Reciprocity and the Labor Market Effects of Trade Liberalization*

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Abstract

We formalize the GATT/WTO principle of reciprocity in workhorse quantitative trade models, characterizing reciprocal tariff cuts that hold terms of trade fixed and investigating their labor-market impacts. We provide closed-form expressions mapping reciprocal tariff cuts to labor reallocations. We demonstrate that a country's own tariff liberalization is a sufficient statistic for the labor reallocation it can expect from tariff negotiations that satisfy reciprocity. Applying our theoretical results to China's 2001 WTO accession, we find that China's tariff cuts exceeded those required to reciprocate the Uruguay Round tariff cuts that were implemented contemporaneously by the rest of the world. Had China instead reciprocated these tariff cuts, real incomes in the United States and the rest of the world would have been lower but the labor reallocation in those countries associated with China's WTO accession would also have been dampened.

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1 Introduction

When China joined the World Trade Organization (WTO) in 2001, it secured the right to access the markets of all other WTO member countries at the favorable most-favored-nation (MFN) tariffs that each WTO member offers to every other WTO member. The levels of those tariffs had been agreed as a result of the General Agreement on Tariffs and Trade (GATT) Uruguay Round negotiations that created the WTO in 1995, and they were implemented with tariff reductions over the period 1995-2005. In exchange for the right to face those tariffs, China was obligated to implement its own MFN tariff cuts beginning in 2001. These tariff cuts were specified in China's Protocol of Accession, and they were the result of negotiations with the GATT/WTO membership that began when the Uruguay Round negotiations were in their infancy.

At the time, China stated that achieving a balance between rights and obligations – *reciprocity* in GATT/WTO parlance – was its guiding principle in these negotiations (WTO, 2001a, p 2), a statement that is not surprising given the central role reciprocity (along with MFN) is understood to play in the GATT/WTO architecture.[1] Nevertheless, the United States among others has subsequently accused China of not living up to its commitment to reciprocity, and of harming US workers as a result.[2] Independent of the merits of the US position, its accusation begs the question: Is there a link between the reciprocity norm in GATT/WTO market access negotiations and the labor market adjustments that negotiated tariff cuts imply?

Economists and legal scholars have long acknowledged the potential link between reciprocity and labor market adjustments. For example, in describing the presumed benefits of reciprocity, Trebilcock (2014) observes:

> Despite wide recognition of the theoretical support for unilateral trade liberalization, countries rarely agree to open their markets to foreign competition without a reciprocal agreement from trading partners to liberalize foreign access to their own economies. Reciprocity provides a liberalizing country some assurance that adjustment costs caused by greater import penetration can be partially offset by increased access to export markets into which displaced resources can be redeployed over time. (p 73)

But missing from the literature is a formal exploration of this link. In this paper we develop a framework that is suitable for studying the link between reciprocity and labor market adjustments in workhorse quantitative trade models, and we apply our framework to the case of China's accession to the WTO.

The first contribution of our paper is to provide a formal characterization of reciprocity in quantitative trade models. To this end, we begin by deriving a set of results in a many-country many-sector Ricardian world with a continuum of tradable goods in each sector produced under constant returns, as in Eaton and Kortum (2002) and its many-sector extension. Throughout we also assume that there is a non-tradable sector in each country.

We adapt the definition of reciprocity proposed by Bagwell and Staiger (1999, 2002) to this setting, and we establish that tariff changes that satisfy reciprocity leave all relative wages – and hence each country's terms of trade – unchanged. We also characterize reciprocal tariff cuts and interpret their features. We show that reciprocal tariff changes depend on the relative country size

[1] The concept of reciprocity that applies in the context of the GATT/WTO architecture is distinct from the concept of "reciprocal tariffs" associated with President Trump's views on tariff policy, as articulated most clearly by his first Secretary of Commerce Wilbur Ross (Ross, 2017), whereby tariff levels are matched product by product and country by country. We describe the GATT/WTO notion of reciprocity more fully in section 2.

[2] See, for example, the United States Trade Representative's *2020 Report to Congress on China's WTO Compliance* (USTR, 2020).

as well as trade openness. In particular, a larger or less open country reciprocates with a tariff change that is smaller in magnitude, relative to a smaller or more open country.

We then turn to the implications of reciprocity in this setting for the magnitude of the labor-market effects associated with tariff negotiations. We consider three distinct measures of labor-market effects. Our first two measures – the magnitude of labor reallocation within the tradable sectors, and the magnitude of labor reallocation between the tradable sectors and the non-tradable sector – maintain the assumption of frictionless labor mobility. Our third measure adopts the polar opposite assumption of complete labor immobility between the tradable sectors and the non-tradable sector, and focuses on the magnitude of the adjustment in the non-tradable/tradable wage differential.

We derive closed-form expressions for these measures that partition the contributions of multilateral tariff changes to a country's labor-market effects into two components: first, conditional on reciprocity, the country's own tariff changes; second, conditional on the country's own tariff changes, the deviation from reciprocity that the negotiated tariff changes imply and the consequences of this deviation for changes in relative wages and the terms of trade. For each measure, we show that if the tariff reductions from a country's trading partners fall short of (exceed) those necessary to reciprocate the country's own tariff reductions, then the labor-market effects experienced by the country will be dampened (amplified) compared to the effects that the country would experience under reciprocal tariff reductions from its trading partners.

An implication of these results is that a country's own tariff changes are a sufficient statistic for calculating the labor-market effects it will experience as a result of negotiated tariff liberalization if and only if those tariff negotiations conform with reciprocity. This implication is of particular interest because of what it means for assessing the expected labor-market effects from tariff negotiations. According to this finding, as long as a country is confident that the outcome of its tariff negotiations will conform to MFN and satisfy the reciprocity norm, it can assess the expected labor-market effects that will result from those negotiations by focusing entirely on the labor-market consequences of its own tariff cuts and need not be concerned with the details of the (reciprocal) tariff cuts that other countries agree to implement in exchange.

We next extend our analysis to include the possibility of intermediate goods and consider as well input-output linkages as in Caliendo and Parro (2015). In this setting, the cost of an input bundle in a country – which includes the country's wage of labor but also now includes the country's cost of acquiring the intermediate goods used in production – plays the role of the wage in Ricardian models without intermediates.

We show that our earlier results on reciprocity extend without qualification to this setting provided that there is a single tradable sector and hence no input-output linkages across tradable sectors. But with intermediate goods and many tradable sectors where input-output linkages exist, we show that our results must be qualified. This is because it is then possible that sets of tariff changes may exist that satisfy reciprocity even while inducing in some sectors changes in relative world prices, provided that these changes in sectoral relative world prices balance out across sectors in a way that fixes each country's overall terms of trade as the reciprocity restriction requires. And if reciprocity is satisfied in this way, a country's own tariff changes will no longer be a sufficient statistic for the labor-market effects within its borders. Nevertheless, we argue that if tariff changes satisfy reciprocity also at the *sectoral* level, our earlier results extend without qualification to this setting as well, and a country's own tariff changes continue to be a sufficient statistic for the labor-market effects that it experiences from negotiated tariff changes.

Armed with these analytical results, we turn to our quantitative analysis. We ask whether the tariff cuts agreed to by China in its Protocol of Accession reciprocated the Uruguay Round tariff cuts that were implemented contemporaneoulsy by the rest of the WTO membership. If they did,

then in a many-country world with many tradable sectors (and in a world with intermediate goods and input-output linkages if reciprocity held sector by sector) our theoretical findings indicate that the tariff cuts implemented over this period as a result of the Uruguay Round and China's accession to the WTO would have left each WTO member country's terms of trade largely unaltered, and each country's own tariff cuts would be a sufficient statistic for the labor market effects that the country experienced as a result of these negotiated tariff changes. If China's tariff cuts did not reciprocate the Uruguay Round tariff cuts from the rest of the WTO membership, then our goal is to quantify the direction and extent of the deviation from this benchmark and its implications for labor market effects and country welfare.

Our quantitative results reveal that China's tariff cuts did in fact fail to reciprocate the rest of the world's Uruguay Round tariff cuts, but that China *exceeded* the tariff cuts that would have achieved this. If China had instead reciprocated these tariff cuts, our findings indicate that real incomes in the United States and in the rest of the world would have been lower as a result of less favorable terms of trade but the labor-market effects in those countries associated with China's WTO accession would also have been dampened. In fact, we find that with respect to the labor-market effects experienced by the United States from these world-wide tariff changes, the contribution of China's deviation from reciprocity was roughly comparable in magnitude to the contribution of the United States' own tariff cuts over this period. And compared with the case of no intermediate goods, we find that the presence of intermediate goods magnified these effects. These insights into the labor-market effects of China's WTO-accession-related tariff cuts and the quantitative results that underlie them are the second contribution of our paper.

Finally, we consider how the existence of trade imbalances would impact both our analytical and our quantitative results, maintaining the assumption that trade imbalances are exogenous to tariff policy but allowing that they may differ from zero and possibly change over time. We show that from the perspective of our analytical results, there are two ways that the introduction of trade imbalances can matter. A first way is straightforward: if trade imbalances exist at the time that countries are negotiating tariff cuts, and if countries seek to achieve reciprocal tariff changes in light of these existing trade imbalances, then our characterization of reciprocity is unchanged and its terms-of-trade preserving properties still hold, but the formula for reciprocal tariff changes will be impacted. A second way is more involved and arises when trade imbalances change through time. For this case we derive an extended notion of reciprocity that would require a country to make tariff adjustments that stabilize world prices not only in the presence of tariff changes from its trading partners, but also in the presence of changes in its own trade imbalances, which could themselves have implications for world prices and hence labor-market effects in other countries through the logic of the transfer problem. We show that our labor-market-effects measures must be augmented in the presence of trade imbalances that change through time, but that these measures still preserve key features of our earlier analysis. And given that a prominent feature of China's economic performance after its WTO accession was its large and growing trade surplus, we ask how compliance with this extended notion of reciprocity would have altered the labor-market outcomes associated with China's accession to the WTO.

We find that with no offsetting Chinese tariff adjustments, China's growing trade surplus implies that its terms of trade would deteriorate even further than under balanced trade. Thus, under an extended view of reciprocity where China would further adjust its tariffs to neutralize the terms-of-trade impact of its growing trade surplus, China would have had to lower its tariffs even less to maintain reciprocity than in the case of balanced trade, and hence its tariff cuts could be said to have exceeded by even more the tariff cuts that would have been required under this extended view of reciprocity. And we find that asking China to abide by this extended view of reciprocity could have further reduced the size of the labor-market effects experienced by the United States over this

period. Extending our analytical and quantitative results to the possibility of trade imbalances that change through time is the third contribution of our paper.

The rest of the paper proceeds as follows. In section 2 we describe the role of reciprocity in the GATT/WTO. In section 3 we present our analytical results in the Ricardian settings of Eaton and Kortum (2002) and its multi-sector extension contained in Costinot, Donaldson and Komunjer (2012). In section 4 we extend these results to a world of intermediate goods and input-output linkages across sectors as in Caliendo and Parro (2015). Section 5 presents our main quantitative results. Section 6 extends our analysis to allow for changing trade imbalances. Section 7 concludes. A pair of Appendices present supporting material not included in the body of the paper.

2 Reciprocity in the GATT/WTO

Along with MFN, reciprocity is a key feature of the GATT/WTO architecture. The concept of reciprocity refers to mutual changes in trade policy that bring about changes in the volume of each country's imports that are roughly equal to changes in the volume of its exports. Reciprocity plays a critical role in two aspects of GATT/WTO practice.

First, when governments negotiate reductions in trade barriers, they do so with the goal, found in the preamble to GATT, of striking "reciprocal and mutually advantageous arrangements directed to the substantial reduction in tariffs and other barriers to trade and to the elimination of discriminatory treatment in international commerce." In this context, governments approach negotiations seeking a "balance of concessions," whereby the market access benefit from a tariff cut offered by one government is matched by an "equivalent" concession from its trading partner. This aspect of reciprocity applies to changes in tariffs and other trade barriers resulting in trade liberalization. For example, Preeg (1970, pp. 130-134) observes that negotiators in the GATT Kennedy Round sought to achieve a balance between the forecasted increases in the volume of imports and the estimated increase in the volume of exports that would accompany a proposed set of tariff concessions.[3]

Second, when a government seeks to withdraw or modify its liberalizing commitments, or otherwise takes an action that impairs the benefits of the agreement to another government, adversely affected trading partners are permitted to respond by withdrawing "substantially equivalent concessions" of their own. This second aspect of reciprocity applies to changes in trade policy that restrict trade.

The balance achieved through reciprocity in tariff negotiations and the role of withdrawing prior concessions to restore that balance when the benefits of the bargain are impaired is reflected in a remark by a drafter of the GATT Articles quoted by Jackson (1969, pp. 170-71):

> What we have really provided, in the last analysis, is not that retaliation shall be invited or sanctions invoked, but that a balance of interests once established, shall be maintained.

This commitment to maintain the balance of concessions through retaliatory suspension of concessions is further emphasized by Dam (1970, pp. 80-81):

> The best guarantee that a commitment of any kind will be kept (particularly in an international setting where courts are of limited importance and, even more important, marshals and jails are nonexistent) is that the parties continue to view adherence to their agreement as in their mutual interest. ... Thus, the GATT system, unlike most legal systems... is not designed

[3]Dam (1970, pp. 58-61 and pp. 87-91) and Hoekman and Kostecki (1995, pp. 68-76) provide further discussion of the concept of reciprocity in GATT negotiations, as well as the various manners in which reciprocity has been measured in practice.

> to exclude self-help in the form of retaliation. Rather, retaliation, subjected to established procedures and kept within prescribed bounds, is made the heart of the GATT system.

Accordingly, one important virtue of reciprocity lies in calibrating the penalty for deviating from the bargain, which promotes stability in trade agreements that by their nature must be self-enforcing.

A further virtue is emphasized by Bagwell and Staiger (1999, 2002). They observe that adopting a natural formalization of the notion of reciprocity as it occurs in GATT practice leads to the conclusion that (MFN) tariff changes conforming to reciprocity will leave the terms of trade unchanged. The literature on the economics of trade agreements has shown that a key purpose of trade agreements is to expand market access to internationally efficient levels, a purpose that is formally equivalent to providing members with an escape from an international terms-of-trade-driven prisoner's dilemma.[4] To this end, the potential benefits of a reciprocity norm that fixes the terms of trade in the face of changes in trade policy become apparent. These benefits have been explored in various papers (see Staiger, 2022, for a recent review) and include the following: the mitigation of beggar-thy-neighbor incentives in tariff setting; the mitigation of third-party spillovers from bilateral tariff negotiations; and the mitigation of strategic features in multilateral tariff negotiations.

The concept of reciprocity can apply either bilaterally or multilaterally. In a multi-country setting such as the GATT/WTO, trade negotiating rounds involve the entire membership, and each member's desire for reciprocity is best understood as a desire for multilateral reciprocity – an expansion of global export opportunities commensurate with the market access opportunities afforded to other members by trade concessions on imports. Indeed, according to one early GATT Report (ICITO 1949), a key innovation of GATT relative to the US Reciprocal Trade Agreements Act that preceded it was precisely that the multi-country tariff bargaining rounds of GATT facilitated multilateral as opposed to bilateral reciprocity (see also Bagwell, Staiger and Yurukoglu, 2020, for evidence of the importance of multilateral reciprocity in the specific context of the bargaining records from the GATT Torquay Round). But in other contexts – such as the suspension of concessions against a nation that withdraws or violates its commitments – members tend to focus on bilateral reciprocity between themselves and the counterparty at issue. An agreement to permit the accession of a new member country (such as China, the focus of our quantitative analysis below) may fall somewhere in between these two settings depending on how the negotiations are structured, but often new member countries negotiate their accession agreements in the context of an ongoing multilateral negotiating round (as was the case with China), which would then place such accession negotiations firmly in the first setting. An additional question that arises in the context of accession negotiations is whether the new member is being asked to reciprocate the contemporaneous tariff cuts of other members or the entire history of those tariff cuts or something in between. We will return to this question in the context of China's WTO accession when we present our quantitative analysis below.

3 Reciprocity in a Many-Country Many-Sector Ricardian World

In this section we consider a many-country many-sector Ricardian world with a continuum of tradable goods in each sector produced under constant returns, as in Eaton and Kortum (2002) and its many-sector extension developed in Costinot, Donaldson and Komunjer (2012). In section 4 we introduce intermediate goods and consider as well input-output linkages as in Caliendo and

[4]This point was made by Bagwell and Staiger (1999, 2002). See Bagwell, Bown and Staiger (2016) and Staiger (2022) for recent reviews of this literature.

Parro (2015). Throughout we also assume that there is a non-tradable sector in each country, which for now we keep in the background and only describe later when its details become relevant. In section 6 we will consider the implications of trade imbalances for our analysis, but until then we maintain the assumption of balanced trade.

The world consists of N countries indexed by i or n, and J tradable sectors indexed by j, and there is a constant mass of households in each country denoted by $L = (L_1, \ldots, L_N)$. Goods are produced with a constant-returns-to-scale technology using labor, and we denote by $w = (w_1, \ldots, w_N)$ the vector of wages paid in each country. Tradable goods are subject to tariffs, denoted by τ_{inj} and defined as one plus the ad-valorem tariff applied by country i to sector-j purchases from country n, where $\tau_{inj} \equiv 1$ for $i = n$ and all j, and with tariff revenue redistributed lump sum to consumers. We also assume that shipping sector-j goods from country n to country i is subject to iceberg trade costs κ_{inj}, where κ_{inj} is the quantity of a good in sector j that must be shipped from country n in order for one unit of the good to arrive in country i, and where we assume for all j that $\kappa_{inj} \geq 1$ for $i \neq n$ and $\kappa_{inj} \equiv 1$ for $i = n$.

Let $z_j = (z_{1j}, \ldots, z_{Nj})$ be the vector of technology draws (output per worker) for any given tradable good for the N countries in a given sector, with $z \in \mathbb{R}^N_+$. Following Eaton and Kortum (2002), we assume that the $z's$ are independent draws from a Frechet distribution. A tradable good $z_j = (z_{1j}, \ldots, z_{Nj})$ from sector j is then available in country i at unit prices

$$\frac{w_1\kappa_{i1j}\tau_{i1j}}{z_{1j}}, \frac{w_2\kappa_{i2j}\tau_{i2j}}{z_{2j}} \ldots\ldots \frac{w_N\kappa_{iNj}\tau_{iNj}}{z_{Nj}},$$

and country i buys from the lowest cost suppliers in the world. Hence, the effective sector-j price of any good z in country i is given by

$$p_{ij}(z_j) = min_m \left\{ \frac{w_m\kappa_{imj}\tau_{imj}}{z_{mj}} \right\}.$$

We define the set $B_{inj} \subset \mathbb{R}^N_+$ as the set of sector-j goods that households in country i purchase from producers in country n (or the set of $z's$ in which country n is the lowest cost supplier to country i):

$$B_{inj} = \left\{ z \in \mathbb{R}^n_+ : p_{ij}(z_j) = \frac{w_n\kappa_{inj}\tau_{inj}}{z_{nj}} \right\}.$$

Denoting by $D_{ij}(z)$ the quantity of sector-j good z demanded in country i, and denoting by

$$p^w_{inj}(z_j) \equiv \frac{p_{ij}\left(z_j\right)}{\tau_{inj}} = \frac{w_n\kappa_{inj}}{z_{nj}} \tag{1}$$

the "world" (exporter) price of good z in sector j between country i and the lowest cost supplier country n, country $i's$ trade balance condition is given by

$$\sum_{n\neq i}\sum_j \int_{B_{inj}} p^w_{inj}(z_j)D_{ij}(z_j)\phi_j(z_j)dz_j = \sum_{n\neq i}\sum_j \int_{B_{nij}} p^w_{nij}(z_j)D_{nj}(z_j)\phi_j(z_j)dz_j,$$

where $\phi_j(z_j)$ is the sector-j joint density of z_j.

We now proceed to define reciprocity in this setting, and to characterize (i) the implications of reciprocity for changes in the terms of trade, (ii) the implications of reciprocity for the labor market, and (iii) the tariff changes that conform to reciprocity. To develop intuition, we first provide these characterizations for the special case of a world of two countries and one tradable sector, and we then extend the analysis to a many-country world with many tradable sectors.

3.1 Two Countries and One Tradable Sector

We consider first a two-country world with one tradable sector, which we will refer to as a two-country "Eaton and Kortum world." We index the two countries by n and i, where $n \in \{1, 2\}$ and i is "not n," and we drop the sector index j. We will use the superscripts 0 and 1 to denote equilibrium magnitudes under the initial and new tariff schedules $(\tau_{in}^0, \tau_{ni}^0)$ and $(\tau_{in}^1, \tau_{ni}^1)$, respectively.

3.1.1 Reciprocity and the Terms of Trade

We begin by defining $\hat{p}_{in}^{w0}(z) \equiv \frac{w_n^0 \kappa_{in}}{z_n}$ as the world price that would have prevailed for a good z under the initial tariff schedule $(\tau_{in}^0, \tau_{ni}^0)$ and the implied initial equilibrium wage in country n, w_n^0, had this good been sourced by country i from country n. Notice that $\hat{p}_{in}^{w0}(z)$ is not necessarily equal to the *equilibrium* world price $p_{in}^{w0}(z)$ since z can potentially be a good that was not sourced by country i from country n under the initial tariffs. In other words, $\hat{p}_{in}^{w0}(z) = p_{in}^{w0}(z)$ only for the set of goods that actually *were* imported by country i from country n under the initial tariffs.

We are now ready to define reciprocity. Following Bagwell and Staiger (1999, 2002) we say that a change in tariffs between countries n and i satisfies reciprocity for country i if these tariff changes lead to a change in the volume of country i imports, measured at initial world prices $\hat{p}_{in}^{w0}(z)$ for those country-i imports, that is equal in magnitude to the change in volume in country i exports, measured at initial world prices $\hat{p}_{ni}^{w0}(z)$ for those country-i exports.

Formally, we say that the change in tariffs implied by the tariff schedules $(\tau_{in}^0, \tau_{ni}^0)$ and $(\tau_{in}^1, \tau_{ni}^1)$ satisfies reciprocity for country i if and only if

$$\int_{B_{in}^1} \hat{p}_{in}^{w0}(z) D_i^1(z) \phi(z) dz - \int_{B_{in}^0} \hat{p}_{in}^{w0}(z) D_i^0(z) \phi(z) dz = \int_{B_{ni}^1} \hat{p}_{ni}^{w0}(z) D_n^1(z) \phi(z) dz - \int_{B_{ni}^0} \hat{p}_{ni}^{w0}(z) D_n^0(z) \phi(z) dz. \quad (2)$$

The left-hand side of the reciprocity condition (2) is the change in the volume of country $i's$ imports sourced from country n, where imports of the different goods z are aggregated using the initial world prices $\hat{p}_{in}^{w0}(z)$ that would have prevailed under the initial set of tariffs $(\tau_{in}^0, \tau_{ni}^0)$ and country n's implied initial equilibrium wage w_n^0 had these goods initially been sourced from country n. The right-hand side of the reciprocity condition (2) is the change in the volume of country $i's$ exports to country n, where exports of the different goods z are aggregated using the world prices $\hat{p}_{ni}^{w0}(z)$ that would have prevailed under the initial set of tariffs $(\tau_{in}^0, \tau_{ni}^0)$ and country i's implied initial equilibrium wage w_i^0 had these goods initially been sourced from country i. It is straightforward to show that if the reciprocity condition holds for country i, it must also hold for country n.

Exploiting the Ricardian structure of the Eaton and Kortum (2002) model, we can also express the reciprocity condition (2) in a more compact form. In particular, denoting by

$$D_{in} \equiv \int_{B_{in}} \frac{\kappa_{in} D_i(z)}{z} \phi(z) dz \quad (3)$$

the labor content of the volume of country $i's$ imports from country n inclusive of trade costs, we can use (3) and $\hat{p}_{in}^{w0}(z) \equiv \frac{w_n^0 \kappa_{in}}{z_n}$ to express the reciprocity condition (2) equivalently as

$$w_n^0 \left(D_{in}^1 - D_{in}^0 \right) = w_i^0 \left(D_{ni}^1 - D_{ni}^0 \right). \quad (4)$$

According to (4), tariff changes satisfy reciprocity in this setting if and only if each country experiences a change in the labor content of its imports valued at its trading partner's initial wage

that is equal to the change in the labor content of its exports valued at its own initial wage. We record this in:

Proposition 1 *In a two-country Eaton and Kortum world, tariff changes that satisfy reciprocity as defined by Bagwell and Staiger lead each country to experience a change in the labor content of its imports valued at its trading partner's initial wage that is equal to the change in the labor content of its exports valued at its own initial wage.*

To derive the implications of reciprocity for the terms of trade, we first write down country $i's$ trade balance condition at the initial tariffs $(\tau_{in}^0, \tau_{ni}^0)$ and at the new tariffs $(\tau_{in}^1, \tau_{ni}^1)$ respectively,

$$\int_{B_{in}^0} p_{in}^{w0}(z) D_i^0(z) \phi(z) dz = \int_{B_{ni}^0} p_{ni}^{w0}(z) D_n^0(z) \phi(z) dz$$

$$\int_{B_{in}^1} p_{in}^{w1}(z) D_i^1(z) \phi(z) dz = \int_{B_{ni}^1} p_{ni}^{w1}(z) D_n^1(z) \phi(z) dz.$$

As with the reciprocity condition, these trade balance conditions can be written in the more compact form using (3) and the definition of $p_{in}^{w0}(z)$:

$$w_n^0 D_{in}^0 = w_i^0 D_{ni}^0, \tag{5}$$

$$w_n^1 D_{in}^1 = w_i^1 D_{ni}^1. \tag{6}$$

As (5) and (6) reflect, trade balance requires that for a given pair of tariffs, the labor content of a country's imports valued at its trading partner's wage given those tariffs is equal to the labor content of the country's exports valued at its own wage given those tariffs.

But substituting the trade balance condition (5) that must hold under the initial tariffs $(\tau_{in}^0, \tau_{ni}^0)$ into the reciprocity condition (4) and defining $\omega_n \equiv w_n / w_i$ we obtain

$$\omega_n^0 D_{in}^1 = D_{ni}^1. \tag{7}$$

And substituting the trade balance condition (6) that must hold under the new tariffs $(\tau_{in}^1, \tau_{ni}^1)$ into the right-hand side of (7) yields

$$\left(\omega_n^1 - \omega_n^0\right) D_{in}^1 = 0. \tag{8}$$

Since $D_{in}^1 > 0$ given that in each country there is a positive measure of lowest-cost suppliers under the properties of the Frechet distribution, it follows from (8) that reciprocity implies $\omega_n^1 = \omega_n^0$: tariff changes that conform to reciprocity hold fixed the relative wage between country i and country n. We may therefore state:

Proposition 2 *In a two-country Eaton and Kortum world, relative wages are unchanged by reciprocal tariff changes, that is,* $\omega_n^1 - \omega_n^0 = 0$.

