Market Structure, Preferential Trade Agreements, and Multilateral Tariff Cooperation*

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April 23, 2013

Abstract

How do the circumstances under which preferential trade agreements (PTAs) promote or slow multilateral trade liberalization depend on market structure? The model consists of a three-country world in which countries are asymmetric with respect to market structure. Markets are segmented and there is intraindustry trade under Cournot oligopoly. In the static tariff game, we find that both free trade agreements (FTAs) and customs unions (CUs) induce reductions in external tariffs relative to most-favored nation (MFN) in most circumstances. Moreover, when two asymmetric countries form a PTA, the PTA can reduce static welfare relative to MFN of the country with fewer firms. Under infinite repetition of the static tariff game, countries cooperate multilaterally over free trade where such cooperation is self-enforcing. We find that a country's ability to enforce cooperation declines as the number of firms in its market increases. There exist circumstances where PTAs promote cooperation relative to MFN and CUs enable cooperation relative to FTAs.

Keywords: market structure, preferential trade agreements, multilateral tariff cooperation, free trade agreement, customs union.

JEL classifications: F13, F12.

*I gratefully acknowledge the support of Professor Saggi in the research and writing of this paper. I also thank Professor Bond for serving as the second reader and Professor Crucini for helpful comments.

1 Introduction

The most-favored nation (MFN) clause, specified in Article I of the General Agreements of Tariffs and Trade (GATT), stipulates World Trade Organization (WTO) members cannot discriminate between trading partners. Preferential trade agreements constitute an exception to the MFN clause. Under a *preferential trade agreement* (PTA), countries can liberalize trade among one another if they do not raise external tariffs.[1] In the last twenty years, the number of PTAs has more than quadrupled. Currently, all but one WTO member belongs to at least one PTA, with the average member in agreements with twelve countries.[2] The growth in the number of PTAs underscores their increasing importance within the world trading system.

Preferential liberalization and multilateral liberalization through GATT reduce trade barriers in fundamentally different ways: whereas preferential liberalization reduces tariffs against select trading partners, multilateral liberalization reduces tariffs against all trading partners. Concerns about the effects of PTAs on the multilateral trading system began to surge in the early 1990s. As the United States entered into PTAs with Mexico, Canada, and several Latin American countries, GATT negotiations under the Uruguay Round teetered on the brink of collapse. Many economists and policymakers saw causality in this temporal correlation (Baldwin and Freund 2011), eliciting the key question of whether PTAs are PTAs *building* or *stumbling* blocks to multilateral liberalization, as Bhagwati (1991) best articulates. Given the recent proliferation of PTAs, the answer to this question remains important, possibly even more so today then in 1991.

There is an extensive literature that examines the circumstances under which PTAs promote or slow multilateral trade liberalization.[3] This paper examines how these circumstances depend on market structure. That is, when countries are asymmetric with respect to market structure, how do PTAs affect incentives for multilateral tariff cooperation? This question is relevant as structure asymmetries between members characterize many PTAs. Under what Ethier (1998) calls the "new regionalism", small countries often sign trade agreements with large countries to gain access to large-country markets. Prominent exam-

[1]The WTO permits three types of PTAs: (a) FTAs and CUs for trade in goods by Article XXIV of GATT, (b) agreements between developing countries for trade in goods by the Enabling Clause, and (c) agreements between developed and developing countries for trade in services by Article V of the General Agreements on Trade in Services (GATS). The focus of this paper are FTAs and CUs sanctioned under Article XXIV. By Article XXIV, countries can form PTAs with one another, as long as (1) member countries do not raise tariffs on nonmember countries, (2) the preference is 100 percent, and (3) the agreement covers almost all trade among its members. In this paper, (2) and (3) are true by construction. In most cases, (1) is also true.

[2]As of 10 January 2013, the WTO has recieved 546 notifications of PTAs, of which 354 were in force.

[3]For surveys of the literature, see Bhagwati, Krishna, and Panagariya (1999), Freund and Ornelas (2010), and Baldwin and Freund (2011).

ples of such agreements include the North American Free Trade Agreement (NAFTA) and the Euro-Med Agreement between the European Union and the Mediterranean Countries. Given the prevalence of PTAs between countries of asymmetric market structure, it is important to understand how these asymmetries affect incentives to cut tariffs multilaterally.

The model consists of a three-country world in which countries are asymmetric with respect to market structure. We use the oligopoly trade model (as in Brander and Krugman 1983), where markets are segmented and trade is intraindustry in nature. Governments use tariffs to extract rents from foreign firms (as in Brander and Spencer 1992). The oligopoly trade model best captures trade in manufacturing and service industries between industrialized countries. Moreover, as is well known, most trade between industrialized nations is intraindustry in nature. We consider both free trade agreements and customs unions. Under a *free trade agreement* (FTA), countries eliminate internal tariffs and each member individually sets an external tariff to maximize welfare. Under a *customs union* (CU), members also eliminate internal tariffs, but they jointly set a common external tariff.

We first examine a two-stage static tariff game in which countries set tariff policy in the first stage and choose outputs in the second stage. Countries set tariffs to maximize national welfare, equal to the sum of consumer surplus, producer surplus and tariff revenue. In static sense, PTAs are generally conducive to multilateral liberalization: in all but one case, internal liberalization due to a PTA induces member countries to lower their external tariffs on nonmembers.[4] Futhermore, we find that PTAs between asymmetric countries can reduce welfare of members relative to MFN.

Under infinite repetition of the static game, countries attempt to cooperate over free trade. We assume weak enforcement mechanisms prevent implementation of multilateral free trade. Therefore, free trade must be incentive compatible: the immediate benefit of defection must be less than the present value of the future costs of defection under a trade war. Countries use infinite reversion to static Nash tariffs as trigger strategies to enforce cooperation. We find that a country's ability to enforce cooperation declines as the number of firms in its market becomes larger. Moreover, PTAs can be a building block to multilateral liberalization: there are circumstances where PTAs promote multilateral cooperation relative to MFN and CUs enable multilateral cooperation relative to FTAs.

This paper proceeds as follows. Section 2 reviews the relevant literature on preferential trade agreements and multilateral tariff liberalization. Section 3 describes the static game, derives Nash tariffs and compares welfare under MFN, an FTA, and a CU. Section 4 develops the stationary dynamic game and compares incentives for tariff cooperation. Section 5 concludes. The appendix contains proofs omitted from the text.

[4] The exception is a symmetric CU.

2 Relevant literature

This section briefly reviews the relevant literature. Saggi (2006) is most similiar to the present paper; he also examines how PTAs affect incentives for multilateral tariff cooperation. This paper adopts Saggi's static and dynamic game with one major change: we assume countries are asymmetric with respect to market structure. In contrast, Saggi's model assumes there is a monopolist in every country. When countries are completely symmetric, his main result is that both FTAs and CUs undermine multilateral tariff cooperation. Under an FTA, the nonmember country is less willing to cooperate relative to MFN; under a CU, member countries are less willing to cooperate relative to MFN. Like the present paper, Saggi investigates how this conclusion depends on symmetry: he finds that when countries are asymmetric with respect to market size or cost, there are circumstances where PTAs facilitate multilateral tariff cooperation.

This paper is also similiar to Bagwell and Staiger (1998), Freund (2000), Krishna (1998) and Ornelas (2005, 2007). Ornelas (2007) investigates how small countries may form customs unions to induce nonmember countries to cooperate multilaterally. He too employs the oligopoly model, but in his paper, countries are asymmetric with respect with respect to both market size and market structure. His main result is that small countries can use customs unions to promote multilateral cooperation. Because CU members can coordinate external tariffs to improve members' welfare at the expense of the nonmember's welfare, two small countries can use a CU as a credible threat to enforce cooperation over free trade. However, unlike this paper, Ornelas does not explore cooperation in an infinitely repeated game. Instead, he follows Riezman (1999) and uses the core to examine incentives for multilateral cooperation.

Similiar forces are at work in Bagwell and Staiger (1998) and the present paper: tariff complementarity and the punishment effect. Although their underlying trade model is different, Bagwell and Staiger also employ a static and dynamic model. In the static sense, tariff complementarity induces PTA members to lower external tariffs. But from a dynamic standpoint, tariff complementarity weakens members' ability to enforce multilateral cooperation as the threat of high external tariffs is no longer credible. This is known the punishment effect.

Like this paper, Freund (2000) also uses the oligopoly model of trade, but she explores how multilateral trade liberalization affects incentives for preferential trade liberalization. She finds that multilateral trade liberalization increases both incentives to form PTAs and the likelihood that PTAs are self-enforcing. In her model, PTAs are endogenous, but multilateral cooperation is not. Krishna (1998) and Ornelas (2005) both consider political economy factors within the oligopolistic model of trade. Krishna finds that FTAs are poltically viable only when they are welfare-decreasing, but his result is not robust to endogenization of tariffs. Ornelas extends Krishna's model and endogenizes tariffs: it turns out only welfare-improving FTAs are politically viable.

3 Static tariff game

There are three countries (i, j, k) and two goods (x, y). Good y is freely traded, but good x is not. Good y is the numeraire and is produced under perfect competition with constant returns to scale technology.[5] Good x is produced by a monopolist in countries i and j, but by n_k firms in country k. The fixed and marginal costs of good x production are both zero in every country.[6] With the exception of the market structure of good x production, countries i, j, and k are symmetric.

Markets are segmented: each producer of x (a firm) makes independent decisions about how much to sell in each market. Market segmentation implies that while a country can affect its own import prices, it cannot influence the import prices of other countries (regardless of its size). Using price data from Spain's accession to the European Community and from Mercosur's formation, Winters and Chang (2000) and Chang and Winters (2002), respectively, provide empirical support for market segmentation. They find that even small countries can exhibit substantial control over their import prices.[7]

We do not explicitly account for transportation costs: as in Dixit (1986), assume such costs are zero for each firm, but are sufficiently high for all other entities as to prevent arbitrage between markets. Firms compete in quantities, and thus, the equilibrium concept is Cournot-Nash.[8]

Where $z = \{i, j, k\}$ is a country index, the basic notation is as follows:

[5] The purpose of the numeraire is to settle the balance of trade. The numeraire also helps abstract from various theoretical technicalities, which include income effects and aggregation problems due to other distortions in the economy (Brander and Spencer 1992).

[6] The marginal cost of good x production could equal c, where $0 \leq c \leq 1$. To simplify the analysis, we assume $c = 0$.

[7] Brander and Spencer (1992) observe that most firms seem to operate by the segmented markets assumption. For instance, Toyota makes independent decisions about how many cars to produce in Japan and the United States. Toyota does not bring all its cars to market in Japan for distribution throughout the world.

[8] Helpman and Krugman (1985) note that it is difficult to justify the Cournot assumption: in practice, firms seem to compete in prices, not quantities. Nonetheless, because it produces results that are intuitive, Cournot has become the workhorse model of imperfect competition.

x_{zi} is the quantity of x a firm from country z supplies to the market in country i

$x_i = \sum x_{zi}$ is the total quantity of good x sold in country i's market

t_{zi} is the specific tariff country i imposes on imports from country z, where $t_{ii} = 0$

π_{zi} is the profit made by a firm from country z in country i's market

n_i is the number of firms in country i

$N = \sum n_z = 2 + n_k$ is the total number of firms in the world

Preferences over the two goods are quasilinear such that

$$u_i(x_i, y_i) = u(x_i) + y_i$$

where

$$u_i(x_i) = x_i - \frac{x_i^2}{2}$$

It follows that the inverse demand curve is linear:

$$p_i = 1 - x_i \tag{1}$$

The static tariff game consists of two stages. In the first stage, countries simultaneously set tariffs; in the second stage, firms simultaneously choose outputs. Under backward induction, we begin with the second stage. Firms simultaneously choose outputs that maximize profits, taking the output levels of all other firms as given. To determine how much to supply to the market in country i, each firm from country z solves the following problem:

$$\max_{x_{zi}} (p_i - t_{zi})\, x_{zi} \tag{2}$$

Using the inverse demand curve in (1), we solve problem (2) for the output function of each firm. These functions are derived in Appendix A. Note that output functions in one market are analogous to the expressions in other markets. We find that:

$$x_{zi} = \frac{1}{N+1} + \frac{\sum n_z t_{zi}}{N+1} - t_{zi} \tag{3}$$

In this model, the output function (3) is dependent on n_k. Countries simultaneously set tariffs in the first stage of the static game. The remainder of this section considers tariff policy under most-favored nation, a free trade agreement and a customs union.

3.1 MFN tariffs

Under MFN, each country simultaneously sets a non-discriminatory tariff that maximizes national welfare.[9] We define national welfare as the sum of a country's consumer surplus, producer surplus and tariff revenue. Where $z = \{i, j, k\}$, denote the welfare of country z as:

$$W_z(t_{ji}, t_{ki}, t_{ij}, t_{kj}, t_{ik}, t_{jk})$$

Under MFN, country i solves:

$$\begin{aligned} \max_{t_{ji}, t_{ki}} \quad & W_i = CS_i(t_{ji}, t_{ki}) + PS_i(t_{ji}, t_{ki}, t_{ij}, t_{kj}, t_{ik}, t_{jk}) + TR_i(t_{ji}, t_{ki}) \\ \text{subject to} \quad & t_{ji} = t_{ki} \end{aligned} \tag{4}$$

where $CS_i(t_{ji}, t_{ki})$ is consumer surplus in country i and is equal to

$$CS_i(t_{ji}, t_{ki}) = u_i(x_i) - p_i x_i \tag{5}$$

$PS_i(t_{ji}, t_{ki}, t_{ij}, t_{kj}, t_{ik}, t_{jk})$ is the producer surplus of firms in country i and is equal to

$$PS_i(t_{ji}, t_{ki}, t_{ij}, t_{kj}, t_{ik}, t_{jk}) = n_i \sum \pi_{iz} = n_i \sum (p_z x_{iz} - t_{iz} x_{iz}) \tag{6}$$

and $TR_i(t_{ji}, t_{ki})$ is country i's tariff revenue and is equal to

$$TR_i(t_{ji}, t_{ki}) = \sum_{z \neq i} n_z t_{zi} x_{zi} \tag{7}$$

Due to segmented markets, the MFN tariff choosen by country i does not affect its export profits. Thus, (4) yields the same tariff as the following problem:

$$\begin{aligned} \max_{t_{ji}, t_{ki}} \quad & S_i = CS_i(t_{ji}, t_{ki}) + \pi_{ii}(t_{ji}, t_{ki}) + TR_i(t_{ji}, t_{ki}) \\ \text{subject to} \quad & t_{ji} = t_{ki} \end{aligned} \tag{8}$$

where $S_i(t_{ji}, t_{ki})$ is the domestic surplus of country i. Where $z = \{i, j, k\}$, denote the MFN tariff of country z as t_z^M. The solution to (8) yields t_i^M. Because countries i and j are symmetric, $t_i^M = t_j^M$. The MFN tariff problem for country k is analogous to (8). These tariffs are derived in Appendix B.1. Due to market segmentation and constant marginal

[9] We assume governments maximize national welfare. We do not consider political economy factors under which governments weigh producer surplus differently than consumer surplus and tariff revenue. For instance, the objective function in Grossman and Helpman (1994, 1995) is a weighted sum of campaign contributions from lobbyists and the welfare of voters.

costs, Nash tariffs do not depend upon the tariff schedules of other countries.[10] We find that:

$$t_i^M = t_j^M = \frac{3}{n_k + 9}$$

$$t_k^M = \frac{1 + 2n_k}{4 + 4n_k + 2n_k^2}$$

It can be shown that $t_i^M = t_j^M > t_k^M$ for all $n_k > 1$. The intuition is as follows. When market structure consists of a single firm, government imposes higher tariffs to reduce access by foreign firms to the domestic market. This protects monopoly profits and maximizes national welfare.[11] In contrast, when market structure consists of more than a single firm, there are fewer profits to protect because the market is more competitive and thus, government imposes lower tariffs.

