A World Trading System For Whom? Evidence from Global Tariffs*

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Abstract

We use global tariffs to reveal the weights that nations implicitly place on the welfare of their trading partners relative to their own. Our estimated welfare weights suggest that formal and informal rules of the world trading system make countries internalize the impact of their policies onto others to a substantial extent, though not fully. On average, countries place 25% less value on transfers to foreigners than transfers to their own residents. Across nations, we find that countries that put higher welfare weights on the welfare of foreigners also tend to receive higher weights from them, consistent with a general form of reciprocity among nations. Using our estimated welfare weights, we provide a first look at what countries stand to lose, or gain, from the dissolution of the world trading system as we know it.

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1 Introduction

The world trading system is under stress. It is unclear how much of the formal rules and informal norms that have sustained globalization for more than half a century will survive the onslaught. How concerned should we be? Looking back, was the post-WWII trading system successful at fostering international cooperation and, if so, who benefited from such cooperation? Looking ahead, how much is there to win or lose for a country now committed to extracting the largest possible share of a potentially shrinking global pie? The goal of this paper is to shed light on these questions.

Our starting point is the observation that international cooperation is, at its core, about countries internalizing the impact that their own policies impose on others. Measuring international cooperation therefore amounts to estimating the extent to which they do. In this paper we operationalize this general idea by using countries' observed tariff-setting choices as a way to reveal the weights that they implicitly place on the welfare of each of their trading partners relative to their own.

In practice, there are many institutional features, both formal and informal, that might give countries incentives to set their tariffs in a cooperative manner. Countries may choose low tariffs by fear of future retaliation, as in Dixit (1987) and Maggi (1999), or they may simply be constrained by GATT/WTO rules, as in Bagwell and Staiger (1999). The key advantage of our empirical strategy is that it does not require us to take a stand on the specific ways through which such considerations might shape international cooperation. If rules of the world trading system are completely ineffective, then we should observe that countries follow their own self-interest and put zero weight on the welfare of others. If instead these rules are successful in fostering cooperation, then we should observe that countries at least partly internalize the impact of their own policies on their trading partners and place non-zero weight on changes in their utilities.

Our baseline analysis focuses on 2001, just as the phase-in of the tariff concessions from the WTO's last round of negotiations was approaching universal completion. To learn about how much countries value each other's welfare, we combine data on global tariffs with measures of the incidence of these tariffs on real incomes around the world. Intuitively, if imports of certain goods have disproportionately positive effects on real incomes in some countries, then a country imposing low tariffs on these goods reveals that, all else equal, it puts more weight on the welfare of these countries. We formalize this intuition via an optimal tariff formula that allows for "as-if" altruistic motives across countries.

According to this formula, optimal trade taxes can be decomposed into the sum of two terms: (i) a classical terms-of-trade manipulation motive; and (ii) a new altruistic motive. The altruistic motive is itself a weighted sum of the changes in real income around the world caused by import restrictions, with weights equal to the marginal utility of income that the country restricting imports assigns to each of its trading partners relative to itself. If there are no altruistic motives, the tariffs predicted by our formula coincide with those of a one-shot Nash equilibrium. If all countries agree on the marginal utility of income that should be given to any country around the world, our formula describes the set of globally Pareto efficient tariffs. In between these extreme cases, our formula also applies to a wide class of dynamic tariff-setting games in which any one country's deviation from the welfare levels promised to trading partners along the equilibrium path can trigger retaliation. Under this interpretation, welfare weights correspond to the Lagrange multipliers associated with each of these utility constraints.

From an empirical standpoint, our formula opens up the possibility of estimating the marginal value β_{ij} that a given country j assigns to the income of one of its trading partners i, relative to its own income, by running a simple linear regression. The regression's dependent variable is the difference between country j's observed tariff on a given good g and the opportunistic tariff predicted by the classical terms-of-trade manipulation motive, and its regressors are the changes in real income in different countries i caused by country j's import restrictions of good g. To implement this strategy, we need data on global tariffs, estimates of opportunistic tariffs, and estimates of the welfare incidence of various import restrictions on the rest of the world. For global tariffs, we rely on the Global Tariff Database from Teti (2024). Our baseline analysis focuses on 28 trading partners and 5,113 products. For estimates of opportunistic tariffs and the incidence of import restrictions on foreign welfare, we use quantitative model of the world economy featuring multiple sectors, each with multiple products, and global input-output linkages. We calibrate it using estimates from Fajgelbaum et al. (2020) and show using the procedure from Adão et al. (2025a) that the calibrated model is able to replicate the relationship between changes in tariffs and changes in real income observed in the data between 1996 and 2019.

Our baseline estimates reveal three key features. First, there is significant international cooperation. All of the countries in our sample internalize the impact of their policies onto others to a non-trivial extent. The average value of β_{ij} that we estimate is 0.75. This implies that, for a typical importer, the value of one dollar transferred to another country is 25% lower than the value of that same dollar transferred to its own residents. Second, despite this widespread and generous as-if altruism, we do formally reject that the tariffs in our sample are set in a Pareto-efficient manner. Third, our analysis reveals that "cooperative" countries, which put more weight on the welfare of foreigners, also tend to receive higher welfare weights from foreigners. This positive correlation between β_{ij} and β_{ji} suggests a general form of reciprocity à la Axelrod (1984) within the world trading system: cooperative behavior by one country, in the form of a higher welfare weight, is reciprocated with cooperative behavior by its partner, also in the form of higher welfare weight.

Interestingly, this reciprocal pattern is not a salient feature of raw tariff data, nor does it appear to be a manifestation of participation in formal trade agreements, either related to membership in the WTO or a Preferential Trade Agreement (PTA), since reciprocal behavior is evident even after conditioning on such participation. The same pattern also holds in the time series. When using tariffs over the full period 1996-2019, we find that the average value of β_{ij} rises over the period and that reciprocity in welfare weights is strong year by year as well as in changes over time (in a way that, like in the cross-section, reciprocity in raw tariffs is not).

These findings are robust to a number of departures from our baseline analysis. One extension introduces multiple factors of production in our baseline model, thereby creating redistributive motives for trade protection within each country. A second considers alternative calibrations of our model's key parameters. Despite the fact that opportunistic tariff levels are sensitive to these considerations, we show that our main findings are not. The last extensions we pursue incorporate real-world features of GATT/WTO rules and negotiations, as well as the potential for simultaneity bias in our baseline OLS regressions.

The final part of our paper provides a first look at what countries stand to lose—or gain—from the dissolution of the world trading system as we know it. We begin by studying each country's individual incentives to exit the global system by asking how its real income would change if it assigned zero welfare weights to others and others reciprocated by assigning zero weight to it. All countries lose from such exits, consistent with the idea that gains from reciprocal behavior have, historically, held together the world trading system. We then consider an alternative scenario in which a breakaway United States assigns zero welfare weights to others while managing—perhaps through threats of further punishment—to induce other countries to place equal welfare weights on the United States and themselves. Even in such an extreme scenario, the United States would only gain 0.8% of real income, an order of magnitude smaller than the overall US gains from trade.

Related Literature

To evaluate the consequences of international rules and institutions, trade economists typically proceed as follows. They start from a hypothetical world in which such institutions are absent, solve for the "Nash" tariffs that countries would unilaterally choose if left unconstrained, and then characterize how the introduction of specific institutions, either in the form of constraints on their strategy sets or repeated interactions, may lead to new policy choices and sustain international cooperation. Bagwell and Staiger (2002) offer an overview and various applications of this canonical approach.

In this paper, we propose instead to estimate directly the combined effect of these institutions on international cooperation, as measured by the extent to which each country internalizes the impact of its own policy on each of its trading partners, without making explicit assumptions about how different rules and institutions affect countries' strategic interactions. This general strategy is the global counterpart to the revealed preference approach that we have used in Adão et al. (2025b) to estimate the determinants of redistributive trade protection within the United States. It has similar benefits, in terms of the robustness of our welfare weight estimates, and costs, in terms of ruling out counterfactual simulations where these weights may endogenously change.

Throughout our analysis, we assume that the impact of countries' tariffs onto their trading partners travels through changes in their terms of trade. This creates a direct relationship between our findings and prior evidence about the role played by terms-of-trade considerations, both when countries set their tariffs unilaterally (Broda et al., 2008) and when they negotiate them (Bagwell and Staiger, 2011 and Ludema and Mayda, 2013). In their test of the classical optimal tariff motive, Broda et al. (2008) document that, for a number of non-WTO countries, tariffs are positively correlated with the inverse of the foreign export supply elasticities that they have estimated. Although the sign of this correlation is qualitatively consistent with the classical optimal tariff motive, the magnitude of this relationship is much smaller than what self-interested manipulation alone would predict. The perspective put forward by our paper is that the latter observation is informative about the extent to which countries happen to internalize terms-of-trade externalities and therefore cooperate with one another.

Our findings that cooperative behavior by one country, in the form of a higher welfare weight, tends to be reciprocated with cooperative behavior by its partner, also in the form of a higher welfare weight, is consistent with the evidence from Limão (2006) about US tariff cuts during the Uruguay round. He documents that such tariff cuts were systematically larger on products exported by countries that had themselves offered larger tariff cuts. However, as alluded to before, we find that reciprocal behavior is far more apparent in our estimated welfare weights than in the raw tariff data.[1] We also find that it holds both among WTO countries and non-WTO countries who have never directly participated in such trade negotiations. This suggests that the pattern of international cooperation via reciprocity that we document may reflect more than the impact of formal GATT/WTO rules.

Our analysis also contributes to the quantitative literature on the costs of trade wars and the benefits of trade talks, including Perroni and Whalley (2000) and Ossa (2014), the welfare and labor market consequences of specific WTO rules, as in Bagwell et al. (2021) and Bown et al. (2023), and the broader gains from international cooperation in Ritel (2024). Among the previous papers, our analysis is closely related to Ritel (2024) who also introduces and estimates altruistic motives across countries. Although his paper and ours share a common starting point and similar objectives, they differ both in terms of their implementation and substantial findings. From a theoretical standpoint, we build our analysis around a general tariff formula with as-if altruistic motives, which, as we formally establish, can capture the impact of both formal and informal features of the world trading system. From an empirical standpoint, we use granular tariff data to estimate welfare weights for more than 700 importer-exporter pairs. This focus on pair-specific welfare weights is critical to uncover reciprocity among nations as well as to identify the conditions under which reciprocity is more likely to emerge.[2]

Finally, our analysis relates to, and has implications for, the recent literature on geoeconomics. It is common in this area to use UN voting behavior as a proxy for political alignment between nations (e.g. Clayton et al. 2024, Kleinman et al. 2024, Becko et al. 2025, Broner et al. 2025, and Gopinath et al. 2025). The welfare weights estimated in this paper offer an alternative measure of alignment based on evaluating whether trade policies chosen by one country tend to systematically benefit another.

2 Optimal Trade Taxes with As-If Altruism

The goal of this section is to characterize the structure of optimal trade taxes with as-if altruism across countries. As we will explain shortly, these motives can be interpreted as the reduced-form impact of formal constraints on the strategy sets faced by otherwise self-interested countries or as the reduced-form impact of the informal threats of punishment

[1] In Limão (2006), the preferred estimates of the impact of foreign tariff cuts on US tariff cuts range from 0.014 to 0.018 for products not subject to Non-Tariff Barriers (NTBs). They are of the opposite signs for products subject to NTBs.

[2] In using a quantitative model to shed light on the efficiency of the world trading system, our paper also bears some broad relation to the test of optimal international risk sharing developed by Fitzgerald (2012).

that they face in a dynamic game.

2.1 A General Neoclassical Environment

We consider a general neoclassical environment à la Dixit and Norman (1980). There are multiple countries, indexed by either i or $j \in \mathcal{I}$, and multiple goods, indexed by $g \in \mathcal{G}$.[3]

Supply. In each origin country i, there is a representative firm with production set Y_i. Aggregate factor endowments in country i are implicitly embedded in Y_i. The firm chooses its net output vector $y_i \equiv \{y_{gi}\}$ to solve

$$\max_y p_i \cdot y \quad (1)$$
$$\text{subject to: } y \in Y_i,$$

where $p_i \equiv \{p_{gi}\}$ denotes the vector of prices in country i and the dot product $\cdot$ refers to the inner product, $p_i \cdot y = \sum_g p_{gi} y_g$. We let $r_i(p_i) \equiv \max\{p_i \cdot y | y \in Y_i\}$ denote the associated revenue function.

Demand. In each destination country j, there is a representative consumer with utility $u_j(c_j)$ that depends on her consumption vector $c_j \equiv \{c_{gj}\}$. The consumer chooses c_j to solve

$$\max_c u_j(c) \quad (2)$$
$$\text{subject to: } p_j \cdot c = r_j(p_j) + \tau_j,$$

where τ_j denotes a lump-sum transfer from country j's government. Below we let $e_j(p_j, u) \equiv \min_c\{p_j \cdot c | u_j(c) \geq u\}$ denote her expenditure function.

Government. In each country j, the government may impose specific trade taxes $t_j \equiv \{t_{gj}\} \in \mathcal{T}_j$. Trade taxes create a wedge between local prices $p_j \equiv \{p_{gj}\}$ and world prices $p^w \equiv \{p^w_g\}$. For any good g traded between country j and the rest of the world,

$$p_{gj} = p^w_g + t_{gj}. \quad (3)$$

[3] In standard Arrow-Debreu fashion, we implicitly allow goods to be differentiated by their location of production and consumption. Consistent with this convention, the counterpart of a good g in our empirical analysis will be a triplet consisting of a product category, an origin country, and a destination country. We come back to this point in Section 3.

If country j imports good g, $t_{gj} \geq 0$ corresponds to an import tariff, while $t_{gj} \leq 0$ corresponds to an import subsidy. If country j exports good g, $t_{gj} \geq 0$ corresponds to an export subsidy, while $t_{gj} \leq 0$ corresponds to an export tax. Trade taxes on a given good g are either unrestricted, $t_{gj} \in \mathbb{R}$, or restricted to be zero, $t_{gj} \in \{0\}$. We let $\mathcal{G}_j^T$ denote the set of goods that can be taxed in country j and assume that at least one good is excluded from $\mathcal{G}_j^T$. In our quantitative model, all goods exported by a given country j will be excluded.[4] Government budget balance requires

$$t_j \cdot (c_j - y_j) = \tau_j + T_j, \tag{4}$$

with T_j the transfer received by country j from the rest of the world, expressed in units of the numeraire. Throughout our analysis, we treat T_j as an exogenous parameter whose only purpose is to rationalize observed trade imbalances. By definition, $\sum_{j \in \mathcal{I}} T_j = 0$.

Market Clearing. Supply equals demand for all goods,

$$\sum_{i \in \mathcal{I}} c_i = \sum_{i \in \mathcal{I}} y_i. \tag{5}$$

Competitive Equilibrium. We are now ready to define a competitive equilibrium.

Definition 1. *A competitive equilibrium with trade taxes $\{t_i\}$ is a vector of output $\{y_i\}$, consumption $\{c_i\}$, local prices $\{p_i\}$, world prices $\{p^w\}$, and transfers $\{\tau_i\}$ such that: (i) y_i solves (1); (ii) c_i solves (2); (iii) p_i and p^w satisfy (3); (iv) τ_i satisfies (4); and (vi) all markets clear, as described in (5).*

2.2 Definition of Optimal Trade Taxes with As-If Altruism

It is standard in the trade literature to model each country as choosing its own policy in order to maximize its own welfare, potentially subject to constraints imposed by the WTO or other international arrangements. The question of interest then is how different constraints map into different policy choices. We propose instead to remain agnostic about the specifics of these institutional constraints and focus attention on the extent to which these constraints are successful in making countries internalize the impact of their policies onto others.

[4] Anchoring trade taxes at zero for some goods rules out indeterminacy in the optimal level of taxes.

Definition 2. *In any country j, we say that the vector of trade taxes t_j is optimal with as-if altruism if there exists a vector of welfare weights $\{\lambda_{ij}\}$ such that t_j solves*

$$\max_{t \in \mathcal{T}_j, \{u_i\}} u_j + \sum_{i \neq j} \lambda_{ij} u_i \tag{6}$$
$$\text{subject to: } \{u_i\} \in \mathcal{U}(t, t_{-j}),$$

where $\mathcal{U}(t, t_{-j})$ is the set of utility profiles attainable in a competitive equilibrium with trade taxes (t, t_{-j}) and t_{-j} is the vector of trade taxes imposed by the rest of the world.

Definition 2 nests several important special cases from the existing literature.

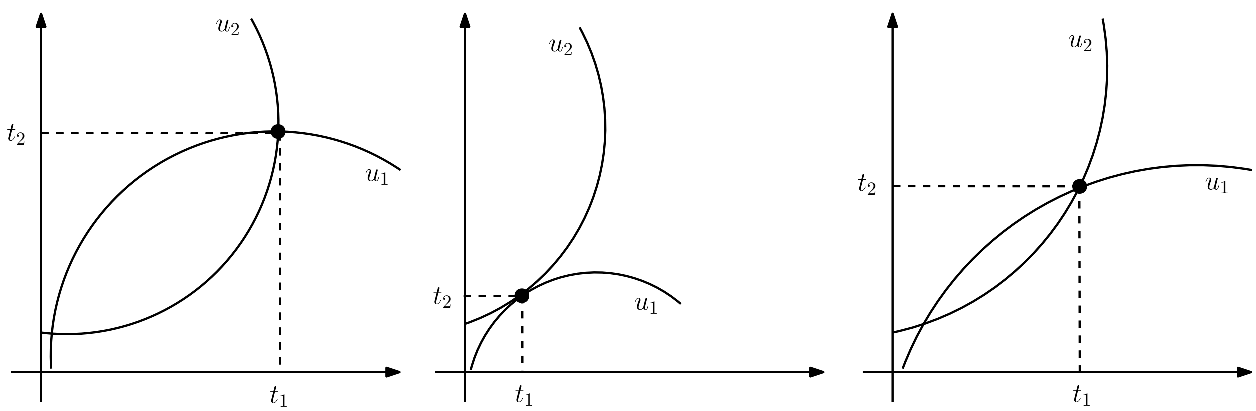
Example 1: Nash Tariffs. If $\lambda_{ij} = 0$ for all $i \neq j$, then countries are purely opportunistic. In this situation, the trade taxes given by (6) coincide with the one-shot Nash equilibrium of the unconstrained tariff game between self-interested countries. This is the situation illustrated in Figure 1a.

Example 2: Efficient Tariffs. If the welfare weights instead take the form $\lambda_{ij} = \lambda_i / \lambda_j > 0$ for some underlying vector $\lambda \equiv \{\lambda_j\} > 0$, then the trade taxes given by (6) instead coincide with a global Pareto optimum, in which tariffs $\{t_j\}$ maximize a common global welfare function, $\sum_j \lambda_j u_j$, as shown in Figure 1b.[5] One particular point of interest along the global Pareto frontier is the one where the vector λ equalizes the social marginal utility of income across countries. As shown by Bagwell and Staiger (1999), it corresponds to the only Pareto optimum implementable when formal rules—akin to those imposed by the WTO—incentivize countries to ignore their ability to manipulate their terms of trade. We return to this important observation below.

Example 3: Self-Enforcing Tariffs. Definition 2 applies more generally to self-enforcing tariffs in a dynamic environment. To see this, suppose that countries' tariffs in each year are their actions in a repeated game whose stage payoffs are determined by the economic environment described in Section 2.1. Suppose, furthermore, that the equilibrium of this game is such that if country j were to deviate from its on-the-equilibrium-path tariffs t_j in

[5] Note that the set of global Pareto optima is the same regardless of whether one views the true preferences in country j as being given by u_j or $u_j + \sum_{i \neq j} \lambda_{ij} u_i$, i.e., regardless of whether one chooses to treat altruistic motives as "as-if" or not. This follows from the observation that if $\{t_j\}$ maximizes $\sum_j \lambda_j (u_j + \sum_{i \neq j} \lambda_{ij} u_i)$, then it also maximizes $\sum_j \tilde{\lambda}_j u_j$ with $\tilde{\lambda}_j \equiv \lambda_j + \sum_{i \neq j} \lambda_i \lambda_{ji}$. The same observation applies if the welfare weights λ_{ij} are negative, as emphasized by Mattoo et al. (2024) when analyzing international trade agreements in the presence of geopolitical motives.

Figure 1: Optimal Trade Taxes with As-If Altruism



Notes: This figure describes optimal trade taxes with as-if altruistic motives for two countries, $j = 1$ and $j = 2$, each of which taxes the imports of a single good. The two curves represent combinations of trade taxes that keep their utility constant at u_1 and u_2, respectively. Figure 1a illustrates the case of Nash tariffs imposed by self-interested countries in the unconstrained one-shot game, i.e., $\lambda_{ij} = 0$ if $i \neq j$. Figure 1b illustrates the case of efficient tariffs where countries maximize the same global welfare function, i.e., $\lambda_{ij} = \lambda_i/\lambda_j > 0$. Figure 1c illustrates the case of self-enforcing tariffs where λ_{ij} is the Lagrange multiplier associated with (7).

a way that affects the welfare of its trading partners $i \neq j$, then others might punish or reward it in the future. If not, they would continue to impose the same on-the-equilibrium-path tariffs t_{-j}.[6]

Given this restriction, on-the-equilibrium-path tariffs t_j must solve

$$\max_{t \in \mathcal{T}_j, \{u_i\}} u_j \tag{7}$$
$$\text{subject to: } u_i = \underline{u}_i \text{ for all } i \neq j,$$
$$\{u_i\} \in \mathcal{U}(t, t_{-j}),$$

where $\underline{u}_i$ denotes the utility received by country i along the equilibrium path. The formal argument is straightforward. If t_j does not satisfy (7), then country j could strictly increase

[6]We view this equilibrium refinement as extremely mild. It excludes equilibria where country j deviates from its on-the-equilibrium-path tariffs t_j *without* changing the welfare of its trading partners $i \neq j$, but its trading partners nevertheless punish or reward country j for deviating. Such equilibria are implausible for two reasons. First, they require a high level of sophistication among trading partners that are able to sustain greater cooperation by punishing deviations that have no direct welfare effects. Second, they may run afoul of WTO rules. In his discussion of the role of remedies in the WTO system, for instance, Lawrence (2003) notes that under the Understanding on Rules and Procedures Governing the Settlement of Disputes, "allowed responses, particularly retaliation, relate to nullification and impairment of benefits between the parties rather than violations of the rules in general."

its utility without triggering any change in the future behavior of its trading partners, thereby contradicting the optimality of t_j along the equilibrium path.[7]

In such an environment, the welfare weights appearing in (6) correspond to the Lagrange multipliers associated with the utility constraint, $u_i = \underline{u}_i$. Accordingly, the as-if altruistic motives in Definition 2 may capture the primitive determinants of equilibrium utility levels, from differences in geography or size that affect countries' ability to punish and be punished, as in Maggi (1999), to political considerations that affect the extent to which policy makers discount the benefits from future cooperation, as in Conconi et al. (2014). Figure 1c describes what such self-enforcing tariffs may look like. Compared to the two cases plotted in Figures 1a and 1b, the indifference curves of the two countries are neither orthogonal nor tangent, but instead intersect at an acute angle. Since countries may disagree on the welfare weights that each of them should receive, a "lens" of Pareto-superior allocations opens up, unlike in Figure 1b. But since countries at least partially internalize the impact of their own actions on others, this lens is smaller than in the one-shot Nash equilibrium depicted in Figure 1a.

