The Role of the Most Favored Nation Principle of the GATT/WTO in the New Trade Model*

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December 2016

Abstract

I study the impact of the Most Favored Nation (MFN) principle of the GATT/WTO on the characterization of Pareto-improving bilateral trade agreements. The paper offers four main predictions. First, bilateral trade agreements improve the welfare of negotiating countries and leave the welfare of the outside country unchanged only if they include third-country tariff adjustments. Second, the MFN principle guarantees that a bilateral trade agreement always improves the welfare of the outside country and potentially causes a free-rider problem. Third, the MFN principle can prevent possible Pareto-improving trade agreements if initial tariffs are generally low or the elasticity of substitution is sufficiently low. The MFN principle has been effective in the past, but it may prevent further tariff negotiations. Lastly, free trade agreements (FTAs) could be more desirable than bilateral trade agreements under the MFN principle. I quantify the firm-delocation effects and welfare effects in three counterfactual situations: a bilateral trade agreement without third-country tariff adjustments, a bilateral trade agreement under the MFN principle, and a global free-trade economy. The quantitative results support the model predictions.

Keywords: WTO, Bilateral Trade Agreements, Most-Favored-Nation principle.
JEL classification numbers: F12, F13, O19.

*I am hugely grateful to my advisor, Robert Staiger, for his advice and invaluable comments and suggestions. I also thank Kamran Bilir, Charles Engel, Eric Bond, Mario Crucini, Mostafa Beshkar, James Lake, and Mitchell Morey for insightful conversations. I have benefited from discussions with seminar participants at the University of Wisconsin-Madison, Vanderbilt University, and Midwest International Trade conference (Fall 2016). All remaining errors are mine.

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1 Introduction

The General Agreement on Tariffs and Trade (GATT) and its successor, the World Trade Organization (WTO), have played a major role in encouraging tariff reductions between member countries. One of the four pillars of the GATT/WTO is the Most Favored Nation (MFN) treatment:

> "Any advantage, favour, privilege or immunity granted by any contracting party to any product originating in or destined for any other country shall be accorded immediately and unconditionally to the like product originating in or destined for the territories of all other contracting parties." (GATT Article I)

The basic idea of the MFN principle is that countries must not discriminate between trading partners; favorable treatment a country grants to its trading partner must also be granted to all other WTO members. The arguments for the MFN principle include efficiency of production, reduced cost of determining an import's origin, and reduced cost of maintaining the multilateral trading system. The MFN principle is also a fundamental principle in the General Agreement on Trade in Services (Article II) and the Agreement on Trade-Related Aspects of Intellectual Property Rights (Article IV).

This paper investigates the impact of the MFN principle on the set of Pareto-improving bilateral trade agreements in the New Trade model. The key mechanism in the model is a firm-delocaion effect: a trade agreement affects the welfare of countries through changes in the numbers of firms in all countries. The basic model in this paper follows the three-country model in Ossa (2011): country 1 can trade with country 2 and country 3, but country 2 and country 3 cannot trade with each other. This is the simplest setup that we can use to study the role of the MFN principle. I characterize three types of bilateral trade agreements: (i) a bilateral trade agreement *without* third country tariff adjustments, in which negotiating countries bilaterally and reciprocally cut their tariffs, (ii) a bilateral trade agreement *with* third country tariff adjustments, in which negotiating countries reciprocally cut their tariffs and also cut their tariffs against the outside country, and (iii) a bilateral trade agreement under the MFN principle, in which negotiating countries have to reciprocally cut their tariffs and grant the same treatment to the outside country. I later extend the basic model by allowing country 2 and country 3 to trade with each other. In the augmented model the additional trade flows create indirect effects that change the results in the basic model.

In the basic model a bilateral trade agreement without a third-country tariff adjustment that preserves the welfare of the outside country exists but it requires firm-delocation effects. To keep the welfare of country 3 unchanged, the underlying mechanism requires that a trade agreement must increase the number of firms in country 3 and decrease the number of firms in country 1 in such a way that country 3 is indifferent. I then characterize bilateral trade agreements with third-country tariff adjustments that keep the welfare of country 3 unchanged. In this case, country 1 can use its tariff against country 3 as an additional instrument in a bilateral tariff negotiation between country 1 and country 2. I show that country 1 and country 2 can both strictly gain from a bilateral trade agreement while country 3 is no worse off; country 1 can use a third-country tariff adjustment to cover the welfare loss of the outside country from the bilateral trade agreement between countries 1 and 2.

Subsequently, I analyze the MFN principle as a simple restriction that reconciles third-country tariff adjustments. I find that the MFN principle itself ensures that any bilateral trade agreements always benefit the outside country. This is because the MFN principle forces negotiating countries to reduce their tariffs against the outside country more than the third-country tariff adjustment suggests. While Ossa (2011) concludes that only multilaterally reciprocal trade agreements can improve the welfare of all countries, I show that a bilateral trade agreement under the MFN principle is sufficient to protect the outside country without any further interventions from the outside country.

One main result is that the MFN principle creates a free-rider problem, because the outside country can freely receive welfare gains without reducing its tariffs. Consequently, no country has an incentive to initiate a tariff negotiation as it can get the same benefit with no costs. To solve this problem, the two negotiating countries should be able to use a third-country tariff adjustment, which compensates the outside country just enough to cover its welfare loss. The third-country tariff cut against the outside country must be smaller than the tariff cut under the MFN principle. This additional flexibility leads to a larger set of Pareto-improving trade agreements and avoids the free-rider problem.

In the augmented model a unilateral increase in an import tax rate of country 1 against country 2 always benefits country 3, while in the basic model it hurts country 3. In the basic model, country 3 is worse off because the manufacturing sector in country 1 expands and the manufacturing firms in country 3 lose profits from exporting to country 1. In the augmented model, country 3 is better off because country 3 has an advantage over weakened manufacturing firms in country 2 and gains its larger market share in country 2 despite the loss of its market share in country 1. Based on this mechanism, a bilateral trade agreement without third-country tariff adjustments always hurts the outside country. As a result, to preserve the welfare of the outside country, bilateral trade agreements need third-country tariff adjustments.

The augmented model provides a generalized condition for a set of Pareto-improving bilateral trade agreements under the MFN principle. In the augmented model the MFN principle makes the outside country better off but the two negotiating countries may not be able to agree on a bilateral trade agreement if starting tariffs are generally low because welfare gains from a bilateral trade agreement are not large enough to cover welfare loss from tariff cuts in the outside country. This result suggests that when current tariffs are sufficiently low, free trade agreements (FTAs) are more desirable than bilateral trade agreements under the MFN principle. The MFN principle has been effective in the past when tariffs were high but it may prevent further tariff negotiations.

This paper quantitatively evaluates welfare changes from several types of trade agreements considered in the theoretical model. I apply the method from Dekle et al. (2007), which requires only small restrictions on calibrated parameter values. Tariff revenues, which are absent from the theoretical model, are included as a country's income. As a result, I can decompose welfare changes into three parts: a price level effect, an income effect, and a firm-delocation effect. I focus on a tariff negotiation between Europe and the USA and perform three experiments: (i) a bilateral trade agreement without third-country tariff adjustments, (ii) a bilateral trade agreement under the MFN principle, and (iii) moving the world economy to a global free trade economy. The quantitative results support my theoretical predictions. First, a bilateral trade agreement without third-country tariff adjustments benefits the negotiating countries and hurts all other countries. Second, the MFN principle guarantees that any bilateral trade agreements weakly improve the welfare of negotiating countries. Third, when the starting tariffs are sufficiently low, a bilateral trade agreement hurts negotiating countries.

The main contribution of this paper is to study the design of negotiation rules of the GATT/WTO in the new trade model. The GATT and the WTO have employed the principle of reciprocity and the MFN principle as simple negotiation rules that aim to promote tariff negotiations. Bagwell and Staiger (1999) show that in a model with perfectly competitive markets, when both the principle of reciprocity and the MFN treatment are applied, efficiency can be achieved, despite the government's political goals. These two principles focus on eliminating different price distortions simultaneously. The principle of reciprocity preserves world price ratios to prevent terms-of-trade inefficiency, while the MFN principle prevents a local-price externality that would distort price ratios from a foreign exporter's point of view.

In models with imperfectly competitive markets with fixed numbers of firms, a profit-shifting externality naturally arises (Bagwell & Staiger, 2009; 2012; Ossa, 2012). In this environment, a country unilaterally raises its tariffs to shift profits from foreign firms and directs those profits toward domestic firms. Bagwell and Staiger (2012) show that the principle of reciprocity and the MFN principle policy are sufficient conditions in enhancing efficiency in this class of models.

The main feature of this paper is a firm-delocation externality that can be viewed as a consequence of a profit-shifting externality when free entry and exit is allowed in an imperfectly competitive market (Bagwell & Staiger, 2009; DeRemer, 2010; Ossa, 2011). After a country's unilateral tariff shifts profits from foreign firms to domestic firms, foreign firms exit and new domestic firms enter the domestic market. In other words, a country unilaterally raises its tariffs to delocate foreign firms to the home market. This externality is consistent with the fact that governments tend to favor certain production sectors. Because of a firm-delocation externality, domestic consumers benefit from more varieties of relatively cheap, locally produced goods which replace some varieties of relatively expensive imported goods.

This paper is closest to Ossa (2011). Following the idea of preserving competitiveness of other countries from Bagwell and Staiger (1999), Ossa (2011) restricts reciprocity as tariff changes that do not affect the trade balance in the manufacturing sector. According to Ossa (2011), a bilaterally reciprocal trade agreement, which keeps the trade balance in manufacturing goods between the negotiating countries unchanged, eliminates firm-delocation effects within the negotiating countries and improves the welfare of the two negotiating countries, but generates a negative firm-delocation effect on the outside country. Ossa (2011) concludes that a bilaterally reciprocal trade agreement is not sufficient to preserve the welfare of the outside country and a multilaterally reciprocal trade agreement is needed to ensure the outside country does not experience welfare loss from such a bilateral trade agreement. In contrast to Ossa (2011), this paper shows that in the same model a bilateral trade agreement that preserves the welfare of the outside country exists, but it must cause a firm-delocation effect in a proper way. While Ossa (2011) studies how the principle of reciprocity can preserve the welfare of the outside country, this paper mainly focuses on how the MFN principle can preserve the welfare of the outside country.

The remainder of this paper proceeds as follows. Section 2 describes the basic model. Section 3 discusses differences between Ossa (2011) and this paper and characterizes a set of Pareto-improving bilateral trade agreements. Section 4 studies the role of the MFN principle. Section 5 introduces the augmented model and characterizes a set of Pareto-improving bilateral trade agreements in the augmented model. Section 6 provides numerical results from counterfactual experiments. Concluding remarks are offered in section 7.

2 The Basic Model

In this section, I describe the model, which is identical to the three-country model in Ossa (2011). It is a static model capturing labor movements across sectors and firm de-locations across countries.

There are three countries: country 1, country 2, and country 3. In the basic model, country 2 and country 3 cannot trade with each other, but in the augmented model in Section 5 country 2 and country 3 are allowed to trade with each other. Henceforth, I use subscript $i \in \{1, 2, 3\}$ to denote producer-related variables in country i and subscript $j \in \{1, 2, 3\}$ to denote consumer-related variables in country j.

2.1 Households' preference

Households in country j have an identical preference deriving utility from consuming two types of goods: a continuum of differentiated manufacturing goods and unique homogeneous non-manufacturing goods. The preference of country j can be represented by the utility function U_j such that

$$
\begin{aligned}
U_j &= Q_j^{\mu} Y_j^{1-\mu}, \\
Q_j &= \left[\int_{\omega \in \Omega_j} q_{ij}(\omega)^{\frac{\sigma-1}{\sigma}} d\omega \right]^{\frac{\sigma}{\sigma-1}}, \\
Y_j &= \sum_{i=1}^{3} y_{ij},
\end{aligned}
$$

where Q_j is the Dixit-Stiglitz composite good of all varieties of manufacturing goods that are available in country j, $q_{ij}(\omega)$ is the quantity of variety ω of differentiated manufacturing goods from country i that is consumed in country j, Ω_j is a set of every variety ω that is sold in country j, Y_j is an aggregate consumption of the non-manufacturing good, y_{ij} is the quantity of the homogeneous non-manufacturing goods exported from country i to country j, $\sigma > 1$ denotes the constant elasticity of substitution between manufacturing goods, and $\mu \in (0,1)$ is the expenditure share of manufacturing goods in the Cobb-Douglass preference.

2.2 Production

The production functions of the same sectors are identical across countries. A manufacturing firm indexed by ω has an increasing return-to-scale production function. The production cost of producing $q_i(\omega)$ units of a manufacturing goods ω in country i includes a fixed labor requirement of manufacturing production f and the marginal labor requirement $c < 1$ for each unit of manufacturing goods. On the other hand, the production function of non-manufacturing goods exhibits a linear, constant-return-to scale technology. Therefore, the total costs in terms of labor requirements are described as

$$\begin{aligned} l_i^q(\omega) &= f + cq_i(\omega), \\ l_i^y &= y_{ij}, \end{aligned}$$

where $l_i^q(\omega)$ is a labor requirement of firm ω in country i and l_i^y is a labor requirement of a non-manufacturing firm. The total amount of labor in country i is L_i.

The non-manufacturing good is treated as a numeraire and, therefore, its price is normalized to one. Since the marginal product of labor in the non-manufacturing sector is one, the wage rate is pinned down exogenously by a perfectly competitive labor market and is equal to one.

The manufacturing sector is monopolistically competitive, whereas the non-manufacturing sector is perfectly competitive. Markets for manufacturing goods are segmented; an arbitrage opportunity is impossible. In both sectors, a free-entry condition ensures that every firm yields zero profit. As a result, firm ownership is irrelevant in this model.

2.3 International trade frictions

International trades are subjected to two types of frictions: transportation costs and tariffs. First, when a manufacturing firm exports one unit of manufacturing goods to another country, it faces an identical iceberg transportation cost and has to ship $\theta > 1$ units of goods. Selling in a domestic market does not involve this transportation cost. Moreover, firms do not pay additional fixed costs to enter an export market. Second, a government imposes tariffs in terms of final goods. An import tax rate on manufacturing goods imported from country i imposed by country j is defined as t_{ij}. I define an after-tax mark-up $\tau_{ij} \equiv (1 + t_{ij})$. However, tariff revenue is not redistributed to consumers and, hence, becomes a deadweight loss in the theoretical model. In quantitative exercises in Section 6, tariff revenues are redistributed in a lump-sum manner. The interaction between the price-level effect and the income effect will be displayed numerically later.

In conclusion, to sell one unit of manufacturing goods in country j, a manufacturing firm in country i has to initially deliver $\theta\tau_{ij} = \theta\left(1+t_{ij}\right)$ units. Exporting a non-manufacturing good is frictionless without any trade barriers. Hereafter, to simplify algebraic terms, I define $B_{ij} = \left(\theta\tau_{ij}\right)^{1-\sigma} \geq 0$ as an inverted effective trade barrier. Note that $B_{ii} = 1$, since a firm does not face an international trade barrier in a domestic market.

2.4 Equilibrium conditions

The total income of country i consists of labor income and a tariff revenue. The labor income is L_i because there are L_i units of labor and the wage rate is 1. Tariff revenue is assumed to be a sunk cost in a theoretical framework but is included in a government's income in a quantitative framework. Let G_j be a manufacturing price index in country j. Households' utility optimization problem implies that the demand for the product of firm ω from country i is

$$q_{ij}\left(\omega\right) = \left(\frac{p_{ii}\left(\omega\right)}{G_i}\right)^{-\sigma} B_{ij}^{\frac{\sigma}{\sigma-1}} \frac{\mu L_i}{G_i}$$

Given the demand function, a profit-maximizing firm sets a factory price $p_{ij}\left(\omega\right) = \frac{\sigma}{\sigma-1}c$ which is a mark-up price above a marginal cost regardless of the destination of sales. The factory price of each firm is identical and a notation can be dropped to $p_{ij}\left(\omega\right) \equiv p$. Since firms enter and exit freely, existing firms yield only zero profit. This implies that $\sum_j \left(\theta\tau_{ij}\right) q_{ij}\left(\omega\right) = \frac{f(\sigma-1)}{c} \equiv q$. Manufacturing firms in each country share the same production technology; they have an identical market-clearing condition and an indexation ω can be neglected.

I define $\lambda_{ij} = \left(\theta\tau_{ij}\right) q_{ij}\left(\omega\right) / \sum_j \left(\theta\tau_{ij}\right) q_{ij}\left(\omega\right)$ as a fraction of total manufacturing goods leaving manufacturing firms in country i's factory that are exported to country j. We can interpret it as a relative market access of manufacturing firms in country i. Note that this term includes iceberg transportation costs and tariffs.