Where $z = \{i, j, k\}$, denote the welfare of country z under MFN as:

$$W_z^M(t_i^M, t_j^M, t_k^M) = W_z(t_i^M, t_i^M, t_j^M, t_j^M, t_k^M, t_k^M)$$

It can be shown that $W_i^M = W_j^M > W_k^M$.

3.2 Nash tariffs under a symmetric FTA

We consider two PTA arrangements. The first is when countries i and j form a PTA. As countries i and j are symmetric, denote this arrangement as a *symmetric* PTA. The second is when countries i and k form a PTA. As countries i and k are asymmetric, denote this arrangement as an *asymmetric* PTA.[12] The superscript will indicate both the type of PTA and arrangement as follows:

SF = symmetric FTA

SU = symmetric CU

AF = asymmetric FTA

AU = asymmetric CU

Under a free trade agreement (FTA), member countries eliminate internal tariffs and each member individually sets an external tariff to maximize welfare. This subsection considers a symmetric FTA where countries i and j liberalize trade between each another: $t_{ji} = t_{ij} = 0$. To set its Nash tariff on the nonmember country k, country i solves the

[10]Admittedly, strategic independence of trade policy is not realistic, but simplifies the problem at hand. For an overview of strategic trade policy, see Brander (1995).

[11]In this sense, profits are more important than consumers' welfare for national welfare.

[12]Although countries j and k are also asymmetric, we refer to an asymmetric PTA as to an agreement between countries i and k.

following problem:

$$\begin{aligned} \max_{t_{ji},t_{ki}} \quad & W_i = CS_i(t_{ji},t_{ki}) + PS_i(t_{ji},t_{ki},t_{ij},t_{kj},t_{ik},t_{jk}) + TR_i(t_{ji},t_{ki}) \\ \text{subject to} \quad & t_{ji} = 0 \end{aligned} \tag{9}$$

As with MFN, export profits are not relevant due to market segmentation and (9) yields the same tariff as the following problem:

$$\begin{aligned} \max_{t_{ji},t_{ki}} \quad & S_i = CS_i(t_{ji},t_{ki}) + \pi_{ii}(t_{ji},t_{ki}) + TR_i(t_{ji},t_{ki}) \\ \text{subject to} \quad & t_{ji} = 0 \end{aligned} \tag{10}$$

Where $z = \{i, j\}$, denote the Nash tariff of country z on the nonmember country k as t_z^{SF}. The solution to (10) yields t_i^{SF}. Since member countries are symmetric, $t_i^{SF} = t_j^{SF}$. These tariffs are derived in Appendix B.2. We find that:

$$t_i^{SF} = t_j^{SF} = \frac{1}{n_k + 6}$$

Where $z = \{i, j, k\}$, denote the welfare of of country z under a symmetric FTA as:

$$W_z^{SF}(t_i^{SF}, t_j^{SF}, t_k^M) = W_z(0, t_i^{SF}, 0, t_j^{SF}, t_k^M, t_k^M)$$

The following result can be shown.[13]

Proposition 1. *Under a symmetric FTA,*

1. *The Nash tariff of country i (country j) on the nonmember country k is lower than its MFN tariff: $t_i^{SF} = t_j^{SF} < t_j^M = t_i^M$.*

2. *All countries have higher welfare relative to MFN: $W_j^M = W_i^M < W_i^{SF} = W_j^{SF}$ and $W_k^M < W_k^{SF}$.*

Bagwell and Staiger (1998) refer to this as the *tariff complementarity effect*.[14] The intuition is that when countries i and j liberalize trade between each other, imports from country k fall, reducing welfare in country i. When country i lowers its tariff on country k, imports from country k rise, offsetting welfare reducing trade diversion due to the PTA. It can be shown that tariff complementarity is both *necessary and sufficient* for an FTA

[13] In a similiar model, Ornelas (2007) finds essentially the same result for both a symmetric FTA and a symmetric CU.

[14] Under different assumptions about demand and cost, tariff complementarity may be weaker or may not hold.

nonmember to be better off relative to MFN. As all countries have higher welfare relative to MFN, world welfare also increases under a symmetric FTA.

3.3 Nash tariffs under a symmetric CU

Under a customs union (CU), members eliminate internal tariffs and jointly set a common external tariff. This subsection considers a symmetric CU where $t_{ji} = t_{ij} = 0$. To set their Nash tariff on the nonmember country k, countries i and j solve the following the problem:

$$\begin{aligned} \max_{t_{ji},t_{ki},t_{ij},t_{kj}} \quad & W_i(t_{ji}, t_{ki}, t_{ij}, t_{kj}, t_{ik}, t_{jk}) + W_j(t_{ji}, t_{ki}, t_{ij}, t_{kj}, t_{ik}, t_{jk}) \\ \text{subject to} \quad & t_{ji} = t_{ij} = 0 \text{ and } t_{ki} = t_{kj} \end{aligned} \tag{11}$$

Unlike an FTA, each CU member internalizes the positive effect of its tariff on the export profits of the other member country: a higher tariff increases the welfare of the other member at the expense of the nonmember.[15] Due to market segmentation, country i's tariff does not affect the domestic surplus of the other country. Therefore, (11) yields the same tariff as the following problem:

$$\begin{aligned} \max_{t_{ji}} \quad & S_i(t_{ji}, t_{ki}) + \pi_{ji}(t_{ji}, t_{ki}) \\ \text{subject to} \quad & t_{ji} = 0 \end{aligned} \tag{12}$$

Denote the Nash tariff on the nonmember country k as t^{SU}. The solution to (12) yields t^{SU}. This tariff is derived in Appendix B.3. We find that:

$$t^{SU} = \frac{5}{n_k + 18}$$

Where $z = \{i, j, k\}$, denote the welfare of country z under a symmetric CU as:

$$W_z^{SU}(t^{SU}, t_k^M) = W_z(0, t^{SU}, 0, t^{SU}, t_k^M, t_k^M)$$

The following result can be shown.

Proposition 2. *Under a symmetric CU,*

1. *The joint Nash tariff of countries i and j on the nonmember country k is lower than each country's individual Nash tariff under MFN for sufficiently small n_k, but necessarily higher than each country's individual Nash tariff under an FTA: $t_i^{SF} = t_j^{SF} < t^{SU} < t_j^M = t_i^M$ for $n_k < 4.5$.*

[15] Due to this fact, we expect (and find) tariff complementarity to be weaker under a symmetric CU.

2. *Member country i (member country j) has higher welfare relative to both MFN and an FTA:* $W_i^M = W_j^M < W_j^{SF} = W_i^{SF}$.

3. *The nonmember country k has lower welfare relative to MFN and an FTA:* $W_k^{SU} < W_k^M < W_k^{SF}$.

Relative to an FTA, tariff complementarity is weaker and does not hold for sufficiently large n_k. When n_k is sufficiently large, output from foreign firms threatens local profits of the CU. Therefore, the CU raises external tariffs in order to reduce access by foreign firms to the common market and protect local profits.[16] As a CU member internalizes the externality of its tariff on the other member, both countries i and j are better off relative to an FTA. But the nonmember country k is worse off relative to MFN because tariff complementarity is either too weak or not present.[17]

Although the results under a symmetric PTA are generally consistent with those in Saggi (2006), this is not the case under an asymmetric PTA. The remainder of this section analyzes both an asymmetric FTA and an asymmetric CU.

3.4 Nash tariffs under an asymmetric FTA

This subsection considers an asymmetric FTA where countries i and k liberalize trade between each other: $t_{ki} = t_{ik} = 0$. Where $z = \{i, k\}$, denote the Nash tariff of country z on the nonmember country j as t_z^{AF}. Members are asymmetric and therefore, $t_i^{AF} \neq t_k^{AF}$. The Nash tariff problems are analogous to (10). These tariffs are derived in Appendix B.4. We find that:

$$t_i^{AF} = \frac{3}{9 + 10n_k + 2n_k^2}$$

$$t_k^{AF} = \frac{1 + 2n_k}{11 + 8n_k + 2n_k^2}$$

Where $z = \{i, j, k\}$, denote the welfare of country z under asymmetric FTA as:

$$W_z^{AF}(t_i^{AF}, t_j^M, t_k^{AF}) = W_z(t_i^{AF}, 0, t_j^M, t_j^M, 0, t_k^{AF})$$

The following result can be shown.

[16] That profits drive the tariff decision for a CU is intuitive as its objective function (12) consists not only of local profits to domestic firms, but also export profits to foreign firms.

[17] We find external tariff discrimination under a CU, but for different reasons than in the literature. Studies with general equilibrium models find that a CU uses its joint market power in world markets to raise external tariffs and improve its terms of trade. For instance, see Bond and Syropoulos (1996), Kennan and Riezman (1990), Krugman (1991) and Syropoulos (1999). Within this model, however, the market power of a CU is irrelevant due to segmented markets.

Proposition 3. *Under an asymmetric FTA,*

1. *The Nash tariff of country i (country k) on the nonmember country k is lower than its MFN tariff: $t_i^{AF} < t_i^M$ and $t_k^{AF} < t_k^M$.*

2. *Member country i has lower welfare relative to MFN for sufficiently large n_k: $W_i^{AF} < W_i^M$ for $n_k > 2.44$.*

3. *Nonmember country j (member country k) has higher welfare relative to MFN: $W_j^M < W_j^{AF}$ and $W_k^M < W_k^{AF}$.*

It can be shown that tariff complementarity is weaker for country i. The intuition is analogous to the reason why $t_i^M > t_k^M$ for $n_k > 1$. Nonetheless, tariff complementarity is sufficiently strong such that the nonmember country j is better off relative to MFN. However, unlike a symmetric FTA, an asymmetric FTA does not necessarily make members better off: country i's welfare may decrease if n_k is sufficiently large.

Consider how country i's welfare changes under an asymmetric FTA. Its consumer surplus increases because prices decrease. Its producer surplus decreases as unrestricted entry of foreign firms diminishes monopoly profits. Its tariff revenue decreases because of the PTA and tariff complementarity. Due to demand linearity, the costs to producers and the government outweigh the benefits to consumers and therefore, country i is worse off relative to MFN.

How do these changes differ for country k? First, consumers gain less because the market in country k is not monopolistic. Second, due to weaker tariff complementarity, prices are higher in country i and thus, unrestricted access to country i actually benefits producers. Third, as only the monopolist gains unrestricted access to country k, liberalization does not hurt local profits as significantly. Finally, as $t_i^M > t_k^M$, country i loses far more tariff revenue than country k. These differences are enough to guarantee country k is better off relative to MFN.

Viner (1950) demonstrates that a PTA does not necessarily make member countries better off. A PTA may induce trade diversion in which imports shift away from the most efficient supplier to the country receiving preferential treatment. Such trade diversion may reduce the welfare of the member. In this model, it is not trade diversion but market structure asymmetries that work to reduce the welfare of the member.

3.5 Nash tariffs under an asymmetric CU

This subsection considers an asymmetric CU where $t_{ki} = t_{ik} = 0$. Denote the joint Nash tariff on the nonmember country j as t^{AU}. The Nash tariff problem is analogous to (12).

This tariff is derived in Appendix B.5. We find that:

$$t^{AU} = \frac{3 + 2n_k}{9 + 8n_k + 2n_k^2}$$

Where $z = \{i, j, k\}$, denote the welfare of of country z under an asymmetric CU as:

$$W_z^{AU}(t^{AU}, t_j^M) = W_z(t^{AU}, 0, t_j^M, t_j^M, 0, t^{AU})$$

The following result can be shown.

Proposition 4. *Under an asymmetric CU,*

1. *The joint Nash tariff of countries i and k on the nonmember country j is higher than each country's individual Nash tariff under MFN, but lower than each country's individual Nash tariff under an FTA: $t_i^{AF} < t^{AU} < t_i^M$ and $t_k^{AF} < t^{AU} < t_k^M$.*

2. *Member country i has lower welfare relative to MFN and an FTA for sufficiently large n_k: $W_i^{AU} < W_i^{AF} < W_i^M$ for $n_k > 1.41$.*

3. *The nonmember country j has lower welfare relative to MFN and an FTA: $W_j^{AU}) < W_j^M < W_j^{AF}$.*

4. *Member country k has higher welfare relative to MFN and an FTA: $W_k^M < W_i^{AF} < W_k^{AU}$.*

For reasons similiar to those under a symmetric CU, tariff complementarity is weaker and the nonmember is worse off relative to MFN. However, unlike a symmetric CU, country i is worse off relative to an FTA. In general, relative to an FTA, a CU member's increase in export profits (in the other member's market) outweighs its decrease in domestic surplus (as it no longer imposes its Nash tariff) and the CU member is better off. However, as n_k becomes larger, country k's market becomes more competitive and profits decrease. For sufficiently large n_k, country i's increase in export profits does not outweigh its decrease in domestic surplus and country i is worse off relative to an FTA.

Estevadeordal, Freund, and Ornelas (2008) examine empirically the effect of preferential liberalization on external tariffs. They use data from Latin American countries from 1990 to 2001. They find strong evidence of tariff complementarity in FTAs, but no statistically significant evidence in CUs. To a certain degree, the present model explains their result: as tariff complementarity is weaker (or not present) under a CU, it is more difficult to isolate statistically.

In the static game, the formation of a symmetric FTA, an asymmetric FTA and an asymmetric CU induced lower external tariffs. Therefore, the immediate effects of these PTAs were conducive to multilateral liberalization.

4 Dynamic tariff game

Under infinite repetition of the static game, countries attempt to cooperate over free trade, using infinite reversion to static Nash tariffs as a trigger strategy to enforce cooperation.[18] We assume weak enforcement mechanisms impede multilateral free trade. Therefore, free trade must be self-enforcing: free trade is sustainable if and only if for all countries, the immediate benefit from defection is less than the present value of the future costs of defection under a trade war.

This section proceeds as follows. First, we examine tariff cooperation under MFN. Then, we examine how exogenous formation of a preferential trade agreement changes the degree of equilibrium cooperation. We assume preferential trade agreements are permanent and need not be self-enforcing.