In the Ricardian framework considered here, for given iceberg costs and productivities, world (exporter) prices are pinned down by wages as (1) reflects. Hence, country $n's$ export prices can be expressed in terms of country $n's$ wage while country $i's$ export prices can be expressed in terms of country $i's$ wage, and the relative wage plays the role that the terms of trade plays in the neoclassical model.

We therefore may also state:

Corollary *In a two-country Eaton and Kortum world, tariff changes that satisfy reciprocity leave the terms of trade unchanged.*

The result in Proposition 2 and its corollary establishes for the two-country Eaton and Kortum (2002) model the analog of the reciprocity-fixes-the-terms-of-trade result that was derived by Bagwell and Staiger (1999, 2002) in the context of the neoclassical trade model. Note also that it is straightforward to generalize the result in Proposition 2 to other trade models with product differentiation such as Armington (1969).

3.1.2 Reciprocity and the Labor Market

We now consider the implications of reciprocity for the magnitude of labor market adjustments associated with tariff negotiations in the two-country Eaton and Kortum world. We will consider three distinct measures of labor market adjustment. Our first two measures – the magnitude of labor reallocation within the tradable sector, and the magnitude of labor reallocation between the tradable sector and the non-tradable sector – maintain the assumption of frictionless labor mobility. Our third measure adopts the polar opposite assumption of complete labor immobility between the tradable and the non-tradable sector, and focuses on the magnitude of the adjustment in the non-tradable/tradable wage differential.

Labor Reallocation Within the Tradable Sector We begin by considering the implications of reciprocity for the magnitude of labor reallocation within the tradable sector. To construct this measure, we condition on the amount of labor employed in a country's tradable sector, and we ask how much of this tradable-sector labor would have to reallocate between production that serves domestic demand and production that is export-oriented if the country reduced its tariff. This is closely related to the labor reallocation that would occur in the two-good neoclassical trade model in response to a tariff cut.

To proceed, we now denote tradable-sector magnitudes with the superscript "T" to distinguish these magnitudes from those that apply to the non-tradable sector. We denote country i's total expenditure on tradable goods by X_i^T and the expenditure (inclusive of tariffs) on tradable goods purchased by country i from country n as X_{in}^T. The share of the total expenditure in country i on tradable goods that is spent on imported goods is given by $\pi_{in} \equiv X_{in}^T/X_i^T$, where we supress the T superscript on π_{in} since for the non-tradable sector this share is identically zero. In the context of the model's structure described above, it can be shown that $\int_{B_{in}} p_{in}(z)\, D_i(z)\phi(z)dz = X_i^T \pi_{in}$, where the bilateral trade shares π_{in} adopt a gravity structure as in Eaton and Kortum (2002), namely

$$\pi_{in} = \frac{A_n \left(w_n \tau_{in}\right)^{-\theta}}{A_i \left(w_i\right)^{-\theta} + A_n \left(w_n \kappa_{in} \tau_{in}\right)^{-\theta}}, \tag{9}$$

where θ and A are the shape and scale parameters of the Frechet distribution.

With this notation, and denoting by L_n^T the labor employed in the tradable sector, we can now write down country n's labor market clearing condition for labor employed in the tradable sector,

$$w_n L_n^T = \pi_{nn} X_n^T + \frac{\pi_{in} X_i^T}{\tau_{in}}. \tag{10}$$

We can also express the labor market clearing condition for the labor employed in the tradable-sector production that is sold domestically, L_{nn}^T, as

$$w_n L_{nn}^T = \pi_{nn} X_n^T. \tag{11}$$

The trade balance condition can be written as

$$\frac{\pi_{in} X_i^T}{\tau_{in}} = \frac{\pi_{ni} X_n^T}{\tau_{ni}}. \tag{12}$$

Hence, using the expressions (10), (11), and (12), we have

$$L_{nn}^T = \pi_{nn} \frac{X_n^T}{w_n} = \frac{\tau_{ni} \pi_{nn} L_n^T}{1 + (\tau_{ni} - 1)\, \pi_{nn}}.$$

Differentiating this expression yields a measure of within-sector labor reallocation,

$$dln \frac{L_{nn}^T}{L_n^T} = -\left(\frac{\pi_{ni} \theta}{1 + (\tau_{ni} - 1)\, \pi_{nn}} \right) dln \omega_n + \left(\frac{\pi_{ni}\, (1 + \theta)}{1 + (\tau_{ni} - 1)\, \pi_{nn}} \right) dln \tau_{ni}. \tag{13}$$

When $dln \frac{L_{nn}^T}{L_n^T} \neq 0$, country n's labor within the tradable sector must reallocate between production that serves domestic demand and production that is export-oriented. Proposition 2 implies that the first term in (13) will be zero when country n's tariff cut is reciprocated by the tariff cut of country i, and the positive coefficient on $dln \tau_{ni}$ then dictates the degree to which, in response to these reciprocal tariff cuts, country n's labor in the tradable sector must reallocate from production that serves domestic demand to production that is export-oriented. Clearly, then, (13) implies that country n's own tariff cut is a sufficient statistic for its within-tradable-sector labor reallocation when country i responds with a tariff cut of its own that satisfies reciprocity. And the negative coefficient on $dln \omega_n$ implies that if country $i's$ tariff cut falls short of (exceeds) that necessary to reciprocate the tariff cut of country n and leads to a fall (rise) in ω_n, the reallocation of country $n's$ labor within the tradable sector will be dampened (amplified) compared to the reallocation that country n would experience under a reciprocal tariff cut from country i. We may therefore state:

Proposition 3 *In a two-country Eaton and Kortum world, if country $i's$ tariff reductions fall short of (exceed) those necessary to reciprocate the tariff reductions of country n, country $n's$ within-tradable-sector labor reallocation will be dampened (amplified) compared to the reallocation that country n would experience under reciprocal tariff reductions from country i.*

We may also state the following:

Corollary *In a two-country Eaton and Kortum world, a country's own tariff changes are a sufficient statistic for calculating the within-tradable-sector labor reallocation it will experience as a result of negotiated tariff liberalization if and only if those tariff negotiations conform with reciprocity.*

Intuitively, the result of Proposition 3 reflects the fact that the competitive effects of a country's tariff liberalization on producers in its tradable sector who produce for domestic consumption and must compete with foreign imports will be dampened (amplified) when the domestic relative price effects of the country's tariff liberalization are dampened (amplified), as they will be by the terms-of-trade deterioration (improvement) that the country will experience when the tariff cuts of its trading partner fall short of (exceed) those necessary to satisfy reciprocity.

Labor Reallocation Between the Tradable and Non-Tradable Sector Recalling that in the background of the model there is a non-tradable sector, we now bring this sector to the forefront and consider the implications of reciprocity for the magnitude of the labor reallocation between the tradable and non-tradable sector. To this end, we next provide the relevant details on the non-tradable sector, distinguishing non-tradable-sector variables with the superscript "NT." We denote the constant final consumption share in the non-tradable sector by α^{NT} and in the tradable sector by α^T, with the two shares summing to one.

To develop a measure of the loss of jobs in the tradable sector, we begin with the labor market clearing condition in the non-tradable sector, which is given by

$$w_n L_n^{NT} = X_n^{NT}, \tag{14}$$

where total expenditure in the non-tradable sector can be written as

$$X_n^{NT} = \alpha^{NT}\left(w_n L_n + X_n^T \frac{(\tau_{ni}-1)(1-\pi_{nn})}{\tau_{ni}}\right)$$

with π_{nn} the share of total expenditure in country n that is spent on tradable goods produced in country n. Using the fact that $X_n^{NT}/X_n^T = \alpha^{NT}/\alpha^T$, we obtain

$$X_n^{NT} = \frac{\alpha^{NT} w_n L_n}{\left(1 - \frac{\alpha^T(\tau_{ni}-1)(1-\pi_{nn})}{\tau_{ni}}\right)}. \tag{15}$$

Combining expressions (14) and (15) yields

$$\frac{L_n^{NT}}{L_n} = \alpha^{NT}\left[1 - \frac{\alpha^T(\tau_{ni}-1)(1-\pi_{nn})}{\tau_{ni}}\right]^{-1}. \tag{16}$$

Taking the total differential of (16), we obtain

$$dlnL_n^{NT} = -\frac{\alpha^T L_n^{NT}}{\alpha^{NT} L_n}\left[\frac{\pi_{nn}(\tau_{ni}-1)}{\tau_{ni}} dln\pi_{nn} - \frac{\pi_{ni}}{\tau_{ni}} dln\tau_{ni}\right]$$

where we have used the fact that $\pi_{ni} = (1-\pi_{nn})$. Using the total differential for the bilateral expenditure shares

$$dln\pi_{nn} = \theta\pi_{ni}(dlnw_i - dlnw_n) + \theta\pi_{ni} dln\tau_{ni},$$

and defining employment reallocation in the tradable sector as $dlnL_n^T \equiv \frac{-L_n^{NT}}{L_n^T} dlnL_n^{NT}$, we arrive at

$$\begin{aligned} dlnL_n^T = &-\left(\frac{L_n^{NT}}{L_n^T}\frac{L_n^{NT}}{L_n}\frac{1}{\alpha^{NT}}\left[\frac{\alpha^T\pi_{ni}\pi_{nn}(\tau_{ni}-1)\theta}{\tau_{ni}}\right]\right) dln\omega_n \\ &+\left(\frac{L_n^{NT}}{L_n^T}\frac{L_n^{NT}}{L_n}\frac{1}{\alpha^{NT}}\left[\frac{\alpha^T\pi_{ni}(\pi_{nn}(\tau_{ni}-1)\theta-1)}{\tau_{ni}}\right]\right) dln\tau_{ni}. \end{aligned} \tag{17}$$

When $dlnL_n^T \neq 0$, country n's labor must reallocate between the tradable and the non-tradable sector. Equation (17) describes the employment effect in the tradable sector that arises from changes in tariffs, and it has an analogous interpretation to (13). In particular, as with (13), Proposition 2 implies that the first term in (17) will be zero when country n's tariff cut is reciprocated by the tariff cut of country i, and the coefficient on $dln\tau_{ni}$ then dictates the degree to which, in response to these reciprocal tariff cuts, country n's labor must reallocate between the tradable and the non-tradable sector. Equation (17) therefore implies that country n's own tariff cut is a sufficient statistic for its between-sector labor reallocation when country i responds with a tariff cut of its own that satisfies reciprocity. And the coefficient on $dln\omega_n$ is negative provided that $\tau_{ni} > 1$, implying that if country $i's$ tariff cut falls short of (exceeds) that necessary to reciprocate the tariff cut of country n and leads to a fall (rise) in ω_n, the reallocation of country $n's$ labor toward the non-tradable sector will be dampened (amplified) compared to the reallocation that country n would experience under a reciprocal tariff cut from country i.[5] We may therefore state:

[5]As we note, the coefficient on $dln\omega_n$ is negative provided that $\tau_{ni} > 1$, which is the relevant starting point for the negotiated tariff reductions that we are considering. But it is informative to consider why the coefficient would be positive if one were to consider starting at an import subsidy ($\tau_{ni} < 1$). The reason is that country $n's$ labor

Proposition 4 *In a two-country Eaton and Kortum world, if country $i's$ tariff reductions fall short of (exceed) those necessary to reciprocate the tariff reductions of country n, country $n's$ labor reallocation from the tradable to the non-tradable sector will be dampened (amplified) compared to the reallocation that country n would experience under reciprocal tariff reductions from country i.*

We may also state the following:

Corollary *In a two-country Eaton and Kortum world, a country's own tariff changes are a sufficient statistic for calculating the labor reallocation between the tradable and the non-tradable sector that it will experience as a result of negotiated tariff liberalization if and only if those tariff negotiations conform with reciprocity.*

The result reported in Proposition 4 is intuitive, but the logic for this result is very different from the logic that underlies the result reported in Proposition 3. If country i falls short of (exceeds) reciprocating country $n's$ tariff cuts and as a result country n experiences a deterioration (an improvement) in its terms of trade, the resulting decrease (increase) in country $n's$ real income contributes to a fall (rise) in expenditures on non-tradable-sector goods that dampens (amplifies) the reallocation of country $n's$ labor toward the non–tradable sector. The corollary then follows because under the reciprocity norm the terms of trade remain fixed, and hence only the movement in country $n's$ local relative prices are relevant for determining the reallocation of country $n's$ labor toward the non–tradable sector, and under reciprocity the movement in country $n's$ local relative prices is fully determined by its own tariff cuts.

Notice that in contrast to the within-tradable-sector labor reallocation expression in (13), the coefficient on $dln\tau_{ni}$ in (17) describing the impact of country $n's$ own tariff change on employment in the tradable sector has an ambiguous sign that depends on whether $(\tau_{ni} - 1)$ is greater than or less than $\frac{1}{\theta\pi_{nn}}$, which we show in Appendix A.1 is the value of country $n's$ tariff that would maximize tariff revenue for fixed ω_n. In particular, when τ_{ni} is set below this revenue-maximizing level, as is typically the case for the tariffs that we consider in our quantitative analysis of section 5, the coefficient on $dln\tau_{ni}$ is negative, implying that, with the terms of trade (and hence ω_n) held fixed, a drop in τ_{ni} would lead to a *rise* in L_n^T. In other words, absent terms-of-trade effects, lowering a country's tariff pulls resources out of its non-tradable sector and into its tradable sector. Intuitively, this can be understood by referring to the labor market-clearing condition in the non-tradable sector given by (14). With ω_n and therefore w_n held fixed, country $n's$ labor income is held fixed and hence its total income – and therefore its expenditure in the non-tradable sector X_n^{NT} – changes in the same direction as the change in its tariff revenue. And (14) implies that with w_n held fixed L_n^{NT} then also changes in the same direction as the change in tariff revenue, which falls with a drop in τ_{ni} beginning from any tariff below the revenue-maximizing level.

Adjustment in Relative Wages Between the Tradable and Non-Tradable Sector Finally, we consider an interpretation of the pressures for labor reallocation between the tradable and non-tradable sectors that takes the form of adjustments in relative wages across sectors rather employment, as would occur in an economy with frictional labor mobility across sectors. Here

income increases more than its total income (labor income + tariff revenue) when it subsidizes imports and there is an increase in its terms of trade (i.e., when $dln\omega_n > 0$), because with an increase in the terms of trade country n becomes more open (π_{nn} declines) and since country n is subsidizing imports its tariff revenue becomes more negative. But for the labor market to clear in the non-tradable sector, the payment to labor employed in the non-tradable sector must be equal to the total expenditure on non-tradable-sector goods as (14) indicates; and since the wage increases by more than total income, labor must then move away from the non-tradable sector and find employment in the tradable sector.

we assume that labor is sector specific, so that all labor market adjustments occur in the form of relative wage movements.

As given by (14), labor market clearing in the non-tradable sector requires that by $w_n^{NT} L_n^{NT} = X_n^{NT}$, where total expenditure in the non-tradable sector can be written as

$$X_n^{NT} = \alpha^{NT} \left(w_n^{NT} L_n^{NT} + w_n^T L_n^T + X_n^T \frac{(\tau_{ni} - 1)\, \pi_{ni}}{\tau_{ni}} \right),$$

with X_n^T satisfying

$$X_n^T = \alpha^T \left(w_n^{NT} L_n^{NT} + w_n^T L_n^T + X_n^T \frac{(\tau_{ni} - 1)\, \pi_{ni}}{\tau_{ni}} \right).$$

Writing the trade balance condition as

$$w_n^T L_n^T = X_n^T \left(\frac{1 + \pi_{nn} (\tau_{ni} - 1)}{\tau_{ni}} \right)$$

and using the fact that $X_n^{NT}/X_n^T = \alpha^{NT}/\alpha^T$, we therefore have

$$\frac{X_n^T}{X_n^{NT}} = \frac{w_n^T L_n^T}{w_n^{NT} L_n^{NT} \left(\frac{1 + \pi_{nn}(\tau_{ni} - 1)}{\tau_{ni}} \right)}$$

and hence implies,

$$dln \frac{w_n^{NT}}{w_n^T} = -\frac{(\tau_{ni} - 1)\, \pi_{nn}}{1 + \pi_{nn} (\tau_{ni} - 1)} dln \pi_{nn} + \frac{\pi_{ni}}{1 + \pi_{nn} (\tau_{ni} - 1)} dln \tau_{ni}.$$

Finally, using the total differential for the bilateral expenditure shares $dln\pi_{nn} = -\pi_{ni}\theta dln\omega_n + \pi_{ni}\theta dln\tau_{ni}$, where it is understood that ω_n is the relative wage in the tradable sector between country n and country i, we arrive at

$$dln \frac{w_n^{NT}}{w_n^T} = \left(\frac{\pi_{ni} \pi_{nn} (\tau_{ni} - 1)\, \theta}{1 + \pi_{nn} (\tau_{ni} - 1)} \right) dln \omega_n - \left(\frac{\pi_{ni} (\pi_{nn} (\tau_{ni} - 1)\, \theta - 1)}{1 + \pi_{nn} (\tau_{ni} - 1)} \right) dln \tau_{ni}. \tag{18}$$

The expression in (18) describes the adjustment in relative wages across the non-tradable and tradable sectors of country n in response to a change in tariffs when labor is sector specific. It has the analogous interpretation to (17) when sectoral labor mobility is frictionless (with the signs of the coefficients flipped to reflect movements in wages rather than movements in labor). We may therefore state:

Proposition 5 *In a two-country Eaton and Kortum world with sector-specific labor, if country i's tariff reductions fall short of (exceed) those necessary to reciprocate the tariff reductions of country n, the reduction in country n's relative wage of tradable-sector workers compared to workers in the non-tradable sector will be dampened (amplified) compared to the reduction that country n would experience under reciprocal tariff reductions from country i.*

We may also state the following:

Corollary *In a two-country Eaton and Kortum world with sector-specific labor, a country's own tariff changes are a sufficient statistic for calculating the change in the between-sector wage differential it will experience as a result of negotiated tariff liberalization if and only if those tariff negotiations conform with reciprocity.*

3.1.3 Reciprocal Tariff Changes

We next characterize reciprocal tariff changes in a two-country Eaton and Kortum world. In particular, we solve for the schedule of reciprocal tariff changes between country n and country i, $\frac{dln\tau_{in}}{dln\tau_{ni}}$, that preserves the terms of trade between both countries unchanged (see Appendix A.2 for the derivation).[6]

The formula for reciprocal tariff changes is given by

$$\frac{d\ln\tau_{ni}}{d\ln\tau_{in}} = \frac{\tau_{in}\alpha^{NT} + \tau_{in}\pi_{ii}\left(\alpha^{T}+\theta\right)}{\tau_{in}\alpha^{NT} + \alpha^{T}\pi_{ii}\left(\tau_{in}-1\right)+\alpha^{T}} \frac{\tau_{ni}\alpha^{NT} + \alpha^{T}\pi_{nn}\left(\tau_{ni}-1\right)+\alpha^{T}}{\tau_{ni}\alpha^{NT} + \tau_{ni}\pi_{nn}\left(\alpha^{T}+\theta\right)}. \tag{19}$$

We may therefore state:

Proposition 6 *In a two-country Eaton and Kortum world, reciprocal changes in tariffs between country i and country n must satisfy equation (19).*

To interpret the reciprocal tariff formula given by (19), it is useful to consider the special case of this formula in the absence of a non-tradable sector, and hence where $\alpha^{T}=1$ and $\alpha^{NT}=0$. In this case, and denoting the share of production sold to domestic producers as $\tilde{\pi}_{ii} \equiv \frac{\tau_{in}\pi_{ii}}{1+\pi_{ii}(\tau_{in}-1)}$, (19) simplifies to

$$\frac{dln\tau_{in}}{dln\tau_{ni}} = \frac{\tilde{\pi}_{nn}}{\tilde{\pi}_{ii}}. \tag{20}$$

According to (20), reciprocal changes in tariffs between countries i and n must be proportional to their country size and initial level of trade openness, contained in the terms $\tilde{\pi}_{ii}$ and $\tilde{\pi}_{nn}$. If, for example, country i is larger or less open than country n so that $\tilde{\pi}_{ii} > \tilde{\pi}_{nn}$, then the change in country i's tariff needed to reciprocate country n's tariff change is smaller in magnitude than country n's tariff change. Intuitively, this is because the tariff change of a larger or less-open country has a greater impact on relative wages and hence the terms of trade than the same tariff change from a smaller or more open country, and so a relatively small tariff change is needed from the former country to reciprocate the latter and hold the terms of trade fixed. It also follows that if countries i and n are symmetric, achieving reciprocity requires the same change in tariffs between both countries, as (20) implies when $\tilde{\pi}_{ii} = \tilde{\pi}_{nn}$.

Finally, the same logic can be used to explain the fact that, for a given change in tariff applied by country n, there is always a change in tariff applied by country i that can neutralize the movements in the terms of trade. This property in an environment with product differentiation as in Eaton and Kortum (2002) follows from the fact that any country has a world's lowest cost supplier located within its borders for a positive measure of goods, hence the country can always exploit its "monopsony power" to move its terms of trade. In Appendix A.4 we also show that a reciprocal reduction in tariffs in this world is Pareto improving as long as both tariffs remain non-negative.

3.2 Many Countries and Many Tradable Sectors

We now extend our analysis to a many-country world with many tradable sectors. As we observed in section 2, while the concept of reciprocity in the GATT/WTO can apply either bilaterally or multilaterally, in the context of multi-country tariff negotiating rounds (including China's accession negotiations which occurred in the context of the ongoing Uruguay Round) each member's desire

[6] In Appendix A.3 we derive the expression for tariff changes that satisfy reciprocity in a two-country Eaton and Kortum world in the presence of sector-specific labor.

for reciprocity is best understood as a desire for multilateral reciprocity. We will therefore focus on multilateral reciprocity. In particular, we will say that multilateral reciprocity is satisfied for country i if the change in the volume of country $i's$ *aggregate* imports from all trading partners, measured at the initial world prices, is equal in magnitude to the change in the volume in country $i's$ *aggregate* exports to all trading partners, measured at initial world prices.

3.2.1 Multilateral Reciprocity and the Terms of Trade

We begin with a formal definition of multilateral reciprocity and a consideration of its implications for the terms of trade. For expositional ease, we will first develop our many-country analysis of these implications restricting attention to the case of a one tradable-sector (Eaton and Kortum) world. We then show how this analysis extends naturally to the many tradable-sector world.

Formally, extending (4) to an N-country world, we say that the change in tariffs implied by the tariff schedules τ_{im}^0 and τ_{im}^1 for all $m \neq i$ satisfies multilateral reciprocity for country i if and only if

$$\sum_{m \neq i} w_m^0 \left(D_{im}^1 - D_{im}^0 \right) = w_i^0 (\sum_{m \neq i} D_{mi}^1 - \sum_{m \neq i} D_{mi}^0). \tag{21}$$

Balanced trade at initial world prices for country i can be written as

$$\sum_{m \neq i} w_m^0 D_{im}^0 = w_i^0 \sum_{m \neq i} D_{mi}^0,$$

and substituting this condition into the multilateral reciprocity condition for country i in (21) yields

$$\sum_{m \neq i} w_m^0 D_{im}^1 = w_i^0 \sum_{m \neq i} D_{mi}^1. \tag{22}$$

But we also have balanced trade at the new world prices for country i, which can be written as

$$\sum_{m \neq i} w_m^1 D_{im}^1 = w_i^1 \sum_{m \neq i} D_{mi}^1,$$

and subtracting (22) from this condition yields

$$\sum_{m \neq i} w_n^1 D_{im}^1 - \sum_{m \neq i} w_m^0 D_{im}^1 = w_i^1 \sum_{m \neq i} D_{mi}^1 - w_i^0 \sum_{m \neq i} D_{mi}^1,$$

or

$$[w_i^1 - w_i^0] \sum_{m \neq i} D_{mi}^1 - \sum_{m \neq i} D_{im}^1 [w_m^1 - w_m^0] = 0.$$

Imposing multilateral reciprocity for every country, choosing the country-1 wage as the numeraire so that $w_1^1 = w_1^0 \equiv 1$, defining ω_n as the relative wage between country n and country 1 and noting that $\omega_n \equiv w_n$ for $n = 2, ..., N$, we arrive at

$$\begin{pmatrix} -D_{12}^1 & -D_{13}^1 & ... & -D_{1N}^1 \\ \sum_{m \neq 2} D_{m2}^1 & -D_{23}^1 & ... & -D_{2N}^1 \\ -D_{32}^1 & \sum_{m \neq 3} D_{m3}^1 & ... & -D_{3N}^1 \\ ... & ... & ... & ... \\ -D_{N2}^1 & -D_{N3}^1 & ... & \sum_{m \neq N} D_{mN}^1 \end{pmatrix} \begin{pmatrix} \omega_2^1 - \omega_2^0 \\ \omega_3^1 - \omega_3^0 \\ ... \\ \omega_N^1 - \omega_N^0 \end{pmatrix} = \begin{pmatrix} 0 \\ 0 \\ 0 \\ ... \\ 0 \end{pmatrix}. \tag{23}$$

Restricting our attention to non-discriminatory (MFN) tariffs, for any vector of new tariffs $\boldsymbol{\tau}^1$, the vector of new relative wages (ω_2^1 ω_3^1 ... ω_N^1) is determined, and the matrix of D_{mk}^1 is determined as well. To find the vector of original tariffs $\boldsymbol{\tau}^0$ that combined with the vector of new tariffs $\boldsymbol{\tau}^1$ would satisfy multilateral reciprocity for all countries, we look for the vector of original relative wages (ω_2^0 ω_3^0 ... ω_N^0) that solves (23) given the vector of new relative wages (ω_2^1 ω_3^1 ... ω_N^1). But the sum of any $N-1$ rows of the left-hand side matrix in (23) equals the negative of the N^{th} row, and so (23) describes a system of $N-1$ independent linear equations in the $N-1$ unknowns (ω_2^0 ω_3^0 ... ω_N^0), which therefore has a unique solution, given by $\omega_m^0 = \omega_m^1$ for $m = 2, 3, ...N$.