Given the Dixit-Stiglitz preference, the aggregate manufacturing price index G_j is described as

$$G_1 = \left[n_1 p^{1-\sigma} + n_2 p^{1-\sigma} B_{21} + n_3 p^{1-\sigma} B_{31}\right]^{\frac{1}{1-\sigma}}, \tag{1}$$

$$G_2 = \left[n_1 p^{1-\sigma} B_{12} + n_2 p^{1-\sigma}\right]^{\frac{1}{1-\sigma}}, \tag{2}$$

$$G_3 = \left[n_1 p^{1-\sigma} B_{13} + n_3 p^{1-\sigma}\right]^{\frac{1}{1-\sigma}}, \tag{3}$$

where n_i denotes the number of manufacturing firms in country i. In addition, market clearing conditions for manufacturing firms in countries 1, 2, and 3 are as follows:

$$
\begin{aligned}
q &= p^{-\sigma} G_1^{\sigma-1} \mu L_1 + p^{-\sigma} G_2^{\sigma-1} B_{12} \mu L_2 + p^{-\sigma} G_3^{\sigma-1} B_{13} \mu L_3, \quad (4)\\
q &= p^{-\sigma} G_1^{\sigma-1} B_{21} \mu L_1 + p^{-\sigma} G_2^{\sigma-1} \mu L_2, \quad (5)\\
q &= p^{-\sigma} G_1^{\sigma-1} B_{31} \mu L_1 + p^{-\sigma} G_3^{\sigma-1} \mu L_3. \quad (6)
\end{aligned}
$$

Using market clearing conditions in equations (4), (5), and (6), manufacturing price indices can be solved explicitly:

$$
\begin{aligned}
G_1 &= \left(\frac{qp^{\sigma}}{\mu L_1} \frac{\Phi_1}{\Omega} \right)^{\frac{1}{\sigma-1}}, \quad (7)\\
G_2 &= \left(\frac{qp^{\sigma}}{\mu L_2} \frac{\Phi_2}{\Omega} \right)^{\frac{1}{\sigma-1}}, \quad (8)\\
G_3 &= \left(\frac{qp^{\sigma}}{\mu L_3} \frac{\Phi_3}{\Omega} \right)^{\frac{1}{\sigma-1}}, \quad (9)
\end{aligned}
$$

where

$$
\begin{aligned}
\Phi_1 &= 1 - B_{12} - B_{13},\\
\Phi_2 &= 1 - B_{21} - B_{13}\left(B_{31} - B_{21}\right),\\
\Phi_3 &= 1 - B_{31} - B_{12}\left(B_{21} - B_{31}\right),\\
\Omega &= 1 - B_{12}B_{21} - B_{13}B_{31}.
\end{aligned}
$$

The indirect welfare function of country j is expressed by

$$
V_j = \mu^{\mu} \left(1-\mu\right)^{(1-\mu)} L_j G_j^{-\mu}.
$$

Because tariff revenue is not redistributed and a country's total income is not affected by a trade agreement, a percentage change in the price level is a sufficient statistic measuring a percentage change in indirect social welfare. To be precise, $dlogV_j = -\mu dlogG_j$. The expression shows a negative relationship between the price index of a country and its social welfare.

Furthermore, given equations (1)-(6), the explicit numbers of manufacturing firms are

$$
\begin{aligned}
n_1 &= \frac{\mu}{qp} \left[\frac{L_1}{\Phi_1} - \frac{B_{21}L_2}{\Phi_2} - \frac{B_{31}L_3}{\Phi_3} \right], \quad (10)\\
n_2 &= \frac{\mu}{qp} \left[-\frac{B_{12}L_1}{\Phi_1} + \frac{\left(1 - B_{13}B_{31}\right) L_2}{\Phi_2} + \frac{B_{31}B_{12}L_3}{\Phi_3} \right], \quad (11)\\
n_3 &= \frac{\mu}{qp} \left[-\frac{B_{13}L_1}{\Phi_1} + \frac{B_{21}B_{13}L_2}{\Phi_2} + \frac{\left(1 - B_{12}B_{21}\right) L_3}{\Phi_3} \right]. \quad (12)
\end{aligned}
$$

Parameter values are restricted such that the manufacturing sector in every country is active; $n_1 > 0$, $n_2 > 0$, and $n_3 > 0$. One important result is that $n_1 + n_2 + n_3 = \frac{\mu}{qp}(L_1 + L_2 + L_3)$; the world number of manufacturing firms is fixed and is independent from tariff policies. This implies that an expansion of manufacturing in one country always comes at the expense of another country. Therefore, a tariff war is possible if all governments want to support their own domestic producers.

3 Bilateral Trade Agreement

The objective of this section is to characterize bilateral tariff changes that improve the welfare of negotiating countries. Without loss of generality, I focus on a bilateral trade agreement between country 1 and country 2. The analysis differs from Ossa (2011) in that I consider a larger set of tariff negotiations that includes those which generate firm-delocation externalities. I then argue that a third country may benefit from a trade agreement although the firm-delocation externality exists.

Reciprocity in Ossa (2011) is defined so that trade balances of manufacturing goods between countries do not change. This idea follows from the principle of reciprocity in Bagwell and Staiger (1999; 2012) which states that an equal increase in imports and exports is desirable.

Definition. Reciprocity in Ossa (2011): Let $\triangle TB_j^M$ be the change in the trade balance of the manufacturing sector in country j.

1. A trade agreement between country 1 and country 2 is *bilaterally reciprocal* if $\triangle TB_2^M = 0$.
2. A trade agreement between country 1 and country 2 is *multilaterally reciprocal* if $\triangle TB_1^M = \triangle TB_2^M = \triangle TB_3^M = 0$.

With this definition of reciprocity, Ossa (2011) describes three results. First, in the two country model, a bilaterally reciprocal trade agreement does not change the number of manufacturing firms in negotiating countries. Second, in the three country model, a bilaterally reciprocal trade agreement between country 1 and country 2 keeps the number of manufacturing firms in country 2 unchanged, raises the number of manufacturing firms in country 1, and reduces the number of manufacturing firms in country 3. It monotonically decreases the welfare of country 3. Third, only a multilaterally reciprocal trade agreement keeps the number of firms in each country unchanged and benefit all countries simultaneously. To see this clearly, note that a multilaterally reciprocal trade agreement does not alter the trade balances and eliminates the firm-delocation effect. Country 3's welfare is unaffected, as equation (3) shows that G_3 is unaffected by the bilateral trade agreement. In the meantime, country 1 and country 2 gain from expanding international trade and lower price levels. A bilaterally reciprocal trade agreement hurts the outside country because it does not eliminate the firm-delocation effect in country 3. This contradicts how actual tariff negotiations occur since the GATT/WTO allows countries to bargain bilaterally under the MFN principle.

In contrast to Ossa (2011), I focus on two types of bilateral trade agreements that differ in terms of third-country tariff adjustments.

Definition. The definitions of bilateral trade agreements in this paper:

1. *A bilateral tariff agreement without third-country tariff adjustment* is a tariff negotiation on $\{t_{21}, t_{12}\}$.
2. *A bilateral tariff agreement with third-country tariff adjustment* is a tariff negotiation on $\{t_{21}, t_{12}, t_{31}\}$.

A bilateral agreement without third-country tariff adjustment is an agreement that involves only tariff reductions between two negotiating countries; country 1 and country 2 negotiate on only t_{21} and t_{12}. In contrast, a bilateral agreement with third-country adjustment is an agreement that requires (i) two negotiating countries to bilaterally and reciprocally reduce their tariffs against each other, and (ii) country 1 adjusts its tariff against country 3 (t_{31}). These definitions allow this paper to focus on how bilateral tariff negotiations are possibly implemented without any further intervention from outside countries.

To prepare for the analysis of bilateral trade agreements, I establish the impacts of bilateral tariff changes on welfare and the numbers of firms in Lemmas 1 and 2.

Lemma 1. *In the basic model, a unilateral increase in the tariff of country 1 on country 2 improves country 1's welfare, but hurts country 2 and country 3. A unilateral increase in the tariff of country 2 on imports from country 1 improves the welfare of country 2 and country 3, but hurts the welfare of country 1.*

Proof. See Appendix B. □

Lemma 2. *In the basic model, a unilateral increase in the tariff of country 1 on country 2 delocates manufacturing firms in country 2 and country 3 to country 1. A unilateral increase in the tariff of country 2 on imports from country 1 delocates manufacturing firms in country 1 to country 2 and country 3.*

Proof. See Appendix B. □

The mechanism is intuitive. An increase in t_{21} reduces competitiveness of country 2 in country 1's market; manufacturing firms in country 2 lose profits from selling to country 1 and some firms exit. Because of the contraction in the manufacturing sector in country 2, manufacturing firms in country 1 gain profits from more sales in its domestic market and in country 2's market, causing new firms to enter the manufacturing market in country 1. This mechanism generates an indirect effect on country 3, as manufacturing firms in country 3 face tough competition in their domestic and export markets. Some firms in country 3 do not survive and are forced to exit. The manufacturing price index in country 1 decreases because households in country 1 benefit from more varieties of relatively cheap, locally produced goods, which replace some varieties of relatively expensive imported goods. In contrast, the manufacturing price indices in country 2 and country 3 increase. Therefore, the effects of an increase in t_{21} are that country 1 is better of while country 2 and country 3 are worse off.

This result is opposite to the results of other trade models with perfect competition that typically predict that an increase in t_{21} improves the welfare of country 3. The key factor is the nature of competition among firms. Other trade models (e.g., Bagwell and Staiger, 1999) commonly assume that country 2 and country 3 export identical goods to country 1. In this class of models, firms in country 2 and country 3 are naturally competing for exports to country 1. An increase in t_{21} shifts the demand for country 2's products to country 3's products and therefore improves the welfare of country 3. In this paper, manufacturing firms in country 3 are not only competing against manufacturing firms in country 2 but also manufacturing firms in country 1. When manufacturing firms in country 1 are well protected by t_{21}, manufacturing firms in country 3 face tough competition in their domestic and export markets. As a result, this model predicts that n_3 will drop as t_{21} increases. In other words, Lerner symmetry (which states that a reduction in tariffs expands international trade and makes exporting firms more productive) does not apply directly to this model; instead, exporting firms lose their profits in their home market and relocate to another country.

The important mechanism in this paper is a firm delocation effect between a manufacturing sector and a non-manufacturing sector. According to Ossa (2011), a bilateral trade agreement that does not change trade balances of negotiating countries causes a contraction in the manufacturing sector and hurts the welfare of country 3. However, the manufacturing price index described by equation (3) suggests a possibility that a bilateral trade agreement between country 1 and country 2 does not hurt country 3 even though country 3 does not participate in the tariff negotiation. For this to occur, country 1 and country 2 must simultaneously reduce their tariffs such that they appropriately cause production relocations on n_1 and n_3 in a way that G_3 is unchanged. On the one hand, the initial decline in the aggregate price level in country 1 hurts the competitiveness of country 3 through the relatively more expensive export prices in country 3. This causes a firm-delocation effect in country 3, leaving it worse off. On the other hand, country 1 reciprocally reduces its tariffs against country 2 and causes a contraction in the manufacturing sector in country 1 that benefits manufacturing firms in country 3. These two effects must offset each other in order to keep the welfare of country 3 unchanged.

Proposition 1 establishes the first result.

Proposition 1. *In the basic model, a bilateral trade agreement without third-country tariff adjustment that keeps the welfare of country 3 unchanged exists and satisfies*

$$\frac{dlog\left(\tau_{12}\right)}{dlog\left(\tau_{21}\right)} = \frac{\lambda_{21}}{\lambda_{22}}.$$

It strictly improves the welfare of country 2 but keeps the welfare of country 1 the same. In addition, the number of manufacturing firms in country 1 decreases while the number of manufacturing firms in country 2 and country 3 increase.

Proof. See Appendix B. □

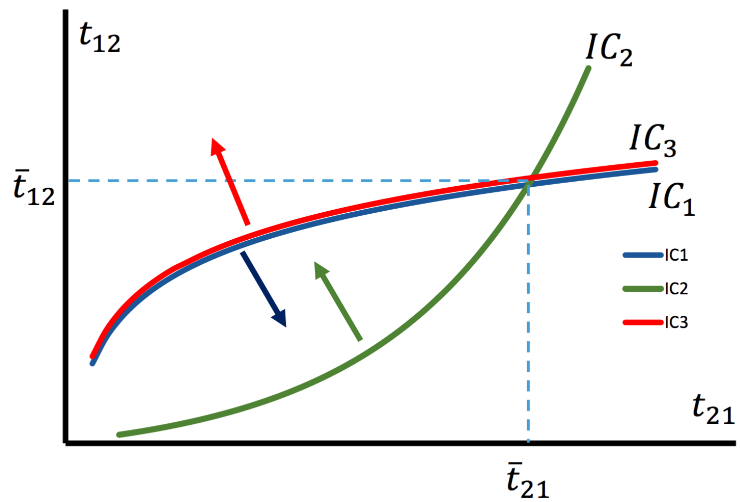


Figure 1: Bilateral trade agreements without third-country tariff adjustments.

A bilateral trade agreement without third party tariff adjustment that keeps the welfare of country 3 must involve a firm-delocation effect and a change in the trade balance. Country 1 becomes a big importer of manufacturing goods and exports non-manufacturing goods to the other countries while country 2 and country 3 export more manufacturing products. While Ossa (2011) shows that a bilaterally reciprocal trade agreement cannot preserve the welfare of the outside country, I show that a bilateral trade agreement that preserves the welfare of the outside country exists but it must cause a firm-delocation effect in a proper way.

It is important to note that the welfare of country 1 and that of country 3 move in opposite directions. A reduction in country 1's price level benefits country 1 while it leaves country 3 worse off. Therefore, country 1 gains from trade liberalization at the expense of country 3. In order to keep country 3's welfare unchanged, country 1 must reduce its tariff against country 2 so that the price level of country 1 is unchanged. Therefore, if the welfare of country 3 must be preserved, country 1 cannot gain from a bilateral trade agreement, but country 2 benefits from its lower price level.

Figure 1 graphically explains the result in Proposition 1. In Figure 1, country 1 and country 2 are negotiating over a reduction of their initial tariffs $\bar{t}_{21}$ and $\bar{t}_{12}$. The shape of the indifference curves follows Lemma 1. The (blue) curve labeled IC_1 represents the upward-sloping indifference curve of country 1 (IC_1). The area on the right of the IC_1 shows combinations of new tariffs that improve the welfare of country 1, because country 1 is better off when it unilaterally increases its tariff t_{21} or when country 2 reduces t_{12}. The (green) curve labeled IC_2 represents the upward-sloping indifference curve of country 2 (IC_2). The area on the left of the curve shows combinations of tariffs that improve the welfare of country 2, as country 2 is better off when it unilaterally increases its tariff t_{12} or when country 1 cuts its tariff t_{21}. The (red) curve labeled IC_3 shows the indifference curve of country 3 (IC_3), which perfectly coincide with the indifference curve of country 1. However, the area to the left of IC_3 is the region that is preferred by country 3.

Country 1 and country 2 want a new pair of tariffs in the area between IC_1 and IC_2 which strictly improves their welfare. However, tariffs in the area between IC_1 and IC_2 harm country3. To preserve the welfare of country 3, a bilateral trade agreement without third-country tariff adjustment must choose a combination of t_{21} and t_{12} that is on IC_3. Therefore, the bilateral trade agreement without third-country tariff adjustment strictly improves the welfare of country 2, but keeps the welfare of country 1 unchanged.

The next proposition considers a case where country 1 is allowed to adjust t_{31} in a bilateral trade agreement *with* a third country tariff adjustment.

Proposition 2. *A bilateral trade agreement with third country tariff adjustment which (i) keeps the welfare of country 3 unchanged and (ii) strictly improves the welfares of country 1 and country 2 exists and satisfies*

$$\frac{\lambda_{21}}{\lambda_{22}} < \frac{dlog\left(\tau_{12}\right)}{dlog\left(\tau_{21}\right)} < \frac{\lambda_{11}}{\lambda_{12}},$$

and

$$\frac{dlog\left(\tau_{31}\right)}{dlog\left(\tau_{21}\right)} = \frac{1}{\frac{\lambda_{11}}{\lambda_{12}} - \frac{\lambda_{21}}{\lambda_{22}}}\left(\frac{dlog\left(\tau_{12}\right)}{dlog\left(\tau_{21}\right)} - \frac{\lambda_{21}}{\lambda_{22}}\right).$$

Proof. See Appendix B. □

Proposition 2 demonstrates that an additional adjustment of t_{31} allows a bilateral trade agreement to improve the two negotiating countries' welfare without hurting country 3's welfare. This mechanism is similar to what the MFN principle does, but the main difference is that country 1 need not reduce t_{31} as much as it does on t_{21}. The underlying mechanism is straightforward. A bilateral trade agreement generates welfare gains to negotiating countries, which then allows country 1 to transfer some of its welfare gains to compensate for the welfare loss of country 3.