Based on the previous observations, we view Definition 2 as a useful starting point for investigating the extent to which countries cooperate internationally. It can capture situations where countries internalize the impact of their trade taxes on some, but not all of their trading partners. This may occur because only a subset of countries are able or willing to bargain over tariffs, say those that are part of the WTO, leading their tariffs $\{t_j\}_{j \in \text{WTO}}$ to maximize $\sum_{j \in \text{WTO}} \lambda_j u_j$. Our framework also accommodates cases where countries place negative weight on one another's welfare due to punitive sanctions, as in Becko (2024), or economic rivalry, as in Mattoo et al. (2024). We acknowledge, though, that not all tariff settings would lead to the form of as-if altruism described in equation (6). In particular, it does not nest the outcome of the bargaining protocol with transfers in Ludema and Mayda (2013) nor the Nash-in-Nash protocol in Bagwell et al. (2021). In both cases, there exist welfare weights that countries implicitly place on each other when choosing trade taxes, but these weights may differ depending on whom they negotiate a

[7] It should be clear that this formal argument does not rely on countries only choosing tariffs. It also applies if each country j chooses its tariff t_j as well as a vector of other policies $s_j \in \mathcal{S}_j$ to solve

$$\begin{aligned} &\max_{t \in \mathcal{T}_j, s \in \mathcal{S}_j, \{u_i\}} u_j \\ &\text{subject to: } u_i = \underline{u}_i \text{ for all } i \neq j, \\ &\qquad\qquad \{u_i\} \in \mathcal{U}(t, s, t_{-j}, s_{-j}). \end{aligned}$$

Other policies s_j may include labor and environmental standards, as in Bagwell and Staiger (2001), various forms of red tape at the border, as in Maggi et al. (2022), or some geopolitical action, as in Becko and O'Connor (2025) .

particular trade tax with.[8]

2.3 Characterization of Optimal Trade Taxes with As-If Altruism

To characterize optimal trade taxes with as-if altruism, we focus on the set of necessary first-order conditions associated with (6). In any country j, for the vector of trade taxes t_j to be optimal, it must be the case that for any small variation dt around country j's vector of trade taxes,

$$du_j + \sum_{i \neq j} \lambda_{ij} du_i = 0. \tag{8}$$

From the budget constraint of the representative consumer in any country i, we know that utility levels in each country are such that $e_i(p_i, u_i) = r_i(p_i) + \tau_i$. Totally differentiating the previous constraint and invoking standard envelope arguments on the demand and supply side, we therefore have

$$e_{i,u} du_i = -m_i \cdot dp^w + t_i \cdot dm_i, \tag{9}$$

where $e_{i,u} \equiv \partial e_i(p_i, u_i)/\partial u_i$ and we have used (3) and (4) to substitute for the change in the lump-sum transfer $d\tau_i$. The first term, $-m_i \cdot dp^w$, captures welfare changes in country i caused by changes in its terms of trade, with $m_i \equiv c_i - y_i$ the vector of country i's net imports, whereas the second term, $t_i \cdot dm_i$, reflects the fiscal externality associated with changes in tariff revenues.

Substituting (9) into (8), we obtain

$$t_j \cdot dm_j = m_j \cdot dp^w - \sum_{i \neq j} \beta_{ij} d\omega_i, \tag{10}$$

where $\beta_{ij} \equiv \lambda_{ij}(e_{j,u}/e_{i,u})$ is the ratio of the marginal utility of income in country i to the marginal utility of income in country j, evaluated from the point of view of country j, and $d\omega_i \equiv -m_i \cdot dp^w + t_i \cdot dm_i$ denotes the change in country i's real income caused by changes in its terms of trade and the fiscal externality.

There are many possible ways to rearrange condition (10). One strategy consists of focusing on a series of variations dt that only changes the tax t_{gj} that country j imposes on a single good $g \in \mathcal{G}_j^T$. Another, which we find both theoretically insightful and empirically convenient, consists of considering a variation dt that may affect multiple taxes simultaneously, but instead only affects the net imports m_{gj} of a single good, as in Costinot and

[8] Appendix A offers a formal discussion as well as a strict generalization of Definition 2 that nests Ludema and Mayda (2013) and Bagwell et al. (2021).

Werning (2023) and Adão et al. (2025b). Using this particular set of first-order conditions is equivalent to treating all equilibrium variables as implicit functions of country j's vector of taxable imports $m_j^T \equiv \{m_{gj}\}_{g \in \mathcal{G}_j^T}$—rather than its trade taxes $t \equiv \{t_{gj}\} \in \mathcal{T}_j$—and then taking partial derivatives with respect to m_{gj} for all $g \in \mathcal{G}_j^T$.[9]

Starting from (10) and implementing this strategy, we obtain the following characterization of optimal trade taxes with as-if altruism.

Proposition 1. *In any country j, the optimal trade tax with as-if altruism satisfies*

$$t_{gj} = t_{gj}^o - \sum_{i \neq j} \beta_{ij} (\partial \omega_i / \partial m_{gj}), \text{ for all goods } g \in \mathcal{G}_j^T, \tag{11}$$

where $t_{gj}^o \equiv m_j \cdot (\partial p^w / \partial m_{gj})$ is the opportunistic tariff that would arise if $\beta_{ij} = \lambda_{ij} = 0$ for $i \neq j$.

Proposition 1 highlights two key determinants of country j's trade taxes. First, country j's optimal tax on any good g depends on how much restricting imports of that good can help it improve its overall terms of trade, as reflected in $t_{gj}^o \equiv m_j \cdot (\partial p^w / \partial m_{gj})$. This is the classical motive for an optimal tariff. Countries' consumers and firms are price-takers that do not internalize the marginal impact of their import decisions on world prices. The optimal trade tax makes them do so. Second, import restrictions on good g in country j also affect any other country i's real income, both via changes in its terms of trade and fiscal revenues, as reflected in $\partial \omega_i / \partial m_{gj}$. A country with (as-if) altruistic motives also wants to take these changes into account, with β_{ij} measuring the extent to which it does.

To understand how we will later identify the as-if altruistic motives of a given country j, consider a simpler environment in which there are no trade taxes in the rest of the world, so that $\partial \omega_i / \partial m_{gj} = -m_i \cdot (\partial p^w / \partial m_{gj})$. If $\beta_{ij} = 0$ for all $i \neq j$, we should therefore observe the opportunistic tariff $t_{gj} = t_{gj}^o$. If $\beta_{ij} = 1$ for all $i \neq j$ instead, then $t_{gj} = 0$ since $m_j \cdot (\partial p^w / \partial m_{gj}) + \sum_{i \neq j} m_i \cdot (\partial p^w / \partial m_{gj}) = 0$ by the good market clearing condition, $\sum_{i \in \mathcal{I}} m_i = 0$. Intuitively, changes in world prices are pure transfers between exporting and importing countries; so, the terms-of-trade manipulation motive disappears when country j puts the same marginal utility of income on all countries, and free trade should be observed. The same simple manipulation of the good market clearing condition implies that if $\beta_{ij} = \beta \in (0,1)$ for all $i \neq j$, then $t_{gj} = (1-\beta) t_{gj}^o$, i.e., a smaller tariff t_{gj} than

[9] Formally, if $\tilde{x}(t)$ denotes the equilibrium value of a variable x as a function of country j's taxes t (holding trade taxes t_{-j} fixed in other countries), then the function of imports $x(m_j)$ that we consider is defined as $x(m_j^T) \equiv \tilde{x}(t^{-1}(m_j^T))$, with $t^{-1}(m_j^T)$ the vector t that solves: $\tilde{m}_{gj}(t) = m_{gj}$ for all $g \in \mathcal{G}_j^T$. This change of variables requires that, local to the observed equilibrium, the inverse $t^{-1}(m_j^T)$ exists and is unique, a weak requirement that will be satisfied in our subsequent analysis.

the one predicted by opportunistic terms-of-trade manipulation. The general idea, which we will put to work in order to estimate the full matrix of welfare weights $\{\beta_{ij}\}$, is that one can use differences between t_{gj} and t^o_{gj} in order to reveal the extent to which country j's internalizes the impact of its own policies onto its different trade partners.

Among the previous examples, the case $\beta_{ij} = 1$ for all $i \neq j$ is an important focal point that nicely illustrates how the introduction of formal rules may create as-if altruistic motives among otherwise self-interested countries. Suppose, following Bagwell and Staiger (1999), that a given country j may only consider (global) tariff changes that are reciprocal in the sense that when evaluated at the original prices p^w, the changes in country j's net imports must satisfy $p^w \cdot dm_j = 0$. Since country j's trade must be balanced, both before and after tariff changes, price and import changes must also satisfy $d(p^w \cdot m_j) = 0$. The two previous observations immediately imply $m_j \cdot dp^w = 0$. From equation (10), it follows that a self-interested country j, with $\beta_{ij} = 0$ for all $i \neq j$, would choose its optimal tariff under the previous rule so that $t_j \cdot dm_j = 0$. A solution to this equation, of course, is $t_j = 0$. That is, a self-interested country required to choose among reciprocal tariff changes, in the sense of Bagwell and Staiger (1999), would act, at least locally, as if it had altruistic motives such that $\beta_{ij} = 1$ for all $i \neq j$.[10]

2.4 Extensions

We have characterized optimal trade taxes in an economy that features (i) international redistribution as the only motive for trade policy and (ii) specific trade taxes as the only policy instruments. We briefly discuss here how departures from these benchmark assumptions would affect Proposition 1. Additional discussion of these issues can be found in Adão et al. (2025b).

Other Motives for Trade Policy. Proposition 1 abstracts from concerns for domestic redistribution and distortions. Since Proposition 1 reflects a necessary first-order condition, the introduction of these other motives for trade protection simply adds extra terms to

[10]Faithful readers of Bagwell and Staiger (1999) may rightly remember that their results do not require countries' choices to be free trade. The only reason why $t_j = 0$ appears in the above argument is because, so far, we have abstracted from either domestic redistribution or distortions. When one introduces such considerations, as Bagwell and Staiger (1999) do and as we will in the next subsection, the exact same argument goes through, but with optimal tariffs that are potentially non-zero. The only difference is that the first-order condition in equation (10) now also includes these other motives for trade protection, hence the non-zero tariff choices.

the right-hand side of equation (11):

$$t_{gj} = (t_{gj})_{\text{Proposition 1}} + SMC_{gj}^{\text{redistribution}} + SMC_{gj}^{\text{distortions}}, \tag{12}$$

where $SMC_{gj}^{\text{redistribution}}$ and $SMC_{gj}^{\text{distortions}}$ are the social marginal costs of country j's imports of good g in terms of domestic redistribution and distortions, as we further describe.

Specifically, suppose that each country i is populated by multiple individuals indexed by $n \in \mathcal{N}_i$, each potentially with different preferences, different endowments, and different welfare weights in the social welfare function of their own government. Under the assumption that altruistic motives across countries do not affect the premia assigned to the income of different individuals from the same country—i.e., that each country j assigns a welfare weight $\beta_{ij}(n) = \beta_{ij} + \beta_i(n)$ on any individual $n \in \mathcal{N}_i$, with the normalizations $\beta_{ii} = 1$ and $\sum_{n \in \mathcal{N}_i} \beta_i(n) = 0$—the social marginal cost associated with concerns for domestic redistribution is then equal to

$$SMC_{gj}^{\text{redistribution}} = -\sum_{i \in \mathcal{I}} \sum_{n \in \mathcal{N}_i} \beta_i(n) \times [\partial(\omega_i(n) - \bar{\omega}_i)/\partial m_{gj}], \tag{13}$$

where $\partial \omega_i(n)/\partial m_{gj}$ denotes the change in individual n's real income caused by the increase in net imports of good g from country j via its impact on the local prices p_i and transfers in country i, where $\partial \bar{\omega}_i/\partial m_{gj} \equiv \frac{1}{|\mathcal{N}_i|} \sum_{n \in \mathcal{N}_i} \partial \omega_i(n)/\partial m_{gj}$ denotes the average impact.[11]

Likewise, suppose that production and consumption are subject to externalities $z \equiv \{z_k\}$, e.g. local pollution or global carbon emissions. Formally, production sets and utility functions take the form $Y_i(z)$ and $u_j(c, z)$, respectively, with the externalities a function of the choices of firms and consumers around the world, $z \in \mathcal{Z}(\{y_i, c_i\})$. In this environment, one can show that

$$SMC_{gj}^{\text{distortions}} = \sum_{i \in \mathcal{I}} \beta_{ij}(e_{i,z} - r_{i,z}) \cdot (\partial z/\partial m_{gj}), \tag{14}$$

where $\partial z/\partial m_{gj} \equiv \{\partial z_k/\partial m_{gj}\}$ denotes the marginal changes in externalities caused by imports of good g by country j and $e_{i,z} \equiv \{\partial e_i(p_i, z, u_i)/\partial z_k\}$ and $r_{i,z} \equiv \{\partial r_i(p_i, z)/\partial z_k\}$ denote the derivatives of the expenditure and revenue functions with respect to different externalities, respectively.[12] From an empirical standpoint, equations (13)-(14) are

[11] In the special case where $\beta_{ij} = 1$ for all $i \neq j$, adding $SMC_{gj}^{\text{redistribution}}$ to the tariffs from Proposition 1 leads to the tariffs chosen under "trade talks" in Grossman and Helpman (1995) and the "politically optimal tariffs" in Bagwell and Staiger (1999).

[12] The same logic can be used to compute the social marginal cost of distortions due to imperfect com-

important because they provide a structural interpretation of the error term in our baseline regression in Section 4.1. They also suggest ways to add controls in order to relax exclusion restrictions. We will do so in our sensitivity analysis in Section 4.5.

Policy Instruments. For expositional purposes, we have focused on an environment where countries choose specific rather than ad-valorem trade taxes. The extension to an environment with ad-valorem trade taxes is straightforward. If countries can choose ad-valorem trade taxes $\{t^{\text{av}}_{gj}\}$ such that $p_{gj} = p^{w}_{g}(1 + t^{\text{av}}_{gj})$, then the optimal ad-valorem trade tax is equal to $t^{\text{av}}_{gj} = t_{gj}/p^{w}_{g}$, with t_{gi} satisfying equation (11). The only subtle observation is that the value of the partial derivatives entering this expression (e.g. $\partial\omega_i/\partial m_{gj}$) may differ depending on whether one assumes that other countries $i \neq j$ are holding fixed their specific or ad-valorem tariffs. Given their prevalence in practice, we will assume that foreign ad-valorem tariffs are being held fixed when constructing our tariff variations in all subsequent sections.

Because trade taxes are the only taxes available to governments in Section 2.1, the only fiscal externalities entering Proposition 1 are those associated with the revenues from trade taxes. If there are other policy instruments available, but these do not create fiscal externalities, then equation (11) is unchanged.[13] If other taxes also create fiscal externalities, then their social marginal cost must be added to equation (11), in the same way that we have added the social marginal cost of other, non-tax distortions.

The same observation applies to the case where a subset of trade taxes are exogenously constrained, but non-zero. For any good $g \in \mathcal{G}^{T}_{j}$ whose trade tax is being adjusted by country j, it is easy to see from (10) that the social marginal cost associated with the fiscal externality on goods whose specific trade taxes $\bar{t}$ are held fixed must be equal to

$$SMC^{\text{distortion}}_{gj} = -\bar{t} \cdot (\partial\bar{m}/\partial m_{gj}). \tag{15}$$

Finally, if trade taxes are prohibited to vary across subsets of goods, e.g. because of the most-favored-nation (MFN) clause, then Proposition 1 continues to hold provided that marginal changes in imports are aggregated at the level at which trade taxes can vary, e.g. total imports of a given product from all WTO countries. In our baseline analysis, we ignore MFN, thereby treating countries' decision to abide by it as a choice. We will

petition, including in environments with firm-delocation effects, as in Venables (1987) and Ossa (2011), or profit-shifting effects, as in Brander and Spencer (1984) and Mrazova (2024).

[13]Such instruments therefore would only affect our estimates of the weights β_{ij} to the extent they affect the value of the statistics in (11). For instance, if there are unrestricted lump-sum transfers between countries, then all trade taxes should be equal to zero, leading to $\beta_{ij} = 1$ for all $i \neq j$.

introduce it as an external constraint in our sensitivity analysis in Section 4.5.

3 Measuring the Incidence of Import Restrictions

Our goal is to use Proposition 1 to reveal each country's valuation of its trading partners' welfare from the trade taxes that it chooses to impose and, in turn, to explore the efficiency and distributional properties of the global trading system. Doing so requires measures of the incidence of import restrictions entering equation (11), namely the opportunistic tariff $t^o_{gj} \equiv m_j \cdot (\partial p^w / \partial m_{gj})$ and the changes in foreign real income $\partial \omega_i / \partial m_{gj}$. To arrive at such measures, we build and calibrate a quantitative model of the world economy that imposes further parametric restrictions on Section 2's general environment.

3.1 A Quantitative Model of the World Economy

Our quantitative model of the world economy features multiple sectors, each with multiple products, and global input-output linkages.

Supply. In each origin country i, the representative firm can allocate a fixed endowment of labor, N_i, to the production of multiple products $h \in \mathcal{H}_s$ in multiple sectors $s \in \mathcal{S}$ and for multiple destinations $j \in \mathcal{I}$. The labor resource constraint is

$$\sum_{j \in \mathcal{I}} \sum_{s \in \mathcal{S}} \sum_{h \in \mathcal{H}_s} \ell_{ijh} \leq N_i, \tag{16}$$

where ℓ_{ijh} denotes the amount of labor from country i used to produce product h for country j. For a given product $h \in \mathcal{H}_s$ and destination country j, the gross output of country i's representative firm is equal to

$$q_{ijh} = \theta_{ijh} \left[(\ell_{ijh})^{\alpha_{is}} \prod_{k \in \mathcal{S}} (Q_{ik,ijh})^{(1-\alpha_{is})\alpha_{iks}} \right], \tag{17}$$

$$Q_{ik,ijh} = \left[\sum_{o \in \mathcal{I}} \sum_{v \in \mathcal{H}_k} (\theta_{oikv})^{\frac{1}{\sigma}} (q_{oiv,ijh})^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}}, \tag{18}$$

where $q_{oiv,ijh}$ denotes intermediate inputs of product v from country o delivered to country i used in the production of good (i,j,h) and $\sigma \geq 0$ is the elasticity of substitution between different inputs. We also normalize input demand shifters so that $\alpha_{is} \in [0,1]$ and $\sum_{k \in \mathcal{S}} \alpha_{iks} = \sum_{o \in \mathcal{I}} \sum_{v \in \mathcal{H}_k} \theta_{oikv} = 1$. Note that trade costs of the standard iceberg form are implicitly embedded in input demand shifters. For instance, if a product v from sector k is non-tradable from an origin o to country i, then $\theta_{oikv} = 0$.

Demand. In each destination country j, the utility of the representative consumer is

$$u_j = \prod_{s \in \mathcal{S}} (C_{js})^{\gamma_{js}}, \tag{19}$$

$$C_{js} = \left[\sum_{i \in \mathcal{I}} \sum_{h \in \mathcal{H}_s} (\theta_{ijsh})^{\frac{1}{\sigma}} (c_{ijh})^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}}, \tag{20}$$

where $c_j \equiv \{c_{ijh}\}$ denotes the consumption of all products h from all origin countries i that have been delivered to country j. Except for the Cobb-Douglas parameters $\{\gamma_{js}\}$ that may differ from $\{\alpha_{iks}\}$ in equation (17), note that the demand shifters as well as the elasticity of substitution in equation (20) are the same as those in equation (18). That is, within any country, firms and the representative consumer demand the same "sector composite," a standard data-driven restriction in quantitative trade models. We again impose the normalization $\sum_{s \in \mathcal{S}} \gamma_{js} = 1$.

Government. In each country j, we assume that there are no export taxes or subsidies. The only available trade taxes are ad-valorem import tariffs t^{av}_{ijh} that may vary across foreign origins $i \neq j$ and products h. We assume that the transfer T_j received by country j is fixed as a share of world GDP, which we use as our numeraire.

Mapping between Quantitative and General Models. Our quantitative model is a special case of the general model in Section 2. A good g corresponds to a unique origin-destination-product triplet (i, j, h). Each origin country i has a production set Υ_i, which is determined by the resource constraint (16) and the production functions (17)-(18). Each destination country j obtains utility u_j from consuming goods delivered there, as described in (19)-(20). The specific tariff t_{gj} equivalent to the ad valorem tariff t^{av}_{gj} imposed on good g by country j's government satisfies $t_{gj} = t^{\text{av}}_{gj} p^w_g$, with p^w_g the world price of good g. Note also that since a good corresponds to a unique triplet $g = (i, j, h)$, two distinct countries cannot produce the same good. Thus for each good g imported by country j, j's net imports m_{gj} are also its gross imports.

3.2 Baseline Calibration

The last piece of information needed to measure the incidence of import restrictions in equation (11) is the values of the structural parameters that determine the competitive equilibrium of our quantitative model. These parameters comprise the elasticity of substitution σ as well as the technology and preference shifters in (17)-(18) and (19)-(20), the labor endowments $\{N_i\}$, the international transfers $\{T_j\}$, and the specific import tariffs, $\{t_{gj}\}$. We now briefly describe how we calibrate them. Details about data construction and calibration can be found in Appendix B.1.1 and Appendix C.3, respectively.

We use the Global Tariff Database of Teti (2024) to measure the ad-valorem equivalent (AVE) tariffs for all origin-destination-product triplets $g = (i, j, h)$. We then compute the tariffs charged by the rest-of-the-world aggregate via the simple average of the countries in that group. Without loss of generality, we choose units of account so that the world price p_g^w of any good g is equal to one in our baseline calibration. Hence, the associated specific import tariff is equal to the ad-valorem one: $t_{gj} = t_{gj}^{\text{av}}$.

We set $\sigma = 2.53$ consistent with the estimates of Fajgelbaum et al. (2020). We set the values of the technology shifters, preference shifters, labor endowments, and international transfers to match global data from 2001 on output and input use by country and sector—from the OECD Inter-Country Input-Output (ICIO) database—and international trade flows by country pair, sector, and product—from the ICIO and CEPII BACI databases.