In Appendix A.5 we prove that this result extends naturally to a setting with many tradable sectors, hence we may state the many-country many-tradable-sectors extension of Proposition 2:

Proposition 7 *In a many-country many-tradable-sector world, relative wages are unchanged by tariff changes that deliver multilateral reciprocity for each country, that is, $\omega_n^1 - \omega_n^0 = 0$ for all n.*

And recalling that, for given iceberg costs and productivities, world prices for each sector are pinned down by wages according to (1), we therefore may also state:

Corollary *In a many-country many-tradable-sector world, tariff changes that satisfy reciprocity leave the terms of trade unchanged sector by sector.*

3.2.2 Multilateral Reciprocity and the Labor Market

We next consider the implications of multilateral reciprocity for the labor market adjustments associated with tariff changes. We derive in Appendix A.6 the many-country many-tradable-sector extensions of our three measures of labor market adjustment given by (13), (17) and (18) as derived in the two-country Eaton and Kortum world of the previous subsection.

The generalization of our measure of labor reallocation within the set of tradable sectors given by (13) now becomes

$$d\ln\frac{L_{nn}^T}{L_n^T} = \frac{\sum_{s=1}^J \alpha^s \sum_{i\neq n} \frac{\pi_{ni}^s}{\tau_{ni}^s}\theta^s d\ln\omega_{ni}^s}{\sum_{s=1}^J \alpha^s \sum_i \frac{\pi_{ni}^s}{\tau_{ni}^s}} + \frac{\sum_{s=1}^J \alpha^s (1+\theta^s) \sum_{i\neq n} \frac{\pi_{ni}^s}{\tau_{ni}^s} d\ln\tau_{ni}^s}{\sum_{s=1}^J \alpha^s \sum_i \frac{\pi_{ni}^s}{\tau_{ni}^s}} + \Theta_n \qquad (24)$$

with

$$\Theta_n \equiv \frac{\sum_{s=1}^J \alpha^s\theta^s \left(\vartheta_n\pi_{nn}^s - \sum_{i\neq n}\frac{\pi_{ni}^s}{\tau_{ni}^s}\right)\left(-d\ln\omega_{nn}^s + \sum_m \pi_{nm}^s d\ln\tau_{nm}^s\right)}{\sum_{s=1}^J \alpha^s \sum_i \frac{\pi_{ni}^s}{\tau_{ni}^s}}$$

and where $\vartheta_n = \left(\frac{\sum_{s=1}^J \alpha^s \sum_{i\neq n}\frac{\pi_{ni}^s}{\tau_{ni}^s}}{\sum_{s=1}^J \alpha^s \pi_{nn}^s}\right)$ and $d\ln\omega_{ni}^s = d\ln\omega_i - \sum_{m=1}^N \pi_{nm}^s d\ln\omega_m$. The terms $dln\omega_{nn}^s$ and $dln\omega_{ni}^s$ represent the changes in the multilateral sector-s terms of trade for countries n and i, respectively. In a two country Eaton and Kortum world, it is direct to confirm that $\Theta_n = 0$; noting that in that world country n's terms of trade is the inverse of country i's terms of trade, it then follows that (24) collapses to (13). Although (24) is more involved than (13), the implications of reciprocity remain the same. In particular, the terms $dln\omega_n$ and $dln\omega_i$ are zero under multilateral reciprocity according to Proposition 7 and therefore $dln\omega_{nn}^s$ and $dln\omega_{ni}^s$ are also zero, leaving country n's tariffs as the sole determinants of labor reallocation within its tradable sector when multilateral reciprocity is satisfied. In Appendix A.6.1 we show that $d\ln\frac{L_{nn}^T}{L_n^T}$ is decreasing in $dln\omega_{nn}$

and increasing in $dln\omega_{ni}$, the many-country many-tradable-sector analog of the implications of deviations from reciprocity implied by (13).

Turning to our other two measures of labor market adjustment, the generalization of our measure of labor reallocation between the tradable and the nontradable sector given by (17) to a world with many countries and many tradable sectors now becomes

$$d\ln L_n^T = \frac{L_n^{NT}}{L_n^T}\frac{L_n^{NT}}{L_n}\frac{1}{\alpha^{NT}}\left[\sum_{i=1}^{N}\sum_{s=1}^{J}\frac{\alpha^s\pi_{ni}^s\left(\tau_{ni}^s-1\right)\theta^s}{\tau_{ni}^s}d\ln\omega_{ni}^s\right] + \frac{L_n^{NT}}{L_n^T}\frac{L_n^{NT}}{L_n}\frac{1}{\alpha^{NT}}\left[\sum_{i=1}^{N}\sum_{s=1}^{J}\alpha^s\pi_{ni}^s\left[\frac{\left[\left(\tau_{ni}^s-1\right)\theta^s-1\right]}{\tau_{ni}^s}-\sum_{m=1}^{N}\frac{\pi_{nm}^s\left(\tau_{nm}^s-1\right)\theta^s}{\tau_{nm}^s}\right]d\ln\tau_{ni}^s\right]. \tag{25}$$

The generalization of our measure of the adjustment in relative wages across the non-tradable and tradable sectors of country n when labor is sector specific given by (18) to a world with many countries and many tradable sectors now becomes

$$d\ln\frac{w_n^{NT}}{w_n^T} = \frac{\sum_{s=1}^{J}\frac{\alpha^s}{\alpha^{NT}}\sum_i\frac{\pi_{ni}^s}{\tau_{ni}^s}\left(\theta^s d\ln\omega_{ni}^s+\left(1+\theta^s\right)d\ln\tau_{ni}^s-\theta^s\sum_m\pi_{nm}^s d\ln\tau_{nm}^s\right)}{\sum_{s=1}^{J}\frac{\alpha^s}{\alpha^{NT}}\sum_i\frac{\pi_{ni}^s}{\tau_{ni}^s}}. \tag{26}$$

Using the definition of $d\ln\omega_{ni}^s$, it follows from inspection of (25) and (26) that these expressions also inherit the same basic structure exhibited by their two-country one-tradable-sector analogs (17) and (18), respectively.

Armed with Proposition 7 and its corollary, we may therefore state:

Proposition 8 *Propositions 3-5 and their corollaries extend without qualification to a many-country many-tradable-sector world.*

Proposition 8 is of particular interest because of what it implies for assessing the expected labor market impacts associated with tariff negotiations. More specifically, according to Proposition 8, as long as a country is confident that the outcome of the tariff negotiations it is engaged in will conform to MFN and satisfy the multilateral reciprocity norm, it can assess the expected labor market effects that will result from those negotiations by focusing entirely on the labor market consequences of its own tariff cuts and need not be concerned with the details of the tariff cuts that other countries agree to implement.

Finally, in Appendix A.7 we derive an expression for tariff changes that satisfy multilateral reciprocity in a many-country world with many tradable sectors. There we also show that, in a world with multiple countries and multiple tradable sectors, further conditions are required to ensure that there are enough instruments (tariffs) to fix all the terms of trade across all countries, and we establish conditions for the existence of a set of tariff changes that satisfies multilateral reciprocity in such a world.

4 Reciprocity with Intermediate Goods

In this section we extend our analysis to incorporate intermediate goods. We begin by focusing on a world with a single tradable sector, before considering the complications that arise in a world with many tradable sectors and input-output linkages across sectors as in Caliendo and Parro (2015). As before, there is also a non-tradable sector which we keep in the background until we need it.

4.1 A World with Intermediate Goods and One Tradable Sector

We assume that a good z is produced with labor and input materials that are aggregated with Cobb-Douglas shares. As a result a tradable good $z = (z_1, \ldots, z_N)$ is now available in country i at unit prices

$$\frac{w_1^{\beta} P_1^{1-\beta} \kappa_{i1} \tau_{i1}}{z_1}, \frac{w_2^{\beta} P_2^{1-\beta} \kappa_{i2} \tau_{i2}}{z_2} ..... \frac{w_N^{\beta} P_N^{1-\beta} \kappa_{iN} \tau_{iN}}{z_N},$$

where β is the share of value added in gross output and P_i is the price index of materials in country i. As in Eaton and Kortum (2002), in this formulation we assume that intermediates goods z are aggregated into a composite good, whose price is P_i and which can be used for the production of intermediate varieties and for final consumption. The cost of a bundle of inputs in country i is therefore given by

$$c_i = w_i^{\beta} P_i^{1-\beta}. \tag{27}$$

As before, all producers in i buy from the lowest cost suppliers in the world. Hence, the effective price of any good z in country i is given by

$$p_i(z) = min_m \left\{ \frac{c_m \kappa_{im} \tau_{im}}{z_m} \right\}.$$

The set B_{in} of goods that households in i purchases from producers in n (or the set of $z's$ for which country n is the lowest cost supplier) is given by

$$B_{in} = \left\{ z \in \mathbb{R}_+^n : p_i(z) = \frac{c_n \kappa_{in} \tau_{in}}{z} \right\}.$$

With $D_i(z)$ denoting the quantity of good z demanded in country i, and denoting by

$$p_{in}^w(z) \equiv \frac{p_i(z)}{\tau_{in}} = \frac{c_n \kappa_{in}}{z_n} \tag{28}$$

the "world" (exporter) price of good z between country i and the lowest cost supplier country n, country $i's$ trade balance condition is given by

$$\sum_{n \neq i} \int_{B_{in}} p_{in}^w(z) D_i(z) \phi(z) dz = \sum_{n \neq i} \int_{B_{ni}} p_{ni}^w(z) D_n(z) \phi(z) dz.$$

We next revisit the implications of reciprocity. For simplicity, in what follows we focus our attention on a two-country world and only briefly discuss extensions to a many-country world.

4.1.1 Reciprocity and the Terms of Trade

As in our earlier discussion, we denote by $\hat{p}_{in}^{w0}(z)$ the initial world price for an import good z of country i, defined as the world price that would have prevailed for a good z under the initial tariff schedule $(\tau_{in}^0, \tau_{ni}^0)$ had this good been sourced by country i from country n. And we continue to denote by $\hat{p}_{ni}^{w0}(z)$ the initial world price for an export good z of country i, defined as the world price that would have prevailed for a good z under the initial tariff schedule $(\tau_{in}^0, \tau_{ni}^0)$ had this good been sourced by country n from country i. Notice, though, that as a comparison of (28) and (1) confirms, in the presence of intermediate goods the world price now includes the price of intermediate materials, with c_n taking the place of w_n.

It follows that the reciprocity condition with intermediate goods is defined exactly as in (2), with the only difference that now world prices include the price of intermediate materials. In analogy with (4), therefore, we can write the reciprocity condition in the more compact form

$$c_n^0 \left(D_{in}^1 - D_{in}^0 \right) = c_i^0 \left(D_{ni}^1 - D_{ni}^0 \right),$$

where the only difference with (4) is that c now takes the place of w. And following similar steps, the trade balance conditions for country i at the initial and new tariffs, respectively, can be written as

$$c_n^1 D_{in}^1 = c_i^1 D_{ni}^1,$$
$$c_n^0 D_{in}^0 = c_i^0 D_{ni}^0.$$

Finally, defining $\tilde{\omega}_n \equiv c_n/c_i$ as the relative cost of an input bundle in countries n and i and using the reciprocity and trade balance conditions, we obtain

$$\left(\tilde{\omega}_n^1 - \tilde{\omega}_n^0 \right) D_{in}^1 = 0.$$

As with the case of no intermediate goods, since $D_{in}^1 > 0$, we can state the following:

Proposition 9 *In a two-country world with intermediate goods and a single tradable sector, relative input-bundle costs are unchanged by reciprocal tariff changes, that is,* $\tilde{\omega}_n^1 - \tilde{\omega}_n^0 = 0$.

With world prices pinned down by input bundles for given iceberg costs and productivities as (28) reflects, we can also state the following:

Corollary *In a two-country world with intermediate goods and a single tradable sector, the terms of trade are unchanged by reciprocal tariff changes.*

It should also be clear that the implications of reciprocity for world prices and the terms of trade in a many-country world with intermediate goods are the same as in the case with no intermediate goods, since we can follow the same steps as before after observing that, for given iceberg costs and productivities, world prices are given by the cost of a bundle of inputs c_n instead of wages w_n. Hence, Proposition 9 and its Corollary extend without qualification to a many-country world.

4.1.2 Reciprocity and the Labor Market

We next consider the implications of reciprocity for the labor market adjustments associated with tariff changes in world with intermediate goods and a single tradable sector.[7] To proceed, we note that the bilateral trade share expression in (9) now becomes

$$\pi_{in} = \frac{A_n \left(c_n \tau_{in} \right)^{-\theta}}{A_i \left(c_i \right)^{-\theta} + A_n \left(c_n \kappa_{in} \tau_{in} \right)^{-\theta}} \tag{29}$$

with the cost of the input bundle c now replacing the wage w.

With this notation, we derive in Appendix A.8 the extensions to this setting of our three measures of labor market adjustment given by (13), (17) and (18) as derived in the two-country Eaton and Kortum world. The generalization of our measure of labor reallocation within the tradable sector given by (13) to a world with intermediate goods now becomes

$$dln \frac{L_{nn}}{L_n} = - \left(\frac{\pi_{ni} \theta}{1 + \left(\tau_{ni} - 1 \right) \pi_{nn}} \right) dln \tilde{\omega}_n + \left(\frac{\pi_{ni} \left(1 + \theta \right)}{1 + \left(\tau_{ni} - 1 \right) \pi_{nn}} \right) dln \tau_{ni}. \tag{30}$$

[7] For simplicity, we abstract from input-output linkages between the tradable and non-tradable sector.

The generalization of our measure of labor reallocation between the tradable and the nontradable sector given by (17) to a world with intermediate goods now becomes

$$dlnL_n^T = -\frac{L_n^{NT}}{L_n^T}\frac{L_n^{NT}}{L_n}\frac{\beta}{\alpha^{NT}}\left[\frac{\alpha^T\pi_{ni}\pi_{nn}\left(\tau_{ni}-1\right)\theta\tau_{ni}}{\left(\tau_{ni}-\left(1-\beta\right)\left(1+\left(\tau_{ni}-1\right)\pi_{nn}\right)\right)^2}\right]dln\tilde{\omega}_n \tag{31}$$
$$+\frac{L_n^{NT}}{L_n^T}\frac{L_n^{NT}}{L_n}\frac{\beta}{\alpha^{NT}}\left[\frac{\alpha^T\pi_{ni}\left(\pi_{nn}\left(\tau_{ni}-1\right)\theta-1\right)\tau_{ni}}{\left(\tau_{ni}-\left(1-\beta\right)\left(1+\left(\tau_{ni}-1\right)\pi_{nn}\right)\right)^2}\right]dln\tau_{ni}.$$

And the generalization of our measure of the adjustment in relative wages across the non-tradable and tradable sectors of country n when labor is sector specific given by (18) now becomes

$$dln\frac{w_n^{NT}}{w_n^T} = \left(\frac{\pi_{ni}\pi_{nn}\left(\tau_{ni}-1\right)\theta}{\left[1+\pi_{nn}\left(\tau_{ni}-1\right)\right]\left(1-\left(1-\beta\right)\left[\frac{\pi_{ni}}{\tau_{ni}}+\pi_{nn}\right]\right)}\right)dln\tilde{\omega}_n \tag{32}$$
$$-\left(\frac{\pi_{ni}\left(\pi_{nn}\left(\tau_{ni}-1\right)\theta-1\right)}{\left[1+\pi_{nn}\left(\tau_{ni}-1\right)\right]\left(1-\left(1-\beta\right)\left[\frac{\pi_{ni}}{\tau_{ni}}+\pi_{nn}\right]\right)}\right)dln\tau_{ni}.$$

It follows from inspection of (30)-(32) that these expressions inherit the same basic structure exhibited by their two-country one-tradable-sector analogs (13), (17) and (18) derived in the absence of intermediate goods. Armed with Proposition 9 and its corollary, we may therefore state:

Proposition 10 *Propositions 3-5 and their corollaries extend without qualification to a two-country world with a single tradable sector and intermediate goods.*

As with Proposition 9 and its Corollary, it is straightforward to show that the results recorded in Proposition 10 extend without qualification to a many-country world provided the (MFN) tariff cuts satisfy multilateral reciprocity for all countries.

4.1.3 Reciprocal Tariff Changes

We next characterize reciprocal tariff changes in a world with a single tradable sector and intermediate goods. In Appendix A.9 we provide this characterization when a non-tradable sector is present. Here we abstract from the presence of a non-tradable sector to facilitate the interpretation of the expression for reciprocal tariff changes that we present below, the derivation of which we also provide in Appendix A.9.

Using the result of Proposition 9 and its Corollary, reciprocal changes in tariffs between country i and country n (i.e., the tariff changes that satisfy $dlnc_n - dlnc_i = 0$) are characterized in the next proposition:

Proposition 11 *In a two-country world with a single tradable sector and intermediate goods, reciprocal changes in tariffs between country i and country n must satisfy*

$$\frac{dln\tau_{in}}{dln\tau_{ni}} = \frac{\left(\tilde{\pi}_{nn}+\frac{(1-\beta)}{\beta(1+\theta)}\left(1-\pi_{nn}\right)\right)}{\left(\tilde{\pi}_{ii}+\frac{(1-\beta)}{\beta(1+\theta)}\left(1-\pi_{ii}\right)\right)}.$$

The result in Proposition 11 shows that the reciprocal change in tariffs between countries i and n depends on two terms. First, as in the case with no intermediate goods, reciprocal tariff changes depend on the relative country sizes ($\tilde{\pi}_{ii}$ and $\tilde{\pi}_{nn}$), reflecting the extent to which each country is able to affect the terms of trade when changing its tariffs. However, the reciprocal tariff changes also depend on the importance of intermediate goods in production, β, interacted with the level of trade openness $(1 - \pi_{ii})$. The intuition is that tariff changes in country n will affect the terms of trade through the cost of intermediate goods. In particular, conditional on country size, if country i is more open than country n, reciprocal tariff changes require that country i change its tariff more relative to country n compared with the case of no intermediate goods, since the terms-of-trade effects will be partly offset by the effect of the change in country $i's$ tariffs on intermediate goods in the other countries, which will impact its export price.

What are the welfare effects of reciprocal tariff changes with intermediate goods? As in the world without intermediate goods, in Appendix A.10 we show that a reciprocal reduction in tariffs in this world is Pareto improving as long as both country's tariffs remain positive.

4.2 A World with Many Tradable Sectors and Input-Output Linkages

We now consider a world with many tradable sectors that we again index by j, and hence a world that features input-output linkages across sectors. In particular, we assume that the production of a good z requires labor plus materials from all sectors according to the input-output structure of the economy. Therefore, the cost of a bundle of inputs in country i and sector j is now given by

$$c_{ij} = w_i^{\gamma^j} \prod_k \left(P_i^k\right)^{\gamma^{kj}},$$

where $\gamma^j + \sum_k \gamma^{kj} = 1$.

As before, we say that the tariff changes between countries n and i satisfy reciprocity for country i if these tariff changes lead to a change in the volume of country i imports, measured at the initial world prices, that is equal in magnitude to the change in volume in country i exports, measured at initial world prices. Hence, following the same steps as before, the reciprocity condition can now be written as

$$\sum_j \left(c_{nj}^0 D_{inj}^1 - c_{nj}^0 D_{inj}^0\right) = \sum_j \left(c_{ij}^0 D_{nij}^1 - c_{ij}^0 D_{nij}^0\right).$$

And similarly, the trade balance condition in country i at initial and new tariffs can be written respectively as

$$\sum_j c_{nj}^0 D_{inj}^0 = \sum_j c_{ij}^0 D_{nij}^0,$$

$$\sum_j c_{nj}^1 D_{inj}^1 = \sum_j c_{ij}^1 D_{nij}^1.$$

Substituting the trade balance condition at the initial tariffs into the reciprocity condition, and substituting the trade balance condition at the new tariffs into the resulting expression, we obtain

$$\sum_j \left(c_{nj}^1 - c_{nj}^0\right) D_{inj}^1 - \sum_j \left(c_{ij}^1 - c_{ij}^0\right) D_{nij}^1 = 0. \tag{33}$$

Notice from (27) that, in the absence of intermediates, we would have $c_{nj} = w_n$ and $c_{ij} = w_i$. And with w_i chosen as the numeraire, in this case (33) would collapse to

$$\left(\omega_n^1 - \omega_n^0\right) \sum_j D_{inj}^1 = 0$$

ensuring that reciprocity fixes the relative wage and therefore the terms of trade sector by sector, as Proposition 7 and its Corollary record for the case also of many countries. In the presence of intermediates and many sectors and hence input-output linkages across sectors, (33) implies that tariff changes that fix c_{nj} and c_{ij} for all j – and hence by (28) fix the terms of trade sector by sector – will still satisfy reciprocity, and when (33) is satisfied in this way it can be shown that the results from Propositions 3-5 and their corollaries extend without qualification to a world with intermediate goods, many tradable sectors and input-output linkages; and therefore, a country's own tariff changes continue to be a sufficient statistic for the labor market effects it will experience as a result of negotiated tariff liberalization in this setting as long (33) is satisfied in this way.

But in the presence of intermediates it is also possible that additional solutions to (33) may exist in which tariff changes satisfy reciprocity even while leading to changes in c_{nj} and c_{ij} for some j's, provided that these changes in sectoral relative world prices balance out in a way that fixes each country's overall terms of trade in the way that (33) requires. Whether these additional solutions to (33) exist will depend on the underlying details of the world economy.[8] But if they do exist, then under such solutions a country's own tariff changes will no longer be a sufficient statistic for the labor market effects it experiences from negotiated tariff liberalization.

Nevertheless, we now argue that a country's own tariff changes continue to be a sufficient statistic in this setting for the labor-market effects of negotiated tariff liberalization, provided that the tariff changes satisfy reciprocity *at the sectoral level*. To formalize this statement, notice that we can always choose the numeraire to rewrite the reciprocity condition in (33) equivalently as

$$\sum_j (c_{nj}^1 - c_{nj}^0) D_{inj}^1 = \sum_j (c_{ij}^1 - c_{ij}^0) D_{nij}^1 = 0. \tag{34}$$

Using the characterization of reciprocity in (34), we say that reciprocity holds "at the sectoral level" if and only if (34) holds sector by sector, so that

$$(c_{nj}^1 - c_{nj}^0) D_{inj}^1 = (c_{ij}^1 - c_{ij}^0) D_{nij}^1 = 0 \quad \text{for } j = 1, ..., N. \tag{35}$$

Of course, if reciprocity holds at the sectoral level then it must hold when summed over all sectors, as the reciprocity restriction in (34) requires. But if reciprocity holds at the sectoral level we can say something more. In particular, it is immediate from (35) that we must have $c_{nj}^1 = c_{nj}^0$ and $c_{ij}^1 = c_{ij}^0$ for $j = 1, ..., N$. But then as discussed just above, in that case the results from Propositions 3-5 and their corollaries extend without qualification to a world with many tradable sectors and input-output linkages across sectors.

Summarizing this discussion, we state the following:

Proposition 12 *Propositions 3-5 and their corollaries extend without qualification to a two-country world with many tradable sectors and input-output linkages across sectors, provided that the tariff changes satisfy reciprocity at the sectoral level.*

[8] For example, it is direct to derive a multi-country version of (33) and show that, once a numeraire is chosen, the restriction of multilateral reciprocity for each of the N countries implies a set of $(N-1)$ equations. If we fix the new tariffs and hence all outcomes evaluated at the new tariffs, then we have $(N-1)$ independent linear equations in $(N-1)J$ unknowns, namely, the c_{nj}^0 associated with the original tariffs, and we have as well the $(N-1)J$ inequality constraints that $c_{nj}^0 \geq 0$ for all n and j. While $c_{nj}^0 = c_{nj}^1$ for all n and j is always a solution, whether or not there exist other solutions that satisfy the inequality constraints will depend on the details of the underlying world economy.

As with Proposition 10, it is straightforward to show that the results recorded in Proposition 12 extend without qualification to a many-country world provided the (MFN) tariff cuts satisfy multilateral reciprocity at the sectoral level for all countries.

To be clear, we are not claiming that in their trade negotiations governments actually seek the sectoral form of reciprocity defined by (35). Instead we are simply observing that (35) can be interpreted as a natural sectoral strengthening of the aggregate reciprocity condition that has been the focus of our analysis, and that with this strengthening our earlier results extend without qualification to a world with many tradable sectors and input-output linkages across sectors.

5 Quantitative Analysis

We now turn to our quantitative analysis. On December 11, 2001, China joined the WTO. As a new WTO member, China secured the right to access the markets of all other WTO member countries at the favorable (MFN) tariff levels that each WTO member imposes on every other WTO member. Those tariffs had been agreed by the GATT membership as a result of the Uruguay Round of GATT negotiations that created the WTO in 1995; they were implemented with gradual tariff reductions over the period 1995-2005. In exchange for the right to face those tariff levels, China was obligated to implement its own MFN tariff cuts beginning in 2001 as enumerated in the Protocol of Accession, a protocol that it had negotiated with GATT/WTO member governments while the Uruguay Round negotiations were ongoing.[9] As we noted in the Introduction, the central goal of China's accession negotiations was to achieve a balance between China's WTO market access rights and obligations consistent with the GATT/WTO norm of reciprocity.

Our quantitative analysis asks whether the tariff cuts agreed to by China in its Protocol of Accession reciprocated the Uruguay Round tariff cuts negotiated by the rest of the GATT/WTO membership. If they did, then in a many-country world with many tradable sectors (and in a world with intermediate goods and input-output linkages if reciprocity held sector by sector) our theoretical findings indicate that the tariff cuts implemented as a result of the Uruguay Round and China's accession to the WTO would have left each WTO member country's terms of trade largely unaltered, and each country's own tariff cuts would be a sufficient statistic for the labor market effects that the country experienced as a result of these negotiated tariff changes. If China's tariff cuts did not reciprocate the Uruguay Round tariff cuts from the rest of the WTO membership, then our goal is to quantify the direction and extent of the deviation from this benchmark and its implications for labor market effects and country welfare.

We emphasize that in posing the question in this way, we are not taking a stand on what the tariff cuts in China's WTO Accession Protocol *ought* to have been in order to conform to the GATT/WTO norm of reciprocity. This is because in the case of an accession negotiation like China's, there is an additional question of *what* tariff cuts the GATT/WTO members wanted China to reciprocate, and there are various answers to this question that seem plausible. For example, given that many WTO members had engaged in multiple previous GATT rounds of negotiated reciprocal tariff reductions from which China was absent, China might have been asked as a condition of joining the WTO to reciprocate the market access value to its exporters of the entire negotiating history of the member governments under GATT.[10] We don't take a stand on

[9] As described in USTR (2001), China applied for admission to GATT in July of 1986, the year that the Uruguay Round of GATT negotiations was initiated, and GATT formed a Working Party in March of 1987 "to examine China's application and negotiated terms of China's accession." These negotiations continued for the next eight years until, on January 1 1995, the WTO was formed, at which point a successor WTO Working Party took over the negotiations until their successful conclusion in 2001 which led to China's Protocol of Accession.