To compensate for the welfare loss of country 3, two opposite effects are needed. First, country 2 must cut its tariff against country 1 more than it does in Proposition 1. Country 1 receives a strictly positive gain from the trade agreement and country 3 is initially worse off. Second, country 1 must reduce its tariff against country 3. This will hurt country 1's welfare but will simultaneously benefit country 2 and country 3. Country 1 cuts t_{31} just enough to cover the welfare loss of country 3.

To summarize the results, country 1 has positive welfare gains because the gain from lower import prices outweighs the negative firm-delocation externality. Country 2 gains from both cheaper import prices and an expansion in the manufacturing sector. Country 3 receives a negative externality from a trade liberalization but is compensated by a decline in t_{31}.

Figure 2 illustrates the idea of Proposition 2. In Figure 2, country 1 and country 2 want to bilaterally cut their tariffs to point A. This bilateral trade agreement will hurt country 3. But with an additional instrument t_{31}, the welfare loss of country 3 can be compensated through a third country tariff adjustment according to the second condition in Proposition 2. This compensation shifts

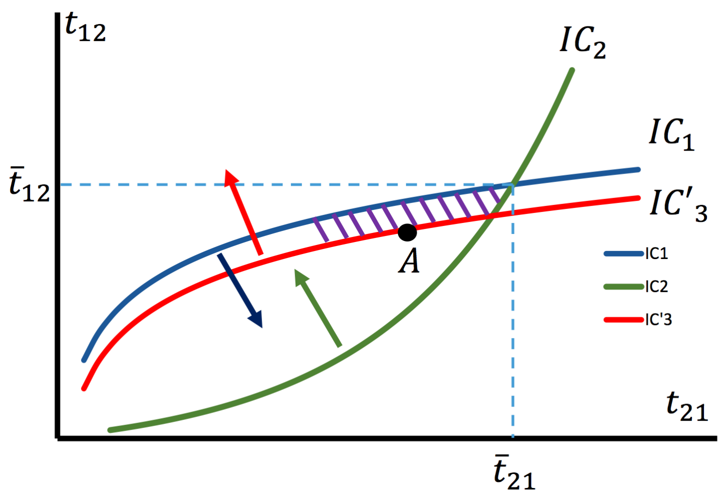


Figure 2: A set of Pareto-improving bilateral trade agreements with third-country tariff adjustments.

IC_3 to the right so that IC_3 passes trough point A.[1] Therefore, a bilateral trade agreement with third-country tariff adjustment keeps the welfare of country 3 unchanged while strictly improving the welfares of country 1 and 2.

Corollary 1 illustrates the difference between Proposition 1 and Proposition 2: a third-country tariff adjustment allows country 1 to benefit from a bilateral trade agreement.

Corollary 1. *Under the condition that the welfare of country 3 is unchanged, a bilateral trade agreement without a third-country tariff adjustment keeps the welfare of country 1 unchanged, but a bilateral trade agreement with a third-country tariff adjustment improves the welfare of country 1.*

4 The Most Favored Nation Principle

In this section, I analyze the role of the MFN principle. That is, country j has to set the same import tax rate for all of its trading partners; that is, $t_{ij} \equiv t_j$ for all exporters in country i. The inverted effective trade barrier B_{ij} is simplified to B_j. The equilibrium conditions have similar intuitions as equations 1 to 9.

Under the MFN principle the manufacturing price indices G_2 and G_3, described by equations 2 and 3, are simplified to

$$G_2 = \left(\frac{qp^\sigma}{\mu L_2} \frac{(1 - B_1)}{\Omega} \right)^{\frac{1}{\sigma - 1}} \text{ and } G_3 = \left(\frac{qp^\sigma}{\mu L_3} \frac{(1 - B_1)}{\Omega} \right)^{\frac{1}{\sigma - 1}}.$$

The simplified manufacturing price indices establish an obvious relationship between the wel-

[1]Technically, the third-country tariff adjustment actually shifts IC_1 as country 1 has welfare loss from the compensation. However, the welfare loss of country 1 is relatively small and can be negligible. It is not shown in figure 2 to avoid confusion from an extra curve.

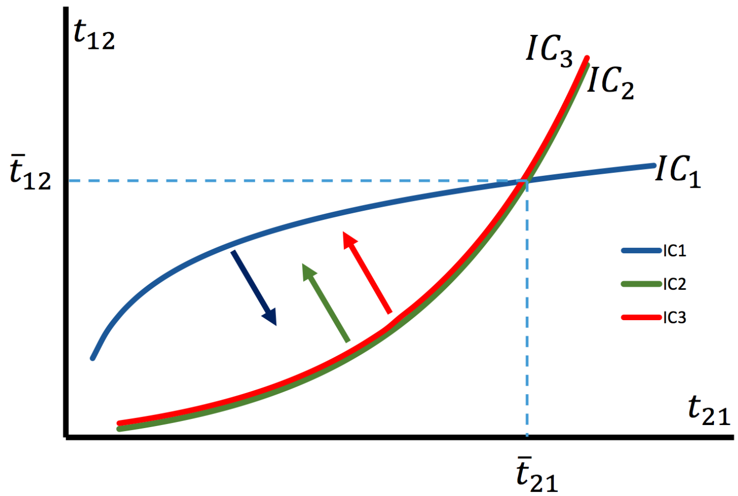


Figure 3: A set of Pareto-improving bilateral trade agreements under the MFN principle.

fare of country 2 and country 3:

$$G_2 = (L_3/L_2)^{\frac{1}{\sigma-1}} G_3.$$

The manufacturing price index of country 2 is proportional to the manufacturing price index of country 3 scaled by a ratio of country sizes. It is clear that percentage changes of G_2 and G_3 due to any tariff policy are equal. Lemma 3 summarizes this finding.

Lemma 3. *Welfare Linkage: In the presence of the MFN principle, the welfare of country 2 is proportional to the welfare of country 3. In particular, for any tariff change, the percentage change of country 2's welfare is equal to the percentage change of country 3's welfare.*

$$\frac{dlogG_2}{dlog\tau_j} = \frac{dlogG_3}{dlog\tau_j}, \forall j \in \{1, 2, 3, \}$$

Proof. See Appendix B. □

This result is in contrast to existing literature. The welfare of country 2 and country 3, which are linked through the price level in country 1, move in the same direction. A decrease in the price level of country 1 decreases the competitiveness of exporting firms in country 2 and country 3 and subsequently reduces the welfare of country 2 and country 3. Without the MFN principle, a trade agreement without a third-country tariff adjustment creates a wedge between t_{21} and t_{31}, which benefits manufacturing firms in country 2 at the expense of country 3. The MFN principle eliminates the advantage from the tariff difference and tightens welfare linkage. As a result, Lemma 3 can provide a strong prediction: percentage changes in the welfare of country 2 and country 3 not only have the same sign but also are identical. Lemma 3 suggests that as long as a trade agreement yields welfare gains for country 2, country 3 always benefits as well.

Figure 3 demonstrates the result in Lemma 3. The MFN principle rotates IC_3 counterclockwise until IC_3 coincides with IC_2. Keeping the welfare of country 3 unchanged therefore implies that the welfare of country 2 is also unchanged.

Next, I characterize the bilateral trade agreements between country 1 and country 2 under the MFN principle. The effects of changes in import tax rates are similar to those in Lemma 1 and 2, but the MFN principle magnifies the effect of a reduction in t_1 on country 1. Not only does country 1 lower its protection against country 2, it also lowers its protection against country 3. Country 2 and country 3's welfare gains from a decrease in t_1 are larger than their gains in Lemma 1 because their only competitor, country 1, is more vulnerable. These welfare changes are summarized in Proposition 3.

Proposition 3. *A bilateral trade agreement between country 1 and country 2 under the MFN principle that keeps the welfare of country 3 unchanged satisfies*

$$\frac{dlog\left(\tau_2\right)}{dlog\left(\tau_1\right)} = \frac{\lambda_{11}}{\lambda_{12}}.$$

It always benefits country 1 but keeps the welfare of country 2 unchanged. In addition, the agreement increases the number of manufacturing firms in country 1. The number of manufacturing firms in country 2 declines more than the number of manufacturing firms in country 3.

Proof. See Appendix B. □

As shown in Figure 3, a bilateral trade agreement under the MFN principle that keeps the welfare of country 3 unchanged must move along IC_3. Therefore, the new point must also be on IC_2 and country 2 does not gain from the trade agreement under the MFN principle. However, because the new point is to the right of IC_1, country 1 strictly gains from a bilateral trade agreement under the MFN principle.

Intuitively, the MFN principle causes a trade agreement to heavily damage the manufacturing sector in country 1 because country 1 must reduce its protection against both country 2 and country 3, not just country 2. This results in an expansion of the manufacturing sector in country 2 and country 3. Therefore, in order to keep the welfare of country 3 unchanged, country 1 must maintain the same level of competition in the domestic manufacturing sector. Country 2 must sufficiently raise the number of manufacturing firms in country 1 by reducing t_2. However, this requirement is strong enough to offset all the gains accrued by country 2. Therefore, country 2 does not benefit from this trade agreement.

This is an interesting result because the MFN principle completely shifts gains from a bilateral reciprocal trade agreement from country 2 to country 1. It is worth making this conclusion the subject of the next proposition.

Proposition 4. *Conditional on keeping the welfare of country 3 unchanged, a bilateral trade agreement without a third-country tariff adjustment requires that the welfare of country 1 is unchanged, but a bilateral trade agreement under the MFN principle requires that the welfare of country 2 is unchanged.*

Proof. From Proposition 1 and Proposition 3. □

A bilateral trade agreement links the welfare of country 3 to the welfare of country 1 through competition in the manufacturing sector in country 1. However, under the MFN principle, the tariff advantage from a gap between t_{21} and t_{31} is neutralized and country 3 may benefit from a bilateral trade agreement. This result is formalized in the following proposition.

Proposition 5. *In the basic model, the MFN principle sufficiently guarantees that any bilateral trade agreement leads to a Pareto improvement.*

The existence of bilaterally reciprocal trade agreements benefiting both country 1 and country 2 is ensured by Proposition 2. Because the welfare of country 3 is perfectly tied with the welfare of country 2, any bilateral trade agreement without tariff adjustment that benefits both country 1 and country 2 will also benefit country 3.

Proposition 5 supports the economic rationale of the MFN principle. With this rule, the GATT/WTO ensures that bilateral tariff negotiations make all countries weakly better off. This result renders the multilateral tariff negotiations in Ossa (2011) unnecessary. Nonetheless, Proposition 5 also suggests a free rider problem. Country 3 has an incentive to choose not to negotiate with country 1 because it can freely obtain access to country 1's market. According to Proposition 2, a bilateral trade agreement with a *flexible* third-country tariff adjustment can avoid this problem because negotiating countries can exactly compensate the welfare loss of the outside country.

Proposition 6. *In the basic model, a bilateral trade agreement under the MFN principle exists and satisfies*

$$\frac{\lambda_{21}}{\lambda_{22}}\left(1+\frac{B_3}{B_2}\right) \quad < \quad \frac{d\log\left(\tau_2\right)}{d\log\left(\tau_1\right)} < \frac{\lambda_{11}}{\lambda_{12}}.$$

Proof. See Appendix B. □

Proposition 6 ensures the existence of a bilateral trade agreement in which all countries are better off under the MFN principle. The range of $d\log\left(\tau_2\right)/d\log\left(\tau_1\right)$ is smaller than the condition in Proposition 2. This is because the MFN principle enforces country 1 to over-compensate for the welfare loss of country 3. Therefore, country 2 has to cut t_2 more to ensure that country 1 receives gains from the trade liberalization. The lower bound of $d\log\left(\tau_2\right)/d\log\left(\tau_1\right)$ increases. One interpretation is that the indifference curve of country 1 (IC_1) in figure 3 is steeper than it is in figure 1. Thus the MFN principle contracts the area between IC_1 and IC_2; it is more difficult to negotiate on tariffs when country 1 has to cut t_{31} at the same amount as it cuts t_{21}.

5 The Augmented Model

In this section, I extend the basic model in Section 2 in two dimensions. First, I add heterogeneity in transportation costs. Transportation costs depend on the origin and the destination. When a manufacturing firm in country i exports one unit of manufacturing goods to country j, it faces an iceberg transportation cost and must ship $\theta_{ij} > 1$ units of goods. Therefore, inverted effective trade barriers are slightly adapted to $B_{ij} = \left(\theta_{ij}\tau_{ij}\right)^{1-\sigma}$, $\forall i \neq j$ while $B_{ii} = 1$, $\forall i$. Second, bilateral trade flows between country 2 and country 3 exist. We can interpret the basic model as the special case when $\theta_{23} = \theta_{32} = \infty$.

Throughout this paper, I assume that $\left(\theta_{ij}\tau_{ij}\right) < \left(\theta_{ik}\tau_{ik}\right)\left(\theta_{kj}\tau_{kj}\right) < \infty, \forall i \neq j \neq k \in \{1,2,3\}$. This assumption means that the transportation costs of exporting from country i to country j are finite and are lower than the transportation costs of exporting from country i to country j via country k. In other words, there are no profitable arbitrage opportunities. Note that this assumption can be written as $B_{ij} - B_{ik}B_{kj} > 0$, which will appear frequently in this section.

5.1 Bilateral Trade Agreements

The generalized equilibrium conditions are shown in Appendix B. Without loss of generality, the following discussion provides the intuition for the effect of an increase in t_{21}. The derivatives of G_1, G_2, and G_3 with respect to t_{21} are

$$
\begin{aligned}
\frac{\partial G_1}{\partial t_{21}} &= -\frac{\left[B_{12} - B_{13}B_{32}\right] B_{21}}{\Omega}\frac{G_1}{\tau_{21}} < 0, \\
\frac{\partial G_2}{\partial t_{21}} &= \frac{\Phi_1\left[1 - B_{31}B_{13}\right] B_{21}}{\Omega\Phi_2}\frac{G_2}{\tau_{21}} > 0, \\
\frac{\partial G_3}{\partial t_{21}} &= -\frac{\Phi_1\left[B_{32} - B_{31}B_{12}\right] B_{21}}{\Omega\Phi_3}\frac{G_3}{\tau_{21}} < 0.
\end{aligned}
$$

The effects of an increase in t_{21} on the welfare of country 1 and country 2 are standard. Country 1 benefits from a stronger tariff protection while country 2 is worse off. The key difference is the effect of an increase in t_{21} on the welfare of country 3. According to Lemma 1 in the basic model (where country 2 and country 3 cannot trade with each other), a unilateral increase in the tariff of country 1 on country 2 hurts country 3. The assumption of zero bilateral trade flows between country 2 and country 3 ($\theta_{32} \to \infty$ and $\theta_{23} \to \infty$) automatically implies that $dG_3/dt_{21} > 0$. An increase in t_{21} strengthens the manufacturing firms in country 1, which is country 3's only export market; the manufacturing firms in country 3 face more competition and are worse off. The augmented model shows that the result is reversed. Once country 2 and country 3 are allowed to trade, country 3 benefits from facing the weakened manufacturing firms in country 2 despited tough competition against manufacturing firms in country 1.

Lemma 4 formalizes this finding.

Lemma 4. *In the augmented model, a unilateral increase in the tariff of country i on country j benefits country i and country k but hurts country j, for any $i \neq j \neq k$ such that $i, j, k \in \{1,2,3\}$.*

Proof. See Appendix B. □

Next I analyze a bilateral trade agreement without third-country tariff adjustments and summarize the result in Proposition 7.

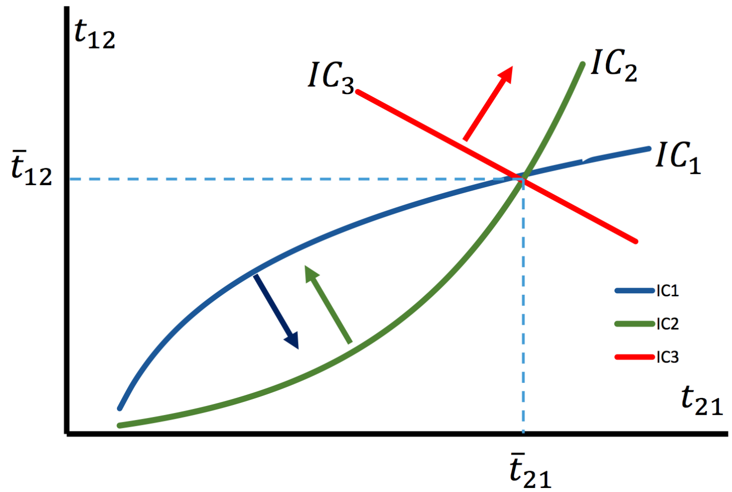


Figure 4: Bilateral trade agreements without third-country tariff adjustment.

Proposition 7. *In the augmented model, a bilateral trade agreement without third-country tariff adjustments that strictly improves the welfares of country 1 and country 2 satisfies*

$$\left(\frac{B_{12}-B_{13}B_{32}}{B_{12}-B_{12}B_{23}B_{32}}\right)\frac{\lambda_{21}}{\lambda_{22}}<\frac{dlog\left(\tau_{12}\right)}{dlog\left(\tau_{21}\right)}<\frac{\lambda_{11}}{\lambda_{12}}\left(\frac{B_{21}-B_{21}B_{13}B_{31}}{B_{21}-B_{23}B_{31}}\right).$$

Such an agreement always reduces the welfare of country 3.

