Non-Enforceability of Trade Treaties and Investment Distortions.[1]

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Abstract The paper considers incentives for irreversible investments in exports when governments are imperfectly committed to their trade obligations. Once investments have been undertaken, *ex post,* it is frequently optimal for the governments to renegotiate *ex ante* trade barriers. In our game, these negotiations are costly; the greater the policy adjustment, the greater the expenses. We find that when the governments cannot fully commit to their trade obligations, bilateral trade agreements may be welfare superior to multilateral ones. We suggest that high costs of trade regime changes serve as a mechanism alleviating investment distortions stemming from low enforceability of international law.

Keywords: Trade Agreements, Enforcement, Time-inconsistent, Kemp-Wan, Imperfect Commitment, Game Theory and Bargaining

JEL classification: F02, F13, C7

Seductive doctrine of the strong that power and virtue go together.

Jagdish Bhagwati (1999)

1 Introduction

Economists unanimously agree that free trade regime is superior to a regime with trade restrictions. Low enforceability of international law complicates the transition to free trade and its sustainability. In this paper we suggest that high costs of trade regime changes (i.e., trade treaty renegotiations) serve as a mechanism alleviating deficiencies of international law.

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We study irreversible investment in production of export goods, when governments cannot fully commit to their *ex ante* trade policies and impose higher *ex post* trade barriers. The divergence of *ex ante* and *ex post* trade policies hinders investment in exports, and adversely affects aggregate welfare. *From this perspective, a pursuit of free trade is just a quest for commitment.*

Beautifully concise and clear, influential Kemp and Wan's (1976) paper shows that it is always possible to construct a welfare improving custom union for any subset of the countries, and leave the nonmember countries at their initial welfare levels. It follows from the Kemp-Wan Theorem that the Most-Favored Nation (MFN) clause could be the first best only if it is redundant. Theoretically it is natural that a bilateral trade regime would result in a higher aggregate welfare than a multilateral one.

Our results yield lower tariffs and higher aggregate welfare in a bilateral than multilateral regime. Legalized by Article XXIV of the General Agreement on Tariffs and Trade (GATT), Preferential Trade Agreements (PTAs) permit to circumvent the MFN clause and lessen its attendant distortion. We suggest that Article XXIV and a variety of present-day trade arrangements reflects the GATT's (and its successor, the World Trade Organization (WTO)) limitations in enforcing trade agreements. In our game, the MFN requirement is, in general, non-distortive only if the countries are identical. *The MFN clause* can be viewed as *an explicit price regulation,* with *governments* being analogous to *firms*, *tariffs* to *prices*, and *negotiation costs* to *production costs.* Our analysis suggests that the MFN clause distorts incentives for export investments and makes sustaining low tariffs more costly.

There has been no empirical assessment of losses from the imposition of the MFN clause. Nevertheless, PTAs net benefits proxy the lower bound of these losses. [3] Baldwin, Forslid, and Haaland (1995) study investment effects of European integration by simulating what would have occurred to European Free Trade Association (EFTA) nations if they had no access to the EU Single Market Programme. The results show a modest drop in EFTA capital stock when EFTA nations are excluded, and a rise of about five percent otherwise, with trivially small effects on the USA and Japan. Kouparitsas (1997a) attributes to North American Free Trade Agreement (NAFTA) a two to three percent rise of the Mexican capital stock with negligible effects on USA, Canada and other countries. [4]

Many other studies do not take into account dynamic effects of the MFN clause on investment. Such methodologies, perhaps, bias the estimated gains from PTAs downward. Consequently, distortions from the MFN clause are understated. The PTAs proliferation and the aforementioned evidence indicate

[3] I am grateful to Prof. Dixit for this idea.
[4] See Kouparitsas (1997b) for a review of the estimates for NAFTA.

that this distortion may be more substantial than it is perceived currently.

Distortions from the imposition of the MFN clause have been studied by Caplin and Krishna (1988), and Ludema (1991) in a bargaining context. The former paper suggests that the MFN clause creates an externality. Ludema shows that bilateral lowering of tariffs with MFN clause imposed may be less effective than otherwise. Both papers suggest considerable country specific distributional effects of the MFN clause.

The closest analogy to the economic effects of trade restrictions are the effects of industrial restrictions (i.e., regulations), considered in the regulation literature. Its approach is to identify a distortion and propose a remedy. The use of such remedies in trade practices is limited because available instruments are scarce, but some instruments were suggested. Fung and Staiger (1994), and Staiger (1994) explore trade liberalization in environments with self-enforcing arrangements. Their proposed instruments are policies that induce the resources of the import-competing sector to lose their sector-specific skills, which permits to maintain lower tariffs. Similarly, our model emphasizes the enforcement problem as a major free trade obstacle. Our approach differs from the papers cited above, as we provide a positive perspective: we propose that costly trade negotiations are widely used as an instrument alleviating government commitment deficiencies. Previous studies addressed only the bargaining aspect, with no explicit consideration of negotiation costs or comparative analysis of the costs of sustaining bilateral and multilateral trade regimes.

We start with a two-country tariff negotiation game. The players are governments and investors, and the game has three stages. First, governments choose *ex ante* tariffs. Second, investors make their irreversible investment decisions and invest in production of export goods. Third, in the *ex post* subgame, governments can renegotiate *ex ante* tariffs at the exogenous costs.

We assume that export goods must be produced in the exporting country. Since we do not consider foreign direct investment (FDI), in our model, entire exports are subject of the importing country tariff. We relate our results with the literature that considers activities of multinational corporations (MCs) and the FDI patterns in Section 5 (Discussion).

Clearly, once investments are undertaken, if the government can alter the tariffs at zero cost, it benefits from an increase of its own *ex ante* tariff, and a decrease of the tariff in another country. In this case, government optimal policy is time-inconsistent, and export investment is suboptimal: in equilibrium, there would be no trade in goods that require irreversible investment. We propose that costly trade negotiations serve as a mechanism reducing the wedge between optimal *ex ante* and *ex post* policies, and thus, alleviate investment distortion.