4.1 Cooperation under MFN

This subsection analyzes cooperation when tariffs conform to MFN and there are no PTAs. Where $z = \{i, j, k\}$, denote the welfare of country z under free trade as:

$$W_z^{FT}(0) = W_z(0, 0, 0, 0, 0, 0)$$

Under MFN, denote the benefit of defection to country z as $B_z^M(t_z^M, t_z^M)$ and the per-period cost of defection to country z as $C_z^M(t_i^M, t_j^M, t_k^M)$, where $z = \{i, j, k\}$. Country i's immediate benefit of defection from free trade to its MFN tariff t_i^M is:

$$B_i^M(t_i^M, t_i^M) = S_i(t_i^M, t_i^M) - S_i(0, 0) \tag{13}$$

Due to market segmentation, defection increases country i's domestic surplus, but does not affect its export profits. Defection is followed by a permanent trade war, under which all countries revert to their MFN tariffs. The per-period cost of defection to country i is:

$$C_i^M(t_i^M, t_j^M, t_k^M) = W_i^{FT}(0) - W_i^M(t_i^M, t_j^M, t_k^M) \tag{14}$$

Free trade must be self-enforcing: the immediate benefit of defection must be less than

[18] In this model, all punishments are multilateral.

the present value of the future costs of defection. The critical discount factor, $\delta \in [0, 1)$, represents the patience required to sustain cooperation.[19] Where $z = \{i, j, k\}$, denote the critical discount factor for country z under MFN as δ_z^M. The following incentive constraint (IC) must hold for country i:

$$B_i^M(t_i^M, t_i^M) \leq \frac{\delta_i^M}{1 - \delta_i^M} \, C_i^M(t_i^M, t_j^M, t_k^M) \tag{15}$$

We substitute (13) and (14) into (15) and solve for δ_i^M. By symmetry, the IC of country j equals that of country i (15) and therefore, $\delta_i^M = \delta_j^M$. The expressions for δ_i^M, δ_j^M and δ_k^M are derived in Appendix C.1. Under MFN, two unique ICs must bind for free trade to be sustainable.

In this model, the discount factors alone are insufficient. In certain cases, either the benefit or cost of defection is nonpositive.[20] A nonpositive benefit is actually a cost; a nonpositive cost is actually a benefit. If the benefit of defection is nonpositive, then the country will *unconditionally cooperate* over free trade. Likewise, if the cost of defection is nonpositive, then the country will *unconditionally defect* from free trade. In either case, the country's willingness to cooperate does not depend on its discount factor. Under a particular trade regime, $\phi_z(\delta_z, B_z, C_z)$ returns a country's degree of cooperation.

Definition 1. (Degree of cooperation by country) *Where $z = \{i, j, k\}$, $\phi_z(\delta_z, B_z, C_z)$ uses a country's discount factor δ_z, benefit of defection B_z and cost of defection C_z to determine its degree of cooperation as follows:*

$\boldsymbol{B_z}$	$\boldsymbol{C_z}$	$\boldsymbol{\phi_z}$
Positive	*Positive*	δ_z
Nonpositive	*Positive*	*Cooperate*
Positive	*Nonpositive*	*Defect*

Note that ϕ is a function of n_k. Under MFN, denote country z's degree of cooperation as $\phi_z^M(\delta_z^M, B_z^M, C_z^M)$, where $z = \{i, j, k\}$. The degree of cooperation by country is as follows:

$$\phi_i^M(\delta_i^M, B_i^M, C_i^M) = \phi_j^M(\delta_j^M, B_j^M, C_j^M) = \begin{cases} \delta_i^M & : \quad n_k \in [1.00, 3.85) \\ \text{Defect} & : \quad n_k \in [3.85, \infty) \end{cases} \tag{16}$$

$$\phi_k^M(\delta_k^M, B_k^M, C_k^M) = \Big\{ \delta_k^M \quad : \quad n_k \in [1.00, \infty) \tag{17}$$

[19]The critical discount factor δ is increasing in the patience required to sustain cooperation. Therefore, cooperation is decreasing in the critical discount factor.

[20]We do not find any circumstances where the both the benefit and cost of defection are nonpositive.

For sufficiently large n_k, why do countries i and j unconditionally defect from free trade? Note that punishment strategies effectively consist of a reduction in market access. This only constitutes an effective punishment if there are sufficient profits to be lost under a trade war. As n_k increases, country k's market becomes more competitive, profits decrease and the severity of country k's punishment strategy decreases. For sufficiently large n_k, reduced market access fails to sufficiently harm the defector and country k's punishment strategy is too weak to enforce cooperation. Denote the range of n_k for which countries i and j are willing to cooperate as the relevant range.

As it is the IC of the country *least willing to cooperate* multilaterally that determines the degree of equilibrium cooperation, ϕ_i^M, ϕ_j^M and ϕ_k^M alone are insufficient. Under a particular trade regime, $\Phi(\phi_i, \phi_j, \phi_k)$ returns the degree of equilibrium cooperation.

Definition 2. (Degree of equilibrium cooperation) $\Phi(\phi_i, \phi_j, \phi_k)$ *uses each country's degree of cooperation* (ϕ_i, ϕ_j, ϕ_k) *to determine the degree of equilibrium cooperation as follows:*

1. *If* $\phi_i = $ *Defect or* $\phi_j = $ *Defect or* $\phi_k = $ *Defect, then* $\Phi = $ *No cooperation.*

2. *If* $\phi_i = $ *Cooperate and* $\phi_j = $ *Cooperate and* $\phi_k = $ *Cooperate, then* $\Phi = $ *Cooperation.*

3. *If one and two are false, then ignore non-numerical values of* ϕ *and let* $\Phi = max(\phi_i, \phi_j, \phi_k)$.

Like ϕ, the degree of equilibrium cooperation Φ is a function of n_k. The intuition for Definition 2 is as follows. If any country unconditionally defects from free trade, then cooperation is never sustainable. If every country unconditionally cooperates over free trade, then cooperation is always sustainable. In all other cases, the degree of equilibrium cooperation depends on the critical discount factor of the country least willing to cooperate (numerical by construction). Using (16) and (17), the following result can be shown.

Lemma 1. $\Phi^M(\phi_i^M, \phi_j^M, \phi_k^M)$ *yields the degree of equilibrium cooperation under MFN:*

$$\Phi^M(\phi_i^M, \phi_j^M, \phi_k^M) = \begin{cases} \delta_i^M, \delta_j^M & : \quad n_k \in [1.00, 3.85) \\ \textit{No cooperation } (i,j) & : \quad n_k \in [3.85, \infty) \end{cases}$$

Under MFN, multilateral cooperation over free trade is sustainable if and only if all countries are sufficiently patient ($\delta \geq \delta_i^M = \delta_j^M$) and n_k is sufficiently small. If n_k is sufficiently large, then cooperation is not sustainable: countries i and j will unconditionally defect. The remainder of this section considers how exogenous formation of an FTA or a CU affects the degree of equilibrium cooperation.

4.2 Cooperation under a symmetric FTA

This subsection analyzes cooperation under a symmetric FTA. Under a symmetric FTA, countries i and j liberalize trade between each another: $t_{ji} = t_{ij} = 0$. Where $z = \{i, j\}$, the Nash tariff of country z on the nonmember country k is t_z^{SF}. The notation is as follows:

$B_z^{SF}(0, t_z^{SF})$ is the immediate benefit of defection to country z, where $z = \{i, j\}$

$B_k^{SF}(t_k^M, t_k^M)$ is the immediate benefit of defection to country k

$C_z^{SF}(t_i^{SF}, t_j^{SF}, t_k^M)$ is the per-period cost of defection to country z, where $z = \{i, j, k\}$

δ_z^{SF} is the critical discount factor of country z, where $z = \{i, j, k\}$

$\phi_z^{SF}(\delta_z^{SF}, B_z^{SF}, C_z^{SF})$ is country z's degree of cooperation, where $z = \{i, j, k\}$

By assumption, the FTA is permanent: a member country can only raise its tariff on the nonmember country k. Therefore, country i's immediate benefit of defection to its Nash tariff t_i^{SF} is:

$$B_i^{SF}(0, t_i^{SF}) = S_i(0, t_i^{SF}) - S_i(0, 0) \tag{18}$$

As with MFN, the benefit of defection does not involve country i's export profits. Country k's one-time payoff of defection to its MFN tariff t_k^M is:

$$B_k^{SF}(t_k^M, t_k^M) = S_k(t_k^M, t_k^M) - S_k(0, 0) = B_k^M(t_k^M, t_k^M) \tag{19}$$

Due to market segmentation, the benefit of defection does not depend on the tariff schedules of other countries. Therefore, the benefit of defection to country k is the same as that under MFN. Under a trade war, all countries revert to their Nash tariffs. The per-period cost of defection to country i is:

$$C_i^{SF}(t_i^{SF}, t_j^{SF}, t_k^M) = W_i^{FT}(0) - W_i^{SF}(t_i^{SF}, t_j^{SF}, t_k^M) \tag{20}$$

The per-period cost of defection to country k is:

$$C_k^{SF}(t_i^{SF}, t_j^{SF}, t_k^M) = W_k^{FT}(0) - W_k^{SF}(t_i^{SF}, t_j^{SF}, t_k^M) \tag{21}$$

For free trade to be self-enforcing under a symmetric FTA, the following IC must hold for country i:

$$B_i^{SF}(0, t_i^{SF}) \leq \frac{\delta_i^{SF}}{1 - \delta_i^{SF}} C_i^{SF}(t_i^{SF}, t_j^{SF}, t_k^M) \tag{22}$$

We substitute (18) and (20) into (22) and solve for δ_i^{SF}. By symmetry, the IC of country j equals that of country i (22) and therefore, $\delta_i^{SF} = \delta_j^{SF}$. Likewise, the following IC must hold for country k:

$$B_k^{SF}(t_k^M, t_k^M) \leq \frac{\delta_k^{SF}}{1-\delta_k^{SF}} C_k^{SF}(t_i^{SF}, t_j^{SF}, t_k^M) \tag{23}$$

We substitute (19) and (21) into (23) and solve for δ_k^{SF}. The expressions for δ_i^{SF}, δ_j^{SF} and δ_k^{SF} are derived in Appendix C.2. Under a symmetric FTA, two unique ICs must bind for free trade to be self-enforcing. The degree of cooperation by country is as follows:

$$\phi_i^{SF}(\delta_i^{SF}, B_i^{SF}, C_i^{SF}) = \phi_j^{SF}(\delta_j^{SF}, B_j^{SF}, C_j^{SF}) = \begin{cases} \delta_i^{SF} & : \quad n_k \in [1.00, 2.00) \\ \text{Defect} & : \quad n_k \in [2.00, \infty) \end{cases} \tag{24}$$

$$\phi_k^{SF}(\delta_k^{SF}, B_k^{SF}, C_k^{SF}) = \left\{ \delta_k^{SF} \quad : \quad n_k \in [1.00, \infty) \right. \tag{25}$$

As country k enforces cooperation of countries i and j, they unconditionally defect from free trade for sufficiently large n_k. The intuition is analogous to that under MFN. Using (24) and (25), the following result can be shown.

Lemma 2. $\Phi^{SF}(\phi_i^{SF}, \phi_j^{SF}, \phi_k^{SF})$ *yields the degree of equilibrium cooperation under a symmetric FTA:*

$$\Phi^{SF}(\phi_i^{SF}, \phi_j^{SF}, \phi_k^{SF}) = \begin{cases} \delta_k^{SF} & : \quad n_k \in [1.00, 1.40) \\ \delta_i^{SF}, \delta_j^{SF} & : \quad n_k \in [1.40, 2.00) \\ \textit{No cooperation } (i,j) & : \quad n_k \in [2.00, \infty) \end{cases}$$

Under a symmetric FTA, multilateral cooperation over free trade is sustainable if and only if all countries are sufficiently patient and n_k is sufficiently small. If n_k is sufficiently large, then cooperation is not sustainable: countries i and j will unconditionally defect.

Proposition 5. *Relative to MFN, a symmetric FTA affects the degree of equilibrium cooperation as follows:*

n_k	Φ^M	Φ^{SF}	**Equilibrium cooperation**
$(1.00, 1.38]$	δ_i^M, δ_j^M	δ_k^{SF}	*Decreases as* $\delta_i^M < \delta_k^{SF}$
$(1.38, 1.40)$	δ_i^M, δ_j^M	δ_k^{SF}	*Increases as* $\delta_i^M > \delta_k^{SF}$
$[1.40, 1.42)$	δ_i^M, δ_j^M	$\delta_i^{SF}, \delta_j^{SF}$	*Increases as* $\delta_i^M > \delta_i^{SF}$
$[1.42, 2.00)$	δ_i^M, δ_j^M	$\delta_i^{SF}, \delta_j^{SF}$	*Decreases as* $\delta_i^M < \delta_i^{SF}$
$[2.00, 3.84)$	δ_i^M, δ_j^M	*No cooperation*	*Decreases*
$[3.84, \infty)$	*No cooperation*	*No cooperation*	*No effect*

Proposition 5 follows immediately from Lemma 1 and Lemma 2.[21] Relative to MFN, a symmetric FTA increases the degree of equilibrium cooperation for $n_k \in (1.38, 1.42)$. But we ought to interpret this result with caution: n_k does not take on integer values in this range.[22]

4.3 Cooperation under a symmetric CU

This subsection analyzes cooperation under a symmetric CU. Under a symmetric CU, countries i and j liberalize trade between each other: $t_{ji} = t_{ij} = 0$. Their Nash tariff on the nonmember country k is t^{SU}. The notation is as follows:

$B_z^{SU}(0, t^{SU}, 0, t^{SU})$ is the immediate benefit of defection to country z, where $z = \{i, j\}$

$B_k^{SU}(t_k^M, t_k^M)$ is the immediate benefit of defection to country k

$C_z^{SU}(t^{SU}, t_k^M)$ is the per-period cost of defection to country z, where $z = \{i, j, k\}$

δ_z^{SU} is the critical discount factor of country z, where $z = \{i, j, k\}$

$\phi_z^{SU}(\delta_z^{SU}, B_z^{SU}, C_z^{SU})$ is country z's degree of cooperation, where $z = \{i, j, k\}$

Like an FTA, we assume that a CU is permanent: a member country can only raise its tariff on the nonmember country k. Under a CU, member countries jointly set an external tariff and therefore, defection by one member necessarily entails defection by other. Country i's immediate benefit of defection to its Nash tariff t^{SU} is:

$$B_i^{SU}(0, t^{SU}, 0, t^{SU}) = S_i(0, t^{SU}) - S_i(0, 0) + \pi_{ij}(0, t^{SU}) - \pi_{ij}(0, 0) \tag{26}$$

Unlike MFN and an FTA, defection affects not only country i's domestic surplus, but also its export profits in country j's market, as both member countries raise their tariff against the nonmember. Country k's one-time payoff of defection to its MFN tariff t_k^M is:

$$B_k^{SU}(t_k^M, t_k^M) = S_k(t_k^M, t_k^M) - S_k(0, 0) = B_k^M(t_k^M, t_k^M) \tag{27}$$

Due to market segmentation, the benefit of defection to country k is the same as that under MFN and a symmetric FTA. Under a trade war, the per-period cost of defection to country i is:

$$C_i^{SU}(t^{SU}, t_k^M) = W_i^{FT}(0) - W_i^{SU}(t^{SU}, t_k^M) \tag{28}$$

[21] Under a symmetric FTA, Figure 2 displays the degree of cooperation by country relative to MFN. For a member, both the benefit and cost of defection are lower relative to MFN. The benefit is lower as a member can only raise tariffs against the nonmember. The cost is lower as only a nonmember can punish a member. For the nonmember, while the benefit of defection is the same, the cost is lower due to tariff complementarity. Tariff complementarity weakens members' ability to enforce multilateral cooperation: Bagwell and Staiger (1998) call this the *punishment effect*.