Proof. See Appendix B. □

Proposition 7 shows that a bilateral trade agreement without third country tariff adjustments that preserves the welfare of country 3 does not exist. A bilateral trade agreement between country 1 and country 2 must hurt the welfare of country 3 because, according to Lemma 4, each tariff cut reduces country 3's welfare. This is in contrast to the result in Proposition 1. Because of the missing trade in the basic model, Proposition 1 shows that the welfare of country 3 can be non-decreasing if country 1 gains nothing. Proposition 7 concludes that in the augmented model, in which country 2 and country 3 are allowed to trade with each other, a bilateral trade agreement without third-country tariff adjustment always generates a negative externality to country 3 because country 3 receives additional externality through international trade with country 2.

Figure 4 shows the indifference curves of all countries that pass through the initial tariffs $\bar{t}_{21}$ and $\bar{t}_{12}$. The key difference between Figure 4 and Figure 1 is the slope of country 3's indifference curve. According to Lemma 1, in the basic model a unilateral increase in the tariff of country 1 on country 2 hurts country 3 but a unilateral increase in the tariff of country 2 on imports from country 1 benefits country 3. Therefore, the indifference curve of country 3 in Figure 1 is upward sloping. In contrast, Lemma 4 states that in the augmented model both a unilateral increase in the tariff of country 1 on country 2 and a unilateral increase in the tariff of country 1 on country 2 hurt country 3. Therefore, the indifference curve of country 3 in Figure 4 is downward sloping.

In Figure 4, country 1 prefers a new pair of tariffs that is to the right of IC_1 and country 2 wants a new pair that is to the left of IC_2. Thus the outcome of a bilateral trade agreement is in the area between IC_1 and IC_2. However, the new tariffs must be below IC_3. This implies that country 3 must be worse off from a bilateral trade agreement without third-country tariff adjustments as shown in Proposition 7.

Motivated by the welfare loss of country 3, I consider a situation in which t_{31} and t_{32} are additional instruments in a bilateral trade agreement. With more policy instruments, country 1 and country 2 can now compensate for the welfare loss of country 3. Proposition 8 summarizes the result.

Proposition 8. *In the augmented model, a bilateral trade agreement with third-country tariff adjustments which (i) keeps the welfare of country 3 unchanged and (ii) strictly improves the welfares of country 1 and country 2 exists and satisfies*

$$\frac{\lambda_{21}}{\lambda_{22}} < \frac{dlog\left(\tau_{12}\right)}{dlog\left(\tau_{21}\right)} < \frac{\lambda_{11}}{\lambda_{12}}, \tag{13}$$

and

$$\lambda_{31}dlog\left(\tau_{31}\right) + \lambda_{32}dlog\left(\tau_{32}\right) = \frac{\left[B_{32} - B_{31}B_{12}\right]}{\left[1 - B_{12}B_{21}\right]}\lambda_{21}dlog\left(\tau_{21}\right) + \frac{\left[B_{31} - B_{32}B_{21}\right]}{\left[1 - B_{12}B_{21}\right]}\lambda_{12}dlog\left(\tau_{12}\right). \tag{14}$$

Proof. See Appendix B. □

The main finding of Proposition 8 is that an adjustment of t_{31} and t_{32} allows a bilateral trade agreement to improve the two negotiating countries' welfare without hurting country 3's welfare. Without a third-country tariff adjustment ($dt_{31} = dt_{32} = 0$), all bilateral trade agreements hurt the welfare of country 3 because there are no $dt_{31} < 0$ and $dt_{32} < 0$ that satisfy the condition in equation (14). This is consistent with the conclusion in Proposition 7. With a third-country tariff adjustment, country 1 and country 2 can compensate for the welfare loss of country 3 by reducing t_{31} and t_{32} according to equation (14). Therefore, the welfare of country 3 is preserved and country 1 and country 2 gain from the bilateral trade agreement.

Figure 5 graphically explains the idea behind Proposition 8. Suppose that country 1 and country 2 are negotiating a trade agreement that bilaterally cuts their tariffs from $\left(\bar{t}_{21}, \bar{t}_{12}\right)$ to point B. Country 3 is worse off from a bilateral trade agreement without third-country tariff adjustments because point B is below IC_3. Proposition 8 suggests that country 1 and country 2 can reduce t_{31} and t_{32} to compensate for the welfare loss of country 3. The third-country tariff adjustment shifts the indifference curve of country 3 from IC_3 to IC_3' which passes through point B. Therefore the welfare of country 3 is unaffected by a bilateral trade agreement with third-country tariff adjustment and county 1 and country 2 are better off.[2]

[2]To be precise, the third-country tariff adjustment should also shift IC_1 and IC_2 because country 1 and country 2 are worse off from the compensation. However, the welfare loss can be negligible and the negotiating countries can choose t_{31} and t_{32} in a way that point B is still a Pareto improvement. Thus, I eliminate extra curves from Figure 5 to avoid confusion that may arise.

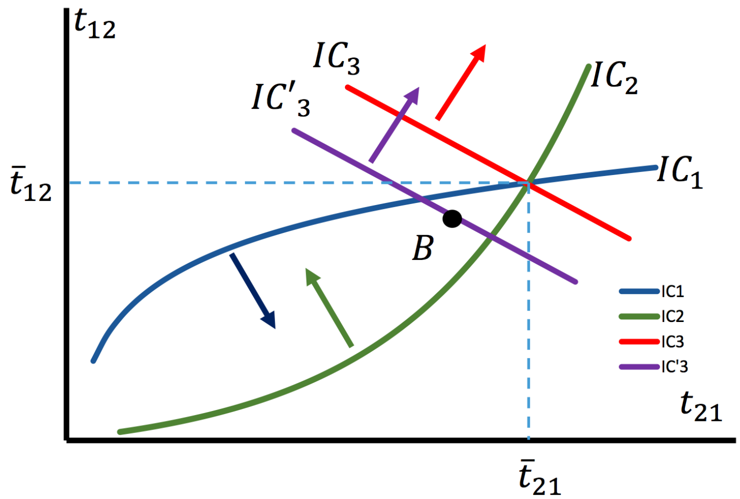


Figure 5: A set of Pareto-improving bilateral trade agreements with third-country tariff adjustment.

5.2 The MFN Principle In The Augmented Model

Under the MFN principle, each country must set the same import tax rate on every trading partner. The subscript on t_{ij} is simplified to t_j, which refers to the MFN import tax rate imposed by country j. However, because of potentially different iceberg transportation costs, the inverted effective trade barrier $B_{ij} = \left(\theta_{ij}\tau_j\right)^{1-\sigma}$ may not be identical across all origins.

The equilibrium conditions are as same as the conditions in Section 5.1. However, the impacts of a tariff reduction are different because the MFN principle requires equal tariff reductions among all trading partners. Without loss of generality, I show only the impacts of a decrease in t_1:

$$
\begin{aligned}
\frac{\partial G_1}{\partial t_1} &= -\frac{\left[B_{12} - B_{13}B_{32}\right]B_{21} + \left[B_{13} - B_{12}B_{23}\right]B_{31}}{\Omega}\frac{G_1}{\tau_1} < 0, \\
\frac{\partial G_2}{\partial t_1} &= \frac{\Phi_1\left[B_{21} - B_{23}B_{31}\right]}{\Omega\Phi_2}\frac{G_2}{\tau_1} > 0, \\
\frac{\partial G_3}{\partial t_1} &= \frac{\Phi_1\left[B_{31} - B_{32}B_{21}\right]}{\Omega\Phi_3}\frac{G_3}{\tau_1} > 0,
\end{aligned}
$$

The main difference between these derivatives and those in Section 4 comes from the positive international trade flow between country 2 and country 3. A tariff cut always hurts the country itself but benefits every trading partner due to the MFN principle.

When the MFN principle is not enforced, a decrease in t_1 hurts the welfare of country 3, but when the MFN principle is enforced, a decrease in t_1 improves the welfare of country 3. This is because the MFN principle eliminates the tariff advantage that country 2 is granted. Country 3 benefits from larger market access to country 1 although it faces more competition from manufacturing firms in country 2.

Welfare changes from a bilateral trade agreement under the MFN principle are summarized in the following proposition.

Proposition 9. *In the augmented model, the MFN principle guarantees that any bilateral trade agreement is always a Pareto improvement.*

Proof. See Appendix B. □

Proposition 9 confirms that the finding in Proposition 5 holds in the augmented model; whenever country 1 and country 2 agree on a bilateral trade agreement, country 3 always gains from the agreement although it is not involved in the negotiation. Thus, the outside countries can be free riders.

Proposition 10. *In the presence of the MFN principle, country 3 always acts as a free rider.*

Proof. From proposition 5 and proposition 9. □

This result is consistent with the idea of Schwartz and Sykes (1996) and contradicts the goals of the GATT/WTO. The MFN principle, which is designed to reduce negotiation costs, provides the wrong incentives to member countries. To overcome this free rider problem, a bilateral trade agreement must be flexible like those shown in Proposition 2 and Proposition 8; negotiating countries must compensate outside countries just enough to cover the welfare loss from the agreement.

Note that Proposition 9 does not conclude that a Pareto-improving bilateral trade agreement exists. It only says that if a bilateral trade negotiation under the MFN principle exists, the outside country is not worse off. Therefore, to characterize the set of Pareto improving bilateral trade agreements, it is sufficient to focus on bilateral trade agreements that benefit both country 1 and country 2.

Next, I characterize the bilateral trade agreements between country 1 and country 2 under the MFN principle.

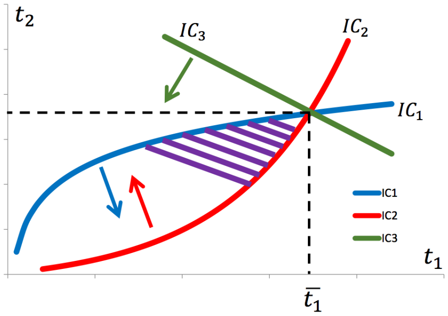
Proposition 11. *In the augmented model, a bilateral trade agreement under the MFN principle satisfies*

$$\frac{\lambda_{21}}{\lambda_{22}}\left(1+\frac{B_{31}\left(B_{13}-B_{12}B_{23}\right)}{B_{21}\left(B_{12}-B_{13}B_{32}\right)}\right) \quad < \quad \frac{dlog\left(\tau_{2}\right)}{dlog\left(\tau_{1}\right)} < \frac{\lambda_{11}}{\lambda_{12}}\left(\frac{1}{1+\frac{B_{32}\left(B_{23}-B_{21}B_{13}\right)}{B_{12}\left(B_{21}-B_{23}B_{31}\right)}}\right),$$

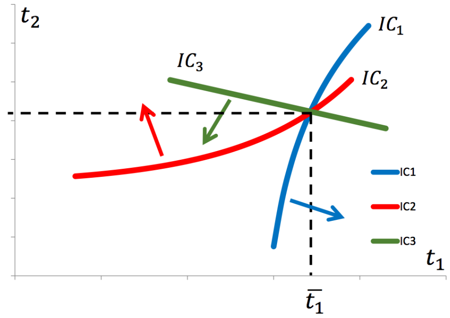
and exists only if $B_{13}+B_{23}<1$.

Proof. See Appendix B. □

Proposition 11 shows the parameter restrictions for the existence of a bilateral trade agreement under the MFN principle. The condition in Proposition 11 differs from the condition in Proposition 8 in three ways. First, the MFN principle requires $d\log\left(\tau_{31}\right) = d\log\left(\tau_{21}\right)$ and $d\log\left(\tau_{32}\right) = d\log\left(\tau_{12}\right)$, which are too strong; negotiating countries overcompensate country 3. As a result, country 3 is better off. Second, the set of potential Pareto improving trade agreements is smaller because the upper bound and the lower bound of $dlog\left(\tau_{2}\right)/dlog\left(\tau_{1}\right)$ decreases and increases, respectively. This can be seen from the following inequalities:



6-A: $B_{13} + B_{23} < 1$



6-B: $B_{13} + B_{23} > 1$

Figure 6: A set of Pareto-improving bilateral trade agreements under the MFN principle.

$$\frac{\lambda_{21}}{\lambda_{22}} < \frac{\lambda_{21}}{\lambda_{22}}\left(1 + \frac{B_{31}\left(B_{13} - B_{12}B_{23}\right)}{B_{21}\left(B_{12} - B_{13}B_{32}\right)}\right) \text{ and } \frac{\lambda_{11}}{\lambda_{12}}\left(\frac{1}{1 + \frac{B_{32}(B_{23} - B_{21}B_{13})}{B_{12}(B_{21} - B_{23}B_{31})}}\right) < \frac{\lambda_{11}}{\lambda_{12}}$$

That is, some possible Pareto-improving trade agreements are no longer feasible because one of the negotiating countries does not receive enough welfare gains to cover the welfare loss from cutting its tariff against country 3.

Third, the MFN principle is sometimes too restrictive. Pareto-improving bilateral trade agreements might not exist, because welfare gains from trade agreements are not large enough to cover the welfare losses from MFN tariff cuts. The condition $B_{13} + B_{23} < 1$ means that the MFN principle makes country 1 and country 2 more vulnerable from competition with manufacturing firms in country 3 if country 3 is their large exporting market. While the trade agreement stimulates international trade between country 1 and country 2, the MFN principle allows country 3 to access both country 1's and country 2's domestic markets. The manufacturing sector in country 3 expands and manufacturing firms in country 1 and country 2 face more competition for exporting to country 3. However, this welfare loss in country 1 and country 2 is negligible if exports to country 3 are initially small.

Figure 6 shows a set of bilateral tariff changes under the MFN principle. Again, any point on the right of IC_1 improves the welfare of country 1, any point above IC_2 benefits country 2, and any point below IC_3 benefits country 3. This suggest a free rider problem when an outside country does nothing and expects to get a positive externality from the bilateral trade negotiations of other countries. The question of whether a bilateral trade agreement is profitable for the negotiating countries or not depends on the slope of each indifference curve. The MFN principle changes the slopes of IC_1 and IC_2 because the MFN principle forces the negotiating countries to overcompensate for the welfare loss of country 3. IC_1 becomes steeper because country 1 requires a larger reduction in t_{12} to cover an additional welfare loss from reducing its own protections against country 3. IC_2 also becomes flatter analogously.

Figure 6-A shows a case where $B_{13} + B_{23} < 1$. In this case, a bilateral trade agreement is

possible because there is a shaded area in which both country 1 and country 2 are made better off. However, the MFN principle sometimes unnecessarily restricts the options of the negotiating countries and impedes a beneficial agreement. The later scenario is shown in Figure 6-B where the MFN principle changes the slopes of IC_1 and IC_2 such that a bilateral trade agreement that benefits country 1 and country 2 does not exist. That is, MFN potentially blocks some possible Pareto improving bilateral trade agreements.

Corollary 2. *The MFN principle has been effective in the past but it may prevent further tariff negotiaions.*

Corollary 2 suggests that in the past when tariffs were generally high the condition in Proposition 8 likely holds. Therefore, countries were interested in negotiating tariff reductions. However, because current tariffs are generally low, the condition in Proposition 8 likely is violated and the MFN principle may eliminate Pareto improving trade agreements.

Assuming that $\theta_{13} = \theta_{23} = \theta_3$, the condition $B_{13} + B_{23} < 1$ is equivalent to $\theta_3\tau_3 > 1.21$ for $\sigma = 4.6$ (Bernard, Eaton, Jensen, & Kortum, 2003) and $\theta_3\tau_3 > 1.08$ for $\sigma = 9.28$ (Eaton & Kortum, 2002). The prediction is confirmed by counterfactual exercises in Section 6. This provides one reason why countries may prefer free trade agreements (FTAs): the MFN principle is too strong.

Corollary 3. *Free trade agreements (FTAs) are more desirable than bilateral trade agreements under the MFN principle.*

6 Quantitative Results

This section quantifies the welfare changes from three counterfactual exercises: (i) a bilateral trade agreement without third-country tariff adjustments, (ii) a bilateral trade agreement under the MFN principle, and (iii) moving to global free trade. The exercises support three main predictions. First, a bilateral trade agreement without a third country tariff adjustment hurts third party countries. Second, the MFN principle ensures that a bilateral trade agreement weakly improves the welfare of third party countries, but negotiating countries may be worse off. Third, a bilateral trade agreement under the MFN principle can improve the welfare of all countries when tariffs are sufficiently high, but the MFN principle hurts the negotiating countries when tariffs are small. I derive the indifference curves predicted by the model and quantify welfare gains from moving to global free trade.