The set of countries $\mathcal{I}$ features 28 distinct trading partners: the EU and the 26 largest non-EU countries in ICIO (accounting for 91% of global trade in 2001) as well as an additional rest-of-the-world aggregate that combines all other countries, see Table B.1. The set of sectors $\mathcal{S}$ consists of 44 industries based on the ICIO classification (which is similar to ISIC revision 4 categories); these are listed in Table B.2. The set of all products $\mathcal{H} \equiv \cup_{s \in \mathcal{S}} H_s$ is based on the 6-digit HS system (revision 1, from 1996), resulting in 5,113 products for which BACI reports positive trade in 2001, plus one residual product for each sector. Residual products allow us to match ICIO data on domestic trade flows in all sectors and international trade flows in non-merchandise sectors.

3.3 Model-Implied Incidence of Import Restrictions

In our empirical analysis, we will use equation (11) to estimate each importer j's vector of welfare weights $\{\beta_{ij}\}$ via a linear regression whose dependent variable is the difference between observed tariffs t_{gj} and opportunistic tariffs $t_{gj}^o \equiv m_j \cdot (\partial p^w / \partial m_{gj})$ and whose regressors are the changes in real income $\{\partial \omega_i / \partial m_{gj}\}$ of various exporters i when country

j restricts its imports of good g. Before presenting our estimates of welfare weights, we describe key features of the previous variables and establish their empirical credibility. Throughout we focus on the same sample of goods and countries that will be used in the empirical analysis of Section 4. The full procedure used to compute t^o_{gj} and $\partial\omega_i/\partial m_{gj}$ can be found in Appendix C.5.

Opportunistic Tariffs vs. Observed Tariffs. The full distribution of opportunistic tariffs t^o_{gj} is reported in Appendix Figure B.1. Under our price normalization, the opportunistic specific tariff t^o_{gj} is equal to its ad-valorem equivalent. For our baseline calibration, its median value is equal to 45%. This is similar to the opportunistic tariffs suggested by the work of Ossa (2014), who reports a median value around 60% across 7 regions and 33 sectors, though it is somewhat lower than that of Broda et al. (2008), who find a median value of 160% among non-WTO countries.

Observed tariffs t_{gj} tend to be much lower than opportunistic tariffs. The distribution of the dependent variable in our regressions $t_{gj} - t^o_{gj}$ is almost always negative. Through the lens of Proposition 1, this already suggests that countries internalize the impact of their policy on others—though it says nothing at this point about the identity of countries who give or receive more weight from others. Our estimation below draws on the substantial heterogeneity in $t_{gj} - t^o_{gj}$, across importers and goods to reveal the full structure of such altruistic motives.[14]

Sensitivity of Foreign Real Income to Changes in Imports. We turn now to the regressors in our empirical procedure: the sensitivity of the real earnings of exporters to changes in the imports of their trading partners, i.e., $\partial\omega_i/\partial m_{gj}$. Appendix Figure B.4 displays, in a 28×28 matrix, the mean value of $\partial\omega_i/\partial m_{gj}$, across all goods $g = (i, j, h)$ that are sold in our sample by an exporter i to importer j. A few features are worth pointing out. First, entries are positive for all cells. Thus, when a typical country imports more from a typical exporter, this improves the exporter's real income. This happens in our calibrated model mainly because the terms of trade of the exporter improve. Fiscal externalities triggered by changes in another country's imports, which are also part of changes in foreign real income, are an order of magnitude smaller. Second, large row entries tend to correspond to countries whose exports are concentrated in a few destinations or products, like Saudi

[14] Although the parametric model of Section 3.1 features nested CES technology and preferences with a single elasticity of substitution σ, the heterogeneity in the trade flows and input-output flows targeted in our calibration generates variation in countries' ability to manipulate their terms of trade. In our model, larger importers have greater monopsony power, leading to larger opportunistic tariffs as can be seen from Appendix Figure B.3.

Arabia. Finally, large column entries tend to correspond to countries that are large importers of many products and so exert larger impacts on world prices, consistent with our earlier discussion of optimal tariffs.[15]

Validating Model-Implied Incidence of Import Restrictions. The empirical credibility on the welfare weights β_{ij} that we will estimate in the next section hinges on the empirical credibility of the response of real income to tariff-induced import changes $\partial\omega_i/\partial m_{gj}$ predicted from our calibrated model. To establish it, we follow the model-testing procedure developed in Adão et al. (2025a), as described in detail in Appendix B.3.

Specifically, we consider all annual tariff changes $\Delta t_{gj,t} \equiv t_{gj,t+1} - t_{gj,t}$ that occurred in our sample of goods g and countries j for any year t between 1996 and 2019. We first use our model to predict the (log) change in real income $\Delta \ln \omega_{i,t}^{\text{pred.}}$ that would result from such tariff changes around the world, if all other exogenous model elements (preferences, technologies, endowments) were held at their initial levels of year t. We then test the accuracy of our model's predictions by comparing the actual observed changes in real income, $\Delta \ln \omega_{i,t}^{\text{obs.}}$, which only depends on observed changes in prices and quantities, to its model-predicted counterparts, $\Delta \ln \omega_{i,t}^{\text{pred.}}$. Since observed changes also incorporate the impact of other non-tariff shocks, we compare the projections of predicted and observed variables on a third variable that is only a function of (de-meaned) tariff shocks. A small difference between the two projections indicates that the model's predicted responses to tariff shocks line up with the actual responses observed in the data. This is what we document in Appendix Table B.3: the difference between the projections of $\Delta \ln \omega_{i,t}^{\text{obs.}}$ and $\Delta \ln \omega_{i,t}^{\text{pred.}}$ is equal to 0.305 with a p-value of 0.604, thereby lending credibility to our use of the calibrated model to estimate as-if altruism weights β_{ij}, as we do next.

Finally, we note that our calibrated model is also able to replicate the micro-level evidence on the pass-through rates of tariffs in Fajgelbaum et al. (2020). That is, if we run the same regression of changes in world prices on changes in tariffs as in Fajgelbaum et al. (2020), at the same origin-product-destination level and with the same rich set of fixed effects, but with world price changes generated from our model, we find a precise zero. This is in line with the complete pass-through of tariffs into local prices documented in Fajgelbaum et al. (2020). Yet, as just discussed, our model does predict meaningful terms-of-trade effects from tariff-induced changes that are consistent with those observed in the data. These effects just express themselves at higher levels of aggregation.

[15]In addition to the mean value of $\partial\omega_i/\partial m_{gj}$ within each exporter-importer pair (i, j) discussed here, there remains substantial variation in terms of how import restrictions on different goods may affect real income in the origin countries, as illustrated in Appendix Figure B.5. We will use this source of variation to identify as-if altruism from observed trade taxes in the next section.

4 A World Trading System for Whom?

4.1 Baseline Specification

Using Proposition 1, we propose to estimate the welfare weight that an importer j assigns to each of its trading partners i by regressing the difference between importer j's observed and opportunistic tariffs on measures of the sensitivity of its trading partners' real income to j's imports. Moving opportunistic tariffs t^o_{gj} from the right- to the left-hand side of (11) and adding a vector of controls and an error term, we get

$$t_{gj} - t^o_{gj} = -\sum_{i \neq j} \beta_{ij}(\partial \omega_i / \partial m_{gj}) + \gamma \cdot \text{Controls}_{gj} + \epsilon_{gj}. \tag{21}$$

This is a linear regression model with 756 parameters of interest $\{\beta_{ij}\}$, one corresponding to each pair of our 28 destinations j and 27 origins $i \neq j$. Each observation "gj" corresponds to an origin-destination-product triplet.

Estimation Sample. Our baseline sample includes a total of 435, 246 observations. It balances two main objectives. On the one hand, we want to keep a sufficiently large number of products for each origin–destination pair in order to obtain precise estimates of $\{\beta_{ij}\}$. On the other hand, we need the number of product-origin-destination triplets to be low enough in order to keep the computation of the regressors $\{\partial \omega_i / \partial m_{gj}\}$ feasible. We balance these two objectives as follows. For each origin-destination pair, we first include the largest HS6 products that together account for 95% of the value of their bilateral trade flows in 2001. For origin-destination pairs that have fewer than 500 products within this set, we then add products until we reach 500 products per pair or the total number of products exported, if it less than 500 for this pair.[16] Following Teti (2024), we drop observations with extreme tariff values that are likely driven by measurement error, excluding the origin-destination-product triplets in the top 1% of the distribution of ad valorem equivalent tariffs.

Controls and Error Term. The baseline vector Controls_{gj} only includes the fiscal externality associated with goods outside our sample—for which we hold tariffs fixed when constructing the tax variation leading to $dm_{gj} \neq 0$ within our sample. It is computed using equation (15). Consistent with theory, we set the associated coefficient γ to one. The error term ϵ_{gj} in (21) can either be interpreted as measurement error in tariffs, mistakes

[16] Out of the 756 origin-destination pairs, 11 have exports of fewer than 75 products in 2001. For each of these 11 pairs, we do not attempt to estimate a separate β_{ij} and instead impose the restriction: $\beta_{ij} = \beta_{ROWj}$.

by the government in their tariff choices, or other motives for trade protection, such as concerns for domestic redistribution and distortions, as described in equations (12)-(14).[17]

Orthogonality Condition. In our baseline analysis, we estimate the welfare weights $\{\beta_{ij}\}$ in equation (21) via OLS. This requires the regressors $\{\partial\omega_i/\partial m_{gj}\}$ to be uncorrelated with the residual ϵ_{gj}. This orthogonality condition may fail, for instance, if the same import restrictions that tend to lower real income in country i also tend to aggravate domestic distortions or worsen the income distribution in country j. In such cases, failures to control for other motives for trade protection would lead to omitted variable bias. In Section 4.5, we will deal with this issue by considering alternative specifications with additional controls. Orthogonality may also fail because of simultaneity bias: tariffs (the dependent variable) may have their own causal impact on the sensitivity of the real earnings of exporters to changes in the imports of their trading partners. In Section 4.5, we will deal with this issue by constructing an instrumental variable (IV) that again leverages the incidence of import restrictions predicted by our quantitative model, but now computed around a counterfactual economy with zero tariffs, i.e., $(\partial\omega_i/\partial m_{gj})_{t=0}$.

Inference. We cluster standard errors by origin-sector pair. This allows for arbitrary correlation in residuals across importers for goods from the same exporter and sector.

4.2 Baseline Results

The heatmap in Figure 2a presents the 756 values of $\hat{\beta}_{ij}$ that we obtain from estimating equation (21) via OLS, along with the convention of $\hat{\beta}_{ii} = 1$ to populate the diagonal. Three key features emerge.

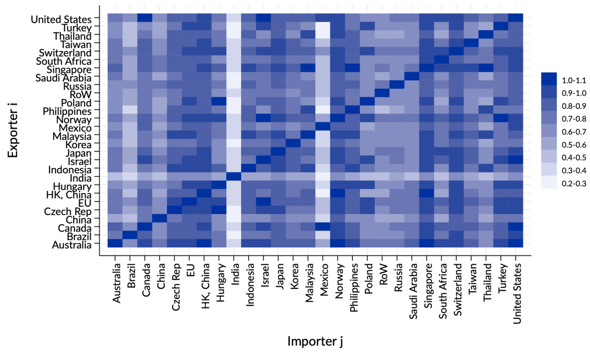
Significant International Cooperation. First, all off-diagonal elements are statistically significantly greater than zero at the 5 percent level. The two lowest values are 0.23 and 0.24 placed by India on Thailand and China, respectively. Even the 10th percentile value is 0.53. This finding is strikingly inconsistent with the one-shot Nash tariffs described in Figure 1a—in which $\beta_{ij} = 0$ for all $i \neq j$, and hence the matrix of values is the identity matrix.

Second, while all off-diagonal estimates $\hat{\beta}_{ij}$ are positive, very few of the estimates rise to the level of one that would be consistent with the efficient tariffs described in Figure

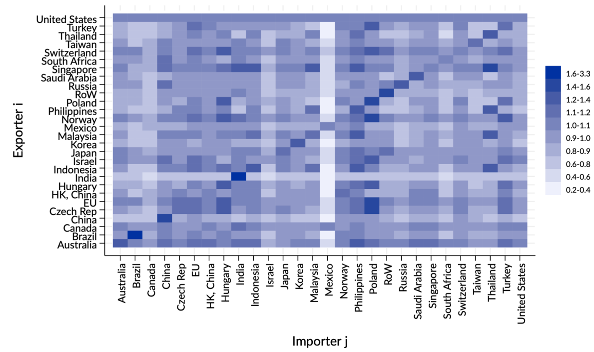
[17] In the case of distortions caused by externalities, provided that the externalities z only enter utility multiplicatively, i.e., $u_j(c,z) = E_j(z)u_j(c)$, the predictions of our quantitative model would remain unchanged, with the opportunistic tariffs t^o_{gj} and the sensitivity of foreign income $\partial\omega_i/\partial m_{gj}$ as described in Section 3.3.

Figure 2: Baseline Estimates of Welfare Weights

(a) Estimates of β_{ij}



(b) Estimates of β_{ij}/β_{USj}



Notes: This figure displays estimates of welfare weights that importer j places on exporter i obtained from the estimation of (21). We use the convention $\beta_{jj} = 1$. Figure 2a reports the original estimates (i.e. $\hat{\beta}_{ij}$) and Figure 2b reports each estimate normalized by the importer's weight on the United States (i.e. $\hat{\beta}_{ij}/\hat{\beta}_{USj}$).

1b. For example, the average is 0.75 and the 90th percentile value is 0.95. This reflects an implicit national bias in preferences: for a typical importer, the value of one dollar transferred to another country is 25% lower than the value of that same dollar transferred to its own residents. Again, a version of this finding that adjusts for uncertainty—a formal joint test of the hypothesis that $\beta_{ij} = 1$ for all $i \neq j$—rejects at standard levels.

Global Inefficiencies. The existence of national bias uncovered in most countries already points towards the world trading system's inability to deliver an equilibrium on the global efficiency frontier. We investigate this hypothesis further in Figure 2b. It again reports our estimates of the value that each importer j implicitly places on transfers to an exporter i, but now relative to a common reference exporter, which we take to be the United States, i.e., $\hat{\beta}_{ij}/\hat{\beta}_{USj}$. If the world economy were on the global efficient frontier, then there would be a common vector of social marginal utility of income $\{\beta_i\}$ such that the true values of β_{ij} would satisfy $\beta_{ij}/\beta_{USj} = \beta_i$ for all importers j and exporters i. Put differently, the matrix displayed in Figure 2b would be rank one, with no variation across columns. In practice, however, it is hard to discern any column structure to the displayed estimates. While sampling variance could explain this, it is straightforward to conduct the formal test of $\beta_{ij}/\beta_{USj} = \beta_i$, separately for each exporter i. The results from such tests are reported in Appendix Table B.4 and the null of efficiency is rejected ($p < 0.01$) in every case. Perhaps surprisingly, we can also reject, again for each exporter separately, that $\beta_{ij}/\beta_{USj} = \beta_i$ for all $j \neq i$, indicating that the departure from global efficiency is not only driven by national bias but also by dispersion in relative values among foreign trading partners.[18] This implies that the world trading system could enjoy Pareto improvements by arbitraging differences in the returns to (trade-policy-induced) transfers that are currently being made across its members.

Note that Figure 2b also gives little support to the claim that the world trading system is "rigged" against the United States. A simple way to evaluate this claim is to check whether the welfare weights received by the United States are systematically lower than those received by other countries. Out of the 756 values of $\hat{\beta}_{ij}/\hat{\beta}_{USj}$ reported in Figure 2b, 67% are less than one.

Reciprocity. It is often argued that reciprocity—in which actors exchange a good for a good and a bad for a bad—is key to sustaining cooperation in a variety of contexts (Axelrod, 1984) and in international relations in particular (Keohane, 1986). One can also use our estimates of welfare weights to look for traces of such cooperative behavior.

The case of India in Figure 2a gives a hint of the importance of such considerations. As one can see from the "Indian column," India puts low values on other countries' welfare, and as one can see from the "Indian row," other countries appear to reciprocate by putting low values on Indian welfare. More systematically, Figure 3a plots on the x-axis the average of the welfare weights $\hat{\beta}_{ij}$ that each importer j gives to others (weighted by its import values) against the average of the welfare weights that the same country j receives from others (weighted by its export values) on the y-axis.[19] The strong upward-sloping relationship (both with and without the outlier, India, included) is consistent with reciprocity at work.

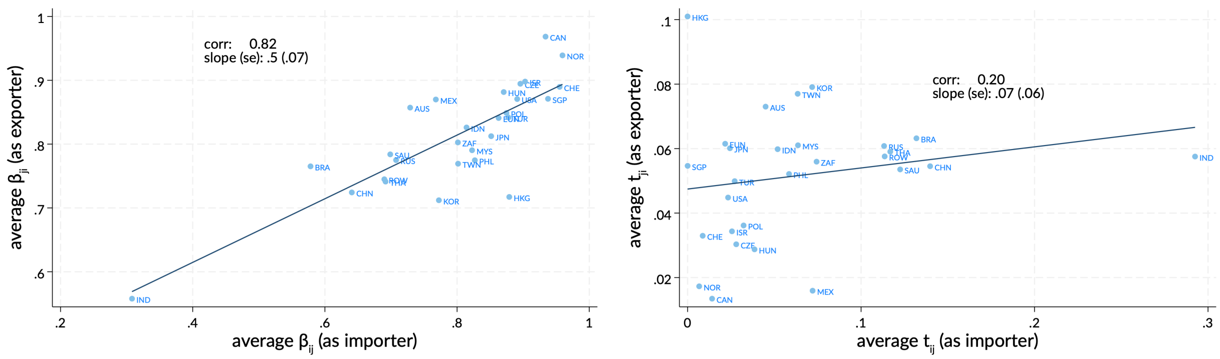
At this point, a skeptical reader may wonder whether the pattern of reciprocity that we have uncovered could be observed more easily by looking directly at the raw tariff data. Figure 3b shows that the answer is no. On the x-axis is the average tariff charged by each country j and on the y-axis is the average tariff imposed on the same country by others, again weighted by import and export values, respectively. We see that raw tariffs exhibit a weaker positive correlation of 0.20. In comparison, the correlation amongst

[18] One can also perform these tests for Pareto efficiency within subsets of the world trading system, such as among WTO members only. We again reject the null of efficiency in this case. Further visualization of our Pareto-efficiency test can be found in Appendix Figure B.6. There we plot two histograms of $\hat{\beta}_{ij}/\hat{\beta}_{USj}$ values, one after residualizing them with respect to a constant and one that is further residualized with respect to exporter fixed-effects. Global efficiency mandates that the latter distribution should display no variance, whereas in practice it shows just as much variance as the former distribution.

[19] To purge Figure 3a from a mechanical relationship due to countries exporting more to destinations that place a high welfare weight on them, we weigh using import and export values in a counterfactual free trade equilibrium, similar to the one we use in our IV estimation below. Using the observed value of exports instead makes little difference.

Figure 3: Reciprocity in the World Trading System

(a) Revealed by Welfare Weights **(b)** Revealed by Tariffs



Notes: This figure assesses the extent of reciprocity in the world trading system in 2001. In Figure 3a, for each country j, we plot on the x-axis the average value of $\hat{\beta}_{ij}$ for all $i \neq j$, weighted by its imports in the counterfactual free trade equilibrium, against the average value of $\hat{\beta}_{ji}$ for all $i \neq j$, weighted by exports in the counterfactual free trade equilibrium on the y-axis. In Figure 3b, for each country j, the x-axis is the average import tariff that j imposes on other countries and the y-axis is the average tariff that other countries impose on j, weighted by imports and exports in the counterfactual free trade equilibrium, respectively.

corresponding estimates of welfare weights in Figure 3a is 0.82.

It may seem surprising that reciprocity is far more evident in our estimates of welfare weights than in the raw tariffs that they leverage. Intuitively, the high correlation for welfare weights captures the fact that when a country j's tariffs are lower for goods whose imports matter more to another country i, leading to a high value of $\hat{\beta}_{ij}$, we also observe that country i's tariffs are lower for goods whose imports matter to j, leading to a high value of $\hat{\beta}_{ji}$. This is consistent with a lower correlation for tariffs, which simply captures the fact that when a country j has lower average tariffs on another country i, we do not observe that country i tends to have lower average tariffs on j.

4.3 Which Countries Give and Receive Higher Welfare Weights?

From an empirical standpoint, the fact that reciprocity is more apparent in welfare weights (in Figure 3a) than tariffs (in Figure 3b) suggests that it may reflect a broader set of forces than the basic mechanics of negotiated tariff concessions. To investigate this issue more systematically, as well as to offer further insights about the nature of international cooperation, we now consider descriptive regressions of the welfare weight $\hat{\beta}_{ij}$—that country j places on country i—on the welfare weight $\hat{\beta}_{ji}$—that country i places on country j—and a series of controls—that range from participation in formal trade agreements to standard "gravity" covariates like physical distance, population, and GDP per capita. The results are reported in Table 1.

Accounting for the Heterogeneity in Welfare Weights. We begin in column (1) with a specification that extends the study of reciprocity introduced above. Here, conditional on a constant, we regress $\hat{\beta}_{ij}$ on the value of $\hat{\beta}_{ji}$ to assess the extent to which i internalizing the impact of its policy on j is reciprocated by j internalizing the impact of its policy on i. In line with Figure 3a, countries tend to place higher value on other countries that also value them more. The causal interpretation of the estimated coefficient would be that, for a typical importer i, moving from no altruism ($\beta_{ji} = 0$) to no national bias ($\beta_{ji} = 1$) triggers an increase of 0.55 in the partner's reciprocal weight.

In the next two columns, we ask whether the previous pattern can be accounted for by participation in formal trade agreements. In column (2), we include a set of dummies that equal one or zero for all combinations of whether the exporter i and importer j are WTO members or not (apart from the omitted category, in which both are WTO members). In column (3), we further add a dummy for whether there is a Preferential Trade Agreement (PTA) between the exporter and importer. As might have been expected, we see that when two countries are part of the same PTA the importing country tends to assign the exporter a higher welfare weight (of approximately 0.10). In contrast, perhaps more surprisingly, the role of the WTO is mixed: there is statistically significant evidence of non-WTO members assigning lower weights towards WTO members (by about 0.04), but the evidence for WTO members treating non-WTO members differently is much weaker. Beyond these agreement effects *per se*, we see that the estimated coefficients on $\hat{\beta}_{ji}$ are almost unchanged in columns (1) through (3).

Column (4) shows that the positive relationship between $\hat{\beta}_{ij}$ and $\hat{\beta}_{ji}$ is also robust to controlling for physical distance, population, and GDP per capita.[20] Everything else being equal, countries place lower weights on partners that are further away or poorer. Meanwhile, smaller and richer countries place higher welfare weights on their trading partners. But these considerations cannot fully account for the relationship between $\hat{\beta}_{ij}$ and $\hat{\beta}_{ji}$, with the estimated coefficient in column (4) equal to 0.28.[21]

Finally, column (5) adds US dummies, both as origin and destination. In line with our discussion in Section 4.2, we do not find any systematic evidence that the United States is treated poorly by the rest of the world. There is no statistically significant difference between the average welfare weight received by the United States and the average welfare

[20] We obtain these variables from the CEPII gravity dataset in 2001.

