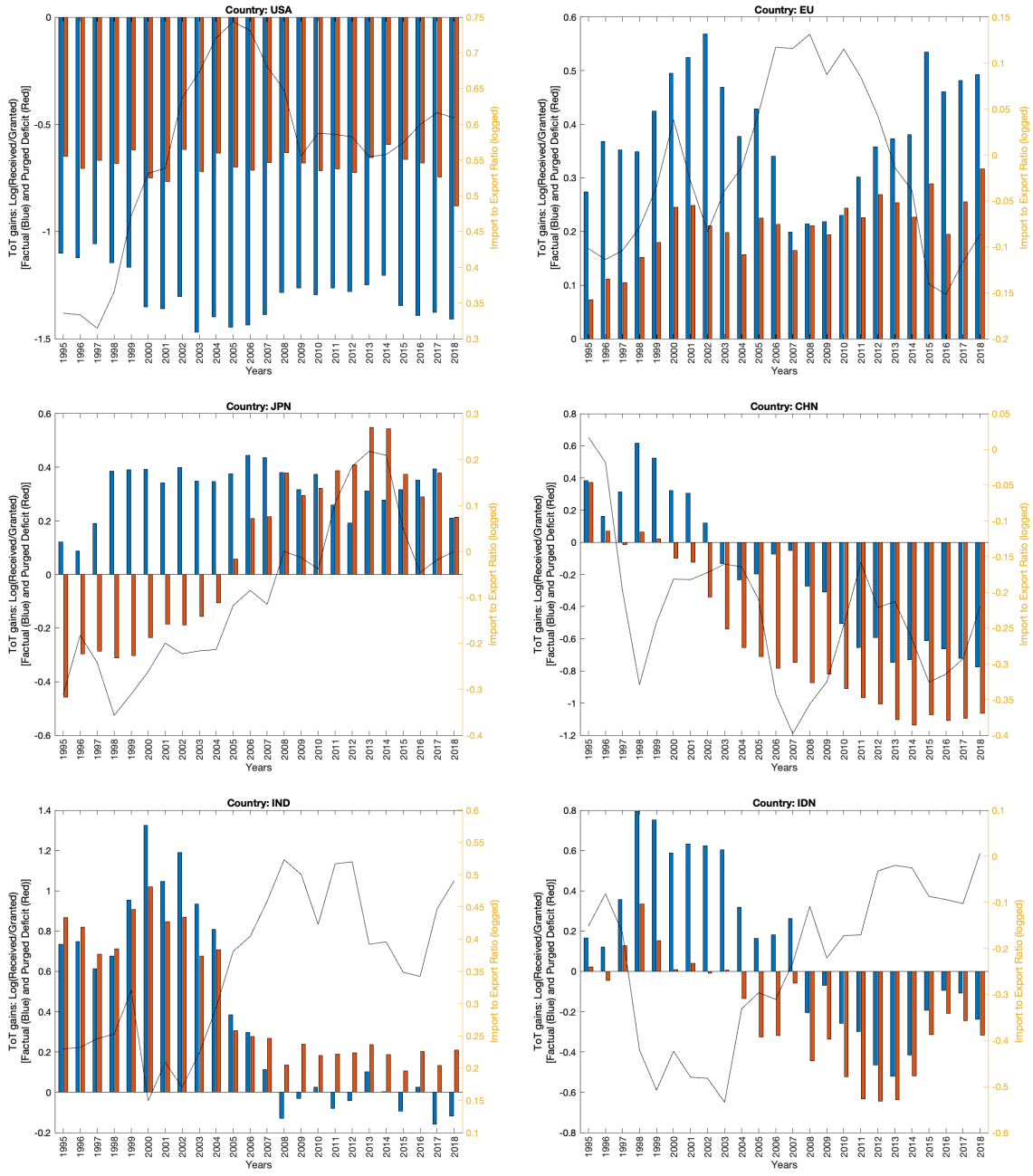
Figure 5 is the counterpart to Figure 4 for the Nexus of Bilateral Agreements framework: It illustrates the net ToT gains that each of these countries extract from all of their bilateral relationships. The key difference between the outcomes of these two frameworks is that larger countries appear to have made more concessions under the Nexus of Bilateral Agreements framework. This result reflects the fact that large countries have a relatively better bargaining position in bilateral relationships compared to the multilateral setting of the Grand Coalition framework. However, as discussed above, these figures show a similar declining trend in the net ToT gains of China, Indonesia, and the Philippines. The time trend for the US, EU, and Japan under the Nexus of Bilateral Agreements framework is less pronounced compared to that generated by the Grand Coalition framework.

Through the lens of the Nexus of Bilateral Agreements framework, a small number of countries have received a less-than-reciprocal treatment from their trading partners, while the majority of the WTO members have received net ToT concessions compared to the bilateral trade war counterfactual (Figure 6). The countries with more-than-reciprocal tariff cuts are the United States and Switzerland in the early years of the WTO, while a few other countries—notably, China, Saudi Arabia, and India—join this club in later years. The increase in the net concessions granted by these emerging economies has led to a reduction in the skewness of the distribution of ToT gains (Figure 7).