Methodology

This calibration uses the technique from Dekle et al. (2007), which allows me to generalize the model in several ways. First, following Ossa (2011), I generalize the number of countries in the model to seven (groups of) countries and allow them to trade with every other country. Using data from Dekle et al. (2007), countries are aggregated into seven groups: the European Union (EU), Brazil, China (and Hong Kong), India, Japan, the United States, and the rest of the world (ROW).

These countries are selected because they are the main players in recent trade negotiations; in addition, this categorization matches that in Ossa (2011). Second, I relax the identical production technology and identical transportation cost assumptions. The cost functions can have either a different marginal cost or a different fixed cost, and transportation costs can be asymmetric. Third, I include trade imbalances and tariff revenues. Therefore, the quantitative results can capture the income effect due to the existence of tariff revenues, which are absent in the theoretical model.

Given parameter values, import tax rates τ_{ij}, and trade imbalances, the equilibrium manufacturing prices indices, the equilibrium number of manufacturing firms, and the equilibrium aggregate income from the system of equations are given by

$$G_j = \left[\sum_{i=1}^{7} n_i \left(p_i \theta_{ij} \tau_{ij}\right)^{1-\sigma}\right]^{\frac{1}{1-\sigma}}, \tag{15}$$

$$q_i = \sum_{i=1}^{7} p_i^{-\sigma} \theta_{ij}^{1-\sigma} \tau_{ij}^{-\sigma} G_j^{\sigma-1} \mu X_j, \tag{16}$$

$$X_j = w_j L_j - TB_j + \sum_{i=1}^{7} t_{ij} n_i \left(p_i \theta_{ij}\right)^{1-\sigma} \tau_{ij}^{-\sigma} G_j^{\sigma-1} \mu X_j. \tag{17}$$

Equation (15) illustrates generalized manufacturing price indices when all seven countries can trade with every other country. Note that $\theta_{ii} = 1$ and $\tau_{ii} = 1$ for $i = 1, 2, ..., 7$. Equation (16) summarizes the extended market clearing conditions. Equation (17) denotes a generalized identity of total expenditures in country j by introducing a trade imbalance and tariff revenue.

Following the method of Dekle et al. (2007), I create changes of variables by comparing the initial equilibrium and a counterfactual equilibrium. For a variable z in the initial equilibrium, I define z' as the value of z in a counterfactual equilibrium and define $\hat{z} \equiv z'/z$. Using the new notation, the system of equations (15)-(17) are re-written as

$$\widehat{G}_j = \left[\sum_{i=1}^{7} a_{ij} \widehat{n}_i \left(\widehat{\tau}_{ij}\right)^{1-\sigma}\right]^{\frac{1}{1-\sigma}}, \tag{18}$$

$$1 = \sum_{j=1}^{7} b_{ij} \widehat{\tau}_{ij}^{-\sigma} \widehat{G}_j^{\sigma-1} \widehat{X}_j, \tag{19}$$

$$\widehat{X}_j = \gamma_j + \sum_{i=1}^{7} d_{ij} t'_{ij} \widehat{n}_i \widehat{\tau}_{ij}^{-\sigma} \widehat{G}_j^{\sigma-1} \widehat{X}_j, \tag{20}$$

where a_{ij} denotes the fraction of the total expenditures on manufacturing goods by country j that is spent on imported manufacturing goods from country i, b_{ij} denotes the fraction of the total value of manufacturing goods from country i that is consumed by country j, γ_j denotes the fraction of the total income of country i that is not from tariff revenue, and d_{ij} denotes the fraction of pre-tax

Table 1: Aggregated trade matrix.

	ROW	EU	Brazil	China	India	Japan	USA
ROW	3907.4	551.6	15.1	434.4	20.4	91.2	550.8
EU	656.9	6372.9	14.3	83.6	16.9	48.3	235.9
Brazil	24.1	9.3	314.6	2.1	0.3	1.0	16.4
China	349.7	161.6	3.9	801.7	7.0	82.4	212.2
India	18.6	17.3	0.4	6.2	387.0	1.4	14.6
Japan	191.8	96.1	2.9	123.1	2.9	3074.1	128.4
USA	390.4	177.4	10.7	45.6	5.5	44.0	5201.3

Table 2: Aggregated tariff matrix.

	ROW	EU	Brazil	China	India	Japan	USA
ROW	0	2.5	12.7	4.2	14.8	1.3	2.2
EU	7.0	0	12.7	4.2	14.8	1.3	2.2
Brazil	7.0	2.5	0	4.2	14.8	1.3	2.2
China	7.0	2.5	12.7	0	14.8	1.3	2.2
India	7.0	2.5	12.7	4.2	0	1.3	2.2
Japan	7.0	2.5	12.7	4.2	14.8	0	2.2
USA	7.0	2.5	12.7	4.2	14.8	1.3	0

expenditure on imports from country i in the total expenditure of country j.[3]

Data on actual tariffs and aggregate trade flows in 2004 are shown in Tables 1 and 2. Parameter values are the same as those in Ossa (2001). Following Eaton and Kortum (2002), I choose an elasticity of substitution $\sigma = 9.28$ and an expenditure share of manufacturing goods $\mu = 0.188$. An alternative value of the elasticity of substitution $\sigma = 4.60$ is chosen according to Bernard, Eaton, Jensen, and Kortum (2003).

The three counterfactual experiments focus on tariff negotiations between Europe and the USA because they have the largest bilateral trade flows among the all possible pairs of countries. First, I consider a standard trade agreement when Europe and the USA reciprocally cut $\tau_{EU,USA}$ and $\tau_{USA,EU}$ by one percent. This cut satisfies the condition in Proposition 8. The model predicts that both Europe and the USA should be better off while other countries may be worse off. Second,

[3]Formal algebraic definitions are included in Appendix A

Table 3: Predicted Nash tariffs with $\sigma = 9.28$ from Ossa (2011)

	ROW	EU	Brazil	China	India	Japan	USA
ROW	0	13.0	12.1	11.6	12.0	12.4	12.4
EU	11.0	0	12.1	11.9	12.0	12.1	12.0
Brazil	11.6	12.5	0	12.0	12.1	12.2	12.3
China	10.3	11.5	12.0	0	12.0	12.5	10.9
India	12.2	12.5	12.1	12.0	0	12.1	12.1
Japan	11.3	12.0	12.1	11.6	12.1	0	11.9
USA	11.4	12.1	12.1	12.0	12.1	12.1	0

Table 4: Predicted Nash tariffs with $\sigma = 4.6$ from Ossa (2011)

	ROW	EU	Brazil	China	India	Japan	USA
ROW	0	28.7	27.8	26.2	27.7	28.3	27.8
EU	26.3	0	27.7	27.6	27.78	27.8	27.7
Brazil	26.7	28.2	0	27.6	27.8	27.9	27.8
China	28.4	26.9	27.7	0	27.7	28.9	25.6
India	27.5	28.0	27.8	27.5	0	27.8	27.6
Japan	26.3	27.5	27.8	26.9	27.8	0	27.5
USA	27.0	27.8	27.8	27.8	27.8	27.9	0

I quantify the effect of the MFN principle when Europe and the USA reduce their tariffs against all other countries by one percent. The model predicts that the MFN principle increases the welfare of all other countries (Proposition 9) but may decrease the welfare of Europe and the USA (Proposition 11).

The last experiment evaluates welfare changes that would occur if the world economy were to move from its existing tariffs to global free trade. There is a possibility that some countries may be hurt by moving to free trade; therefore, these countries may not willing to implement free trade. This situation possibly occurs when current tariffs are sufficiently asymmetric. In this case, bilateral reciprocal trade agreements may be insufficient to bring the world economy to a free trade.

For each experiment, I start with the existing tariffs in 2004 from Dekle et al. (2007) (given in Table 2) and two values of the elasticity of substitution: 9.28 from Eaton and Kortum (2002) and 4.6 from Bernard et al. (2003). Then I perform a robustness check by using the predicted Nash tariffs provided by Ossa (2011). The predicted Nash tariffs from Ossa (2011) depend on the elasticity of substitution; the Nash tariffs corresponding to $\sigma = 9.28$ are shown in Table 3 and the Nash tariffs corresponding to $\sigma = 4.6$ are shown in Table 4. Tables of results are in Appendix A.

Counterfactual Experiment 1 : Bilateral Trade Agreement without Third-Country Tariff Adjustments

The first experiment quantifies the effects of a bilateral trade agreement between Europe and the USA. The experiment tests the conclusion of Proposition 7: a bilateral trade agreement without third-country tariff adjustments always reduces the welfare of the outside countries. To test this hypothesis, I consider a case when Europe and the USA bilaterally reduce tariffs by one percent so that $\triangle \log (\tau_{EU,USA}) = \triangle \log (\tau_{USA,EU}) = -0.01$. The result is shown in Table 5 in Appendix.

The results from the first counterfactual experiment support Proposition 7. A large reduction in price levels for Europe and the USA dominates the drop in income. As a result, Europe and the USA experience welfare gains from the bilateral trade agreement without third-country tariff adjustments. The result is true for all four combinations of the starting tariffs and the elasticity of substitution. As highlighted by Ossa (2011), the main mechanism of the New Trade Model is a firm-delocation effect. In all cases except the case of Nash tariffs with $\sigma = 4.6$, the trade agreement expands the manufacturing sector in both countries. Therefore, other trading partners (especially China and ROW) which trade mostly with Europe and the USA face tough competition against the manufacturing firms in Europe and the USA and experience welfare losses.

Counterfactual Experiment 2: Bilateral Trade Agreement under the MFN principle

Now I study the effect of the MFN principle by testing the model predictions in Proposition 9 and Proposition 11. First, Proposition 9 shows that any bilateral trade agreements under the MFN principle must increase the welfare of all outside countries. Second, according to Proposition 11, a bilateral trade agreement under the MFN principle exists if other countries' tariffs are generally high, and it may not exist if other countries' tariffs are sufficiently low. To be precise, a bilateral trade agreement under the MFN principle improves the welfare of Europe and the USA if $B_{USA,j} + B_{EU,j}$ for every outside country j is sufficiently low.

I quantify the impact of a bilateral trade agreement between Europe and the USA when the MFN principle is enforced. In other words, I consider a case when Europe and the USA reduce their tariffs against all their trading partners by one percent so that $\triangle \log(\tau_{i,USA}) = \triangle \log(\tau_{i,EU}) = -0.01$ for all exporters in country i. Table 6 summarizes the numerical results.

The results support both model predictions. In all cases, the trade agreement improves the welfare of all outside countries through an expansion of the manufacturing sector and a lower price index, especially China and ROW, who are big exporters to Europe and the USA. This is consistent with the intension of the MFN principle. The GATT/WTO want to ensure that outside countries need not be concerned about negotiating bilateral trade agreements with trading partners. But since outside countries freely gain from bilateral trade agreements they have fewer incentives to negotiate, which creates a free rider problem.

The welfare change of negotiating countries is ambiguous. Europe and the USA have welfare gains when the starting tariffs are the (relatively low) actual tariffs in 2004 but have welfare losses when the starting tariffs are the (relatively high) Nash tariffs from Ossa (2011). Starting at the actual tariffs, the reduction in tariff revenue and strong competition from foreign firms outweigh the benefits of the price level. The result is consistent with the condition in Proposition 11: MFN has been effective in the past when tariffs were high, but it may prevent further tariff negotiations because tariffs have decreased in recent decades.

Counterfactual experiment 3: Moving to Global Free Trade

In the last counterfactual experiment, I measure the impacts of moving the world economy in 2004 to a global free trade economy. When the free trade economy is implemented, China becomes the biggest exporter in the manufacturing sector. The firm-delocation effect is relatively large when σ is high. The manufacturing firms in Brazil, India, and ROW face a large contraction in the manufacturing sector while China and Europe have a large expansion in the manufacturing sector. As a result, Brazil, India, and ROW have welfare losses equal to -0.14%, -0.22%, and -0.3% respectively for $\sigma = 9.28$, and -0.15%, -0.23%, and -0.26% respectively for $\sigma = 4.6$.

7 Conclusion

This paper extended Ossa (2011) by considering a more general class of tariff changes. In contrast to Ossa (2011), it shows the existence of bilateral reciprocal trade agreements that improve the welfare of negotiating countries without hurting other countries. The key feature of this model is a firm-delocation effect among countries. A bilateral trade agreement can preserve welfare of the outside country if the trade agreement causes firm-delocation effects such that the outside country is indifferent. However, the firm-delocation effects from the this trade agreement cause country 1 to be indifferent as well. Country 1 and country 2 can both strictly gain from a bilateral trade agreement without hurting country 3 by using an additional instrument, country 1's tariff against country 3. The third-country tariff adjustment exactly compensates for the welfare loss of country 3 and allows for flexibility between country 1 and country 2 to divide gains from a bilateral trade agreement.

This paper then studied the MFN principle and show that the MFN principle is a simple rule that protects the outside country from a bilateral trade agreement. The MFN principle mimics the third-country tariff adjustment, but it over-compensates for the welfare loss of the outside country and makes the outside country better off. This suggests a free-rider problem.

I introduce an augmented model in which country 2 and country 3 are allowed to trade with each other. In the generalized model, a bilateral trade agreement without third-country tariff adjustments always hurts the outside country. Third-country tariff adjustments are needed to compensate welfare loss of the outside country. Again, the MFN principle provides additional gains to the outside country and causes a free-rider problem.

I quantify welfare changes from different tariff negotiations: (i) a bilateral trade agreement without third-country tariff adjustments, (ii) a bilateral trade agreement under the MFN principle, and (iii) moving to global free trade. The results support model predictions.

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A Appendix: Quantitative Results

Definitions of Parameters

- $T_{ij} \equiv N_i q_{ij}$: the total value of manufacturing goods that country i exports to country j
- $S_j \equiv \sum_{i=1}^{7} T_{ij}$: the total value of manufacturing goods are produced in country i
- $X_j \equiv \frac{1}{\mu} \sum_{i=1}^{7} \tau_{ij} T_{ij}$: total expenditure of consumers in country j
- $R_j \equiv \sum_{i=1}^{7} t_{ij} T_{ij}$: tariff revenue of country j
- $a_{ij} \equiv \frac{\tau_{ij} T_{ij}}{\mu X_j}$: a fraction of total expenditure on manufacturing goods of country j that is spent in imported manufacturing goods from country i
- $b_{ij} \equiv \frac{T_{ij}}{S_i}$: a fraction of total value of manufacturing goods from country i that are exported to country j
- $\gamma_j \equiv \frac{X_j - R_j}{X_j}$: a fraction of total income of country i that is not from tariff revenue
- $d_{ij} \equiv \frac{T_{ij}}{X_i}$: a fraction of pre-tax expenditure on imports from country i in total expenditure of country j.

			ROW	EU	Brazil	China	India	Japan	USA
Actual tariffs	$\sigma = 9.28$	$\%\triangle log$ (Income)	0.00045	-0.00425	0.00006	0.00020	0.00002	-0.00001	-0.00658
		$\%\triangle log$ (Price level)	0.00994	-0.04290	0.00246	0.01459	0.00270	0.00179	-0.03881
		$\%\triangle log$ (Number of firms)	-0.16534	0.18287	-0.02359	-0.17165	-0.02330	-0.01041	0.00595
		$\%\triangle log$ (Welfare)	-0.00142	0.00382	-0.00041	-0.00254	-0.00049	-0.00035	0.00072
	$\sigma = 4.6$	$\%\triangle log$ (Income)	0.00025	-0.00443	0.00005	0.00010	0.00002	0.00000	-0.00685
		$\%\triangle log$ (Price level)	0.01108	-0.04713	0.00274	0.01628	0.00301	0.00200	-0.04223
		$\%\triangle log$ (Number of firms)	-0.06974	0.10025	-0.01253	-0.08334	-0.01193	-0.00539	0.02246
		$\%\triangle log$ (Welfare)	-0.00183	0.00443	-0.00047	-0.00296	-0.00054	-0.00038	0.00109
Nash tariffs	$\sigma = 9.28$	$\%\triangle log$ (Income)	0.00065	-0.00168	0.00003	0.00055	0.00000	-0.00011	-0.00194
		$\%\triangle log$ (Price level)	0.00992	-0.04321	0.00247	0.01455	0.00271	0.00180	-0.03937
		$\%\triangle log$ (Number of firms)	-0.13199	0.17054	-0.02221	-0.17394	-0.02247	-0.00945	-0.01821
		$\%\triangle log$ (Welfare)	-0.00121	0.00645	-0.00043	-0.00219	-0.00051	-0.00045	0.00546
	$\sigma = 4.6$	$\%\triangle log$ (Income)	0.00074	-0.00168	0.00004	0.00055	0.00000	-0.00012	-0.00186
		$\%\triangle log$ (Price level)	0.01095	-0.04790	0.00274	0.01615	0.00302	0.00203	-0.04362
		$\%\triangle log$ (Number of firms)	-0.06818	0.08733	-0.01110	-0.08572	-0.01095	-0.00426	-0.00305
		$\%\triangle log$ (Welfare)	-0.00132	0.00733	-0.00047	-0.00249	-0.00056	-0.00050	0.00634

Table 5: The impacts of a bilateral trade agreement between Europe and USA without third-country tariff adjustments.