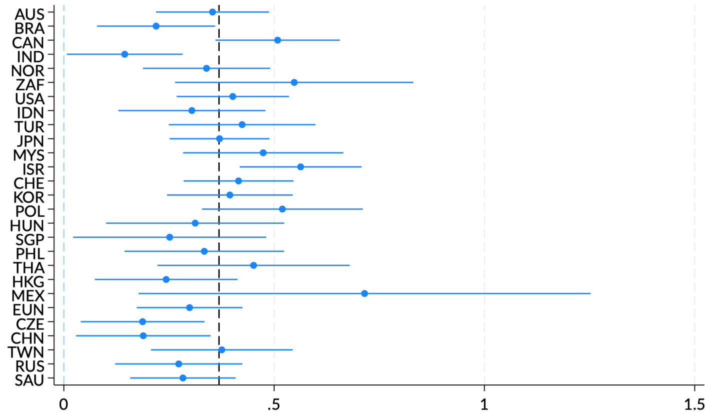
[21] The estimated relationship between $\hat{\beta}_{ij}$ and $\hat{\beta}_{ji}$ is also robust to controlling for exporter and imported fixed effects. In such a specification, the point estimate is 0.34 with a standard error of 0.036.

Table 1: Which Countries Give and Receive Higher Welfare Weights?

	Dependent variable: β_{ij}				
	(1)	(2)	(3)	(4)	(5)
$\hat{\beta}_{ji}$	0.550***	0.548***	0.479***	0.281***	0.278***
	(0.031)	(0.032)	(0.033)	(0.037)	(0.037)
$D\{i \in \text{WTO}, j \notin \text{WTO}\}$		-0.037***	-0.024**	-0.040***	-0.039***
		(0.011)	(0.011)	(0.009)	(0.009)
$D\{i \notin \text{WTO}, j \notin \text{WTO}\}$		-0.023	-0.012	-0.030	-0.029
		(0.027)	(0.027)	(0.024)	(0.025)
$D\{i \notin \text{WTO}, j \in \text{WTO}\}$		0.003	0.014	-0.005	-0.007
		(0.016)	(0.017)	(0.015)	(0.015)
pta			0.102***	0.084***	0.081***
			(0.014)	(0.020)	(0.019)
log distance$_{ij}$				-0.014*	-0.016**
				(0.008)	(0.008)
log population$_i$				0.005	0.006
				(0.005)	(0.006)
log population$_j$				-0.035***	-0.046***
				(0.005)	(0.006)
log p.c. income$_i$				0.028***	0.029***
				(0.006)	(0.007)
log p.c. income$_j$				0.049***	0.038***
				(0.006)	(0.006)
D{i = US}					-0.006
					(0.023)
D{j = US}					0.113***
					(0.019)
Constant	0.339***	0.343***	0.381***	0.654***	0.673***
	(0.026)	(0.027)	(0.027)	(0.075)	(0.076)
Observations	756	756	756	756	756
R^2	0.302	0.306	0.337	0.512	0.523

Notes: This table reports estimates of a regression of $\hat{\beta}_{ij}$ obtained from (21) on the regressors listed on each row. Standard errors in parentheses are clustered by exporter-importer pair. *** p<0.01, ** p<0.05, * p<0.1.

Figure 4: Reciprocity and GATT/WTO Tenure



Notes: This figure reports the estimated slope of a regression of $\hat{\beta}_{ij}$ on $\hat{\beta}_{ji}$ (with a constant) separately for the importer listed in each row, with dots representing the point estimate and horizontal bars representing associated 95% confidence interval. Importers are ordered by the number of years of membership in GATT/WTO. The black vertical bar denotes the pooled estimate across all importers controlling for importer fixed effects. $\hat{\beta}_{ij}$ obtained from estimation of (21).

weight received by other countries, conditional on other observables. We do see, however, that the United States does tend to give higher weights to other countries, consistent with the narrative of the United States being a "benevolent hegemon" towards the end of the twentieth century.[22]

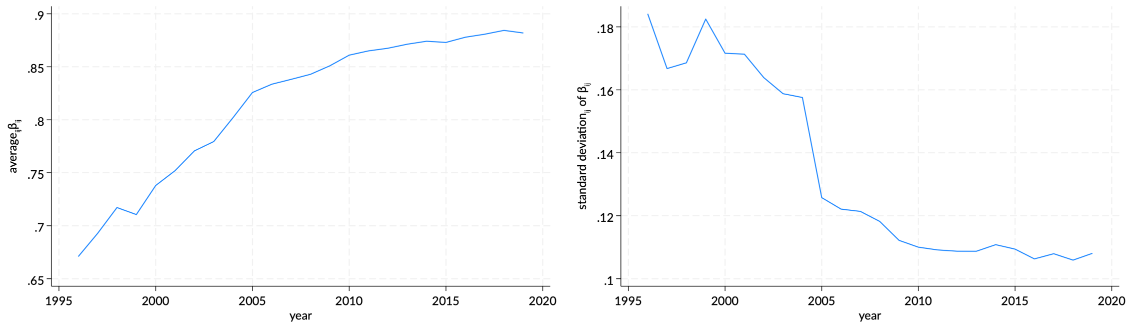
International Cooperation and GATT/WTO tenure. As a final exercise, we also examine the estimated relationship between $\hat{\beta}_{ij}$ and $\hat{\beta}_{ji}$ separately for each importer j in our sample. The results are reported in Figure 4, with countries ordered by the numbers of years that each importer has been a member of the GATT/WTO. Despite only having 27 observations for each importer, the estimated coefficient is positive and statistically significant at the 5% level for all importers in our sample. There is a correlation of 0.22 between the estimated coefficient and the GATT/WTO tenure of the importer, as reported in Appendix Figure B.7. Thus formal GATT/WTO rules may have contributed to the pattern of reciprocity uncovered in Figure 3, but they do not appear to be its main driver.[23]

[22]A similar pattern is also visible in the raw tariff data: in 2001, the (trade-weighted) average tariff imposed on US goods is 4.5%, whereas the (trade-weighted) average tariff imposed by the United States is 2.3%.

[23]From a theoretical standpoint, Bagwell and Staiger (1999) have offered a first and influential formalization of the reciprocity principle inside the GATT/WTO. One of their key results offers conditions under which $\hat{\beta}_{ij} = 1$ may be observed, but it does not explain more generally why the matrix of $\{\hat{\beta}_{ij}\}$ displayed in Figure 3 would tend to be symmetric. It is possible, however, that other features of bargaining protocols inside the GATT/WTO may have contributed to the positive correlation between $\hat{\beta}_{ij}$ and $\hat{\beta}_{ji}$ that we document. In practice, bargaining over tariff lines at the WTO only involved a subset of countries, following the

Figure 5: Welfare Weights Over Time

(a) Global average $\hat{\beta}_{ij,t}$ **(b)** Global standard deviation of $\hat{\beta}_{ij,t}$



Notes: This figure describes changes in welfare weights from 1996 to 2019. In Figure 5a, for each year t, we plot the global average of $\hat{\beta}_{ij,t}$. Figure 5b is analogous but for the standard deviation of $\hat{\beta}_{ij,t}$.

4.4 Time-Series Evidence

The estimates of welfare weights $\{\beta_{ij}\}$ reported so far have been obtained from global tariffs in 2001, just as the WTO's crowning achievement, the Uruguay Round, was fully phased in. We now go further and ask whether the pattern of international cooperation documented earlier can be observed over time.

To explore this issue, we apply the same procedure as above separately to data from every year between 1996 and 2019. This draws on dynamic versions of the sources described in Section 3.2—namely, annual records on tariffs from Teti's (2024) Global Tariff Database, product-level trade flows from BACI, and sector-level inputs from ICIO. Armed with such data we then re-compute the values of the regressors $\{\partial\omega_{i,t}/\partial m_{gj,t}\}$ in each year t, and estimate the weights $\{\beta_{ij,t}\}$ by estimating equation (21) separately, year by year.

The time path of the welfare weights that we estimate is summarized in Figure 5. Echoing the results of Ritel (2024), we find that there is evidence for growing cooperation in the world trading system throughout this time period, with the average welfare weight rising from 0.75 in 2001 to 0.84 in 2007 and then plateauing to around 0.88 in 2019.[24] We also find that this rise in as-if altruism is accompanied by a halving in the global standard deviation in $\hat{\beta}_{ij,t}$.

Principal Supplier Rule, as discussed in Bagwell et al. (2020). This could also explain why values of $\hat{\beta}_{ij}$ and $\hat{\beta}_{ji}$ tend to be simultaneously high or low depending on whether or not countries i and j have bargained together. We thank Bob Staiger for suggesting this possibility. We will come back to the specific role that GATT/WTO negotiations might have played in Section 4.5.

[24]This is qualitatively similar to, but quantitatively different from, the findings of Ritel (2024) who concludes that global trade cooperation increased by 265% over the last three decades.

Table 2: Reciprocity in the Time Series

	(1)	(2)	(3)	(4)
Panel (a): Dependent variable $\hat{\beta}_{ij,t}$				
$\hat{\beta}_{ji,t}$	0.473***	0.415***	0.281***	0.229***
	(0.027)	(0.025)	(0.021)	(0.019)
Observations	17,790	17,790	17,790	17,790
R^2	0.363	0.818	0.917	0.920
Panel (b): Dependent variable $t_{ij,t}$				
$t_{ji,t}$	0.069**	0.050*	0.044**	0.015
	(0.030)	(0.026)	(0.018)	(0.016)
Observations	17,790	17,790	17,790	17,790
R^2	0.146	0.768	0.923	0.927
Year fixed effects	Yes	Yes	Yes	Yes
Exporter-importer fixed effects	No	Yes	Yes	Yes
Exporter-importer time trends	No	No	Yes	Yes
Controls from column (5) of Table 1	No	No	No	Yes

Notes: Panel (a) of this table reports regressions of estimated welfare weights $\hat{\beta}_{ij,t}$, for all pairs of exporters j and importers i, and all years t in 1996-2019 on $\hat{\beta}_{ji,t}$ and the controls indicated in each column. We obtain $\hat{\beta}_{ij,t}$ from the estimation of (21) for each year t. Panel (b) is analogous but the dependent variable is $t_{ij,t}$, the simple average of the import tariff that j imposes on country i in year t, and the regressor is $t_{ji,t}$, the simple average of the import tariff that country i imposes on country j in year t. Standard errors in parentheses are clustered by exporter-importer pair. *** p<0.01, ** p<0.05, * p<0.1

Using the estimates of welfare weights $\{\hat{\beta}_{ij,t}\}$ for all years from 1996 to 2019, Table 2 shows that the conclusions from Table 1 about the importance of reciprocity in international cooperation continue to hold in the time series. As can be seen from Panel (a), this is true even after adding controls for year dummies, exporter-importer dummies, and exporter-importer time trends, though the estimated coefficient on $\hat{\beta}_{ji,t}$ goes down to 0.229 in the most stringent specification. Like in the cross-section, reciprocity remains more apparent in welfare weights than tariffs, as can be seen from Panel (b).

4.5 Sensitivity Analysis

In Section 4.2, we have emphasized three key patterns that emerge from our baseline estimates: (i) significant international cooperation, as reflected in a high average value of $\hat{\beta}_{ij}$ and a high fraction of strictly positive estimates; (ii) global Pareto inefficiencies, as reflected in the variation of $\hat{\beta}_{ij}/\hat{\beta}_{USj}$ across importing countries j; and (iii) reciprocity, as reflected in a positive correlation between $\hat{\beta}_{ij}$ and $\hat{\beta}_{ji}$. We now illustrate the robustness of these empirical findings.

Table 3 describes results from ten different specifications—our baseline, in (21), plus nine alternatives—each displayed in a separate row. For each specification we report five

Table 3: Sensitivity Analysis

	Correlation with baseline $\widehat{\beta}_{ij}$ (1)	Average $\widehat{\beta}_{ij}$ (2)	Fraction of $\widehat{\beta}_{ij} > 0$ at 5% significance (3)	Max p-value of global efficiency test (4)	Reciprocity coefficient (5)
Baseline:					
1. No controls, $\sigma = 2.5$, OLS	1.00	0.75	1.00	0.00	0.55
Alternative controls:					
2. Redistribution motives	0.77	0.60	0.99	0.00	0.61
3. Constant	1.00	0.86	1.00	0.00	0.59
4. Sector fixed effects	0.98	0.62	1.00	0.00	0.45
5. All of the above	0.79	0.57	0.99	0.00	0.59
Alternative calibrations:					
6. $\sigma = 1.5$	0.98	0.86	1.00	0.00	0.66
7. $\sigma = 4.0$	0.99	0.61	0.94	0.00	0.42
GATT/WTO rules and negotiations:					
8. MFN constraint	0.96	0.74	1.00	0.00	0.46
9. Uruguay round products	0.92	0.77	1.00	0.00	0.44
IV specification:					
10. Estimation with free trade IV	1.00	0.75	1.00	0.00	0.56

Notes: This table summarizes estimates from the baseline (in row 1) and nine alternative specifications. The first set of alternatives adds controls: redistribution concerns (in row 2), a constant (in row 3), sector fixed effects (in row 4), and all three together (in row 5). The second set considers alternative calibrations, with a lower value of σ (in row 6) and a higher value (in row 7). The third set focuses on features of the GATT/WTO: an alternative tariff formula that imposes MFN (in row 8) and the subsample of products negotiated during the Uruguay Round (in row 9). The final alternative specification uses an IV constructed around free trade. All data is from 2001. Results for other years can be found in Appendix Table B.5.

statistics in separate columns: column 1 reports the correlation between the alternative estimate of $\hat{\beta}_{ij}$ obtained and that of our baseline; column 2 reports the average value of $\hat{\beta}_{ij}$; column 3 reports the fraction of country pairs (for $i \neq j$) whose estimate of $\hat{\beta}_{ij}$ is statistically significantly greater than zero at the 5% significance level; column 4 reports the maximum p-value for the country-specific version of the global efficiency test;[25] and column 5 reports the slope coefficient from our reciprocity regression of $\hat{\beta}_{ij}$ and $\hat{\beta}_{ij}$ (as in column 1 of Table 1). Appendix Table B.5 reports the analogous statistics obtained from the estimates for all years from 1996 to 2019.

Additional Controls. For our first series of robustness checks, in rows 2 to 5, we explore the sensitivity of our findings to adding controls to our baseline specification. For convenience, row 1 reports our baseline findings.

We start in row 2 with controls designed to capture, in a theory-consistent way, concerns for domestic redistribution, as described in equation (13). To make these concerns

[25] That is, for each country i, we test the null hypothesis that: $\beta_{ij}/\beta_{USj} = \beta_i$ for all j. We then report the maximum p-value across all i.

relevant, i.e., $SMC_{gj}^{\text{redistribution}}$ non-zero, we consider a generalization of our quantitative model that allows for different factors within each country. Specifically, we assume that workers are immobile across three broad sectoral groups (agriculture-and-mining, manufacturing, and services) rather than fully mobile across sectors. This implies that wages may now vary both across countries and sectoral groups. All other assumptions are unchanged. Within this alternative environment, we start by computing the changes in real earnings $\{\partial\omega_i(n)/\partial m_{gj}\}$ for workers from country i in each of the three broad sectors n, either agriculture-and-mining, manufacturing or services. We then re-estimate the weights $\{\beta_{ij}\}$ using equation (21), but adding separately each component $\partial(\omega_i(n) - \bar{\omega}_i)/\partial m_{gj}$ of $SMC_{gj}^{\text{redistribution}}$ to the vector of controls, except those associated with services due to collinearity.[26] Despite adding $2 \times 28 = 56$ additional regressors, the correlation between these new estimated welfare weights and our baseline ones is 0.77. The main change is in terms of the average value of $\hat{\beta}_{ij}$, which goes down slightly from 0.75 to 0.60. The pattern of reciprocity, in contrast, is even stronger.

The next specifications add a constant to our baseline (in row 3), sector fixed effects (in row 4), and the combination of sector fixed effects and redistribution controls (in row 5).[27] One might have anticipated that our finding of significant international cooperation relied heavily on the fact our model predicts opportunistic tariffs that are much larger on average than those observed in 2001, as discussed in Section 3.3. Row 3 shows that this is not so. When we incorporate a constant, and therefore only leverage how the gap between observed and opportunistic tariffs varies across goods, the average value of $\hat{\beta}_{ij}$ actually goes up. The lowest value, when all controls are included in row 5, is 0.57. Likewise, global Pareto inefficiencies and reciprocity continue to hold; even the largest p-value on our test for global efficiency, across all countries and these four alternative specifications, is still below $p = 0.01$.

Alternative Calibrations. For our next set of robustness checks, reported in rows 6 and 7, we go back to our baseline model, but consider alternative calibrations of the model's key elasticity σ before again computing the regressors $\{\partial\omega_i/\partial m_{gj}\}$ and estimating the weights $\{\beta_{ij}\}$. Specifically, the case of row 6 reduces the value of σ from its baseline value of 2.53 to $\sigma = 1.5$, whereas row 7 raises it to $\sigma = 4.0$. Lower values of σ give countries greater market power, and, as a result, we estimate somewhat higher average welfare weights at lower σs and vice-versa. Intuitively, the more market power countries have to

[26] Appendix C.5 describes our implementation in detail.

[27] We have also considered an alternative specification that drops the fiscal externality associated with goods outside our sample from the vector of controls. Since, by construction, exports of goods outside our sample are very small, this leaves all our results virtually unchanged.

exploit, the more (as-if) altruism is required to justify their choices not to do so. Still, the new welfare weights that we estimate remain strongly correlated, at 0.98 or higher, with our baseline values. This leads to similar patterns of significant international cooperation, Pareto inefficiencies, and reciprocity.

GATT/WTO Rules and Negotiations. Our next two exercises focus on the potential importance of GATT/WTO rules and negotiations. First, instead of letting countries choose whether or not to abide by the most-favored nation (MFN) clause, we now treat MFN as a constraint that limits the set of feasible tax variations and re-derive our optimal tariff formula accordingly, as discussed in Section 2.4. More precisely, if we observe multiple exporters facing an importer's MFN rate for a given product, then we assume that the importer was constrained to charge the same tariff to this subset of exporters. Although this constraint shrinks our sample by 54%, row 8 shows that it has little impact on our estimates of welfare weights β_{ij}—the correlation with the unconstrained baseline is 0.96—and hence little impact on our conclusions.

As previously discussed, the structure of negotiations within the GATT/WTO may also create a pattern of reciprocal welfare weights. To explore this possibility further, we utilize records of the negotiations that took place during the WTO's Uruguay Round, which determined, after full phase-in, many of the 2001 tariffs. Appendix B.1.2 describes how we identify, for each importer, which products were negotiated at the Round. We then re-run our baseline specification for the subsample of products that have been negotiated. Despite dropping about 38% of the sample, the estimated values of β_{ij} that we obtain in row 9 are essentially identical to those in our baseline. Although we recognize that many products not-included in this subsample are likely to have been negotiated in the past, the similarity of our estimates across samples is suggestive of reciprocity existing both inside and outside of the GATT/WTO.

IV Specification. As previously discussed, tariffs (the dependent variable) may have their own causal impact on the sensitivity of the real earnings of exporters to changes in the imports of their trading partners, thereby leading to simultaneity bias. This concern is particularly acute given the relationship discussed in Section 3.3 between changes in real earnings and equilibrium outcomes—especially bilateral trade flows—which are themselves a function of tariffs. To deal with this issue, we follow the same approach as in Adão et al. (2025b) and use the incidence of import restrictions, now computed around a counterfactual economy with zero tariffs, i.e., $(\partial\omega_i/\partial m_{gj})_{t=0}$, as an instrumental variable (IV) for the incidence of import restrictions in the calibrated economy, i.e., $\partial\omega_i/\partial m_{gj}$. The results are reported in row 10. Since tariffs observed in 2001 are typically low, the IV and OLS estimates of welfare weights are almost perfectly correlated and, in turn, our key findings are almost identical to the baseline ones in row 1.

5 Counterfactual Analysis

We conclude our paper with two sets of counterfactual exercises. First, looking back at the world trading system in 2001, we evaluate the extent to which the empirical pattern of reciprocity documented in the previous section created gains from international cooperation around the world. Second, looking towards the future, we explore how a country like the United States may win, or lose, by departing from existing norms and institutions and trying to reconfigure the world trading system to its own advantage.

5.1 Reciprocity and the Gains from International Cooperation

Our empirical finding that $\hat{\beta}_{ij}$ and $\hat{\beta}_{ji}$ are positively correlated is consistent with the view that countries may benefit from setting trade policies that do not maximize their own welfare precisely because they expect other countries to reciprocate and do the same. That is, gains from international cooperation come about if the losses from giving non-zero welfare weights to others are more than compensated by the gains from others giving non-zero weights as well.

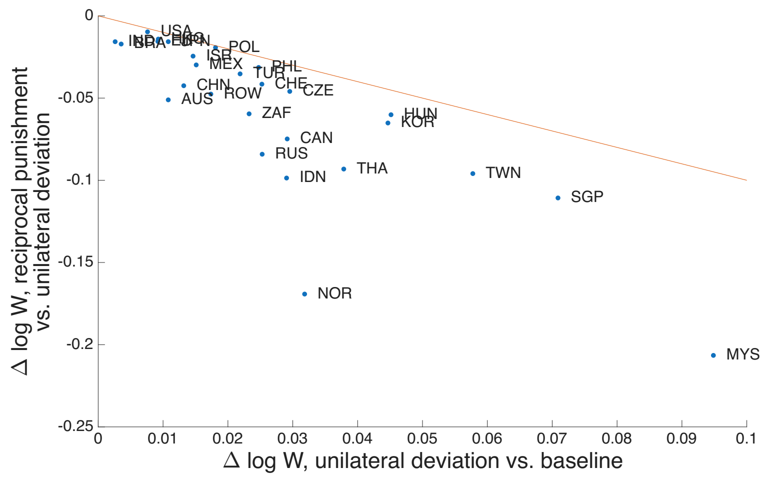
To explore this hypothesis formally, we ask: Everything else being equal, how different would the welfare of a given country j be in a counterfactual world where it stops internalizing the impact of its trade policies onto others, i.e., $(\beta_{ij})' = 0$ for all $i \neq j$ rather than its estimated value $\hat{\beta}_{ij}$, and others stop internalizing the impact of their policies on country j, i.e., $(\beta_{ji})' = 0$ for all $i \neq j$ rather than its estimated value $\hat{\beta}_{ji}$? We answer this question by using our general formula to compute, for each set of counterfactual weights $\{(\beta_{ji})'\}$, the full set of associated tariffs $\{(t_{gj})'\}$:

$$(t_{gj})' = (t^o_{gj})' - \sum_{i \neq j} (\beta_{ij})' (\partial \omega_i / \partial m_{gj})',$$

where both opportunistic tariffs $(t^o_{gj})'$ and marginal changes in real earnings $(\partial \omega_i / \partial m_{gj})'$ are also computed at the counterfactual values consistent with the new tariffs $\{(t_{gj})'\}$.[28]

[28] Throughout our counterfactual analysis, we set the tariff residual $\hat{\epsilon}_{gj}$ to zero, consistent with its interpretation as measurement error. In particular, when we compute welfare changes, we compare the counterfactual equilibrium with tariffs $\{(t_{gj})'\}$ to a simulated baseline $\{(t_{gj})_{\text{baseline}}\}$ without residuals, i.e., with

Figure 6: Gains from Reciprocity



Notes: This figure reports for each country j the welfare (real income) change associated with a counterfactual scenario in which (i) country j's own welfare weights go from $\hat{\beta}_{ij}$ to zero for all $i \neq j$ and, in addition to country j's change in weights, (ii) each other country $i \neq j$'s welfare weights on j go from $\hat{\beta}_{ji}$ to zero. The welfare change associated with (i) is reported on the x-axis, whereas the welfare change associated with (ii) is reported on the y-axis. Gains from reciprocity are equal to (the opposite of) the sum of these two welfare changes. To help with visualization, this figure excludes Saudi Arabia. Appendix Figure B.8 shows results for all countries.