As shown in the top left panel of Figure 5, the high ratio of concessions granted-to-received by the United States is persistent over time. Similarly, Japan is consistently a net receiver of ToT concessions over time (lower-left panel). However, in the case of China, it is a net receiver of concessions up until the year 2002, while it becomes a persistent net granter of concessions after the year 2008. The numbers for EU, which are positive but more volatile over years, should be taken with a grain of salt, as EU's gradual expansion over this time period makes intertemporal comparison of its BoC difficult.[23]

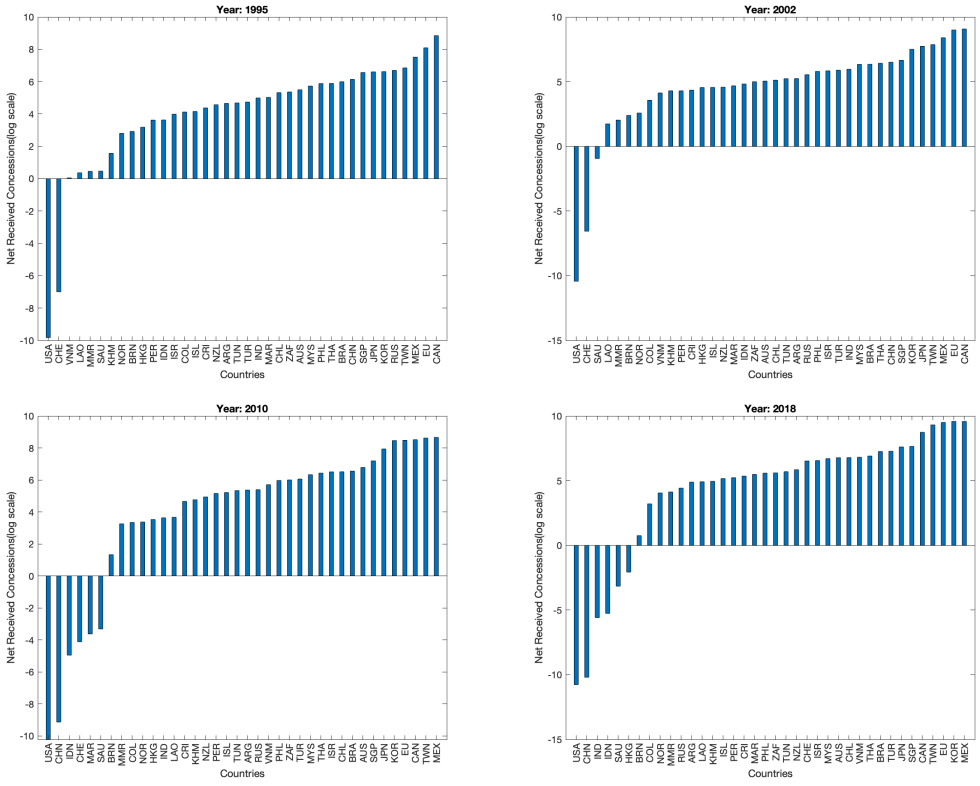
[23]To attain some comparability over time, we group all eventual members of the European Union

Figure 5: WTO as a Nexus of Bilateral Agreements
Log(Received Concessions/Granted Concessions)
Factual (Blue) vs. Balanced-Trade (Red) Scenarios



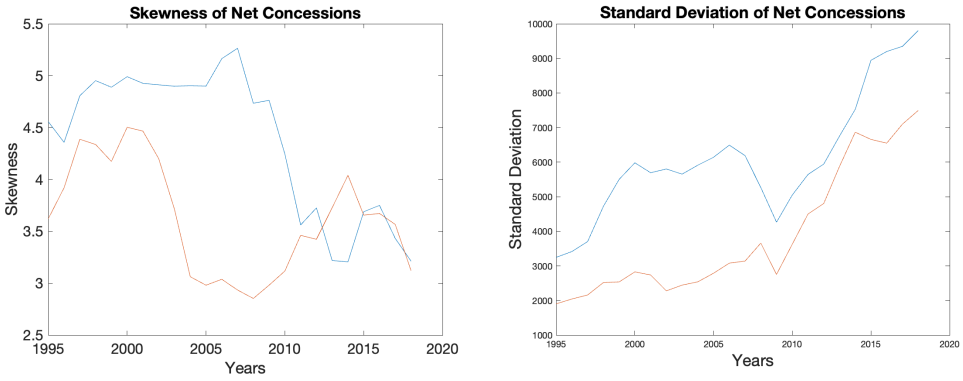
Note: These graphs depict the log-ratio of ToT gains received and granted under the Nexus of Bilateral Agreement framework, for each country across years. The blue and red bars correspond to this measure under the factual and balanced-trade scenarios, respectively. The line graph, measured on the right axis, illustrates the log-ratio of imports and exports for each country across years.

