The Balance of Concessions in Trade Agreements[*]

Mostafa Beshkar[†] Pao-Li Chang[‡] Shenxi Song[§]

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Abstract

We develop a quantitative framework to analyze the WTO's reciprocity principle. Using a consistent measure of bilateral reciprocity in a multilateral setting, we show that trade-balance shocks change the balance of concessions, causing deficit countries to grant larger terms-of-trade concessions than intended under the negotiated agreement. Applying the framework to WTO members reveals substantial cross-country deviations, with the United States emerging as the largest net granter of concessions. The rise in global trade imbalances since the early 1990s has magnified these deviations, accounting for nearly 55 percent of U.S. net concessions in 2018.

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[†]Associate Professor, Department of Economics, Indiana University, Bloomington. Email: mbeshkar@iu.edu.

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

[§]Strategy Analyst, TikTok Pte. Ltd., 1 Raffles Quay, Singapore 048583. Email: shenxi.song@bytedance.com.

1 Introduction

Reciprocity is a fundamental principle in international trade agreements, particularly within the WTO, where negotiations are expected to yield a balanced exchange of market access concessions. This principle is widely recognized for enhancing the resilience and self-enforcing nature of trade agreements while providing a mechanism to induce broader participation in market liberalization. However, whether trade agreements truly adhere to this principle remains an open question, as no established quantitative methodology exists to measure reciprocity in a multilateral setting.

To study the issue of reciprocity in trade agreements, we develop a theoretical framework that generalizes the notion of reciprocity to a multilateral setting and introduces a quantitative metric for the balance of concessions exchanged under WTO agreements. This framework enables us to trace how reciprocity evolves over time as underlying economic fundamentals—such as trade imbalances and relative country size—shift.

A central premise of our study is that shifts in economic fundamentals can alter the balance of concessions embedded in existing trade agreements. Since the entry into force of major agreements such as the WTO and NAFTA, the world economy has experienced a persistent rise in trade imbalances and rapid economic growth in many developing countries. Because the WTO lacks a mechanism to accommodate such changes, it is plausible that these developments have gradually shifted the balance of concessions—a conjecture we examine both theoretically and empirically in this paper.

We work within a standard international trade framework in which unilateral tariff choices create inefficiencies because of their impact on other countries' relative export prices—i.e., *the terms of trade*. In particular, tariffs shift welfare by reducing factor rewards in the exporting countries, creating what is known as a "terms-of-trade externality." In a two-country model, Bagwell and Staiger (1999) show that a reciprocity rule—requiring that mutual tariff cuts lead to equal changes in each country's imports and exports at fixed prices—keeps the terms of trade constant and, thus, neutralizes this externality. This definition of reciprocity is consistent with the language and practice of the GATT/WTO, which emphasizes reciprocal improvements in market access.[1]

[1] In section 2.1, we provide the institutional and theoretical foundations for using the terms-of-

Building on Bagwell and Staiger (1999), we extend the concept of reciprocity to a multi-country setting. We define a set of bilateral tariff cuts as reciprocal if they generate equal changes in each country's multilateral terms-of-trade gains—or, equivalently, equal changes in net imports when measured at fixed prices. In contrast to the two-country case, where one country's gain is necessarily the other's loss, bilateral tariff cuts in a multi-country world can raise the joint terms-of-trade gains of both partners by diverting trade away from third countries. In a multilateral setting, we define a country's net bilateral concession to a partner as the gap between the partner's terms-of-trade gain and the average gain of the two countries resulting from bilateral tariff cuts.

Trade Imbalances A key insight from our analysis is that changes in trade imbalances systematically alter the balance of concessions under existing trade agreements. An increase in the trade deficit can be interpreted as an exogenous shock that expands the country's expenditure relative to that of the rest of the world. As the trade deficit widens, the country's tariff exerts greater influence on the world prices relative to its trading partner's tariff. Consequently, when agreement tariffs remain fixed, a rise in the trade deficit shifts the balance of concessions in favor of the surplus country.

The evolution of the U.S. trade balance since the early 1990s provides an empirical counterpart to this theoretical result. As noted by Kehoe, Ruhl, and Steinberg (2018), the United States maintained a roughly balanced trade position in the early 1990s and did not anticipate the emergence of a large and persistent deficit. It is therefore likely that U.S. negotiators in the Uruguay Round—conducted at that time—structured tariff cuts under the assumption that trade balances would remain relatively stable. Our analysis indicates that the subsequent and sustained rise in U.S. trade deficits altered the balance of concessions embedded in these agreements, reducing the terms-of-trade gains the United States derives from them.

The impact of trade-balance shocks is particularly relevant because any deviation from tariff reciprocity at the time an agreement entered into force likely reflected deliberate considerations—such as concessions in other policy areas or geopolitical factors. By contrast, the deviations induced by later trade-balance shocks were unanticipated and not incorporated into the original agreements, yet they can substantially alter the distribution of gains from trade liberalization and

trade externality as the basis for measuring tariff concessions.

undermine the stability of the agreements.[2]

Noncooperative Benchmark A key component of our analysis is the choice of a noncooperative benchmark against which tariff concessions are measured. We define this benchmark as the outcome that would arise if countries acted independently and set their best-response tariffs in bilateral trade wars. This approach reflects the sovereign right of WTO members to determine their trade policies and is consistent with the institutional framework of the GATT, which recognizes that low tariff bindings are themselves valuable concessions and allows members to revise or withdraw concessions unilaterally when negotiations fail. Alternative benchmarks—such as free trade or pre-agreement tariffs—are less suitable because they do not necessarily reflect reciprocal starting points.[3]

Quantitative Findings at a Glance We quantify the balance of concessions implied by the applied tariffs under the WTO using a multi-country, multi-sector trade model that allows for exogenous trade imbalances. For each pair of countries, we compute net bilateral concessions as deviations from equal terms-of-trade gains due to tariff cuts from noncooperative to applied tariffs.

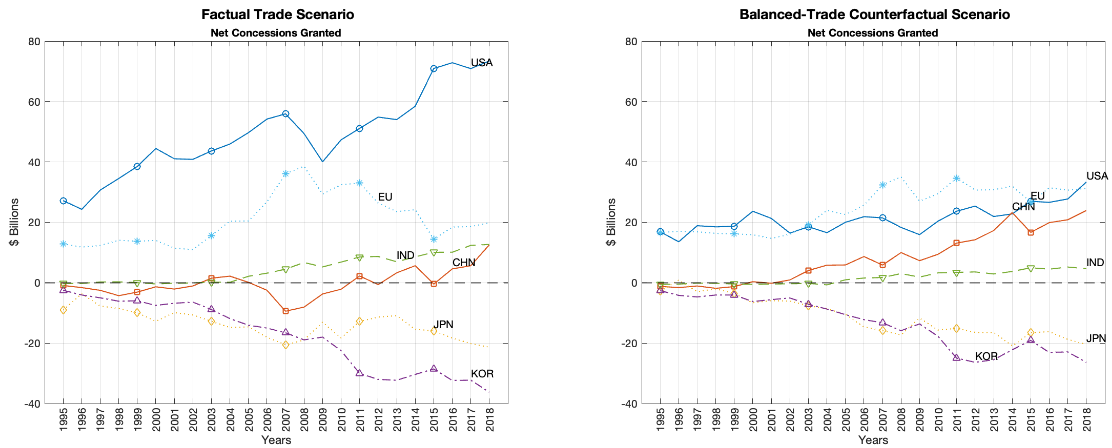
The analysis covers 38 economies from 1995 to 2018 and reveals large and persistent asymmetries in the distribution of concessions (Figure 1). The United States consistently emerges as the largest net granter of concessions, with net transfers to the rest of the world rising from about \$24 billion in 1996 to over \$73 billion in 2018—a magnitude exceeding the United States' total foreign-aid spending of roughly \$47 billion in that year. In contrast, countries such as South Korea and Japan are among the largest net recipients. These magnitudes are moderated by the introduction of the service sector and input-output linkages but the qualitative patterns remain the same.

To assess the quantitative importance of trade imbalances for reciprocity, we compare the observed balance of concessions under current trade patterns to a

[2]Existing WTO flexibility measures—such as safeguards, anti-dumping duties, and countervailing duties—do not address these trade-imbalance-driven departures from reciprocity. These instruments are designed and used to respond to sector-specific disturbances—such as import surges or injury from dumping or subsidies (see, e.g., Bown and Crowley (2013))—and are permitted only under those conditions. Because trade-balance shocks are economy-wide and fall outside these criteria, current temporary trade barriers cannot mitigate the aggregate reciprocity shifts generated by persistent trade imbalances.

[3]We discuss the justification for this benchmark in greater detail in Section 2.2.

Figure 1: Net Multilateral Terms-of-Trade Concessions Granted by Selected Countries (1995-2018)



Left panel: Factual trade scenario. **Right panel:** Balanced-trade counterfactual scenario. The analysis is based on the baseline model.

counterfactual scenario in which all countries have balanced trade. The results reveal striking asymmetries: eliminating global trade imbalances reduces the United States' net multilateral concessions by nearly 55 percent, while reversing China's position from near-zero or negative values to positive net concessions. These magnitudes indicate that the persistent trade imbalances that have emerged since the early 1990s—when the WTO agreements were concluded—have substantially altered the distribution of concessions among members.

These findings confirm the central implication of our theoretical framework: trade imbalances systematically undermine the intended balance of concessions under the agreement, resulting in deficit countries granting larger net concessions than originally envisaged. By showing that the scale of terms-of-trade concessions is shaped by trade imbalances quantitatively, our analysis points to a mechanism through which persistent external deficits can fuel protectionist pressures and weaken support for multilateral cooperation.[4]

Finally, while tariff concessions are often linked—formally or informally—to

[4] This observation aligns with evidence from Delpeuch, Fize, and Martin (2021), who show that trade imbalances are a strong predictor of protectionist pressures. Moreover, it reinforces the broader argument that, as trade patterns and countries' relative economic sizes evolve, trade agreements require built-in flexibility—through recurring WTO negotiations or other mechanisms—that allow members to adjust tariff obligations in response to persistent shifts in economic fundamentals, thereby preserving reciprocity and enhancing the resilience of the trading system (Jakubik, Keck, and Piermartini, 2023; Pauwelyn, 2025).

areas such as intellectual property, security cooperation, and regulatory policy, our quantitative analysis focuses exclusively on tariff commitments and should therefore be interpreted within this specific scope. That said, even if tariff commitments were originally designed to reflect a broader cross-issue bargain, the finding that the balance of concessions in tariff space has shifted substantially due to changes in economic fundamentals likely indicates a broader shift in the overall balance of concessions as well. We return to this point in Section 2.3.

The remainder of the paper is organized as follows. Section 2 discusses the theoretical and institutional basis for our measure of reciprocity. Section 3 presents our theoretical findings, and Section 4 describes the quantitative trade model used to simulate counterfactual scenarios. Section 5 reports the quantitative results and analyzes the anatomy of tariff concessions. Section 6 concludes with final remarks and caveats.

2 Theoretical and Institutional Basis for Reciprocity

We take the view that sovereign states assert the right to determine their trade policies independently, and they voluntarily give up this right when others agree to do the same, echoing Hobbes's (1651) notion of reciprocity as the mutual transfer of rights for mutual benefit. This understanding aligns with the language and practice of the GATT/WTO, which emphasizes reciprocal improvements in market access as the foundation of negotiated liberalization.[5]

Although some critics (see Trebilcock and Trachtman, p. 7) have dismissed GATT's focus on reciprocity as "economically illiterate mercantilism," Bagwell and Staiger's (1999; 2004) analysis highlights that reciprocity plays an essential role by preventing governments from manipulating their terms of trade at the expense of trading partners.[6] Building on this insight, we define reciprocity as the condition that neutralizes the terms-of-trade externality created by unilateral tariff choices and serves as the conceptual foundation for our measure of concessions.

[5] Moreover, the so-called withdrawal clause of the GATT (Article XXXI) establishes the right for any contracting party to withdraw from the agreement.

[6] The subsequent literature, including Mrázová (2023), Cole et al. (2021), DeRemer (2016), Bagwell and Staiger (2012), Ossa (2011), Blanchard (2010), and Zissimos (2009), 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.

In this section, we first discuss the rationale for using changes in the terms-of-trade gains as the appropriate measure of concessions. We then justify our use of bilateral trade wars as the noncooperative benchmark for evaluating those concessions. Finally, we explain why our analysis focuses on tariff-cut concessions, while recognizing that in practice such concessions may also be linked to other trade or non-trade policy instruments.

2.1 Terms-of-Trade Change as Measure of Concessions

Our measure of concessions in trade agreement is based on the terms-of-trade effects of tariff cuts. In standard trade models, unilateral tariff choices create inefficiencies because of their impact on other countries' relative export prices—i.e., *the terms of trade*. In particular, tariffs shift welfare toward importing countries by reducing factor rewards in the exporting countries, creating what is known as a "terms-of-trade externality."

In a two-country model, Bagwell and Staiger (1999) show that this externality is the sole inefficiency in unilateral trade policy that may be corrected by a trade agreement. They further show that a reciprocity rule—requiring that mutual tariff cuts lead to equal changes in each country's imports and exports at fixed prices—keeps the terms of trade constant. Therefore, trade agreements that require reciprocal tariff cuts may be understood as a device to neutralize this externality.