Figure 6 displays the associated welfare effects of each exercise. That is, each dot in this figure is a separate simulation, centered on the fate of country j, one at a time.[29] On the x-axis, we report the change in real income experienced by a given country j as its own welfare weights go from $\hat{\beta}_{ij}$ to $(\beta_{ij})' = 0$ if $i \neq j$, i.e., as country j stops cooperating with the rest of the world. On the y-axis, we report the welfare change experienced by each country j as the welfare weights of its trading partners further go, for each $i \neq j$, from $\hat{\beta}_{ji}$ to $(\beta_{ji})' = 0$, i.e., as the rest of the world stops cooperating with country j. We interpret (the opposite of) the sum of these two welfare changes as country j's gains from international cooperation via reciprocity.

The key finding that emerges from Figure 6 is that all observations lie below the -45 degree line. This implies gains from reciprocity for all countries—i.e., the gains from opportunistic deviations are overcome by the losses of being punished for such deviations.

$(t_{gj})_{\text{baseline}} = (t^o_{gj})_{\text{baseline}} - \sum_{i \neq j} \hat{\beta}_{ij} (\partial \omega_i / \partial m_{gj})_{\text{baseline}}$.

[29] To help with visualization, we exclude one outlier: Saudi Arabia, which is extreme in terms of the sectoral concentration of its exports—74% are in the "'mining and quarrying, energy producing products" sector—and the size of its trade surplus—19% of GDP. These features are associated with large gains from unilateral deviations and especially large losses from reciprocal punishment. Appendix Figure B.8 shows results for all countries. For completeness, we also report in Appendix Figure B.9 the same counterfactual results under an alternative calibration in which imbalances are set to zero. Without imbalances, we reach similar qualitative conclusions and Saudi Arabia is less of an outlier.

Note also that the relationship is steeper than the 45 degree line. Thus gains tend to be larger for countries who gain more from opportunistic deviations (i.e., have larger x-axis values). This is consistent with the idea that more cooperative countries are rewarded more by their trading partners. In terms of magnitude, the median gain from reciprocity is 1.9%. To put this number in perspective, going from Nash tariffs—those that obtain when *all* countries act opportunistically vis-a-vis *all* trading partners, i.e., $\beta_{ij} = 0$ for all j and $i \neq j$—to the baseline tariffs—those that obtain when $\beta_{ij} = \hat{\beta}_{ij}$—would cause a median gain of 2.2%, whereas going from the baseline tariffs to free trade would cause a further median gain of 0.1%.

5.2 Reconfiguring the World Trading System for Whom?

A prominent narrative emerging from the second Trump administration is that the current world trading system is rigged against the United States. The implication of this narrative is that the US government should seek to "reconfigure the global trading and financial systems to America's benefit," as discussed by Miran (2024). Rather than being a "benevolent hegemon" that lets the global pie grow, but settles for a small share, the basic idea is that the United States should instead attempt to extract a share commensurate to its power on the international stage.

We have already discussed in Section 4 that there is little evidence of the world trading system being rigged against the United States. About 2/3 of countries in the world receive welfare weights that are lower than those of the United States, though it is true that in 2001, the welfare weights that the United States gives to other countries tend to be larger than the welfare weights that other countries give to the United States, as can be seen from Table 1. Be that as it may, we conclude our analysis by asking how much the United States could gain if it were successful in incentivizing other countries to choose policies that benefit the United States as much as their own, while eschewing any considerations for one another's welfare. In the context of a repeated game, this may occur by fear of US retaliation either via tariffs or some other tools. This is obviously an extreme scenario, but we would expect it to be an upper-bound on the gains from reconfiguring the world trading system, which one can then compare to the potential losses.

Formally, we now consider a counterfactual world in which any country j has welfare weights $(\beta_{USj})' = 1$ and $(\beta_{ij})' = 0$ for all $i \neq US, j$. That is, each country only cares about its own welfare and that of the United States, which it values equally. We find that the United States gains 0.8% of real income from this preferential treatment. One way to contextualize these gains is to compare them to what the United States stands to lose if its attempts at moving away from "benevolent hegemony" fail and other countries punish the United States. Through the lens of our model, setting aside geopolitical and other non-economic considerations, the most the United States could lose is its ability to trade with the rest of the world. If changes in foreign trade policy were designed to send the United States back to autarky, the associated welfare losses would stand at 17.8%, an order of magnitude larger.

6 Concluding Remarks

We have used data on global tariffs to reveal the extent and nature of international cooperation in the world trading system at the beginning of the 21st century. Our approach rests on a formula for optimal trade taxes with as-if altruism that does not require us to take a stand on the specific ways through which international cooperation comes about. Three key empirical findings emerge. First, international cooperation is strong and widespread, with the vast majority of countries in our sample placing substantial weight on the welfare of every other country. Second, even though as-if altruism is prevalent, tariffs are not set in a manner that is Pareto-efficient globally. Finally, we uncover a previously undocumented form of reciprocity in trade policy: when countries offer cooperative behavior towards a foreign country this tends to be reciprocated with cooperative behavior from that country in return. Interestingly, all three of these findings are strikingly similar both within and outside of formal trade agreements such as the GATT/WTO.

Using our estimated bilateral welfare weights, we have evaluated the extent to which countries in our sample may lose or gain from the dissolution of the world trading system. We have shown that no country has incentives to stop cooperating with the rest of the world, in the sense of assigning zero welfare weights to its trading partners, if such departure is reciprocated by other countries assigning zero weight in return. In contrast, an alternative rearrangement of the world trading system tilted towards US interests—one in which the United States assigns zero welfare weights to foreigners and manages to induce every other country to treat the United States as generously as they treat themselves—does raise US real income. But even such an extreme rebalancing of power would only provide the United States with benefits that are about twenty times smaller than the gains from trade that it currently enjoys.

We do not know where the future of the world trading system lies. But as new discussions about trade wars, economic sanctions, geoeconomics, and national security continue to emerge, we hope that the approach developed in this paper can prove useful to learn about the nature of cooperation and conflict around us.

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A Theoretical Appendix

In this appendix, we present a strict generalization of the as-if altruistic trade taxes introduced in Definition 2 and relate it to previous work on negotiated tariffs by Ludema and Mayda (2013) and Bagwell et al. (2021).

Consider a partition of all tariff lines into $n = 1, ..., N$ subsets. We let $t_n \in \mathcal{B}_n$ denote the vector of trade taxes associated with subset n, with $\mathcal{B}_n$ the set of feasible values. One can then generalize the notion of as-if altruism in Definition 2 as follows.

Definition 3 (Generalized as-if altruism)**.** *For any subset $n = 1, ..., N$, we say that a vector of trade taxes $t_n \in \mathcal{B}_n$ is optimal with generalized as-if altruism if there exists a vector of welfare weights $\{\lambda_i^n\}$ such that t_n solves*

$$\max_{t \in \mathcal{B}_n, \{u_i\}} \sum_i \lambda_i^n u_i \quad \text{(A.1)}$$
$$\text{subject to:} \{u_i\} \in \mathcal{U}(t, t_{-n}),$$

where $\mathcal{U}(t, t_{-n})$ is the set of utility profiles attainable in a competitive equilibrium with trade taxes (t, t_{-n}) and t_{-n} is the vector of other trade taxes.

Definition 2 corresponds to the special case where each subset n is equal to the set of all tariff lines in some country j with $\mathcal{B}_n = \mathcal{T}_j$. More generally, Definition 3 further allows situations where welfare weights may vary across goods, perhaps because countries negotiate different taxes with different trading partners. This is the situation considered in Ludema and Mayda (2013) and Bagwell et al. (2021).

Ludema and Mayda (2013) corresponds to the special case where each subset n corresponds to a different coalition of negotiating countries, with $\lambda_i^n = 1$ if country i is part of the coalition and zero otherwise. Bagwell et al. (2021) corresponds to the special case where each subset n corresponds to a different pair of negotiating countries, i_1 and i_2, with the welfare weights $\lambda_{i_1}^n$ and $\lambda_{i_2}^n$, determined by the exogenous Nash bargaining weights of the two countries as well as their endogenous outside options, which take as given trade taxes emerging from all other bilateral negotiations (including those also including i_1 or i_2).

The notion of as-if altruism that we focus on in Definition 2 is therefore more restrictive than the tariff settings considered in in Ludema and Mayda (2013) and Bagwell et al. (2021) along some dimensions, but less restrictive along others. Namely, Definition 2 does not let the as-if welfare weights vary across goods, but it otherwise does not impose any restriction on the structure of $\{\lambda_{ij}\}$.

B Empirical Appendix

This appendix provides details about data sources and measurement of the variables used throughout the paper, as well as our model validation exercise and additional empirical results that complement the baseline estimates.

B.1 Data Construction

B.1.1 Data for Model Calibration

We begin by describing the data sources and methodology that we adopt to measure the variables used to calibrate the model. We define the set of trading partners in the world $\mathcal{I}$ as the European Union (EU), which includes its 15 members in 2001, plus 26 other countries in the OECD ICIO database (see Table B.1). We aggregate all remaining countries in a rest-of-the-world composite. Our sector classification contains 44 sectors $\mathcal{S}$ based on the ICIO's categories (see Table B.2). Our product set $\mathcal{H} \equiv \cup_{s \in \mathcal{S}} \mathcal{H}_s$ consists of the 5,113 products that populate the 6-digit HS (revision 1) categories, plus a set of fictitious sector-specific products used to accommodate differences between data sources. These fictitious products allow us to match the data on trade flows but do not feature in our estimation sample.

We now describe how we build the variables used in our calibration from various available datasets in each year from 1996 through 2019.

Global Sector-Level Input-Output Tables. We begin with the OECD's ICIO database. This source measures the flow of goods and services from any origin country-sector (in $\mathcal{I} \times \mathcal{S}$) to any destination country-sector around the globe. The 27 trading partners in our sample tend to be large and relatively high-income, and together represent 91% of world trade in 2001. The ICIO sector categories are based on minor aggregations of ISIC revision 4 categories.

For every sector $s$and country i, we use the ICIO database to compute gross output, Y_{is}^{ICIO}, and intermediate spending on goods from each other sector k (from all origins), I_{iks}^{ICIO}.[30] From the ICIO database, we also obtain final spending of each country i on each sector s (from all origins), F_{is}^{ICIO}.[31] Finally, we obtain from the ICIO database bilateral

[30]Whenever intermediate spending exceeds gross output, we set gross output to be equal to $\sum_k I_{iks}^{\text{ICIO}}$. This is the case for less than four country-sector pairs in any given year; all after 2007.

[31]We define final spending in each country-sector as the sum across all origins for that sector of five categories of final demand: private consumption, non-profit consumption, government consumption, investment, and direct purchases abroad.

trade flows between any two country-sector pairs, which we aggregate across destination sectors to obtain bilateral trade flows of goods from sector s of origin i to destination j (for either final or intermediate consumption), X_{ijs}^{ICIO}.

Crosswalk from 6-digit HS (rev 1) to ICIO categories. We also build a crosswalk from 6-digit HS (revision 1) to the ICIO sectors that are based on ISIC revision 4 categories. To this end, we use the OECD crosswalk from 6-digit HS (rev 1) to their category "Desci4" (based on ISIC rev 4) and then to the ICIO sectors.[32] We manually assign three products in Desci4 "Waste" to the sector including waste management, and twelve products in Desci4 "Others" to the sector "Other manufacturing." Finally, since HS codes cover merchandise trade, we reclassify 28 products initially mapped to the service sector "Publishing, audiovisual and broadcasting activities" into the manufacturing sector "Paper and printing products."

International Trade Flows. We use the CEPII BACI database to measure FOB trade flows among all countries, broken down by 6-digit HS (rev 1) product. We aggregate the countries in BACI to those in our sample by summing trade flows among the countries associated with each trade partner. We let $\tilde{X}_{ijh}^{\text{BACI}}$ denote (pre-tax) trade flows of product h from origin i to destination j obtained from BACI for our sample of trading partners. We then rescale all bilateral BACI product-level flows such that the implied sector-level aggregates (within each pair) equals the corresponding flows in ICIO. Formally, we compute adjusted (post-tariff) trade flows from BACI as $X_{ijh}^{\text{BACI}} \equiv (1 + t_{ijh}^{\text{av}})\tilde{X}_{ijh}^{\text{BACI}} X_{ijk}^{\text{ICIO}} / \left(\sum_{v \in \mathcal{H}_k} \tilde{X}_{ijv}^{\text{BACI}}\right)$, where t_{ijh}^{av} is the ad-valorem equivalent import tariff that we describe below. In addition, we create fictitious product h_s^* in each sector. We assume that each such product is untaxed and impute its trade flow to take the value $X_{ijh_s^*}^{\text{BACI}} = X_{ijk}^{\text{ICIO}} \times \mathbb{I}[\sum_{v \in \mathcal{H}_k} \tilde{X}_{ijv}^{\text{BACI}} = 0]$. In other words, for every origin-destination-sector triplet for which $\sum_{v \in \mathcal{H}_k} \tilde{X}_{ijv}^{\text{BACI}} = 0$ and $X_{ijk}^{\text{ICIO}} > 0$, we use the sector-specific fictitious product to match sector-level bilateral flows reported in ICIO. Note that this fictitious product accounts for all triplets not covered by BACI; in particular, domestic trade flows in all sectors and international trade flows in non-merchandise sectors.

Import Tariffs. We obtain tariff data from the Global Trade Database from Teti (2024). For each importer and 6-digit HS88/92 product, the database reports the ad valorem equivalent statutory tariff applied to each exporter. To construct bilateral ad valorem

[32] The crosswalk from H1 to Desci4 is available at this link, and the crosswalk from Desci4 to ICIO sectors is available at this link.

Table B.1: List of Countries in the ICIO Sample

Groups of world regions	
Countries	European Union (EU)
Australia	Austria
Brazil	Belgium-Luxembourg
Canada	Denmark
China	Finland
Chinese Taipei	France
Czech Republic	Germany
Hong Kong, China	Greece
Hungary	Ireland
India	Italy
Indonesia	Netherlands
Israel	Portugal
Japan	Spain
Korea	Sweden
Malaysia	United Kingdom
Mexico	
Norway	
Philippines	
Poland	
Russian Federation	
Saudi Arabia	
Singapore	
South Africa	
Switzerland	
Thailand	
Türkiye	
United States	

Table B.2: List of Sectors in the ICIO Sample

Agriculture, hunting	Fishing and aquaculture	Mining, energy producing
Mining, non-energy producing	Mining support services	Food, beverages, tobacco
Textiles, leather	Wood, products of wood and cork	Paper products and printing
Coke and refined petroleum	Chemicals and pharmaceuticals	Rubber and plastics products
Other non-metallic mineral pr.	Basic metals	Fabricated metal products
Computer and electronic eq.	Electrical equipment	Machinery and equipment, nec
Motor vehicles, trailers	Other transport equipment	Manufacturing; repair, installation
Electricity, gas, steam	Water supply, sewerage	Construction
Wholesale and retail trade	Land transport and via pipelines	Water transport
Air transport	Warehousing, support transport.	Postal and courier
Accommodation, food service	Audiovisual and broadcasting	Telecommunications
IT and information services	Financial and insurance	Real estate
Professional and technical act.	Administrative and support services	Public administration, defence
Education	Human health, social work	Arts, entertainment
Other services	Activities of households; own use	

tariffs at the 6-digit HS (revision 1) level, we assign to each product the bilateral statutory tariff of its associated 6-digit HS88/92 category in the Global Trade Database. For the estimation sample, we follow the guidelines in Teti (2024) and exclude origin-destination-product triplets with extreme tariff levels, which are more likely to reflect measurement error in the conversion of specific tariffs into ad valorem equivalents. In our baseline specification, we drop observations in the top 1% of the tariff distribution in each year. Finally, in the extension imposing MFN restrictions, we classify tariff lines as constrained when the statutory tariff rate equals the MFN rate in the Global Trade Database.

B.1.2 Other Data Sources

Country Variables. We draw country-level and bilateral characteristics from the CEPII gravity dataset for the regressions reported in Tables 1 and 2. The indicator for a preferential trade agreement (PTA) is equal to one if the country pair is engaged in a regional trade agreement ("fta_wto"). We measure bilateral distance as the population-weighted arithmetic average distance between the most populated cities of each country pair ("distw_arithmetic"). We also use country population ("pop") and GDP in current U.S. dollars ("gdp"). For the European Union and the Rest of the World aggregates, we construct population-weighted averages of distance and GDP per capita.

Sample of Negotiated Products at the Uruguay Round. To identify which products were negotiated by each importer during the Uruguay Round, we rely on WTO Schedules of Concessions ("Goods Schedules"), which legally record countries' tariff commitments resulting from the negotiations. These schedules report, at the product level, both pre-negotiation base tariff rates and post-negotiation bound MFN tariff rates. We restrict attention to the 24 economies in our sample whose tariff schedules were established as part of the Uruguay Round.[33]

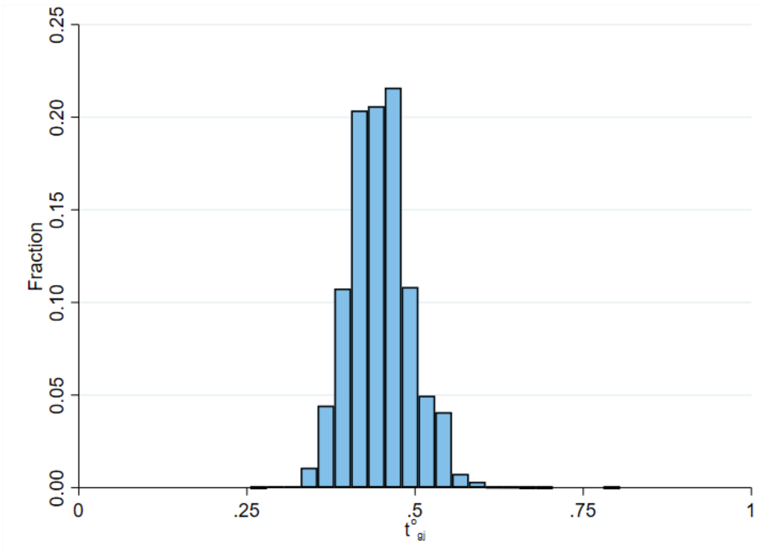
Using these records, we determine whether a 6-digit HS88/92 product was actively negotiated by comparing pre-negotiation base tariffs with post-negotiation tariff bindings. For each importer-product pair, we code a product as negotiated if the bound tariff differs from the base tariff, if an unbound tariff becomes bound, or if the tariff is converted from a specific or compound duty into an ad valorem rate. All remaining products are classified as non-negotiated. Because many schedules report tariffs at levels finer than

[33]We therefore exclude economies whose tariff commitments were negotiated through post-Uruguay Round accessions; namely, Russia, Saudi Arabia, Taiwan, and the Rest of the World composite. The only exception is China, which we include because its accession protocol was negotiated during the Uruguay Round (Bown et al., 2023).

6-digit products, we classify an importer-product pair as negotiated if the majority of underlying tariff lines were negotiated. To match the trade data used in our analysis, we assign to each 6-digit HS (revision 1) product the negotiated indicator of its corresponding 6-digit HS88/92 category.

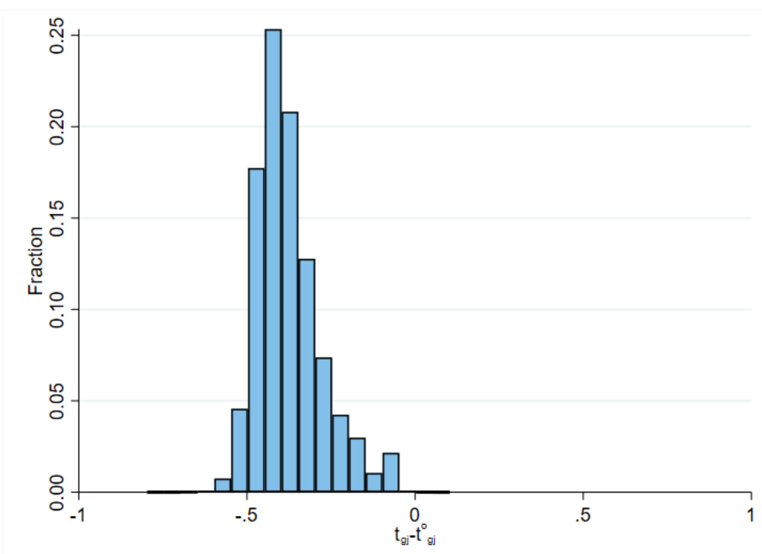
B.2 Model Predictions

Figure B.1: Opportunistic Tariffs



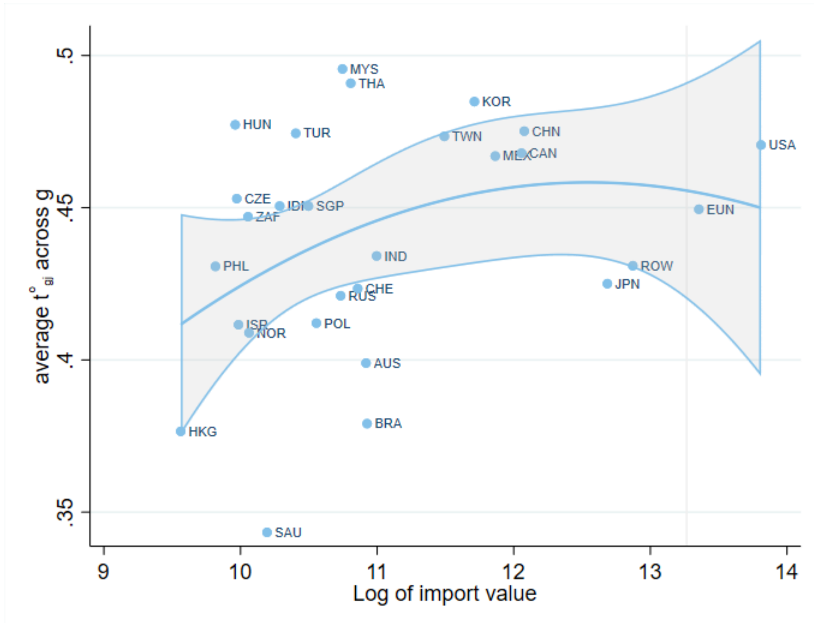
Notes: This figure plots the distribution of opportunistic tariffs t^o_{gj} across all importers j and goods g in our estimation sample.