Figure 6: Multilateral Balance of Concessions
Net Received Concessions (Log Scale)



Notes: These graphs depict the net concessions received by each country on a log scale under the Nexus of Bilatearl Agreements framework. For negative values, x<0, the graph depict -log(-x).

Figure 7:
Skewness and Standard Deviation of Net Concessions over Years



Note: These panels depict the skewness (left panel) and standard deviation (right panel) of net granted concessions under the Nexus of Bilateral Agreements framework, across economies in each year. The blue and red lines correspond to the measure under the factual and balanced-trade scenarios, respectively. Concessions are in millions of US dollars.

6.2 Bilateral Concessions

We have generated a dataset of bilateral concessions covering 38 countries over 24 years, which may be used to investigate the evolution of concessions at a bilateral level. To showcase potential uses of this dataset, we present two sets of observations.

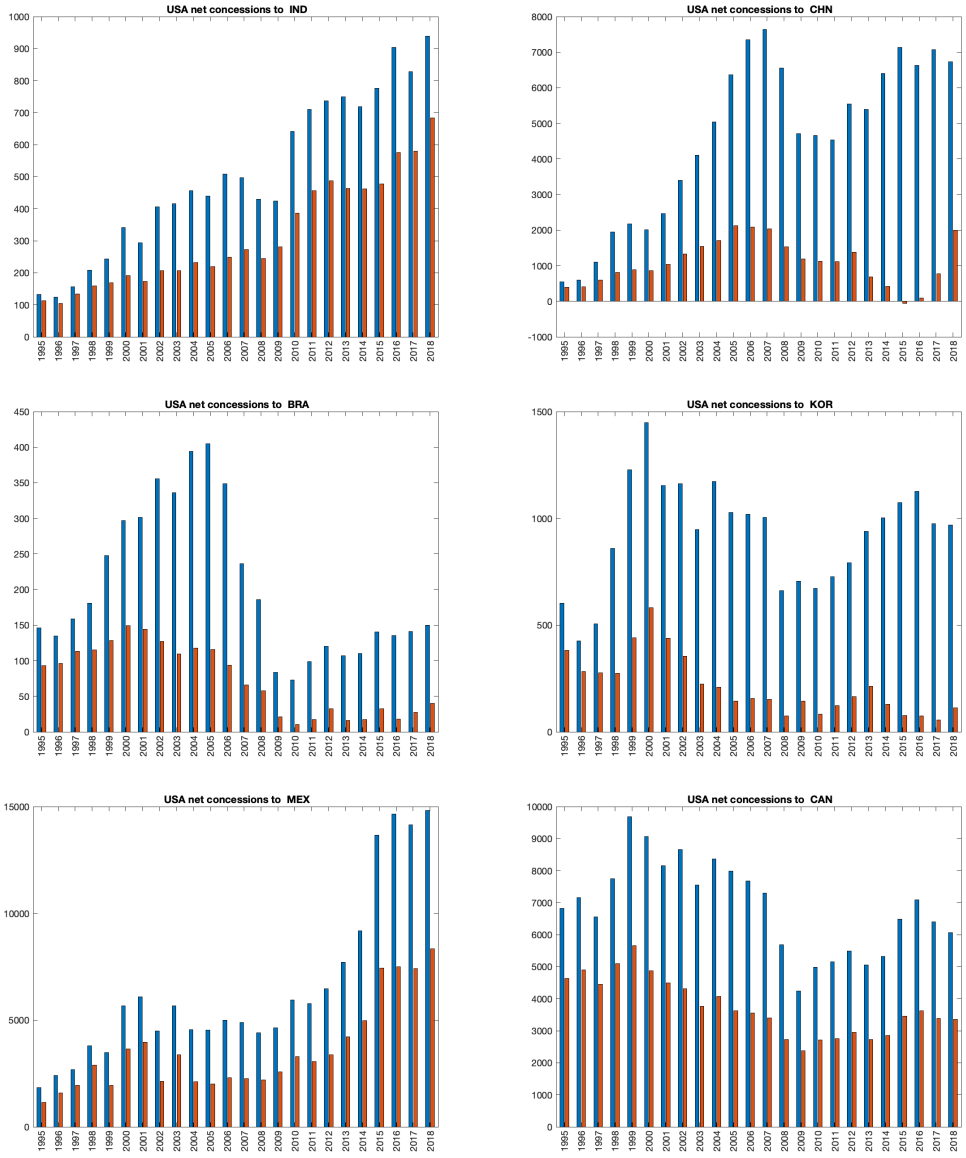
First, we demonstrate the bilateral concessions granted and received by key WTO members in year 2018 (Figure A.3). It reveals that in its bilateral relationships, the United States is a net granter of concessions to all other countries except Saudi Arabia. Moreover, EU is a net receiver of ToT concessions in many of its bilateral relationships, including with the USA, China, Mexico, Australia, and Saudi Arabia. China is a net receiver of concessions from the US, India, Mexico,Turkey, and Colombia in the same year.