We extend Bagwell and Staiger (1999)'s notion of reciprocity, which is defined in a two-country setting, to a multi-country setting. We define a set of bilateral tariff cuts as reciprocal if they generate equal changes in each country's multilateral terms-of-trade gains. The terms-of-trade effects are equivalent to changes in net imports when measured at fixed prices. In contrast to the two-country case, where one country's gain is necessarily the other's loss, bilateral tariff cuts in a multi-country world can raise the joint terms-of-trade gains of both partners by diverting trade away from third countries. In a multilateral setting, we define a country's net bilateral concession to a partner as the gap between the partner's terms-of-trade gain and the average gain of the two countries.

One might argue that a more natural metric would be the impact of tariff changes on real consumption or aggregate welfare. However, using welfare as a benchmark poses important conceptual and empirical 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, from a welfare perspective, a significant portion of tariff cuts would be unilaterally optimal and cannot be interpreted as concessions to trading partners.

The tendency for noncooperative tariffs to exceed the levels that maximize real consumption likely reflects political-economy objectives beyond aggregate welfare, such as income distribution and domestic industry protection. Our framework does not explicitly model these considerations but builds on Bagwell and Staiger (1999), who show that mutual tariff reductions that keep the terms of trade constant neutralize the terms-of-trade externality created by unilateral tariff choices, conditional on national governments' political preferences. This result provides a rationale for focusing on the terms-of-trade effects of tariff choices, while allowing for arbitrary political-economy objectives of national governments.

2.2 Noncooperative Benchmark

In the absence of reciprocal commitments, sovereign states set their trade policies unilaterally to maximize their objective function. The natural disagreement outcome between two countries is therefore a bilateral trade war, in which each government sets its tariff as a best response to the other's policy.

Other benchmarks used in the literature include free trade (Anderson and Yotov, 2025), and pre-agreement tariffs (Bown, Caliendo, Parro, Staiger, and Sykes, 2023).[7] Using free trade as a benchmark is useful to evaluate potential concessions that countries have *withheld* from one another, but it does not reveal how much each has granted or received relative to its unilateral trade policy options. Additionally, using pre-agreement tariffs help identify the additional concessions exchanged in the latest round of liberalization, but because those initial tariffs are themselves not necessarily reciprocal, even exchanging equal concessions in the new round may not yield a reciprocal outcome.[8]

[7] Bown et al.'s (2023) main focus is on examining how multilaterally-reciprocal tariff cuts affect labor reallocation between tradable and non-tradable industries in each country. Our focus instead is on measuring the degree of reciprocity in bilateral relationships and the role of multilateral trade imbalances on the evolution of the balance of concessions over time. Methodologically, the key distinction between the two papers lies in the choice of the noncooperative benchmark to evaluate the level of concessions implied by tariff rates applied under the agreement.

[8] For example, the trade-weighted average applied tariffs of the United States and China in 1995 were approximately 4% and 30%, respectively. Measuring concessions exchanged from this benchmark is not sufficient to determine whether current tariffs are reciprocal, since the 1995 tariffs were clearly not reciprocal to begin with.

Our approach is consistent with GATT/WTO rules, which explicitly recognize that low tariff bindings themselves constitute valuable concessions:

> *"The binding against increase of low duties or of duty-free treatment shall, in principle, be recognized as a concession equivalent in value to the reduction of high duties."* (GATT Article XXVIII bis:2(a))

This clause affirms that low tariffs or duty-free bindings are not to be treated as neutral baselines, but rather as valuable concessions in themselves. In this light, the initially low tariffs of some countries—some established even before the formation of the WTO—should be regarded as concessions already granted. Our framework aligns with this interpretation and treats low-duty bindings as active contributions to the balance of concessions.

Moreover, we take bilateral—rather than multilateral—trade wars as the relevant noncooperative benchmark because this better captures how tariff commitments are actually negotiated and enforced under the GATT/WTO system. Although, in principle, the breach of a bilateral obligation could provoke multilateral sanctions—and a multilateral enforcement system may be more efficient than a web of bilateral relationships (Maggi, 1999)—WTO practice relies overwhelmingly on reciprocal retaliation by the directly affected trading partners rather than collective action by the full membership. Indeed, Article XXVIII:3 specifies that only countries with a *"principal supplying interest"* may withdraw substantially equivalent concessions in response to another member's modification of commitments, effectively ruling out broad multilateral retaliation. For this reason, bilateral trade wars, rather than multilateral conflicts, provide the appropriate noncooperative point for our analysis.

Our choice of bilateral trade wars as the noncooperative outcome is also consistent with the logic of Bagwell, Staiger, and Yurukoglu (2020)'s and Bagwell et al. (2021)'s Nash-in-Nash model of trade agreements.[9] However, we remain agnostic about the precise bargaining protocol and focus only on measuring each country's terms-of-trade gains and losses from moving from bilateral noncooperative tariffs

[9] Bagwell et al. (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.

to WTO-implemented tariffs, keeping all other tariffs in the world constant at their applied (cooperative) levels.

2.3 Issue Linkage and Non-Tariff Measures

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.[10] A fuller assessment of the balance of concessions, therefore, would require quantifying the exchange that occurs across these linked policy domains.

The literature on issue linkage has identified several important forms of linkages and developed theoretical frameworks to explain their rationale and design. Hoekman (1989) emphasizes the role of issue linkage when governments cannot find within-issue concessions to reciprocate, while Conconi and Perroni (2002) show that tying multiple issues together may, under certain conditions, destabilize multilateral cooperation.[11] Limão (2005) demonstrates the benefits of linking policies that are strategic complements, and McGinnis (1986) analyzes how linking multiple issues can help parties overcome a prisoner's dilemma.[12]

A growing empirical literature also seeks to quantify trade-related linkages beyond tariffs, particularly those involving non-tariff measures (NTMs). Kinzius, Sandkamp, and Yalcin (2019) provide systematic evidence on the trade effects of NTMs and their role in shaping protection patterns across sectors and countries, while Dhingra, Freeman, and Huang (2023) show that reductions in NTMs account for a substantial share of the welfare gains from deep trade agreements. Hémous et al. (2025) quantify the effects of the TRIPS agreement, and find that potential gains from international cooperation over patent policies are large.

These studies underscore the importance of broadening trade-concession analysis beyond tariffs. Nevertheless, we focus on tariff-based reciprocity to preserve

[10] 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."

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

[12] Maggi (2016) provides a comprehensive review of this literature.

conceptual clarity, recognizing that tariffs constitute a large and clearly defined component of the formal concessions exchanged under trade agreements. Extending the analysis to non-tariff or regulatory measures is a natural and complementary direction for future research.

Finally, while concessions in other areas were surely considered by the architects of trade agreements when designing tariff concessions, it is important to note that concessions in tariff and non-tariff domains are unlikely to evolve in ways that systematically offset one another. In practice, issue areas such as intellectual property, environmental standards, or security cooperation follow their own political and economic dynamics, often moving independently over time. As a result, a substantial *change* in the balance of tariff concessions over time is likely to cause a corresponding shift in the broader balance of concessions.

3 A Theory of Tariff Concessions

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.

3.1 Basic Model

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

$$U_j = \sum_{i=1}^{N} u\left(q_{ij}\right). \tag{1}$$

To allow for trade imbalances, we assume that countries could hold overseas assets. Specifically, we assume that country j owns a fraction α_{ij} of country i's endowment, where $\sum_{j=1}^{N} \alpha_{ij} = 1$ for all i. Moreover, country j draws income from tariffs, t_{ij}, that it imposes on imports from each country i. Therefore, letting p_{ij} denote the price of country i's good at country j's border, country j's disposable income is given by:

$$Y_j \equiv \sum_{i=1}^{N} \alpha_{ij} p_{ii} Q_i + \sum_{i=1}^{N} t_{ij} p_{ij} q_{ij}, \tag{2}$$

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

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:

$$T_i^{\mathcal{D}} \equiv \sum_{\forall l \neq i} \left[\left(p_{il}^{\mathcal{A}} - p_{il}^{\mathcal{D}} \right) q_{il}^{\mathcal{D}} - \left(p_{li}^{\mathcal{A}} - p_{li}^{\mathcal{D}} \right) q_{li}^{\mathcal{D}} \right]. \tag{3}$$

Note that $T_i^{\mathcal{D}}$ is equivalent to the change in the net imports of country i when evaluated at equilibrium prices under $\mathcal{A}$.[13] We first establish that:

[13]To see this, note that:

$$\begin{aligned} T_i^{\mathcal{D}} &\equiv \sum_{\forall l \neq i} \left[\left(p_{il}^{\mathcal{A}} - p_{il}^{\mathcal{D}} \right) q_{il}^{\mathcal{D}} - \left(p_{li}^{\mathcal{A}} - p_{li}^{\mathcal{D}} \right) q_{li}^{\mathcal{D}} \right] = \sum_{\forall l \neq i} \left[p_{il}^{\mathcal{A}} q_{il}^{\mathcal{D}} - p_{il}^{\mathcal{D}} q_{il}^{\mathcal{D}} - p_{li}^{\mathcal{A}} q_{li}^{\mathcal{D}} + p_{li}^{\mathcal{D}} q_{li}^{\mathcal{D}} \right] \\ &= \sum_{\forall l \neq i} \left[p_{il}^{\mathcal{A}} q_{il}^{\mathcal{D}} - p_{il}^{\mathcal{A}} q_{il}^{\mathcal{A}} - p_{li}^{\mathcal{A}} q_{li}^{\mathcal{D}} + p_{li}^{\mathcal{A}} q_{li}^{\mathcal{A}} \right] = \sum_{\forall l \neq i} \left[p_{li}^{\mathcal{A}} \left(q_{li}^{\mathcal{A}} - q_{li}^{\mathcal{D}} \right) - p_{il}^{\mathcal{A}} \left(q_{il}^{\mathcal{A}} - q_{il}^{\mathcal{D}} \right) \right], \end{aligned}$$

which is equivalent to the change in the net imports of country i when evaluated at equilibrium prices under $\mathcal{A}$. Note that in the derivation from the second to the third expression, we have used the condition that: $\sum_{\forall l \neq i} \left[-p_{il}^{\mathcal{D}} q_{il}^{\mathcal{D}} + p_{li}^{\mathcal{D}} q_{li}^{\mathcal{D}} \right] = \sum_{\forall l \neq i} \left[-p_{il}^{\mathcal{A}} q_{il}^{\mathcal{A}} + p_{li}^{\mathcal{A}} q_{li}^{\mathcal{A}} \right]$ for given trade imbalance. In other words, if country i experiences a terms-of-trade gain from tariff cuts (moving from $\mathcal{D}$ to $\mathcal{A}$), this allows it to obtain more imports for a given level of exports.

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. In a two-country setting, they define a set of bilateral tariff cuts as reciprocal if it leaves 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 one of the two countries involved. Therefore, in a multi-country setting, bilateral reciprocity cannot be defined as holding net imports constant.[14]

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, where one country's terms-of-trade gain

[14]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). To focus on nondiscrimination, they adopt a simplified environment in which the home country trades with multiple foreign countries but the foreign countries have no basis for trading among themselves. In the current paper's multi-country setting, all countries are allowed to trade with each other. Our definition of bilateral reciprocity in Definition 1 generalizes the definition of Bagwell and Staiger (1999) and explicitly acknowledges the fact that bilateral tariff cuts in a multi-country world can raise the joint terms-of-trade gains of both partners by diverting trade away from third countries, as established in Proposition 1.

is the other country's loss, 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:

$$NC_{hf} \equiv \frac{1}{2}\left[T_f^{\{\mathcal{D}_{hf},\mathcal{D}_{fh}\}} - T_h^{\{\mathcal{D}_{hf},\mathcal{D}_{fh}\}}\right], \tag{4}$$

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 as multilaterally-reciprocal for a country if the sum of its bilateral net concessions is zero.