[10] To our knowledge there is no publicly available record of discussions over the basis from which reciprocity was

an answer to this question, because we don't need to. Our motivation for posing the reciprocity question as we do derives from our theory and the implications of reciprocity so defined for the terms-of-trade and labor market effects of tariff negotiations. If we find that, for whatever reason, GATT/WTO member countries chose to demand that China reciprocate more (or less) than their Uruguay Round tariff cuts, then our theory simply implies that this has consequences for the terms-of-trade and labor market effects of the tariff cuts negotiated as a result of the Uruguay Round and China's WTO accession, and our goal is to quantify those consequences.

5.1 Reciprocity and China's WTO Accession

To answer the question posed above, we first abstract from intermediate goods and consider versions of the Eaton and Kortum (2002) model, employing results from both the two-country Eaton and Kortum world characterized in section 3.1 and the model with many countries and many tradable sectors as characterized in section 3.2. We take the model to the trade data at the end of the year 2000, and we study whether the changes in tariffs between 1990 and 2007 that were applied by China – reflecting China's agreed tariff cuts in its Protocol of Accession – reciprocated the changes in tariffs between 1990 and 2007 that were applied by the rest of the world – reflecting the tariff cuts made by the rest of the world as a result of the Uruguay Round of GATT negotiations.[11]

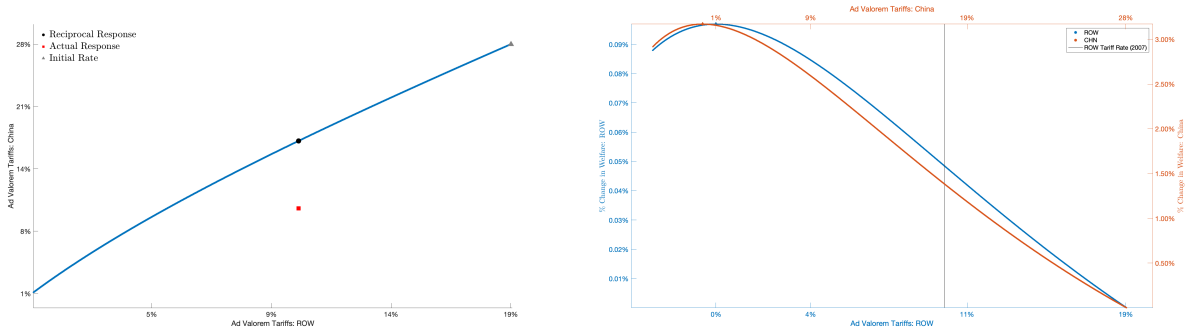
We obtain trade flows between China and the rest of the world from the World Input-Output Database (WIOD). For our first set of quantitative results, we aggregate agricultural, mining, and manufacturing industries into a single tradable sector, and the rest of the industries into a non-tradable sector. We allow the final expenditure shares α (and when we consider intermediates, the input shares β) to vary across countries and sectors. We obtain bilateral sectoral applied tariffs across countries from Caliendo et al. (2023).[12] We aggregate tariff rates across sectors and countries using 1995 trade shares. In Appendix B we also present quantitative results using unweighted tariffs, as well as quantitative results for different initial years, and time frames for tariff changes. We obtain the trade elasticities from Caliendo and Parro (2015).

To quantify whether the tariff cuts agreed by China in its Protocol of Accession reciprocated the Uruguay Round tariff cuts negotiated by the rest of the GATT/WTO membership, we need to confront the fact that after China joined the WTO, several reforms and changes in economic structure took place in all countries around the world. As a consequence, part of the observed changes in trade flows and other economic outcomes might have been the consequence of China's accession to the WTO or the consequence of changes in economic fundamentals other than tariffs. To address this issue, we use the exact-hat algebra method (e.g., Dekle, Eaton and Kortum (2007),

to be gauged in the context of China's WTO accession negotiations, and in private conversations with trade lawyers experienced in accession negotiations we have heard support for various possibilities.

[11] It is worth noting that the GATT/WTO legal commitment is the binding of tariffs at legal maximum levels, and gauging reciprocity in those legal commitments might suggest using bindings rather than applied tariffs for this purpose. However, the applied tariffs are arguably more relevant for the quantitative evaluation of reciprocity performed in this section, since satisfying reciprocity implies a balance in the change of volume of exports and imports evaluated at original world prices, and the use of applied rates is likely to have a tighter connection to trade volumes and to changes in trade volumes. Still, for most industrialized countries and for China, the difference between applied and bound tariff rates is small (see, for example, Bagwell, Bown, and Staiger, 2016).

[12] Caliendo et al. (2023) collected tariff lines from five primary sources: raw tariff schedules from the TRAINS and IDB databases accessed via the World Bank's WITS website, manually collected tariff schedules published by the International Customs Tariffs Bureau (BITD), U.S. tariff schedules from the U.S. International Trade Commission, U.S. tariff schedules derived from detailed U.S. tariff revenue and trade data maintained by the Center for International Data at UC Davis, and the texts of preferential trade agreements primarily sourced from the WTO's website, the World Bank's Global Preferential Trade Agreements Database, or the Tuck Center for International Business Trade Agreements Database.



(a) Reciprocal and actual tariff changes

(b) Welfare under reciprocal and actual tariff changes

Figure 1: Reciprocity and welfare

Note: The left panel in the figure presents the schedule of reciprocal tariffs between China and the rest of the world, starting from the initial equilibrium in 1990 (diamond marker in the upper right corner), and the actual tariff applied in 2007 (diamond marker below the schedule). The right panel shows the welfare effects of the reciprocal tariff schedule between China and the rest of the world, displayed on the vertical axis. The bottom and top axes show the reciprocal tariff schedule.

Costinot and Rodriguez Clare (2014), Caliendo and Parro (2015)). In particular, we evaluate the reciprocity of the actual changes in bilateral tariffs while holding other economic fundamentals constant. To this end, we condition on the data in 2000 just prior to China's 2001 WTO accession, and by doing so, the observed allocation in that year contains all the information on economic fundamentals at the time of China's accession to the WTO. Of course, after the year 2000, changes to other fundamentals could offset potential terms of trade effects of tariff changes and make the tariff changes look more (or less) reciprocal, but since those changes were unrealized in the year 2000, we assume they were unknown and therefore were not part of the tariff negotiations. Finally, we consider a balanced trade world by first computing the model with the observed trade deficits and then solving the model under the constraint of zero aggregate deficit, using the resulting no-deficit world economy as our base year.

We first apply our formula for reciprocal tariff changes in a two-country Eaton and Kortum world to compute the reciprocal tariffs schedule applied between China and the rest of the world. To do so, we start from the economy in 2000 under the actual tariffs applied between China and the rest of the world. We then apply small incremental reductions in the tariffs applied by the rest of the world and use the formula in (19) to compute the corresponding reciprocal tariff changes applied by China.

Figure 1, Panel (a), shows the schedule of reciprocal tariffs between China and the rest of the world. Consistent with our theoretical results, we can see that reciprocal tariff changes between China and the rest of the world are unequal, with China (the smaller country) required to cut its tariffs by more than the rest of the world (the larger country) in order to reciprocate the rest of the world's tariff cuts. Notably, given the fact that the rest of the world has lower initial tariffs than China, we can see that the rest of the world is the first country to achieve free trade (zero tariff) under the reciprocal tariff schedule.

The diamond marker on the upper right corner of the schedule shows the tariff rates applied between China and the rest of the world in 1990. China applied an average tariff of about thirty percent to the rest of the world, while the rest of the world applied a lower average tariff of around seventeen percent to China. The other diamond marker on the schedule shows that the reciprocal tariff applied by China in response to the rest of the world's Uruguay Round tariffs would be approximately twenty percent. However, the diamond marker below the schedule signifies the

actual 2007 tariff level between China and the rest of the world. It is evident from the figure that with a tariff rate of roughly ten percent by 2007, the tariff cuts in China's Protocol of Accession to the WTO *exceeded* those necessary to reciprocate the rest of the world's Uruguay Round tariff cuts according to our model-based formula.

Panel (b) in Figure 1 displays the welfare (aggregate real income) effects in China and in the rest of the world resulting from the reciprocal tariff schedule. In this figure, the bottom and left axes (marked in blue) represent the tariff schedule that would obtain and the welfare effects for the rest of the world if the tariff cuts in the rest of the world had been reciprocated by China, while the right and top axes (marked in red) indicate the same outcomes for China if its tariff cuts had been reciprocated by the rest of the world. As shown in the figure, once the rest of the world achieves free trade (zero tariffs), China implements a reciprocal tariff of about one percent. Notably, these reciprocal tariff changes are Pareto improving as welfare increases for both China and the rest of the world until free trade in the rest of the world is reached, consistent with our theoretical results. The figure also reveals that if China continues to reduce tariffs until it reaches free trade, the reciprocal change in tariffs imposed by the rest of the world leads to the subsidization of their imports from China. And as the theory predicts, under that tariff schedule, welfare in China would be maximized, but the rest of the world would become worse off. The vertical line in the figure marks the actual tariff level achieved by 2007. The figure demonstrates that both China and the rest of the world would have realized welfare gains had their actual tariff cuts been reciprocated, though these gains would have fallen short of what could have been achieved under a reciprocal tariff schedule leading the rest of the world to free trade.

We turn next to quantify the employment reallocation in the rest of the world as a consequence of the deviation from reciprocity, specifically from the fact that China exceeded reciprocity with the rest of the world as displayed in the previous figure. Using the formula in (17), Figure 2 presents the percentage change in employment in the tradable sector and in the non-tradable sector in the rest of the world due to the movement in the terms of trade – which according to (17) would not have occurred under reciprocity and can therefore be attributed to deviations from reciprocity – resulting from the actual changes in tariff between China and the rest of the world from 1990-2007. As the figure depicts, we find that employment shifted from the tradable sector to the non-tradable sector in the rest of the world as a result of the fact that China's tariff cuts exceeded those required to reciprocate the tariff cuts from the rest of the world over this period. As discussed previously, this employment reallocation effect is a consequence of the increase in the terms of trade (and income) in the rest of the world that shifted expenditure towards the non-tradable sector.

In Appendix B, we present a series of robustness exercises. Specifically, we first recompute the reciprocal tariffs and employment effects using unweighted bilateral sectoral tariffs. Additionally, we present results taking the model to the data for the year 1995 and evaluating reciprocity and the employment effects of actual changes in tariffs over the period from 1995 to 2007. The results from all these alternative exercises affirm the conclusions described in this section; namely, we consistently find that the change in tariffs applied by China to the rest of the world exceeded the changes required for reciprocity, which consequently led to a shift in employment to the non-tradable sector in the rest of the world.[13]

[13]It might seem that these results are at odds with the broadly held view, expressed most forcefully by the United States, that, subsequent to its WTO accession, China has intervened in its foreign trade to *stifle* its imports and *promote* its exports. But there is an interpretation of this view that is in line with our results. In particular, our quantitative results indeed imply that China's import volumes were too low, and its export volumes too high, *relative to the benchmark of reciprocity*, since under balanced trade this is simply the trade-volume counterpart of the worsening terms-of-trade for China (which under reciprocity would not have happened); and as we will see, our results from section 6 confirm that China's growing trade surpluses only reinforce this result. Although the aggregate real income of the United States was increased by the resulting terms-of-trade improvements it enjoyed, the magnitude

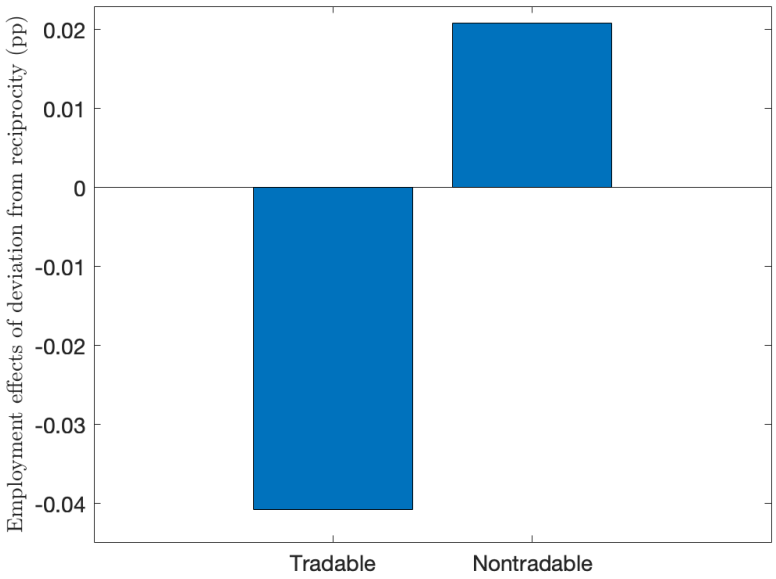


Figure 2: Employment effects across sectors in the rest of the world

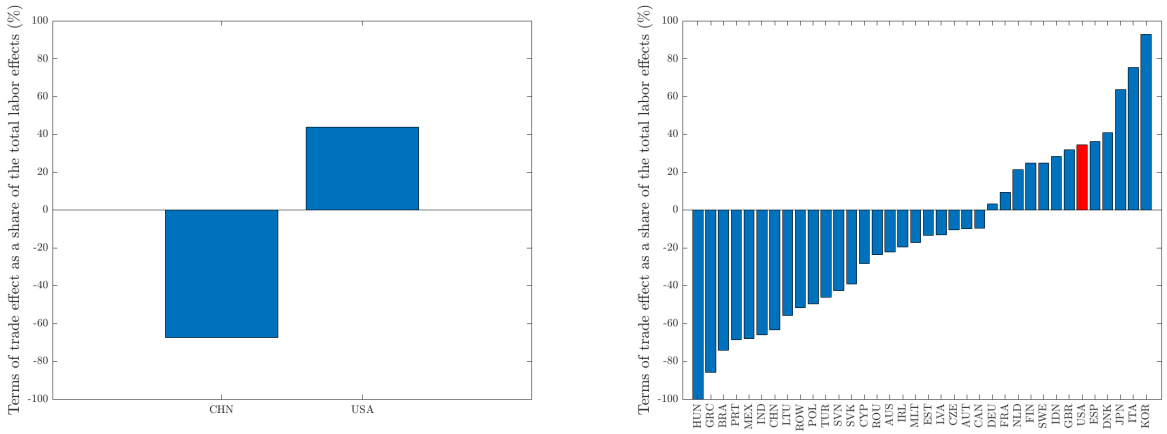
Note: The figure presents the employment effects in the tradable sector and in the non-tradable sector in the rest of the world resulting from the change in wages due to the actual changes in tariffs between China and the rest of the world over the period 1990-2007.

We next quantify the employment effects across individual countries in a world with many (41) countries, many (16) tradable sectors, and a non-tradable sector. As discussed in section 3.2.2 and described further in Appendix A.7, the dimensionality of our many-country many-tradable-sector model implies that there is in fact a multiplicity of tariff-change schedules that could satisfy multilateral reciprocity; therefore, we cannot derive closed-form formulas for reciprocal tariff changes and compare the actual tariff changes to the tariff changes predicted by the formula, as we did for the two country case. However, we can rely on the total differential of the employment effects derived in (25) in order to compute employment reallocation in a world with many countries and tradable sectors. We use that equation to calculate the share of the employment effects resulting from actual changes in each country's tariffs that can be attributed to the influence of terms-of-trade movements on employment in the non-tradable sector.

That is, we can take advantage of expression (25) to answer the following question: What is the contribution of the change in terms of trade (which according to our theory can be attributed to deviations from reciprocity) to the change in employment in the non-tradable sector of a country that arises from the combined effect of the change in the terms of trade and the change in the country's own tariffs? Recalling from (25) that the impact of a country's own tariff cuts and terms-of-trade movements on its non-tradable sector employment can be of opposite signs, we calculate this share in terms of absolute magnitudes to ensure that the share must fall between 0 and 1.

Figure 3 displays the employment reallocation effects across individual countries, measured as the percentage change in employment in the non-tradable sector due to the deviation from reciprocity as a share of the absolute employment effects given by (25). As constructed, the magnitude of this measure provides an understanding of the quantitative significance of the deviation from

of the US manufacturing-sector labor effect was also amplified, as we have emphasized, providing the United States with a possible reason to complain about China's deviation from reciprocity.



(a) Bilateral terms of trade effects on employment (b) Multilateral terms of trade effects on employment

Figure 3: Employment effects in the non-tradable sector across countries

Note: The left panel in the figure presents the employment reallocation effects from a bilateral change in tariffs between China and the United States over the period 1990-2007. The right panel shows the employment reallocation effect across countries from multilateral changes in tariffs over the period 1990-2007. The employment effects in the non-tradable sector due to the deviations from reciprocity are computed as the percentage change in employment in the non-tradable sector due to deviation from reciprocity as a share of absolute employment effects given by (25).

reciprocity on employment in the non-tradable sector, in comparison to the effect of the changes in the country's own tariffs on employment in that same sector.

On the left panel, we highlight the impacts on the United States by computing the effects of the actual bilateral change in tariffs between the United States and China over the period from 1990 to 2007. Consistent with our previous results, we find that the deviation from reciprocity, specifically the fact that China exceeded reciprocity, led to a shift of employment from the tradable sector into the non-tradable sector in the United States, with the opposite effects in China. Quantitatively, and using the decomposition of effects given by (25), the left panel can be interpreted as showing that the contribution of China's deviation from reciprocity to changes in tradable sector employment in the United States over this period is roughly comparable in magnitude to the contribution of the United States' own tariff cuts over the period.

On the right panel, we present the contribution of China's deviation from reciprocity to changes in tradable sector employment of individual countries over the same period. Interestingly, we find positive employment effects in the non-tradable sector for some countries and negative for others. Intuitively, China's tariff reduction worsened the terms of trade in countries that compete in exports with China, such as Mexico and India, which resulted in employment moving into the tradable sector in those countries.

Turning to our within-tradable-sector measure of labor-market reallocation, we return to our more aggregate (China and the rest of the world, one tradable sector) specification of the model and make use of the formula in (13). We find that the improvement in rest-of-world terms of trade as a result of China exceeding reciprocity resulted in a within sector employment reallocation of 0.76% in the rest of the world: put differently, if China's tariff cuts had reciprocated the Uruguay Round tariff cuts from the rest of the world, the share of workers in the tradable sector of the rest of the world that was devoted to production for domestic consumption would have fallen by 0.76 percentage points less. Intuitively, and as discussed before, the terms-of-trade improvement experienced by the rest of the world resulted in access to cheaper imported varieties that before

were produced domestically, which moved employment away from production of those varieties within the tradable sector.

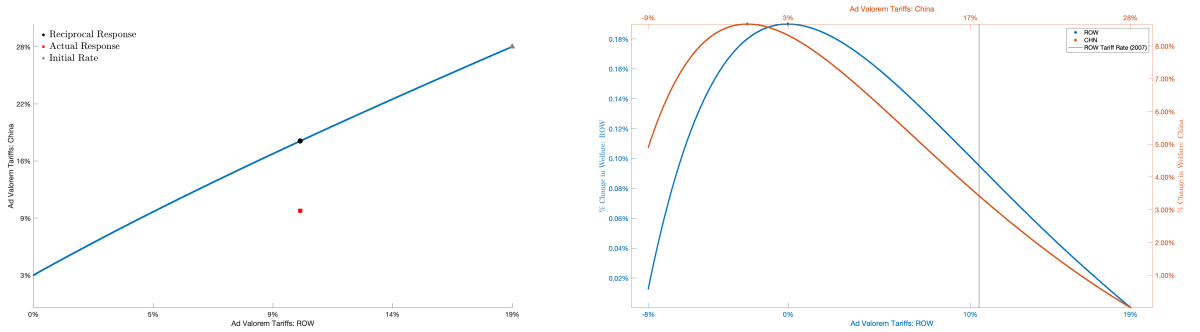
Finally, we also computed the alternative interpretation of labor market reallocation in an economy with frictional labor mobility across sectors. To do so, in Appendix A.3 we confirm that the formula for reciprocal tariff changes in a two-country economy with a tradable sector, a non-tradable sector, and fixed labor across sectors is the same as the formula in (20) derived for the frictionless one-tradable-sector economy in the absence of a non-tradable sector. We then used the formula in (18) to compute the labor market reallocation as a result of deviations from reciprocity, measured by changes in relative wages. We find that as a consequence of China exceeding reciprocity, the relative wage between the non-tradable and tradable sectors in the rest of the world increases by 0.07 percentage points, while this relative wage declines by 0.93 percentage points in China. As expected, there is a mapping between employment reallocation in an economy with labor mobility and the change in relative wages between the non-tradable and the tradable sectors in the economy with mobility frictions.

5.2 Reciprocity with Intermediate Goods

We next extend our quantitative analysis to incorporate intermediate goods. Similar to our quantitative analysis with no intermediate goods, we study reciprocity as the changes in tariffs that preserve world prices. These prices are given, in this case, by the input bundle costs. However, as discussed in section 4.2, in the presence of intermediate goods and multiple tradable sectors, it is possible that specific movements in the world prices across sectors might also satisfy the reciprocity condition (33). As Proposition 12 indicates, this possibility is ruled out if tariff changes satisfy reciprocity at the sectoral level. Rather than impose a sector-level reciprocity restriction in the many sector world with intermediate goods and input-output linkages, we choose for simplicity to rule out this possibility by restricting our focus here to a (two-country) world with a single tradable (and a non-tradable) sector. This approach ensures that the reciprocal tariffs are unique and keep the input bundle cost and hence the world price in the tradable sector unchanged, and we can apply our reciprocal tariff formula with intermediate goods derived in Proposition 11 (extended to include a non-tradable sector as we did before). Of course, the input bundle cost in the non-tradable sector can still vary due to changes in wages.

Analagous to Panel (a) in Figure 1, Panel (a) of Figure 4 shows the schedule of reciprocal tariffs between China and the rest of the world, but now with intermediate goods. Similar to the quantitative results without intermediates, we can see that reciprocal tariffs between China and the rest of the world are unequal, and that the change in reciprocal tariffs in China (the smaller country) is larger than the reciprocal tariffs applied by the rest of the world (the larger country). We can also see that the rest of the world is the first country to achieve free trade (zero tariff) under the reciprocal tariff schedule. In addition, the figure shows that with intermediate goods, the actual tariff applied by China to the rest of the world (the diamond marker below the reciprocal tariff schedule) was about ten percentage points lower than the reciprocal tariff given the actual tariff change by the rest of the world over the period 1990-2007. Therefore, in line with our results with no intermediate goods, we also find that China exceeded reciprocity with respect to the rest of the world. And similar to our analysis of reciprocity with no intermediate goods and again consistent with our theoretical results, Panel (b) shows that under reciprocity the tariff cuts are Pareto improving as long as both country's tariffs remain positive.

Using the formula in (31), Figure 5 presents the percentage change in employment in the tradable sector and in the non-tradable sector in the rest of the world due to the movement in the terms of trade resulting from the actual changes in tariff between China and the rest of the world



(a) Reciprocal and actual tariff changes with intermediate goods

(b) Welfare under reciprocal and actual tariff changes with intermediate goods

Figure 4: Reciprocity and welfare with intermediate goods

Note: The left panel in the figure presents the schedule of reciprocal tariffs with intermediate goods between China and the rest of the world, starting from the initial equilibrium in 1990 (diamond marker in the upper right corner), and the actual tariff applied in 2007 (diamond marker below the schedule). The right panel shows the welfare effects of the reciprocal tariff schedule between China and the rest of the world, displayed on the vertical axis. The bottom and top axes show the reciprocal tariff schedule.

from 1990 to 2007. We find that China exceeding reciprocity with the rest of the world resulted in employment shifting from the tradable sector to the non-tradable sector in the rest of the world. Compared to the results with no intermediate goods, we find that the presence of intermediate goods magnified this employment reallocation.

As we did before, in Appendix B we present a series of robustness exercises, using unweighted tariffs, and evaluating reciprocity for different time periods and tariff changes. We consistently find that the change in tariffs applied by China to the rest of the world exceeded reciprocity, which consequently led to a shift in employment to the non-tradable sector in the rest of the world.

It is important to note that the quantitative results presented in this section rely on three key assumptions with respect to China. First, we assume that China actually implemented the tariff cuts that were specified in its Protocol of Accession. This first assumption is beyond controversy, given the lack of WTO violation complaints against China with claims that China violated its tariff bindings. Second, we assume that China's economy responded to those tariff cuts as would any market economy. This second assumption gets to the question of whether China behaves as a market economy, or rather whether through a web of opaque policy interventions China is able to thwart market forces. We have no measures of China's non-tariff interventions, and so we cannot speak to this question.[14] What we can say based on our quantitative findings, however, is this. If in fact China used other policy interventions to blunt the impacts of its agreed tariff commitments, then if those other policy interventions had been addressed and China had been induced to behave like a market economy given its tariff commitments, the US and rest-of-world terms of trade would have been improved but the labor market reallocation experienced by the United States and the rest of the world would have been even more severe. This brings us to our third key assumption: we have restricted our analysis to consideration of the import tariff cuts agreed by China and its trading partners, putting to the side the many other commitments that WTO members agree to make. Perhaps most relevant for our analysis in the case of China are the commitments to

[14]Even if we did have data on Chinese subsidies, it is not clear how those subsidies would impact our results, since as a general matter the impact of production subsidies on the terms of trade is ambiguous and depends on where in the economy the subsidies are applied. As long as these policies where terms-of-trade neutral, our results would go through.