			ROW	EU	Brazil	China	India	Japan	USA
Actual tariffs	$\sigma = 9.28$	$\%\triangle log$ (Income)	-0.00945	-0.02170	-0.00035	-0.00585	0.00193	0.00032	-0.02997
		$\%\triangle log$ (Price level)	-0.28336	-0.00527	-0.07092	-0.42116	-0.07632	-0.05107	-0.01093
		$\%\triangle log$ (Number of firms)	3.51163	1.77736	0.60862	5.07217	0.54186	0.28116	-2.42875
		$\%\triangle log$ (Welfare)	0.04390	-0.02070	0.01299	0.07352	0.01628	0.00992	-0.02792
	$\sigma = 4.6$	$\%\triangle log$ (Income)	-0.00440	-0.02412	-0.00007	-0.00271	0.00099	0.00015	-0.03252
		$\%\triangle log$ (Price level)	-0.31368	-0.00210	-0.07890	-0.46477	-0.08488	-0.05682	-0.00716
		$\%\triangle log$ (Number of firms)	1.65928	-0.78100	0.28846	2.40550	0.25906	0.13542	-1.06484
		$\%\triangle log$ (Welfare)	0.05468	-0.02373	0.01477	0.08481	0.01695	0.01084	-0.03117
Nash tariffs	$\sigma = 9.28$	$\%\triangle log$ (Income)	-0.01545	0.00696	-0.00052	-0.01650	0.00149	0.00307	0.00664
		$\%\triangle log$ (Price level)	-0.27988	-0.00893	-0.07084	-0.42576	-0.07605	-0.05141	-0.01549
		$\%\triangle log$ (Number of firms)	3.54384	-1.91644	0.61780	5.27282	0.54569	0.26680	-2.62823
		$\%\triangle log$ (Welfare)	0.03725	0.00864	0.01280	0.06373	0.01580	0.01274	0.00955
	$\sigma = 4.6$	$\%\triangle log$ (Income)	-0.01659	0.00765	-0.00051	-0.01674	0.00172	0.00345	0.00813
		$\%\triangle log$ (Price level)	-0.30778	-0.01106	-0.07872	-0.46998	-0.08500	-0.05772	-0.01855
		$\%\triangle log$ (Number of firms)	1.76591	-0.94655	0.29885	2.57389	0.25685	0.11767	-1.29589
		$\%\triangle log$ (Welfare)	0.04136	0.00973	0.01430	0.07185	0.01771	0.01431	0.01162

Table 6: The impacts of a bilateral trade agreement between Europe and USA under the MFN principle.

		ROW	EU	Brazil	China	India	Japan	USA
Actual Tariffs $\sigma = 9.28$	$\%\triangle log$ (Income)	-0.37980	-0.06426	-0.30696	-0.35964	-0.32928	-0.01960	-0.07503
	$\%\triangle log$ (Price level)	-0.42368	-1.20645	-0.88602	-6.93482	-0.56333	-0.69460	-0.86327
	$\%\triangle log$ (Number of firms)	-59.26999	9.80425	-18.90975	163.23344	-29.15743	2.30616	3.73382
	$\%\triangle log$ (Welfare)	-0.30025	0.16405	-0.14002	0.99579	-0.22337	0.11150	0.08798
Actual Tariffs $\sigma = 4.6$	$\%\triangle log$ (Income)	-0.37980	-0.06426	-0.30696	-0.35964	-0.32928	-0.01960	-0.07503
	$\%\triangle log$ (Price level)	-0.62309	-1.12026	-0.81479	-5.66222	-0.53547	-0.73566	-0.81226
	$\%\triangle log$ (Number of firms)	-14.84837	3.58566	-5.60787	38.93716	-8.06711	1.79276	1.60107
	$\%\triangle log$ (Welfare)	-0.26267	0.14763	-0.15351	0.73824	-0.22863	0.11929	0.07830

Table 7: The impacts of moving to free trade.

B Appendix: Proofs

Proof of Lemma 1.

Lemma 1. Welfare : A unilateral increase in the tariff of country 1 on country 2 improves country 1's welfare but hurts country 2 and 3. A unilateral increase in the tariff of country 2 on imports from country 1 improves the welfare of country 2 and country 3 but hurts the welfare of country 1.

Proof. Using equations (7), (8), and (9), the derivatives of G_1, G_2, and G_3 with respect to t_{12} and t_{21} are

$$
\begin{aligned}
\frac{\partial log G_1}{\partial log\left(\tau_{21}\right)} &= -\frac{B_{12}B_{21}}{\Omega} < 0 \\
\frac{\partial log G_1}{\partial log\left(\tau_{12}\right)} &= \frac{\Phi_2 B_{12}}{\Omega\Phi_1} > 0 \\
\frac{\partial log G_2}{\partial log\left(\tau_{21}\right)} &= \frac{\Phi_1\left[1-B_{13}B_{31}\right]B_{21}}{\Omega\Phi_2} > 0 \\
\frac{\partial log G_2}{\partial log\left(\tau_{12}\right)} &= -\frac{B_{21}B_{12}}{\Omega} < 0 \\
\frac{\partial log G_3}{\partial log\left(\tau_{21}\right)} &= \frac{\Phi_1 B_{12}B_{31}B_{21}}{\Omega\Phi_3} > 0 \\
\frac{\partial log G_3}{\partial log\left(\tau_{12}\right)} &= -\frac{\Phi_2 B_{31}B_{12}}{\Omega\Phi_3} < 0
\end{aligned}
$$

□

Proof of Lemma 2.

Lemma 2 Firm-delocation effect : A unilateral increase in the tariff of country 1 on country 2 delocates manufacturing firms in country 2 and 3 to country 1. A unilateral increase in the tariff of country 2 on imports from country 1 delocates manufacturing firms in country 1 to country 2 and 3.

Proof. The production relocation effects from a trade agreement are given by derivatives of equations (10), (11) and (12) with respect to t_{12} and t_{21}.

$$
\begin{aligned}
\frac{dn_1}{dt_{21}} &= \frac{(\sigma-1)\mu}{qp}\left[\frac{(1-B_{13}B_{31})L_2}{\Phi_2^2}-\frac{B_{31}B_{12}L_3}{\Phi_3^2}\right]\frac{B_{21}}{\tau_{21}}>0\\
\frac{dn_2}{dt_{21}} &= \frac{-(\sigma-1)\mu}{qp}\left[\frac{(1-B_{13})(1-B_{13}B_{31})L_2}{\Phi_2^2}+\frac{B_{12}^2B_{31}L_3}{\Phi_3^2}\right]\frac{B_{21}}{\tau_{21}}<0\\
\frac{dn_3}{dt_{21}} &= \frac{-(\sigma-1)\mu}{qp}\left[\frac{B_{13}(1-B_{13}B_{31})L_2}{\Phi_2^2}+\frac{(1-B_{12})B_{31}B_{12}L_3}{\Phi_3^2}\right]\frac{B_{21}}{\tau_{21}}<0\\
\frac{dn_1}{dt_{12}} &= \frac{-(\sigma-1)\mu}{qp}\left[\frac{L_1}{\Phi_1^2}-\frac{(B_{21}-B_{31})B_{31}L_3}{\Phi_3^2}\right]\frac{B_{12}}{\tau_{12}}<0\\
\frac{dn_2}{dt_{12}} &= \frac{(\sigma-1)\mu}{qp}\left[\frac{(1-B_{13})L_1}{\Phi_1^2}-\frac{(1-B_{31})B_{31}L_3}{\Phi_3^2}\right]\frac{B_{12}}{\tau_{12}}>0\\
\frac{dn_3}{dt_{12}} &= \frac{(\sigma-1)\mu}{qp}\left[\frac{B_{13}L_1}{\Phi_1^2}+\frac{(1-B_{21})B_{31}L_3}{\Phi_3^2}\right]\frac{B_{12}}{\tau_{12}}>0
\end{aligned}
$$

□

Proof of Proposition 1.

Proposition 1. A bilateral trade agreement without third-country tariff adjustment that keeps the welfare of country 3 unchanged satisfies

$$\frac{dlog\left(\tau_{12}\right)}{dlog\left(\tau_{21}\right)}=\frac{\lambda_{21}}{\lambda_{22}}.$$

It strictly improves the welfare of country 2, but keeps the welfare of country 1 the same. In addition, the number of manufacturing firms in country 1 decreases, while the number of manufacturing firms in country 2 and country 3 increase.

Proof. The total differentiations are written as

$$
\begin{aligned}
dlogG_1 &= \frac{\partial logG_1}{\partial log\left(\tau_{21}\right)}dlog\left(\tau_{21}\right)+\frac{\partial logG_1}{\partial log\left(\tau_{12}\right)}dlog\left(\tau_{12}\right),\\
dlogG_2 &= \frac{\partial logG_2}{\partial log\left(\tau_{21}\right)}dlog\left(\tau_{21}\right)+\frac{\partial logG_2}{\partial log\left(\tau_{12}\right)}dlog\left(\tau_{12}\right),\\
dlogG_3 &= \frac{\partial logG_3}{\partial log\left(\tau_{21}\right)}dlog\left(\tau_{21}\right)+\frac{\partial logG_3}{\partial log\left(\tau_{12}\right)}dlog\left(\tau_{12}\right).
\end{aligned}
$$

To keep the welfare in country 3 unchanged, we need $\frac{\partial logG_3}{\partial log(\tau_{21})}dlog\left(\tau_{21}\right)+\frac{\partial logG_3}{\partial log(\tau_{12})}dlog\left(\tau_{12}\right)=0$ which implies

$$\frac{dlog\left(\tau_{12}\right)}{dlog\left(\tau_{21}\right)} = -\frac{\frac{\partial logG_3}{\partial log(\tau_{21})}}{\frac{\partial logG_3}{\partial log(\tau_{12})}} = -\frac{\frac{\Phi_1 B_{12} B_{31} B_{21}}{\Omega\Phi_3}}{-\frac{\Phi_2 B_{31} B_{12}}{\Omega\Phi_3}} = \frac{\Phi_1 B_{21}}{\Phi_2} = \frac{\lambda_{21}}{\lambda_{22}}.$$

Under a combination $\left(dlog\left(\tau_{21}\right), dlog\left(\tau_{12}\right)\right)$ such that $dlogG_3 = 0$, we consider its effect on $dlogG_1$ and $dlogG_2$:

$$\begin{aligned}
dlogG_1 &= \frac{\partial logG_1}{\partial log\left(\tau_{21}\right)} dlog\left(\tau_{21}\right) + \frac{\partial logG_1}{\partial log\left(\tau_{12}\right)} dlog\left(\tau_{12}\right) \\
&= -\frac{B_{12}B_{21}}{\Omega} dlog\left(\tau_{21}\right) + \frac{\Phi_2 B_{12}}{\Omega\Phi_1}\frac{\Phi_1 B_{21}}{\Phi_2} dlog\left(\tau_{21}\right) \\
&= 0 \\
dlogG_2 &= \frac{\partial logG_2}{\partial log\left(\tau_{21}\right)} dlog\left(\tau_{21}\right) + \frac{\partial logG_2}{\partial log\left(\tau_{12}\right)} dlog\left(\tau_{12}\right) \\
&= \frac{\Phi_1\left[1 - B_{13}B_{31}\right]B_{21}}{\Omega\Phi_2}\frac{\Phi_2}{\Phi_1 B_{21}} dlog\left(\tau_{12}\right) - \frac{B_{21}B_{12}}{\Omega} dlog\left(\tau_{12}\right) \\
&= dlog\left(\tau_{12}\right)
\end{aligned}$$

Using the fact that $\frac{\partial G_1}{\partial t_{12}} = \frac{\partial G_3}{\partial t_{12}} = 0$ and $\frac{\partial G_2}{\partial t_{12}} = \frac{G_2}{\tau_{12}}$, we conclude that

$$\begin{aligned}
\frac{dn_1}{dt_{12}} &= \frac{\left(\sigma - 1\right) n_2}{\Phi_1 \tau_{12}} > 0 \\
\frac{dn_2}{dt_{12}} &= -\frac{\left(\sigma - 1\right) n_2}{\Phi_1 \tau_{12}}\left(1 - \left(\theta\tau_{13}\right)^{1-\sigma}\right) < 0 \\
\frac{dn_3}{dt_{12}} &= -\frac{\left(\sigma - 1\right) n_2}{\Phi_1 \tau_{12}}\left(\theta\tau_{13}\right)^{1-\sigma} < 0 \\
\frac{dn_2}{dn_3}\mid_{dG_3=0} &= \frac{1 - \left(\theta\tau_3\right)^{1-\sigma}}{\left(\theta\tau_3\right)^{1-\sigma}} > 0
\end{aligned}$$

□

Proof of Proposition 2.

Proposition 2. A bilateral trade agreement with third-country tariff adjustment, that (i) keeps the welfare of country 3 unchanged, and (ii) strictly improves the welfares of country 1 and 2, exists and satisfies

$$\frac{\lambda_{21}}{\lambda_{22}} < \frac{dlog\left(\tau_{12}\right)}{dlog\left(\tau_{21}\right)} < \frac{\lambda_{11}}{\lambda_{12}},$$

and

$$\frac{dlog\left(\tau_{31}\right)}{dlog\left(\tau_{21}\right)} = \frac{1}{\frac{\lambda_{11}}{\lambda_{12}} - \frac{\lambda_{21}}{\lambda_{22}}}\left(\frac{dlog\left(\tau_{12}\right)}{dlog\left(\tau_{21}\right)} - \frac{\lambda_{21}}{\lambda_{22}}\right).$$

Proof. To keep the welfare of country 3 unchanged, tariff changes must satisfy $dlogG_3 = \frac{\partial logG_3}{\partial log(\tau_{21})} dlog(\tau_{21}) + \frac{\partial logG_3}{\partial log(\tau_{12})} dlog(\tau_{12}) + \frac{\partial logG_3}{\partial log(\tau_{31})} dlog(\tau_{31}) = 0$. This leads to

$$
\begin{aligned}
\frac{\Phi_1 \left[1 - B_{12}B_{21}\right] B_{31}}{\Omega \Phi_3} dlog(\tau_{31}) &= -\frac{\Phi_1 B_{31} B_{12} B_{21}}{\Omega \Phi_3} dlog(\tau_{21}) + \frac{\Phi_2 B_{31} B_{12}}{\Omega \Phi_3} dlog(\tau_{12}) \\
\frac{dlog(\tau_{31})}{dlog(\tau_{21})} &= \frac{\Phi_2 B_{12}}{\Phi_1 (1 - B_{12}B_{21})} \left(\frac{dlog(\tau_{12})}{dlog(\tau_{21})} - \frac{\Phi_1 B_{21}}{\Phi_2} \right) \\
&= \frac{1}{\frac{\lambda_{11}}{\lambda_{12}} - \frac{\lambda_{21}}{\lambda_{22}}} \left(\frac{dlog(\tau_{12})}{dlog(\tau_{21})} - \frac{\lambda_{21}}{\lambda_{22}} \right)
\end{aligned}
$$

Country 1's welfare change is

$$
\begin{aligned}
dlogG_1 &= \frac{\partial logG_1}{\partial log(\tau_{21})} dlog(\tau_{21}) + \frac{\partial logG_1}{\partial log(\tau_{12})} dlog(\tau_{12}) + \frac{\partial logG_1}{\partial log(\tau_{31})} dlog(\tau_{31}) \\
&= -\frac{B_{12}B_{21}}{\Omega} dlog(\tau_{21}) + \frac{\Phi_2 B_{12}}{\Omega \Phi_1} dlog(\tau_{12}) - \frac{B_{13}B_{31}}{\Omega} dlog(\tau_{31}) \\
&= -\frac{B_{12}B_{21}}{\Omega} dlog(\tau_{21}) + \frac{\Phi_2 B_{12}}{\Omega \Phi_1} dlog(\tau_{12}) \\
&\quad -\frac{B_{13}B_{31}}{\Omega} \left[-\frac{B_{12}B_{21}}{(1 - B_{12}B_{21})} dlog(\tau_{21}) + \frac{\Phi_2 B_{12}}{\Phi_1 (1 - B_{12}B_{21})} dlog(\tau_{12}) \right] \\
&= -\frac{B_{12}B_{21}}{(1 - B_{12}B_{21})} dlog(\tau_{21}) + \frac{\Phi_2 B_{12}}{\Phi_1 (1 - B_{12}B_{21})} dlog(\tau_{12}) \\
&= \frac{B_{12}}{\Phi_1 (1 - B_{12}B_{21})} \left(-\Phi_1 B_{21} dlog(\tau_{21}) + \Phi_2 dlog(\tau_{12}) \right)
\end{aligned}
$$

The condition that $dlogG_1 < 0$ is $-\Phi_1 B_{21} dlog(\tau_{21}) + \Phi_2 dlog(\tau_{12}) < 0$ which is $\frac{\lambda_{21}}{\lambda_{22}} < \frac{dlog(\tau_{12})}{dlog(\tau_{21})}$. Country 2's welfare change is

$$
\begin{aligned}
dlogG_2 &= \frac{\partial logG_2}{\partial log(\tau_{21})} dlog(\tau_{21}) + \frac{\partial logG_2}{\partial log(\tau_{12})} dlog(\tau_{12}) + \frac{\partial logG_2}{\partial log(\tau_{31})} dlog(\tau_{31}) \\
&= \frac{\Phi_1 \left[1 - B_{31}B_{13}\right] B_{21}}{\Omega \Phi_2} dlog(\tau_{21}) - \frac{B_{21}B_{12}}{\Omega} dlog(\tau_{12}) + \frac{\Phi_1 B_{21} B_{13} B_{31}}{\Phi_2 \Omega} dlog(\tau_{31}) \\
&= \frac{\Phi_1 \left[1 - B_{31}B_{13}\right] B_{21}}{\Omega \Phi_2} dlog(\tau_{21}) - \frac{B_{21}B_{12}}{\Omega} dlog(\tau_{12}) \\
&\quad -\frac{\Phi_1 B_{21} B_{13} B_{31}}{\Phi_2 \Omega} \left[-\frac{B_{12}B_{21}}{(1 - B_{12}B_{21})} dlog(\tau_{21}) + \frac{\Phi_2 B_{12}}{\Phi_1 (1 - B_{12}B_{21})} dlog(\tau_{12}) \right] \\
&= \frac{\Phi_1 B_{21}}{\Phi_2 (1 - B_{12}B_{21})} dlog(\tau_{21}) - \frac{B_{12}B_{21}}{(1 - B_{12}B_{21})} dlog(\tau_{12}) \\
&= \frac{B_{21}}{\Phi_2 (1 - B_{12}B_{21})} \left(\Phi_1 dlog(\tau_{21}) - \Phi_2 B_{12} dlog(\tau_{12}) \right)
\end{aligned}
$$

The condition that $dlogG_2 < 0$ is $\Phi_1 dlog(\tau_{21}) - \Phi_2 B_{12} dlog(\tau_{12}) < 0$ which is $\frac{dlog(\tau_{12})}{dlog(\tau_{21})} < \frac{\lambda_{11}}{\lambda_{12}}$.