3.2 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 have a trade deficit by assuming that it owns its domestic endowment as well as a fraction $\alpha = \sum_{i\neq h}\alpha_{ih}$ of productive assets in the rest of the world. Within this framework, we first establish that:

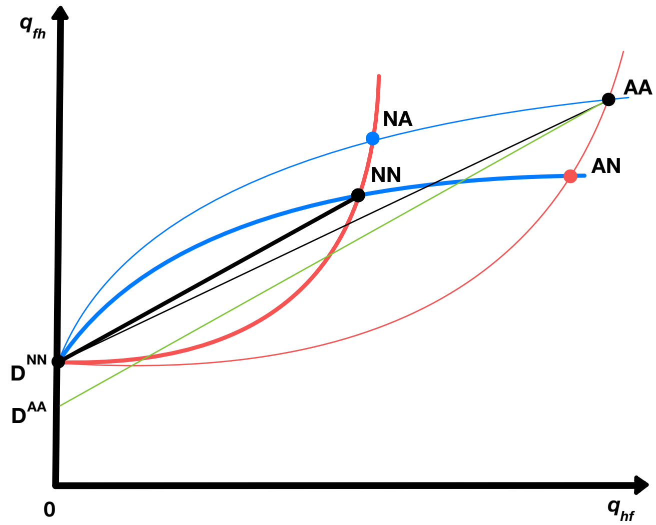
Proposition 2. *For a fixed α, a reciprocal tariff cut between the home country and the rest of the world leaves the terms of trade unchanged.*

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.[15] 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

[15]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

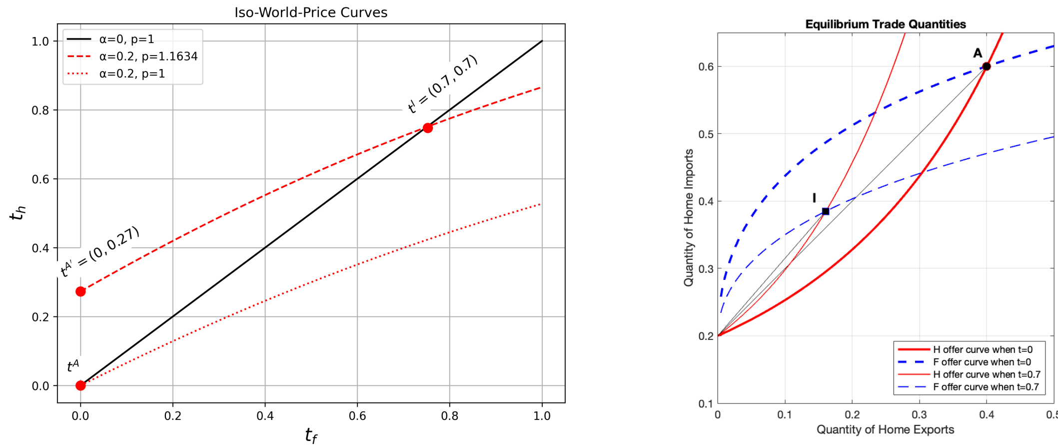


Note: This figure uses trade offer curves—red for the home country and blue for the foreign country—to illustrate the equilibrium trade flows under noncooperative tariffs, NN, and the factual (cooperative) tariffs, AA. These tariff cuts are not reciprocal as they have caused a terms-of-trade loss, equivalent to $D^{AA} - D^{NN}$, for the home 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 terms of trade (ToT). To see this, note that the slope of the line connecting the equilibrium point with $(0, D^{NN})$ 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 cause the home country a ToT loss equivalent to $(p^{AA} - p^{NN})\, q_{hf}^{AA} \equiv D^{AA} - D^{NN} < 0$. 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, $D^{AA} = D^{NN}$.

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 $\sigma = 2$, $\alpha = 0.2$, and $Q_h = Q_f = 1$.

The Impact of Trade-Balance Shocks on Reciprocity A key mechanism we will quantify in the subsequent sections is that a shock to the trade balance can alter the balance of concessions under an existing trade agreement. To gain theoretical insights into this effect, consider the iso-world-price locus under CES preferences:

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

where p is the relative world price of home exports, σ is the CES elasticity of substitution, and α is the share of foreign endowment that is owned by the home country, and τ_h and τ_f are one plus the ad valorem tariff rates levied by the home and foreign countries. The slope of the iso-world-price curve in tariff space can be obtained using the Implicit Function Theorem:

$$\frac{d\tau_h}{d\tau_f} \equiv \frac{\tau_f^{\sigma-1}}{\tau_h^{-\sigma-1}} \left[\frac{p + \left(\frac{p}{\tau_h}\right)^{\sigma}}{p + \left(\tau_f p\right)^{\sigma}} \right]^2 \frac{(1-\alpha)\, Q_f}{p Q_h + \alpha Q_f}. \tag{5}$$

The parameter α appears only in the final term, $\frac{(1-\alpha)Q_f}{pQ_h+\alpha Q_f}$, which represents the ratio of the foreign to home expenditure. Since this ratio decreases with α, it follows that:[16]

Lemma 1. *Assuming CES preferences, as the home country's trade deficit increases (that is, as α rises), the iso-world-price curves in the tariff space become flatter.*

This result is intuitive: as the home country's trade deficit widens, its expenditure relative to that of the rest of the world expands, increasing the influence of its tariff on the world price relative to the foreign country's tariff.[17] Consequently, maintaining a fixed world price requires a relatively smaller tariff cut by the home country when α increases. Formally,

Corollary 1. *For a given reduction in the foreign country's tariff, a smaller reduction in the home country's tariff is required for reciprocity, the larger is the home country's trade deficit.*

The left panel in Figure 3 illustrates this property by depicting the iso-world-price curves passing through an initial tariff pair, t^I, under two 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, when α increases from 0 to 0.2, this reciprocity is disrupted. Under the new trade-balance scenario, the largest reciprocal tariff cuts would drive the surplus country's tariff to zero while the deficit country continues to maintain a positive tariff.

The right panel of Figure 3 presents an equivalent representation in import-export quantity space. Point I shows the traded quantities in the initial equilibrium (before tariff cuts), while point A represents quantities after the cuts. The slope of the lines through each equilibrium point indicates the world price of the home country's exports. 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,

Corollary 2. *Under a given set of mutual tariff cuts, an increase in trade imbalances—represented by an increase in α—shifts the balance of concessions in favor of the trade-surplus country.*

[16] See Appendix A.3 for details.

[17] In a repeated-game framework, Bagwell and Staiger (1990) show that granting governments limited flexibility to raise tariffs in response to a trade-deficit shock can enhance the self-enforceability of an agreement. The intuition parallels the mechanism highlighted in Lemma 1: a larger trade deficit increases a country's ability to influence its terms of trade through import tariffs, thereby strengthening its unilateral incentive to deviate when such a shock occurs.

Given the growth of global trade imbalances since the inception of the WTO in 1995, this corollary implies that the balance of concessions has likely shifted in favor of large surplus countries such as China and against large deficit countries such as the United States. In Section 5, we quantify the magnitude of these shifts by comparing the balance of concessions under factual trade imbalance with a counterfactual scenario in which all countries have balanced trade.

3.3 Input Output Linkages

Bown et al. (2023) provide a detailed theoretical analysis of reciprocity in models with input-output linkages. We draw on their work to highlight how the introduction of input-output linkages influences the implied balance of concessions. Consider the two-country framework of Caliendo and Parro (2015), in which production combines labor and intermediate inputs through a Cobb-Douglas technology, with β denoting the share of labor in total costs and θ the trade elasticity. Each country's domestic expenditure share is π_{ii}, and the tariff-inclusive share is $\tilde{\pi}_{ii} = \frac{\pi_{ii}\tau_{ji}}{1+\pi_{ii}(\tau_{ji}-1)}$. Using these definitions, Bown et al. (2023) show that reciprocal tariff changes between countries i and j must satisfy:

$$\frac{d\ln\tau_{ji}}{d\ln\tau_{ij}} = \frac{\tilde{\pi}_{jj} + \frac{1-\beta}{\beta(1+\theta)}(1-\pi_{jj})}{\tilde{\pi}_{ii} + \frac{1-\beta}{\beta(1+\theta)}(1-\pi_{ii})}. \tag{6}$$

The term $\frac{1-\beta}{\beta(1+\theta)}(1-\pi_{kk})$ for $k = \{i, j\}$ in the above equation captures the influence of intermediate inputs on the schedule of reciprocal tariff cuts. As β decreases (i.e., as intermediates become more important in production), this term increases, and the ratio in the reciprocity condition moves closer to one. This implies weaker asymmetries in reciprocal tariff changes across countries of different sizes. In other words, intermediate inputs attenuate the relative terms-of-trade effect of large-country tariff changes, thereby reducing the net concessions granted by larger countries for a given set of tariff cuts. Formally,

Corollary 3. *In a two-country world with traded intermediate inputs, abstracting from input-output linkages leads to an overestimation of the large country's net terms-of-trade concessions implied by a given set of tariff changes.*

This result implies that quantifying the exchange of concessions within a framework that ignores traded intermediate inputs is likely to overstate the net concessions granted by larger countries in our data set. Accordingly, we compute the concessions implied by existing trade agreements using both a model with input-output linkages and a baseline model without such linkages, and we compare the results.

4 The Quantitative Model

We employ a multi-country, multi-sector framework in which goods are differentiated by their origin of production i, destination of consumption j, and sector k, both in production technology and in preferences. Our baseline analysis covers all non-service sectors—including agriculture, mining, and manufacturing—which are indexed by $k \in \{1, 2, \ldots, K\}$. We begin by focusing on goods rather than services because, unlike goods, trade in services is not subject to tariffs, and negotiations under the General Agreement on Trade in Services (GATS) concern regulatory commitments rather than reciprocal tariff reductions.[18] The inclusion of services in our extended analysis is therefore intended to capture the potential general-equilibrium effects of goods-trade liberalization, rather than the concessions exchanged under the GATS framework.

In the baseline model, we treat the service sector as exogenous by holding its production, consumption, and trade flows fixed in the counterfactual exercises. We then relax this restriction by explicitly incorporating the service sector into the general-equilibrium system, allowing its activity to adjust endogenously to policy changes in goods trade. This extended framework captures additional channels through which goods-trade liberalization can affect the economy, including resource reallocation and relative-price adjustments between goods and services. Which version of the model is more appropriate ultimately depends on the extent of labor mobility between the service and non-service sectors in the economies under study.

Finally, we augment the model with input-output linkages à la Caliendo and Parro (2015). These modeling variations serve both as robustness checks and as a means to evaluate how alternative structural assumptions influence the quantita-

[18] As Marchetti and Mavroidis (2011) argue, GATS was not founded on the same logic of reciprocal tariff liberalization that underpins the GATT. Instead, the GATS emerged from a distinct negotiation dynamic centered on regulatory commitments and domestic policy constraints. Therefore, by concentrating on goods, where tariff concessions are clearly defined, our analysis remains aligned with the theoretical and historical realities of goods-based trade negotiations.

tive results.

4.1 Setup

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

$$U_j = \prod_k (\sum_{i=1}^{N} b_{ij,k}\, \tilde{q}_{ij,k}^{\rho_k})^{\frac{\mu_{j,k}}{\rho_k}}, \tag{7}$$

where, $\tilde{q}_{ij,k}$ is the quantity consumed in country j of country $i's$ output 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:

$$p_{ij,k} = \bar{a}_{ij,k}\, w_i, \tag{8}$$

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

$$\tilde{p}_{ij,k} = (1 + t_{ij,k})(1 + \kappa_{ij,k}) p_{ij,k}, \quad t_{ii,k} = 0, \tag{9}$$

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.,

$$Y_j = w_j L_j + \sum_k \sum_i \frac{t_{ij,k}}{1 + t_{ij,k}} \tilde{p}_{ij,k} \tilde{q}_{ij,k} + D_j. \tag{10}$$

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

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

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

$$\sum_j \delta_j = 0.$$

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

$$W_j = \left(\frac{Y_j}{\prod_k P_{j,k}^{\mu_{j,k}}} \right)^{\mu_j}, \tag{11}$$

where $P_{j,k}$ is the price index in country-sector j,k, and μ_j is the total expenditure share of country j on non-service sectors.[20]

4.2 Input-Output Linkages

To incorporate production linkages across sectors, we extend the baseline model to a multi-country, multi-sector Ricardian framework with input-output (IO) linkages following Caliendo and Parro (2015). Each sector uses labor and intermediate goods from all sectors according to Cobb-Douglas technology, implying that cost and price changes propagate through the IO network. Define $\hat{x} = \frac{x'}{x}$ as the ratio of the counterfactual to factual values of a variable x. The relative change in the unit cost of sector k in country j is given by:

$$\hat{c}_{j,k} = \hat{w}_j^{\gamma_{j,k}} \prod_l \hat{P}_{j,l}^{\gamma_{j,lk}},$$

where w_j is the wage rate of country j; $\gamma_{j,k}$ is the share of value added in country-sector j,k; $\gamma_{j,lk}$ is the cost share of intermediate input l in country-sector j,k; and $P_{j,l}$ is the price index of sector l in country j. The relative change in the price index is given by:

$$\hat{P}_{j,l} = \left[\sum_i \pi_{ij,l} (\hat{c}_{i,l} \hat{\tau}_{ij,l})^{-\theta_l} \right]^{-1/\theta_l},$$

[19] This is a variation of the assumption, stated in Section 3, about cross-border ownership of factors of production.

[20] See Appendix F for details of our calibration exercise.

where θ_l is the productivity dispersion parameter (or trade elasticity) of sector l; $\tau_{ij,k} \equiv (1 + t_{ij,k})$ denotes one plus the ad valorem tariff rate levied by country j against country i in sector k; and the relative change in bilateral trade shares is given by:

$$\hat{\pi}_{ij,k} = \left[\frac{\hat{c}_{i,k}\hat{\tau}_{ij,k}}{\hat{P}_{j,k}}\right]^{-\theta_k}. \tag{12}$$

Finally, country j's disposable income, given by the sum of labor income, tariff revenues, and trade deficit, is:

$$I'_j = \hat{w}_j w_j L_j + \sum_k \sum_i t'_{ij,k} \frac{\pi'_{ij,k}}{1 + t'_{ij,k}} X'_{j,k} + D'_j,$$

where

$$X'_{j,k} = \sum_l \gamma_{j,kl} \sum_i \frac{\pi'_{ji,l}}{1 + t'_{ji,l}} X'_{i,l} + \alpha_{j,k} I'_j$$

is country j's aggregate expenditure on goods of sector k, and $\alpha_{j,k}$ is the share of country j's final consumption expenditure on goods of sector k. Given our assumption that a country's trade deficit is a fixed share δ_j of the world gross output, the trade deficit will be given by $D'_j = \delta_j \sum_{j'} \sum_k \sum_i \frac{\pi'_{ij',k}}{1+t'_{ij',k}} X'_{j',k}$.

4.3 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 (4) to measure the net concessions exchanged between each pair of countries as a result of moving from bilateral trade war to the cooperative equilibrium under trade agreements.

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 (1988)'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. 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.