Second, we depict the evolution of United States' bilateral concessions under the WTO (Figure 8), which reveals varying patterns with respect to different trading partners. Countries like India and Mexico have seen a steady increase in net concessions from the United States. Similarly, China and Korea have consistently received substantial net concessions from the US, although this upward trend was briefly interrupted following the Great Recession. In contrast, the US net concessions to Brazil, which began to decline in 2006, experienced a sharp drop after the Great Recession and have struggled to recover since.

Figure 8 also shows the effect of trade imbalances on bilateral concessions of the United

into one region (EU) for the entire period of study. The results for the EU are qualitatively similar if in each year we only include EU members of that particular year.

Figure 8: United States' Net Bilateral Concessions



Note: These graphs depict the US' net concessions granted under the Nexus of Bilateral Agreement framework, to each trading partner across years. The blue and red bars correspond to this measure under the factual and balanced-trade scenarios, respectively. Concessions are in millions of US dollars.

States, which we discuss in the next subsection.

6.3 Trade Imbalances and ToT Concessions

In Section 5, 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.[24]

Figure 5 compares the level of net concessions received under the factual scenario (blue bars) and the balanced trade scenario (red bars) for selected countries. For the US and EU, the trade agreements tend to be farther from reciprocity, the larger is trade imbalances. Notably, purging trade deficits from the data, reduces the log-difference between granted and received concessions for the United States by 40-50%, thereby making the trade agreements more reciprocal for the United States. Purging trade imbalances from the data has a similar effect on the BoC for EU: In years when EU runs a larger trade surplus, it has a more substantial deviation from reciprocity.

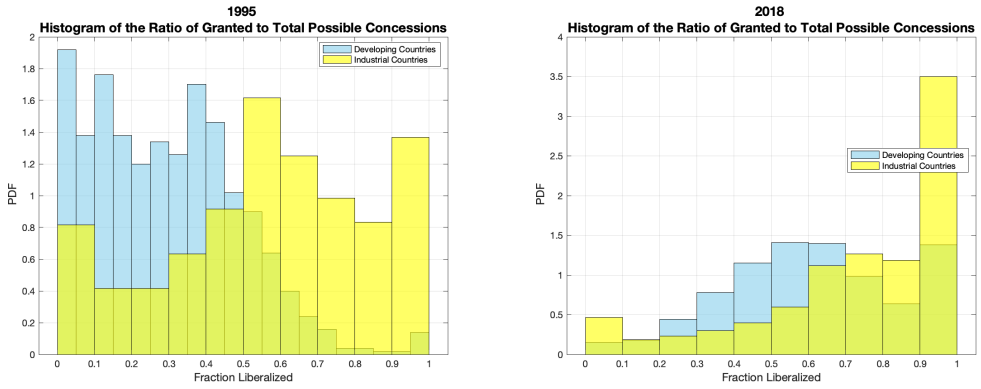
Despite China's massive trade surplus, the substantial tariff cuts that it implemented shortly after joining the WTO led to China offering more concessions to other countries than it received. As a result, eliminating trade imbalances further increases the multilateral imbalance of concessions for China. In other words, the tariff reductions implemented by China after its WTO accession were significant enough to constitute net concessions to the other members, even as it maintains a large trade surplus.

Our analysis, therefore, shows that both the United States and China extend net concessions to their trade partners. In this bilateral relationships, however, the United States has given more ToT concessions to China than it has received in return. This disparity in bilateral concessions, as illustrated in the top-right panel of Figure 8, is largely attributable to trade imbalances. Specifically, in a hypothetical balanced-trade scenario, the relationship between China and the US steadily approaches reciprocity from 2005 to 2016, after which the net concessions of the US to China starts to rebound. Similarly, without trade imbalances, the net concessions that South Korea receives from the US decline steadily from 2000 onward, reaching near reciprocity in 2017.

Japan has consistently been a net receiver of concessions between 1995 and 2018. Under a balanced-trade counterfactual scenario, Japan would have been a net granter of concessions until 2004. This suggests that while Japan's tariff cuts were significant, its effective net concessions to the rest of the world were negative due to its substantial trade surplus during those years. After 2004, Japan remained a considerable net receiver of concessions

[24] 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.

Figure 9: Degree of Liberalization — Developing vs. Industrialized Countries



Note: Distribution of ToT concessions granted as a proportion of the total possible ToT concessions, by countries of different development status (1995 vs. 2018).