In our model, the higher the tariff adjustment, the higher the negotiation expenses that the governments incur. These expenses include: the costs to attain legislative support and conduct public relations campaigns, to perform cost-benefit analysis, and the costs to adjust legal provisions, such as bureaucratic costs and menu-costs.[5] Our model permits to analyze government incentives for breaching trade obligations. In this case, the term "negotiation expenses" includes all expenses that the government bears when it deviates from *ex ante* obligations. These expenses are comprised of legal costs, which might include fines, penalties and other tools that governments and international organizations use to proxy for enforceable contracts. We see the current dispute settlement mechanism (DSM) as a codification of practices and tools, which help to resolve inter-government conflicts.

We prove the existence of equilibrium, and show that our game has a Pareto-dominant equilibrium, in which aggregate welfare is *lower* than when governments are perfectly committed, i.e., the *ex ante* and *ex post* tariffs are identical. The equilibrium welfare in our game is *higher* than in the game, in which government cost of changing its *ex post* tariff is zero. In the latter game, equilibrium exports of goods that require irreversible investment are zero. We show that if government adjustment cost functions for its own and foreign country tariffs are equal, equilibrium *ex ante* and *ex post* tariffs are equal. Interestingly, this feature holds even when equilibrium negotiation expenses are positive, because government *ex post* actions offset each other. In this case, costly negotiations sustain the status quo only. This result supports our analogy of *negotiation costs* and *production costs.* Governments incur negotiation costs to produce (i.e., deliver) the compliance with *ex ante* trade obligations.

Next, we study how the equilibrium of the game is affected by its parameters. We prove that equilibrium exports and negotiation expenses increase when technology improves, or investment market competition intensifies, or the outside option return decreases. We show that a government, whose costs of changing *ex ante* tariffs are low, inflicts a negative externality on its trading partner due to higher negotiation costs, borne equally by the trading partners.

Lastly, we extend the game to the case of N countries. We compare N-country game of with the restricted N-country game, in which governments are mandated to adhere to their lowest tariff with all trading partners from whom identical goods are imported. This restriction captures the principle of non-discrimination, i.e., the MFN clause. We show that both N-country games have a Pareto-dominant equilibrium. The Pareto-dominant equilibrium of the

[5] Horse-trading expenses among the legislators, and between the legislators and executives are substantial, see Thompson (1995), and Baldwin and Magee (1998) on campaign contributions.

non-restricted game dominates the one of the restricted game.

We interpret the non-restricted game, in which tariffs with each trading partner are negotiated separately as a bilateral trade regime (or PTAs regime), and the game with the MFN restriction – as a multilateral one.

The efficiency loss from the MFN clause is two-fold. The loss manifests itself through higher negotiation costs and greater distortion of investment incentives. Thus, the segmentation of trade agreements into bilateral ones improves their enforceability. This idea has a similar flavor to the contract theory principle – that using a series of enforceable short-term contracts instead of a non-enforceable long-term contract improves investment incentives, see Hart and Moore (1988). Our results are in line with the findings in the industrial organization literature on the effects of the most favored-customer-protection (MFC) clause (see Kalai, Postlewaite, and Roberts (1978), Chao and Wilson (1987), and DeGraba (1987)).

In the spirit of our analogy with regulation, misallocation of resources due to trade diversion is analogous to the welfare losses from deregulation. When the allocation of resources was distorted by the previous regulatory regime, partial deregulation might result in welfare loss. Since our model does not have the prior allocation, we do not address the question of trade diversion.

The remainder of the paper is organized as follows. In Section 2, the two-country game is introduced and its equilibrium studied. In Section 3, comparative analysis of two-country games with different parameters is provided. In Section 4, the N-country games are considered. The discussion and conclusion are presented in Sections 5 and 6. Proofs and technical details are relegated to the Appendices.

2 The Model

We start with a two country model and denote the corresponding game by $\mathcal{T}$. In each country i, players are a government and K^i identical investors, $i = 1, 2$. The game $\mathcal{T}$ has three stages. First, the governments announce *ex ante* tariffs x^i. Second, the investors make their irreversible investments in export good, whose value is zero in the exporting country, and is increasing and concave in investment in the importing country.. Investment in export goods, i.e., export good production, takes place in the exporting country: we do not consider FDI. Thus, all exports are subject a tariff of the importing country.

The assumption of zero domestic value of the export good is not crucial and is imposed to simplify the exposition. To justify this assumption, notice that any good can be decomposed into two parts, with one of them having zero domestic value. For some goods, such as autos produced in US for export to Japan, the value in the exporting country is naturally close to zero. Investors have an option of investing in the production of a domestically consumed good, which provides a fixed investment return ξ^i (the outside option).

Third, after investments have been undertaken, the governments can alter their own and the other country's *ex ante* tariffs – with the respective actions denoted by r^i and s^i – through costly trade negotiations. Then, *ex post* tariffs t^i are defined as:

$$t^i = x^i + r^i - s^j, \quad i, j = 1, 2 \quad \text{and} \quad i \neq j. \tag{1}$$

Here and below, when i and j appear, we imply that $i \neq j$ and $i, j = 1, 2$. To simplify, we drop the indices when it does not create a confusion. We call country i home, and j – foreign.

We call government ability to alter their tariffs "*negotiation*", and their expenses on modifying tariffs *negotiation costs*, emphasizing the direct government actions to alter the tariffs. The word *negotiation* is somewhat narrow. Our definition of *negotiation costs* includes any government expenses on activities intended to modify the tariffs. [6]

The causes of negotiation expenses differ, but in essence they are related and should be considered together. The greater the tariff adjustment, the more complex the structure of expenses. Thus, we expect a disproportional increase of government expenses with an increase of the tariff adjustment size. To reflect that, we assume that adjustment cost is concave in the size of adjustment. For example, the cost-benefit analysis of a greater tariff adjustment is, clearly, more complex due to the necessity to account for the indirect effects. Therefore, such cost-benefit analysis is relatively more costly than if the size of adjustment is insignificant, which justifies the assumption of concave adjustment cost.