4.4 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. 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.[21] One direct implication of the above argument is that a country's applied tariff on a product can be considered a lower bound for

[21] Ossa (2014) proposes an alternative method for calculating noncooperative tariffs by using exist-

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.[22]

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:

$$\left\{t^N_{fh,k}\right\}_k \equiv \max_{\left\{t_{fh,k}\right\}_k} W_h\left(\left\{t_{fh,k}\right\}_k, \left\{t^N_{hf,k}\right\}_k\right), \tag{13}$$

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

$$t_{fh,k} \geq \max_i \{t^A_{ih,k}\}, \tag{14}$$

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

$$t_{fh,k} = t^A_{fh,k}, \forall k \in U, \tag{15}$$

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.[23] Table 1 presents the summary statistics of the noncooperative tariffs computed using the above method for year 2018.[24]

Finally, we note that the above tariffs are calculated using the baseline model without input-output linkages. One of the challenges of using models with input-output linkage in trade policy analysis is that standard competitive models fail

ing 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.

[22]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.

[23]In implementing this optimization problem, we cap the upper bound of optimal tariffs at 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 upper 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.

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

to capture tariff escalation, the widely observed pattern where governments impose lower tariffs on intermediate inputs than on final goods. 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.[25] For the sake of transparency, therefore, we compute noncooperative tariffs using the baseline model without input-output linkages.

Alternative Noncooperative Benchmarks The calculation of bilateral Nash tariffs in Equations (13)-(15) 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 in that sector 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 these potential concerns, 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.[26] For example, the United States imposed an average tariff of around 60% following the Smoot-Hawley Tariff Act. Similarly, China's average tariffs in the 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

[25]Recent papers have addressed this issue by incorporating monopolistic distortions (Caliendo, Feenstra, Romalis, and Taylor, 2023) and scale economies (Antràs, Fort, Gutiérrez, and Tintelnot, 2024), which generate lower optimal tariffs on intermediate inputs, aligning more closely with observed tariff escalation patterns.

[26]Results under a uniform tariff rate of 25% is available upon request.

(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 de-location 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.

4.5 Mapping the Model to Data

We obtain production and bilateral trade data (in intermediate and final goods) 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.[27] 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.[28] Tables F.3 and F.4 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 F.1 and Table F.2 summarize the list of the parameters and variables that are constructed using the data on trade flows, and applied tariff rates, $t_{ij,k}$, for the baseline model and the extended model with IO linkages, respectively. Finally, we estimate the trade elasticities following the approach in Caliendo and Parro (2015). In particular, the trade structure

[27]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.

[28]See Section 6 for a discussion of potential data limitations and their implications for our results.

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 in Equations (13)-(15).

in the baseline model implies that:

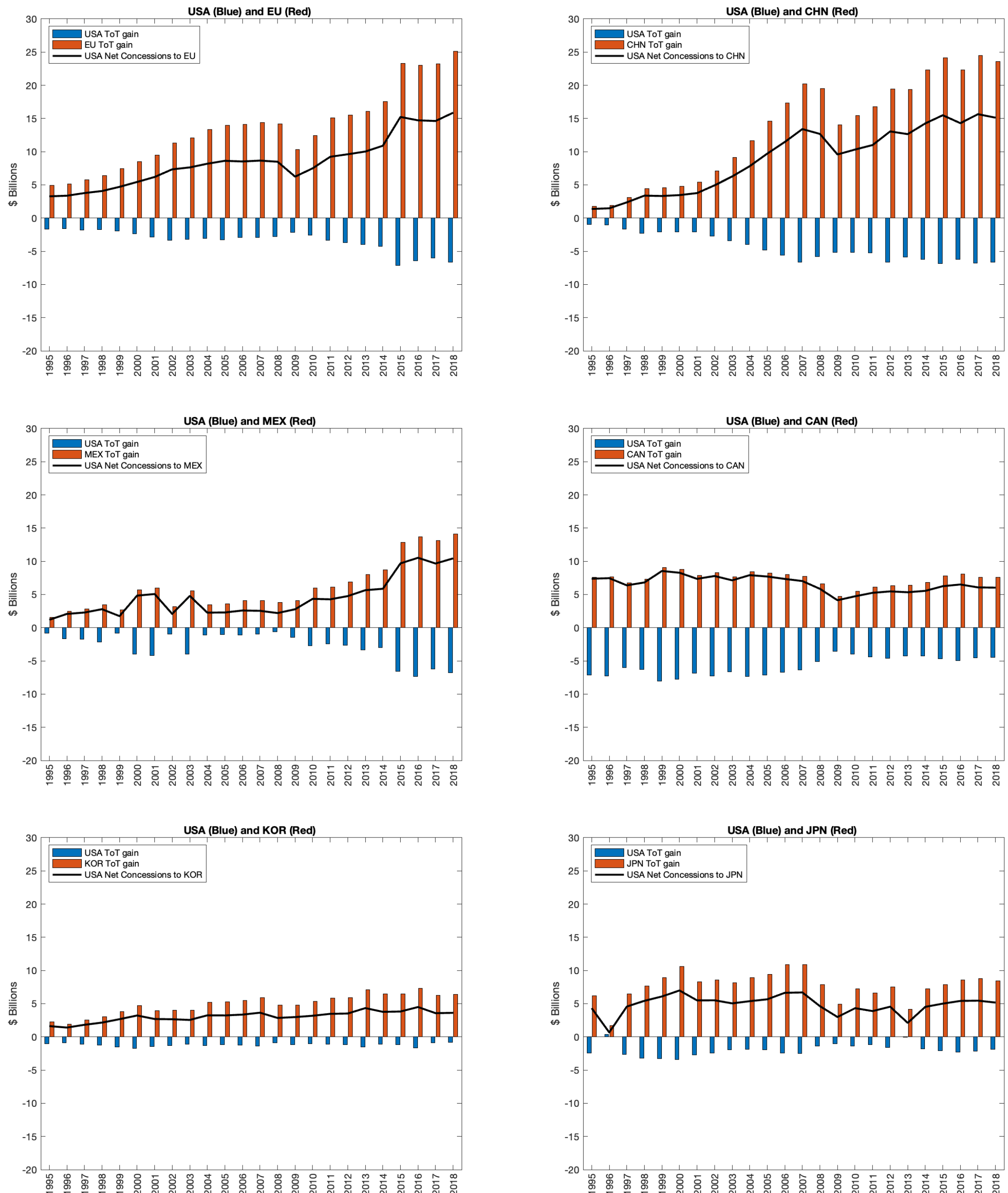
$$\ln \frac{x_{in,k} x_{nj,k} x_{ji,k}}{x_{ni,k} x_{jn,k} x_{ij,k}} = (1 - \sigma_k) \ln \frac{\tau_{in,k} \tau_{nj,k} \tau_{ji,k}}{\tau_{ni,k} \tau_{jn,k} \tau_{ij,k}} + \varepsilon_{inj,k}, \tag{16}$$

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 non-service sector k. The estimates of $\sigma_k - 1$ are reported in Table F.4. For quantitative analyses that include the service sector, we set the trade elasticity for the combined service sector to 6. This choice is in line with the median estimates for the service sectors reported by Ahmad and Schreiber (2024) and Freeman et al. (2025).

5 Anatomy of WTO Concessions

In this section, we present our findings on the bilateral and multilateral balance of concessions (BoC) among WTO members from 1995 to 2018. We also examine how trade imbalances affect the magnitude of concessions exchanged across countries. Finally, we assess the robustness of our quantitative results to both the choice of tariff benchmarks—by considering an alternative trade war scenario—and to alter-

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



Note: Each panel illustrates the terms-of-trade effects of bilateral cooperation between the U.S. and one of its major trading partners. Blue (red) bars depict the magnitude of the effect on the U.S. (its partner). The black line depicts the net concessions granted by the U.S., computed using Equation (4). The analysis is based on the baseline model.

native modeling assumptions regarding trade in services and input-output linkages. Unless stated otherwise, the results reported below are based on the baseline specification.

5.1 Bilateral and Multilateral Balance of Concessions

We begin by measuring the terms-of-trade effects of bilateral cooperation—relative to bilateral trade wars—for each pair of countries in our dataset.[29] For the United States, as shown in Figure 4, bilateral cooperation with its major trading partners implies a deterioration in its terms of trade. At the same time, the partners' terms-of-trade gains exceed the U.S. loss—an outcome that, as described in Proposition 1, reflects the externality that bilateral tariff cuts have on third countries.

The black line in Figure 4 depicts the net concessions of the U.S., calculated as the gap between the partner's terms-of-trade gain and the average gain of the two countries (Equation (4)). It shows that the U.S. net concessions to the EU, China, and Mexico have increased over time, while those to Canada, Korea, and Japan have remained relatively stable.

Next, the hollow bars in Figure 5 illustrate the net bilateral concessions made by key WTO members in year 2018, computed using our baseline model with no service trade or IO linkages.[30] In this year, the United States was 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. The European Union, in turn, granted net concessions to several countries, including China ($12 billion) and Japan ($4 billion).[31]

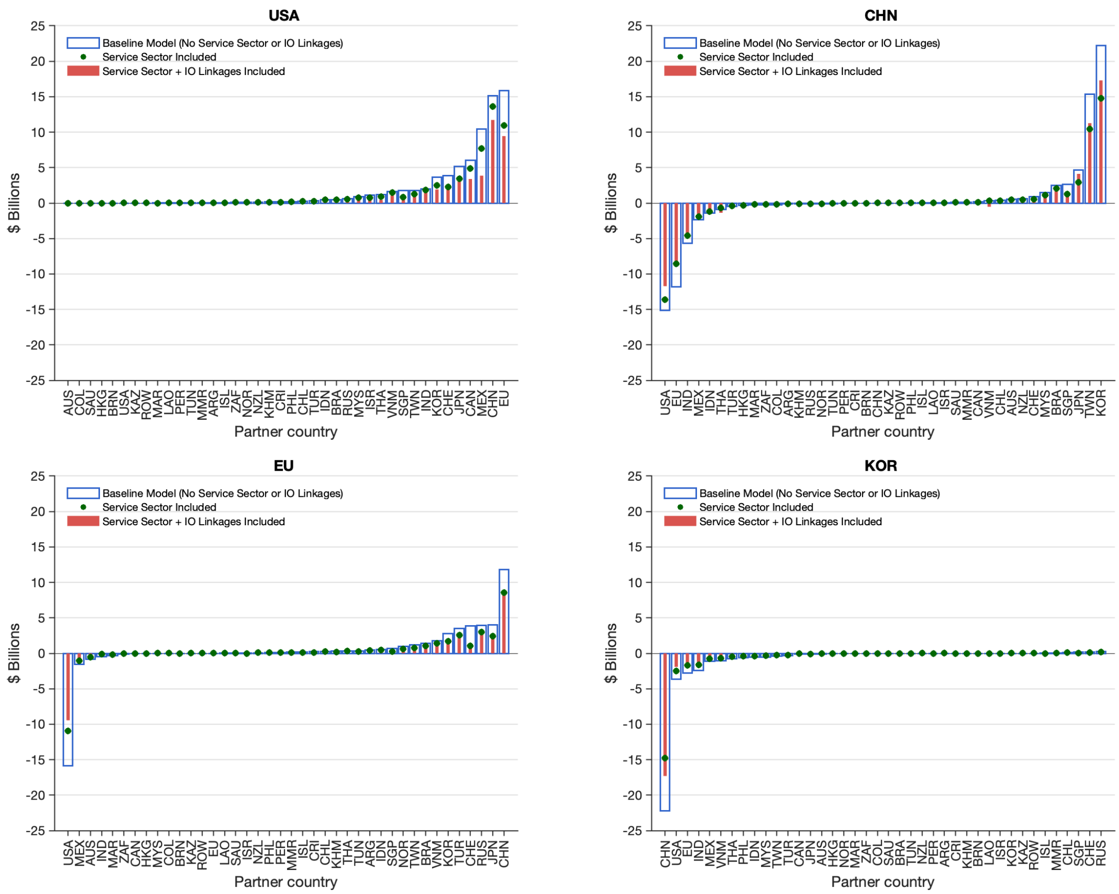
Service Sector The dots in Figure 5 represent results from a model that includes the service sector in the general equilibrium framework. The qualitative patterns remain highly consistent across the two model specifications—the ranking of partner countries by net concessions changes little when services are included. Quantitatively, however, the absolute magnitudes of net concessions tend to be smaller.

[29] Recall that Equation (3) defines bilateral concessions in each year as the terms-of-trade effects of lowering tariffs from noncooperative to applied levels for each pair of countries.

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

[31] For consistency over time, all eventual EU member states are aggregated into a single region (EU) throughout the sample period.