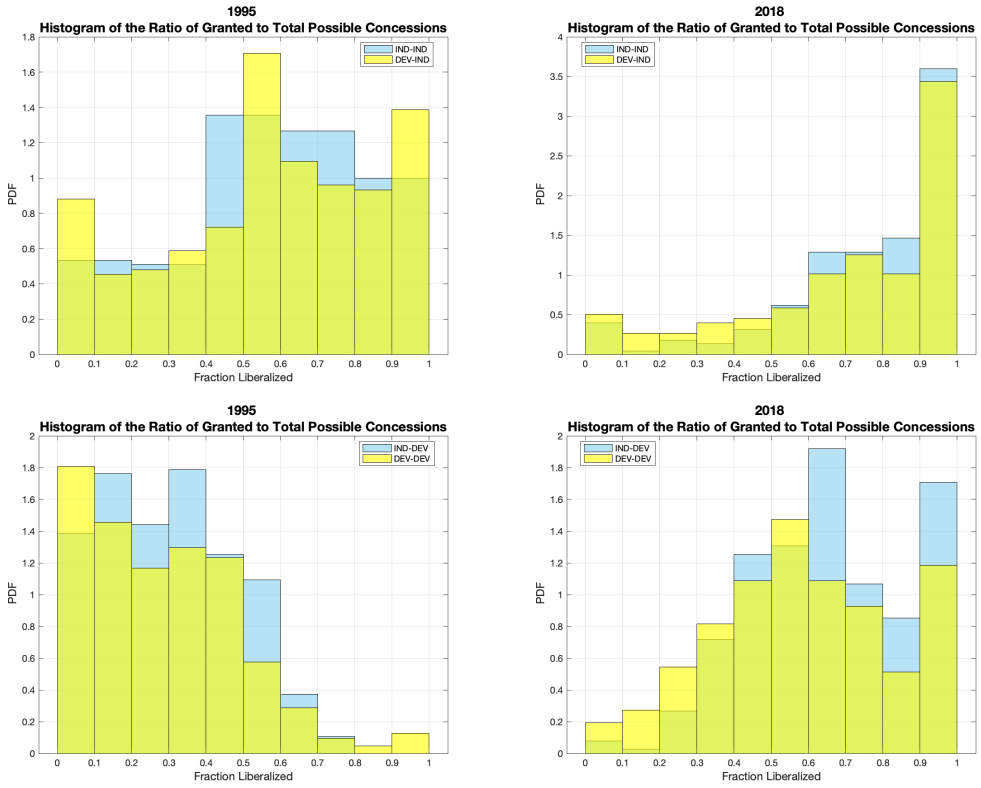
even under balanced trade. This shift can be attributed to two factors: the significant reduction of Japan's trade surplus over time, eventually turning into a deficit for several years after 2010, and the substantial terms-of-trade gains Japan experienced following China's accession to the WTO.

6.4 Development Status and the Level of Concessions

Under the GATT/WTO agreement, developing nations benefit from "Special and Differential Treatments," granting them the leeway to undertake less-than-reciprocal tariff reductions in comparison with developed countries. This arrangement also permits developed countries to provide more advantageous tariff cuts to developing nations without being obligated to apply these same concessions to other developed countries. Furthermore, the GATT/WTO's principle of non-discrimination ensures that any tariff reductions agreed upon among developed countries are automatically applicable to the developing nations within the WTO. It is, therefore, expected that developing countries have adopted tariff reduction measures that are less reciprocal in nature.

Despite apparent advantages that the WTO rules afford the developing nations, early critics of the GATT/WTO argued that the trading system was primarily developed through negotiations among industrial countries, with developing members of the WTO often sidelined in discussions on tariff reductions. Even though the non-discrimination principle of the GATT/WTO meant that developing countries could benefit from the tariff cuts negotiated by industrial nations, tariffs in their primary export sectors, such as agriculture and labor-intensive manufacturing goods like textiles, remained high (IMF and World Bank, 2001). This viewpoint suggests that trade liberalization has mainly favored exporters from

Figure 10: Degree of Liberalization
By Development Status of Country Pairs



Note: Distribution of ToT concessions granted as a proportion of the total possible ToT concessions. The graphs on the first (second) row compares the distributions of industrial (developing) countries' concessions to exporting countreis of different development status.

industrial countries because these countries avoided negotiating tariff reductions in sectors that were important to exporters from developing countries.

In this section, we evaluate the above arguments regarding the pattern of concessions exchanged by developing and industrial countries in the WTO. In particular, we evaluate whether the level of bilateral exchange of concessions differs systematically across the development status of bilateral country pairs, and whether any asymmetry pattern identified changes over the years.

To this end, we construct an index that shows concessions granted as a fraction of total

possible concessions to a trading partner, namely:

$$FractionLiberalized_{ij} \equiv \frac{Concession_{ij}}{PossibleConcession_{ij}}, \tag{23}$$

where, $Concession_{ij}$ and $PossibleConcession_{ij}$ denote the amount of concession that country j could potentially offer to country i by reducing its bilateral tariffs from the unilaterally optimal level to the current tariffs and zero, respectively. $PossibleConcession_{ij} - Concession_{ij}$ may be interpreted as the concession withheld by country j in its bilateral relationship with i. The variable $FractionLiberalized_{ij}$ provides an index of the degree to which country j has conceded 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 fixed-effects and pertinent trade flow determinants:

$$\begin{aligned} &FractionLiberalized_{ij} = \\ &\beta_1 * IND_IND_{ij} + \beta_2 * DEV_IND_{ij} + \beta_3 * IND_DEV_{ij} + \beta_4 * DEV_DEV_{ij} \\ &+\boldsymbol{\gamma}' Z_{ij} + FE_i + FE_j + \epsilon_{ij}, \end{aligned} \tag{24}$$

where Z_{ij} denotes a list of trade cost proxies.[25] 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. For example, IND_DEV_{ij} equals one if the exporter is an industrial country and the importer is a developing country. Based on the World Bank classification of high-income countries, the list of industrial economies includes Australia, Canada, Iceland, Israel, Japan, Korea, New Zealand, Norway, USA, Brunei, Hong Kong, Singapore, Taiwan, and Switzerland. Note that all industrial economies in the sample are members and joined the GATT/WTO before 1995 (except Taiwan, which joined the WTO in 2002). On the other hand, all individual developing economies in the sample became members by the end of the sample period.

Table 3 reports the results of a Tobit estimation of equation (24) for every four years during the period of study from 1995 to 2018. The estimates show that compared to developing countries, industrial countries have granted a larger fraction of their maximum possible ToT concessions.[26] This is also evident in Figure 9, which contains histograms de-

[25] Trade cost proxies include an indicator on whether the exporting and importing countries have a free trade agreement, bilateral trade distance (in log), whether the exporting country is a colonizer of the importing country, whether the importing country is a colonizer of the exporting country, whether the exporting and importing countries share a common colonizer post 1945, a common border, a common official language, and a common religion, respectively. The EU is excluded in this set of analysis because Z_{ij} is unavailable when i, j involves a group of economies.

[26] In most years, the estimated coefficients for IND_IND and DEV_IND are significantly larger than that for IND_DEV and DEV_DEV, respectively.

Table 3: Fraction Liberalized by the Development Status – Tobit Regression

Year	1995	1998	2002	2006	2010	2014	2018
IND_IND	0.745***	0.522***	0.652***	0.638***	0.834***	1.029***	1.078***
	(0.0778)	(0.0891)	(0.0884)	(0.103)	(0.108)	(0.100)	(0.102)
DEV_IND	0.700***	0.471***	0.631***	0.682***	0.862***	0.997***	1.021***
	(0.0695)	(0.0828)	(0.0845)	(0.0937)	(0.102)	(0.0984)	(0.0980)
IND_DEV	0.476***	0.0969	0.275***	0.266***	0.602***	0.767***	0.780***
	(0.0704)	(0.0809)	(0.0804)	(0.0937)	(0.0982)	(0.100)	(0.0976)
DEV_DEV	0.417***	0.0237	0.248***	0.303***	0.632***	0.753***	0.699***
	(0.0663)	(0.0793)	(0.0798)	(0.0904)	(0.0943)	(0.0989)	(0.0965)
Exporter FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Importer FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Trade Cost Variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1328	1327	1328	1328	1326	1327	1328
F statistic	334.9	313.3	390.6	446.5	399.8	556.3	567.0
p-value for model test	0	0	0	0	0	0	0
IND_IND = DEV_IND	0.24	0.24	0.61	0.26	0.53	0.47	0.19
IND_DEV = DEV_DEV	0.08	0.06	0.50	0.30	0.46	0.74	0.05
IND_IND = IND_DEV	0.00	0.00	0.00	0.00	0.00	0.00	0.00
DEV_IND = DEV_DEV	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Notes: This table presents the results of a Tobit regression analysis of the fraction liberalized, as defined in equation (**??**), on the development status of the exporting and importing economies. For example, IND_DEV = 1 if the exporting and importing economies are industrialized and developing economies, respectively. In addition, the regression controls for the exporter and the importer fixed effects (FEs) and trade cost proxies. The last four rows report the p-value for the hypothesis tests of whether the coefficients of interest are identical. Robust standard errors are reported in parentheses under the estimates. The asterisks ***/**/* denote $p < 0.01$, $p < 0.05$, $p < 0.1$, respectively.

picting the distribution of the extent of liberalization by developing and industrial countries. For both types of countries, the extent of liberalization has increased over time from 1995 to 2018, while their corresponding distributions tend to merge as time passes.

Although industrial countries initiated market liberalization earlier and more aggressively, we find no substantial evidence to suggest a systematic bias in WTO concessions based on the development status of the exporting countries.[27] As shown in the lower panel of Table 3, there are no significant differences between the coefficients of IND_IND and DEV_IND, implying that bilateral concessions (as a fraction of total possible bilateral con-

[27]It is important to clarify that this does not imply that the applied tariffs against developing and industrial countries are similar. Rather, it indicates that the ToT gains granted to exporting countries—as a proportion of the total possible ToT gains—are comparable, regardless of the development status of the exporting countries.

cessions) given by industrial countries are not influenced by the development status of the receiving countries. Similarly, for most years during 1995 and 2018, we find no significant differences between the coefficients of IND_DEV and DEV_DEV. Figure 10 depicts these results graphically by comparing related histograms for 1995 and 2018.