The k-th investor maximizes his expected profit $\Pi^i_k(\mathbf{a})$ from investment q^i_k net of his opportunity cost:

$$\Pi^i_k(\mathbf{a}) = (1 - t^j)\alpha^i P(Q^i)\frac{q^i_k}{Q^i} - \xi^i q^i_k, \quad , \alpha^i > 0, \quad \mathbf{a}^i = (x^i, r^i, s^i, \mathbf{q}^i), \tag{2}$$

where $k = 1, \ldots, K^i$, and Q^i denotes aggregate investment:

$$Q^i = \sum_{k=1}^{K^i} q^i_k$$

[6] Governments negotiation expenses include legal, political and bureaucratic costs.

determines aggregate exports $\alpha^i P(Q^i)$:and a constant α^i characterizes technology. The vector $\mathbf{a} \in \mathbf{A}$, and $\mathbf{A}$ is the set of action profiles of the game $\mathcal{T}$. The components of the vector $\mathbf{a}$ are three actions of each government (x^i, r^i, s^i) and one action of each investor ($\mathbf{q}^i = (q_1^i, \ldots, q_{K^i}^i)$). The function P is continuous, concave and three times continuously differentiable at all $Q \in (0, \infty)$. When $t^j = 0$ (free trade), investment in exports is positive, i.e. the function $\alpha^i P'$ evaluated at zero exceeds the outside option:

$$P'(Q) > 0, \quad P''(Q) < 0, \quad P'''(Q) < 0, \quad \alpha^i \lim_{Q \to 0} P'(Q) > \xi^i.$$

Each government maximizes its welfare W^i, which is equal to a sum of export profits and tariff revenues net of negotiation costs, which are exogenous and denoted $\beta^i B(r^i)$ and $\gamma^i B(s^i)$ for the own and the other country tariffs:

$$W^i(\mathbf{a}) = \Pi^i(\mathbf{a}) + t^i \alpha^j P(Q^j) - \beta^i B(r^i) - \gamma^i B(s^i), \quad 0 < \beta^i \leq \gamma^j, \tag{3}$$

where Π^i denotes the aggregate profit of country i investors. The relationship between constants ($\beta^i \leq \gamma^j$) reflects that modifying ones own tariff is cheaper than the other country one. The function B is continuous, convex and three times continuously differentiable for $v \in (0, \infty)$:

$$B'(v) > 0, \quad B''(v) > 0, \quad B'''(v) \leq 0 : v \in (0, \infty)$$

and possibly discontinuous at zero, reflecting a nonzero fixed-cost of starting negotiations. The conditions

$$P''' \leq 0 \text{ and } B''' \leq 0 \tag{4}$$

are not crucial: they ease presenting the proofs and can be relaxed. For the given functions P and B, each country in the game $\mathcal{T}$ has 5 parameters: $\alpha, \beta, \gamma, \xi$, and K:

$$\mathcal{T} = \mathcal{T}(\mathbf{o}), \quad \text{where} \quad \mathbf{o} = (\alpha^i, \beta^i, \gamma^i, \xi^i, K^i), \quad i = 1, 2.$$

To analyze the game $\mathcal{T}$ we use a concept of a subgame perfect Nash equilibrium, symmetric with respect to investors. We denote equilibrium outcomes and payoffs by the superscript '*'. In symmetric equilibria investor actions are identical:

$$q_k^{i*} = \frac{Q^{i*}}{K^i}.$$

Theorem 1 *There exists an equilibrium in the game $\mathcal{T}$.*

Proof: *See Appendix.* □

For the intuition behind the proof, notice that in the subgame that starts after $(x^i, \mathbf{q}^i)$ best responses r^i and s^j are unique. They turn out to depend on x^i and $\mathbf{q}^j$ only. Thus, for any given x^i, r^i, s^j and $\mathbf{q}^j$, the optimal t^i is unique. We substitute government *ex post* best responses the in investor objective, and solve the investor maximization problem. We show that in the subgame that starts after (x^i, x^j) a unique best response $\mathbf{q}^{i*}(x^i, x^j)$ exists, and turns out to be independent from the home government action: $\mathbf{q}^{i*}(x^i, x^j) = \mathbf{q}^{i*}(\cdot, x^j)$.

Therefore, finding the equilibria of the game $\mathcal{T}$ is the same as finding the equilibria of two games Γ^i with action spaces $(x^i, r^i, s^j, \mathbf{q}^j)$. The games Γ^i are similar to the game Γ from Schwartz (2000), where a commitment constrained ruler maximizes his tax revenues and faces underinvestment due to investor anticipation of an *ex post* tax increase. Player incentives in the games Γ^i and Γ differ, but the same logic is applicable. We show that there exists an equilibrium in each game Γ^i, which provides that there exists an equilibrium in the game $\mathcal{T}$. We also show that there exists a Pareto-dominant equilibrium in the game $\mathcal{T}$ by proving the existence of a Pareto-dominant equilibrium in each of the games Γ^i, thus:

Proposition 1 *The game $\mathcal{T}$ has a Pareto-dominant equilibrium. In a Pareto-dominant equilibrium, tariffs are minimal and investments maximal within the set of their equilibrium values.*

Proof: *See Appendix.* □

Corollary 1 *Let two equilibria of the game $\mathcal{T}$ differ by investment(s) only. Then, in the equilibrium with higher investment(s) the tariffs on the respective exports are lower, and negotiation expenses higher.*

Proof: *See Appendix.* □

Henceforth, we consider only the Pareto-dominant equilibrium of the game $\mathcal{T}$ and refer to it as **the equilibrium**. When equilibrium negotiation expenses are zero, i.e., the equilibrium does not involve negotiations, the mere possibility of negotiations improves player payoffs. This result is analogous to the contract theory result: fully enforceable (at a cost) contracts might lead to an equilibrium with zero enforcement costs due to no incentives to deviate.

Proposition 2 *Let the games $\mathcal{T}(\breve{\mathbf{o}})$ and $\mathcal{T}(\tilde{\mathbf{o}})$ differ only in γ, and let $\breve{\gamma}^i < \tilde{\gamma}^i$, for $i = 1$ or 2, or both. Then, in equilibrium, foreign tariff t^{j*} is lower and home exports Q^{i*} higher in $\mathcal{T}(\breve{\mathbf{o}})$ than $\mathcal{T}(\tilde{\mathbf{o}})$.*

Proof: *See Appendix.* □

Proposition 2 permits us to study how the equilibrium depends on government costs of negotiations of the other country tariff. From Proposition 2, the lower the constant γ, the easier it is to affect the foreign (another country) tariff, and the higher player equilibrium surplus. This result is in tune with the observation that binding international commitments can relax political constraints on economic reform.[7] From Proposition 2 and Corollary 1, when the games $\mathcal{T}$ differ only by the constant γ^i, equilibrium player surplus is the highest in the game with the lowest γ^i, i.e., at $\gamma^i = \beta^j$, because in this case governments maximally constrain each other.