[22] We display the comparisons of the degree of equilibrium cooperation functions graphically in Figure 1.

The per-period cost of defection to country k is:

$$C_k^{SU}(t^{SU}, t_k^M) = W_k^{FT}(0) - W_k^{SU}(t^{SU}, t_k^M) \tag{29}$$

If free trade is self-enforcing, then the following IC must hold for country i:

$$B_i^{SU}(0, t^{SU}, 0, t^{SU}) \leq \frac{\delta_i^{SU}}{1 - \delta_i^{SU}} \, C_i^{SU}(t^{SU}, t_k^M) \tag{30}$$

We substitute (26) and (28) into (30) and solve for δ_i^{SU}. By symmetry, the IC of country j is equivalent to that of country i (30) and therefore, $\delta_i^{SU} = \delta_j^{SU}$. Likewise, the following IC must hold for country k:

$$B_k^{SU}(t_k^M, t_k^M) \leq \frac{\delta_k^{SU}}{1 - \delta_k^{SU}} \, C_k^{SU}(t^{SU}, t^{SU}, t_k^M) \tag{31}$$

We substitute (27) and (29) into (31) and solve for δ_k^{SU}. The expressions for δ_i^{SU}, δ_j^{SU} and δ_k^{SU} are derived in Appendix C.3. Under a symmetric CU, two unique ICs must bind for free trade to be self-enforcing. The degree of cooperation by country is as follows:

$$\phi_i^{SU}(\delta_i^{SU}, B_i^{SU}, C_i^{SU}) = \phi_j^{SU}(\delta_j^{SU}, B_j^{SU}, C_j^{SU}) = \begin{cases} \delta_i^{SU} & : \quad n_k \in [1.00, 1.40) \\ \text{Defect} & : \quad n_k \in [1.40, \infty) \end{cases} \tag{32}$$

$$\phi_k^{SU}(\delta_k^{SU}, B_k^{SU}, C_k^{SU}) = \begin{cases} \delta_k^{SU} & : \quad n_k \in [1.00, \infty) \end{cases} \tag{33}$$

As with a symmetric FTA, as country k enforces cooperation of countries i and j, they unconditionally defect from free trade for sufficiently large n_k. The intuition is analogous to that under MFN. Using (32) and (33), the following result can be shown.

Lemma 3. $\Phi^{SU}(\phi_i^{SU}, \phi_j^{SU}, \phi_k^{SU})$ *yields the degree of equilibrium cooperation under a symmetric CU:*

$$\Phi^{SU}(\phi_i^{SU}, \phi_j^{SU}, \phi_k^{SU}) = \begin{cases} \delta_i^{SU}, \delta_j^{SU} & : \quad n_k \in [1.00, 1.40) \\ \textit{No cooperation } (i, j) & : \quad n_k \in [1.40, \infty) \end{cases}$$

Under a symmetric CU, multilateral cooperation over free trade is sustainable if and only if all countries are sufficiently patient and n_k is sufficiently small. If n_k is sufficiently large, then cooperation is not sustainable: countries i and j will unconditionally defect.

Proposition 6. *Relative to MFN, a symmetric CU affects the degree of equilibrium cooperation as follows:*

n_k	Φ^M	Φ^{SU}	**Equilibrium cooperation**
$(1.00, 1.40)$	δ_i^M, δ_j^M	$\delta_i^{SU}, \delta_j^{SU}$	*Decreases as* $\delta_i^M < \delta_i^{SU}$
$[1.40, 3.84)$	δ_i^M, δ_j^M	*No cooperation*	*Decreases*
$[3.84, \infty)$	*No cooperation*	*No cooperation*	*No effect*

Relative to an FTA, a symmetric CU affects the degree of equilibrium cooperation as follows:

n_k	Φ^{SF}	Φ^{SU}	**Equilibrium cooperation**
$(1.00, 1.40)$	δ_k^{SF}	$\delta_i^{SU}, \delta_j^{SU}$	*Decreases as* $\delta_i^M < \delta_i^{SU}$
$[1.40, 2.00)$	$\delta_i^{SF}, \delta_j^{SF}$	*No cooperation*	*Decreases*
$[2.00, \infty)$	*No cooperation*	*No cooperation*	*No effect*

Proposition 6 follows immediately from Lemma 1, Lemma 2, and Lemma 3.[23] Unlike a symmetric FTA, a symmetric CU does not increase the degree of equilibrium cooperation relative to either MFN or an FTA. In fact, for sufficiently small n_k, a symmetric CU decreases the degree of equilibrium cooperation relative to both MFN and an FTA.

4.4 Cooperation under an asymmetric FTA

This subsection analyzes cooperation under an asymmetric FTA. Under an asymmetric FTA, countries i and k liberalize trade between each another: $t_{ki} = t_{ik} = 0$. Where $z = \{i, k\}$, the Nash tariff of country z on the nonmember country j is t_z^{AF}. The notation is as follows:

$B_i^{AF}(t_i^{AF}, 0)$ is the immediate benefit of defection to country i

$B_j^{AF}(t_j^M, t_j^M)$ is the immediate benefit of defection to country j

$B_k^{AF}(0, t_k^{AF})$ is the immediate benefit of defection to country k

$C_z^{AF}(t_i^{AF}, t_j^M, t_k^{AF})$ is the per-period cost of defection to country z, where $z = \{i, j, k\}$

δ_z^{AF} is the critical discount factor of country z, where $z = \{i, j, k\}$

$\phi_z^{AF}(\delta_z^{AF}, B_z^{AF}, C_z^{AF})$ is country z's degree of cooperation, where $z = \{i, j, k\}$

The expressions for δ_i^{AF}, δ_j^{AF} and δ_k^{AF} are derived in Appendix C.4. As member countries are asymmetric, three ICs must bind for free trade to be self-enforcing. Under an asymmetric FTA, the degree of cooperation by country is as follows:

$$\phi_i^{AF}(\delta_i^{AF}, B_i^{AF}, C_i^{AF}) = \left\{ \delta_i^{AF} \quad : \quad n_k \in [1.00, \infty) \right. \tag{34}$$

[23]Under a symmetric CU, Figure 3 and Figure 4 display the degree of cooperation by country relative to MFN and an FTA, respectively. For a member, for sufficiently large n_k, the benefit is larger and cost lower relative to MFN. The benefit is larger as a CU can discriminate and raise tariffs against the nonmember. The cost is lower as only a nonmember can punish a member. For a nonmember, while the benefit of defection is the same, the cost if higher due to weak (or no) tariff complementarity.

$$\phi_j^{AF}(\delta_j^{AF}, B_j^{AF}, C_j^{AF}) = \begin{cases} \delta_j^{AF} & : \quad n_k \in [1.00, 2.44) \\ \text{Defect} & : \quad n_k \in [2.44, \infty) \end{cases} \tag{35}$$

$$\phi_k^{AF}(\delta_k^{AF}, B_k^{AF}, C_k^{AF}) = \left\{ \delta_k^{AF} \quad : \quad n_k \in [1.00, \infty) \right. \tag{36}$$

As country k enforces cooperation of country j, it unconditionally defects from free trade for sufficiently large n_k. The intuition is analogous to that under MFN. Note that due to the asymmetric FTA, country j enforces cooperation of country i. In contrast to MFN, country i does not unconditionally defect from free trade because country j has stronger punishment strategies. Using (34), (35), and (36), the following result can be shown.

Lemma 4. $\Phi^{AF}(\phi_i^{AF}, \phi_j^{AF}, \phi_k^{AF})$ *yields the degree of equilibrium cooperation under an asymmetric FTA:*

$$\Phi^{AF}(\phi_i^{AF}, \phi_j^{AF}, \phi_k^{AF}) = \begin{cases} \delta_j^{AF} & : \quad n_k \in [1.00, 2.44) \\ \textit{No cooperation } (j) & : \quad n_k \in [2.44, \infty) \end{cases}$$

Under an asymmetric FTA, multilateral cooperation over free trade is sustainable if and only if all countries are sufficiently patient and n_k is sufficiently small. If n_k is sufficiently large, then cooperation is not sustainable: country j will unconditionally defect.

Proposition 7. *Relative to MFN, an asymmetric FTA affects the degree of equilibrium cooperation as follows:*

$\boldsymbol{n_k}$	$\boldsymbol{\Phi^M}$	$\boldsymbol{\Phi^{AF}}$	**Equilibrium cooperation**
$(1.00, 2.44)$	δ_i^M, δ_j^M	δ_j^{AF}	*Decreases as* $\delta_i^M < \delta_j^{AF}$
$(2.44, 3.84)$	δ_i^M, δ_j^M	*No cooperation*	*Decreases*
$[3.84, \infty)$	*No cooperation*	*No cooperation*	*No effect*

Proposition 7 follows immediately from Lemma 1 and Lemma 4.[24] Unlike a symmetric FTA, an asymmetric FTA does not does not increase the degree of equilibrium cooperation relative to MFN. For sufficiently small n_k, an asymmetric FTA decreases the degree of equilibrium cooperation relative to MFN.

[24]Under an asymmetric FTA, Figure 5 displays the degree of cooperation by country relative to MFN. The intuition for changes in the costs and benefits of defection is somewhat similiar to that under a symmetric FTA. However, note that the costs for country i under an asymmetric FTA are no longer negative as with MFN, as discussed above.

4.5 Cooperation under an asymmetric CU

This subsection analyzes cooperation under an asymmetric CU. Under an asymmetric CU, countries i and k liberalize trade between each other: $t_{ki} = t_{ik} = 0$. Their Nash tariff on the nonmember country j is t^{AU}. The notation is as follows:

$B_z^{AU}(t^{AU}, 0, 0, t^{AU})$ is the immediate benefit of defection to country z, where $z = \{i, k\}$

$B_j^{AU}(t_j^M, t_j^M)$ is the immediate benefit of defection to country j

$C_z^{AU}(t^{AU}, t_j^M)$ is the per-period cost of defection to country z, where $z = \{i, j, k\}$

δ_z^{AU} is the critical discount factor of country z, where $z = \{i, j, k\}$

$\phi_z^{AU}(\delta_z^{AU}, B_z^{AU}, C_z^{AU})$ is country z's degree of cooperation, where $z = \{i, j, k\}$

The expressions for δ_i^{AU}, δ_j^{AU}, are δ_k^{AU} are derived in Appendix C.5. As with an asymmetric FTA, three ICs must bind for free trade to be sustainable. Under an asymmetric CU, the degree of cooperation by country is as follows:

$$\phi_i^{AU}(\delta_i^{AU}, B_i^{AU}, C_i^{AU}) = \begin{cases} \delta_i^{AU} & : \ n_k \in [1.00, 3.13) \\ \text{Cooperate} & : \ n_k \in [3.13, \infty) \end{cases} \tag{37}$$

$$\phi_j^{AU}(\delta_j^{AU}, B_j^{AU}, C_j^{AU}) = \begin{cases} \delta_j^{AU} & : \ n_k \in [1.00, 5.33) \\ \text{Defect} & : \ n_k \in [5.33, \infty) \end{cases} \tag{38}$$

$$\phi_k^{AU}(\delta_k^{AU}, B_k^{AU}, C_k^{AU}) = \begin{cases} \delta_k^{AU} & : \ n_k \in [1.00, \infty) \end{cases} \tag{39}$$

As with an asymmetric FTA, country j unconditionally defects from free trade for sufficiently large n_k. The reasoning is analogous to that under MFN. Unlike an asymmetric FTA, country i unconditionally cooperates over free trade for sufficiently large n_k. The intuition is that for sufficiently large n_k, the increase in local profits, export profits (in country k's market) and government revenue from defection fail to outweigh the loss to consumers from defection: the increase in profits is not sufficient as country k's market becomes more competitive. Therefore, the benefit to country i is negative. Using (37), (38) and (39), the following result can be shown.

Lemma 5. $\Phi^{AU}(\phi_i^{AU}, \phi_j^{AU}, \phi_k^{AU})$ *yields the degree of equilibrium cooperation under an asymmetric CU:*

$$\Phi^{AU}(\phi_i^{AU}, \phi_j^{AU}, \phi_k^{AU}) = \begin{cases} \delta_k^{AU} & : \ n_k \in [1.00, 2.60) \\ \delta_j^{AU} & : \ n_k \in [2.60, 5.33) \\ \textit{No cooperation } (j) & : \ n_k \in [5.33, \infty) \end{cases}$$

Under an asymmetric CU, multilateral cooperation over free trade is sustainable if and only if all countries are sufficiently patient and n_k is sufficiently small. If n_k is sufficiently large, then cooperation is not sustainable: country j will unconditionally defect. As it is the IC of the member least willing to cooperate that determines the degree of equilibrium cooperation, that country i unconditionally cooperates does not affect equilibrium cooperation.

Proposition 8. *Relative to MFN, an asymmetric CU affects the degree of equilibrium cooperation as follows:*

n_k	Φ^M	Φ^{AU}	**Equilibrium cooperation**
$(1.00, 2.20)$	δ_i^M, δ_j^M	δ_k^{AU}	*Decreases as* $\delta_i^M < \delta_k^{AU}$
$[2.20, 2.25)$	δ_i^M, δ_j^M	δ_k^{AU}	*Increases as* $\delta_i^M > \delta_k^{AU}$
$[2.25, 2.60)$	δ_i^M, δ_j^M	δ_k^{AU}	*Increases as* $\delta_i^M > \delta_k^{AU}$
$[2.60, 3.84)$	δ_i^M, δ_j^M	δ_j^{AU}	*Increases as* $\delta_i^M > \delta_j^{AU}$
$[3.84, 5.33)$	*No cooperation*	δ_j^{AU}	*Increases*
$[5.33, \infty)$	*No cooperation*	*No cooperation*	*No effect*

Relative to an FTA, an asymmetric CU affects the degree of equilibrium cooperation as follows:

n_k	Φ^{AF}	Φ^{AU}	**Equilibrium cooperation**
$(1.00, 1.51)$	δ_j^{AF}	δ_k^{AU}	*Decreases as* $\delta_j^{AF} < \delta_k^{AU}$
$[1.51, 2.44)$	δ_j^{AF}	δ_k^{AU}	*Increases as* $\delta_j^{AF} > \delta_k^{AU}$
$[2.44, 2.60)$	*No cooperation*	δ_k^{AU}	*Increases*
$[2.60, 5.33)$	*No cooperation*	δ_j^{AU}	*Increases*
$[5.33, \infty)$	*No cooperation*	*No cooperation*	*No effect*

Proposition 8 follows immediately from Lemma 1, Lemma 4, and Lemma 5.[25] Unlike a symmetric CU, an asymmetric CU increase the degree of equilibrium cooperation relative to both MFN for $n_k \in [2.20, 3.84)$ and an FTA for $n_k \in [1.51, 5.33)$. This result dominates that with the symmetric FTA, as n_k takes on integer values in this range.