Therefore, country 1 and 2 agree on a bilateral trade agreement if

$$\frac{\lambda_{21}}{\lambda_{22}} < \frac{dlog\left(\tau_{12}\right)}{dlog\left(\tau_{21}\right)} < \frac{\lambda_{11}}{\lambda_{12}}.$$

□

The effects of tariffs on price indices under the MFN principle

According to equations (**??**), (**??**) and (**??**), the derivative of G_1, G_2, and G_3 with respect to t_1, t_2 are

$$\begin{aligned}
\frac{\partial logG_{31}}{\partial log\left(\tau_1\right)} &= -\frac{\left[B_2+B_3\right]B_1}{\Omega} \\
\frac{\partial logG_{1}}{\partial log\left(\tau_2\right)} &= \frac{\Phi_2 B_2}{\Omega\Phi_1} \\
\frac{\partial logG_{2}}{\partial log\left(\tau_1\right)} &= \frac{\Phi_1 B_1}{\Omega\Phi_2} \\
\frac{\partial logG_{2}}{\partial log\left(\tau_2\right)} &= -\frac{B_1 B_2}{\Omega} \\
\frac{\partial logG_{3}}{\partial log\left(\tau_1\right)} &= \frac{\Phi_1 B_1}{\Omega\Phi_3} \\
\frac{\partial logG_{3}}{\partial log\left(\tau_2\right)} &= -\frac{B_1 B_2}{\Omega}
\end{aligned}$$

Proof of Proposition 3.

Proposition 3. A bilateral trade agreement between country 1 and country 2 under the MFN principle that keeps the welfare of country 3 unchanged satisfies

$$\frac{dlog\left(\tau_2\right)}{dlog\left(\tau_1\right)} = \frac{\lambda_{11}}{\lambda_{12}}.$$

It always benefits country 1 but keeps the welfare of country 2 unchanged. In addition, the agreement increases the number of manufacturing firms in country 1. The number of manufacturing firms in country 2 declines more than the number of manufacturing firms in country 3 does.

Proof. To keep the welfare in country 3 unchanged, we need $\frac{\partial logG_3}{\partial log(\tau_1)}dlog\left(\tau_1\right) + \frac{\partial logG_3}{\partial log(\tau_2)}dlog\left(\tau_2\right) = 0$ which implies

$$\frac{dlog\left(\tau_2\right)}{dlog\left(\tau_1\right)} = -\frac{\frac{\partial logG_3}{\partial log(\tau_1)}}{\frac{\partial logG_3}{\partial log(\tau_2)}} = -\frac{\frac{\Phi_1 B_1}{\Omega\Phi_3}}{-\frac{B_1 B_2}{\Omega}} = \frac{\Phi_1}{\Phi_2 B_2} = \frac{\lambda_{11}}{\lambda_{12}}.$$

Under a combination $\left(dlog\left(\tau_1\right), dlog\left(\tau_2\right)\right)$ such that $dlogG_3 = 0$, we consider its effect on

$dlogG_1$ and $dlogG_2$:

$$\begin{aligned}
dlogG_1 &= \frac{\partial logG_1}{\partial log\left(\tau_1\right)} dlog\left(\tau_1\right) + \frac{\partial logG_1}{\partial log\left(\tau_2\right)} dlog\left(\tau_2\right) \\
&= -\frac{\left[B_2+B_3\right] B_1}{\Omega} dlog\left(\tau_1\right) + \frac{\Phi_2 B_2}{\Omega \Phi_1} \frac{\Phi_1}{\Phi_2 B_2} dlog\left(\tau_1\right) \\
&= dlog\left(\tau_1\right) \\
dlogG_2 &= 0
\end{aligned}$$

The explicit solutions of numbers of manufacturing firms are

$$n_1 = \frac{\mu}{qp}\left[\frac{L_1}{\Phi_1} - \frac{L_2\left(\theta\tau_1\right)^{1-\sigma}}{\Phi_2} - \frac{L_3\left(\theta\tau_1\right)^{1-\sigma}}{\Phi_3}\right] \tag{21}$$

$$n_2 = \frac{\mu}{qp}\left[\frac{L_2\left[1-\left(\theta\tau_1\theta\tau_3\right)^{1-\sigma}\right]}{\Phi_2} + \frac{L_3\left(\theta\tau_1\theta\tau_2\right)^{1-\sigma}}{\Phi_3} - \frac{L_1\left(\theta\tau_2\right)^{1-\sigma}}{\Phi_1}\right] \tag{22}$$

$$n_3 = \frac{\mu}{qp}\left[\frac{L_3\left[1-\left(\theta\tau_1\theta\tau_2\right)^{1-\sigma}\right]}{\Phi_3} + \frac{L_2\left(\theta\tau_1\theta\tau_3\right)^{1-\sigma}}{\Phi_2} - \frac{L_1\left(\theta\tau_3\right)^{1-\sigma}}{\Phi_1}\right] \tag{23}$$

From equation (21),

$$\begin{aligned}
\frac{dn_1}{dlog\left(\tau_2\right)} &= -\frac{\left(\sigma-1\right)\mu B_2}{\Phi_1 qp}\left[\frac{L_1}{\Phi_1} - \frac{L_2+L_3}{\Phi_2}\left(\theta\tau_1\right)^{1-\sigma}\right] \\
&= -\frac{\left(\sigma-1\right) B_2}{\Phi_1} n_1 < 0
\end{aligned}$$

Using equation (22) and (23), and $dG_2 = dG_3 = 0$,

$$\begin{aligned}
0 &= \frac{dn_1}{dt_2}\left(\theta\tau_2\right)^{1-\sigma} + n_1\left(1-\sigma\right)\theta^{1-\sigma}\tau_2^{-\sigma} + \frac{dn_2}{dt_2} \\
0 &= \frac{dn_1}{dt_2}\left(\theta\tau_3\right)^{1-\sigma} + \frac{dn_3}{dt_2}
\end{aligned}$$

Therefore,

$$\begin{aligned}
\frac{dn_2}{dlog\left(\tau_2\right)} &= -\frac{dn_1}{dlog\left(\tau_2\right)} B_2 - n_1\left(1-\sigma\right) B_2 \\
&= \frac{\left(\sigma-1\right) B_2}{\Phi_1} n_1\left(1-B_3\right) > 0 \\
\frac{dn_3}{dlog\left(\tau_2\right)} &= -\frac{dn_1}{dlog\left(\tau_2\right)} B_3 \\
&= \frac{\left(\sigma-1\right) B_2 B_3}{\Phi_1} n_1 > 0
\end{aligned}$$

$\square$

Proof of Proposition 6.

Proposition 6. In the basic model, a bilateral trade agreement under the MFN principle exists and satisfies

$$\frac{\lambda_{21}}{\lambda_{22}}\left(1+\frac{B_3}{B_2}\right) \quad < \quad \frac{dlog\left(\tau_2\right)}{dlog\left(\tau_1\right)} < \frac{\lambda_{11}}{\lambda_{12}}.$$

Proof. We need a combination of $\left(dlog\left(\tau_1\right), dlog\left(\tau_2\right)\right)$ such that $dlogG_1 < 0$ and $dlogG_2 < 0$.

To get $dlogG_1 < 0$,

$$\begin{aligned} dlogG_1 < 0 \longleftrightarrow & \quad \frac{\partial logG_1}{\partial log(\tau_1)} dlog\left(\tau_1\right) + \frac{\partial logG_1}{\partial log(\tau_2)} dlog\left(\tau_2\right) & < 0 \\ \longleftrightarrow & \quad -\frac{[B_2+B_3]B_1}{\Omega} dlog\left(\tau_1\right) + \frac{\Phi_2 B_2}{\Omega\Phi_1} dlog\left(\tau_2\right) & < 0 \\ \longleftrightarrow & \quad -\left[B_2+B_3\right] B_1\Phi_1 dlog\left(\tau_1\right) + \Phi_2 B_2 dlog\left(\tau_2\right) & < 0 \\ \longleftrightarrow & \quad \frac{dlog(\tau_2)}{dlog(\tau_1)} > \frac{\lambda_{21}}{\lambda_{22}}\left(1+\frac{B_3}{B_2}\right) & \end{aligned}$$

To get $dlogG_2 < 0$,

$$\begin{aligned} dlogG_2 < 0 \longleftrightarrow & \quad \frac{\partial logG_2}{\partial log(\tau_1)} dlog\left(\tau_1\right) + \frac{\partial logG_2}{\partial log(\tau_2)} dlog\left(\tau_2\right) & < 0 \\ \longleftrightarrow & \quad \frac{\Phi_1 B_1}{\Omega\Phi_2} dlog\left(\tau_1\right) - \frac{B_1 B_2}{\Omega} dlog\left(\tau_2\right) & < 0 \\ \longleftrightarrow & \quad \Phi_1 dlog\left(\tau_1\right) - B_2\Phi_2 dlog\left(\tau_2\right) & < 0 \\ \longleftrightarrow & \quad \frac{dlog(\tau_2)}{dlog(\tau_1)} < \frac{\lambda_{11}}{\lambda_{12}} & \end{aligned}$$

□

Therefore, a bilateral trade agreement under the MFN principle satisfies

$$\frac{\lambda_{21}}{\lambda_{22}}\left(1+\frac{B_3}{B_2}\right) \quad < \quad \frac{dlog\left(\tau_2\right)}{dlog\left(\tau_1\right)} < \frac{\lambda_{11}}{\lambda_{12}}.$$

A combination of $\left(dlog\left(\tau_1\right), dlog\left(\tau_2\right)\right)$ exists if $\frac{\lambda_{21}}{\lambda_{22}}\left(1+\frac{B_3}{B_2}\right) < \frac{\lambda_{11}}{\lambda_{12}}$. The condition is equivalent to which holds true due to the parameter restriction that $\Omega > 0$.

Equilibrium conditions in the augment model

The generalized market clearing conditions for manufacturing firms in country 1, country 2, and country 3 are

$$q = p^{-\sigma}G_1^{\sigma-1}\mu L_1 + p^{-\sigma}G_2^{\sigma-1}B_{12}\mu L_2 + p^{-\sigma}G_3^{\sigma-1}B_{13}\mu L_3, \tag{24}$$

$$q = p^{-\sigma}G_1^{\sigma-1}B_{21}\mu L_1 + p^{-\sigma}G_2^{\sigma-1}\mu L_2 + p^{-\sigma}G_3^{\sigma-1}B_{23}\mu L_3, \tag{25}$$

$$q = p^{-\sigma}G_1^{\sigma-1}B_{31}\mu L_1 + p^{-\sigma}G_2^{\sigma-1}B_{32}\mu L_2 + p^{-\sigma}G_3^{\sigma-1}\mu L_3. \tag{26}$$

The aggregate manufacturing price indices are described as

$$G_1 = \left[n_1 p^{1-\sigma} + n_2 p^{1-\sigma} B_{21} + n_3 p^{1-\sigma} B_{31}\right]^{\frac{1}{1-\sigma}}, \tag{27}$$
$$G_2 = \left[n_1 p^{1-\sigma} B_{12} + n_2 p^{1-\sigma} + n_3 p^{1-\sigma} B_{32}\right]^{\frac{1}{1-\sigma}}, \tag{28}$$
$$G_3 = \left[n_1 p^{1-\sigma} B_{13} + n_2 p^{1-\sigma} B_{23} + n_3 p^{1-\sigma}\right]^{\frac{1}{1-\sigma}}. \tag{29}$$

Using the market clearing conditions in equations (24), (25), and (26), manufacturing price indices can be solved explicitly as

$$G_1 = \left(\frac{qp^\sigma}{\mu L_1}\frac{\Phi_1}{\Omega}\right)^{\frac{1}{\sigma-1}}, \tag{30}$$
$$G_2 = \left(\frac{qp^\sigma}{\mu L_2}\frac{\Phi_2}{\Omega}\right)^{\frac{1}{\sigma-1}}, \tag{31}$$
$$G_3 = \left(\frac{qp^\sigma}{\mu L_3}\frac{\Phi_3}{\Omega}\right)^{\frac{1}{\sigma-1}}, \tag{32}$$

where

$$\begin{aligned}
\Phi_1 &= [1 - B_{12}]\,[1 - B_{13}] - [B_{12} - B_{32}]\,[B_{13} - B_{23}]\,, \\
\Phi_2 &= [1 - B_{23}]\,[1 - B_{21}] - [B_{21} - B_{31}]\,[B_{23} - B_{13}]\,, \\
\Phi_3 &= [1 - B_{31}]\,[1 - B_{32}] - [B_{31} - B_{21}]\,[B_{32} - B_{12}]\,, \\
\Omega &= 1 - B_{21}B_{12} - B_{31}B_{13} - B_{32}B_{23} + B_{12}B_{23}B_{31} + B_{32}B_{21}B_{13}.
\end{aligned}$$

The number of manufacturing firms in each country is solved from equation (24) to (29) and is given by

$$n_1 = \frac{\mu}{pq}\left[\frac{1 - B_{23}B_{32}}{\Phi_1}L_1 - \frac{B_{21} - B_{23}B_{31}}{\Phi_2}L_2 + \frac{B_{31} - B_{32}B_{21}}{\Phi_3}L_3\right], \tag{33}$$
$$n_2 = \frac{\mu}{qp}\left[-\frac{B_{12} - B_{13}B_{32}}{\Phi_1}L_1 + \frac{1 - B_{13}B_{31}}{\Phi_2}L_2 - \frac{B_{32} - B_{31}B_{12}}{\Phi_3}L_3\right], \tag{34}$$
$$n_3 = \frac{\mu}{qp}\left[-\frac{B_{13} - B_{12}B_{23}}{\Phi_1}L_1 - \frac{B_{23} - B_{21}B_{13}}{\Phi_2}L_2 + \frac{1 - B_{12}B_{21}}{\Phi_3}L_3\right]. \tag{35}$$