When government can fully commit to its policies, a foreign dictate of internal policy typically reduces country welfare. This statement may be incorrect or even reversed when governments are unable to commit. From the above presented analysis, the foreign government influence could be welfare improving when the home government is commitment constrained with respect to its trade obligations.

Corollary 2 *Let in the game $\mathcal{T}$ have $\gamma^j = \beta^i$ Then, in equilibrium, $r^{i*} = s^{j*}$.*

Proof: *See Appendix.* □

From Corollary 2, when $\gamma^i = \beta^j$ equilibrium *ex ante* and *ex post* tariffs are equal. In this case, even when equilibrium negotiation expenses are positive, costly negotiations sustain the status quo only: they do not entail any tariff changes. This result is due to offsetting effects from government *ex post* actions: their efforts cancel out. Here negotiations seem to bring no welfare gain but entail wasteful expenses only. We suggest that primary role of such negotiations is to instrument government commitment.

The proof of Theorem 1 does not utilize the assumption that only one good is exported from each country. Thus, results of Theorem 1 hold for an any finite number of goods, domestically consumed and exported. Hence:

Corollary 3 *Let the game $\mathfrak{T}$ denote the game $\mathcal{T}$, in which country i produces H^i goods for domestic consumption and F^{ij} goods for export to country j, where H^i, F^{ij} are natural numbers. Then, Theorem 1 holds.*

3 Comparative Analysis

Next, we compare equilibria of the games $\mathcal{T}$ with different parameters. We let $\gamma^i = \beta^j$ to assure that Corollary 2 holds. We study how the equilibrium is affected by technology, investment market competition, or tariff negotiation costs. We interpret the constant α as a characteristic of export technology.

[7] Reviewed by Persson and Tabellini (1997).

Higher constants α, or ξ, or K^i imply, respectively, a more advanced export technology, or higher outside return, or more competitive investment market.

3.1 Export Technologies Differ

Proposition 3 *Let the games $\mathcal{T}(\breve{\mathbf{o}})$ and $\mathcal{T}(\tilde{\mathbf{o}})$ differ only in α^i for some $i = 1, 2$, and let $\breve{\alpha}^i > \tilde{\alpha}^i$. Then, in equilibrium, foreign tariff t^{j*} and home exports $\alpha^i P(Q^{i*})$ are higher, and home investment Q^{i*} lower in $\mathcal{T}(\breve{\mathbf{o}})$ than $\mathcal{T}(\tilde{\mathbf{o}})$.*

Proof: *See Appendix.* □

Proposition 3 implies that technology improvement results in increase of equilibrium exports, tariffs, and negotiation expenses. These inferences are robustly supported by data.[8]

3.2 Outside Options Differ

Proposition 4 *Let the games $\mathcal{T}(\breve{\mathbf{o}})$ and $\mathcal{T}(\tilde{\mathbf{o}})$ differ only in ξ^i for some $i = 1, 2$ and let $\breve{\xi}^i < \tilde{\xi}^i$. Then, in equilibrium, home investment Q^{i*} is higher and foreign tariff t^{j*} lower in $\mathcal{T}(\breve{\mathbf{o}})$ than $\mathcal{T}(\tilde{\mathbf{o}})$.*

Proof: *See Appendix.* □

We defined the outside option ξ as return on investment in the domestically consumed good. Thus, Proposition 4 permits to compare the games, in which the countries differ in production technology of the domestically consumed good. From Proposition 4, a lower outside option return makes export investments more attractive for country i investors. This causes an increase in equilibrium exports, and leads to higher negotiation expenses on the respective tariff.

3.3 Investment Markets Differ

Proposition 5 *Let the games $\mathcal{T}(\breve{\mathbf{o}})$ and $\mathcal{T}(\tilde{\mathbf{o}})$ differ only in K^i for some $i = 1, 2$ and let $\breve{K}^i > \tilde{K}^i$. Then, in equilibrium, home investment Q^{i*} is higher in $\mathcal{T}(\breve{\mathbf{o}})$ than $\mathcal{T}(\tilde{\mathbf{o}})$.*

Proof: *See Appendix.* □

[8] See Rodriguez and Rodrik's (2001).

Interestingly, from Proposition 5, greater investment market competition in one of the countries benefits the other country's government. To explain this result, we notice that in our model, with respect to investors of the other country, the government of the importing country is a monopolist. Thus, Proposition 5 provides that the monopolist's surplus share increases when investment market competition intensifies. Proposition 5 permits us to investigate how the intensity of investment market competition affects trade regime. Equilibrium exports and aggregate surplus of the game increases with the intensity of the competition, despite the higher associated negotiation costs. The data supports these inferences.[9]

3.4 Negotiation Costs Differ

We use constants β^i and γ^j to proxy for government commitment capacity. Lower constants β^i and γ^j make the costs of tariff adjustment lower. Ceretus parabis, the government with lower constants β^i and γ^j gains more from *ex post* negotiations than the one with higher constants. When equation

$$\gamma^j = \beta^i > \beta^j = \gamma^i \tag{5}$$

holds, we say that government j is more commitment constrained. From equation (5), negotiation expenses of such a government on the tariff adjustment of a fixed size are relatively lower than the expenses of the other government.

Proposition 6 *Let the games $\mathcal{T}(\breve{\mathbf{o}})$ and $\mathcal{T}(\tilde{\mathbf{o}})$ differ only in β and γ, and let $\breve{\gamma}^j = \breve{\beta}^i > \tilde{\gamma}^j = \tilde{\beta}^i$. Then, in equilibrium, foreign investment Q^{j*} is higher and home tariff t^{i*} lower in $\mathcal{T}(\breve{\mathbf{o}})$ than $\mathcal{T}(\tilde{\mathbf{o}})$.*

Proof: *See Appendix.* □

From Proposition 6, negotiations of the tariff of the country with a more commitment constrained government are more costly for both governments. Thus, such a government inflicts an externality on its trading partner. Both countries benefit if the commitment constraint is relaxed. Proposition 6 highlights the fact that improvement of government commitment capacity fosters trade liberalization. A possible mechanism of such an improvement is through the advancement of the internal legal institutions. More advanced legal institutions reduce government commitment deficiency in general, and, specifically, commitment imperfections with respect to international obligations.