We conclude this subsection with Corollary 1, which follows immediately from all preceding lemmas.

[25] Under an asymmetric CU, Figure 6 and Figure 7 display the degree of cooperation by country relative to MFN and an FTA, respectively. The intuition for changes in the costs and benefits of defection are similiar to that under a symmetric CU. However, note that asymmetric CU members do not raise external tariffs and thus, there is no gain from such relative to MFN.

Corollary 1. *Cooperation over free trade is not sustainable under any trade regime for* $n_k > 5.33$*.*

4.6 Discussion

We find that (1) a symmetric FTA and an asymmetric CU can promote cooperation relative to MFN and (2) an asymmetric CU can promote cooperation relative to an FTA. We emphasize that this result does not indicate that for cooperation over free trade, a symmetric FTA dominates an asymmetric FTA and an asymmetric CU dominates a symmetric CU. We can disprove this notion by slightly adjusting the model.

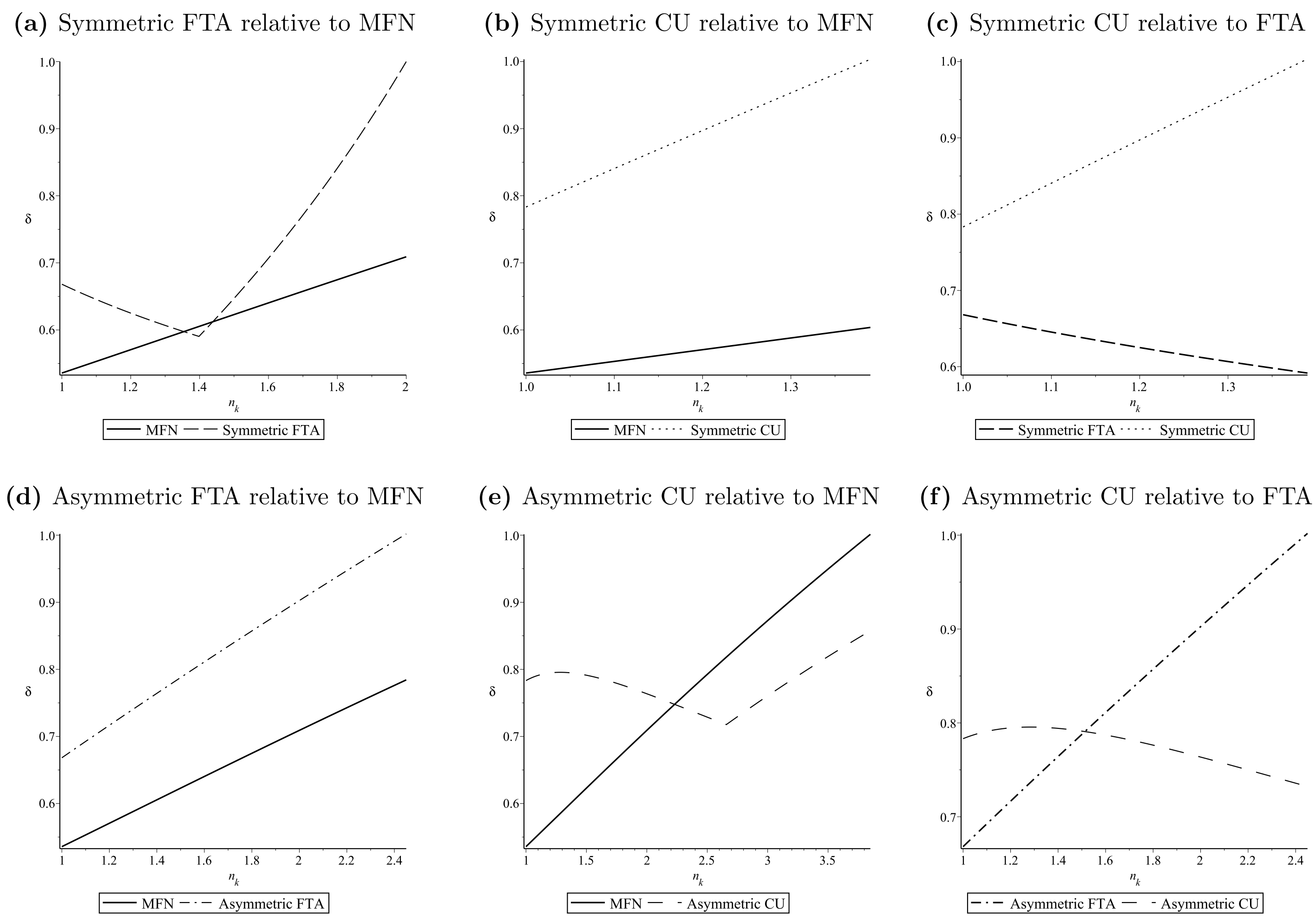
Consider an alternative market structure specification: good x is produced by a monopolist in country k, but by n_{ij} firms in both country i and country j. All other assumptions and notation remain the same. Under this specification, we find that (1) an asymmetric FTA and a symmetric CU can promote cooperation relative to MFN and (2) a symmetric CU can promote cooperation relative to an FTA. We omit the supporting algebra, but point the reader to Figure 8, which demonstrates this result graphically. Note that these results are the opposite of those from the original market structure specification. This suggests that general conclusion ought to be that PTAs can be building blocks to free trade when countries are asymmetric with respect to market structure. But the exact composition of such PTAs is unclear.

Generally speaking, there are two drawbacks to this model. First, it is unclear whether the results are robust to different assumptions about demand and cost. Second, in the case of the symmetric FTA, we examine noninteger numbers of firms. Although we prefer only integer numbers, there is no clear method that corrects for this deficiency.

5 Conclusions

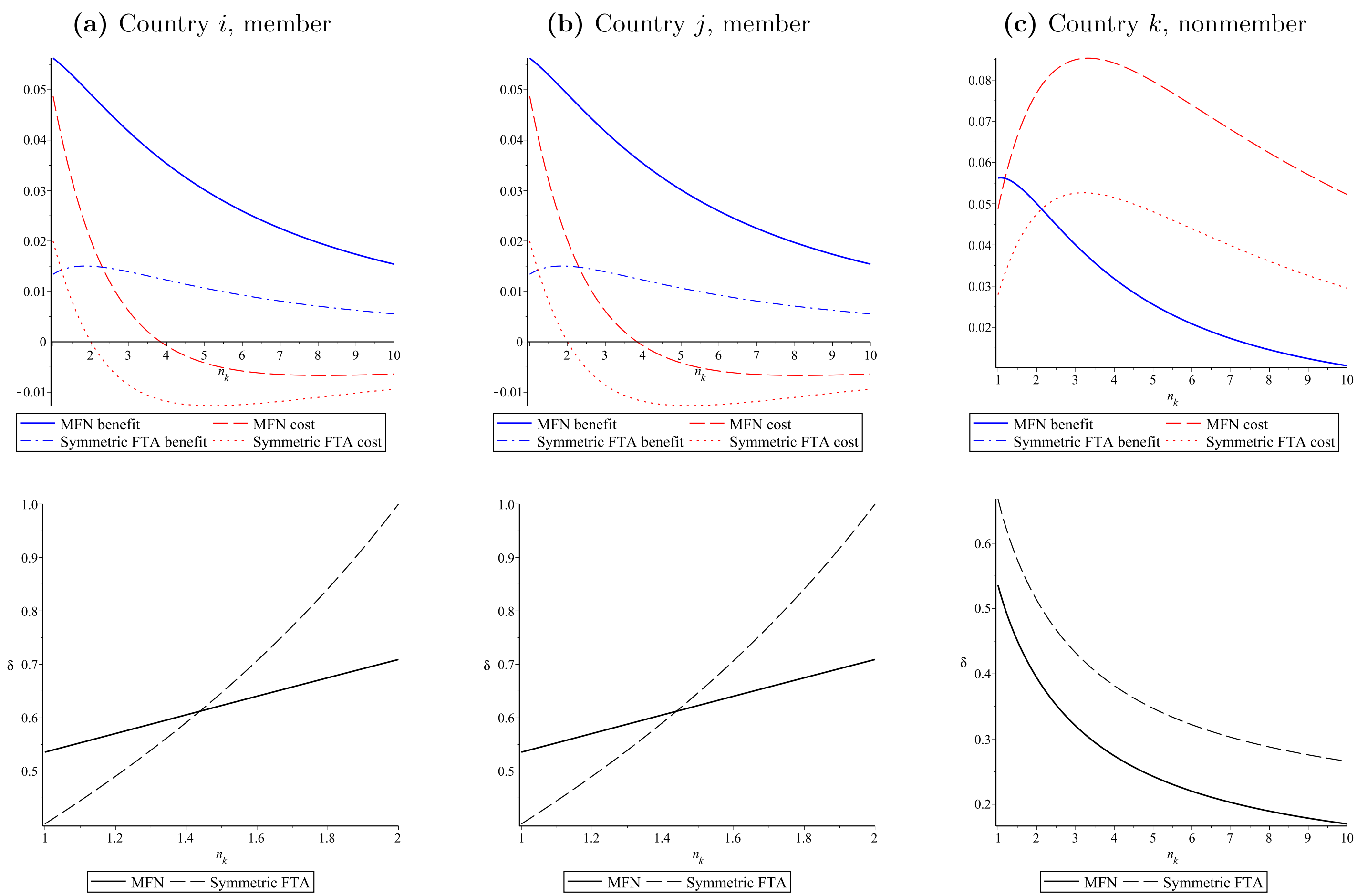
In this paper, we examine how the circumstances under which preferential trade agreements promote or slow multilateral trade liberalization depend on market structure. We find that the formation of a symmetric FTA, an asymmetric FTA and an asymmetric CU induced lower external tariffs in the static game. A PTA between two asymmetric countries may reduce members welfare relative to MFN. Under infinite repetition of the static tariff game, countries attempt to cooperate over free trade. Countries use infinite reversion to Nash tariffs as a punishment strategy to enforce cooperation over free trade. We find that the severity of a country's punishment strategy declines with the number of firms in its market: as a result, we find instances where countries may unconditionally defect from free trade. The key result is that there are circumstances where PTAs promote cooperation relative to MFN and CUs enable cooperation relative to FTAs. In all, this paper suggests that market structure is an important variable that ought not be ignored in theoretical models of regionalism and multilateralism.

Figure 1: Degree of equilibrium cooperation



Note: A symmetric FTA and an asymmetric CU can promote cooperation relative to MFN. An asymmetric CU can promote cooperation relative to an FTA. All other tariff regimes never promote cooperation relative to comparable regimes.

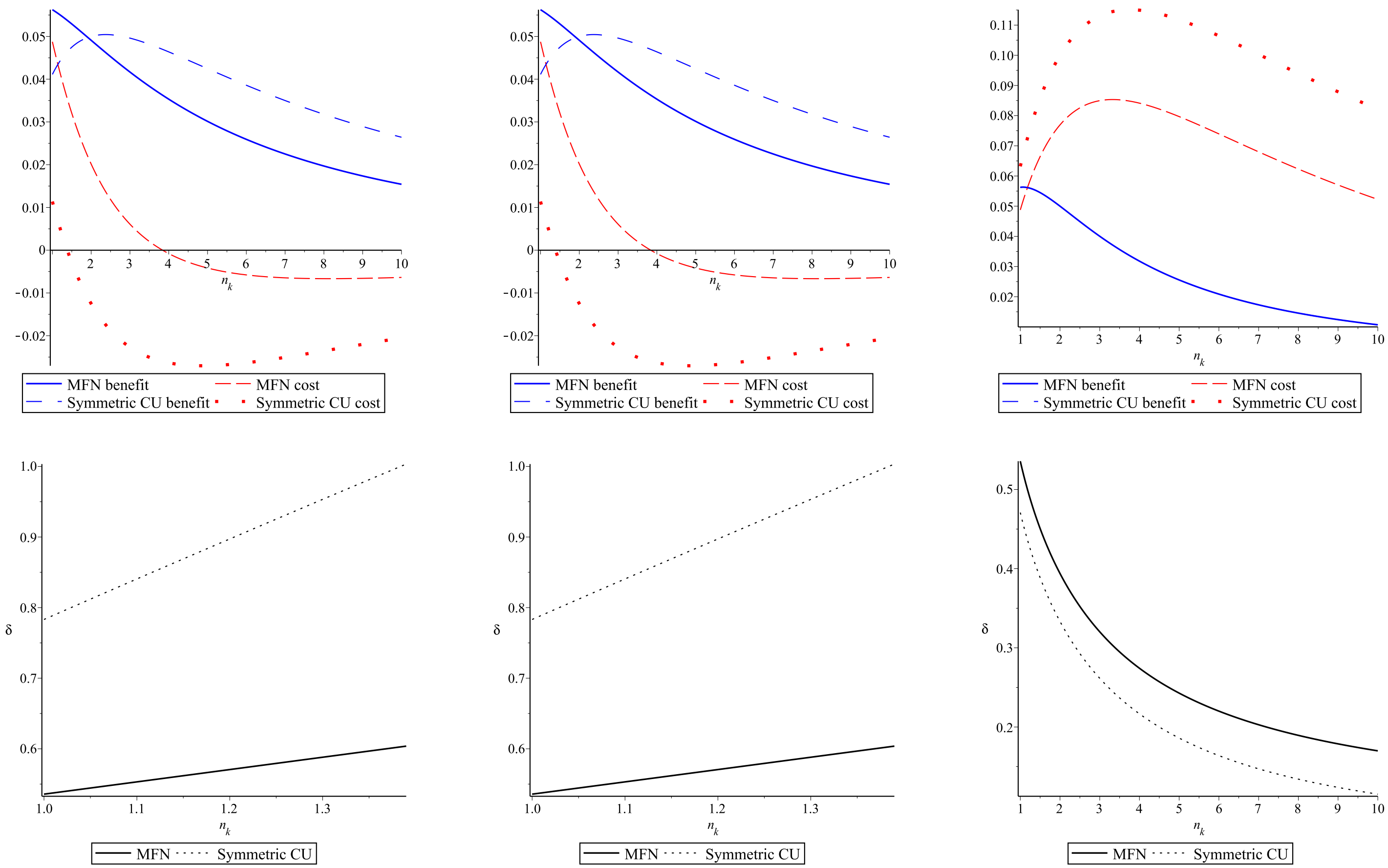
Figure 2: Degree of cooperation by country, symmetric FTA relative to MFN



Note: For member countries i and j, $B_i^{SF} = B_j^{SF} < B_j^M = B_i^M$ and $C_i^{SF} = C_j^{SF} < C_j^M = C_i^M$. We have that $\delta_i^{SF} = \delta_j^{SF} < \delta_j^M = \delta_i^M$ for $n_k \in [1, 1.44)$. For the nonmember country k, $B_k^{SF} = B_k^M$ and $C_k^{SF} < C_k^M$. Therefore, $\delta_k^M < \delta_k^{SF}$.