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



Since services are not subject to tariffs and thus not directly affected by tariff negotiations, this attenuation reflects the general-equilibrium effects of goods-trade liberalization on the production and trade in the service sector.[32]

To understand how incorporating the service sector alters the terms-of-trade effects of goods-trade liberalization, note that this setup allows labor to move between the service and non-service sectors. Labor mobility introduces two opposing forces. On the one hand, when workers can move freely across sectors, a tariff cut by the U.S. trading partners on the U.S. exports in the non-service sector raises the U.S. terms of trade in both sectors, thereby amplifying the overall gains. On the

[32] As discussed earlier, our main analysis focuses on goods rather than services because services are not subject to tariffs, and negotiations under the GATS involve regulatory commitments rather than reciprocal tariff reductions (see Footnote 18 for details). We set the noncooperative tariffs for the combined service sector to be the factual rate (i.e., zeros). The inclusion of services here is therefore meant only to capture their general-equilibrium response to goods-trade liberalization.

other hand, sectoral mobility makes U.S. manufacturing exports more responsive to foreign tariffs, as labor can shift toward services when demand for manufacturing goods declines. This adjustment increases the elasticity of U.S. export supply and dampens the effect of foreign tariffs on export prices. In our quantitative results, however, the amplifying effect on the terms-of-trade gains dominates this mitigating channel, leading to larger overall gains (and lower net concessions by the U.S.) when labor is mobile across sectors. In practice, the degree of labor mobility between the service and non-service sectors likely varies across economies. Nevertheless, our analysis indicates that the overall patterns of concessions remain similar across the two extreme cases—when labor is either completely immobile or perfectly mobile between the two sectors.

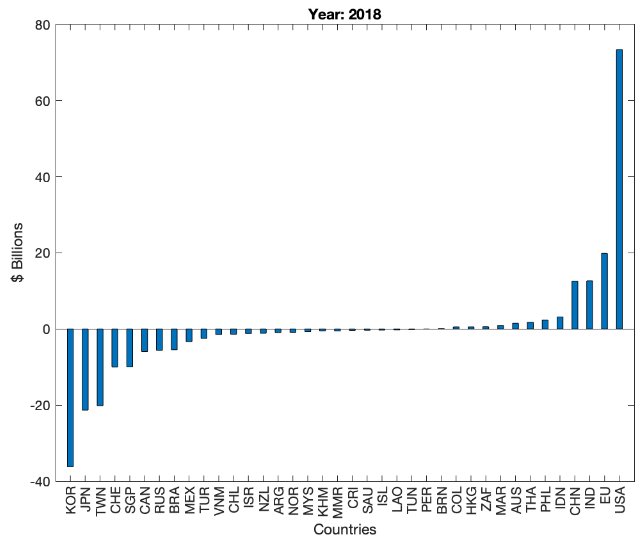
IO Linkages The solid bars in Figure 5 present results from the model that incorporates input-output linkages and includes the service sector. The overall pattern of concessions remains broadly consistent with the version of the model without input-output linkages. Quantitatively, however, the magnitude of net concessions decreases for some countries and increases for others, with notable heterogeneity across trading partners. In particular, introducing input-output linkages tends to lower the United States' net bilateral concessions, especially vis-à-vis Mexico and China. Ignoring input-output linkages leads to an overestimation of the U.S. net concessions to Mexico by roughly 100 percent and to China by about 15 percent. These findings are consistent with Corollary 3 indicating that abstracting from input-output linkages tends to overstate the net terms-of-trade concessions granted by large countries for a given set of tariff changes.

Multilateral BoC Figure 6 reports the net **multilateral concessions** of each country in 2018, calculated as the sum of its bilateral concessions. The figure reveals substantial cross-country variation, with the United States standing out as the largest net contributor to the system and South Korea as the largest recipient.

Examining the evolution of bilateral concessions over time reveals a consistent pattern: the United States acts as a net granter in nearly all of its bilateral relationships, while China—following its accession to the WTO—emerges as a net granter to most of its trading partners, with the notable exceptions of the United States, the European Union, and India.

Figure 1 in the Introduction traces the evolution of net multilateral concessions

Figure 6: Net Multilateral Concessions by Country, 2018



Note: The figure shows the net multilateral concessions granted by each country in 2018, calculated as the sum of bilateral concessions. The same measure for selected countries over the period 1995–2018 appears in Figure 1 in the Introduction. The analysis is based on the baseline model.

for selected countries over time. Following its accession to the WTO in 2001, China initially appears as a net recipient of concessions before becoming a net granter, while Korea and Japan consistently remain among the largest net recipients throughout the period.

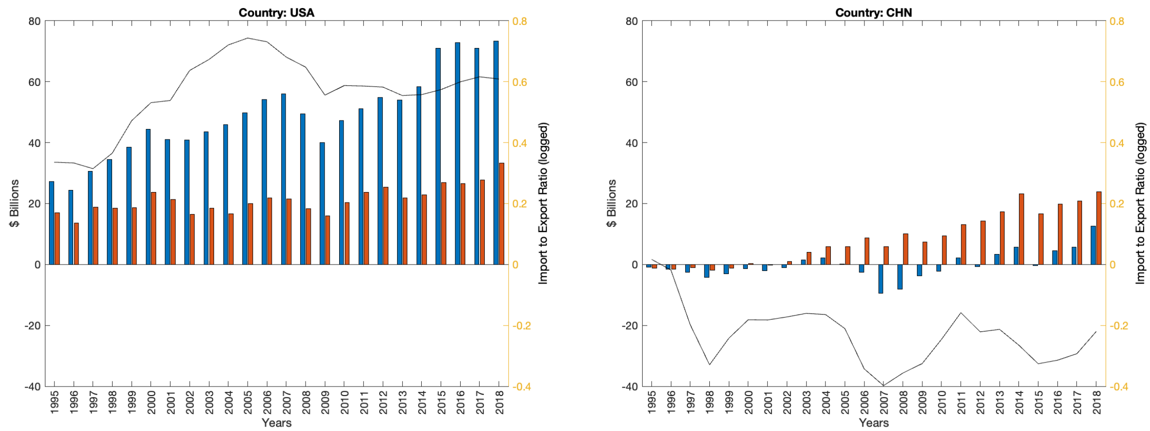
5.2 The Impact of Trade Imbalances on Reciprocity

In Section 3.2, we showed that, within our model, an exogenous shock to trade balances shifts the BoC in favor of countries experiencing an increase in their trade surplus. To quantify this implication, we compute the BoC under a counterfactual scenario in which all countries have balanced trade and compare it to the BoC observed under the factual trade pattern.[33]

Comparing the current situation to a balanced-trade counterfactual is informative because it captures the steady rise in global trade imbalances since the early 1990s, when the final round of GATT negotiations that led to the establishment of the WTO was concluded. At that time, the United States maintained a roughly bal-

[33] To construct the balanced-trade counterfactual scenario, we set $\delta_j = 0$ for all countries in our quantitative model, and employ the hat-algebra method to compute trade volumes under the new equilibrium.

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



Note: 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. The analysis is based on the baseline model.

anced trade position and did not foresee the emergence of the large and persistent deficit that followed (Kehoe et al., 2018).

The balanced-trade counterfactual confirms a key implication of our theoretical framework. As shown in Figure 7, removing multilateral trade imbalances reduces the multilateral concessions granted by the United States from $73 billion to $33 billion—a decline of nearly 55 percent—thereby making the trade agreements more reciprocal.[34] Conversely, eliminating these imbalances has the opposite effect for China, increasing its net multilateral concessions from about $13 billion to $24 billion—an increase of roughly 90 percent.

These findings suggest that the impact of trade balance shifts on the balance of concessions under existing agreements is substantial and warrants greater attention, particularly in the design of flexibility mechanisms to address large and unintended deviations from reciprocity in trade commitments. This issue is especially relevant because any deviations from reciprocity present at the time of negotiation likely reflected deliberate considerations—such as concessions in other policy areas or geopolitical factors—whereas the deviations caused by subsequent trade-balance shocks were unanticipated and not incorporated into the original agreements.

[34]For a detailed breakdown, Figure C.1 in the Appendix illustrates how removing multilateral trade imbalances affects the United States' bilateral concessions to selected countries.

5.3 The Impact 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) and 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.

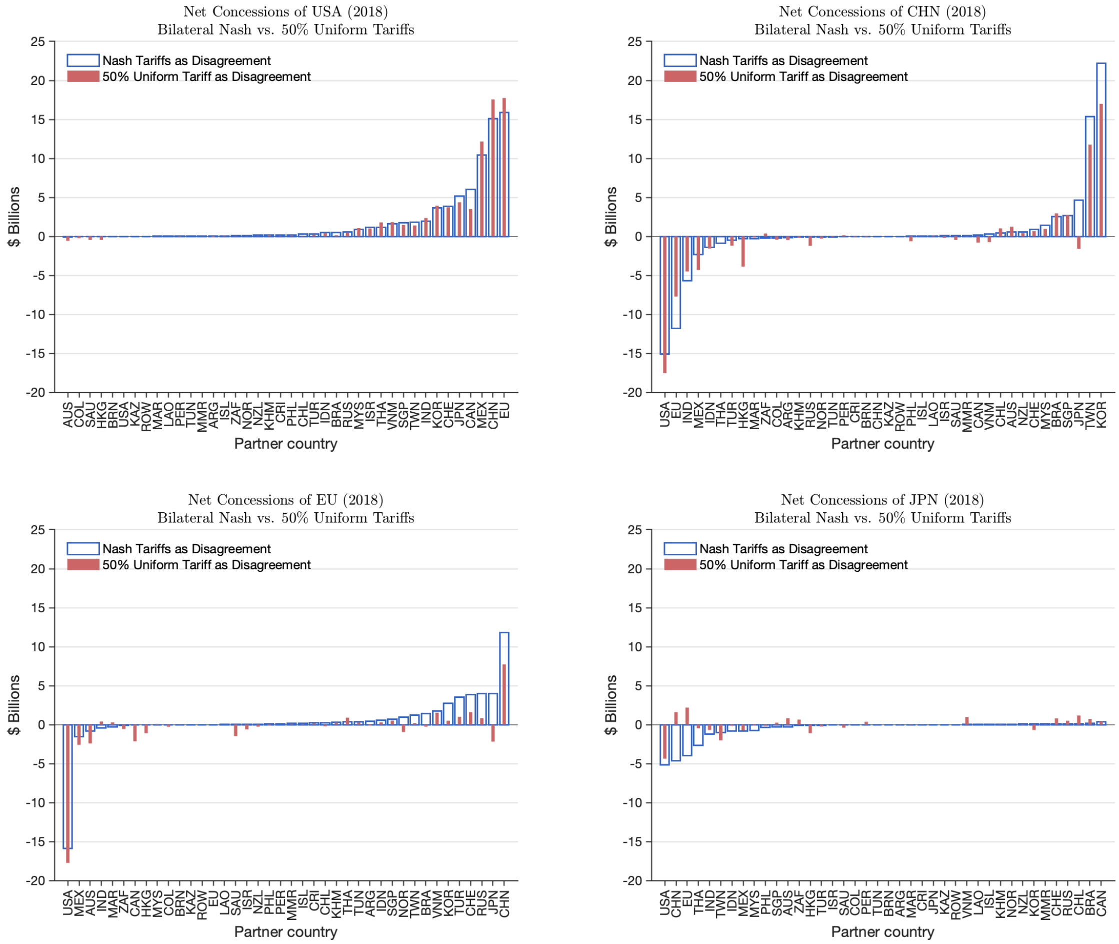
However, this tendency—where larger, more powerful countries impose lower tariffs—contradicts the principle of reciprocity, as larger countries, with their greater international market power, should theoretically be able to secure larger tariff cuts from their trading partners in exchange for their own 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 the BoC for the U.S. in a counterfactual scenario where the United States applies to its imports the same sector-specific tariff rates that it faces in each of its bilateral relationships. We find that such an adjustment in the U.S. tariffs reduces its net concessions by 1–10% in different years (Figure C.3). Comparing this magnitude with the effect of trade imbalances on deviations from reciprocity (Figure C.1) indicates that trade imbalances contribute far more to deviations from reciprocity than do asymmetric tariff rates.

5.4 Alternative Benchmarks for Noncooperative Tariffs

Our main benchmark for measuring tariff concessions is based on bilateral Nash tariffs computed given estimated trade elasticities. Because these estimates are imprecise and depend on calibration choices, it is useful to check robustness using a simpler and more transparent benchmark. We therefore consider an alternative "trade-war" scenario in which both countries impose the same uniform tariff on their imports. As discussed in Section 4.4, a uniform 50 percent tariff lies well within the range of historical noncooperative tariffs, as well as model-based estimates of optimal tariffs in the literature. This benchmark abstracts from potential cross-country differences in import market power and political-economy parame-

Figure 8: Net Concessions Under Alternative Benchmarks for Noncooperative Tariffs



Note: The thin bars illustrate the net concessions made by a country to each of its partners in 2018 using 50% tariffs as disagreement tariffs. The hollow bars show the net concessions under the bilateral Nash tariffs. The analysis is based on the baseline model.

ters, providing a neutral reference point for evaluating the robustness of our findings.

As shown in Figure 8, replacing bilateral Nash tariffs with a uniform 50% tariff as the noncooperative benchmark leaves the overall pattern of U.S. bilateral concessions largely unchanged. In contrast, both China and the European Union experience a reduction in the net bilateral concessions they grant—or, an increase in the concessions they receive from other countries. As a result, these countries shift from having positive net multilateral concessions under the Nash benchmark to negative net concessions under the uniform 50% tariff benchmark.

This sharp change in the balance of concessions for China and the European Union reflects their relatively high imputed Nash tariffs compared with those of their trading partners. Two factors contribute to this pattern. First, Nash tariffs tend to be higher for larger countries, but adopting a uniform 50% benchmark removes this source of heterogeneity. Second, in computing noncooperative tariffs, we use each country's highest applied tariff in a sector as a lower bound for its optimal tariff. This procedure raises the imputed noncooperative tariffs for countries that have maintained high applied rates since the inception of the WTO—most notably China—relative to countries with persistently low tariffs such as the United States. Consequently, our method may introduce a downward bias in the estimated optimal tariffs of WTO members that have pursued more open trade policies over this period.