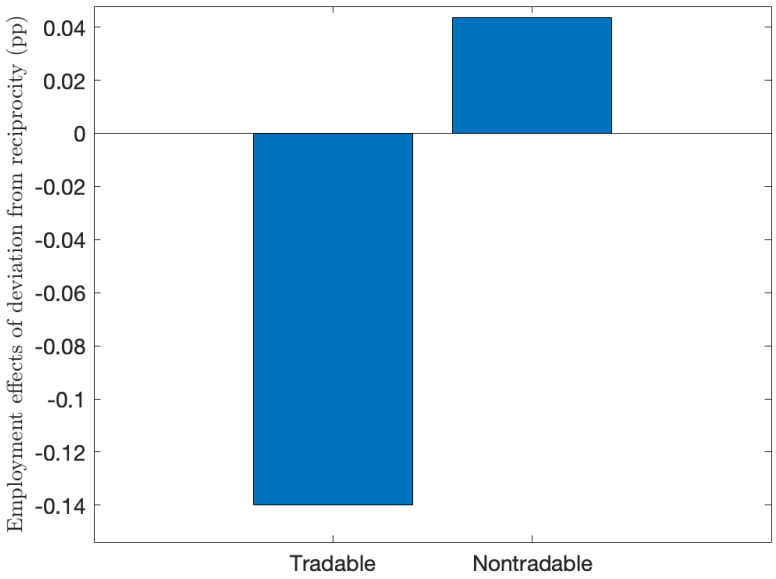


Figure 5: Employment effects across sectors in the rest of the world with intermediate goods

Note: The figure presents the employment effects in the tradable sector and in the non-tradable sector in the rest of the world resulting from the change in terms of trade due to the actual changes in tariffs between China and the rest of the world over the period 1990-2007.

reduce export taxes that China agreed to as part of its Protocol of Accession which, by Lerner symmetry, could be said to have trade effects analogous to and therefore complementary to China's commitments to reduce its import tariffs. Of course, if we had taken these additional commitments into account, they would have only reinforced our finding that China over-liberalized relative to the reciprocity norm.[15]

6 Trade Imbalances

Until now we have maintained the assumption of balanced trade between countries in our formal analysis. In this section we consider briefly how the existence of trade imbalances would impact our results. In particular, while we continue to take trade imbalances as exogenous, we now allow them to differ from zero, and to possibly change over time.[16] For simplicity, we develop our findings below in the context of a two-country Eaton and Kortum world, since the extensions to the other models considered above follow similar arguments to those we have already made.

[15]Bond, Duan, Ji and Lu (2023) provide evidence that China offset to some degree the trade impacts of its commitment to reduce export taxes by reducing the rebates of the value added tax (VAT) for its exporters. In this light, it is not clear that accounting for China's export tax commitments would have much of an impact on our quantitative findings, if we were to also account for the VAT rebate changes described by Bond, Duan, Ji and Lu.

[16]The treatment of trade balances as exogenous for purposes of tariff analysis has traditionally been defended by economists on the grounds that the determination of a country's trade balances reflect macro-economic policies that impact intertemporal prices, rather than trade policies which are usually thought to primarily impact intratemporal prices. Recently, motivated by the renewed policy interest in this question that has come with President Trump's "Liberation Day" tariff announcements of April 2, 2025, a growing literature has begun to reexamine this question. Despite important nuances raised by this literature, we feel comfortable maintaining the traditional exogeneity assumption for purposes of our analysis here.

There are two ways that the introduction of trade imbalances can alter our results. The first way is straightforward. If trade imbalances exist at the time that countries are negotiating tariff cuts, and if countries seek to achieve reciprocal tariff changes in light of these existing trade imbalances, then it is direct to show that the characterization of reciprocity provided in (4) is unchanged and its terms-of-trade preserving properties still hold. But the formula for reciprocal tariff changes in the two-country Eaton and Kortum world will be altered. For example, consider the formula given by (20) under balanced trade that applies in the absence of a non-tradable sector. Denoting by TB_i the (fixed) trade balance in country i (positive if trade surplus, negative if trade deficit), this formula now becomes

$$\frac{dln\tau_{in}}{dln\tau_{ni}} = \frac{\tilde{\pi}_{nn}}{\tilde{\pi}_{ii}} + TB_i \frac{\tau_{in}}{X_i} \frac{\tilde{\pi}_{nn}}{\tilde{\pi}_{ii}\left(1-\pi_{ii}\right)}. \tag{36}$$

As (36) indicates, if country i is running a trade surplus (trade deficit), it must reduce its tariff by a greater amount in order to reciprocate a given tariff reduction from country n. In the presence of a non-tradable sector, the formula given by (19) that applies under balanced trade is similarly impacted by the presence of trade imbalances. And the expressions for labor-market adjustments associated with tariff negotiations in the two-country Eaton and Kortum world are also impacted. For example, the expression for the labor reallocation between the tradable and non-tradable sector under balanced trade as given in (17) becomes

$$\begin{aligned} dlnL_n^T = &- \left(\frac{L_n^{NT}}{L_n^T} \frac{L_n^{NT}}{\left(L_n - TB_n\right)} \frac{1}{\alpha^{NT}} \left[\frac{\alpha^T \pi_{ni} \pi_{nn} \left(\tau_{ni}-1\right)\theta}{\tau_{ni}} \right] \right) dln\omega_n \\ &+ \left(\frac{L_n^{NT}}{L_n^T} \frac{L_n^{NT}}{\left(L_n - TB_n\right)} \frac{1}{\alpha^{NT}} \left[\frac{\alpha^T \pi_{ni} \left(\pi_{nn}\left(\tau_{ni}-1\right)\theta - 1\right)}{\tau_{ni}} \right] \right) dln\tau_{ni} \end{aligned} \tag{37}$$

when country n runs a (fixed) trade imbalance in the amount TB_n.

A second way that the introduction of trade imbalances can alter our results is more involved. In particular, when trade imbalances are changing through time it is interesting to consider an extended notion of reciprocity that would require a country to make tariff adjustments that stabilize world prices not only in the presence of tariff changes from its trading partners, but also in the presence of changes in its own trade imbalances, which could themselves have implications for world prices through the logic of the transfer problem.[17] Of particular interest is how compliance with this extended notion of reciprocity might have altered the labor-market outcomes associated with China's accession to the WTO, given that a prominent feature of China's economic performance after its WTO accession was its large and growing trade surplus.[18]

[17] While as traditionally interpreted in the GATT/WTO context, reciprocity would almost certainly not include an obligation to make these additional tariff adjustments, these adjustments could be seen as broadly consistent with the spirit of the reciprocity norm (see, for example, the discussion of GATT Article XXIII:1(c) "situation complaints" in Staiger and Sykes, 2013), as well as a possible complement to the IMF's rules promoting "external stability" (see, for example, IMF, 2009) and the avoidance of disruptions to the world economy associated with large and sustained global imbalances.

[18] According to data from the IMF, China's current account surplus as a share of its GDP fell from 4 percent in 1997 to 1 percent in 2001 at the time of its WTO accession. However, immediately upon WTO entry, China's surplus began to grow and ultimately peaked at 10 percent of GDP in 2007, at which point the surplus subsequently declined alongside the global financial crisis and trade collapse. During most of that early period especially, China intervened to fix the value of its currency vis-a-vis the US dollar – despite calls on China to allow it to appreciate – which provoked allegations that China was manipulating its currency. For a broader discussion of the accusations that China was manipulating its currency, see Staiger and Sykes (2010). See also Beshkar, Chang and Song (2024), who emphasize changing trade imbalances as an important determinant of deviations from reciprocity since the WTO was formed.

To investigate this second possibility, we write down our extended notion of reciprocity for country i, exploiting the Ricardian structure of the Eaton and Kortum (2002) model and written in the compact form analogous to (4) which was written for the case of balanced trade:

$$w_i^0\left(D_{ni}^1 - D_{ni}^0\right) - w_n^0\left(D_{in}^1 - D_{in}^0\right) = \left(TB_i^1 - TB_i^0\right), \tag{38}$$

As before, the first term on the left-hand side of equation (38) is the change in the labor content of country i's exports valued at its initial wage, while the second term on the left-hand side is the change in the labor content of country i's imports valued at its trading partner's initial wage. The term on the right-hand side is the change in country i's trade balance TB_i, measured at contemporaneous world prices. Notice that extended reciprocity as defined by (38) differs from reciprocity as defined by (4) only when trade imbalances are changing through time so that $TB_i^1 \neq TB_i^0$. And it is straightforward to see that if the reciprocity condition is satisfied for country i, then it is also satisfied for country n.

In Appendix A.11 we prove that achieving extended reciprocity defined by (38) implies that world prices are preserved in a two-country Eaton and Kortum world with exogenous changes in trade imbalances, the same implication that (4) has in a world of balanced trade. We also derive the formula for reciprocal tariff changes implied by (38), which is given by

$$\frac{dln\tau_{in}}{dln\tau_{ni}} = \frac{\tilde{\pi}_{nn}}{\tilde{\pi}_{ii}} + TB_i\frac{\tau_{in}}{X_i}\left[\frac{\tilde{\pi}_{nn}}{\tilde{\pi}_{ii}\left(1-\pi_{ii}\right)} + \left(\frac{\pi_{nn}\pi_{ii}\left(\tau_{ni}\tau_{in}-1\right)+\pi_{nn}+\pi_{ii}-1}{\tilde{\pi}_{ii}\left(1-\pi_{ii}\right)\left(1+\pi_{nn}\left(\tau_{ni}-1\right)\right)\left(1+\pi_{ii}\left(\tau_{in}-1\right)\right)\left(1+\theta\right)}\right)\frac{dlnTB_i}{dln\tau_{ni}}\right]. \tag{39}$$

Notice that the term multiplying $\frac{dlnTB_i}{dln\tau_{ni}}$ is generally positive given that the domestic expenditure shares across countries tend to be large due to home bias. Hence, if country i starts with a trade surplus that grows over time, everything else constant, a reduction in tariffs applied by country n must be reciprocated with a smaller tariff decline by country i, compared with the case of balanced trade (or unchanging trade imbalances). The opposite happens when country i is running a growing trade deficit; in this case country i must reciprocate with a larger decline in tariffs. The properties of (39) conform with the intuition from the transfer problem in the presence of "home bias" in consumption, whereby an increase in one country's transfer to (trade surplus with) a second country would typically be expected to worsen the first country's terms of trade, thereby requiring that the first country then reduce its tariff less in response to a given tariff reduction from the second country in order to maintain world prices and satisfy our extended notion of reciprocity.

Finally, we can write down the expression for the labor reallocation between the tradable and non-tradable sector when trade balances are changing, which is given by

$$\begin{aligned} dlnL_n^T = &-\left(\frac{L_n^{NT}}{L_n^T}\frac{L_n^{NT}}{\left(L_n - TB_n\right)}\frac{1}{\alpha^{NT}}\left[\frac{\alpha^T\pi_{ni}\pi_{nn}\left(\tau_{ni}-1\right)\theta}{\tau_{ni}}\right]\right)dln\omega_n \\ &+\left(\frac{L_n^{NT}}{L_n^T}\frac{L_n^{NT}}{\left(L_n - TB_n\right)}\frac{1}{\alpha^{NT}}\left[\frac{\alpha^T\pi_{ni}\left(\pi_{nn}\left(\tau_{ni}-1\right)\theta-1\right)}{\tau_{ni}}\right]\right)dln\tau_{ni} \\ &+\left(\frac{L_n^{NT}}{L_n^T\left(L_n - TB_n\right)}\left[TB_n\right]\right)dlnTB_n. \end{aligned} \tag{40}$$

When trade balances are non-zero and changing through time, (40) confirms that the analog of Proposition 4 still applies provided that reciprocity is replaced by extended reciprocity in the statement of these results. But the magnitude of the labor reallocation between the tradable and non-tradable sector experienced by country n under extended reciprocity will now be determined

by two things: according to the second line of (40), it will reflect the tariff cuts that country n itself has made ($dln\tau_{ni}$), the implications of which will depend in part on country n's trade imbalance TB_n; and according to the third line of (40), it will reflect as well the direct impact of country n's changing trade imbalance ($d\ln TB_n$), with a growing trade deficit (surplus) shifting employment to country n's non-tradable (tradable) sector.

6.1 Quantitative Analysis with Trade Imbalances

We turn now to evaluate quantitatively whether China's accession to the WTO satisfied extended reciprocity with its trading partners as defined by (38) in a world with trade imbalances, and to evaluate quantitatively the implications of any deviations from extended reciprocity for employment reallocation. Recalling that extended reciprocity differs from reciprocity only when trade imbalances are changing through time, Table 1 reports the actual tariffs applied by China to the rest of the world in 2000 and in 2007, as well as the Chinese tariffs that would satisfy reciprocity and extended reciprocity given the actual changes in tariffs applied by the rest of the world with (i) balanced trade, (ii) a constant Chinese trade surplus set at its initial 2000 level, and (iii) the actual (exogenous) growth in China's trade surplus between 2000 and 2007.

As Table 1 reflects, we can conclude that whether or not trade imbalances are incorporated into our calculations, China exceeded the tariff cuts that would have been implied by extended reciprocity. Compared with balanced trade, the growing trade surplus experienced by China over the period 2000-2007 would have required an even smaller change in tariffs – and as a result, China exceeded reciprocity by a larger margin – when reciprocity takes the extended form defined by (38). These results follow closely our theoretical discussion just above. If China had to reciprocate in light of its initial trade surplus only, its tariff reduction should have been slightly larger than under balanced trade, but we still find that the actual change exceeded reciprocity.

Table 1: China's Reciprocal Tariffs

Initial (2000)	Actual (2007)	Balanced trade	Constant surplus	Growing surplus
27.6%	10.3%	17.4%	16.6%	21.3%

Note: This table presents the initial (2000) ad valorem tariff rate applied by China to the rest of the world, the actual ad valorem tariff rate applied in 2007, and the ad valorem tariff rates that would satisfy reciprocity under balanced trade and under a constant trade imbalance set at the initial (2000) level, and that would satisfy extended reciprocity under the actual change in China's trade surplus with the rest of the world.

Turning to labor-market effects, Table 2 displays the labor reallocation between the tradable and non-tradable sector for the rest of the world and for China under different scenarios. The first three rows present the employment reallocation effects across sectors in China and the rest of the world associated with deviation from extended reciprocity under (i) balanced trade, (ii) a constant trade surplus for China set at its initial (2000) level, and (iii) the actual growing trade surplus of China with respect to the world. The results follow intuitively those of the previous table. Since China exceeded both reciprocity and the extended reciprocity conditions, its actual tariff changes resulted in an improvement in the terms of trade in the rest of world, and following our theoretical discussion, result in employment moving away from the tradable sector in the rest of world, and in the opposite direction in China. The last row of Table 2 shows the employment effects if China would have only satisfied reciprocity as defined by (4), but not extended reciprocity as defined by (38), even when its trade surplus grew over this period. Comparing the numbers in the third and fourth rows of Table 2, our results indicate that in the presence of China's growing trade surpluses, while tradable employment in the rest of the world would have been 0.016% higher if China had conformed to reciprocity, it would have been 0.057% higher if China had conformed to extended

reciprocity.

Table 2: Employment effects from deviation from reciprocity

	ROW		China	
	Non-tradable	Tradable	Non-tradable	Tradable
Reciprocity with balanced trade	0.021%	-0.041%	-0.433%	0.285%
Reciprocity with constant trade imbalance	0.019%	-0.037%	-0.405%	0.264%
Extended reciprocity with growing trade surplus	0.029%	-0.057%	-0.494%	0.321%
Reciprocity with growing trade surplus	0.008%	-0.016%	-0.057%	0.037%

Note: This table presents the employment effects in the tradable and non-tradable sectors from deviation from reciprocity, and from deviations from extended reciprocity. They are computed as the difference between the employment effects from a reciprocal change in tariffs and the employment effects from the actual change in tariffs applied between China and the rest of the world.

7 Conclusion

The principle of reciprocity plays a central role in GATT/WTO market access negotiations. We have formalized this principle in workhorse quantitative trade models, characterizing reciprocal tariff cuts and investigating their labor-market impacts. We have provided closed-form expressions mapping reciprocal tariff cuts to labor reallocations. And we have demonstrated that a country's own tariff liberalization is a sufficient statistic for the labor reallocation it can expect from tariff negotiations that satisfy reciprocity.

We have applied our theoretical results to the tariff cuts negotiated by China in the context of its 2001 WTO accession, the negotiation and implementation of which overlapped with the negotiation and implementation of the tariff cuts from the rest of the world associated with the Uruguay Round of GATT negotiations. Our quantitative results reveal that China's tariff cuts exceeded those required to reciprocate the rest of the world's Uruguay Round tariff cuts. If China had instead reciprocated these tariff cuts, real incomes in the United States and in the rest of the world would have been lower but the labor reallocation in those countries associated with China's WTO accession would also have been dampened.

Our quantitative findings indicate that the case of China does not track the usual complaint at the WTO that some member has failed to provide the reciprocal market access that it promised (such as by failing to deliver promised tariff cuts, or frustrating market access expectations with behind the border measures that impede imports). Most WTO obligations are aimed at ensuring market access rather than curtailing it, and nothing in WTO obligations affords a general remedy for the problem of "over-reciprocation." WTO law does provide options for dealing with injury to import-competing industries, however, as well as limited constraints on certain measures that may contribute to a deterioration in a member's terms of trade. An open question raised by our quantitative results is why the United States did not make greater use of these options and/or appeal more vigorously to these constraints in responding to the labor-market effects of China's WTO accession.[19]

[19] As we discuss more fully in our working paper, there are a number of possible answers to this question, ranging from the shortcomings of WTO rules for constraining the subsidy policies of economies with important non-market elements such as China's, to the difficulty that the IMF in cooperation with the WTO has in addressing accusations of currency manipulation, to the sometimes cumbersome nature of GATT/WTO renegotiation (GATT Article XXVIII) and safeguard (GATT Article XIX) provisions.

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A Appendix: Theory

A.1 The Revenue-Maximizing Tariff for Fixed Terms of Trade in a Two-Country World

In this Appendix section, we derive the formula for the revenue-maximizing tariff for fixed terms of trade in the two-country Eaton and Kortum (2002) model. We begin with the expression for tariff revenue,

$$\frac{(\tau_{ni}-1)\,\pi_{ni}}{\tau_{ni}}X_n,$$

which can be written as

$$\frac{(\tau_{ni}-1)\,\pi_{ni}}{\tau_{ni}}\frac{w_n\tau_{ni}}{1+(\tau_{ni}-1)\,\pi_{nn}}=\frac{w_n\,(\tau_{ni}-1)\,(1-\pi_{nn})}{1+(\tau_{ni}-1)\,\pi_{nn}}.$$

Taking logs and totally differentiating, we obtain

$$\frac{d\tau_{ni}}{\tau_{ni}-1}-\frac{d\pi_{nn}}{1-\pi_{nn}}-\frac{d\tau_{ni}\pi_{nn}+(\tau_{ni}-1)\,d\pi_{nn}}{1+(\tau_{ni}-1)\,\pi_{nn}}=0,$$

where we use that under reciprocity $dlnw_n=0$. Arranging the terms

$$\left(\frac{1}{\tau_{ni}-1}-\frac{\pi_{nn}}{1+(\tau_{ni}-1)\,\pi_{nn}}\right)d\tau_{ni}=\left(\frac{(\tau_{ni}-1)}{1+(\tau_{ni}-1)\,\pi_{nn}}+\frac{1}{1-\pi_{nn}}\right)d\pi_{nn},$$

we obtain

$$\left(\frac{1}{(\tau_{ni}-1)}\right)\frac{d\tau_{ni}}{\tau_{ni}}=\left(\frac{\pi_{nn}}{1-\pi_{nn}}\right)\frac{d\pi_{nn}}{\pi_{nn}},$$

and using $dln\pi_{ii}=\pi_{ii}\theta\,(dlnw_n-dlnw_i)+(1-\pi_{ii})\,\theta dln\tau_{in}$ we get

$$\left(\frac{1}{(\tau_{ni}-1)}\right)dln\tau_{ni}=\left(\frac{\pi_{nn}}{1-\pi_{nn}}\right)(1-\pi_{nn})\,\theta dln\tau_{ni},$$

to finally arrive at the formula for the revenue-maximizing tariff for fixed terms of trade in the two-country Eaton and Kortum (2002) model:

$$(\tau_{ni}-1)=\frac{1}{\pi_{nn}\theta},$$

as reported in the main text.

A.2 Reciprocal Tariffs in a Two-Country World

In this section of the Appendix, we derive the formula for reciprocal tariffs in a two-country Eaton and Kortum (2002) world. To this end, we begin by noting that total expenditure on goods in country i in the tradable sector is given by:

$$X_i^T=\alpha^T\left(w_iL_i+(\tau_{in}-1)\,X_i^T\frac{\pi_{in}}{\tau_{in}}\right).$$

We then rewrite country i's total expenditure as

$$X_i^T=\frac{\alpha^T w_iL_i\tau_{in}}{\tau_{in}-\alpha^T\,(\tau_{in}-1)\,\pi_{in}}$$

which can be expressed as

$$X_i^T=\frac{\alpha^T w_iL_i\tau_{in}}{\alpha^{NT}\tau_{in}+\alpha^T\,(1+(\tau_{in}-1)\,\pi_{ii})}. \tag{41}$$

An analogous expression holds for country n's total expenditure.

Taking the total differential of the expression in (41) and imposing the reciprocity condition $dlnw_i=0$, we obtain

$$dlnX_i^T=dln\tau_{in}-\frac{\alpha^{NT}\tau_{in}+\alpha^T\pi_{ii}\tau_{in}}{\alpha^{NT}\tau_{in}+\alpha^T\,(1+(\tau_{in}-1)\,\pi_{ii})}dln\tau_{in}-\frac{\alpha^T\,(\tau_{in}-1)\,\pi_{ii}}{\alpha^{NT}\tau_{in}+\alpha^T\,(1+(\tau_{in}-1)\,\pi_{ii})}dln\pi_{ii}. \tag{42}$$

Taking the total differential of the trade balance condition (12), which yields

$$dlnX_i^T - \frac{\pi_{ii}}{1-\pi_{ii}} dln\pi_{ii} - dln\tau_{in} = dlnX_n^T - \frac{\pi_{nn}}{1-\pi_{nn}} dln\pi_{nn} - dln\tau_{ni},$$

and using the total differential of country i's domestic expenditure shares $dln\pi_{ii} = (1-\pi_{ii})\,\theta dln\tau_{in}$ and similarly for country n, we obtain the formula for reciprocal tariff changes, given by

$$\frac{d\ln\tau_{ni}}{d\ln\tau_{in}} = \frac{\tau_{in}\alpha^{NT} + \tau_{in}\pi_{ii}\left(\alpha^T + \theta\right)}{\tau_{in}\alpha^{NT} + \alpha^T\pi_{ii}\left(\tau_{in}-1\right) + \alpha^T} \frac{\tau_{ni}\alpha^{NT} + \alpha^T\pi_{nn}\left(\tau_{ni}-1\right) + \alpha^T}{\tau_{ni}\alpha^{NT} + \tau_{ni}\pi_{nn}\left(\alpha^T + \theta\right)}. \tag{43}$$

In the absence of a non-tradable sector, and hence where $\alpha^T = 1$ and $\alpha^{NT} = 0$. In this case, and denoting the share of production sold to domestic producers as $\tilde{\pi}_{ii} \equiv \frac{\tau_{in}\pi_{ii}}{1+\pi_{ii}(\tau_{in}-1)}$, expression (19) simplifies to

$$\frac{dln\tau_{in}}{dln\tau_{ni}} = \frac{\tilde{\pi}_{nn}}{\tilde{\pi}_{ii}} \tag{44}$$

as reported in the main text.

A.3 Reciprocal Tariffs in a Two-Country World with Sector-Specific Labor

In this section of the Appendix, we derive the formula for reciprocal tariffs in a two-country Eaton and Kortum (2002) world with sector-specific labor and with a tradable and a non-tradable sector.

Total expenditure in the tradable sector in country n is given by

$$X_n^T = \alpha^T\left(w_n^T L_n^T + w_n^{NT} L_n^{NT} + \left(\tau_{ni}-1\right) X_n^T \frac{\pi_{ni}}{\tau_{ni}}\right),$$

and in the non-tradable sector is given by

$$X_n^{NT} = \alpha^{NT}\left(w_n^T L_n^T + w_n^{NT} L_n^{NT} + \left(\tau_{ni}-1\right) X_n^T \frac{\pi_{ni}}{\tau_{ni}}\right).$$

Hence, we have that

$$X_n^{NT} = \frac{\alpha^{NT}}{\alpha^T} X_n^T,$$

and therefore, total expenditure in the tradable sector can be re-expressed as

$$X_n^T = w_n^T L_n^T \frac{\tau_{ni}}{1+\pi_{nn}\left(\tau_{ni}-1\right)}.$$

Substituting into the trade balance condition we obtain,

$$w_n^T L_n^T \frac{1-\pi_{nn}}{1+\pi_{nn}\left(\tau_{ni}-1\right)} = w_i^T L_i^T \frac{1-\pi_{ii}}{1+\pi_{ii}\left(\tau_{in}-1\right)}.$$

Total differentiating this trade balance condition and imposing the reciprocity condition $dlnw_i^T = 0$, we arrive at the formula of reciprocal tariff changes,

$$\frac{d\ln\tau_{ni}}{d\ln\tau_{in}} = \frac{\tilde{\pi}_{ii}}{\tilde{\pi}_{nn},}$$

which is the same formula as that presented in the main text for the one-sector case.

A.4 The Welfare Effects of Reciprocal Tariff Changes in a Two-Country World

In this Appendix section we show that under a reciprocal tariff change, a reduction in tariffs in the two-country model of Eaton and Kortum (2002) is Pareto improving provided that tariffs are positive. Once at least one country reaches free trade, a further reciprocal reduction in tariffs cannot improve welfare in both countries.

To see this result, consider the change in welfare given a change in tariffs that satisfies reciprocity; we know from Proposition 2 that this implies that relative wages and hence world prices are preserved. Welfare in country n is defined as the real income, given by

$$W_n = \frac{w_n L_n + R_n}{P_n}, \tag{45}$$

where $R_n = (\tau_{ni} - 1) X_n \frac{\pi_{ni}}{\tau_{ni}}$ is tariff revenue and $P_n = \Gamma \left(A_n (w_n)^{-\theta} + A_i (w_i \tau_{ni})^{-\theta} \right)^{-1/\theta}$ is the price index in country n (and Γ is a constant). Taking the total differential of equation (45) under reciprocity, we obtain

$$dlnW_n = \frac{R_n}{(w_n L_n + R_n)} dlnR_n - logP_n.$$

Taking the total differential of tariff revenue and the price index, we obtain

$$d \ln R_n = -\frac{\tau_{ni}\pi_{nn}}{(1-\pi_{nn})(1+\pi_{nn}(\tau_{ni}-1))} d \ln \pi_{nn} - \frac{\tau_{ni}}{(1-\tau_{ni})(1+\pi_{nn}(\tau_{ni}-1))} d \ln \tau_{ni},$$

$$d \ln P_n = \pi_{ni} d \ln \tau_{ni}.$$

And using the expression derived in the main text for the total differential of the domestic expenditure shares $d \ln \pi_{nn} = \theta (1 - \pi_{nn}) d \ln \tau_{ni}$, it follows that the change in welfare in country n from a reciprocal change in tariff is given by

$$\frac{d \ln W_n}{d \ln \tau_{ni}} = -(1+\theta) \frac{(1-\pi_{nn}) \pi_{nn} (\tau_{ni} - 1)}{1 + \pi_{nn} (\tau_{ni} - 1)}.$$

As this expression confirms, welfare is a decreasing function of tariff changes provided $\tau_{ni} > 1$, and $\pi_{nn} < 1$. In other words, in the absence of terms-of-trade effects from tariff changes, the price effect of a tariff reduction always more than offset the revenue effect of the tariff reduction. In particular, note that at free trade we have that $\left. \frac{d \ln W_n}{d \ln \tau_{ni}} \right|_{\tau_{ni}=1} = 0$, and that if tariffs are negative (subsidy) we obtain that $\left. \frac{d \ln W_n}{d \ln \tau_{ni}} \right|_{\tau_{ni}<1} < 0$. Therefore, given that to achieve reciprocity countries need to change tariffs proportionally, reducing tariffs increases welfare in both countries; namely, reducing tariffs in a reciprocal way is Pareto improving as long as $\tau_{ni} > 1$, and $\tau_{in} > 1$. Once at least one country reaches the zero tariff (free trade) equilibrium, then a further reduction in tariffs does not increase welfare in both countries. Also, the initial level of tariffs as well as the relative country size matters for determining which country first reaches the free trade equilibrium.