Figure B.2: Opportunistic Tariffs vs. Observed Tariffs



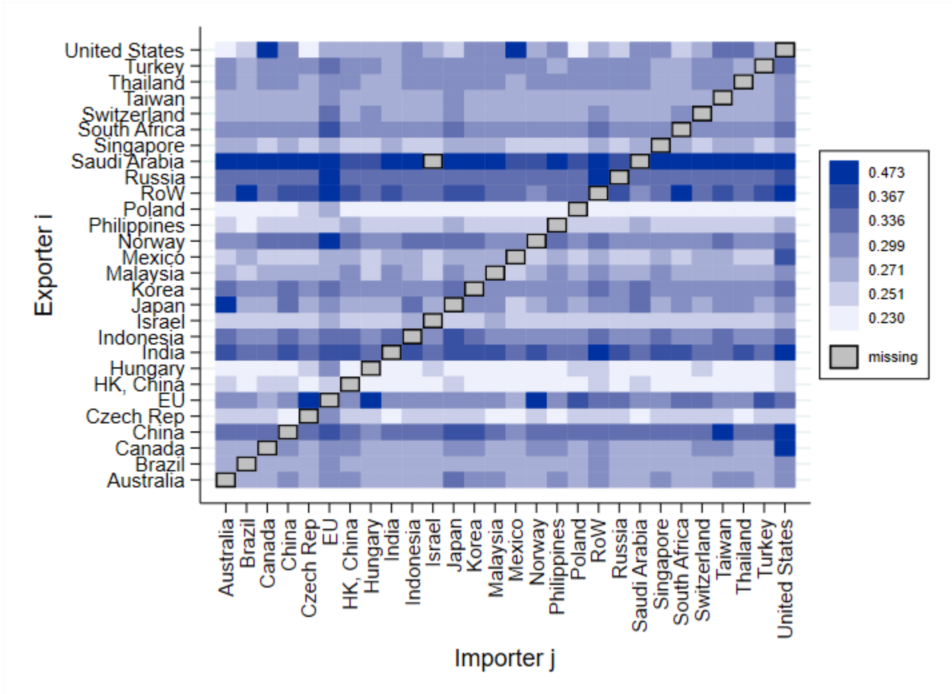
Notes: This figure plots the distribution of the difference between observed and opportunistic tariffs (i.e. $t_{gj} - t^o_{gj}$) across all importers j and goods g in our estimation sample.

Figure B.3: Opportunistic Tariffs and Importer Size



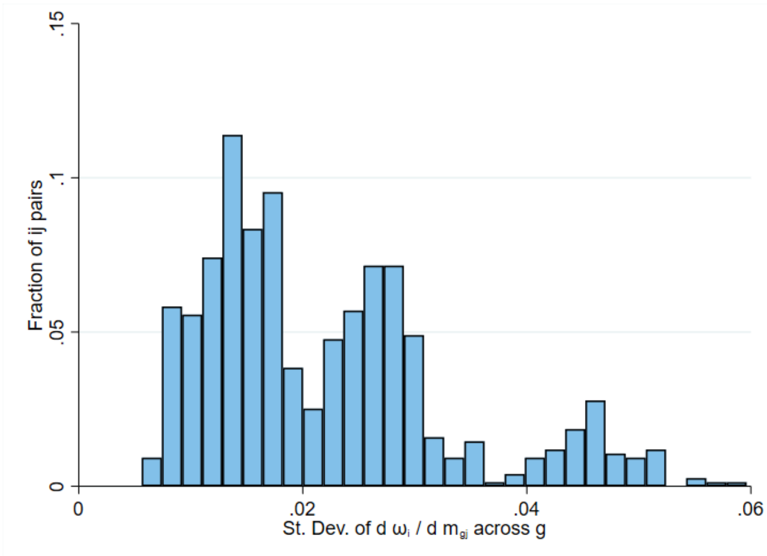
Notes: This figure reports the mean value of the opportunistic tariff t^o_{gj}, taken across all goods g, on the y-axis against the log of the total value of imports of a given importer j on the x-axis. The blue line reports the best quadratic fit polynomial, along with its 95% confidence level.

Figure B.4: Sensitivity of Foreign Real Income to Changes in Imports



Notes: This figure plots, for each origin country i on the y-axis and each destination country j on the x-axis, the mean of $\partial\omega_i/\partial m_{gj}$ (in dollars per dollar of imports) across $g = (i, j, h)$ such that j imports product h from i in our sample for 2001. The entries along the diagonal as well as those with zero trade in our sample are omitted (shaded gray).

Figure B.5: Standard Deviation of Sensitivity of Foreign Real Income to Changes in Imports



Notes: This figure plots the distribution, across all origin-destination pairs, of the standard deviation of $\partial\omega_i/\partial m_{gj}$ across across $g = (i, j, h)$ such that j imports product h from i in our sample for 2001.

B.3 Model Validation

As discussed in Section 3.3, we follow the model-testing procedure developed in Adão et al. (2025a) (ACD). The goal is to compare our model's predictions about the (log) change in a country i's real income $\Delta \ln \omega_{i,t}^{\text{pred.}}$ that would result from tariff changes, if all other exogenous model elements (preferences, technologies, endowments) were held at their year t levels, to the actual observed changes in real income, $\Delta \ln \omega_{i,t}^{\text{obs.}}$. We use all annual tariff changes $\Delta t_{gj,t} \equiv t_{gj,t+1} - t_{gj,t}$ that occurred in our sample of goods g and countries j for any year t in 1996-2019.

For any small change in tariffs, predicted (log) changes in a country i's real income are equal to:

$$\Delta \ln \omega_{i,t}^{\text{pred.}} = \sum_g \frac{p_{gi,t} m_{gi,t}}{GPD_{i,t}} \Delta \ln p_{gi,t}^{\text{pred.}} + \sum_g \frac{t_{gi,t} m_{gi,t}}{GDP_{i,t}} \Delta \ln m_{gi,t}^{\text{pred.}}, \tag{B.1}$$

where $\Delta \ln p_{gi,t}^{\text{pred.}}$ and $\Delta \ln m_{gi,t}^{\text{pred.}}$ denote the predicted changes in traded prices and quantities that would result from these tariff changes, holding other exogenous model elements to their year t levels. The first term in (B.1) captures the change in country i's terms of trade and the second term captures the change in its fiscal externality due to its own tariff policies; both are normalized by the country's initial GDP. The observed counterpart of changes in real income is:

$$\Delta \ln \omega_{i,t}^{\text{obs.}} = \sum_{g} \frac{p_{gi,t} m_{gi,t}}{GDP_{i,t}} \Delta \ln p_{gi,t}^{\text{obs.}} + \sum_{g} \frac{t_{gi,t} m_{gi,t}}{GDP_{i,t}} \Delta \ln m_{gi,t}^{\text{obs.}}, \tag{B.2}$$

where $\Delta \ln p_{gi,t}^{\text{obs.}}$ and $\Delta \ln m_{gi,t}^{\text{obs.}}$ are the observed changes in prices and quantities. In what follows, in order to attenuate concerns about measurement error in import prices and prices, we compute the sums in (B.1) and (B.2) using only the subset of goods in our baseline sample whose observed changes between consecutive years lie between the 1st and 99th percentiles of their empirical distribution.

Since observed changes also incorporate the impact of other non-tariff shocks, we compare the projections of predicted and observed variables on a third variable that is a function of tariff shocks only, which we refer to as an instrumental variable (IV). Following ACD, we construct $z_{i,t}$ as the shift-share IV whose shifters are the (demeaned) changes in tariffs and the shares are the associated derivatives in our model of changes in real income in country i at time t with respect to tariff changes,

$$z_{i,t} \equiv \sum_{g,j} \frac{\partial \ln \omega_{i,t}}{\partial \ln t_{gj,t}} (\Delta \ln t_{gj,t} - \mu_t),$$

where $\partial \ln \omega_{i,t} / \partial \ln t_{gj,t}$ denotes the derivative of country i's real income of country i with respect to the tariff charged on good g by country j, as predicted by our calibrated model at date t; and μ_t denotes the trade-weighted mean of $\Delta \ln t_{gj,t}$ across all goods g and countries j at time t. Given the IV $z_{i,t}$, we then estimate the following two linear regressions:

$$\Delta \ln \omega_{i,t}^{\text{obs.}} = \zeta_i^{\text{obs.}} + \zeta_t^{\text{obs.}} + \alpha^{\text{obs.}} z_{i,t} + \varepsilon_{i,t}^{\text{obs.}}, \tag{B.3}$$

$$\Delta \ln \omega_{i,t}^{\text{pred.}} = \zeta_i^{\text{pred.}} + \zeta_t^{\text{pred.}} + \alpha^{\text{pred.}} z_{i,t} + \varepsilon_{i,t}^{\text{pred.}}, \tag{B.4}$$

across all countries i and years t in our sample, where $(\zeta_i^{\text{obs.}}, \zeta_i^{\text{pred.}})$ and $(\zeta_t^{\text{obs.}}, \zeta_t^{\text{pred.}})$ denote country and year fixed effects, respectively. If tariff changes are mean independent of non-tariff shocks, conditional on country and year fixed effects, the difference between the two regression coefficients $\alpha^{\text{obs.}}$ and $\alpha^{\text{pred.}}$ should be zero under the null that there is no misspecification in the model's predicted response of real income to tariff changes.

Table B.3 reports the estimates from this procedure. Columns (1) and (2) report the values of $\alpha^{\text{obs.}}$ and $\alpha^{\text{pred.}}$, respectively. Both observed and predicted changes in real income are positively related to our IV, with precisely estimated coefficients that are similar in magnitude. Column (3), in turn, reports the difference between the two coefficients,

Table B.3: Responses of Real Income to Tariff Changes: A Test

	Dep. var.: change in log real income ($\Delta \ln \omega_{i,t}$)		
	Observed (1)	Predicted (2)	Obs.-Pred. (3)
Instrumental variable ($z_{i,t}$)	1.594	1.290	0.305
	(0.471)	(0.192)	(0.580)
	[0.002]	[0.000]	[0.604]

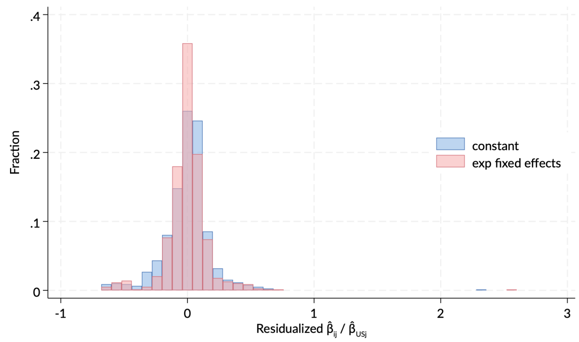
Notes: Sample of 644 observations of countries i and years t. All specifications include time and country fixed effects. Predicted outcomes in columns (2) and (3) are computed according to equation (B.1) using our model's predicted responses in the price and quantity of traded goods to tariff changes, holding everything else constant. Observed outcomes are computed analogously using observed changes in the price and quantity of the same set of traded goods. Standard errors in parentheses are clustered by country. Corresponding p-values for the test the null that each coefficient is zero are in brackets

which is our test statistic. We find that this difference is not statistically different from zero ($p = 0.604$), implying that the test does not reject the null that there is no misspecification in the model's predicted response of real income to tariff changes.

Note that standard errors in Table B.3 are clustered by country to reflect the variation in our IV while accounting for auto-correlation in residuals. In ACD, we provide an inference procedure based on the independence of the shifters that accounts for any correlation structure in residuals. Implementing this procedure is not feasible here because of the high-dimension of the "share" matrix used to construct the shift-share IV—it accounts for more than 400,000 tariff lines in any given year in our sample.

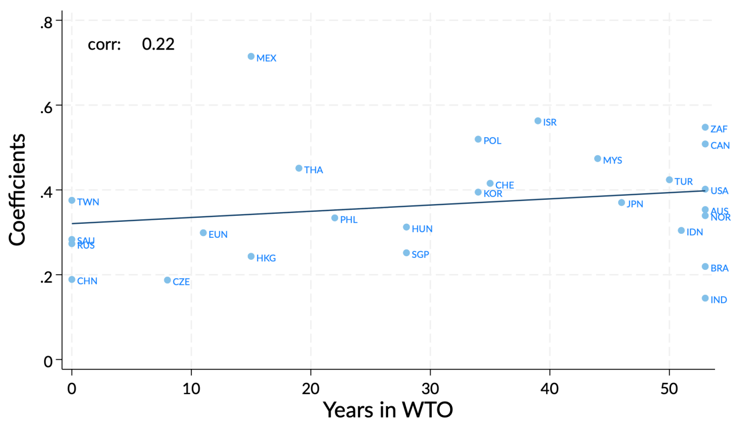
B.4 Additional Empirical Results

Figure B.6: Are Tariffs Pareto Efficient?



Notes: This figure plots the distribution of $\hat{\beta}_{ij}/\hat{\beta}_{USj}$ both after residualizing for a constant and for exporter fixed effects. Under Pareto efficiency, the latter distribution should display no variance, whereas in practice it shows just as much variance as the former distribution.

Figure B.7: Reciprocity and GATT/WTO Tenure



Notes: This figure plots, for each country j, on the y-axis the estimated slope of a regression of $\hat{\beta}_{ij}$ on $\hat{\beta}_{ji}$ (with a constant) separately for the importer against the number of years of membership in WTO/GATT on the x-axis. The estimates $\hat{\beta}_{ij}$ are based on (21).

Table B.4: Are Tariffs Pareto Efficient?

	avg. $\frac{\beta_{jj}}{\beta_{USj}}$	avg. $\frac{\beta_{ij}}{\beta_{USj}}$	sd. $\frac{\beta_{ij}}{\beta_{USj}}$	p-value	
				$\frac{\beta_{ij}}{\beta_{USj}} = \beta_i$ for all i	$\frac{\beta_{ij}}{\beta_{USj}} = \beta_i$ for all $i \neq j$
AUS	1.31	1.05	0.14	0.00	0.00
BRA	1.61	0.91	0.13	0.00	0.00
CAN	0.99	0.99	0.05	0.00	0.00
CHE	1.07	1.03	0.13	0.00	0.00
CHN	1.57	0.80	0.12	0.00	0.00
CZE	1.15	0.98	0.18	0.00	0.00
EUN	1.16	1.03	0.16	0.00	0.00
HKG	1.09	0.91	0.17	0.00	0.00
HUN	1.35	0.93	0.18	0.00	0.00
IDN	1.23	0.95	0.19	0.00	0.00
IND	3.29	0.65	0.10	0.00	0.00
ISR	0.97	0.99	0.15	0.00	0.00
JPN	1.11	0.97	0.12	0.00	0.00
KOR	1.21	0.86	0.12	0.00	0.00
MEX	1.02	0.88	0.08	0.00	0.00
MYS	1.19	0.94	0.17	0.00	0.00
NOR	1.08	1.03	0.15	0.00	0.00
PHL	1.31	0.86	0.19	0.00	0.00
POL	1.50	0.88	0.18	0.00	0.00
ROW	1.44	0.86	0.12	0.00	0.00
RUS	1.26	0.91	0.13	0.00	0.00
SAU	1.36	0.87	0.12	0.00	0.00
SGP	1.03	1.04	0.18	0.00	0.00
THA	1.36	0.85	0.18	0.00	0.00
TUR	1.19	0.89	0.19	0.00	0.00
TWN	1.15	0.92	0.13	0.00	0.00
USA	1.00	1.00	0.00		
ZAF	1.07	0.93	0.13	0.00	0.00
All	1.29	0.92	0.14	0.00	0.00

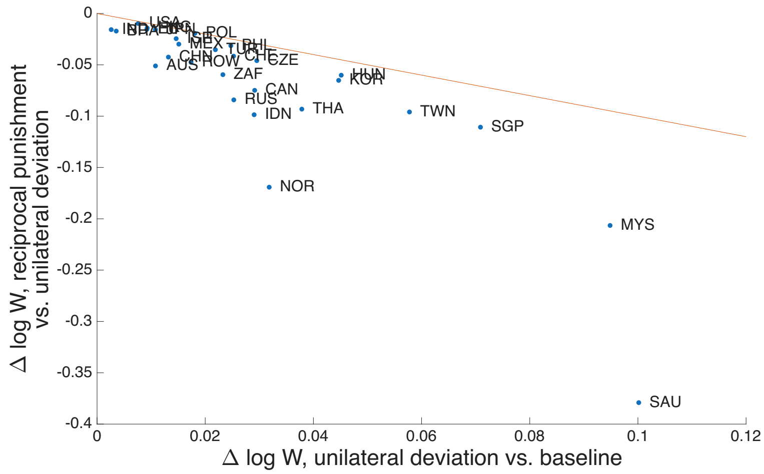
Notes: This table reports statistics based on the estimates of $\hat{\beta}_{ij}/\hat{\beta}_{USj}$ obtained from (21). For the exporter i listed in each row, column 1 reports i's value for its own residents $\hat{\beta}_{ii}/\hat{\beta}_{USi}$, column 2 reports the average value that others place on i $\frac{1}{N-1}\sum_{j:j\neq i}\hat{\beta}_{ij}/\hat{\beta}_{USj}$, column 3 reports the standard deviation across importers j of their value for i, column 4 reports the p-value of the test $\hat{\beta}_{ij}/\hat{\beta}_{USj} = \beta_i$ for all exporters i, and column 5 reports the p-value of the test $\hat{\beta}_{ij}/\hat{\beta}_{USj} = \beta_i$ for all foreign exporters i. The last row reports the average of the statistic in the corresponding column across countries.

Table B.5: Estimates Summary, 1996-2019

	Correlation with baseline $\widehat{\beta}_{ij}$ (1)	Average $\widehat{\beta}_{ij}$ (2)	Fraction of $\widehat{\beta}_{ij} > 0$ at 5% significance (3)	Max p-value of global efficiency test (4)	Reciprocity coefficient (5)
Baseline:					
1. No controls, $\sigma = 2.5$, OLS	1.00	0.82	1.00	0.00	0.47
Alternative controls:					
2. Redistribution motives	0.75	0.67	0.99	0.01	0.48
3. Constant	0.95	0.97	1.00	0.00	0.50
4. Sector fixed effects	0.94	0.73	1.00	0.00	0.37
5. All of the above	0.77	0.70	0.99	0.13	0.51
Alternative calibrations:					
6. $\sigma = 1.5$	0.98	0.90	1.00	0.00	0.56
7. $\sigma = 4.0$	0.99	0.71	0.97	0.00	0.37
GATT/WTO rules and negotiations:					
8. MFN constraint	0.92	0.81	0.99	0.00	0.35
9. Uruguay round products	0.92	0.83	1.00	0.00	0.36
IV specification:					
10. Estimation with free trade IV	1.00	0.82	1.00	0.00	0.47

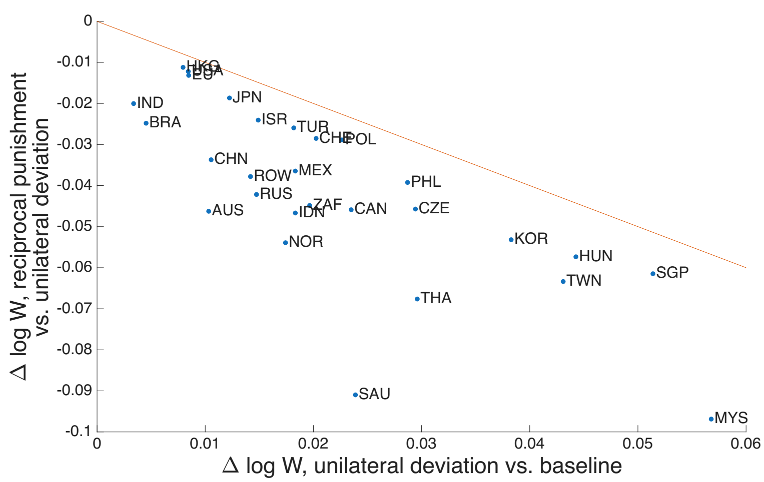
Notes: This table summarizes estimates from the baseline (in row 1) and nine alternative specifications. The first set of alternatives adds controls for: redistribution concerns (in row 2), a constant (in row 3), sector fixed effects (in row 4), and all three together (in row 5). The second set considers alternative calibrations, with a lower value of σ (in row 6) and a higher value (in row 7). The third set focuses on features of the GATT/WTO: an alternative tariff formula that imposes MFN (in row 8) and the subsample of products negotiated during the Uruguay Round (in row 9). The final alternative specification uses an IV constructed around free trade. Column (1) reports the corelation between baseline and alternative, pooled across all years, and columns (2) and (5) are analogous for the average coefficient estimate and reciprocity coefficient estimate, respectively. Column (3) reports the fraction of all estimates, across bilateral pairs and years, that are statistically significant. And column (4) reports the maximum p-value across all year-specific tests and years.

Figure B.8: Gains from Reciprocity, including Saudi Arabia



Notes: This figure replicates the results of Figure 6 including Saudi Arabia. The figure shows for each country j the welfare (real income) change associated with a counterfactual scenario in which (i) country j's welfare weights go from $\hat{\beta}_{ij}$ to zero for $i \neq j$ and (ii) in addition to country j's change in weights, each other country $i \neq j$'s welfare weights on j go from $\hat{\beta}_{ji}$ to zero. The welfare change associated with (i) is reported on the x-axis, whereas the welfare change associated with (ii) is reported on the y-axis. Gains from reciprocity are equal to (the opposite of) the sum of these two welfare changes.

Figure B.9: Gains from Reciprocity, Without Imbalances



Notes: This figure replicates the results of Figure B.8 under an alternative calibration where all imbalances are set to zero. The figure shows for each country j the welfare (real income) change associated with a counterfactual scenario in which (i) country j's welfare weights go from $\hat{\beta}_{ij}$ to zero for $i \neq j$ and (ii) in addition to country j's change in weights, each other country $i \neq j$'s welfare weights on j go from $\hat{\beta}_{ji}$ to zero. The welfare change associated with (i) is reported on the x-axis, whereas the welfare change associated with (ii) is reported on the y-axis. Gains from reciprocity are equal to (the opposite of) the sum of these two welfare changes.

C Quantitative Model

This appendix characterizes the competitive equilibrium of our model economy (Section C.2), describes our calibration procedure (Section C.3), outlines an algorithm to solve the equilibrium given a set of trade taxes and exogenous parameters (Section C.4), and presents the expressions used to compute the sensitivity of terms of trade and tariff revenue to imports (Section C.5). The entire appendix considers the model variant with imperfect mobility across segments of the labor market, as described in Section 4.5; our baseline analysis corresponds to the case where the number of such segments is one per country.