7 Concluding Remarks

To methodologically advance the study of international trade agreements, this paper develops an approach that facilitates a detailed examination of both bilateral and multilateral relationships among WTO members through the lens of the terms-of-trade theory. Our quantitative model generates a dataset of bilateral and multilateral exchange of ToT concessions that may be used to explore a wide array of questions related to the exchange of concessions under trade agreements, including the effect of balance of concessions on trade disputes, the resilience of trade agreements, and geopolitical interactions.

Our main quantitative findings may be summarized as follows. There is a significant variation in net terms-of-trade gains across countries, with the United States standing out as the country with the largest net contributions to the system, and a net granter in almost all of its bilateral relationships throughout the years. After its accession to the WTO in 2002, China emerges as a large net contributor to the system, experiencing notable terms-of-trade losses (compared to a scenario with reciprocal tariff cuts) in most of its bilateral relationships. Trade imbalances prove to be a significant factor in the balance of concessions. Specifically, eliminating trade imbalances worldwide reduces the log-difference between granted and received concessions for the United States by 40-50%, thereby rendering the trade agreements more reciprocal for the United States. Finally, we confirm that industrial countries have extended a larger portion of their total potential market access to the rest of the world. However, we do not find evidence that industrial countries, compared to developing countries, have secured a disproportionately larger share of market access in their export destination.

Finally, we recognize that tariff cuts may be linked to concessions in other trade-related areas such as intellectual property right protection, product standards, labor laws, etc, or broader geopolitical cooperations such as security alliances. Our framework may be extended to study the linkage among various international agreements and the use of behind-the-border measures that could nullify or impair the benefits from tariff cuts. Linking tariff cut negotiations to these other aspects of international relations remains an open field of research.

Our framework, combined with the data on bilateral concessions we generate, offers a versatile tool for analyzing various trade policy questions. For instance, it allows for evaluating the effects of preferential trade agreements on bilateral and multilateral balances of concessions among WTO members (Limão 2006). Additionally, our framework can assess

the impact of China's WTO accession on these balances, exploring whether the agreement would have been more balanced without China's inclusion (Bown 2010). This includes scenarios where China, as a non-WTO member, initiates bilateral free trade agreements with individual WTO members. Furthermore, our framework is useful for examining the consequences of WTO accession for major oil-exporting countries, which typically do not benefit significantly from terms of trade improvements on their primary exports (Selivanova 2007).

Another promising avenue for future research, which can benefit from our quantitative framework, is the interplay between reciprocity and geopolitical interactions. For instance, a potential strategy employed by large countries may involve offering net concessions to a partner nation, aiming to draw them into its sphere of influence. On the flip side, a persistent imbalance in concessions can backfire, leading to political tensions, trade disputes, or even renegotiation of existing trade agreements. Such analyses could utilize the dataset that is generated by our quantitative framework.

By providing a measure of concessions, our framework serves as a starting point for discussing the resilience of trade agreements. An imbalanced agreement can be destabilizing, as recent complaints from major WTO members about a lack of reciprocity illustrate. Notably, the WTO's dispute settlement process, which is arguably designed to manage "trade skirmishes" under a relatively balanced agreement (Beshkar 2010a,b), may face increasing pressure if the system's deviation from reciprocity is large and persistent.

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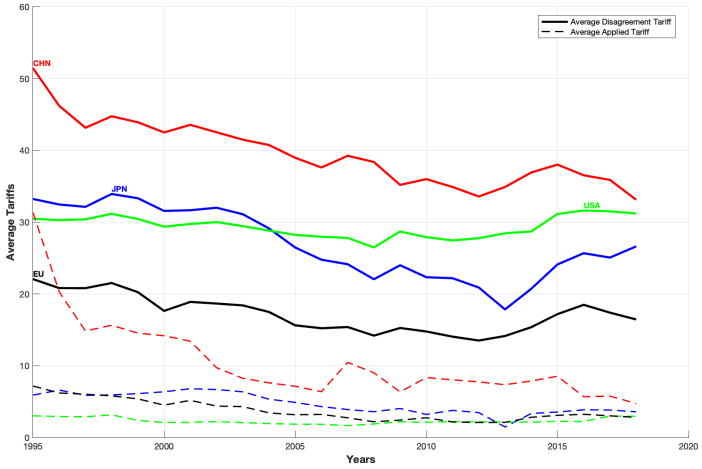
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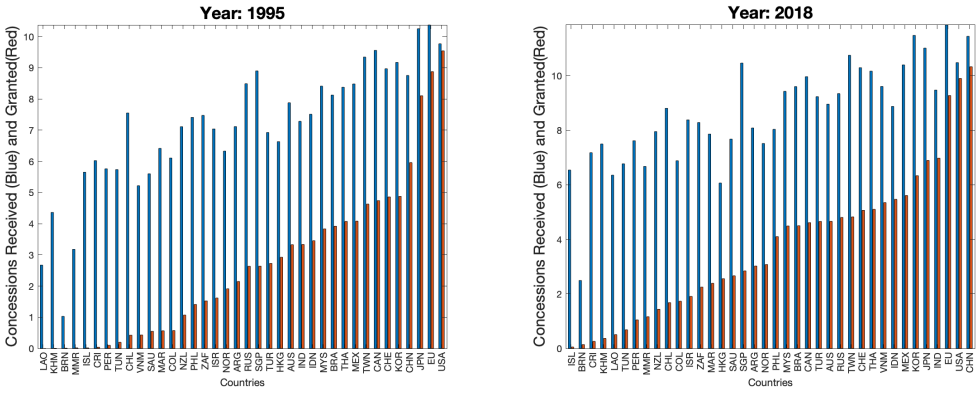
Appendix: Additional Figures and Tables