We can now summarize with:

Proposition A1. *In a two-country Eaton and Kortum (2002) world, a reciprocal change in tariffs is Pareto improving up to the point that at least one country achieves free trade.*

In the quantitative section of the paper, we compute the schedule of reciprocal tariffs in the economy with a tradable and a non-tradable sector. As in the main text, the final consumption share in the tradable sector is given by α^T.

Taking the total differential of tariff revenue and the price index, which are given by

$$d\ln R_n = -\frac{\tau_{ni}\pi_{nn}\left(1-\pi_{nn}\right)^{-1}}{\left(\alpha^T\left[1+\pi_{nn}\left(\tau_{ni}-1\right)\right]+\alpha^{NT}\tau_{ni}\right)}d\ln\pi_{nn} - \frac{\tau_{ni}\left(1-\tau_{ni}^{-1}\right)}{\left(\alpha^T\left[1+\pi_{nn}\left(\tau_{ni}-1\right)\right]+\alpha^{NT}\tau_{ni}\right)}d\ln\tau_{ni},$$

$$d\ln P_n = \alpha^T\left(1-\pi_{nn}\right)d\ln\tau_{ni}.$$

And using the expression derived in the main text for the total differential of the domestic expenditure shares $d\ln\pi_{nn} = \theta\left(1-\pi_{nn}\right)d\ln\tau_{ni}$, it follows that the change in welfare in country n from a reciprocal change in tariff is given by

$$d\ln W_n = \alpha^T\left[\frac{\left(1-\pi_{nn}\right)\left[1-\pi_{nn}\theta\left(\tau_{ni}-1\right)-\left(\alpha^T\left[1+\pi_{nn}\left(\tau_{ni}-1\right)\right]+\alpha^{NT}\tau_{ni}\right)\right]}{\left(\alpha^T\left[1+\pi_{nn}\left(\tau_{ni}-1\right)\right]+\alpha^{NT}\tau_{ni}\right)}\right]d\ln\tau_{ni}.$$

Similar to the single sector case, at free trade we have that $\left.\frac{d\ln W_n}{d\ln\tau_{ni}}\right|_{\tau_{ni}=1} = 0$, and that if tariffs are negative (subsidy) we obtain that $\left.\frac{d\ln W_n}{d\ln\tau_{ni}}\right|_{\tau_{ni}<1} < 0$. Hence, Proposition A1 remains the same in the presence of a non-tradable sector.

A.5 Proof of Proposition 7

Does the result of Proposition 2 extend to an Eaton and Kortum (2002) world with many tradable sectors? Here we maintain our assumption of two countries but extend the analysis to a many tradable-sectors world, and we show that this result extend without qualification.

We index tradable sectors by the subscript j, and we continue to index the two countries by i and n. As before, we say that the tariff changes between countries n and i satisfy reciprocity for country i if these tariff changes lead to a change in the volume of country i imports, measured at initial world prices, that is equal in magnitude to the change in volume in country i exports, measured at initial world prices.

Formally, we say that the change in tariffs implied by the tariff schedules $(\tau^0_{in1},\tau^0_{in2},...\tau^0_{inJ},\tau^0_{ni1},\tau^0_{ni2},...\tau^0_{niJ})$ and $(\tau^1_{in1},\tau^1_{in2},...\tau^1_{inJ},\tau^1_{ni1},\tau^1_{ni2},...\tau^1_{niJ})$ satisfies reciprocity for country i if and only if

$$\sum_j\int_{B^1_{inj}}\hat{p}^{w0}_{inj}(z_j)D^1_{ij}(z)_j\phi_j(z_j)dz_j - \sum_j\int_{B^0_{inj}}\hat{p}^{w0}_{inj}(z_j)D^0_{ij}(z_j)\phi_j(z_j)dz_j =$$
$$\sum_j\int_{B^1_{nij}}\hat{p}^{w0}_{nij}(z_j)D^1_{nj}(z_j)\phi_j(z_j)dz_j - \sum_j\int_{B^0_{nij}}\hat{p}^{w0}_{nij}(z_j)D^0_{nj}(z_j)\phi_j(z_j)dz_j,$$

which using $\hat{p}^{w0}_{inj}(z_j)\equiv\frac{w^0_n\kappa_{inj}}{z_{nj}}$ and $D_{inj}\equiv\int_{B_{inj}}\frac{\kappa_{inj}D_{ij}(z_j)}{z_j}\phi_j(z_j)dz_j$ can be rewritten as

$$w^0_n\left(\sum_j D^1_{inj}-\sum_j D^0_{inj}\right) = w^0_i\left(\sum_j D^1_{nij}-\sum_j D^0_{nij}\right).$$

Similarly, the trade balance conditions for country i at the initial tariff schedules and the new tariff schedules are given respectively by,

$$\sum_j\int_{B^0_{inj}}p^{w0}_{inj}(z_j)D^0_{ij}(z_j)\phi_j(z_j)dz_j = \sum_j\int_{B^0_{nij}}p^{w0}_{nij}(z_j)D^0_{nj}(z_j)\phi_j(z_j)dz_j$$

$$\sum_j \int_{B^1_{inj}} p^{w1}_{inj}(z_j) D^1_{ij}(z_j)\phi_j(z_j)dz_j = \sum_j \int_{B^1_{nij}} p^{w1}_{nij}(z_j) D^1_{nj}(z_j)\phi_j(z_j)dz_j,$$

and using $p^w_{inj}(z_j) \equiv \frac{p_{ij}(z_j)}{\tau_{inj}} = \frac{w_n \kappa_{inj}}{z_{nj}}$ and the definition of D_{inj} these conditions can be rewritten as

$$w^0_n \sum_j D^0_{inj} = w^0_i \sum_j D^0_{nij}$$

$$w^1_n \sum_j D^1_{inj} = w^1_i \sum_j D^1_{nij}.$$

Substituting the trade balance condition under the initial tariffs into the reciprocity condition and using $\omega_i \equiv w_i/w_n$, we obtain

$$\omega^0_i \sum_j D^1_{nij} = \sum_j D^1_{inj}.$$

And substituting the trade balance condition under the new tariffs into this expression and rearranging yields

$$\left(\omega^1_i - \omega^0_i\right) \sum_j D^1_{nij} = 0 \tag{46}$$

which, given that $\sum_j D^1_{nij} > 0$, implies the following:

Proposition A2. *In a two-country world with many tradable sectors, relative wages are unchanged by reciprocal tariff changes, that is,* $\omega^1_i - \omega^0_i = 0$.
Recalling that, for given iceberg costs and productivities, world prices for each sector are pinned down by wages according to (1), we therefore may also state:

Corollary *In a two-country world with many tradable sectors, tariff changes that satisfy reciprocity leave the terms of trade unchanged sector by sector.*

This result extends naturally to a setting with many countries and many tradable sectors.

Following the previous analysis, extending (4) to an N-country and J-tradable sector world, we say that the change in tariffs satisfies multilateral reciprocity for country i if and only if

$$\sum_{m\neq i} w^0_m \sum_j \left(D^1_{imj} - D^0_{imj}\right) = w^0_i \left(\sum_{m\neq i}\sum_j D^1_{mij} - \sum_{m\neq i}\sum_j D^0_{mij}\right). \tag{47}$$

Balanced trade at initial world prices for country i can be written as

$$\sum_{m\neq i} w^0_m \sum_j D^0_{imj} = w^0_i \sum_{m\neq i}\sum_j D^0_{mij},$$

and substituting this condition into the multilateral reciprocity condition for country i in (47) yields

$$\sum_{m\neq i} w^0_m \sum_j D^1_{imj} = w^0_i \sum_{m\neq i}\sum_j D^1_{mij}. \tag{48}$$

But we also have balanced trade at the new world prices for country i, which can be written as

$$\sum_{m\neq i} w^1_m \sum_j D^1_{imj} = w^1_i \sum_{m\neq i}\sum_j D^1_{mij},$$

and subtracting (48) from this condition yields

$$\sum_{m\neq i}\sum_{j} w_n^1 D_{imj}^1 - \sum_{m\neq i} w_m^0 \sum_{j} D_{imj}^1 = w_i^1 \sum_{m\neq i}\sum_{j} D_{mij}^1 - w_i^0 \sum_{m\neq i}\sum_{j} D_{mij}^1,$$

or

$$[w_i^1 - w_i^0]\sum_{m\neq i}\sum_{j} D_{mij}^1 - \sum_{m\neq i}\sum_{j} D_{im}^1[w_m^1 - w_m^0] = 0.$$

It follows that the same argument as in 3.2.1 applies, namely this condition describes a system of $N-1$ independent linear equations in the $N-1$ unknowns $(w_2^0\ w_3^0\ ...\ w_N^0)$, which therefore has a unique solution, given by $w_m^0 = w_m^1$ for $m = 2, 3, ...N$.

A.6 Labor Market Effects of Tariffs with Many Countries and Many Sectors

In this appendix, we derive the three distinct measure of labor market reallocation discussed in the main text.

A.6.1 Within-Sector Employment Reallocation in a World with Many Sectors and Many Countries

In this section of the appendix, we derive the within sector labor reallocation in a version of the model with many tradable sectors and a non-tradable sector.
The market clearing condition in any tradable sector $s \in J$ is given by

$$w_n L_n^s = \pi_{nn}^s X_n^s + \sum_{i\neq n} \frac{\pi_{in}^s}{\tau_{in}^s} X_i^s,$$

where the labor market clearing for the subset of varieties that are sold domestically is given by

$$w_n L_{nn}^s = \pi_{nn}^s X_n^s.$$

It then follows that

$$w_n L_{nn}^T = \sum_{s=1}^{J} \pi_{nn}^s X_n^s.$$

We also have that

$$w_n L_n^T = \sum_{s=1}^{J} \pi_{nn}^s X_n^s + \sum_{i\neq n}\sum_{s=1}^{J} \frac{\pi_{in}^s}{\tau_{in}^s} X_i^s.$$

Using trade balance, we get

$$w_n L_n^T = \sum_{s=1}^{J} \pi_{nn}^s X_n^s + \sum_{i\neq n}\sum_{s=1}^{J} \frac{\pi_{ni}^s}{\tau_{ni}^s} X_n^s.$$

We now find an expression for $\frac{L_{nn}^T}{L_n^T}$. In particular, given that $\frac{X_n^s}{X_n^k} = \frac{\alpha^s}{\alpha^k}$, we can express

$$\frac{L_{nn}^T}{L_n^T} = \frac{\sum_{s=1}^{J} \alpha^s \pi_{nn}^s}{\sum_{s=1}^{J} \alpha^s \sum_i \frac{\pi_{ni}^s}{\tau_{ni}^s}}.$$

Total differentiating this expression, we obtain,

$$d\ln\frac{L_{nn}^T}{L_n^T} = \frac{\sum_{s=1}^J \alpha^s \pi_{nn}^s d\ln\pi_{nn}^s}{\sum_{s=1}^J \alpha^s \pi_{nn}^s} - \frac{\sum_{s=1}^J \alpha^s \sum_i \frac{\pi_{ni}^s}{\tau_{ni}^s} d\ln\pi_{ni}^s}{\sum_{s=1}^J \alpha^s \sum_i \frac{\pi_{ni}^s}{\tau_{ni}^s}} + \frac{\sum_{s=1}^J \alpha^s \sum_i \frac{\pi_{ni}^s}{\tau_{ni}^s} d\ln\tau_{ni}^s}{\sum_{s=1}^J \alpha^s \sum_i \frac{\pi_{ni}^s}{\tau_{ni}^s}}.$$

Rearranging the terms in this condition we get

$$\begin{aligned} d\ln\frac{L_{nn}^T}{L_n^T} = & \left(\frac{\sum_{s=1}^J \alpha^s \sum_{i\neq n} \frac{\pi_{ni}^s}{\tau_{ni}^s}}{\sum_{s=1}^J \alpha^s \sum_{i=n} \frac{\pi_{ni}^s}{\tau_{ni}^s}}\right) \frac{\sum_{s=1}^J \alpha^s \pi_{nn}^s d\ln\pi_{nn}^s}{\sum_{s=1}^J \alpha^s \pi_{nn}^s} \\ & - \frac{\sum_{s=1}^J \alpha^s \sum_{i\neq n} \frac{\pi_{ni}^s}{\tau_{ni}^s} d\ln\pi_{nn}^s}{\sum_{s=1}^J \alpha^s \sum_i \frac{\pi_{ni}^s}{\tau_{ni}^s}} \\ & + \frac{\sum_{s=1}^J \alpha^s \sum_i \frac{\pi_{ni}^s}{\tau_{ni}^s} \left(d\ln\pi_{nn}^s - d\ln\pi_{ni}^s\right)}{\sum_{s=1}^J \alpha^s \sum_i \frac{\pi_{ni}^s}{\tau_{ni}^s}} \\ & + \frac{\sum_{s=1}^J \alpha^s \sum_i \frac{\pi_{ni}^s}{\tau_{ni}^s} d\ln\tau_{ni}^s}{\sum_{s=1}^J \alpha^s \sum_i \frac{\pi_{ni}^s}{\tau_{ni}^s}}. \end{aligned}$$

Using the following expressions,

$$d\ln\omega_{ni}^s = d\ln w_i - \sum_m \pi_{nm}^s d\ln w_m,$$

$$d\ln\pi_{ni}^s = -\theta^s d\ln\omega_{ni}^s + \theta^s \left(\sum_m \pi_{nm}^s d\ln\tau_{nm}^s - d\ln\tau_{ni}^s\right),$$

$$d\ln\pi_{nn}^s = \theta^s \left(-d\ln\omega_{nn}^s + \sum_m \pi_{nm}^s d\ln\tau_{nm}^s\right),$$

then we solve for the total differential given by

$$\begin{aligned} d\ln\frac{L_{nn}^T}{L_n^T} = & \left(\frac{\sum_{s=1}^J \alpha^s \sum_{i\neq n} \frac{\pi_{ni}^s}{\tau_{ni}^s}}{\sum_{s=1}^J \alpha^s \sum_i \frac{\pi_{ni}^s}{\tau_{ni}^s}}\right) \frac{\sum_{s=1}^J \alpha^s \pi_{nn}^s \theta^s \left(-d\ln\omega_{nn}^s + \sum_m \pi_{nm}^s d\ln\tau_{nm}^s\right)}{\sum_{s=1}^J \alpha^s \pi_{nn}^s} \\ & - \frac{\sum_{s=1}^J \alpha^s \sum_{i\neq n} \frac{\pi_{ni}^s}{\tau_{ni}^s} \theta^s \left(-d\ln\omega_{nn}^s + \sum_m \pi_{nm}^s d\ln\tau_{nm}^s\right)}{\sum_{s=1}^J \alpha^s \sum_i \frac{\pi_{ni}^s}{\tau_{ni}^s}} \\ & + \frac{\sum_{s=1}^J \alpha^s \sum_{i\neq n} \frac{\pi_{ni}^s}{\tau_{ni}^s} \theta^s d\ln\omega_{ni}}{\sum_{s=1}^J \alpha^s \sum_i \frac{\pi_{ni}^s}{\tau_{ni}^s}} + \frac{\sum_{s=1}^J \alpha^s \left(1+\theta^s\right) \sum_{i\neq n} \frac{\pi_{ni}^s}{\tau_{ni}^s} d\ln\tau_{ni}^s}{\sum_{s=1}^J \alpha^s \sum_i \frac{\pi_{ni}^s}{\tau_{ni}^s}}, \end{aligned}$$

which we re-expressed as

$$
\begin{aligned}
d\ln\frac{L_{nn}^T}{L_n^T} \quad = \quad & \frac{\vartheta_n \sum_{s=1}^J \alpha^s \pi_{nn}^s \theta^s \left(-d\ln\omega_{nn}^s + \sum_m \pi_{nm}^s d\ln\tau_{nm}^s\right)}{\sum_{s=1}^J \alpha^s \pi_{nn}^s} \\
& - \frac{\sum_{s=1}^J \alpha^s \sum_{i\neq n} \frac{\pi_{ni}^s}{\tau_{ni}^s} \theta^s \left(-d\ln\omega_{nn}^s + \sum_m \pi_{nm}^s d\ln\tau_{nm}^s\right)}{\sum_{s=1}^J \alpha^s \sum_i \frac{\pi_{ni}^s}{\tau_{ni}^s}} \\
& + \frac{\sum_{s=1}^J \alpha^s \sum_{i\neq n} \frac{\pi_{ni}^s}{\tau_{ni}^s} \theta^s d\ln\omega_{ni}}{\sum_{s=1}^J \alpha^s \sum_i \frac{\pi_{ni}^s}{\tau_{ni}^s}} + \frac{\sum_{s=1}^J \alpha^s \left(1+\theta^s\right) \sum_{i\neq n} \frac{\pi_{ni}^s}{\tau_{ni}^s} d\ln\tau_{ni}^s}{\sum_{s=1}^J \alpha^s \sum_i \frac{\pi_{ni}^s}{\tau_{ni}^s}},
\end{aligned}
$$

where $\vartheta_n = \left(\frac{\sum_{s=1}^J \alpha^s \sum_{i\neq n} \frac{\pi_{ni}^s}{\tau_{ni}^s}}{\sum_{s=1}^J \alpha^s \sum_i \frac{\pi_{ni}^s}{\tau_{ni}^s}} \right)$ as reported in the text.

We now show that the labor market implications of deviation from reciprocity holds in a world with many countries and many tradable sectors.

The expression for $d\ln\frac{L_{nn}^T}{L_n^T}$ consists of three terms, as shown before:

The first term is given by

$$\frac{\sum_{s=1}^J \alpha^s \pi_{nn}^s d\ln\pi_{nn}^s}{\sum_{s=1}^J \alpha^s \pi_{nn}^s}$$

The sign of this expression depends on the sign of $d\ln\pi_{nn}^s$, since all other terms are positive. And from above, we know that $d\ln\pi_{nn}^s$ is decreasing in the multilateral terms of trade in n, $d\ln\omega_{nn}^s$.

The second term is given by

$$-\frac{\sum_{s=1}^J \alpha^s \sum_i \frac{\pi_{ni}^s}{\tau_{ni}^s} d\ln\pi_{ni}^s}{\sum_{s=1}^J \alpha^s \sum_i \frac{\pi_{ni}^s}{\tau_{ni}^s}}$$

The sign of this expression depends on the sign of $d\ln\pi_{ni}^s$. And from above, we know that $d\ln\pi_{ni}^s$ is decreasing in the multilateral terms of trade in i, $d\ln\omega_{ni}^s$, hence this second term is increasing in $d\ln\omega_{ni}^s$.

The third term is given by

$$\frac{\sum_{s=1}^J \alpha^s \sum_i \frac{\pi_{ni}^s}{\tau_{ni}^s} d\ln\tau_{ni}^s}{\sum_{s=1}^J \alpha^s \sum_i \frac{\pi_{ni}^s}{\tau_{ni}^s}}$$

The sign of this expression depends on the sign of $d\ln\tau_{ni}^s$. Given a reduction in tariffs that achieves reciprocity, $d\ln\frac{L_{nn}^T}{L_n^T}$ will be negative. This result follows from the sign relationships established above and the fact that tariff reductions lead to predictable changes in trade shares that, when combined, produce a net negative effect on the domestic labor share. Similarly, deviations from reciporcity that improve the multilateral terms of trade in country n relative to a given country i leads to a negative effect on the domestic labor share.

A.6.2 Between-Sector Employment Reallocation in a World with Many Countries and Many Sectors

In this section of the Appendix, we first describe the implications of reciprocity for the magnitude of labor market reallocation associated with tariff negotiations in the two-country world with multiple

sectors. In light of our result in Proposition A2, it is direct to extend the expression for the employment reallocation in the tradable sector given in (17) to the case of many tradable sectors. For the many-tradable-sector case, the analogous expression is given by

$$d\ln L_n^T = -\frac{L_n^{NT}}{L_n^T}\frac{L_n^{NT}}{L_n}\frac{1}{\alpha^{NT}}\left[\sum_{s=1}^{J}\frac{\alpha^s\left(1-\pi_{nn}^s\right)\pi_{nn}^s\left(\tau_{ni}^s-1\right)\theta^s}{\tau_{ni}^s}d\ln\omega_n\right] \tag{49}$$
$$+\frac{L_n^{NT}}{L_n^T}\frac{L_n^{NT}}{L_n}\frac{1}{\alpha^{NT}}\left[\sum_{s=1}^{J}\frac{\alpha^s\left(1-\pi_{nn}^s\right)\left(\pi_{nn}^s\left(\tau_{ni}^s-1\right)\theta^s-1\right)}{\tau_{ni}^s}d\ln\tau_{ni}^s\right].$$

As can be seen, expression (49) has the same interpretation as expression (17). We summarize these results with:

Proposition A3. *In a two-country world with many sectors, deviations from reciprocity have implications for the size of labor market disruption associated with tariff liberalization. If country $i's$* tariff cuts fall short of (*exceed) those necessary to reciprocate the tariff cuts of country n, country $n's$ labor market reallocation will be dampened (amplified) compared to the reallocation that country n would experience under reciprocal tariff cuts from country i.*
We may also state the following:

Corollary *In a two-country world with many sectors, a country's own tariff changes are a sufficient statistic for calculating the labor market reallocation it will experience as a result of negotiated tariff liberalization with its trading partner if and only if those tariff negotiations conform with the reciprocity norm.*

Proposition A3 and its Corollary extend without qualification Proposition 4 and its Corollary to a two-country Eaton and Kortum (2002) world with many tradable sectors.

We now derive an expression for labor market reallocation in a many-country multi-sector Eaton and Kortum (2002) world as in Costinot, Donaldson and Komunjer (2012).

Using the fact that $X_n^s/X_n^j = \alpha^s/\alpha^j$, total expenditure in country n and sector j can be expressed as

$$X_n^j = \alpha^j w_n L_n + X_n^j\sum_{i=1}^{N}\sum_{s=1}^{J}\alpha^s\left(\tau_{ni}^s-1\right)\frac{\pi_{ni}^s}{\tau_{ni}^s},$$

which can be written as

$$X_n^j = \alpha^j w_n L_n\left[1-\sum_{i=1}^{N}\sum_{s=1}^{J}\alpha^s\left(\tau_{ni}^s-1\right)\frac{\pi_{ni}^s}{\tau_{ni}^s}\right]^{-1}.$$

Market clearing condition in the non-tradable sector is given by

$$w_n L_n^{NT} = X_n^{NT},$$

which can be expressed as

$$w_n L_n^{NT} = w_n L_n \alpha^{NT}\left[1-\sum_{i=n}^{N}\sum_{s=1}^{J}\alpha^s\left(\tau_{ni}^s-1\right)\frac{\pi_{ni}^s}{\tau_{ni}^s}\right]^{-1}.$$

Hence we have

$$\frac{L_n^{NT}}{L_n} = \alpha^{NT}\left[1-\sum_{i=n}^{N}\sum_{s=1}^{J}\alpha^s\left(\tau_{ni}^s-1\right)\frac{\pi_{ni}^s}{\tau_{ni}^s}\right]^{-1},$$

and taking the total differential we get

$$d\ln L_n^{NT} = \frac{L_n^{NT}}{L_n \alpha^{NT}} \left[\sum_{i=1}^{N} \sum_{s=1}^{J} \frac{\alpha^s \pi_{ni}^s \left(\tau_{ni}^s - 1\right)}{\tau_{ni}^s} d\ln \pi_{ni}^s + \sum_{i=1}^{N} \sum_{s=1}^{J} \frac{\alpha^s \pi_{ni}^s}{\tau_n^s} d\ln \tau_{ni}^s \right].$$

Using the following expressions

$$d\ln \pi_{ni}^s = \sum_{m=1}^{N} \theta^s \pi_{nm}^s d\ln w_m - \theta^s d\ln w_i + \sum_{m=1}^{N} \theta^s \pi_{nm}^s d\ln \tau_{nm}^s - \theta^s d\ln \tau_{ni}^s,$$

$$d\ln \omega_{ni}^s = d\ln w_i - \sum_{m}^{N} \pi_{nm}^s d\ln w_m,$$

we get

$$d\ln L_n^{NT} = -\frac{L_n^{NT}}{L_n} \frac{1}{\alpha_n^{NT}} \left[\sum_{i=1}^{N} \sum_{s=1}^{J} \frac{\alpha^s \pi_{ni}^s \left(\tau_{ni}^s - 1\right) \theta^s}{\tau_{ni}^s} d\ln \omega_{ni}^s \right]$$
$$+ \frac{L_n^{NT}}{L_n} \frac{1}{\alpha_n^{NT}} \left[\sum_{i=1}^{N} \sum_{s=1}^{J} \left[\theta^s \pi_{ni}^s \sum_{m=1}^{N} \frac{\alpha_n^s \pi_{nm}^s \left(\tau_{nm}^s - 1\right)}{\tau_{nm}^s} + \frac{\alpha^s \pi_{ni}^s \left[1 - \theta^s \left(\tau_{ni}^s - 1\right)\right]}{\tau_{ni}^s} \right] d\ln \tau_{ni}^s \right].$$

Finally, using the fact that $d\ln L_n^T = -\frac{L_n^{NT}}{L_n^T} d\ln L_n^T$, we arrive at

$$d\ln L_n^T = \frac{L_n^{NT}}{L_n^T} \frac{L_n^{NT}}{L_n} \frac{1}{\alpha^{NT}} \left[\sum_{i=1}^{N} \sum_{s=1}^{J} \frac{\alpha^s \pi_{ni}^s \left(\tau_{ni}^s - 1\right) \theta^s}{\tau_{ni}^s} d\ln \omega_{ni}^s \right]$$
$$+ \frac{L_n^{NT}}{L_n^T} \frac{L_n^{NT}}{L_n} \frac{1}{\alpha^{NT}} \left[\sum_{i=1}^{N} \sum_{s=1}^{J} \alpha^s \pi_{ni}^s \left[\frac{\left[\left(\tau_{ni}^s - 1\right) \theta^s - 1\right]}{\tau_{ni}^s} - \sum_{m=1}^{N} \frac{\pi_{nm}^s \left(\tau_{nm}^s - 1\right) \theta^s}{\tau_{nm}^s} \right] d\ln \tau_{ni}^s \right],$$

where $d\ln \omega_{ni}^s = \sum_{m=1}^{N} \pi_{nm}^s d\ln w_m - d\ln w_i$, which is the expression reported in the text.