The impact of tariff changes on manufacturing price indices in the augmented model:

$$
\begin{aligned}
\frac{\partial G_1}{\partial t_{21}} &= -\frac{[B_{12} - B_{13}B_{32}]\, B_{21}}{\Omega} \frac{G_1}{\tau_{21}} \\
\frac{\partial G_1}{\partial t_{12}} &= \frac{\Phi_2\, [1 - B_{23}B_{32}]\, B_{12}}{\Omega \Phi_1} \frac{G_1}{\tau_{12}} \\
\frac{\partial G_1}{\partial t_{31}} &= -\frac{[B_{13} - B_{12}B_{23}]\, B_{31}}{\Omega} \frac{G_1}{\tau_{31}} \\
\frac{\partial G_1}{\partial t_{32}} &= -\frac{\Phi_2\, [B_{13} - B_{12}B_{23}]\, B_{32}}{\Phi_1 \Omega} \frac{G_1}{\tau_{32}} \\
\frac{\partial G_2}{\partial t_{21}} &= \frac{\Phi_1\, [1 - B_{31}B_{13}]\, B_{21}}{\Omega \Phi_2} \frac{G_2}{\tau_{21}} \\
\frac{\partial G_2}{\partial t_{12}} &= -\frac{[B_{21} - B_{23}B_{31}]\, B_{12}}{\Omega} \frac{G_2}{\tau_{12}} \\
\frac{\partial G_2}{\partial t_{31}} &= -\frac{\Phi_1\, [B_{23} - B_{21}B_{13}]\, B_{31}}{\Phi_2 \Omega} \frac{G_2}{\tau_{31}} \\
\frac{\partial G_2}{\partial t_{32}} &= -\frac{[B_{23} - B_{21}B_{13}]\, B_{32}}{\Omega} \frac{G_2}{\tau_{32}} \\
\frac{\partial G_3}{\partial t_{21}} &= -\frac{\Phi_1\, [B_{32} - B_{31}B_{12}]\, B_{21}}{\Omega \Phi_3} \frac{G_3}{\tau_{21}} \\
\frac{\partial G_3}{\partial t_{12}} &= -\frac{\Phi_2\, [B_{31} - B_{32}B_{21}]\, B_{12}}{\Omega \Phi_3} \frac{G_3}{\tau_{12}} \\
\frac{\partial G_3}{\partial t_{31}} &= \frac{\Phi_1\, [1 - B_{12}B_{21}]\, B_{31}}{\Omega \Phi_3} \frac{G_3}{\tau_{31}} \\
\frac{\partial G_3}{\partial t_{32}} &= \frac{\Phi_2\, [1 - B_{12}B_{21}]\, B_{32}}{\Omega \Phi_3} \frac{G_3}{\tau_{32}}
\end{aligned}
$$

The impact of tariff changes on the numbers of firms in the augmented model:

The firm-delocation effects can be calculated from the derivatives of n_1, n_2, and n_3 with respect to t_{21} and t_{12}:

$$\frac{dn_1}{dt_{21}} = \frac{(\sigma-1)\mu}{qp}\left[(1-B_{23})\frac{(1-B_{13}B_{31})L_2}{\Phi_2^2} - (1-B_{32})\frac{(B_{32}-B_{31}B_{12})L_3}{\Phi_3^2}\right]\frac{B_{21}}{\tau_{21}},$$

$$\frac{dn_2}{dt_{21}} = \frac{(\sigma-1)\mu}{qp}\left[-(1-B_{13})\frac{(1-B_{13}B_{31})L_2}{\Phi_2^2} + (B_{12}-B_{32})\frac{(B_{32}-B_{31}B_{12})L_3}{\Phi_3^2}\right]\frac{B_{21}}{\tau_{21}}$$

$$\frac{dn_3}{dt_{21}} = \frac{(\sigma-1)\mu}{qp}\left[-(B_{13}-B_{23})\frac{(1-B_{13}B_{31})L_2}{\Phi_2^2} + (1-B_{12})\frac{(B_{32}-B_{31}B_{12})L_3}{\Phi_3^2}\right]\frac{B_{21}}{\tau_{21}}$$

$$\frac{dn_2}{dt_{12}} = \frac{(\sigma-1)\mu}{qp}\left[(1-B_{13})\frac{(1-B_{23}B_{32})L_1}{\Phi_1^2} - (1-B_{31})\frac{(B_{31}-B_{32}B_{21})L_3}{\Phi_3^2}\right]\frac{B_{12}}{\tau_{12}}$$

$$\frac{dn_1}{dt_{12}} = \frac{(\sigma-1)\mu}{qp}\left[-(1-B_{23})\frac{(1-B_{23}B_{32})L_1}{\Phi_1^2} + (B_{21}-B_{31})\frac{(B_{31}-B_{32}B_{21})L_3}{\Phi_3^2}\right]\frac{B_{12}}{\tau_{12}}$$

$$\frac{dn_3}{dt_{12}} = \frac{(\sigma-1)\mu}{qp}\left[-(B_{23}-B_{13})\frac{(1-B_{23}B_{32})L_1}{\Phi_1^2} + (1-B_{21})\frac{(B_{31}-B_{32}B_{21})L_3}{\Phi_3^2}\right]\frac{B_{12}}{\tau_{12}}$$

Proof of Lemma 4.

Lemma 4. A unilateral increase in the tariff of country i on country j improves country i's welfare but hurts country j and country k, for any $i \neq j \neq k$ that $i, j, k \in \{1, 2, 3\}$.

Proof. It's straightforward from the derivatives in Appendix B □

Proof of Proposition 7.

Proposition 7. In the augmented model, a bilateral trade agreement without third-country tariff adjustments that strictly improves the welfares of country 1 and 2 satisfies

$$\left(\frac{B_{12}-B_{13}B_{32}}{B_{12}-B_{12}B_{23}B_{32}}\right)\frac{\lambda_{21}}{\lambda_{22}} < \frac{dlog\left(\tau_{12}\right)}{dlog\left(\tau_{21}\right)} < \frac{\lambda_{11}}{\lambda_{12}}\left(\frac{B_{21}-B_{21}B_{13}B_{31}}{B_{21}-B_{23}B_{31}}\right).$$

It always reduces welfare of country 3.

Proof. We need a combination of $(dlog\left(\tau_1\right), dlog\left(\tau_2\right))$ such that $dlogG_1 < 0$ and $dlogG_2 < 0$.

To get $dlogG_1 < 0$,

$$\begin{aligned}
dlogG_1 < 0 \longleftrightarrow & \quad \tfrac{\partial logG_1}{\partial log(\tau_{21})}dlog\left(\tau_{21}\right) + \tfrac{\partial logG_1}{\partial log(\tau_{12})}dlog\left(\tau_{12}\right) & < 0 \\
\longleftrightarrow & \quad -\tfrac{[B_{12}-B_{13}B_{32}]B_{21}}{\Omega}dlog\left(\tau_{21}\right) + \tfrac{\Phi_2[1-B_{23}B_{32}]B_{12}}{\Omega\Phi_1}dlog\left(\tau_{12}\right) & < 0 \\
\longleftrightarrow & \quad -\Phi_1\left[B_{12}-B_{13}B_{32}\right]B_{21}dlog\left(\tau_{21}\right) + \Phi_2\left[1-B_{23}B_{32}\right]B_{12}dlog\left(\tau_{12}\right) & < 0 \\
\longleftrightarrow & \quad \tfrac{dlog(\tau_{12})}{dlog(\tau_{21})} > \left(\tfrac{B_{12}-B_{13}B_{32}}{B_{12}-B_{12}B_{23}B_{32}}\right)\tfrac{\lambda_{21}}{\lambda_{22}} &
\end{aligned}$$

To get $dlogG_2 < 0$,

$$\begin{aligned} dlogG_2 < 0 \longleftrightarrow & \quad \frac{\partial logG_2}{\partial log(\tau_{21})} dlog(\tau_{21}) + \frac{\partial logG_2}{\partial log(\tau_{12})} dlog(\tau_{12}) & < 0 \\ \longleftrightarrow & \quad \frac{\Phi_1[1-B_{31}B_{13}]B_{21}}{\Omega\Phi_2} dlog(\tau_{21}) - \frac{[B_{21}-B_{23}B_{31}]B_{12}}{\Omega} dlog(\tau_{12}) & < 0 \\ \longleftrightarrow & \quad \Phi_1[1-B_{31}B_{13}]B_{21}dlog(\tau_{21}) - [B_{21}-B_{23}B_{31}]B_{12}\Phi_2 dlog(\tau_{12}) & < 0 \\ \longleftrightarrow & \quad \frac{dlog(\tau_{12})}{dlog(\tau_{21})} < \frac{\lambda_{11}}{\lambda_{12}} \left(\frac{B_{21}-B_{21}B_{13}B_{31}}{B_{21}-B_{23}B_{31}}\right) & \end{aligned}$$

□

Therefore, a bilateral trade agreement under the MFN principle satisfies

$$\left(\frac{B_{12}-B_{13}B_{32}}{B_{12}-B_{12}B_{23}B_{32}}\right)\frac{\lambda_{21}}{\lambda_{22}} < \frac{dlog(\tau_{12})}{dlog(\tau_{21})} < \frac{\lambda_{11}}{\lambda_{12}}\left(\frac{B_{21}-B_{21}B_{13}B_{31}}{B_{21}-B_{23}B_{31}}\right).$$

$$\begin{aligned} \frac{\partial G_3}{\partial t_{21}} dlogG_3 &= -\frac{\Phi_1[B_{32}-B_{31}B_{12}]B_{21}}{\Omega\Phi_3} dlog(\tau_{21}) - \frac{\Phi_2[B_{31}-B_{32}B_{21}]B_{12}}{\Omega\Phi_3} dlog(\tau_{12}) \\ &> 0, \forall dlog(\tau_{21}) < 0, dlog(\tau_{12}) < 0 \end{aligned}$$

Proof of Proposition 8.

Proposition 8. In the augmented model, A bilateral trade agreement with third-country tariff adjustments negotiating over $(t_{21}, t_{12}, t_{31}, t_{32})$, that(i) keeps the welfare of country 3 unchanged, and (ii) strictly improves the welfares of country 1 and 2, exists and satisfies

$$\frac{\lambda_{21}}{\lambda_{22}} < \frac{dlog(\tau_{12})}{dlog(\tau_{21})} < \frac{\lambda_{11}}{\lambda_{12}},$$

and

$$\lambda_{31} dlog(\tau_{31}) + \lambda_{32} dlog(\tau_{32}) = \frac{[B_{32}-B_{31}B_{12}]}{[1-B_{12}B_{21}]}\lambda_{21} dlog(\tau_{21}) + \frac{[B_{31}-B_{32}B_{21}]}{[1-B_{12}B_{21}]}\lambda_{12} dlog(\tau_{12}).$$

Proof. Similar to the proof of Proposition 2. □

Proof of Proposition 9.

Proposition 9. In the augmented model, MFN sufficiently guarantees that any bilateral trade agreements that the two negotiating countries agree upon always are a Pareto improvement.

Proof. The proof first shows that country 3 is not worse off. □

$$
\begin{aligned}
dlogG_3 &= \frac{\partial logG_3}{\partial log\left(\tau_1\right)}dlog\left(\tau_1\right)+\frac{\partial logG_3}{\partial log\left(\tau_2\right)}dlog\left(\tau_2\right)\\
&= \frac{\Phi_1\left[B_{31}-B_{32}B_{21}\right]}{\Omega\Phi_3}dlog\left(\tau_1\right)+\frac{\Phi_2\left[B_{32}-B_{31}B_{12}\right]}{\Omega\Phi_3}dlog\left(\tau_2\right)\\
&< 0,\forall dlog\left(\tau_{21}\right)<0, dlog\left(\tau_{12}\right)<0
\end{aligned}
$$

The two negotiating countries mutually agree only if the trade agreement weekly improve their welfare. As a result, this is a Pareto improvement.

Proof of Proposition 11.

Proposition 11. In the augmented model, a bilateral trade agreement under the MFN principle satisfies

$$
\frac{\lambda_{21}}{\lambda_{22}}\left(1+\frac{B_{31}\left(B_{13}-B_{12}B_{23}\right)}{B_{21}\left(B_{12}-B_{13}B_{32}\right)}\right) < \frac{dlog\left(\tau_2\right)}{dlog\left(\tau_1\right)}<\frac{\lambda_{11}}{\lambda_{12}}\left(\frac{1}{1+\frac{B_{32}\left(B_{23}-B_{21}B_{13}\right)}{B_{12}\left(B_{21}-B_{23}B_{31}\right)}}\right),
$$

and exists only if $B_{13}+B_{23}<1$.

Proof. Because a bilateral trade agreement under the MFN principle always improves welfare of country 3 as concluded in Proposition 9. A mutually agreed bilateral trade agreement must satisfy $dlogG_1<0$ and $dlogG_2<0$.

We need a combination of $\left(dlog\left(\tau_1\right), dlog\left(\tau_2\right)\right)$ such that $dlogG_1<0$ and $dlogG_2<0$.

To get $dlogG_1<0$,

$$
\begin{aligned}
dlogG_1<0 \longleftrightarrow \quad & \tfrac{\partial logG_1}{\partial log(\tau_1)}dlog\left(\tau_1\right)+\tfrac{\partial logG_1}{\partial log(\tau_2)}dlog\left(\tau_2\right) && <0\\
\longleftrightarrow \quad & -\tfrac{[B_{12}-B_{13}B_{32}]B_{21}+[B_{13}-B_{12}B_{23}]B_{31}}{\Omega}dlog\left(\tau_1\right)\\
& +\tfrac{\Phi_2[1-B_{23}B_{32}]B_{12}-\Phi_2[B_{13}-B_{12}B_{23}]B_{32}}{\Omega\Phi_1}dlog\left(\tau_2\right) && <0\\
\longleftrightarrow \quad & -\left(\left(B_{12}-B_{13}B_{32}\right)B_{21}+\left(B_{13}-B_{12}B_{23}\right)B_{31}\right)dlog\left(\tau_1\right)+\tfrac{\Phi_2(B_{12}-B_{13}B_{32})}{\Phi_1}dlog\left(\tau_2\right) && <0\\
\longleftrightarrow \quad & \tfrac{dlog(\tau_2)}{dlog(\tau_1)}>\tfrac{\Phi_1B_{21}}{\Phi_2}\tfrac{((B_{12}-B_{13}B_{32})B_{21}+(B_{13}-B_{12}B_{23})B_{31})}{B_{21}(B_{12}-B_{13}B_{32})}\\
& =\tfrac{\lambda_{21}}{\lambda_{22}}\left(1+\tfrac{B_{31}(B_{13}-B_{12}B_{23})}{B_{21}(B_{12}-B_{13}B_{32})}\right)
\end{aligned}
$$

To get $dlogG_2 < 0$,

$$
\begin{aligned}
dlogG_2 < 0 \longleftrightarrow & \quad \frac{\partial logG_2}{\partial log(\tau_1)} dlog(\tau_1) + \frac{\partial logG_2}{\partial log(\tau_2)} dlog(\tau_2) & < 0 \\
\longleftrightarrow & \quad \left[\frac{\Phi_1[1-B_{31}B_{13}]B_{21} - \Phi_1[B_{23}-B_{21}B_{13}]B_{31}}{\Omega\Phi_2}\right] dlog(\tau_1) & \\
& \quad - \frac{[B_{21}-B_{23}B_{31}]B_{12} + [B_{23}-B_{21}B_{13}]B_{32}}{\Omega} dlog(\tau_2) & < 0 \\
\longleftrightarrow & \quad \frac{\Phi_1[B_{21}-B_{23}B_{31}]}{\Phi_2} dlog(\tau_1) - \left([B_{21}-B_{23}B_{31}]B_{12} + [B_{23}-B_{21}B_{13}]B_{32}\right) dlog(\tau_2) & < 0 \\
\longleftrightarrow & \quad \frac{dlog(\tau_2)}{dlog(\tau_1)} < \frac{\Phi_1}{\Phi_2 B_{12}} \frac{B_{21}(B_{21}-B_{23}B_{31})}{([B_{21}-B_{23}B_{31}]B_{12} + [B_{23}-B_{21}B_{13}]B_{32}) dlog(\tau_2)} & \\
& \quad = \frac{\lambda_{11}}{\lambda_{12}} \left(\frac{1}{1+\frac{B_{32}(B_{23}-B_{21}B_{13})}{B_{12}(B_{21}-B_{23}B_{31})}}\right) &
\end{aligned}
$$

Therefore, a bilateral trade agreement under the MFN principle satisfies

$$
\frac{\lambda_{21}}{\lambda_{22}} \left(1 + \frac{B_{31}(B_{13}-B_{12}B_{23})}{B_{21}(B_{12}-B_{13}B_{32})}\right) < \frac{dlog(\tau_2)}{dlog(\tau_1)} < \frac{\lambda_{11}}{\lambda_{12}} \left(\frac{1}{1+\frac{B_{32}(B_{23}-B_{21}B_{13})}{B_{12}(B_{21}-B_{23}B_{31})}}\right).
$$

To show an existence, we need that

$$
\begin{aligned}
\frac{\lambda_{21}}{\lambda_{22}} \left(1 + \frac{B_{31}(B_{13}-B_{12}B_{23})}{B_{21}(B_{12}-B_{13}B_{32})}\right) & < \frac{\lambda_{11}}{\lambda_{12}} \left(\frac{1}{1+\frac{B_{32}(B_{23}-B_{21}B_{13})}{B_{12}(B_{21}-B_{23}B_{31})}}\right) \\
\longleftrightarrow & \quad B_{12}B_{21}\Omega(1-B_{13}-B_{23}) > 0 \\
\longleftrightarrow & \quad B_{13}+B_{23} < 1
\end{aligned}
$$

□