[9] See Rodriguez and Rodrik's (2001).

The conditions of Propositions 3 - 6 are restrictive. They permit to compare the games in which only one parameter differs, yet the parameters of the game $\mathcal{T}$ are likely endogenous. In reality, these parameters may change simultaneously. For example, historically, technology advancement has been accompanied by increase in investment market competition, which, clearly, violates the condition that all other parameters are fixed.

Propositions 3 or 5 suggest that negotiation expenses increase as technology improves or investment market competition intensifies. Thus, when higher exports are optimal due to technology advancement or more competitive investment markets, the surplus loss due to government commitment imperfections increases. Hence, the importance of commitment increases with improvement of technology or competition. To mitigate this increase of negotiation expenses these improvements should be accompanied by the improvement of government commitment capacity.

4 The N-country Games

To model multi-country trade, we extend the game $\mathcal{T}$ to the case of N countries. Let the game $\mathcal{T}_N$ denote the N-country game, in which each country produces N goods: one for domestic consumption, and $N-1$ for exports, with each export good valuable only in the country for which it was specifically produced. This condition assures separability, i.e., in equilibrium, the outcome of bilateral negotiations depends on the players from the negotiating countries only.

The separability condition is not as restrictive as it might appear at the first glance. We use a 'reduced form model,' i.e, we do not model consumer demand explicitly. Instead, in Appendix we derive concavity of the function P and the player objectives specified by equations (2) and (3) from a single assumption of well-behaved (i.e., continuous and concave) aggregate consumer demand for a specific export good.

The parameters and variables in the game $\mathcal{T}_N$ have two superscripts: the first refers to the country itself, and the second – to the country with which trade is considered. Player objectives in the game $\mathcal{T}$ are the generalization of their objectives in the game $\mathcal{T}$. Country i investors maximize their profit from exports to county j:

$$\Pi^{ij}(\mathbf{a}_N) = (1 - t^{ji})\alpha^{ij} P(Q^{ij}) - \xi^i Q^{ij}, \quad \mathbf{a}_N = (x^{ij}, r^{ij}, s^{ij}, \mathbf{q}^{ij}) \in \mathbf{A}_N,$$

where $\mathbf{A}_N$ is the set of action profiles in the game $\mathcal{T}_N$, and

$$Q^{ij} = \sum_{k=1}^{K^i} q_k^{ij}, \text{ and } t^{ij} = x^i + r^{ij} - s^{ji}, \quad i, j = 1, \ldots, N$$

.Government i objective W^i is to maximize a sum of its country export profits and tariff revenues, net of negotiation expenses:

$$W^i(\mathbf{a}_N) = \sum_j \left[(1 - t^{ji}) \Pi^{ij}(\mathbf{a}_N) + t^{ij} \alpha^{ji} P(Q^{ji}) - \beta^i B(r^{ij}) - \gamma^{ij} B(s^{ij}) \right].$$

Due to that, the constant β^{ij} the same with all countries: $B^i = B^{ij}$. Other governments may differ in their ability to negotiate country i tariffs with its government. Thus capability is reflected by the constant Γ^{ji}, which can differ across the countries. As in the game $\mathcal{T}$, we assume theorem 1 can be extended to the game $\mathcal{T}_N$ and due to the separability and additivity of player utilities. To find the equilibria of the game $\mathcal{T}_N$ we find the equilibria of $N \times (N-1)$ games Γ^{ij}, with action spaces $(x^{ij}, r^{ij}, s^{ji}, \mathbf{q}^{ji})$. By Theorem 1 and Proposition 1 each game Γ^{ij} has a Pareto-dominant equilibrium. The tariffs of countries i and j on each other's export good, and the respective investments in export goods, are affected by player actions from these countries only. Clearly, equilibrium actions in the games Γ^{ij} and Γ^{ji}, and, thus, $\mathcal{T}_N$ are identical to the equilibrium actions in the two-country game $\mathcal{T}$ between countries i and j. We assume that each country i renegotiations cost function for its own tariffs is determined by internal economic institutions.

Theorem 2 *There exists an equilibrium in the game $\mathcal{T}_N$. The game $\mathcal{T}_N$ has a Pareto-dominant equilibrium.*

Corollary 3 extends to the game $\mathcal{T}_N$ because the proof of Theorem 2 does not utilize the assumption that one good is exported from each country to another specific country. Hence, we infer:

Corollary 4 *Theorem 2 holds for the game $\mathfrak{T}_N$ with any natural number of goods, domestically consumed or exported.*

Proof: *Follows from Corollary 3 and Theorem 2.* □

Finally, let $\mathfrak{T}_{MFN}$ denote the game $\mathfrak{T}_N$ in which each country has the same tariff on its imports that differ by country of origin only. This tariff has to be equal to the lowest tariff:

$$x^i = \min_j x^{ij} \quad \text{and} \quad t^i = \min_j t^{ij}, \tag{6}$$

as the MFN clause requires. The game $\mathfrak{T}_{MFN}$ implies the MFN clause imposed, and we call this case a multilateral trade regime. Likewise, the game

$\mathfrak{T}_N$ implies no MFN requirement, which we call the case of a bilateral trade regime. Clearly, our setting permits identical export goods. We consider the game in which restriction (6) is imposed on the subset of identical import goods, and call such a game $\mathfrak{T}_{MFN}$. Theorem 2 and Corollary 3 permit to analyze such a game.