Figure 3: Degree of cooperation by country, symmetric CU relative to MFN

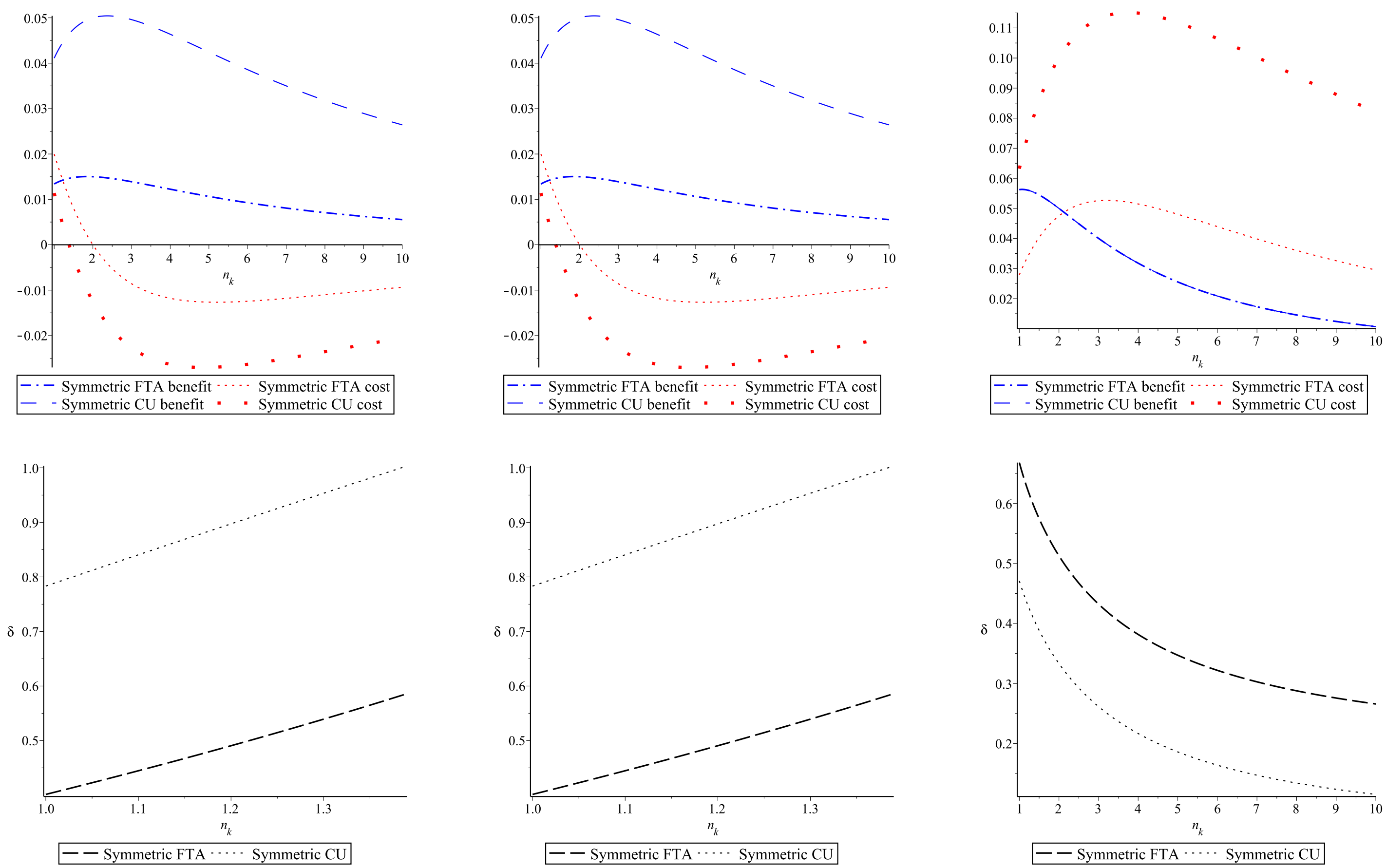
(a) Country i, member **(b)** Country j, member **(c)** Country k, nonmember



Note: For member countries i and j, $B_i^{SU} = B_j^{SU} < B_j^M = B_i^M$ for sufficiently large n_k and $C_i^{SU} = C_j^{SU} < C_j^M = C_i^M$. We have that $\delta_i^M = \delta_j^M < \delta_j^{SU} = \delta_i^{SU}$ for $n_k \in [1, 1.39)$. For the nonmember country k, $B_k^{SU} = B_k^M$ and $C_k^M < C_k^{SU}$. Therefore, $\delta_k^{SU} < \delta_k^M$.

Figure 4: Degree of cooperation by country, symmetric CU relative to FTA

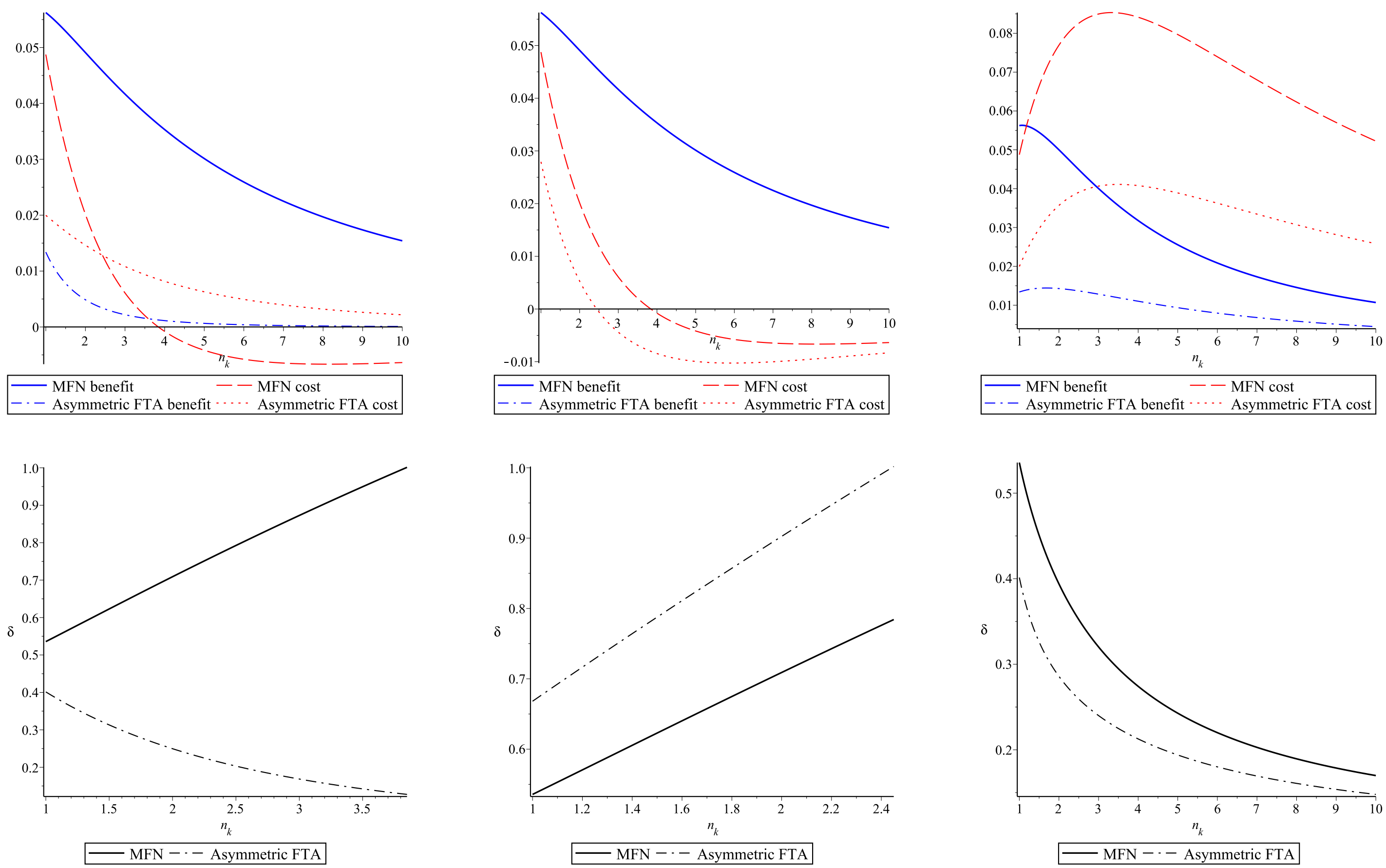
(a) Country i, member — **(b)** Country j, member — **(c)** Country k, nonmember



Note: For member countries i and j, $B_i^{SU} = B_j^{SU} < B_j^{SF} = B_i^{SF}$ and $C_i^{SU} = C_j^{SU} < C_j^{SF} = C_i^{SF}$. We have that $\delta_i^{SF} = \delta_j^{SF} < \delta_j^{SU} = \delta_i^{SU}$ for $n_k \in [1, 1.39)$. For the nonmember country k, $B_k^{SU} = B_k^{SF}$ and $C_k^{SF} < C_k^{SU}$. Therefore, $\delta_k^{SU} < \delta_k^{SF}$.

Figure 5: Degree of cooperation by country, asymmetric FTA relative to MFN

(a) Country i, member **(b)** Country j, nonmember **(c)** Country k, member



Note: For member country i, $C_i^M < C_i^{AF}$ for sufficiently small n_k and $B_i^{AF} < B_i^M$. Therefore, $\delta_i^{AF} < \delta_i^M$ for $n_k \in [1, 3.85)$. For member country k, $C_k^{AF} < C_k^M$ and $B_k^{AF} < B_k^M$. We have that $\delta_k^{AF} < \delta_k^M$. For nonmember country j, $B_j^{AF} = B_j^M$ and $C_j^{AF} < C_j^M$. Therefore, $\delta_k^M < \delta_k^{AF}$ for $n_k \in [1, 2.44)$.