Figure A.1:
Trade-Weighted Average Disagreement and Applied Tariffs for Selected Countries



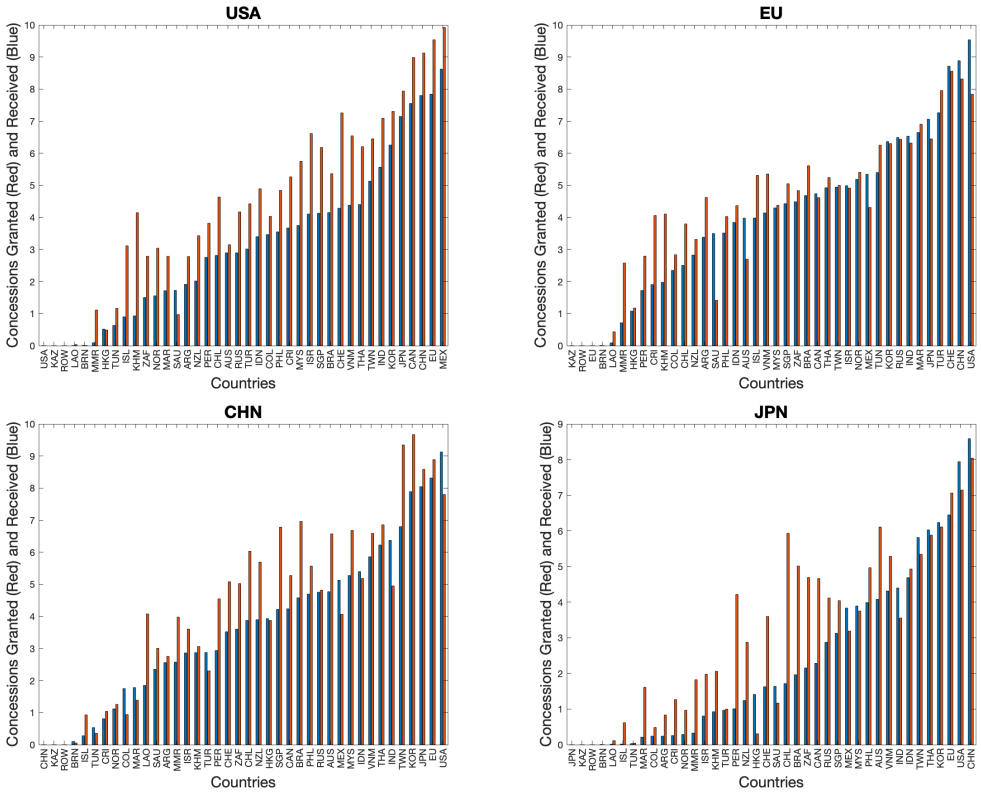
Note: This figure illustrates trade-weighted average of disagreement and applied tariffs (in percentage points), using current-year trade flows as weights. Disagreement and applied tariffs are depicted by solid and dashed lines, respectively. Comparison with Figure 3 suggests that the weighted-average disagreement tariffs shown in this graph exhibit a downward trend, primarily due to changes in the composition of trade flows rather than changes in the computed disagreement tariffs.

Figure A.2: WTO as a Grand Coalition
ToT Gains Received (blue) and Granted (red) by each Member



Note: The red (blue) bars represent the ToT gains granted (received) by each member to (from) the Grand Coalition. The values shown in the graph are $\log(1+x)$.

Figure A.3: Bilateral Concessions in 2018
Selected Countries vs. Other Members



Note: Each panel shows the bilateral concession granted (red) and received (blue) by one country (USA, EU, Japan, and China) in year 2018 under the Nexus of Bilateral Agreements framework. In each panel, countries are ranked according to the amount of concessions they received from the concerned country. The values shown in the graph are $\log(1+x)$.

Table A.1: 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 A.2: 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†
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†
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†
16	D26	26	Computer, electronic and optical equipment	1.72†
17	D27	27	Electrical equipment	1.72†
18	D28	28	Machinery and equipment, nec	0.44
19	D29	29	Motor vehicles, trailers and semi-trailers	1.72†
20	D30	30	Other transport equipment	1.93
21	D31T33	31-33	Manufacturing nec; repair and installation of machinery and equipment	1.72†
22	D35	35	Electricity, gas, steam and air conditioning supply	10.00‡

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.