Theorem 3 *The game $\mathfrak{T}_{MFN}$ has the Pareto-dominant equilibrium, in which player surplus is lower than in the Pareto-dominant equilibrium of the game $\mathfrak{T}_N$.*

Proof: *Analogous to Theorems 1 and 2.* $\square$

For the intuition behind the second statement of Theorem 3, compare government *ex post* incentives in the games $\mathfrak{T}_N$ and $\mathfrak{T}_{MFN}$. From government *ex post* optimization, the higher the trade volume over which the tariff is negotiated, the higher are the optimal negotiation expenses. Thus, government optimal policies in negotiations of their home tariff rates, i.e. the tariffs on imports in the games $\mathfrak{T}_N$ and $\mathfrak{T}_{MFN}$ differ. In the game $\mathfrak{T}_N$ the relevant trade volumes are equal to the bilateral trade volumes, and in the game $\mathfrak{T}_{MFN}$ – to the entire imports of the good, which differs by country origin. Government optimal behavior in negotiations of the foreign tariffs is the same in both games. Thus, if equilibrium exports are equal in both games, negotiation expenses in the game $\mathfrak{T}_{MFN}$ are at least as high as in $\mathfrak{T}_N$.

When the governments' *ex ante* actions in both games are the same, their payoffs in the game $\mathfrak{T}_N$ are higher than in the game $\mathfrak{T}_{MFN}$. Hence, government payoffs in the Pareto-dominant equilibrium in $\mathfrak{T}_N$ are at least as high as in $\mathfrak{T}_{MFN}$. When *ex post* tariffs in both games are the same, investor profits are the same also. When exports are the same in both games, aggregate surplus in the game $\mathfrak{T}_N$ is at least as high as in the game $\mathfrak{T}_{MFN}$. Hence, equilibrium aggregate exports are, clearly, higher in the game $\mathfrak{T}_N$, investor aggregate profit is at least as high in $\mathfrak{T}_N$ as in $\mathfrak{T}_{MFN}$.

Our model suggests that with commitment constrained governments, MFN clause can be viewed as an *explicit price regulation*, with *governments* being analogous to *firms, tariffs* to *prices*, and *negotiation costs* to *production costs*, where by government production costs we mean the government expenses on alleviating its commitment deficiencies, i.e., expenses on producing the compliance with the *ex ante* trade arrangements When countries differ, the MFN requirement is equivalent to the regulatory regime constraining a firm to charge the *same* price for its products, even if production costs of these products *differ*.

We do not address the question of trade diversion for two reasons. First, in our game, resource allocation is not distorted by prior trade regime(s). Thus, our game does not permit to study welfare implications of partial trade liberalization. Second, even if we consider a repeated extension of our game, its stationary equilibrium depends on player actions in the current period only, in which case trade diversion is not an issue.

The comparative analysis of Section 3 naturally extends to the case of N-country games, through the appropriate adjustment of the superscripts. Thus, the results of Sections 3 and 4 permit us to study effects of the MFN clause in the case of the N-countries, which differ in production technologies, or investment market competition, or government commitment capacity.

5 Discussion

5.1 International Law Advancement

Globalization necessitates advancement of international law, just as the industrial revolution (and induced specialization in production) necessitated the advancement of contractual law. Deardorff and Stern (2002) present the evidence that WTO is more advanced in its capacity as an international law enforcer than its predecessor, GATT. Deardorff and Stern discuss a new DSM introduced by WTO, which makes DSM a working legal tool. They also point out WTO expansion to new areas, such as TRIPS (Trade Related Intellectual Property) and coordination of the agreement on financial services, which lowers transactions costs for movements of financial capital. We suggest that increased institutional sophistication of WTO relative to GATT reflects increased globalization, and the improvement of international legal institutions that globalization necessitates.

We suggest that the international legal system improves as a by-product of trade negotiations. Then, negotiation expenses relax the government commitment problem in two ways: directly, through imposing negotiation costs, and indirectly, through international law advancement.

5.2 Formation of Trade Blocs

Our model permits us to explain active formation of trade blocs and the empirical observation of high exports between similar countries, which are, clearly, the countries with similar parameters.[10] From Proposition 2, equilibrium exports and player surplus are the highest when the constants β^i and

[10] We have not seen in the literature any theoretical explanation of the empirical observation of high exports between homogeneous countries.

γ^j are equal. We suggest that the similarity reduces the costs of joint legal developments, facilitates the formation of trade blocs, and leads to higher sustainable exports. Our results support Krishna (1997) analysis, which suggests that trade blocs with significant trading partners are preferable to trade blocs with geographically proximate partners. Our model rationalizes the observation that exports increase as countries converge.

5.3 Multinational Corporations

Our approach naturally raises questions of MCs impact on trade regimes. Data analysis suggests that MCs engage in FDI when trade barriers are high. In Markusen and Venables (1995), MCs arise endogenously when tariffs are high. Brainard (1993) finds that relative factor endowments explain only a small part of MCs activities, and suggests that trade barriers are essential in explaining these activities.

The growing importance of FDI relative to trade among developed countries is in tune with Propositions 3 and 5 which suggest higher costs of sustaining low tariffs when technology or investment market competition improves. FDI, i.e., the relocation of production to an otherwise importing country, reduces exports and lessens government incentives to renege on the *ex ante* trade policies.

The above-presented justification of FDI would not be convincing, if governments could use discriminatory taxes on FDI as trade barriers instead of using tariffs. However the pattern of FDI taxation suggests, that governments are unable to substitute taxes for tariffs.[11] Our model permits us to explain this evidence by relating it to the government commitment problem. In the case of tariffs, optimal policy of the commitment constrained government is an *ex post* tariff *increase*. On the contrary, in the case of FDI taxation, government inability to commit to the *ex ante* tax regime makes an *ex post* tax *decrease* optimal due to MCs ability to report their profits in constituencies with liberal taxes.[12] Government efforts to harmonize the FDI taxation were short-lived and unsuccessful, confirming our intuition that government inability to commit impairs the policy coordination.[13]

In short, inter-government competition to attract FDI and the ease (at least for accounting purposes) with which MCs relocate between the countries causes advantageous tax policies for FDI. Thus, FDI reduces exports, without providing governments with possibilities to recap tariff revenue losses through

[11] See Hines (1996) review.
[12] Ibid.
[13] Ibid.

unfavorable FDI taxation. Thus, more liberal trade regime is sustainable with MCs even if technology or investment market competition improve, while government commitment capacity does not. Export reduction due to the FDI presence can be interpreted as a higher constant ξ or a lower constant K. Then, Propositions 4 and 5 imply that lower tariffs are sustainable in the presence of FDI.