A.6.3 Relative Wage Adjustments in a World with Many Sectors and Many Countries

In this section of the appendix, we derive the within sector labor reallocation in a version of the model with many tradable sectors and a non-tradable sector.

From the labor market clearing of tradable goods $s \in J$, we have that

$$w_n^T L_n^T = \sum_{s=1}^{J} \sum_{i} \frac{\pi_{in}^s}{\tau_{in}^s} X_i^s.$$

Using trade balance, we get

$$w_n^T L_n^T = \sum_{s=1}^{J} \sum_{i=1}^{N} \frac{\pi_{ni}^s}{\tau_{ni}^s} X_n^s,$$

and given that $\frac{X_n^{NT}}{X_n^s} = \frac{\alpha^{NT}}{\alpha^s}$,we obtain

$$w_n^T L_n^T = \frac{X_n^{NT}}{\alpha^{NT}} \sum_{s=1}^{J} \sum_{i} \alpha^s \frac{\pi_{ni}^s}{\tau_{ni}^s}.$$

The labor market clearing of non-tradables is given by

$$w_n^{NT} L_n^{NT} = X_n^{NT},$$

and therefore we obtain

$$\frac{w_n^T L_n^T}{w_n^{NT} L_n^{NT}} = \sum_{s=1}^{J} \frac{\alpha^s}{\alpha^{NT}} \sum_i \frac{\pi_{ni}^s}{\tau_{ni}^s}.$$

Totally differentiating this expression we have

$$\begin{aligned} d \ln \frac{w_n^T}{w_n^{NT}} &= d \ln \sum_{s=1}^{J} \frac{\alpha^s}{\alpha^{NT}} \sum_i^N \frac{\pi_{ni}^s}{\tau_{ni}^s} \\ &= \frac{\sum_{s=1}^J \frac{\alpha^s}{\alpha^{NT}} \sum_i \frac{\pi_{ni}^s}{\tau_{ni}^s} (d \ln \pi_{ni}^s - d \ln \tau_{ni}^s)}{\sum_{s=1}^J \frac{\alpha^s}{\alpha^{NT}} \sum_i \frac{\pi_{ni}^s}{\tau_{ni}^s}}. \end{aligned}$$

Using

$$d \ln \pi_{ni}^s = -\theta^s d \ln \omega_{ni}^s + \theta^s \left(\sum_m \pi_{nm}^s d \ln \tau_{nm}^s - d \ln \tau_{ni}^s \right),$$

we get

$$d \ln \frac{w_n^T}{w_n^{NT}} = \frac{\sum_{s=1}^J \frac{\alpha^s}{\alpha^{NT}} \sum_i \frac{\pi_{ni}^s}{\tau_{ni}^s} \left(-\theta^s d \ln \omega_{ni}^s + \theta^s \sum_m \pi_{nm}^s d \ln \tau_{nm}^s - (1+\theta^s) d \ln \tau_{ni}^s \right)}{\sum_{s=1}^J \frac{\alpha^s}{\alpha^{NT}} \sum_i \frac{\pi_{ni}^s}{\tau_{ni}^s}}.$$

A.7 Reciprocal Tariff Changes in a World with Many Countries and Many Sectors

In this Appendix section, we characterize multilateral reciprocal tariff changes for the many-country many-sector Eaton and Kortum (2002) model. We first show the total differential of all equilibrium conditions in a world with N countries and J sectors. In doing so, we allow all countries to change tariffs in order to achieve multilateral reciprocity, namely we impose that world prices are preserved.

The total differential of prices is given by

$$d \ln P_n^k = \sum_{i=1}^{N} \pi_{ni}^k d \ln \tau_{ni}^k, \tag{50}$$

and the total differential of the bilateral trade shares is given by

$$d \ln \pi_{in}^k = \theta^k \ln P_i^k - \theta^k d \ln \tau_{in}^k. \tag{51}$$

The total differential of the sectoral total expenditure is

$$d \ln X_n^j = \sum_{k=1}^{J} \sum_{i=1}^{N} \frac{\alpha_n^j \left(\tau_{ni}^j - 1 \right) X_n^k \pi_{ni}^k}{X_n^j \tau_{ni}^k} d \ln X_n^k + \sum_{k=1}^{J} \sum_{i=1}^{N} \frac{\alpha_n^j \left(\tau_{ni}^j - 1 \right) X_n^k \pi_{ni}^k}{X_n^j \tau_{ni}^k} d \ln \pi_{ni}^k + \sum_{k=1}^{J} \sum_{i=1}^{N} \frac{\alpha_n^j X_n^k \pi_{ni}^k}{X_n^j \tau_{ni}^k} d \ln \tau_{ni}^k. \tag{52}$$

Finally the labor market clearing condition is given by

$$d \ln w_n = \sum_{k=1}^{J} \sum_{i=1}^{N} \frac{X_i^k \pi_{in}^k}{w_n L_n \tau_{in}^k} d \ln X_i^k + \sum_{k=1}^{J} \sum_{i=1}^{N} \frac{X_i^k \pi_{in}^k}{w_n L_n \tau_{in}^k} d \ln \pi_{in}^k - \sum_{k=1}^{J} \sum_{i=1}^{N} \frac{X_i^k \pi_{in}^k}{w_n L_n \tau_{in}^k} d \ln \tau_{in}^k. \tag{53}$$

We then exploit the fact that the system of equilibrium conditions is square to express the previous equilibrium conditions in matrix form. Starting with prices from equation (50) we obtain,

$$d\ln P = \mathbf{A}d\ln w + \mathbf{B}d\ln\tau.$$

Similarly, we express bilateral trade shares (51) as

$$d\ln\pi, = \mathbf{C}\ln P - \mathbf{D}d\ln w - \mathbf{E}d\ln\tau,$$

and plugging the vector of prices we have that

$$\begin{aligned} d\ln\pi =& \left[\mathbf{CA}-\mathbf{D}\right]d\ln w + \left[\mathbf{CB}-\mathbf{E}\right]d\ln\tau \\ =& \mathbf{F}d\ln w + \mathbf{G}d\ln\tau, \end{aligned}$$

with $\mathbf{F} = \mathbf{CA} - \mathbf{D}$ and $\mathbf{G} = \mathbf{CB} - \mathbf{E}$. The equilibrium condition for total expenditure (52) can similarly be expressed in matrix notation as

$$\begin{aligned} d\ln X =& \mathbf{H}d\ln w + \mathbf{J}d\ln X + \mathbf{K}d\ln\pi + \mathbf{L}d\ln\tau \\ =& \left[\mathbf{I}-\mathbf{J}\right]^{-1}\left[\mathbf{H}+\mathbf{KF}\right]d\ln w + \left[\mathbf{I}-\mathbf{J}\right]^{-1}\left[\mathbf{L}+\mathbf{KG}\right]d\ln\tau \\ =& \mathbf{M}d\ln w + \mathbf{N}d\ln\tau, \end{aligned}$$

where $\mathbf{M} = \left[\mathbf{I}-\mathbf{J}\right]^{-\mathbf{1}}\left[\mathbf{H}+\mathbf{KF}\right]$and $\mathbf{N} = \left[\mathbf{I}-\mathbf{J}\right]^{-\mathbf{1}}\left[\mathbf{L}+\mathbf{KG}\right]$. Finally the labor market clearing (or trade balance) under reciprocity (i.e. $d\ln w = 0$) can be expressed as

$$d\ln w = \mathbf{O}d\ln X + \mathbf{P}d\ln\pi - \mathbf{P}d\ln\tau.$$

Using the above expression we get

$$\begin{aligned} d\ln w =& \left[\mathbf{OM}+\mathbf{PF}\right]d\ln w + \left[\mathbf{ON}+\mathbf{PG}-\mathbf{P}\right]d\ln\tau \\ =& \mathbf{T}d\ln\tau, \end{aligned}$$

with $\mathbf{T} = \mathbf{Q^{-1}R}$, and where $\mathbf{Q} = \left[\mathbf{I}-(\mathbf{OM}+\mathbf{PF})\right]^{-1}$and $\mathbf{R} = \left[\mathbf{ON}+\mathbf{PG}-\mathbf{P}\right]$. Therefore, reciprocity satisfies

$$\mathbf{T}d\ln\tau = 0.$$

We next impose that $d\ln w = 0$ for all n and solve for the null space. Let $N^* \times J^*$ be the number of instruments allowed to vary (for instance, sectoral MFN tariffs). The number of linearly independent vectors that span the solution space is given by

$$(N^* \times J^*) - (N-1)$$

and there exists at least one solution if and only if

$$(N^* \times J^*) - (N-1) > 0.$$

We can now summarize with:

Proposition A4. *In a many-(N)-country many-(J)-sector Eaton and Kortum (2002) world, changes in tariffs that satisfy multilateral reciprocity for all countries are characterized by* $\mathbf{T}d\ln\tau = 0$ with $\mathbf{T} = \mathbf{Q^{-1}R}$ where $\mathbf{Q} = \left[\mathbf{I}-(\mathbf{OM}+\mathbf{PF})\right]^{-1}$and $\mathbf{R} = \left[\mathbf{ON}+\mathbf{PG}-\mathbf{P}\right]$. *Moreover, with* $N^* \times J^*$ *denoting the number of tariffs allowed to vary, there exists at least one set of tariff changes that delivers multilateral reciprocity for all countries only if* $(N^* \times J^*) > (N-1)$.

A.8 Labor Market Effects of Tariffs in a World with Intermediate Goods Sector

In this appendix, we derive the three distinct measure of labor market reallocation discussed in the main text in the presence of intermediate goods.

A.8.1 Within-Sector Employment Reallocation in a Two-Country World with Intermediate Goods

We start deriving the within-sector labor reallocation. Market clearing condition in any tradable sector is given by

$$w_n L_n^T = \beta \pi_{nn} X_n^T + \beta \frac{\pi_{in}}{\tau_{in}} X_i^T,$$

where the labor market clearing for the subset of varieties that are sold domestically,

$$w_n L_{nn}^T = \beta \pi_{nn} X_n^T.$$

Imposing the trade balance condition in the market clearing condition, we obtain

$$w_n L_n^T = \beta \pi_{nn} X_n^T + \beta \frac{\pi_{ni}}{\tau_{ni}} X_n^T.$$

It follows that

$$w_n L_n^T = \frac{X_n^T}{\beta \left(\pi_{nn} + \frac{\pi_{ni}}{\tau_{ni}} \right)}.$$

Hence

$$\frac{L_{nn}^T}{L_n^T} = \frac{\beta \pi_{nn}}{\beta \left(\pi_{nn} + \frac{\pi_{ni}}{\tau_{ni}} \right)}.$$

Total differentiating this expression, we obtain

$$dln \frac{L_{nn}^T}{L_n^T} = dln \pi_{nn} - \frac{\left(\pi_{nn} dln \pi_{nn} + \frac{\pi_{ni}}{\tau_{ni}} \left(dln \pi_{ni} - dln \tau_{ni} \right) \right)}{\left(\pi_{nn} + \frac{\pi_{ni}}{\tau_{ni}} \right)},$$

which can be expressed as

$$dln \frac{L_{nn}^T}{L_n^T} = \frac{\frac{\pi_{ni}}{\tau_{ni}} \left(dln \pi_{nn} - dln \pi_{ni} \right) + \frac{\pi_{ni}}{\tau_{ni}} dln \tau_{ni}}{\left(\pi_{nn} + \frac{\pi_{ni}}{\tau_{ni}} \right)}.$$

Using

$$d \ln \pi_{nn} - d \ln \pi_{ni} = \theta \left(d \ln \tau_{ni} + \left(d \ln c_i - d \ln c_n \right) \right),$$

to obtain

$$dln \frac{L_{nn}^T}{L_n^T} = \frac{\theta \frac{\pi_{ni}}{\tau_{ni}} \left(d \ln c_i - d \ln c_n \right) + (1 + \theta) \frac{\pi_{ni}}{\tau_{ni}} dln \tau_{ni}}{\left(\pi_{nn} + \frac{\pi_{ni}}{\tau_{ni}} \right)}.$$

Finally, using the definition $\tilde{\omega}_n = c_n / c_i$ we get

$$dln \frac{L_{nn}^T}{L_n^T} = \frac{-\theta \frac{\pi_{ni}}{\tau_{ni}} d \ln \tilde{\omega_n} + (1 + \theta) \frac{\pi_{ni}}{\tau_{ni}} dln \tau_{ni}}{\left(\pi_{nn} + \frac{\pi_{ni}}{\tau_{ni}} \right)},$$

which can be re-expressed as

$$dln\frac{L_{nn}^{T}}{L_{n}^{T}}=\frac{-\theta\pi_{ni}d\ln\tilde{\omega_{n}}+\left(1+\theta\right)\pi_{ni}dln\tau_{ni}}{\left(1+\left(\tau_{ni}-1\right)\pi_{nn}\right)},$$

which is the expression reported in the main text.

A.8.2 Between-Sector Employment Reallocation in a Two-Country World with Intermediate Goods

In this Appendix section we derive an expression for labor market reallocation between the tradable and the non-tradable sectors in a two-country world with intermediate goods.

The labor market clearing conditions in the tradable and non-tradable sectors, respectively, are given by

$$w_{n}L_{n}^{T}=\beta\left(\frac{\pi_{in}}{\tau_{in}}X_{i}^{T}+\pi_{nn}X_{n}^{T}\right),$$
$$w_{n}L_{n}^{NT}=\beta X_{i}^{NT}.$$

Total expenditure in the tradable sector is given by

$$X_{n}^{T}=\left(1-\beta\right)\left(\frac{\pi_{in}}{\tau_{in}}X_{i}^{T}+X_{n}^{T}\pi_{nn}\right)+\alpha^{T}\left(w_{n}L_{n}+\left(\tau_{ni}-1\right)X_{n}^{T}\frac{\pi_{ni}}{\tau_{ni}}\right),$$

which applying trade balance can be expressed as

$$X_{n}^{T}=\frac{\alpha^{T}\left(w_{n}L_{n}+\left(\tau_{ni}-1\right)X_{n}^{T}\frac{\left(1-\pi_{ni}^{n}\right)}{\tau_{ni}}\right)}{\left(1-\left(1-\beta\right)\left(\frac{1+\pi_{nn}\left(\tau_{in}-1\right)}{\tau_{in}}\right)\right)}.$$

The total expenditure in the non-tradable sector is given by

$$X_{n}^{NT}=\frac{\alpha^{NT}}{\beta}\left(w_{n}L_{n}+X_{n}^{T}\frac{\left(\tau_{ni}-1\right)\left(1-\pi_{nn}\right)}{\tau_{ni}}\right).$$

It follows that the relative sectoral expenditures can be expressed as

$$\frac{X_{n}^{T}}{X_{n}^{NT}}=\frac{\frac{\alpha^{T}\beta}{\alpha^{NT}}}{\left(1-\left(1-\beta\right)\left(\frac{1+\pi_{nn}\left(\tau_{in}-1\right)}{\tau_{in}}\right)\right)}.$$

Plugging this expression in the non-tradable expenditure function we obtain

$$X_{n}^{NT}=\frac{\alpha^{NT}}{\beta}\left(w_{n}L_{n}+X_{n}^{NT}\frac{\frac{\alpha^{T}\beta}{\alpha^{NT}}\frac{\left(\tau_{ni}-1\right)\left(1-\pi_{nn}\right)}{\tau_{ni}}}{\left(1-\left(1-\beta\right)\left(\frac{1+\pi_{nn}\left(\tau_{ni}-1\right)}{\tau_{ni}}\right)\right)}\right),$$

or

$$X_{n}^{NT}=\frac{\frac{\alpha^{NT}}{\beta}w_{n}L_{n}}{1-\frac{\alpha^{T}\frac{\left(\tau_{ni}-1\right)\left(1-\pi_{nn}\right)}{\tau_{ni}}}{\left(1-\left(1-\beta\right)\left(\frac{1+\pi_{nn}\left(\tau_{in}-1\right)}{\tau_{ni}}\right)\right)}}.$$

Using the labor market clearing condition for non-tradables we get

$$L_n^{NT} = L_n \alpha^{NT} \left[1 - \frac{\alpha^T (\tau_{ni} - 1)(1 - \pi_{nn})}{(\tau_{ni} - (1-\beta)(1 + \pi_{nn}(\tau_{in} - 1)))}\right]^{-1}.$$

Taking the total differential in the tradable sector we obtain

$$\begin{aligned} dlnL_n^{NT} = &-\frac{L_n^{NT}}{L_n}\frac{\alpha^T}{\alpha^{NT}}\left[\frac{\beta\tau_{in}(\tau_{ni}-1)\pi_{nn}}{(\tau_{in} - (1-\beta)(1+\pi_{nn}(\tau_{ni}-1)))^2}\right] dln\pi_{nn} \\ &+\frac{L_n^{NT}}{L_n}\frac{\alpha^T}{\alpha^{NT}}\left[\frac{\tau_{ni}\beta(1-\pi_{nn})}{(\tau_{ni} - (1-\beta)(1+\pi_{nn}(\tau_{ni}-1)))^2}\right] dln\tau_{ni}. \end{aligned}$$

Finally using the total differential of the expenditure shares $dln\pi_{nn} = (1-\pi_{nn})\theta(dlnc_i - dlnc_n) + (1-\pi_{nn})\theta dln\tau_{ni}$, and defining $dln\tilde{\omega}_n = dlnc_n - dlnc_i$ we obtain

$$\begin{aligned} dlnL_n^T = &-\frac{L_n^{NT}}{L_n^T}\frac{\alpha^T L_n^{NT}\beta}{\alpha^{NT}L_n}\left[\frac{(\tau_{ni}-1)\pi_{nn}\tau_{ni}(1-\pi_{nn})\theta}{(\tau_{ni} - (1-\beta)(1+(\tau_{ni}-1)\pi_{nn}))^2}\right] dln\tilde{\omega}_n \\ &+\frac{L_n^{NT}}{L_n^T}\frac{\alpha^T L_n^{NT}\beta}{\alpha^{NT}L_n}\left[\frac{\tau_{ni}(1-\pi_{nn})((\tau_{ni}-1)\pi_{nn}\theta - 1)}{(\tau_{ni} - (1-\beta)(1+(\tau_{ni}-1)\pi_{nn}))^2}\right] dln\tau_{ni}, \end{aligned}$$

as reported in the text.

A.8.3 Relative Wage Adjustments in a Two-Country World with Intermediate Goods

We now derive the labor market adjustment with sector-specific wages across sectors.

From the labor market clearing of tradable goods, we have that

$$w_n^T L_n^T = \beta\left(\frac{\pi_{in}}{\tau_{in}}X_i^T + \pi_{nn}X_n^T\right),$$

and using trade balance, we obtain

$$w_n^T L_n^T = \beta\left(\frac{\pi_{ni}}{\tau_{ni}}X_i^T + \pi_{nn}X_n^T\right),$$

Total expenditure in the tradable sector is

$$X_n^T = (1-\beta)\left(\frac{\pi_{in}}{\tau_{in}}X_i^T + \pi_{nn}X_n^T\right) + \alpha^T\left(w_n^T L_n^T + w_n^{NT}L_n^{NT} + \frac{(\tau_{ni}-1)\pi_{ni}}{\tau_{ni}}X_n^T\right),$$

and using trade balance again, we get

$$X_n^T = \frac{\alpha^T\left(w_n^T L_n^T + w_n^{NT}L_n^{NT} + \frac{(\tau_{ni}-1)\pi_{ni}}{\tau_{ni}}X_n^T\right)}{\left(1 - (1-\beta)\left(\frac{\pi_{ni}}{\tau_{ni}} + \pi_{nn}\right)\right)}.$$

Similarly, total expenditure in the non-tradable sector is

$$X_n^{NT} = (1-\beta)X_n^{NT} + \alpha^{NT}\left(w_n^T L_n^T + w_n^{NT}L_n^{NT} + \frac{(\tau_{ni}-1)\pi_{ni}}{\tau_{ni}}X_n^T\right),$$

and can be re-expressed as

$$X_n^{NT} = \frac{\alpha^{NT}\left(w_n^T L_n^T + w_n^{NT} L_n^{NT} + \frac{(\tau_{ni}-1)\pi_{ni}}{\tau_{ni}} X_n^T\right)}{\beta}.$$

Hence,

$$\frac{X_n^{NT}}{X_n^T} = \frac{\alpha^{NT}\left(1-(1-\beta)\left(\frac{\pi_{ni}}{\tau_{ni}}+\pi_{nn}\right)\right)}{\beta\alpha^T}.$$

Using this condition in the market clearing conditions for the trade and non-tradable sectors, we obtain,

$$\frac{w_n^T L_n^T}{w_n^{NT} L_n^{NT}} = \frac{\beta\alpha\left(\frac{\pi_{ni}}{\tau_{ni}}+\pi_{nn}\right)}{\alpha^{NT}\left(1-(1-\beta)\left(\frac{\pi_{ni}}{\tau_{ni}}+\pi_{nn}\right)\right)}.$$

Total differentiating this expression, we obtain

$$dln\frac{w_n^T}{w_n^{NT}} = \frac{\frac{\pi_{ni}}{\tau_{ni}}\left(dln\pi_{ni} - dln\tau_{ni}\right) + \pi_{nn} dln\pi_{nn}}{\left(1-(1-\beta)\left(\frac{\pi_{ni}}{\tau_{ni}}+\pi_{nn}\right)\right)\left(\frac{\pi_{ni}}{\tau_{ni}}+\pi_{nn}\right)}.$$

Using the expression for $d\ln\pi_{ni}$ and $d\ln\pi_{nn}$ derived before in this appendix, we get

$$\begin{aligned} dln\frac{w_n^{NT}}{w_n^T} = &\left(\frac{\pi_{ni}\pi_{nn}\left(\tau_{ni}-1\right)\theta}{\left[1+\pi_{nn}\left(\tau_{ni}-1\right)\right]\left(1-(1-\beta)\left[\frac{\pi_{ni}}{\tau_{ni}}+\pi_{nn}\right]\right)}\right) dln\tilde{\omega}_n \\ &- \left(\frac{\pi_{ni}\left(\pi_{nn}\left(\tau_{ni}-1\right)\theta-1\right)}{\left[1+\pi_{nn}\left(\tau_{ni}-1\right)\right]\left(1-(1-\beta)\left[\frac{\pi_{ni}}{\tau_{ni}}+\pi_{nn}\right]\right)}\right) dln\tau_{ni}. \end{aligned} \tag{54}$$

A.9 Reciprocal Tariff Changes with Intermediate Goods

In this appendix, we characterize reciprocal tariff changes with intermediate goods. We first derive the reciprocal tariff changes in a world with a single tradable sector and intermediate goods. We then present the derivation of reciprocal tariff changes in the presence of a non-tradable sector.

The trade balance condition for country i can be expressed as

$$\frac{\pi_{in}}{\tau_{in}} X_i = \frac{\pi_{ni}}{\tau_{ni}} X_n. \tag{55}$$

And total expenditure on goods in country i is now the sum of intermediate consumption and final consumption, which as before, is the sum of labor income and tariff revenue, namely

$$X_i = (1-\beta)\left(\frac{\pi_{ni}}{\tau_{ni}} X_n + X_i\pi_{ii}\right) + w_i L_i + \left(\tau_{in}-1\right) X_i \frac{\pi_{in}}{\tau_{in}}.$$

Using the trade balance condition (55), we express total expenditure in country i as

$$X_i = \frac{w_i L_i \tau_{in}}{\beta\left(1+\pi_{ii}\left(\tau_{in}-1\right)\right)}. \tag{56}$$

Taking the total differential of total expenditure (56) yields

$$dlnX_i = dlnw_i + dln\tau_{in} - \left(\frac{\pi_{ii}\left(\tau_{in}-1\right) dln\pi_{ii} + \pi_{ii}\tau_{in} dln\tau_{in}}{1+\pi_{ii}\left(\tau_{in}-1\right)} \right).$$

Similarly, the total differential of the domestic expenditure share in country i is given by

$$dln\pi_{ii} = \theta\left(1-\pi_{ii}\right)(d\ln c_n - dlnc_i) + \theta\left(1-\pi_{ii}\right) dln\tau_{in}. \tag{57}$$

Taking the total differential of the trade balance condition (55) yields

$$dlnX_i - \frac{\pi_{ii}}{1-\pi_{ii}} dln\pi_{ii} - dln\tau_{in} = dlnX_n - \frac{\pi_{nn}}{1-\pi_{nn}} dln\pi_{nn} - dln\tau_{ni}.$$

Finally, using the total differential equations for total expenditure (56) we obtain,

$$dlnw_i - \left(\frac{\pi_{ii}\left(\tau_{in}-1\right)}{1+\pi_{ii}\left(\tau_{in}-1\right)} + \frac{\pi_{ii}}{1-\pi_{ii}} \right) dln\pi_{ii} - \left(\frac{\pi_{ii}\tau_{in}}{1+\pi_{ii}\left(\tau_{in}-1\right)} \right) dln\tau_{in} =$$
$$dlnw_n - \left(\frac{\pi_{nn}\left(\tau_{ni}-1\right)}{1+\pi_{nn}\left(\tau_{ni}-1\right)} + \frac{\pi_{nn}}{1-\pi_{nn}} \right) dln\pi_{nn} - \left(\frac{\pi_{nn}\tau_{ni}}{1+\pi_{nn}\left(\tau_{ni}-1\right)} \right) dln\tau_{ni}$$

and, using the expression for $dln\pi_{ii}$ and $dln\pi_{nn}$ in (57), we arrive at

$$\frac{dlnw_i}{1+\theta} - \frac{\theta}{1+\theta} \left(\frac{\pi_{ii}\left(\tau_{in}-1\right)}{1+\pi_{ii}\left(\tau_{in}-1\right)} + \frac{\pi_{ii}}{1-\pi_{ii}} \right) \left[\left(1-\pi_{ii}\right)\left(dlnc_n - dlnc_i\right) \right] - \tilde{\pi}_{ii} dln\tau_{in} =$$
$$\frac{dlnw_n}{1+\theta} - \frac{\theta}{1+\theta} \left(\frac{\pi_{nn}\left(\tau_{ni}-1\right)}{1+\pi_{nn}\left(\tau_{ni}-1\right)} + \frac{\pi_{nn}}{1-\pi_{nn}} \right) \left[\left(1-\pi_{nn}\right)\left(dlnc_i - dlnc_n\right) \right] - \tilde{\pi}_{nn} dln\tau_{ni}$$

where recall that $\tilde{\pi}_{ii} = \frac{\pi_{ii}\tau_{in}}{1+\pi_{ii}\left(\tau_{in}-1\right)}$. Therefore, using the result of Proposition 9 and its Corollary, reciprocal changes in tariffs between country i and country n (i.e., the tariff changes that satisfy $dlnc_n - dlnc_i = 0$) are characterized by

$$\frac{dlnw_i}{1+\theta} - \tilde{\pi}_{ii} dln\tau_{in} = \frac{dlnw_n}{1+\theta} - \tilde{\pi}_{nn} dln\tau_{ni}.$$

Notice that this expression is similar to the expression for reciprocal tariffs with no intermediate goods in (20), with the main difference being that with intermediate goods relative wages can change as long as they preserve the input bundle costs c_i and c_n and hence world prices according to (28). In particular, the changes in relative wages in country i and country n that preserve the input bundle costs must satisfy

$$dlnw_i - dlnw_n = \frac{\left(1-\beta\right)}{\beta} \left(\pi_{ni} dln\tau_{ni} - \pi_{in} dln\tau_{in} \right).$$

This expression is intuitive; it says that in order to keep the input bundle costs unchanged, wages must change to offset the changes in prices due to the changes in reciprocal tariffs, taking into account the importance of intermediate goods in the input bundle cost. Using this condition, we arrive at the characterization of reciprocal tariff changes in the presence of intermediate goods described in the main text:

In particular, in a two-country world with a single tradable sector and intermediate goods, reciprocal changes in tariffs between country i and country n must satisfy

$$\frac{dln\tau_{in}}{dln\tau_{ni}} = \frac{\left(\tilde{\pi}_{nn} + \frac{\left(1-\beta\right)}{\beta\left(1+\theta\right)} \left(1-\pi_{nn}\right) \right)}{\left(\tilde{\pi}_{ii} + \frac{\left(1-\beta\right)}{\beta\left(1+\theta\right)} \left(1-\pi_{ii}\right) \right)}.$$

We now present the schedule of the reciprocal tariff changes in a two-country world with intermediate goods, as well as a tradable and a non-tradable sector.