6 Further Discussion and Concluding Remarks

This paper develops a quantitative framework to assess the balance of concessions in multilateral trade agreements and proposes a consistent definition of bilateral reciprocity in a multilateral setting. Building on the terms-of-trade logic of Bagwell and Staiger (1999), we show theoretically that shocks to trade balances can systematically shift the balance of concessions in favor of countries experiencing larger trade surpluses.

Applying this framework to WTO tariff commitments, we document significant deviations from perfect reciprocity across countries and over time. While differences in applied tariff levels play a minor role, persistent trade imbalances account for a large share of these deviations. The analysis highlights that trade-balance shocks—largely unanticipated when existing agreements were negotiated—can alter the effective distribution of concessions even when tariff schedules remain unchanged.

Our findings indicate that persistent shifts in trade balances can substantially alter the balance of concessions embedded in existing agreements, highlighting the need for greater institutional flexibility. Although some departures from reciprocity at the time of negotiation likely reflected deliberate trade-offs—such as concessions in other policy areas or geopolitical considerations—later deviations caused by evolving trade imbalances were unforeseen and thus never built into the original design of these agreements.

When such imbalances become large and enduring, the WTO's dispute-settlement mechanism—arguably conceived to address occasional "trade skirmishes" within an essentially balanced system (Beshkar, 2010a,b; Maggi and Staiger, 2011; Park, 2011; Anesi and Facchini, 2019; Beshkar and Park, 2021)—may come under growing strain. Preserving the stability of trade agreements may therefore require mechanisms that enable members to recalibrate their commitments when unexpected trade-balance shocks distort reciprocity, ensuring that negotiated obligations remain equitable and sustainable over time.

As with any quantitative trade model, the results should be interpreted with appropriate caution. Quantitative frameworks can yield valuable insights, but their numerical implications inevitably depend on underlying assumptions, data quality, and modeling choices. In addition to the limitations discussed throughout the paper, we conclude by highlighting three issues of particular relevance for our analysis: the modeling of trade imbalances; potential measurement errors in the available tariff data; and potential coalition-based approaches to evaluating each country's net concessions to the rest of the world.

6.1 Trade Imbalances

A static framework with exogenous trade imbalances is appropriate for our purposes to the extent that tariff policy is not a primary driver of persistent external imbalances. If tariffs had a first-order influence on the evolution of trade deficits and surpluses, then treating trade balance positions as exogenous would distort the relationship between tariff changes and terms-of-trade effects. However, existing empirical work—including Furceri et al. (2018)—finds small effects of tariff changes on trade balances. Moreover, various papers show that persistent trade surpluses are driven primarily by factors other than tariff policy, including domestic financial repression and internal market frictions (Song, Storesletten, and Zilibotti, 2011), or demographic differences across countries (Cooper, 2008; Sposi, 2022).

Extending the measurement of reciprocity to a dynamic environment is an important direction for future work, but several conceptual and methodological challenges remain. First, the existing theoretical literature that incorporates intertemporal choice into trade and tax policy—such as Costinot et al. (2014), Beshkar and Shourideh (2020), and Auray et al. (2025)—typically relies on the assumption that governments can commit at date 0 to an entire future sequence of taxes or tariffs. This follows the classic approach of Lucas Jr and Stokey (1983) to dynamic taxation. However, in such frameworks, the tariff path chosen initially is generally not optimal from the perspective of future policymakers, creating a severe time-inconsistency problem. Since real-world governments cannot credibly commit to future tariff schedules, these dynamic models are not well suited for evaluating period-by-period negotiations or for quantifying the balance of concessions in each year—both of which are central to our empirical analysis.

Second, and perhaps partly for this reason, the quantitative trade literature has tended to abstract from observed trade imbalances entirely. As explained by Ossa (2016), a common practice, following Dekle et al. (2007), is to "purge" trade imbalances from the data by interpreting trade deficits as transfers and setting these transfers to zero in counterfactual equilibria. While this approach is useful for certain comparative-static exercises, it removes precisely the cross-country trade imbalances that are central to our analysis of reciprocity.

Therefore, to the extent that tariffs are not a first-order determinant of trade imbalances relative to the scale of world income, treating trade balance positions as exogenous provides a reasonable and tractable approximation for quantifying the terms-of-trade effects of tariff concessions. Developing a dynamic framework that incorporates both endogenous asset accumulation and realistic tariff setting remains an important challenge and a promising avenue for future research.

6.2 Imperfect Tariff Data

Our measurement of reciprocity relies on underlying tariff data that may be subject to substantial error. As Teti (2024) documents, standard cross-country databases—such as WITS—contain missing observations, inconsistent treatment of MFN and preferential rates, and selection biases that omit many importer-exporter-product pairs. Accordingly, our findings should be interpreted with caution. Future work would benefit from improved tariff datasets, and from systematic sensitivity analyses to assess how measurement error may affect reciprocity estimates. Nevertheless, since trade imbalances have undoubtedly increased over time, the central result of our analysis—that this trend has systematically skewed the balance of concessions under existing trade agreements—should remain robust.

6.3 Coalition-Based Approaches to Measuring Trade Concessions

In reality, countries' outside options may take forms more complex than the bilateral noncooperative benchmark discussed in Section 2.2—for example, the formation of preferential trade agreements or the reorganization of broader coalitions. Events such as Brexit underscore these possibilities. The United Kingdom's withdrawal from the European Union not only altered its bilateral relationship with EU members but also created opportunities for the UK to pursue new preferential agreements with third countries. Such systemic realignments—where the dissolution of one trading arrangement prompts a broader reorganization of external commitments—are not captured in our framework, which treats the breakdown of a bilateral relationship as an isolated event and does not allow for endogenous adjustments in other coalitions or reconfigurations of the broader trading network.

Such scenarios can be represented through more elaborate modeling frameworks, including cooperative-game approaches such as Shapley value allocations, which aim to capture how surplus or bargaining power might be distributed within coalitional structures. While these broader approaches to defining outside options are conceptually appealing, incorporating them into a quantitative framework would require modeling a mixed noncooperative-cooperative environment and exploring a very large set of potential coalitions across countries. The resulting combinatorial complexity, together with the need for additional theoretical structure and computational advances, places such extensions beyond the scope of this paper.

For these reasons, and consistent with the standard trade-agreement literature, we adopted bilateral Nash tariffs as the relevant noncooperative point. This benchmark provides a well-defined and tractable reference for evaluating the concessions embodied in observed tariffs, whereas alternative formulations—such as coalition-based or cooperative-game approaches—remain promising avenues for future research.

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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,

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

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 trades 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 import 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 $q_{fh}^A - p^A q_{hf}^A \equiv \alpha Q_f$, and $q_{fh}^N - p^N q_{hf}^N \equiv \alpha Q_f$. 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 $u\left(q_{ij}, q_{jj}\right) \equiv \left(q_{ij}^{\frac{\sigma-1}{\sigma}} + q_{jj}^{\frac{\sigma-1}{\sigma}}\right)^{\frac{\sigma}{\sigma-1}}$ and import taxes are $\tau_h - 1$ and $\tau_f - 1$. Home demand for the home and foreign goods will be:

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

which implies:

$$q_{fh} = \left(\frac{p}{\tau_h}\right)^{\sigma} q_{hh}. \tag{17}$$

Substituting for q_{fh} 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, foreign consumption bundle is given by:

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

Finally, using the world clearing condition $q_{hf} + q_{hh} = Q_h$, equilibrium world price,

p, is implicitly given by:

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

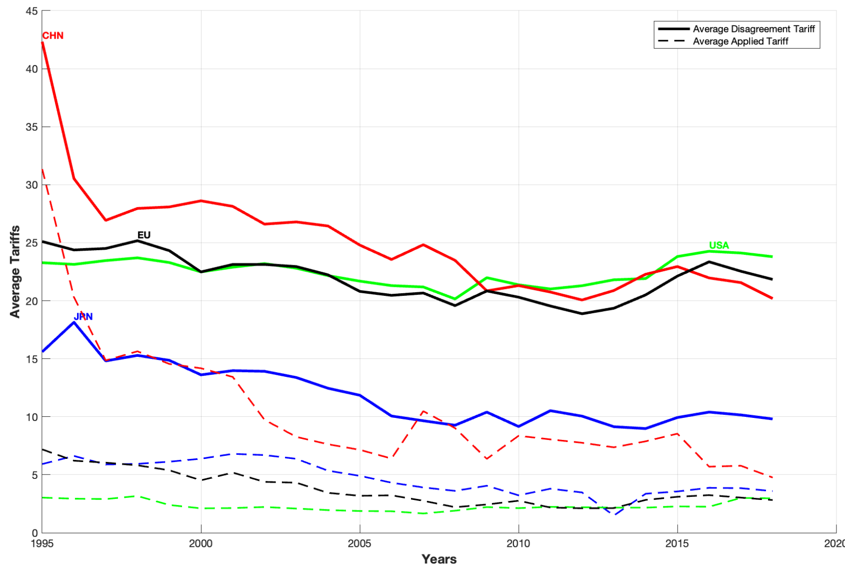
The slope of the iso-world-price curve, can then be calculated using the Implicit Function Theorem as follows:

$$\frac{d\tau_h}{d\tau_f}\equiv-\frac{F_{\tau_f}}{F_{\tau_h}}=\frac{\tau_f^{\sigma-1}}{\tau_h^{-\sigma-1}}\left[\frac{p+\left(\frac{p}{\tau_h}\right)^{\sigma}}{p+\left(\tau_f p\right)^{\sigma}}\right]^2\frac{(1-\alpha)\,Q_f}{pQ_h+\alpha Q_f}.$$

The parameter α only appears in the last term in this expression, $\frac{(1-\alpha)Q_f}{pQ_h+\alpha Q_f}$, which is the ratio of the foreign to home income. Therefore, as α increases, the iso-world-price curves become flatter. QED.