5.4 Extensions

The model can be extended to the case when exported and domestically consumed goods differ in their production functions, and the negotiation cost functions differ across governments. A repeated game can be used to study repeated trade interactions. More rewarding, in our view, is to consider a sequence of dynamically linked negotiation games with *ex ante* and *ex post* tariffs in the games played in subsequent periods constrained to be equal. This restriction reflects a typical trade regime dependence on prior arrangements. Such a game would allow to address the question of trade diversion.

5.5 Complexity and Enforceability

Corollaries 3 and 4 extend our model to any number of exported or domestically consumed goods. The results of Section 4 permit to analyze complex multi-good trade agreements, and compare bilateral, multilateral and mixed (i.e. when some trade blocs are present) trade regimes. The logic of our comparison of multilateral and bilateral regimes can be applied to analyze simple (analogous to multilateral) and complex (analogous to bilateral) trade agreements. Paradoxically, Theorem 3 suggests that equilibrium tariffs for complex trade agreements are *lower* than for simple ones. Thus, complexity of trade treaties, criticized in Bhagwati (1996) is not necessarily a negative phenomenon, as complex treaties actually may distort investment incentives less than simple ones due to making negotiations more costly.

6 Conclusion

In Stiglitz (1998), the former Chairman of the Council of Economic Advisers shares his insights on the incentives of government institutions and provides the reasons for the persistence of inefficiencies. The first reason he cites is government inability to commit. Direct enforcement is virtually impossible for inter-government obligations. Moreover, for some countries their power render collective punishment difficult or impossible. [14] Then, the only feasible option is to draft self-enforcing trade treaties.

We conclude that higher negotiation costs lessen government incentives to restrict trade through alleviating government inability to commit. In this perspective, high government costs of trade negotiations improve investor incentives for investment in exports. We suggest that PTAs increase the costs of negotiating trade treaties. The relevance of PTAs for enforcement of inter-government obligations is transparent and intuitive, given the volume of legal and organizational work attached. However, further research is needed to evaluate the role of specific trade practices as the means to enforce trade obligations.

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7 Technical Appendices

Proof of Theorem 1

Government optimal actions depend on aggregate investment (not on the investments of individual investors), because their objectives are dependant on aggregate investment.

Step 1

To simplify, we speak of a function defined on a closed interval, when it is well defined on the corresponding open interval only. In our calculations, at the boundaries we use the left or the right limit of the function. Consider the following system of equations:

$$P(Q) - bB'(r) = 0, \tag{7}$$
$$P(Q) - cB'(s) = 0, \tag{8}$$
$$(1 - x - r + s)A(Q) - \xi = 0, \tag{9}$$
$$s > 0, \tag{10}$$

where $0 < b \leq c, \quad x \in [0, 1], \quad r, s \in [0, \infty), \quad Q \in [0, \infty)$, and

$$A(Q) = \frac{1}{K}P'(Q) + (1 - \frac{1}{K})\frac{P(Q)}{Q}, \tag{11}$$

with the function A is continuous and twice continuously differentiable from the properties of the function P.

Claim 1 *The system of equations (7) - (10) has at most one solution, which we denote $(r(x), s(x), Q(x))$, Then, the functions r, s and Q are continuous and twice continuously differentiable in x, and $Q' < 0$. There exists $x_h \in [0, 1]$ such that for $x \in [0, x_h)$ a solution of (7) - (10) exists, and for $x \in [x_h, 1]$ - does not.*

Proof of Claim 1: Let h denote $\lim_{v \to 0} cB'(v)$ and Q_h – the solution of equation $P(Q) = h$:

$$h = \lim_{v \to 0} cB'(v) \quad \text{and} \quad P(Q_h) = h.$$

For $Q < Q_h$ the subsystem of equations (8) and (10) has no solution, because from equation (10) and from properties of the functions B and P:

$$P(Q) \leq P(Q_h) = h < cB'(s) \quad \text{if} \quad Q < Q_h \quad \text{and} \quad s > 0.$$

Since $0 < b \leq c$, when a solution of equation (8) exists, a solution of equation (7) exists also. Keep Q and x fixed and differentiate equations (7) and (8) with respect to r and s to show that these derivatives are negative:

$$-bB''(r) < 0, -cB''(s) < 0.$$

Thus, from the properties of P and B, there exist a unique solution of each equation (7) and (8) for any fixed x and $Q \in (Q_h, \infty)$. Let $r^Q(x)$ and $s^Q(x)$ denote these solutions, respectively. Differentiation of equations (7) and (8) with respect to Q, when x is fixed, gives us the derivatives $\frac{dr^Q(x)}{dQ}$ and $\frac{ds^Q(x)}{dQ}$:

$$\left.\frac{dr^Q(x)}{dQ}\right|_{x=const} = \left.\frac{P'(Q)}{bB''(r^Q(x))}\right|_{x=const} > 0, \left.\frac{ds^Q(x)}{dQ}\right|_{x=const} = \left.\frac{P'(Q)}{cB''(s^Q(x))}\right|_{x=const} > 0.$$

Thus for a fixed x, the derivative of equation (9) with respect to Q is:

$$(1 - x - r + s)A'(Q) - \left[\frac{1}{bB''(r^Q(x))} - \frac{1}{cB''(s^Q(x))}\right] P'(Q)A(Q), \qquad (12)$$

where the function A' is negative:

$$A'(Q) = \frac{1}{K}P''(Q) + (1 - \frac{1}{K})\frac{1}{Q}\left[P'(Q) - \frac{P(Q)}{Q}\right] < 0. \qquad (13)$$