C.1 Environment with imperfect labor mobility

Supply. In each origin country i, there is a representative firm in sector group $b \in \mathcal{B}$, with $\mathcal{S}_b$ denoting the sectors in group b (such that $\{\mathcal{S}_b\}_{b\in\mathcal{B}}$ partitions $\mathcal{S}$). This firm allocates a labor endowment N_{ib} to the production of multiple products $h \in \mathcal{H}_s$ in multiple sectors in its group $s \in \mathcal{S}_b$ and for multiple destinations $j \in \mathcal{I}$. The labor resource constraint is

$$\sum_{j\in\mathcal{I}} \sum_{s\in\mathcal{S}_b} \sum_{h\in\mathcal{H}_s} \ell_{ijh} \leq N_{ib}, \tag{C.1}$$

where ℓ_{ijh} denotes the amount of labor from country i used to produce product h for country j. For a given product $h \in \mathcal{H}_s$ and destination country j, the gross output of country i's representative firm is equal to

$$q_{ijh} = \theta_{ijh} \left[(\ell_{ijh})^{\alpha_{is}} \prod_{k\in\mathcal{S}} (Q_{ik,ijh})^{(1-\alpha_{is})\alpha_{iks}} \right], \tag{C.2}$$

$$Q_{ik,ijh} = \left[\sum_{o\in\mathcal{I}} \sum_{v\in\mathcal{H}_k} (\theta_{oikv})^{\frac{1}{\sigma}} (q_{oiv,ijh})^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}}, \tag{C.3}$$

where $\sum_{k\in\mathcal{S}} \alpha_{iks} = \sum_{o\in\mathcal{I}} \sum_{v\in\mathcal{H}_k} \theta_{oikv} = 1$.

Demand. In each country $j \in \mathcal{I}$, the representative firm from sector group $b \in \mathcal{B}$ is owned by a mass N_{ib} of identical consumers $n \in \mathcal{N}_{ib}$, so that the set of consumers in i is $\mathcal{N}_i = \cup_{b\in\mathcal{B}} \mathcal{N}_{ib}$ and $|\mathcal{N}_i| = \sum_{b\in\mathcal{B}} N_{ib} \equiv N_i$. The preferences of each such household n are given by

$$u_j(n) = \prod_{s\in\mathcal{S}} (C_{js}(n))^{\gamma_{js}}, \tag{C.4}$$

$$C_{jk}(n) = \left[\sum_{i\in\mathcal{I}} \sum_{h\in\mathcal{H}_s} (\theta_{ijsh})^{\frac{1}{\sigma}} (c_{ijh}(n))^{\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}}, \tag{C.5}$$

where $c_{ijh}(n)$ denotes n's consumption of product h from country i delivered to country j. In line with our treatment of technology, we impose the normalization $\sum_{s\in\mathcal{S}} \gamma_{js} = 1$. The total spending of each consumer is equal to its share of profits earned by the representative firm in its sector group, plus lump-sum transfers $\tau_j(n)$ from the government of j. We assume lump-sum transfers are uniform, i.e.,

$$\tau_j(n) = \frac{1}{N_j}\tau_j,$$

where τ_j is the total transfers made by the government of country j.

C.2 Equilibrium

Prices. Under perfect competition, (C.2)-(C.3) implies that for all products $h \in \mathcal{H}_s$ shipped from origin country i to destination country j,

$$p_{ijh} = p^w_{ijh} + t_{ijh}, \tag{C.6}$$

$$p^w_{ijh} = (\theta_{ijh})^{-1} p_{is}, \tag{C.7}$$

$$p_{is} = [\alpha_{is}]^{-\alpha_{is}} w_{ib}^{\alpha_{is}} [1-\alpha_{is}]^{-(1-\alpha_{is})} (p^M_{is})^{1-\alpha_{is}}, \tag{C.8}$$

$$p^M_{is} = \prod_{k\in\mathcal{S}} [\alpha_{iks}]^{-\alpha_{iks}} [P_{ik}]^{\alpha_{iks}}, \tag{C.9}$$

$$P_{ik} = \left[\sum_{v\in\mathcal{H}_k} \sum_{o\in\mathcal{I}} \theta_{oikv} [p_{oiv}]^{1-\sigma}\right]^{\frac{1}{1-\sigma}}, \tag{C.10}$$

where w_{ib} is the wage in the group b containing sector s.

Bilateral Trade Flows. The expressions for prices in (C.6)-(C.10) and the expressions for technology and preferences in (C.2)-(C.3) and (C.4)-(C.5) imply that the (tariff-inclusive) spending in country $j \in \mathcal{I}$ on product $h \in \mathcal{H}_s$ in sector $s \in \mathcal{S}$ from Foreign country $i \in \mathcal{I}$

is

$$X_{ijh} = \frac{\theta_{ijsh}[p_{ijh}]^{1-\sigma}}{[P_{js}]^{1-\sigma}} X_{js}, \tag{C.11}$$

where X_{js} is total expenditure on sector s by country j.

Input Demand. Equations (C.2)-(C.3) and the definition of P_{js} imply that the problem of the representative firm in sector-group $b \in \mathcal{B}$ in country $i \in \mathcal{I}$ is

$$\max_{\{\ell_{ijh}, Q_{ik,ijh}\}} \; p^w_{ijh}\theta_{ijh}[\ell_{ijh}]^{\alpha_{is}} \prod_{k\in\mathcal{S}} [Q_{ik,ijh}]^{(1-\alpha_{is})\alpha_{iks}} - \sum_{k\in\mathcal{S}} P_{ik}Q_{ik,ijh},$$

subject to

$$\sum_{j\in\mathcal{I}} \sum_{s\in\mathcal{S}_b} \sum_{h\in\mathcal{H}_s} \ell_{ijh} \leq N_{ib}.$$

This implies

$$w_{ib}\ell_{ijh} = \alpha_{is} Y_{ijh},$$
$$P_{ik}Q_{ik,ijh} = \alpha_{iks}(1-\alpha_{is})Y_{ijh},$$

where $Y_{ijh} = p^w_{ijh} q_{ijh}$ is the total revenue from the sales of (i, j, h).

Aggregating labor and input spending across all goods associated with the same sector and country then implies

$$W_{is} = \alpha_{is} Y_{is}, \tag{C.12}$$
$$I_{iks} = \alpha_{iks}(1-\alpha_{is})Y_{is}, \tag{C.13}$$

where $W_{is} \equiv w_{ib}N_{is}$—for $N_{is} = \sum_{j\in\mathcal{I}} \sum_{h\in\mathcal{H}_s} \ell_{ijh}$ the labor employed in each sector s within country i—and $Y_{is} \equiv \sum_{h\in\mathcal{H}_s} \sum_{j\in\mathcal{I}} Y_{ijh}$ are the aggregate value added and revenue of all goods from sector s of origin i, and where $I_{iks} \equiv \sum_{h\in\mathcal{H}_s} \sum_{j\in\mathcal{I}} P_{ik}Q_{ik,ijh}$ is the aggregate expenditure of all such goods on intermediate inputs from sector k.

Final Demand. Equations (C.4)-(C.5) imply that final expenditure in country j on sector k is

$$F_{jk} = P_{jk}C_{jk} = \gamma_{jk}F_j, \tag{C.14}$$

where P^C_j denotes the consumption price index in j,

$$P^C_j = \prod_{k\in\mathcal{S}} [\gamma_{jk}]^{-\gamma_{jk}} [P_{jk}]^{\gamma_{jk}},$$

and F_j denotes aggregate final spending in j, which must be equal to j's aggregate income,

$$F_j = \sum_{s \in \mathcal{S}} W_{js} + \tau_j, \tag{C.15}$$

with

$$\tau_j = \sum_{k \in \mathcal{S}} \sum_{h \in \mathcal{H}_k} \sum_{o \in \mathcal{I}} \frac{t_{ojh}}{p_{ojh}} X_{ojh} + T_j, \tag{C.16}$$

where $T_j = \phi_j \sum_{i \in \mathcal{I}, s \in \mathcal{S}} W_{is}$ is the international transfer in terms of the world GDP.

Market Clearing. Total spending of each country j on each sector k is

$$X_{jk} = F_{jk} + \sum_{s \in \mathcal{S}} \alpha_{jks}(1 - \alpha_{js}) Y_{js}. \tag{C.17}$$

Goods market clearing requires

$$Y_{is} = \sum_{j \in \mathcal{I}} \sum_{h \in \mathcal{H}_s} \frac{p^w_{ijh}}{p_{ijh}} X_{ijh}, \tag{C.18}$$

for all $i \in \mathcal{I}$ and $s \in \mathcal{S}$.

From the firm's maximization problem, we get the labor resource constraint:

$$w_{ib} N_{ib} = \sum_{s \in \mathcal{S}_b} W_{is}, \tag{C.19}$$

for all $i \in \mathcal{I}$ and $b \in \mathcal{B}$.

C.2.1 Solving for spending conditional on prices

It will be useful in solving the model to derive a linear equation that characterizes country-sector expenditures given prices. To begin, note that, given prices, (C.11) provides a linear expression for all trade flows in terms of country-sector expenditures. That is, for any countries $i, j \in \mathcal{I}$, sector $k \in \mathcal{S}$ and $h \in \mathcal{H}_k$,

$$X_{ijh} = \zeta_{ijkh} X_{jk}, \tag{C.20}$$

$$\text{where} \quad \zeta_{ijkh} \equiv \frac{\theta_{ijsh}[p_{ijh}]^{1-\sigma}}{[P_{jk}]^{1-\sigma}}. \tag{C.21}$$

By (C.16), we similarly obtain a linear expression for tariff revenue, or equivalently, lump-sum transfers net of international transfers, in each country:

$$\tau_j - \phi_j \sum_{i\in\mathcal{I},s\in\mathcal{S}} W_{is} = \sum_{k\in\mathcal{S}} \kappa^{\tau}_{jk} X_{jk},$$
$$\text{where} \quad \kappa^{\tau}_{jk} \equiv \sum_{i\in\mathcal{I}} \sum_{h\in\mathcal{H}_k} \frac{t_{ijh}}{p_{ijh}} \zeta_{ijkh}.$$

Similarly, (C.18) implies

$$Y_{is} = \sum_{j\in\mathcal{I}} \kappa^{Y}_{ijs} X_{js}, \tag{C.22}$$
$$\text{where} \quad \kappa^{Y}_{ijs} = \sum_{h\in\mathcal{H}_s} \frac{p^w_{ijh}}{p_{ijh}} \zeta_{ijsh}.$$

Applying these expressions to (C.17) and substituting for final spending using (C.14), (C.15), and (C.19) implies

$$X_{ik} = \sum_{j\in\mathcal{I},s\in\mathcal{S}} e_{ik,js} X_{js} + E_{ik}, \tag{C.23}$$
$$\text{where} \quad e_{ik,js} \equiv \mathbb{I}_{i=j}\gamma_{ik}\kappa^{\tau}_{is} + \alpha_{iks}(1-\alpha_{is})\kappa^{Y}_{ijs},$$
$$\text{and} \quad E_{ik} \equiv \gamma_{ik}\left[\sum_{s\in\mathcal{S}} w_{is}N_{is} + \phi_j \sum_{j\in\mathcal{I},s\in\mathcal{S}} w_{js}N_{js}\right].$$

C.3 Calibration

We describe the calibration of $\{\alpha_{is}, \alpha_{iks}, \gamma_{js}, \theta_{ijh}, \theta_{ijkh}, N_{ib}, \phi_i\}$. We normalize to one all world prices ($p^w_{ijh} = 1$) and wages ($w_{ib} = 1$) in the initial equilibrium. This normalization implies that

$$t_{ijh} = t^{\text{av}}_{ijh} p^w_{ijh} = t^{\text{av}}_{ijh} \tag{C.24}$$

where t^{av}_{ijh} denotes the ad-valorem equivalent import tariff described in Section 3.2.

Preference and Technology Shifters: $\{\theta_{ijkh}, \theta_{ijh}\}$. From (C.11),

$$\theta_{ijkh} = \frac{[1+t^{\text{av}}_{ijh}]^{\sigma-1} X^{\text{BACI}}_{ijh}}{\sum_{v\in\mathcal{H}_k}\sum_{o\in\mathcal{I}}[1+t^{\text{av}}_{ojv}]^{\sigma-1} X^{\text{BACI}}_{ojv}}. \tag{C.25}$$

Without loss of generality, we set $\theta_{ijkh} = 1/(|\mathcal{H}_k| \times |\mathcal{I}|)$ if the denominator in (C.25) is zero.

Our normalization and (C.6)–(C.10) imply that $p_{ijh} = 1 + t^{\text{av}}_{ijh}$ and, thus,

$$\theta_{ijh} = p_{is} = [\alpha_{is}]^{-\alpha_{is}}[1-\alpha_{is}]^{-(1-\alpha_{is})}(p^M_{is})^{1-\alpha_{is}}, \tag{C.26}$$

where

$$p^M_{is} = \prod_{k\in\mathcal{S}}[\alpha_{iks}]^{-\alpha_{iks}}[P_{ik}]^{\alpha_{iks}}, \tag{C.27}$$

$$P_{ik} = \left[\sum_{v\in\mathcal{H}_k}\sum_{o\in\mathcal{I}}\theta_{oikv}[1+t^{\text{av}}_{oiv}]^{1-\sigma}\right]^{\frac{1}{1-\sigma}}. \tag{C.28}$$

Sector-level Preference Shifters: $\{\gamma_{jk}\}$. The expression for final demand C.14 implies that

$$\gamma_{jk} = \frac{F^{\text{ICIO}}_{jk}}{\sum_{s\in\mathcal{S}} F^{\text{ICIO}}_{js}}, \tag{C.29}$$

with F^{ICIO}_{jk} denoting the final spending in sector k in country j reported in ICIO.

Sector-level Technology Shifters: $\{\alpha_{is}, \alpha_{iks}\}$. The labor and intermediate demand in (C.12)-(C.13) imply that

$$\alpha_{is} = 1 - \frac{\sum_k I^{\text{ICIO}}_{iks}}{Y^{\text{ICIO}}_{is}}, \tag{C.30}$$

$$\alpha_{iks} = \frac{I^{\text{ICIO}}_{iks}}{\sum_{k\in\mathcal{S}} I^{\text{ICIO}}_{iks}}, \tag{C.31}$$

with I^{ICIO}_{iks} and Y^{ICIO}_{is} denoting intermediate spending on sector k and gross output in sector s of country i reported in ICIO. Without loss of generality, we set $\alpha_{is} = 1$ when $Y^{\text{ICIO}}_{is} = 0$ and $\alpha_{iks} = 1/|\mathcal{S}|$ when $\alpha_{is} = 1$.

Country-level parameters: $\{N_{ib}, \phi_i\}$. We now turn to the calibration of the labor endowment of each country. Under the normalization of $w_{ib} = 1$, we use the labor resource constraint in (C.19) to set the labor endowment as

$$N_{ib} = \sum_{s \in \mathcal{S}_b} \alpha_{is} Y_{is}, \tag{C.32}$$

where Y_{is} is the gross output in sector s of country i,

$$Y_{is} = \sum_{h \in \mathcal{H}_s} \sum_{j \in \mathcal{I}} \frac{1}{1 + t^{\text{av}}_{ijh}} X_{ijh}. \tag{C.33}$$

We obtain a measure of gross output that is consistent with the equilibrium conditions of the model using bilateral trade flows,

$$X_{ijh} = \frac{\theta_{ijsh} [1 + t^{\text{av}}_{ijh}]^{1-\sigma}}{[P_{js}]^{1-\sigma}} X_{js}, \tag{C.34}$$

where θ_{ijsh} is given by (C.25), P_{js} is given by (C.28) , and X_{jk} is implied by

$$X = (I - M)^{-1} F^{\text{ICIO}}, \tag{C.35}$$

with $F = [F^{\text{ICIO}}_{js}]$ the vector of final spending reported in ICIO and M the $(\mathcal{I} \times \mathcal{S}) \times (\mathcal{I} \times \mathcal{S})$ matrix whose entries are given by

$$M_{ik,js} = (1 - \alpha_{is}) \alpha_{iks} \sum_{h \in \mathcal{H}_s} \frac{1}{1 + t^{\text{av}}_{ijh}} \frac{\theta_{ijsh} [1 + t^{\text{av}}_{ijh}]^{1-\sigma}}{[P_{js}]^{1-\sigma}}.$$

Note that this guarantees that the vector of gross spending satisfies the equilibrium system in (C.23).

Lastly, we set international transfers to satisfy the representative consumer's budget constraint in (C.15):

$$\phi_i = \frac{\sum_{s \in \mathcal{S}} (X_{is} - Y_{is}) - \sum_{j \in \mathcal{I}} \sum_{s \in \mathcal{S}} \sum_{h \in \mathcal{H}_s} \frac{t^{\text{av}}_{jih}}{1 + t^{\text{av}}_{jih}} X_{jih}}{\sum_{j \in \mathcal{I}} \sum_{b \in \mathcal{B}} N_{jb}}, \tag{C.36}$$

where $\{N_{ib}, Y_{is}, X_{ik}, X_{ijh}\}$ are obtained from (C.32)-(C.35).

C.4 Numerical Algorithm for Equilibrium Computation

This section describes the algorithm that we use to compute equilibrium given any set of parameters and tariffs. We note that, because of the nested CES structure of demand in the model, it is easier to work with ad-valorem equivalent tariffs t^{av}_{ijh}. In this case, the equilibrium conditions above remain the same, but we specify $t_{ijh} = t^{\text{av}}_{ijh} p^{w}_{ijh}$ and thus $p_{ijh} = (1 + t^{\text{av}}_{ijh}) p^{w}_{ijh}$. We consider the following algorithm.

i. We have an outer loop indexed by a. Guess $w^{a=0}_{ib} = 1$ for all i and b.

ii. Given w^{a}_{ib}, we have an inner loop that solves for all prices and price indices p^{a}_{ijh}, p^{a}_{is}, $p^{M,a}_{is}$, P^{a}_{jk}, and P^{C}_{jk}

   (a) The inner loop is indexed by A. Guess $P^{a,A=0}_{jk} = 1$ if $a = 0$ and $P^{a,A=0}_{jk} = P^{a-1}_{jk}$ if $a > 0$.

   (b) Using (C.6)-(C.10), we compute

$$\begin{aligned} p^{M,a,A}_{is} &= \prod_{k \in \mathcal{S}} [\alpha_{iks}]^{-\alpha_{iks}} [P^{a,A}_{ik}]^{\alpha_{iks}}, \\ p^{a,A}_{is} &= [\alpha_{is}]^{-\alpha_{is}} [w^{a}_{ib(s)}]^{\alpha_{is}} [1 - \alpha_{is}]^{-(1-\alpha_{is})} (p^{M,a,A}_{is})^{1-\alpha_{is}}, \\ p^{a,A}_{ijh} &= (1 + t^{\text{av}}_{ijh}) (\theta_{ijh})^{-1} p^{a,A}_{is}, \\ \widetilde{P}^{a,A}_{jk} &= \left[\sum_{h \in \mathcal{H}_k} \sum_{i \in \mathcal{I}} \theta_{ijkh} [p^{a,A}_{ijh}]^{1-\sigma} \right]^{\frac{1}{1-\sigma}}. \end{aligned}$$

   (c) If $\max_{is} |P^{a,A}_{is} - \widetilde{P}^{a,A}_{is}| < \text{tol}$, then we set $p^{a}_{ijh} = p^{a,A}_{ijh}$, $p^{a}_{is} = p^{a,A}_{is}$, $p^{M,a}_{is} = p^{M,a,A}_{is}$, and $P^{a}_{jk} = P^{a,A}_{jk}$. If not, then we set

$$P^{a,A+1}_{jk} = P^{a,A}_{jk} \exp \left[-\chi_P \left(\log P^{a,A}_{jk} - \log \widetilde{P}^{a,A}_{jk} \right) \right],$$

   where χ_P is a positive constant.

iii. Given wages and prices, we compute country-sector gross spending X^{a}_{jk}.

   (a) Compute wage bill in each country:

$$W^{a}_{i} = \sum_{b \in \mathcal{B}} w^{a}_{ib} N_{ib}.$$

(b) Given prices, compute the terms $e^a_{ik,js}$, and E^a_{ik} used in (C.23):

$$\begin{aligned}
e^a_{ik,js} &\equiv \mathbb{I}_{i=j}\gamma_{ik}\kappa^{\tau,a}_{is} + \alpha_{iks}(1-\alpha_{is})\kappa^{Y,a}_{ijs},\\
E^a_{ik} &\equiv \gamma_{ik}(W^a_i + \phi_i \sum_{j\in\mathcal{I}} W^a_j),\\
\text{where}\quad \kappa^{\tau,a}_{is} &\equiv \sum_{o\in\mathcal{I}}\sum_{h\in\mathcal{H}_s} \frac{t^{\text{av}}_{oih}}{1+t^{\text{av}}_{oih}}\zeta^a_{oish},\\
\kappa^{Y,a}_{ijs} &\equiv \sum_{h\in\mathcal{H}_s} \frac{1}{1+t^{\text{av}}_{oih}}\zeta^a_{ijsh},\\
\zeta^a_{ijsh} &= \frac{\theta_{ijsh}[p^a_{ijh}]^{1-\sigma}}{[P^a_{js}]^{1-\sigma}}.
\end{aligned}$$

(c) Applying (C.23), we obtain the vector of gross spending $X^a \equiv \{X^a_{js}\}$ as

$$X^a = (1-e^a)^{-1}E^a.$$

iv. Use the labor demand equation and labor market clearing condition to update wages in the outer loop.

(a) Given country-sector spending, compute country-sector labor demand ND^a_{ib} by substituting (C.22) into (C.12) and summing over sectors in the same group,

$$ND^a_{ib} = \frac{1}{w^a_{ib}} \sum_{s\in\mathcal{S}_b} \alpha_{is} \sum_{j\in\mathcal{I}} \kappa^{Y,a}_{ijs} X^a_{js},$$

where $\kappa^{Y,a}_{ijs}$ is as above.

(b) If $\max_{i,b} |N_{ib} - ND^a_{ib}| < \text{tol}$, then stop. If not, then we set

$$\widetilde{w}_{ib} = w^a_{ib} \exp\left[-\chi_w \left(\log N_{ib} - \log ND^a_{ib}\right)\right]$$

for χ_w a small enough constant and then renormalize to maintain $\sum_{i\in\mathcal{I}}\sum_{b\in\mathcal{B}} w^{a+1}_{ib} N_{ib} = \sum_{i\in\mathcal{I}}\sum_{b\in\mathcal{B}} N_{ib}$, setting

$$w^{a+1}_{ib} = \frac{\sum_{j\in\mathcal{I}}\sum_{b'\in\mathcal{B}} N_{jb'}}{\sum_{j\in\mathcal{I}}\sum_{b'\in\mathcal{B}} \widetilde{w}_{jb'} N_{ib'}} \widetilde{w}_{ib}.$$

C.5 Analytical Jacobian Matrices

We now turn to the analytical Jacobian of our model for changes in terms of trade and tariff revenue with respect to changes in imports of each good. We again use the convenient representation of the model in terms of ad-valorem equivalent import tariffs. Throughout this section, we use variables with hats to denote log-changes in that variable.