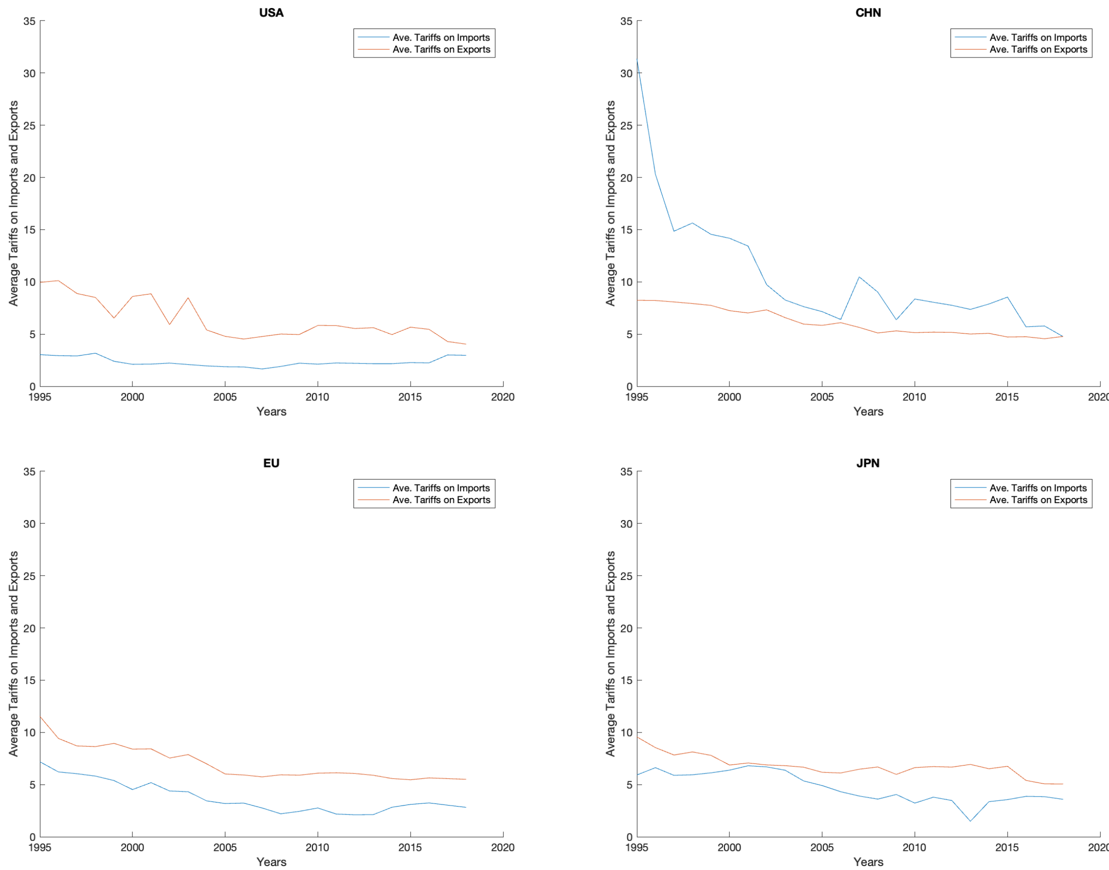
B Tariff Summary Statistics

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



Note: 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



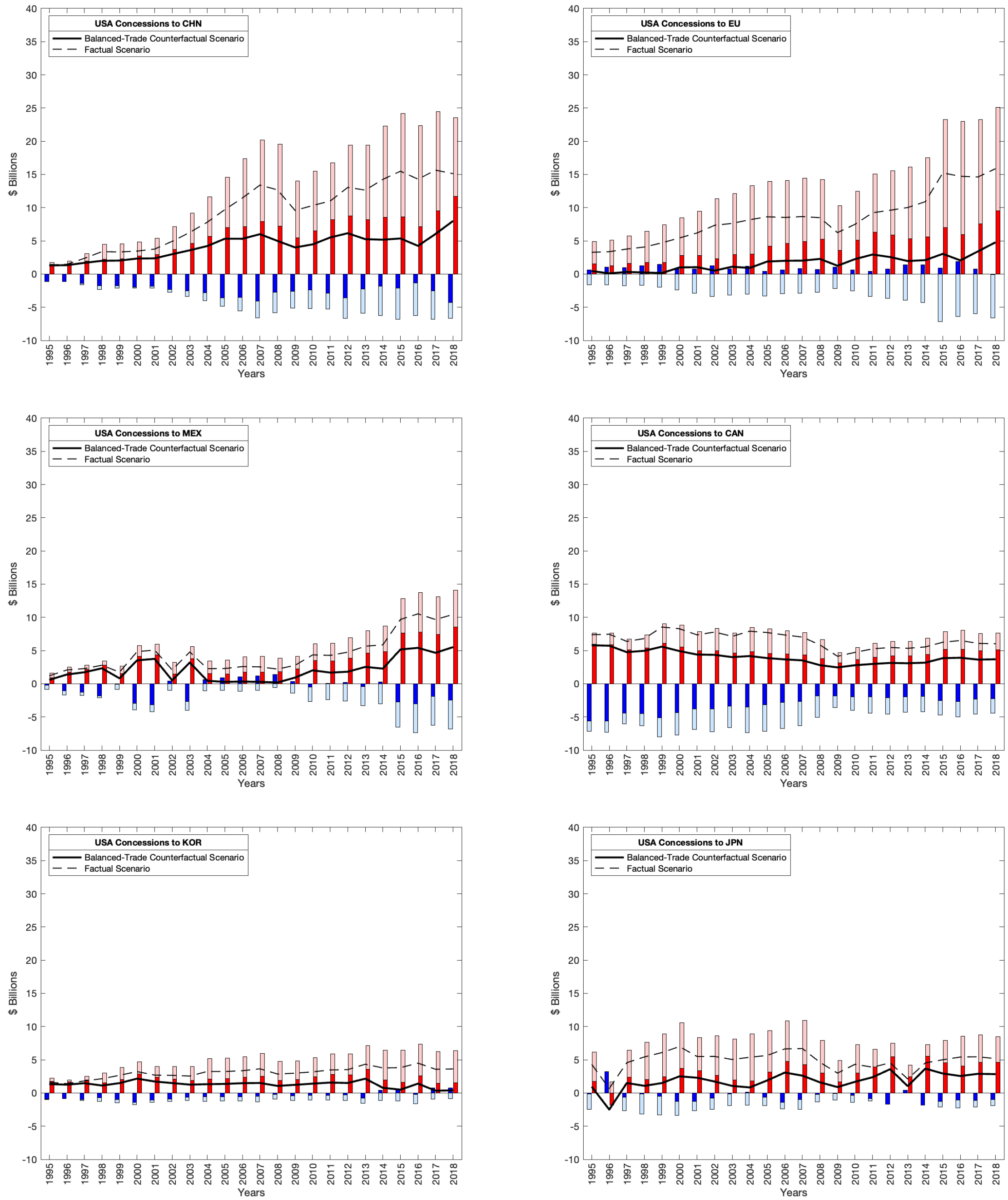
Note: Trade-weighted average of applied tariffs on imports and exports of selected countries.

C Bilateral Trade Wars: Additional Graphs and Tables

Table C.1: Net Bilateral Concessions for Selected Countries in 2018 (Million USD)

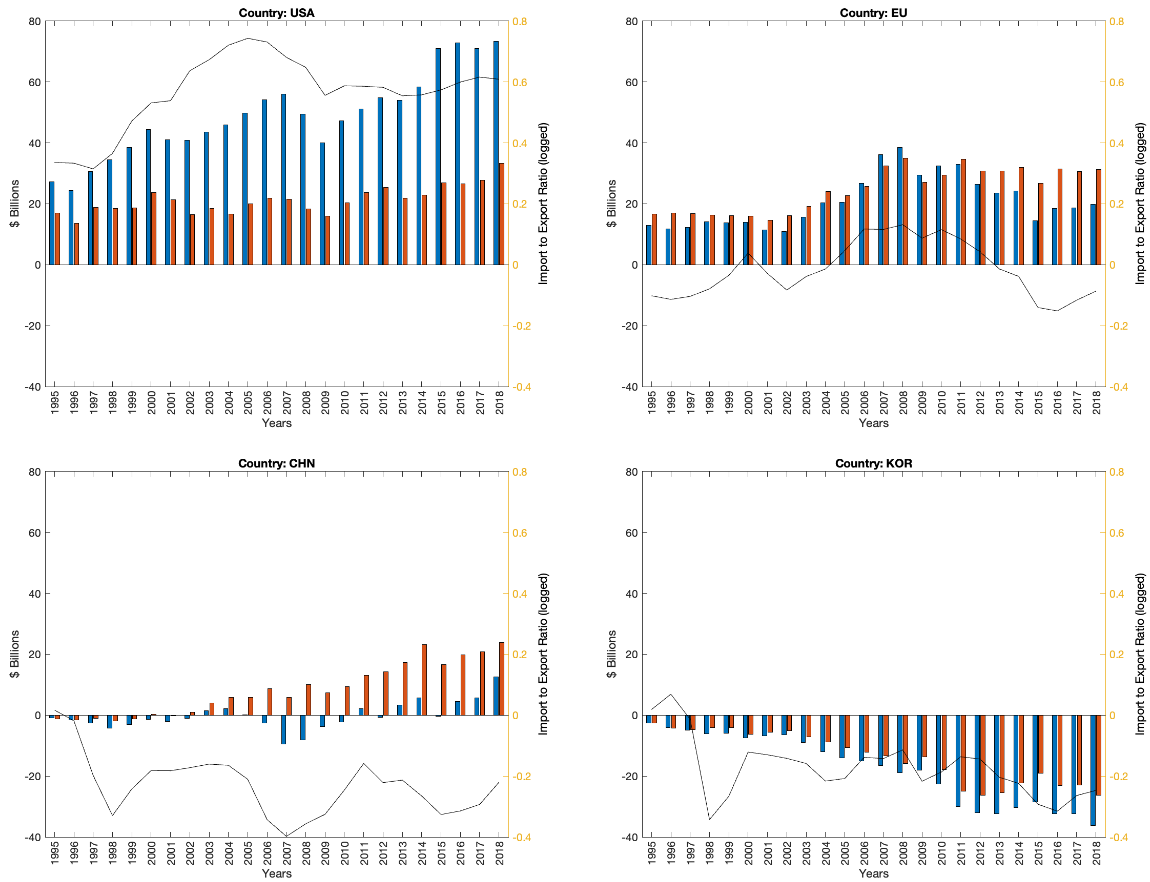
		Top Recipients of Net Concessions										
		KOR	**JPN**	**TWN**	**CHE**	**SGP**	**CAN**	**RUS**	**BRA**	**MEX**	**TUR**	Total
Top Granters of Net Concessions	**USA**	3,620	5,170	1,777	3,853	1,773	6,031	579	485	10,440	320	**73,430**
	EU	2,762	4,013	1,188	3,838	714	-57	3,949	1,385	-1,533	3,500	**19,883**
	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)



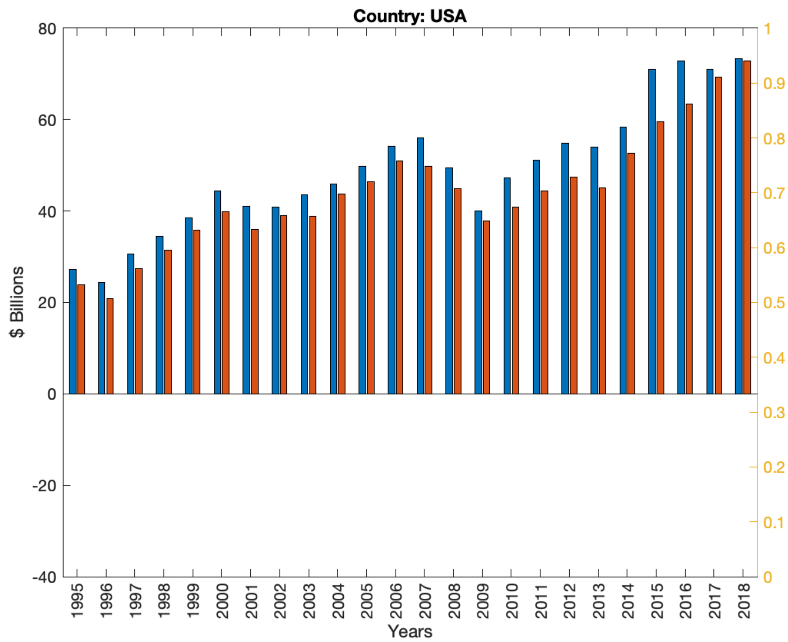
Note: The bars illustrate the terms-of-trade effects of bilateral cooperation between the U.S. (blue) and its partner (red) under two scenarios: the balanced-trade counterfactual scenario (represented by solid colors) and the factual trade scenario (represented by light colors). The net concessions granted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

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



Note: Refer to the footnotes of Figure 7 in the main text for further documentation.

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

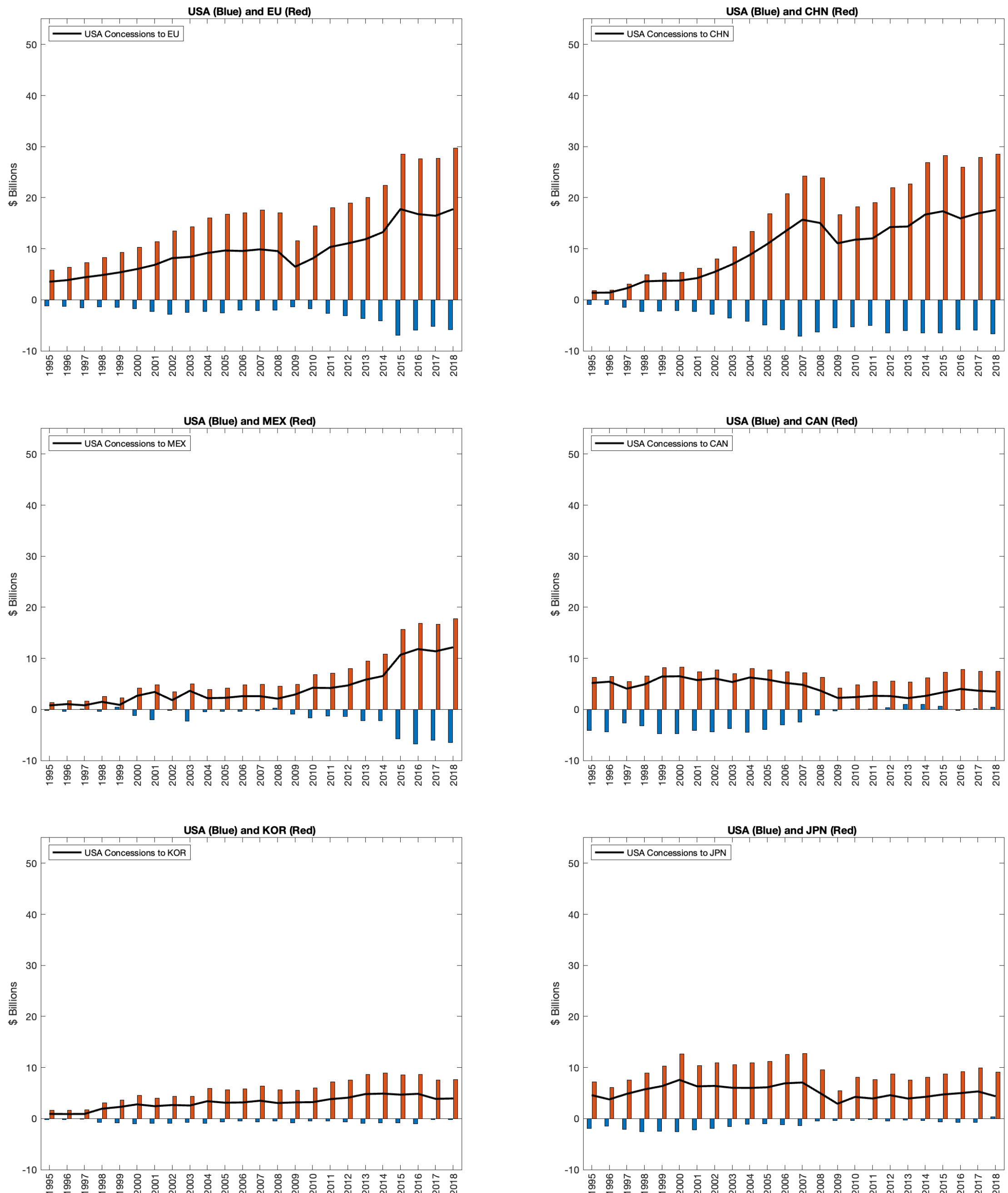


Note: The red bars represent the net concessions granted by the United States under the scenario where the United States applies to its imports the same sector-specific tariff rates that it faces in each of its bilateral relationships. The blue bars are the U.S.'s net concessions under the scenario where the bilateral Nash tariffs are used as the disagreement tariffs. The analysis is based on the baseline model.