Total expenditure on goods in country i is given by

$$X_i^T = (1-\beta) X_i^T \frac{\pi_{in}}{\tau_{in}} + \alpha^T \left(w_i L_i + (\tau_{in} - 1) X_i^T \frac{\pi_{in}}{\tau_{in}} \right),$$

where as in the main text β is the share of intermediate goods in output. We then rewrite total expenditure as

$$X_i^T = \frac{\alpha^T w_i L_i \tau_{in}}{(\tau_{in} - 1)(1 - \alpha^T (1 - \pi_{ii})) + \pi_{ii}(1-\beta) + \beta}.$$

Taking the total differential of the total expenditure expression, using the expressions for the total differential of the trade balance condition and the expenditure shares described previously, we obtain the formula for reciprocal tariff changes, which is given by

$$\frac{d \ln \tau_{ni}}{d \ln \tau_{in}} = \frac{\left[\frac{(1-\beta)(1-\pi_{ii})}{\beta} + \frac{\tau_{in}\left[1-\alpha^T(1-\pi_{ii})-\pi_{ii}(1-\beta(\theta+1))\right]}{\tau_{in}-(1-\beta)(1-\pi_{ii})-(1-\beta)\tau_{in}\pi_{ii}-\alpha^T(\tau_{in}-1)(1-\pi_{ii})} \right]}{\left[\frac{(1-\beta)(1-\pi_{nn})}{\beta} + \frac{\tau_{ni}[1-\alpha^T(1-\pi_{nn})-\pi_{nn}(1-\beta(\theta+1))]}{\tau_{ni}-(1-\beta)(1-\pi_{nn})-(1-\beta)\tau_{ni}\pi_{nn}-\alpha^T(\tau_{ni}-1)(1-\pi_{nn})} \right]}. \tag{58}$$

A.10 The Welfare Effects of Reciprocal Tariff Changes in a Two-Country World with Intermediate Goods

In this Appendix section, we show that a reciprocal reduction in tariffs in a two-country world with intermediate goods is Pareto improving as long as both country's tariffs remain non-negative. To establish this, we start from the observation that welfare is impacted by the effects of the change in reciprocal tariffs on prices and tariff revenue. However, as discussed in section 5, with intermediate goods wages can also change to preserve the input bundle costs, and these wage changes will have an additional impact on welfare that needs to be accounted for.

In particular, the change in welfare from the reciprocal change in tariffs in country n is given by

$$dlnW_n = \frac{w_n L_n}{w_n L_n + R_n} dlnw_n + \frac{R_n}{w_n L_n + R_n} dlnR_n - dlnP_n.$$

Taking the total differential of tariff revenue, the price index, and using the change in wages in country n that preserves the input bundle costs, namely $dlnw_n = -\frac{(1-\beta)}{\beta}(1-\pi_{nn})\, dln\tau_{ni}$, we obtain

$$\frac{dlnW_n}{dln\tau_{ni}} = -\left(\frac{(1-\pi_{nn})(\tau_{ni}-1)}{\beta + (1-(1-\beta)\pi_{nn})(\tau_{ni}-1)} \right) \left(\frac{\pi_{nn}(1+\theta)}{1+\pi_{nn}(\tau_{ni}-1)} \tau_{ni} + \frac{(1-\beta)}{\beta}(1-\pi_{nn}) \right).$$

Therefore, given that to achieve reciprocity countries need to change tariffs proportionally, reducing tariffs starting from any positive tariff levels increases welfare in both countries; that is, reducing tariffs in a reciprocal way is Pareto improving. This elasticity changes sign at free trade, which leads us to establish the following proposition.

Proposition A5. *In a two-country Caliendo and Parro (2015) world, a reciprocal change in tariffs is Pareto improving up to the point that at least one country achieves free trade.*

A.11 Extended Reciprocity

We consider the following extension of the definition of reciprocity for country i:

$$w_i^0 \left(D_{ni}^1 - D_{ni}^0\right) - w_n^0 \left(D_{in}^1 - D_{in}^0\right) = \left(TB_i^1 - TB_i^0\right),$$

where TB_i is the trade balance in country i (positive if trade surplus, negative if trade deficit). The trade balance condition in country i at any moment in time is given by

$$w_i^0 D_{ni}^0 - w_n^0 D_{in}^0 = TB_i^0,$$
$$w_i^1 D_{ni}^1 - w_n^1 D_{in}^1 = TB_i^1.$$

Substituting the trade balanced condition at 0 on the reciprocity condition we obtain

$$w_i^0 D_{ni}^1 - w_n^0 D_{in}^1 = TB_i^1,$$

or

$$D_{in}^1 = \frac{w_i^0}{w_n^0} D_{ni}^1 - \frac{TB_i^1}{w_n^0}.$$

Substituting this expression in the other trade balance condition at 1 yields

$$TB_i^1 \left(\frac{1}{w_n^1} - \frac{1}{w_n^0}\right) = \left(\frac{w_i^1}{w_n^1} - \frac{w_i^0}{w_n^0}\right) D_{ni}^1.$$

Finally, normalizing $w_n = 1$, without loss of generality we obtain,

$$\left(\frac{w_i^1}{w_n^1} - \frac{w_i^0}{w_n^0}\right) D_{ni}^1 = 0.$$

To see what the extended notion of reciprocity in (38) implies, consider first the case of a constant trade balance $TB_i^1 = TB_i^0$ that may be positive or negative. In this case, the right-hand side of (38) is zero and (38) collapses to (4), but we know from Proposition 2 and its Corollary that tariff changes which satisfy (4) must hold fixed the terms of trade. Tariff changes that satisfy equation (38) must therefore hold fixed the terms of trade when the trade balance does not change through time. Now suppose that the trade balance is changing through time, and to fix ideas suppose that $TB_i^1 > TB_i^0 > 0$ so that country i runs a trade surplus in period 0 that grows in period 1. Rewriting (38) in the equivalent form

$$\left(w_i^0 D_{ni}^1 - w_n^0 D_{in}^1\right) - \left(w_i^0 D_{ni}^0 - w_n^0 D_{in}^0\right) = \left(TB_i^1 - TB_i^0\right), \tag{59}$$

it is apparent that equation (38) requires that this growth in country i's trade surplus (the right-hand side of (59)) must be accomplished through changes in trade *volumes* (the left-hand side of (59)) – *not* changes in wages, world prices or the terms of trade – and for the exogenous changes in country i's trade balance over time equation (38) implicitly defines the additional tariff adjustments that will be needed to accomplish this.[20]

Formalizing this logic, we state the following proposition:

[20]To be clear, the terms of trade being referred to here are the intratemporal terms of trade between a country's export goods and its import goods that can be manipulated with a classic Johnson (1953-54) optimal tariff. See Costinot, Lorenzoni and Werning (2014) on the incentive to manipulate *inter*temporal terms of trade with capital controls that alter trade imbalances through time.

Proposition A6. *In a two-country Eaton and Kortum world with exogenous changes in trade imbalances, achieving extended reciprocity defined by (38) implies that world prices are preserved.*

A.11.1 Reciprocal Tariffs with Trade Imbalances

We next characterize the tariff changes that, in the presence of changing trade imbalances, would satisfy our extended definition of reciprocity in the two-country Eaton and Kortum world. According to Proposition A6, these are the tariff changes that will hold world prices fixed in this environment. Noting that the trade balance condition for country i can be expressed as

$$\frac{\pi_{in}}{\tau_{in}}X_i = \frac{\pi_{ni}}{\tau_{ni}}X_n - TB_i, \tag{60}$$

and that total expenditure on goods in country i is equal to income, which is the sum of labor income, tariff revenue and the trade deficit in i,

$$X_i = w_i L_i + (\tau_{in} - 1) X_i \frac{\pi_{in}}{\tau_{in}} - TB_i,$$

we then rewrite total expenditure as

$$X_i = \frac{\tau_{in} w_i L_i - \tau_{in} TB_i}{1 + \pi_{ii}(\tau_{in} - 1)}. \tag{61}$$

Substituting (61) into the trade balance condition (60) yields

$$\frac{(1-\pi_{ii})}{(1+\pi_{ii}(\tau_{in}-1))}(w_i L_i - TB_i) = \frac{(1-\pi_{nn})}{(1+\pi_{nn}(\tau_{ni}-1))}(w_n L_n - TB_n) - TB_i. \tag{62}$$

Taking the total differential of (62), using the total differential of the domestic expenditure share in country i, which is given by

$$dln\pi_{ii} = (1-\pi_{ii})\theta(dlnw_n - dlnw_i) + (1-\pi_{ii})\theta dln\tau_{in}, \tag{63}$$

and using the fact that $TB_i = -TB_n$ and that $TB_i dlnTB_i = -TB_n dlnTB_n$, we obtain an expression that defines the changes in τ_{in} and τ_{ni} that, in the presence of changing trade imbalances, would satisfy our extended definition of reciprocity and hence hold world prices fixed:

$$\frac{(1-\pi_{ii})X_i}{\tau_{in}}\tilde{\pi}_{ii}(\theta+1)dln\tau_{in} = \left(1 - \frac{(1-\pi_{ii})}{(1+\pi_{ii}(\tau_{in}-1))} - \frac{(1-\pi_{nn})}{(1+\pi_{nn}(\tau_{ni}-1))}\right) TB_i dlnTB_i + \left(\frac{(1-\pi_{ii})X_i}{\tau_{in}} + TB_i\right)\tilde{\pi}_{nn}(\theta+1)dln\tau_{ni}. \tag{64}$$

Notice that for $TB_i = -TB_n = 0$ (64) implies (20), the tariff changes implied by reciprocity in a balanced-trade world. What (64) describes is the further tariff adjustments that would also have to be made in a world where trade balances are changing to continue to fix world prices and the terms of trade.

For instance, the term multiplying $dlnTB_i$ is generally positive given that the domestic expenditure shares across countries tend to be very large. Hence, if country i starts with a trade surplus that grows over time, everything else constant, a reduction in tariffs applied by country n must be reciprocated with a smaller tariff decline by country i, compared with the case of balanced trade. The opposite happens when country i is running a growing trade deficit; in this case country i must reciprocate with a larger decline in tariffs. In addition, we have the terms related to the country size multiplying $dln\tau_{in}$ and $dln\tau_{ni}$.

B Appendix: Robustness Exercises

In this Appendix, we present alternative robustness exercises. In particular, we recompute the tradable sector employment reallocation effects using alternative measures of tariff rates and base years. We focus on the employment reallocation effects to highlight that under all the alternative measures of tariff rates and base years we consistently find that China exceeded reciprocity. Consequently, this deviation from reciprocity contributed to employment reallocation out of the tradable sector in the rest of the world, as we have discussed in the main text.[21]

First, we recompute our baseline results using unweighted bilateral sectoral tariffs for China and the rest of the world. The unweighted initial tariff applied by China to the rest of the world in the year 1990 was approximately forty percent, while the unweighted tariff applied by the rest of the world to China was around thirteen percent.

Figure B.1 displays the employment effects in the non-tradable sector of the rest of the world due to the movement in terms of trade resulting from the actual changes in tariffs between China and the rest of the world over the period 1990-2007. Similar to our benchmark result in the main text, the figure shows that employment shifts to the non-tradable sector in the rest of the world.

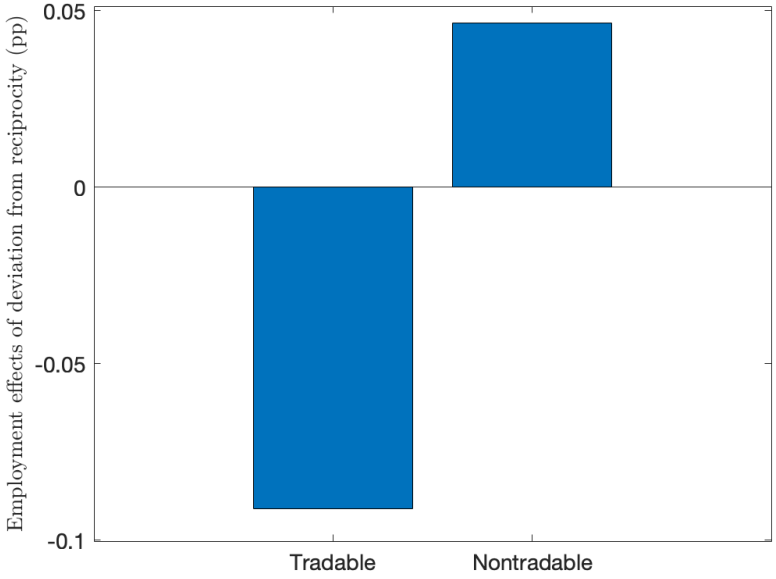

Figure B.1: Employment effects across sectors in the rest of the world

Note: The figure presents the employment effects in the tradable sector and in the non-tradable sector in the rest of the world resulting from deviations from reciprocity due to the actual changes in tariffs between China and the rest of the world over the period 1990-2007. Results are computed using unweighted bilateral sectoral tariffs for China and the rest of the world.

We then present results taking the model to the year 1995, and evaluating reciprocity using the actual tariff change between China and the rest of the world over the period 1995-2007. The weighted tariffs applied by China to the rest of the world in the year 1995 is approximately twenty four percent while the weighted tariff applied by the rest of the world to China is around sixteen percent.

[21] Additional results on reciprocal tariff schedules and welfare effects using these alternative tariff measures and base years are available upon request.

Figure B.2 displays the employment effects in the non-tradable sector of the rest of the world due to the movement in terms of trade resulting from the actual changes in tariffs between China and the rest of the world over the period 1995-2007. Consistent with our results in the main text, the figure shows that employment shifts to the non-tradable sector in the rest of the world.

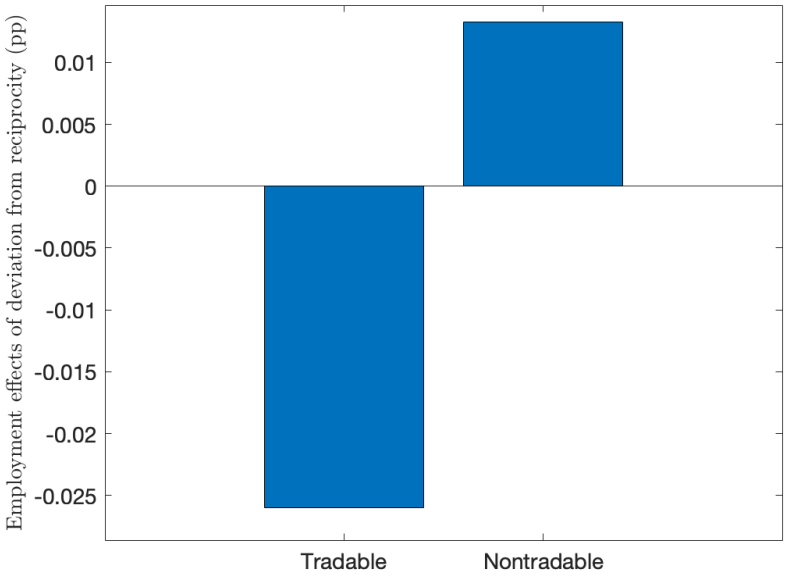

Figure B.2: Employment effects across sectors in the rest of the world

Note: The figure presents the employment effects in the tradable sector and in the non-tradable sector in the rest of the world resulting from deviations from reciprocity due to the actual changes in tariffs between China and the rest of the world over the period 1995-2007. Results are computed using weighted bilateral sectoral tariffs for China and the rest of the world.

We also present results taking the model to the year 1995, and evaluating reciprocity using the actual tariff change between China and the rest of the world over the period 1995-2007, using unweighted bilateral sectoral tariffs applied between China and the rest of the world. The unweighted tariffs applied by China to the rest of the world is about thirty two percent in the year 1995 while the weighted tariff applied by the rest of the world to China is around thirteen percent.

Finally, Figure B.3 displays the employment effects in the non-tradable sector in the rest of the world due to the movement in terms of trade resulting from the actual changes in tariffs between China and the rest of the world over the period 1995-2007, computing unweighted bilateral sectoral tariffs. As in the main text, the figure shows that employment shifts to the non-tradable sector in the rest of the world.

B.1 Additional Results with Intermediate Goods

In this section the Appendix, we present alternative results with intermediate goods. We first recompute our results with intermediate goods using unweighted tariffs. Figure B.4 presents the employment effects of deviation from reciprocity across sectors in the rest of the world. Consistent with our results in the main text, we find that China exceeded reciprocity with respect to the rest of the world, which resulted in employment reallocation to the non-tradable sector in the rest of the world.

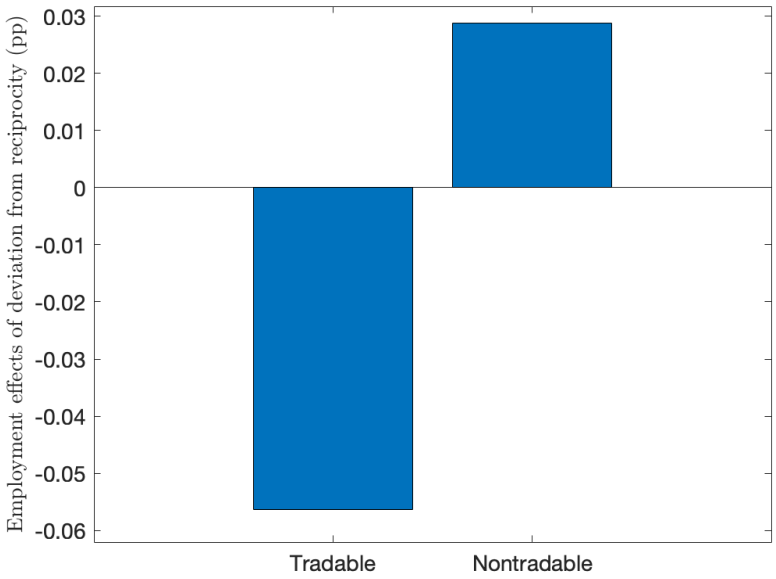

Figure B.3: Employment effects across sectors in the rest of the world

Note: The figure presents the employment effects in the tradable sector and in the non-tradable sector in the rest of the world resulting from deviations from reciprocity due to the actual changes in tariffs between China and the rest of the world over the period 1995-2007. Results are computed using unweighted bilateral sectoral tariffs for China and the rest of the world.

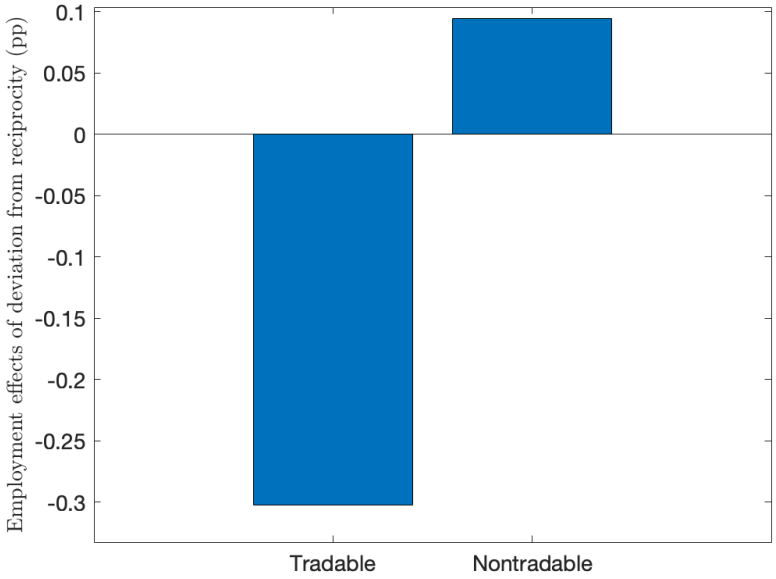

Figure B.4: Employment effects across sectors in the rest of the world

Note: The figure presents the employment effects in the tradable sector and in the non-tradable sector in the rest of the world resulting from deviations from reciprocity due to the actual changes in tariffs between China and the rest of the world over the period 1990-2007. Results are computed in the framework with intermediate goods using unweighted bilateral sectoral tariffs for China and the rest of the world.

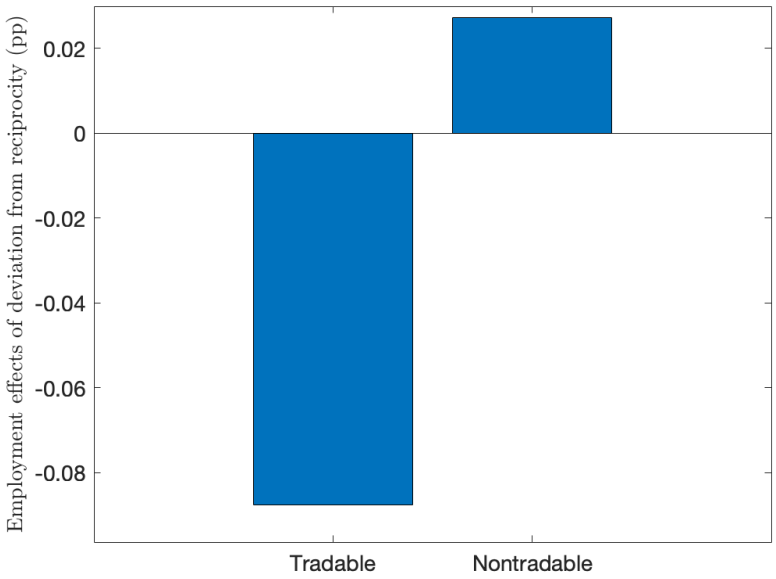

Figure B.5: Employment effects across sectors in the rest of the world

Note: The figure presents the employment effects in the tradable sector and in the non-tradable sector in the rest of the world resulting from deviations from reciprocity due to the actual changes in tariffs between China and the rest of the world over the period 1995-2007. Results are computed in the framework with intermediate goods using weighted bilateral sectoral tariffs for China and the rest of the world.

We then present the results using the model for the year 1995, and evaluating reciprocity over the period from 1995 to 2007. We first do this using weighted tariffs. Figure B.5 shows the employment effects of deviation from reciprocity across sectors in the rest of the world. Consistent again with our previous results, we find employment reallocated to the non-tradable sector in the rest of the world as a consequence of China exceeding reciprocity.

Finally, we present results using unweighted tariffs, again taking the model to the year 1995 and evaluating reciprocity over the period 1995-2007. Analogously to the previous set of figures, Figure B.6 reports the employment effects of deviation from reciprocity across sectors in the rest of the world. We again find that employment reallocated to the non-tradable sector in the rest of the world as a consequence of China's exceeding reciprocity.

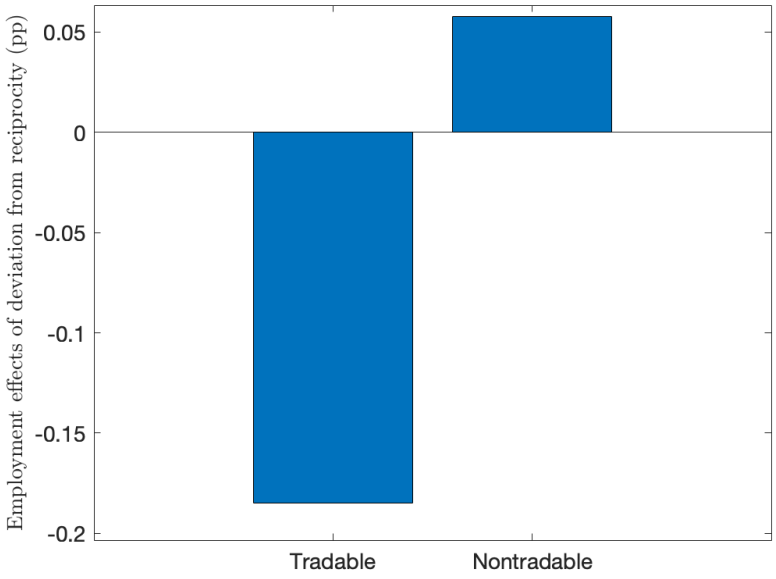

Figure B.6: Employment effects across sectors in the rest of the world

Note: The figure presents the employment effects in the tradable sector and in the non-tradable sector in the rest of the world resulting from deviations from reciprocity due to the actual changes in tariffs between China and the rest of the world over the period 1995-2007. Results are computed in the framework with intermediate goods using unweighted bilateral sectoral tariffs for China and the rest of the world.