Figure 6: Degree of cooperation by country, asymmetric CU relative to MFN

(a) Country i, member **(b)** Country j, nonmember **(c)** Country k, member

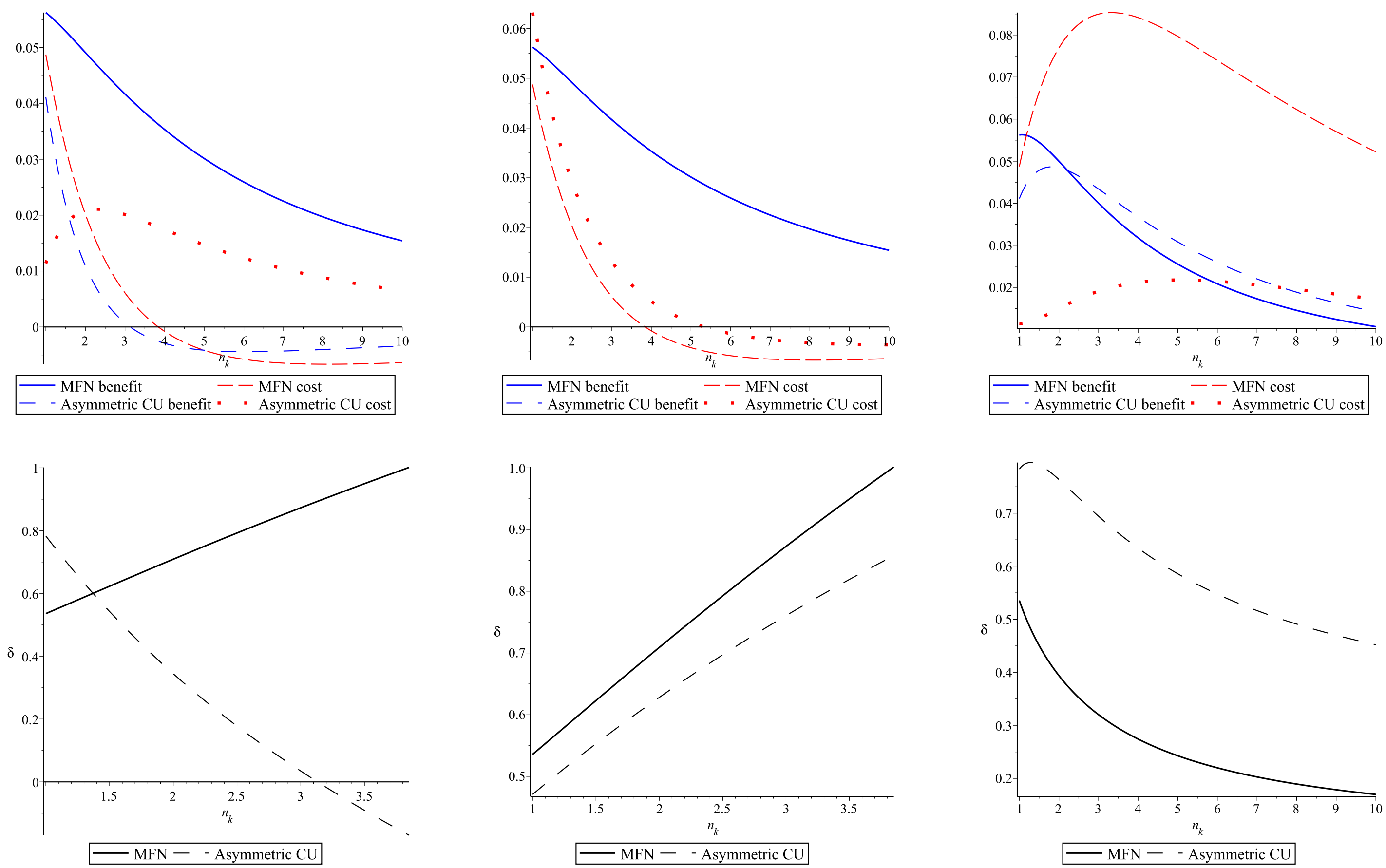


Figure 7: Degree of cooperation by country, asymmetric CU relative to FTA

(a) Country i, member **(b)** Country j, nonmember **(c)** Country k, member

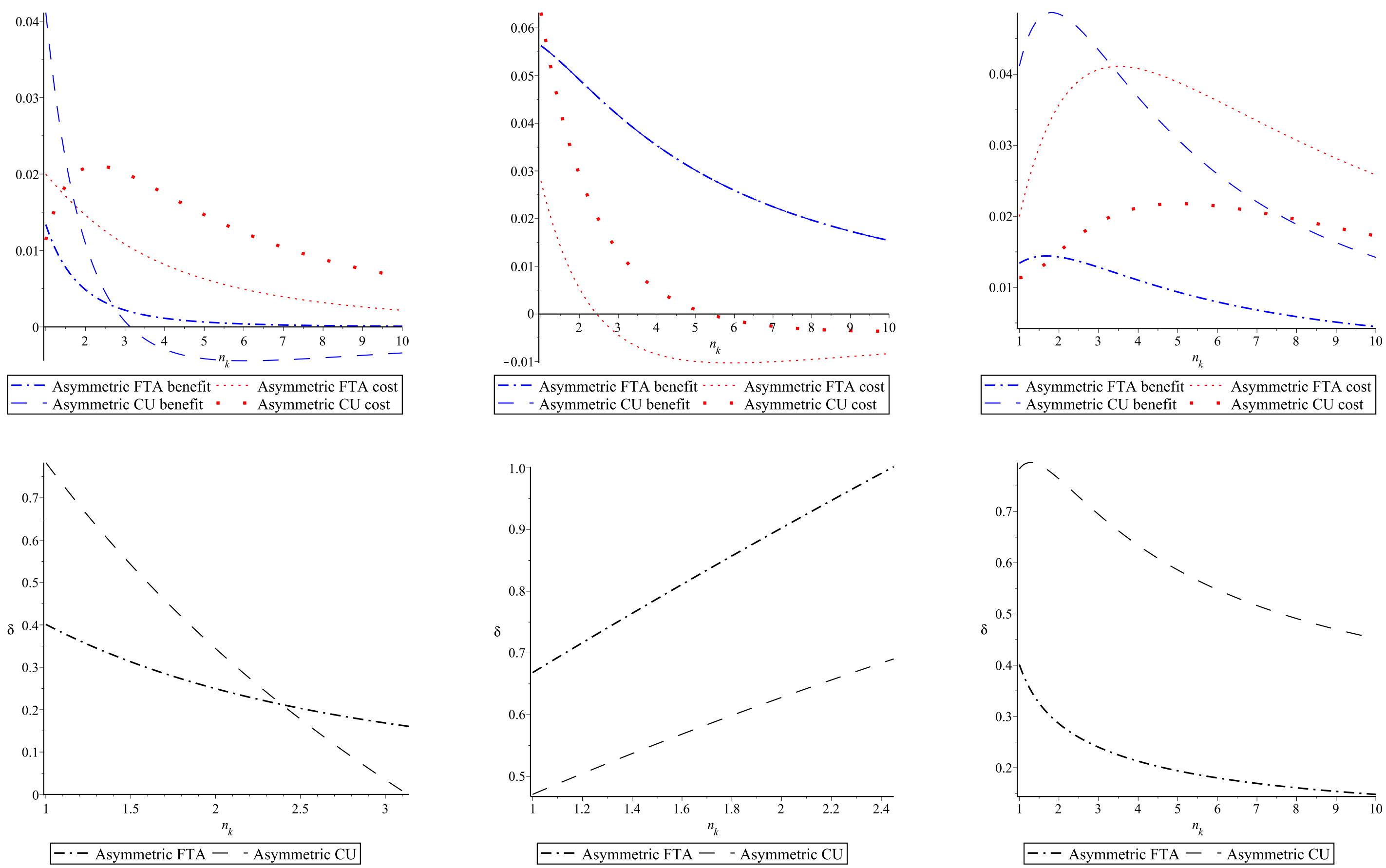
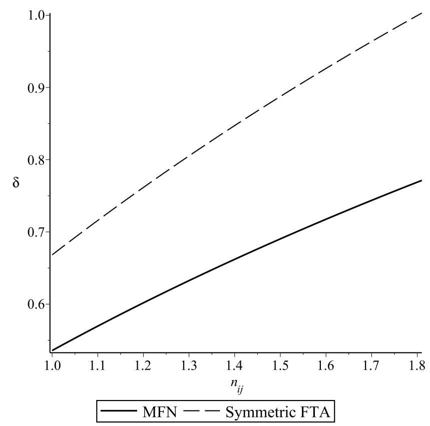
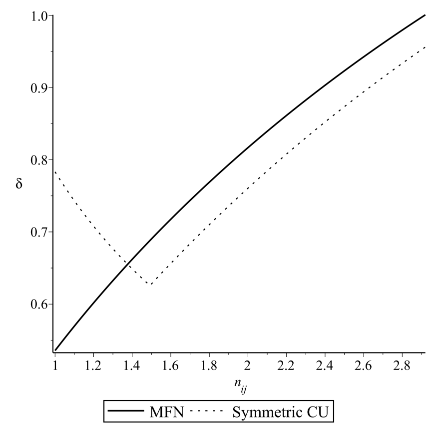


Figure 8: Degree of equilibrium cooperation, alternative market structure specification

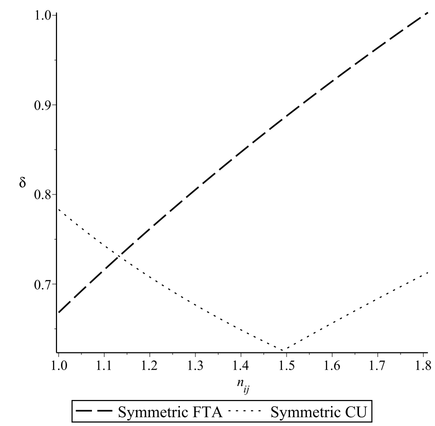
(a) Symmetric FTA relative to MFN



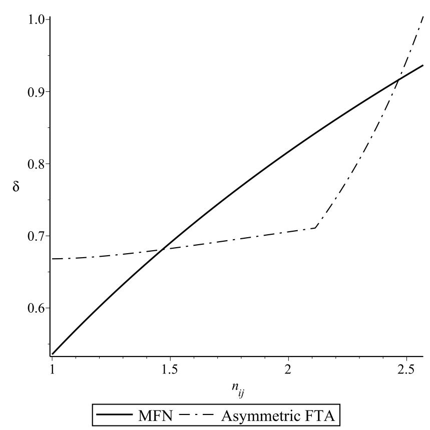
(b) Symmetric CU relative to MFN



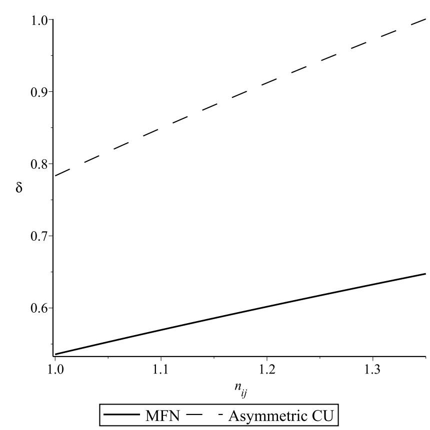
(c) Symmetric CU relative to FTA



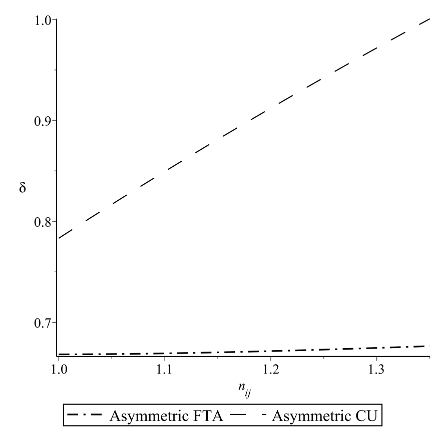
(d) Asymmetric FTA relative to MFN



(e) Asymmetric CU relative to MFN



(f) Asymmetric CU relative to FTA



Note: An asymmetric FTA and a symmetric CU can promote cooperation relative to MFN. A symmetric CU can promote cooperation relative to an FTA. All other tariff regimes never promote cooperation relative to comparable regimes.

Appendix

A Output functions

To choose how much to supply to the market in country i, each firm from country z solves the following problem:

$$\max_{x_{zi}} \pi_{zi} = (p_i - t_{zi})\, x_{zi} \tag{40}$$

The first order condition of (40) is:

$$\frac{d\pi_{zi}}{dx_{zi}} = p_i + \frac{dp_i}{dx_{zi}} x_{zi} - t_{zi}$$

There are $2 + n_k$ first order conditions, one for each firm in the world:

$$\begin{array}{ccccccccccccccccc}
2x_{ii} & + & x_{ji} & + & x_{ki}^{(1)} & + & x_{ki}^{(2)} & + & \cdots & + & x_{ki}^{(n_k-1)} & + & x_{ki}^{(n_k)} & + & t_{ii} & - & 1 \\
x_{ii} & + & 2x_{ji} & + & x_{ki}^{(1)} & + & x_{ki}^{(2)} & + & \cdots & + & x_{ki}^{(n_k-1)} & + & x_{ki}^{(n_k)} & + & t_{ji} & - & 1 \\
x_{ii} & + & x_{ji} & + & 2x_{ki}^{(1)} & + & x_{ki}^{(2)} & + & \cdots & + & x_{ki}^{(n_k-1)} & + & x_{ki}^{(n_k)} & + & t_{ki} & - & 1 \\
x_{ii} & + & x_{ji} & + & x_{ki}^{(1)} & + & 2x_{ki}^{(2)} & + & \cdots & + & x_{ki}^{(n_k-1)} & + & x_{ki}^{(n_k)} & + & t_{ki} & - & 1 \\
\vdots & & \vdots & & \vdots & & \vdots & & & & \vdots & & \vdots & & \vdots & & \vdots \\
x_{ii} & + & x_{ji} & + & x_{ki}^{(1)} & + & x_{ki}^{(2)} & + & \cdots & + & 2x_{ki}^{(n_k-1)} & + & x_{ki}^{(n_k)} & + & t_{ki} & - & 1 \\
x_{ii} & + & x_{ji} & + & x_{ki}^{(1)} & + & x_{ki}^{(2)} & + & \cdots & + & x_{ki}^{(n_k-1)} & + & 2x_{ki}^{(n_k)} & + & t_{ki} & - & 1
\end{array}$$

where

$$x_{ki}^{(1)}, x_{ki}^{(2)}, \cdots, x_{ki}^{(n_k-1)}, x_{ki}^{(n_k)}$$

are the outputs of the n_k firms from country k. These firms are symmetric and face the same tariff schedule in country z. Thus, the outputs of the firms from country k must be equal.

$$x_{ki}^{(1)} = x_{ki}^{(2)} = \cdots = x_{ki}^{(n_k-1)} = x_{ki}^{(n_k)} \tag{41}$$

Using (41), we reduce the $2 + n_k$ first order conditions to a system of three equations with three unknowns, x_{iz}, x_{jz} and x_{kz}:

$$\begin{array}{ccccccccccc}
2x_{iz} & + & x_{jz} & + & n_k x_{kz} & + & t_{iz} & - & 1 & = & 0 \\
x_{iz} & + & 2x_{jz} & + & n_k x_{kz} & + & t_{jz} & - & 1 & = & 0 \\
x_{iz} & + & x_{jz} & + & (n_k+1)x_{kz} & + & t_{kz} & - & 1 & = & 0
\end{array} \tag{42}$$

We solve (42) for the output function of each firm. Derivation of output functions in one market yields expressions for every market. These output functions follow.

$$x_{iz} = \frac{1}{N+1} + \frac{t_{iz} + t_{jz} + n_k t_{kz}}{N+1} - t_{iz}$$

$$x_{jz} = \frac{1}{N+1} + \frac{t_{iz} + t_{jz} + n_k t_{kz}}{N+1} - t_{jz}$$

$$x_{kz} = \frac{1}{N+1} + \frac{t_{iz} + t_{jz} + n_k t_{kz}}{N+1} - t_{kz}$$

B Nash tariffs

In this section, we derive Nash tariffs under various tariff regimes.

B.1 MFN

To set its MFN tariff, country i solves the following problem:

$$\begin{aligned} \max_{t_{ji}, t_{ki}} \quad & S_i = CS_i(t_{ji}, t_{ki}) + \pi_{ii}(t_{ji}, t_{ki}) + TR_i(t_{ji}, t_{ki}) \\ \text{subject to} \quad & t_{ji} = t_{ki} \end{aligned} \tag{43}$$

Because of market segmentation, country i's objective function is its domestic surplus and not its welfare. Let $t_i^M = t_{ji} = t_{ki}$. Using expressions (5), (6), and (7), the first order condition of (43) is:

$$\frac{dS_i}{dt_i^M} = -\frac{(1+n_k)\left(n_k t_i^M - 3 + 9\, t_i^M\right)}{(3+n_k)^2} \tag{44}$$

We solve (44) for country i's MFN tariff.

$$t_i^M = \frac{3}{n_k + 9}$$

By symmetry, $t_i^M = t_j^M$. To set its MFN tariff, country k solves the following problem:

$$\begin{aligned} \max_{t_{ik}, t_{jk}} \quad & S_k = CS_k(t_{ik}, t_{jk}) + n_k \pi_{kk}(t_{ik}, t_{jk}) + TR_k(t_{ik}, t_{jk}) \\ \text{subject to} \quad & t_{ik} = t_{jk} \end{aligned} \tag{45}$$

Because of market segmentation, country k's objective function is its domestic surplus and not its welfare. Let $t_k^M = t_{ik} = t_{jk}$. Using expressions (5), (6), and (7), the first order condition of (45) is:

$$\frac{dS_k}{dt_k^M} = -2\,\frac{-1 - 2\,n_k + 4\,t_k^M + 4\,n_k t_k^M + 2\,n_k^2 t_k}{(3+n_k)^2} \tag{46}$$

We solve (46) for country k's MFN tariff.

$$t_k^M = \frac{1 + 2n_k}{4 + 4n_k + 2n_k^2}$$

B.2 Symmetric FTA

To set its Nash tariff on country k, country i solves the following problem:

$$\begin{aligned} \max_{t_{ji},t_{ki}} \quad & S_i = CS_i(t_{ji},t_{ki}) + \pi_{ii}(t_{ji},t_{ki}) + TR_i(t_{ji},t_{ki}) \\ \text{subject to} \quad & t_{ji} = 0 \end{aligned} \tag{47}$$

Because of market segmentation, country i's objective function is its domestic surplus and not its welfare. Let $t_i^{SF} = t_{ki}$. Using expressions (5), (6), and (7), the first order condition of (47) is:

$$\frac{dS_i}{dt_i^{SF}} = -3\,\frac{n_k\left(n_k t_i^{SF} - 1 + 6\,t_i^{SF}\right)}{\left(3+n_k\right)^2} \tag{48}$$

We solve (48) for country i's Nash tariff on country k.

$$t_i^{SF} = \frac{1}{n_k + 6}$$

By symmetry, $t_i^{SF} = t_j^{SF}$.