D Alternative Noncooperative Benchmark: Uniform 50% Tariffs

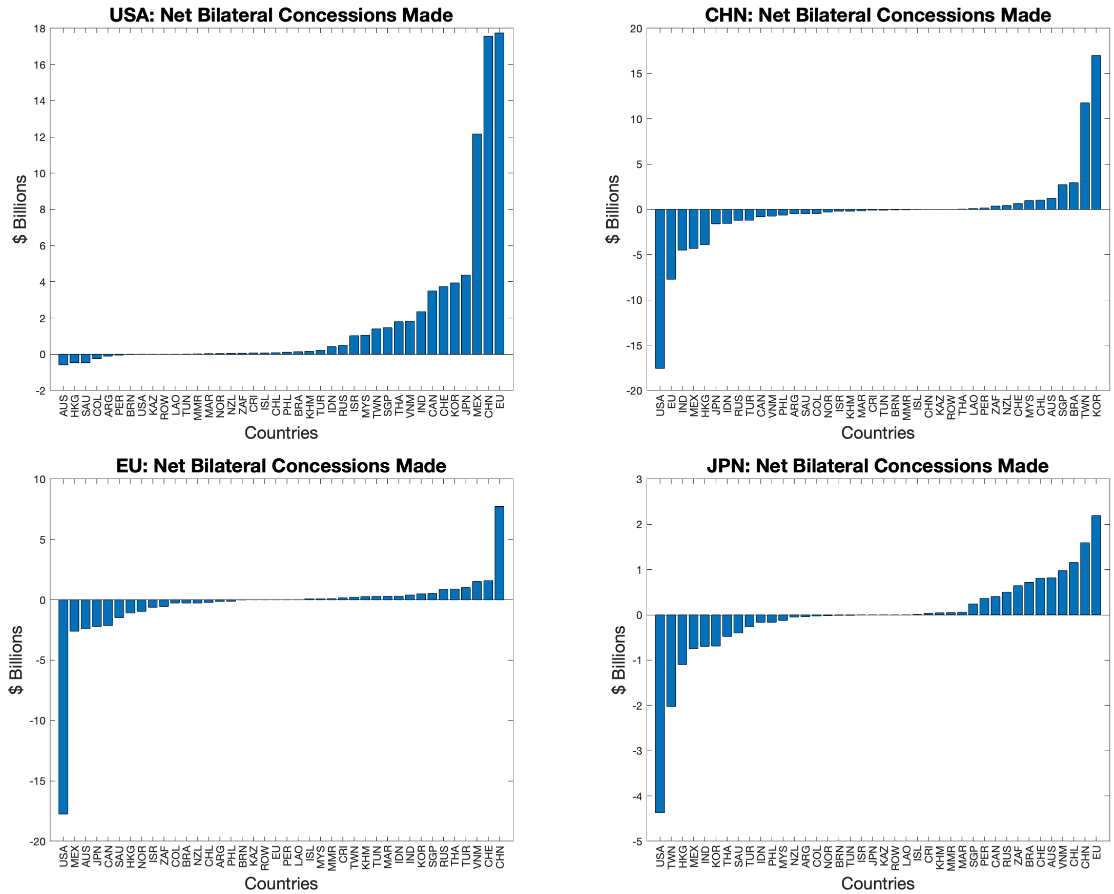
The following graphs illustrate the concessions for the noncooperative scenario where in each bilateral trade wars, both countries apply a tariff of 50% on their imports from each other. In the oil sector, and sectors with applied tariffs above 50%, the noncooperative tariff is set equal to applied tariffs. These figures correspond to Figures 1 and 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 U.S. and its Major Trading Partners (50% Noncooperative Tariffs)



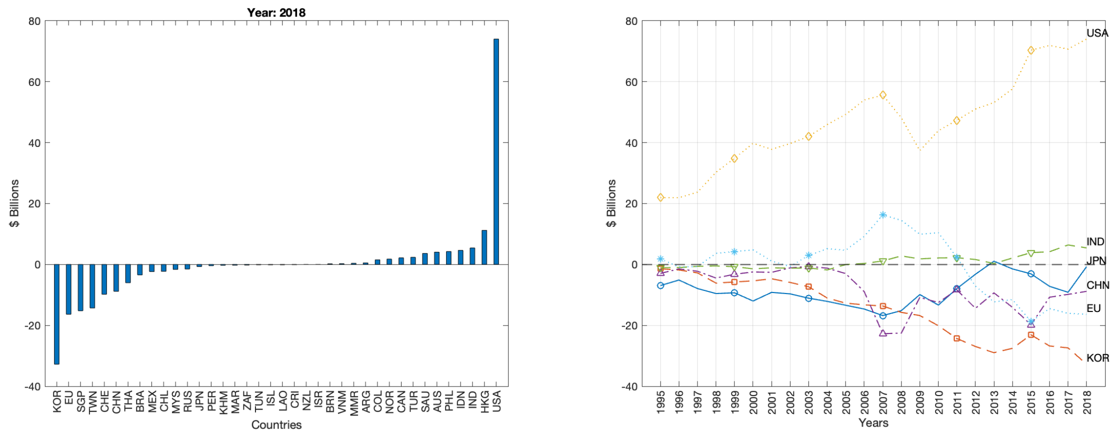
Note: *Compare with Figure 4 for the bilateral Nash noncooperative scenario.* Each panel illustrates the terms-of-trade effects of bilateral cooperation between the U.S. and one of its major trading partners. Blue (red) bars depict the magnitude of the effect on the U.S. (its partner). The black line depicts the net concessions granted by the U.S., computed using Equation (4). The analysis is based on the baseline model.

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



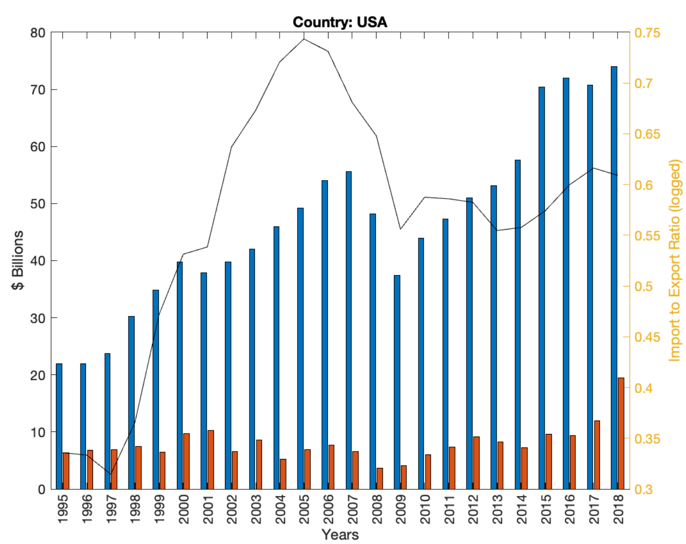
Note: *Compare with Figure 5 for the bilateral Nash noncooperative scenario.*

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



Note: *Compare with Figure 6 and Figure 1 for the bilateral Nash noncooperative scenario.* The left panel depicts the net multilateral concessions granted by each country in 2018. The right panel depicts the same measure for selected countries from 1995 to 2018. The analysis is based on the baseline model.

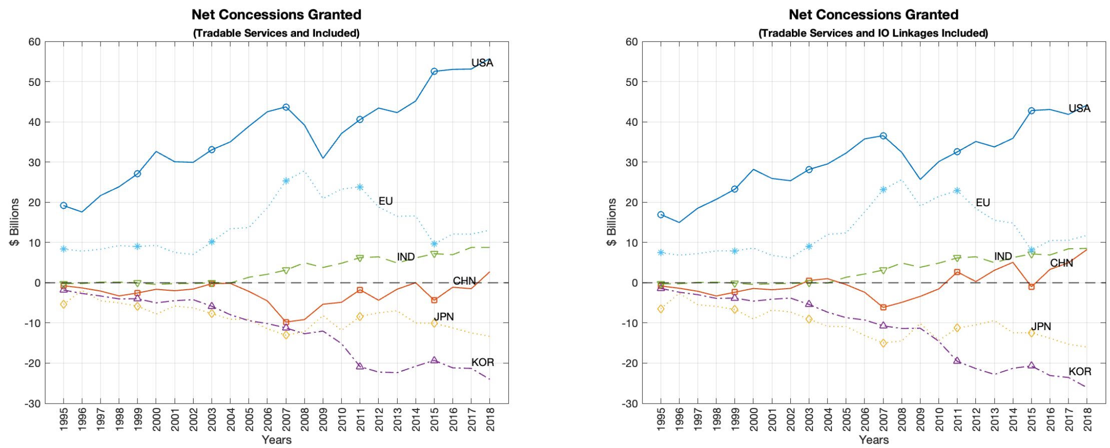
Figure D.4: Net Multilateral Concessions of the United States (50% Noncooperative Tariffs) — The Role of Trade Imbalances



Note: *Compare with Figure 7 for the bilateral Nash 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. The analysis is based on the baseline model.

E Service Sector and Input-Output Linkages: Additional Graphs

Figure E.1: Net Multilateral Terms-of-Trade Concessions Granted by Selected Countries (1995-2018)



Left panel: Service Sector Included. **Right panel:** Service Sector and Input-Output Linkages Included.

F Calibration

Table F.1: Calibration of Parameters and Measurement of Variables

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

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

$$\lambda_{ij,k} = \frac{x_{ij,k}}{\sum_l x_{lj,k}}, \tag{18}$$

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

$$P_{j,k} \equiv \left(\sum_n b_{nj,k}^{\sigma_k} \tilde{p}_{nj,k}^{1-\sigma_k} \right)^{\frac{1}{1-\sigma_k}}. \tag{19}$$

It follows that wage income of country i is:

$$
\begin{aligned}
w_i L_i &= \sum_j \sum_k \frac{\tilde{p}_{ij,k} \tilde{q}_{ij,k}}{1 + t_{ij,k}} \\
&= \sum_j \sum_k \frac{\lambda_{ij,k} \mu_{j,k} Y_j}{1 + t_{ij,k}}.
\end{aligned}
\tag{20}
$$

Therefore, the budget constraint (10) may be written as:

$$
\begin{aligned}
Y_j &= w_j L_j + \sum_k \sum_i \frac{t_{ij,k}}{1 + t_{ij,k}} \tilde{p}_{ij,k} \tilde{q}_{ij,k} + D_j \\
&= w_j L_j + \sum_k \sum_i \frac{t_{ij,k}}{1 + t_{ij,k}} \lambda_{ij,k} \mu_{j,k} Y_j + D_j.
\end{aligned}
\tag{21}
$$

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

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

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

$$\sum_j \delta_j = 0.$$

Given tariffs $\{t_{ij,k}\}$, an equilibrium is a vector of variables $\{w_j, Y_j, \lambda_{ij,k}, P_{j,k}\}$ that satisfies conditions (9) and (18)–(21) 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 (7), the welfare of country j derived from non-service sectors may be written as:

$$W_j = \left(\frac{Y_j}{\prod_k P_{j,k}^{\mu_{j,k}}} \right)^{\mu_j}. \tag{22}$$

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 F.2: Calibration of Parameters and Measurement of Variables for the Caliendo and Parro (2015) Framework

Parameters/Variables	Description
$\gamma_{j,k} = VA_{j,k}/Y_{j,k}$	The ratio of value added $VA_{j,k}$ to gross output $Y_{j,k}$ in sector k of country j
$\gamma_{j,lk} = \frac{Z_{j,lk}}{\sum_{l'} Z_{j,l'k}} \times (1 - \gamma_{j,k})$	The cost share of sector k's spending $Z_{j,lk}$ on goods from sector l as intermediate inputs in country j
$\pi_{ij,k} = \frac{X_{ij,k}}{\sum_{i'} X_{i'j,k}}$	The share of country j's expenditure $X_{ij,k}$ in sector k on goods from country i
$D_j = \sum_k \sum_i \left(\frac{X_{ij,k}}{1+t_{ij,k}} - \frac{X_{ji,k}}{1+t_{ji,k}} \right)$	The trade deficit of country j
$\delta_j = \frac{D_j}{\sum_i \sum_k Y_{i,k}}$	The ratio of country j's trade deficit to world gross output
$R_j = \sum_k \sum_i t_{ij,k} \frac{X_{ij,k}}{1+t_{ij,k}}$	The tariff revenue of country j, imputed by tariff rates multiplied by import values
$I_j = w_j L_j + R_j + D_j = VA_j + R_j + D_j$	The final absorption of country j, imputed by the sum of value added, tariff revenue, and trade deficit
$\alpha_{j,k} = \left(\sum_i X_{ij,k} - \sum_l \gamma_{j,kl} Y_{j,l} \right) / I_j$	The share of country j's final consumption expenditure on goods from sector k
θ_k	Productivity dispersion (or trade elasticity) of sector k

Table F.3: 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 F.4: 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‡
23	D36T39, ..., D97T98	36-39, ..., 97-98	Service sectors combined	6§

Note: The table reports the list of sectors used in the study. The trade elasticity is estimated based on the approach of Caliendo and Parro (2015), corresponding to the regression coefficient of trade flows (in ratios) to tariff variations (in ratios). 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.

§ We choose a trade elasticity of 6 for the combined service sector, in line with the median estimates for the service sectors reported by Ahmad and Schreiber (2024) and Freeman et al. (2025).