Prices. Log linearizing and vectorizing the system of equations for prices in (C.6)-(C.10), we obtain expressions for $\hat{p} \equiv \{\hat{p}_{is}\}$, $\hat{p}^H \equiv \{\hat{p}_{ijh}\}$, $\hat{P} = \{\hat{P}_{is}\}$, and $\hat{p}^M = \{\hat{p}^M_{is}\}$:

$$\hat{p} = \mathcal{E}^{p,w}\hat{w} + \mathcal{E}^{p,1+t}(\widehat{1+t^{av}})$$

$$\text{where} \quad \mathcal{E}^{p,w} \equiv \left(I - \overline{\mathcal{E}}^{p,p^M}\overline{\mathcal{E}}^{p^M,P}\overline{\mathcal{E}}^{P,p^H}\overline{\mathcal{E}}^{p^H,p}\right)^{-1}\overline{\mathcal{E}}^{p,w}$$

$$\mathcal{E}^{p,1+t} \equiv \left(I - \overline{\mathcal{E}}^{p,p^M}\overline{\mathcal{E}}^{p^M,P}\overline{\mathcal{E}}^{P,p^H}\overline{\mathcal{E}}^{p^H,p}\right)^{-1}\overline{\mathcal{E}}^{p,p^M}\overline{\mathcal{E}}^{p^M,P}\overline{\mathcal{E}}^{P,p^H}\overline{\mathcal{E}}^{p^H,1+t^{av}}$$

$$\hat{p}^H = \mathcal{E}^{p^H,w}\hat{w} + \mathcal{E}^{p^H,1+t^{av}}(\widehat{1+t^{av}})$$

$$\text{where} \quad \mathcal{E}^{p^H,w} \equiv \overline{\mathcal{E}}^{p^H,p}\mathcal{E}^{p,w}$$

$$\mathcal{E}^{p^H,1+t^{av}} \equiv \overline{\mathcal{E}}^{p^H,p}\mathcal{E}^{p,1+t} + \overline{\mathcal{E}}^{p^H,1+t^{av}}$$

$$\hat{P} = \mathcal{E}^{P,w}\hat{w} + \mathcal{E}^{P,1+t^{av}}(\widehat{1+t^{av}})$$

$$\text{where} \quad \mathcal{E}^{P,w} \equiv \overline{\mathcal{E}}^{P,p^H}\mathcal{E}^{p^H,w}$$

$$\mathcal{E}^{P,1+t^{av}} \equiv \overline{\mathcal{E}}^{P,p^H}\mathcal{E}^{p^H,1+t^{av}}$$

$$\hat{p}^M = \mathcal{E}^{p^M,w}\hat{w} + \mathcal{E}^{p^M,1+t^{av}}(\widehat{1+t^{av}})$$

$$\text{where} \quad \mathcal{E}^{p^M,w} \equiv \overline{\mathcal{E}}^{p^M,P}\mathcal{E}^{P,w}$$

$$\mathcal{E}^{p^M,1+t^{av}} \equiv \overline{\mathcal{E}}^{p^M,P}\mathcal{E}^{P,1+t^{av}}.$$

The elasticity matrices are defined as follows:

$$
\begin{aligned}
[\overline{\mathcal{E}}^{p^H,p}]_{ijh,ok} &= \mathbb{1}[i=o, h \in \mathcal{H}_k] \\
[\overline{\mathcal{E}}^{p^H,1+t^{av}}]_{ijh,odv} &= \mathbb{1}[ijh = odv] \\
[\overline{\mathcal{E}}^{p,w}]_{is,jb} &= \mathbb{1}[i=j, b(s)=b]\alpha_{is} \\
[\overline{\mathcal{E}}^{p,p^M}]_{is,jk} &= \mathbb{1}[is=jk](1-\alpha_{is}) \\
[\overline{\mathcal{E}}^{p^M,P}]_{is,jk} &= \mathbb{1}[i=j]x^I_{iks} \\
[\overline{\mathcal{E}}^{P,p^H}]_{is,odv} &= \mathbb{1}[i=d, v \in \mathcal{H}_s]x_{oisv},
\end{aligned}
$$

with $x_{oisv} = \frac{\theta_{oisv}[p_{oiv}]^{1-\sigma}}{[P_{is}]^{1-\sigma}}$ and $x^I_{iks} = \alpha_{iks}$.

Given this characterization, the change in consumer price indices can be expressed as

$$
\begin{aligned}
\hat{P}^C &= \mathcal{E}^{P^C,w}\hat{w} + \mathcal{E}^{P^C,1+t}\widehat{(1+t^{\text{av}})} \\
\text{where} \quad \mathcal{E}^{P^C,w} &= \overline{\mathcal{E}}^{P^C,P}\mathcal{E}^{P,w} \\
\mathcal{E}^{P^C,1+t} &= \overline{\mathcal{E}}^{P^C,P}\mathcal{E}^{P,1+t} \\
[\overline{\mathcal{E}}^{P^C,P}]_{j,ik}&\mathbb{I}[i=j]x^C_{jk},
\end{aligned}
$$

with $x^C_{jk} = \gamma_{jk}$.

Labor market clearing. We begin by characterizing changes in trade flows using ζ_{ijsh} in (C.21). Log-linearizing and then vectorizing implies

$$
\begin{aligned}
\hat{\zeta} &= \mathcal{E}^{\zeta,w} + \mathcal{E}^{\zeta,1+t^{av}} \\
\text{where} \quad \mathcal{E}^{\zeta,w} &\equiv \overline{\mathcal{E}}^{\zeta,p^H}\mathcal{E}^{p^H,w} + \overline{\mathcal{E}}^{\zeta,P}\mathcal{E}^{P,w} \\
\mathcal{E}^{\zeta,1+t^{av}} &\equiv \overline{\mathcal{E}}^{\zeta,p^H}\mathcal{E}^{p^H,1+t^{av}} + \overline{\mathcal{E}}^{\zeta,P}\mathcal{E}^{P,1+t^{av}}
\end{aligned}
\tag{C.37}
$$

and where

$$
\begin{aligned}
[\overline{\mathcal{E}}^{\zeta,p^H}]_{ijh,odv} &= \mathbb{I}[ijh = odv](1-\sigma) \\
[\overline{\mathcal{E}}^{\zeta,P}]_{ijh,dk} &= -\mathbb{I}[j=d, h \in \mathcal{H}_k](1-\sigma).
\end{aligned}
\tag{C.38}
$$

We next expand the labor market clearing condition in (C.19), combining it with a normalization that fixes nominal world GDP. Log-linearizing and vectorizing implies

$$\begin{aligned}
\hat{w} &= \mathcal{E}^{w,X}\hat{X} + \mathcal{E}^{w,1+t^{av}}(\widehat{1+t^{av}}) \qquad \text{(C.39)}\\
\text{where} \quad \mathcal{E}^{w,X} &= \left(\text{id} - \overline{\mathcal{E}}^{w,W}\overline{\mathcal{E}}^{W,\zeta}\mathcal{E}^{\zeta,w}\right)^{-1}\overline{\mathcal{E}}^{w,W}\overline{\mathcal{E}}^{W,X}\\
\mathcal{E}^{w,1+t^{av}} &= \left(\text{id} - \overline{\mathcal{E}}^{w,W}\overline{\mathcal{E}}^{W,\zeta}\mathcal{E}^{\zeta,w}\right)^{-1}\overline{\mathcal{E}}^{w,W}\left(\overline{\mathcal{E}}^{W,1+t^{av}} + \overline{\mathcal{E}}^{W,\zeta}\mathcal{E}^{\zeta,1+t^{av}}\right),
\end{aligned}$$

and where

$$\begin{aligned}
[\overline{\mathcal{E}}^{w,W}]_{ib,jb'} &= \mathbb{1}[ib = jb'] - x^W_{jb'}\\
[\overline{\mathcal{E}}^{W,\zeta}]_{ib,odh} &= \mathbb{1}[i = o]\mathbb{1}[s(h) \in \mathcal{S}_b]\frac{\alpha_{is(h)}X_{idh}/(1+t^{av}_{idh})}{W_{ib}}\\
[\overline{\mathcal{E}}^{W,X}]_{ib,js} &= \mathbb{1}[s \in \mathcal{S}_b]\frac{\alpha_{is}}{W_{ib}}\sum_{h\in\mathcal{H}_s}\frac{X_{ijh}}{1+t^{av}_{ijh}}\\
[\overline{\mathcal{E}}^{W,1+t^{av}}]_{ib,odh} &= -\mathbb{1}[i = o]\mathbb{1}[s(h) \in \mathcal{S}_b]\frac{\alpha_{is(h)}X_{idh}/(1+t^{av}_{idh})}{W_{ib}},
\end{aligned}$$

with $x^W_{ib} = \frac{W_{ib}}{\sum_{j\in\mathcal{I},b'\in\mathcal{B}} W_{jb'}}$.

Goods market clearing. We finally turn to the goods market clearing condition,

$$X_{ik} = \gamma_{ik}F_i + \sum_{s\in\mathcal{S}}\alpha_{iks}(1-\alpha_{is})Y_{is}.$$

We begin by characterizing final demand in (C.14)-(C.16). We obtain

$$\begin{aligned}
\hat{F} &= \mathcal{E}^{F,w}\hat{w} + \overline{\mathcal{E}}^{F,X}\hat{X} + \mathcal{E}^{F,1+t}(\widehat{1+t^{\text{av}}}) \qquad \text{(C.40)}\\
\text{where} \quad \mathcal{E}^{F,w} &= \overline{\mathcal{E}}^{F,w} + \overline{\mathcal{E}}^{F,\zeta}\mathcal{E}^{\zeta,w}\\
\mathcal{E}^{F,1+t} &= \overline{\mathcal{E}}^{F,1+t} + \overline{\mathcal{E}}^{F,\zeta}\mathcal{E}^{\zeta,1+t},
\end{aligned}$$

and where

$$[\overline{\mathcal{E}}^{F,w}]_{j,ib} = \mathbb{1}[i=j]\frac{W_{jb}}{F_j}$$

$$[\overline{\mathcal{E}}^{F,X}]_{j,ik} = \mathbb{1}[i=j]\sum_{o\in\mathcal{I}}\sum_{h\in\mathcal{H}_k}\frac{\frac{t^{\text{av}}_{ojh}}{1+t^{\text{av}}_{ojh}}X_{ojh}}{F_j}$$

$$[\overline{\mathcal{E}}^{F,\zeta}]_{j,odh} = \mathbb{1}[d=j]\frac{\frac{t^{\text{av}}_{ojh}}{1+t^{\text{av}}_{ojh}}X_{ojh}}{F_j}$$

$$[\overline{\mathcal{E}}^{F,1+t^{av}}]_{j,odh} = \mathbb{1}[d=j]\frac{X_{ojh}/(1+t^{\text{av}}_{ojh})}{F_j}.$$

Next, we characterize gross output. From (C.18), we obtain

$$\hat{Y} = \mathcal{E}^{Y,w}\hat{w} + \overline{\mathcal{E}}^{Y,X}\hat{X} + \mathcal{E}^{Y,1+t}(\widehat{1+t^{\text{av}}}) \tag{C.41}$$

$$\text{where}\quad \mathcal{E}^{Y,w} = \overline{\mathcal{E}}^{Y,\zeta}\mathcal{E}^{\zeta,w}$$

$$\mathcal{E}^{Y,1+t} = \overline{\mathcal{E}}^{Y,1+t} + \overline{\mathcal{E}}^{Y,\zeta}\mathcal{E}^{\zeta,1+t},$$

and where

$$[\overline{\mathcal{E}}^{Y,\zeta}]_{is,odh} = \mathbb{I}[i=o, h\in\mathcal{H}_s]\frac{X_{idh}/(1+t^{\text{av}}_{idh})}{Y_{is}}$$

$$[\overline{\mathcal{E}}^{Y,X}]_{is,jk} = \mathbb{I}[s=k]\sum_{h\in\mathcal{H}_s}\frac{X_{ijh}/(1+t^{\text{av}}_{ijh})}{Y_{is}}$$

$$[\overline{\mathcal{E}}^{Y,1+t}]_{is,odh} = -\mathbb{I}[i=o, h\in\mathcal{H}_s]\frac{X_{idh}/(1+t^{\text{av}}_{idh})}{Y_{is}}.$$

Combining these expressions with a log-linearization of the goods market clearing condition implies

$$\hat{X} = \mathcal{E}^{X,w}\hat{w} + \mathcal{E}^{X,1+t}(\widehat{1+t^{\text{av}}}) \tag{C.42}$$

$$\text{where}\quad \mathcal{E}^{X,w} = \left(I - \overline{\mathcal{E}}^{X,F}\overline{\mathcal{E}}^{F,X} - \overline{\mathcal{E}}^{X,Y}\overline{\mathcal{E}}^{Y,X}\right)^{-1}\left(\overline{\mathcal{E}}^{X,F}\mathcal{E}^{F,w} + \overline{\mathcal{E}}^{X,Y}\mathcal{E}^{Y,w}\right)$$

$$\mathcal{E}^{X,1+t} = \left(I - \overline{\mathcal{E}}^{X,F}\overline{\mathcal{E}}^{F,X} - \overline{\mathcal{E}}^{X,Y}\overline{\mathcal{E}}^{Y,X}\right)^{-1}\left(\overline{\mathcal{E}}^{X,F}\mathcal{E}^{F,1+t} + \overline{\mathcal{E}}^{X,Y}\mathcal{E}^{Y,1+t}\right),$$

where

$$[\overline{\mathcal{E}}^{X,F}]_{ik,j} = \mathbb{I}[i=j]\frac{\gamma_{ik}F_i}{X_{ik}}$$
$$[\overline{\mathcal{E}}^{X,Y}]_{ik,js} = \mathbb{I}[i=j]\frac{\alpha_{iks}(1-\alpha_{is})Y_{is}}{X_{ik}}.$$

Solving for changes in wages and expenditure. Above, we derived expressions for the changes in wages and expenditures in terms of change in expenditure and wages, respectively, as well as changes in tariffs:

$$\hat{w} = \mathcal{E}^{w,X}\hat{X} + \mathcal{E}^{w,1+t}(\widehat{1+t^{\text{av}}}) \tag{C.43}$$
$$\hat{X} = \mathcal{E}^{X,w}\hat{w} + \mathcal{E}^{X,1+t}(\widehat{1+t^{\text{av}}}).$$

Substituting and inverting, we solve for the change in wages:

$$\hat{w} = \left(I - \mathcal{E}^{w,X}\mathcal{E}^{X,w}\right)^{-1}\left(\mathcal{E}^{w,X}\mathcal{E}^{X,1+t} + \mathcal{E}^{w,1+t}\right)(\widehat{1+t^{\text{av}}}). \tag{C.44}$$

Changes in all other equilibrium variables can be obtained by substituting the change in wages—as well as the implied change in expenditures—into the various expressions above.

Changes in trade quantities. Recall that $X_{ijh} = \zeta_{ijs(h)h}X_{js(h)}$, $X_{ijh} = p_{ijh}m_{ijh}$, and $p_{ijh} = (1+t^{\text{av}}_{ijh})(\theta_{ijh})^{-1}p_{is(h)}$. Normalizing $\hat{m}_{ijh} = 0$ if $m_{ijh} = 0$, we have

$$\hat{m} = \overline{\mathcal{E}}^{m,\zeta}\hat{\zeta} + \overline{\mathcal{E}}^{m,X}\hat{X} + \overline{\mathcal{E}}^{m,p}\hat{p} + \overline{\mathcal{E}}^{m,1+t}(\widehat{1+t^{\text{av}}}) \tag{C.45}$$

where

$$[\overline{\mathcal{E}}^{m,\zeta}]_{ijh,odv} = \mathbb{I}[m_{ijh}>0]\mathbb{I}[ijh=odv]$$
$$[\overline{\mathcal{E}}^{m,X}]_{ijh,dk} = \mathbb{I}[m_{ijh}>0]\mathbb{I}[j=d, h\in\mathcal{H}_k]$$
$$[\overline{\mathcal{E}}^{m,p}]_{ijh,ok} = -\mathbb{I}[m_{ijh}>0]\mathbb{I}[i=o, h\in\mathcal{H}_k]$$
$$[\overline{\mathcal{E}}^{m,1+t}]_{ijh,odv} = -\mathbb{I}[m_{ijh}>0]\mathbb{I}[ijh=odv].$$

Change in terms of trade. Consider the terms-of-trade effect on each country:

$$d\text{ToT}_i = \sum_{d\in\mathcal{I},h\in\mathcal{H}} dp^w_{idh} m_{idh} - \sum_{o\in\mathcal{I},h\in\mathcal{H}} dp^w_{oih} m_{oih}.$$

Since $p^w_{ijh} = p_{ijh}/(1+t^{\text{av}}_{ijh}) = (\theta_{ijh})^{-1} p_{is}$, we have

$$d\text{ToT} = \overline{\mathcal{E}}^{ToT,p}\hat{p} \tag{C.46}$$

$$\text{where} \quad [\overline{\mathcal{E}}^{ToT,p}]_{i,js} = \mathbb{I}[i=j]\left(\sum_{d\in\mathcal{I},h\in\mathcal{H}_s} \frac{X_{idh}}{1+t^{av}_{idh}}\right) - \left(\sum_{h\in\mathcal{H}_s} \frac{X_{jih}}{1+t^{av}_{jih}}\right).$$

Fiscal externalities. Consider the fiscal externality on each country:

$$d\text{R}_i = \sum_{o\in\mathcal{I},h\in\mathcal{H}} t_{oih} dm_{oih}.$$

Vectorizing, we have

$$d\text{R} = \overline{\mathcal{E}}^{R,m}\hat{m} \tag{C.47}$$

$$\text{where} \quad [\overline{\mathcal{E}}^{R,m}]_{i,odh} = \mathbb{I}[i=d] t^{\text{av}}_{oih} \frac{X_{oih}}{1+t^{\text{av}}_{oih}}.$$

From Tariff to Import Changes. The last step of our derivation is to convert the Jacobian matrices above—which are derivatives with respect to tariff changes—into the Jacobian matrices that enter our estimating equation—which are derivatives with respect to import changes. We do so by multiplying each original Jacobian matrix by the inverse of the Jacobian matrix of imports with respect to tariffs:

$$\frac{d\text{ToT}}{d\log m} = \frac{d\text{ToT}}{d\log(1+t)}\left[\frac{d\log m}{d\log(1+t)}\right]^{-1},$$
$$\frac{d\text{R}}{d\log m} = \frac{d\text{R}}{d\log(1+t)}\left[\frac{d\log m}{d\log(1+t)}\right]^{-1}.$$

Finally, we set

$$t^o_{gj} = -\frac{d\text{ToT}_j}{dm_{gj}},$$
$$\frac{\partial \omega_i}{\partial m_{gj}} = \frac{d\text{ToT}_i}{dm_{gj}} + \frac{d\text{R}_i}{dm_{gj}}.$$

Redistribution controls While our baseline analysis assumes there is only one sector group ($|\mathcal{B}| = 1$), we also consider an extended model with three sector groups b corresponding to agriculture, services, and manufacturing. We assume that each importing country j places weights

$$\beta_{ij}(n) = \beta_{ij} + \beta_i(n)$$

on each household $n \in \mathcal{N}_i$ in country i. We assume $\beta_i(n) = \bar{\beta}_{ib}$ for all households $n \in \mathcal{N}_{ib}$ associated with each sector group b, and we normalize the weights to satisfy $\beta_{jj} = 1$ and

$$\sum_{b\in\mathcal{B}} N_{ib}\bar{\beta}_{ib} = 0. \tag{C.48}$$

It follows from (13) that, in the presence of these within-country redistributive motives, tariffs contain an additional, additive term equal to

$$SMC_{gj}^{\text{redistribution}} = -\sum_{i\in\mathcal{I}}\sum_{b\in\mathcal{B}} \bar{\beta}_{ib}N_{ib} \times [\partial(\omega_{ib} - \bar{\omega}_i)/\partial m_{gj}]. \tag{C.49}$$

The term $\partial\omega_{ib}/\partial m_{gj}$ denotes the change in real income for each consumer in country i's sector group b caused by the increase in net imports of good g from country j via its impact on the local prices p_i in country i. The term $\partial\bar{\omega}_i/\partial m_{gj} \equiv \frac{1}{N_i}\sum_{b\in\mathcal{B}} N_{ib}\partial\omega_i(n)/\partial m_{gj}$ denotes the average impact.

Since the terms

$$\left\{\partial(\omega_{ib} - \bar{\omega}_i)/\partial m_{gj}\right\}_{b\in\mathcal{B}}$$

are collinear by construction, we operationalize (C.49) using the fact that for any reference group $b^* \in \mathcal{B}$,

$$\begin{aligned}
-\sum_{b\in\mathcal{B}} \bar{\beta}_{ib}N_{ib} \times [\partial(\omega_{ib} - \bar{\omega}_i)/\partial m_{gj}] &= -\sum_{b\in\mathcal{B}} \bar{\beta}_{ib}N_{ib} \times [\partial\omega_{ib}/\partial m_{gj} - \partial\omega_{ib^*}/\partial m_{gj}] \\
&= -\sum_{b\in\mathcal{B}} \bar{\beta}_{ib}N_{ib} \times [w_{ib}\partial\log w_{ib}/\partial m_{gj} - w_{ib^*}\partial\log w_{ib^*}/\partial m_{gj}] \\
&\quad + \sum_{b\in\mathcal{B}} \bar{\beta}_{ib}N_{ib} \times [(w_{ib} + \tau_i/N_i) - (w_{ib^*} + \tau_i/N_i)]\partial\log P_i^C/\partial m_{gj} \\
&= -\sum_{b\in\mathcal{B}} \bar{\beta}_{ib}N_{ib} \times [\partial\log w_{ib}/\partial m_{gj} - \partial\log w_{ib^*}/\partial m_{gj}].
\end{aligned}$$

Above, the first equality uses the normalization from (C.48), the second equality uses that transfers $\tau_j(n)$ are common across all $n \in \mathcal{N}_i$, and the third equality uses that, under our calibration, $w_{ib} = 1$ for all i and b.

Our regressions with controls for redistribution therefore contain the regressors

$$\left\{N_{ib} \times [\partial \log w_{ib}/\partial m_{gj} - \partial \log w_{ib^*}/\partial m_{gj}]\right\}_{i\in\mathcal{I},b\neq b^*}$$

where we take the omitted group b^* to be services. We compute these regressors by combining (C.44) with the Jacobian of imports with respect to tariffs, analogously to the terms-of-trade and fiscal externality terms described above.