B.3 Symmetric CU

To set their Nash tariff on country k, countries i and j solve the following problem:

$$\begin{aligned} \max_{t_{ji},t_{ki},t_{ij},t_{kj}} \quad & W_i(t_{ji},t_{ki},t_{ij},t_{kj},t_{ik},t_{jk}) + W_j(t_{ji},t_{ki},t_{ij},t_{kj},t_{ik},t_{jk}) \\ \text{subject to} \quad & t_{ji} = t_{ij} = 0 \text{ and } t_{ki} = t_{kj} \end{aligned} \tag{49}$$

Due to market segmentation, (49) yields same tariff as the following problem:

$$\begin{aligned} \max_{t_{ji}} \quad & S_i(t_{ji},t_{ki}) + \pi_{ji}(t_{ji},t_{ki}) \\ \text{subject to} \quad & t_{ji} = 0 \end{aligned} \tag{50}$$

Let $t^{SU} = t_{ki} = t_{kj}$. Using expressions (5), (6), and (7), the first order condition of (50) is:

$$\frac{d(S_i + \pi_{ji})}{dt^{SU}} = -\frac{n_k\left(-5 + n_k t^{SU} + 18\,t^{SU}\right)}{\left(3+n_k\right)^2} \tag{51}$$

We solve (51) for countries i's and j's Nash tariff on country k.

$$t^{SU} = \frac{5}{n_k + 18}$$

B.4 Asymmetric FTA

To set its Nash tariff on country j, country i solves the following problem:

$$\begin{aligned} \max_{t_{ji},t_{ki}} \quad & S_i = CS_i(t_{ji},t_{ki}) + \pi_{ii}(t_{ji},t_{ki}) + TR_i(t_{ji},t_{ki}) \\ \text{subject to} \quad & t_{ki} = 0 \end{aligned} \tag{52}$$

Because of market segmentation, country i's objective function is its domestic surplus and not its welfare. Let $t_i^{AF} = t_{ji}$. Using expressions (5), (6), and (7), the first order condition of (52) is:

$$\frac{dS_i}{dt_i^{AF}} = -\frac{-3 + 9\,t_i^{AF} + 10\,n_k t_i^{AF} + 2\,n_k^2 t_i^{AF}}{(3+n_k)^2} \tag{53}$$

We solve (53) for country i's Nash tariff on country j.

$$t_i^{AF} = \frac{3}{9 + 10n_k + 2n_k^2}$$

To set its Nash tariff on country j, country k solves the following problem:

$$\begin{aligned} \max_{t_{ik},t_{jk}} \quad & S_k = CS_j(t_{ik},t_{jk}) + n_k\pi_{kk}(t_{ik},t_{jk}) + TR_k(t_{ik},t_{jk}) \\ \text{subject to} \quad & t_{ik} = 0 \end{aligned} \tag{54}$$

Because of market segmentation, country k's objective function is its domestic surplus and not its welfare. Let $t_k^{AF} = t_{jk}$. Using expressions (5), (6), and (7), the first order condition of (54) is:

$$\frac{dS_k}{dt_k^{AF}} = -\frac{-1 - 2\,n_k + 11\,t_k^{AF} + 8\,n_k t_k^{AF} + 2\,n_k^2 t_k^{AF}}{(3+n_k)^2} \tag{55}$$

We solve (55) for country k's Nash tariff on country j.

$$t_k^{AF} = \frac{1 + 2n_k}{11 + 8n_k + 2n_k^2}$$

B.5 Asymmetric CU

To set their Nash tariff on country j, countries i and k solve the following problem:

$$\begin{aligned} \max_{t_{ji},t_{ki},t_{ik},t_{jk}} \quad & W_i(t_{ji},t_{ki},t_{ij},t_{kj},t_{ik},t_{jk}) + W_k(t_{ji},t_{ki},t_{ij},t_{kj},t_{ik},t_{jk}) \\ \text{subject to} \quad & t_{ki} = t_{ik} = 0 \text{ and } t_{ji} = t_{jk} \end{aligned} \tag{56}$$

Due to market segmentation, (56) yields same tariff as the following problem:

$$\begin{aligned} \max_{t_{ji}} \quad & S_i(t_{ji},t_{ki}) + n_k\pi_{ki}(t_{ji},t_{ki}) \\ \text{subject to} \quad & t_{ki} = 0 \end{aligned} \tag{57}$$

Let $t^{AU} = t_{ji} = t_{jk}$. Using expressions (5), (6), and (7), the first order condition of (57) is:

$$\frac{d(S_i + \pi_{ki})}{dt^{AU}} = -\frac{-3 - 2\,n_k + 9\,t^{AU} + 8\,n_k t^{AU} + 2\,n_k^2 t^{AU}}{(3+n_k)^2} \tag{58}$$

We solve (58) for countries i's and k's Nash tariff on country j.

$$t^{AU} = \frac{3 + 2n_k}{9 + 8n_k + 2n_k^2}$$

C Incentive constraints

In this section, we derive each country's incentive constraint (IC) under various tariff regimes.

C.1 MFN

The incentive constraint for country i under MFN is derived in the text. By symmetry, $\delta_i^M = \delta_j^M$. The expression for δ_i^M and δ_j^M follows.

$$\delta_i^M = \delta_j^M = 18\,\frac{(9+n_k)\,(n_k+1)\left(2+2\,n_k+{n_k}^2\right)^2}{4728\,n_k + 5674\,{n_k}^2 + 3416\,{n_k}^3 + 1123\,{n_k}^4 + 136\,{n_k}^5 + 4\,{n_k}^6 + 1719}$$

Under MFN, country k's incentive constraint is:

$$B_k^M(t_k^M, t_k^M) \leq \frac{\delta_k^M}{1-\delta_k^M}\; C_k^M(t_i^M, t_j^M, t_k^M) \tag{59}$$

where the immediate benefit of defection is:

$$B_k^M(t_k^M, t_k^M) = S_k(t_k^M, t_k^M) - S_k(0,0) \tag{60}$$

and the future per-period cost of defection is:

$$C_k^M(t_i^M, t_j^M, t_k^M) = W_k^{FT}(0) - W_k^M(t_i^M, t_j^M, t_k^M) \tag{61}$$

We substitute (60) and (61) into (59) and solve for δ_k^M.

$$\delta_k^M = \frac{1}{48}\,\frac{(9+n_k)^2\,(1+2\,n_k)^2}{n_k\,(6+n_k)\,(2+2\,n_k+{n_k}^2)}$$

C.2 Symmetric FTA

The incentive constraint for country i under a symmetric FTA is derived in the text. By symmetry, $\delta_i^{SF} = \delta_j^{SF}$. The expression for δ_i^{SF} and δ_j^{SF} follows.

$$\delta_i^{SF} = \delta_j^{SF} = -6\,\frac{n_k\,(6+n_k)\left(2+2\,n_k+{n_k}^2\right)^2}{-252 - 828\,n_k - 1003\,{n_k}^2 - 494\,{n_k}^3 - 79\,{n_k}^4 + 32\,{n_k}^5 + 8\,{n_k}^6}$$

The incentive constraint for country k under a symmetric FTA is derived in the text. The expression for δ_k^{SF} follows.

$$\delta_k^{SF} = \frac{1}{12} \frac{(6+n_k)^2 (1+2\,n_k)^2}{n_k (2\,n_k+9)(2+2\,n_k+{n_k}^2)}$$

C.3 Symmetric CU

The incentive constraint for country i under a symmetric CU is derived in the text. By symmetry, $\delta_i^{SU} = \delta_j^{SU}$. The expression for δ_i^{SU} and δ_j^{SU} follows.

$$\delta_i^{SU} = \delta_j^{SU} = 50 \frac{n_k \left(2+2\,n_k+{n_k}^2\right)^2}{(18+n_k)(1+2\,n_k)(n_k+1)(2\,{n_k}^2+5\,n_k+7)}$$

The incentive constraint for country k under a symmetric CU is derived in the text. The expression for δ_k^{SU} follows.

$$\delta_k^{SU} = \frac{1}{60} \frac{(18+n_k)^2 (1+2\,n_k)^2}{n_k (2\,n_k+21)(2+2\,n_k+{n_k}^2)}$$

C.4 Asymmetric FTA

Under an asymmetric FTA, country i's incentive constraint is:

$$B_i^{AF}(t_i^{AF}, 0) \leq \frac{\delta_i^{AF}}{1-\delta_i^{AF}} C_i^{AF}(t_i^{AF}, t_j^M, t_k^{AF}) \tag{62}$$

where the immediate benefit of defection is:

$$B_i^{AF}(t_i^{AF}, 0) = S_i(t_i^{AF}, 0) - S_i(0,0) \tag{63}$$

and the future per-period cost of defection is:

$$C_i^{AF}(t_i^{AF}, t_j^M, t_k^{AF}) = W_i^{FT}(0) - W_i^{AF}(t_i^{AF}, t_j^M, t_k^{AF}) \tag{64}$$

We substitute (63) and (64) into (62) and solve for δ_i^{AF}.

$$\delta_i^{AF} = \frac{9}{2} \frac{(9+n_k)^2 \left(11+8\,n_k+2\,{n_k}^2\right)^2}{(9+10\,n_k+2\,{n_k}^2)(40\,{n_k}^5+488\,{n_k}^4+2168\,{n_k}^3+5473\,{n_k}^2+8526\,n_k+6849)}$$

Under an asymmetric FTA, country j's incentive constraint is:

$$B_j^{AF}(t_j^M, t_j^M) \leq \frac{\delta_j^{AF}}{1-\delta_j^{AF}} C_j^{AF}(t_i^{AF}, t_j^M, t_k^{AF}) \tag{65}$$

where the immediate benefit of defection is:

$$B_j^{AF}(t_j^M, t_j^M) = S_j(t_j^M, t_j^M) - S_j(0,0) = B_j^M(t_j^M, t_j^M) \tag{66}$$

The benefit of defection is the same as that under MFN. The future per-period cost of defection is:

$$C_j^{AF}(t_i^{AF}, t_j^M, t_k^{AF}) = W_j^{FT}(0) - W_j^{AF}(t_i^{AF}, t_j^M, t_k^{AF}) \tag{67}$$

We substitute (66) and (67) into (65) and solve for δ_j^{AF}.

$$\delta_j^{AF} = \frac{9}{4} \frac{(n_k+1)\left(9+10\,n_k+2\,{n_k}^2\right)^2\left(11+8\,n_k+2\,{n_k}^2\right)^2}{(9+n_k)(2+n_k)(8\,{n_k}^7+152\,{n_k}^6+1148\,{n_k}^5+4588\,{n_k}^4+ 10576\,{n_k}^3+14080\,{n_k}^2+10119\,n_k+2988)}$$

Under an asymmetric FTA, country k's incentive constraint is:

$$B_k^{AF}(0, t_k^{AF}) \leq \frac{\delta_k^{AF}}{1-\delta_k^{AF}}\; C_k^{AF}(t_i^{AF}, t_j^M, t_k^{AF}) \tag{68}$$

where the immediate benefit of defection is:

$$B_k^{AF}(0, t_k^{AF}) = S_k(0, t_k^{AF}) - S_k(0,0) \tag{69}$$

and the future per-period cost of defection is:

$$C_k^{AF}(t_i^{AF}, t_j^M, t_k^{AF}) = W_k^{FT}(0) - W_k^{AF}(t_i^{AF}, t_j^M, t_k^{AF}) \tag{70}$$

We substitute (69) and (70) into (68) and solve for δ_k^{AF}.

$$\delta_k^{AF} = \frac{1}{6} \frac{(9+n_k)^2(1+2\,n_k)^2\left(9+10\,n_k+2\,{n_k}^2\right)^2}{n_k\,(11+8\,n_k+2\,{n_k}^2)(16\,{n_k}^5+252\,{n_k}^4+1412\,{n_k}^3+3279\,{n_k}^2+2646\,n_k+243)}$$

C.5 Asymmetric CU

Under an asymmetric CU, country i's incentive constraint is:

$$B_i^{AU}(t^{AU}, 0, 0, t^{AU}) \leq \frac{\delta_i^{AU}}{1-\delta_i^{AU}}\; C_i^{AU}(t^{AU}, t_j^M) \tag{71}$$

where the immediate benefit of defection is:

$$B_i^{AU}(t^{AU}, 0, 0, t^{AU}) = S_i(t^{AU}, 0) - S_i(0,0) + \pi_{ik}(0, t^{AU}) - \pi_{ik}(0,0) \tag{72}$$

and the future per-period cost of defection is:

$$C_i^{AU}(t^{AU}, t_j^M) = W_i^{FT}(0) - W_i^{AU}(t^{AU}, t_j^M) \tag{73}$$

We substitute (72) and (73) into (71) and solve for δ_i^{AU}.

$$\delta_i^{AU} = \frac{-1}{24} \frac{(3+2\,n_k)\left(4\,{n_k}^3+6\,{n_k}^2-36\,n_k-69\right)(9+n_k)^2}{(6+n_k)(9+8\,n_k+2\,{n_k}^2)^2}$$

Under an asymmetric CU, country j's incentive constraint is:

$$B_j^{AU}(t_j^M, t_j^M) \leq \frac{\delta_j^{AU}}{1-\delta_j^{AU}}\, C_j^{AU}(t^{AU}, t_j^M) \tag{74}$$

where the immediate benefit of defection is:

$$B_j^{AU}(t_j^M, t_j^M) = S_j(t_j^M, t_j^M) - S_j(0,0) = B_j^M(t_j^M, t_j^M) \tag{75}$$

The benefit of defection is the same as that under MFN. The future per-period cost of defection is:

$$C_j^{AU}(t^{AU}, t_j^M) = W_j^{FT}(0) - W_j(t^{AU}, t_j^M) \tag{76}$$

We substitute (75) and (76) into (74) and solve for δ_j^{AU}.

$$\delta_j^{AU} = \frac{9}{4}\,\frac{(n_k+1)\left(9+8\,n_k+2\,{n_k}^2\right)^2}{(9+n_k)\,(3+2\,n_k)\,(2+n_k)\,(2\,{n_k}^2+9\,n_k+12)}$$

Under an asymmetric CU, country k's incentive constraint is:

$$B_k^{AU}(t^{AU}, 0, 0, t^{AU}) \leq \frac{\delta_k^{AU}}{1-\delta_k^{AU}}\, C_k^{AU}(t^{AU}, t_j^M) \tag{77}$$

where the immediate benefit of defection is:

$$B_k^{AU}(t^{AU}, 0, 0, t^{AU}) = S_k(0, t^{AU}) - S_k(0,0) + \pi_{ki}(t^{AU}, 0) - \pi_{ki}(0,0) \tag{78}$$

and the future per-period cost of defection is:

$$C_k^{AU}(t^{AU}, t_j^M) = W_k^{FT}(0) - W_k^{AU}(t^{AU}, t_j^M) \tag{79}$$

We substitute (78) and (79) into (77) and solve for δ_k^{AU}.

$$\delta_k^{AU} = \frac{1}{24}\,\frac{(3+2\,n_k)\left(12\,{n_k}^3+50\,{n_k}^2+48\,n_k-15\right)(9+n_k)^2}{n_k\,(6+n_k)\,(9+8\,n_k+2\,{n_k}^2)^2}$$

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