From $0 < b \leq c$, properties of the function B, and equations (7) and (8):

$$\frac{1}{bB''(r^Q(x))} - \frac{1}{cB''(s^Q(x))} \geq 0. \qquad (14)$$

From equations (13) and (14), expression (12) is negative. Thus, a unique interior solution of equation (9) exists, which we denote by $Q(x)$. From uniqueness and existence of $r^Q(x)$, $s^Q(x)$ and $Q(x)$ for x such that $Q(x) \in (Q_h, \infty)$, there exist a unique $r(x) = r^{Q(x)}(x)$, and a unique $s(x) = s^{Q(x)}(x)$ and, thus, a unique solution of the system of equations (7) - (10). This solution $(r(x), s(x), Q(x))$ is continuous and twice continuously differentiable from the properties of the underlying functions. Differentiation of equations (7) – (9) with respect to x and the implicit function theorem provide that the function Q' is negative:

$$Q'(x) = \frac{\xi}{(1 - x - r + s)^2 A'(Q) - \left[\frac{1}{bB''(r)} - \frac{1}{cB''(s)}\right] \xi P'(Q)} < 0 \qquad (15)$$

due to the properties of A, P and B. Let x_h denote the solution of equation $Q(x) = Q_h$:

$$Q(x_h) = Q_h.$$

The system of equations (7) - (10) has a unique solution $(r(x), s(x), Q(x))$ for $x \in [0, x_h)$, and no solution for $x \in [x_h, 1]$, because from equation (15) for $x \in [x_h, 1]$ we have $Q(x) < Q_h$. $\square$

Next, consider the system of equations:

$$P(Q) - bB'(r) = 0, \tag{16}$$
$$P(Q) - cB'(s) \geq 0, \tag{17}$$
$$(1 - x - r + s)A(Q) - \xi = 0, \tag{18}$$
$$r > 0, \tag{19}$$

where $0 < b, \quad x \in [x_h, 1], \quad r, s \in [0, \infty), \quad Q \in [0, Q_h]$.

Claim 1.1. *The system of equations (16) - (19) has at most one solution, which we denote $(r(x), s(x), Q(x))$. Then, the functions r, s and Q are continuous and twice continuously differentiable in x, and $Q' < 0$. There exists $x_m \in [x_h, 1]$ such that for $x \in [x_h, x_m)$ a solution of (16) - (19) exists and for $x \in [x_m, 1]$ – does not.*

Proof of Claim 1.1: Let m denote $\lim\limits_{v \to 0} bB'(v)$ and Q_m – the solution of equation $P(Q) = m$:

$$m = \lim_{v \to 0} bB'(v) \quad \text{and} \quad P(Q_m) = m. \tag{20}$$

From Claim 1, since $b \leq c$ we have $Q_m \leq Q_h$. Also from Claim 1, for $x \in [x_h, 1]$, equation (17) does not hold if $s > 0$. Thus, for $x \in [x_h, 1]$ the only solution of equation (17) when $s = 0$. Equations (7) and (16), and (9) and (18) and are identical, which provides that the rest of the proof of Claim 1.1 is the same as of Claim 1. Let x_m denote a solution of equation $Q(x) = Q_m$

$$Q(x_m) = Q_m,$$

then $x_m \geq x_h$. $\square$

Step 2

Let Γ^i be the game between government i and country j players (investors and government). Player objectives in the game Γ^i are derived from their objectives in the game $\mathcal{T}$. We use the subscript 'Γ^i' to denote player objectives in the game Γ^i:

$$\Pi^j_{k\Gamma^i}(\mathbf{e}^{ij}) = (1 - t^i)\alpha^j P(Q^j)\frac{q^j_k}{Q^j} - \xi^j q^j_k, \quad \text{where} \quad \mathbf{e}^{ij} = (x^i, r^i, s^j, \mathbf{q}^j),$$
$$W^i_{\Gamma^i}(\mathbf{e}^{ij}) = t^i \alpha^j P(Q^j) - \beta^i B(r^i) \quad \text{and} \quad W^j_{\Gamma^i}(\mathbf{e}^{ij}) = \Pi^j_{\Gamma^i}(\mathbf{e}^{ij}) - \gamma^j B(s^j),$$

and $\mathbf{e}^{ij} \in \mathbf{E}$, where $\mathbf{E}$ is the set of action profiles in the game Γ^i.

Let $\hat{\mathcal{T}}$ and $\hat{\Gamma}^i$ denote the games $\mathcal{T}$ and Γ^i with government *ex post* and *ex ante* actions restricted to be identical: $t^i \equiv x^i$,in which case $r^i \equiv 0 \quad$ and $\quad s^i \equiv 0$, and:

$$\hat{\mathcal{T}}(x^i, \mathbf{q}^i) = \mathcal{T}(x^i, 0, 0, \mathbf{q}^i) \quad \text{and} \quad \hat{\Gamma}^i(x^i, \mathbf{q}^j) = \Gamma^i(x^i, 0, 0, \mathbf{q}^j).$$

We denote player best response actions and payoffs in the games $\hat{\mathcal{T}}$ and $\hat{\Gamma}^i$ by 'hat'. In the game $\hat{\mathcal{T}}$ player objectives are:

$$\hat{\Pi}^i_k(x^i, x^j, \mathbf{q}^i, \mathbf{q}^j) = \hat{\Pi}^i_{k\hat{\Gamma}^j}(\hat{\mathbf{e}}^{ji}) = \hat{\Pi}^i_{k\hat{\Gamma}^j}(x^j, \mathbf{q}^i),$$
$$\hat{W}^i(x^i, x^j, \mathbf{q}^i, \mathbf{q}^j) = \hat{W}^i_{\Gamma^i}(\mathbf{e}^{ij}) + \hat{W}^i_{\Gamma^j}(\mathbf{e}^{ji}) = \hat{W}^i_{\Gamma^i}(x^i, \mathbf{q}^j) + \hat{\Pi}^i_{\hat{\Gamma}^j}(x^j, \mathbf{q}^i).$$

Claim 2 *An equilibrium of the game* $\hat{\Gamma}^i$ *exists. Let* $\hat{\mathbf{q}}^j(x^i) = (\hat{q}^j(x^i), \dots, \hat{q}^j(x^i))$ *denote investor best response to* x^i*. Then,* $\hat{q}^j(x^i) = \frac{\hat{Q}^j(x^i)}{K}$ *and the functions* $\hat{q}^j$ *and* $\hat{Q}^j$ *are continuous, twice continuously differentiable and*

$$\hat{q}'^j(x^i) < 0 \quad \textit{and} \quad \hat{Q}^j(x^i) < 0 : x^i \in [0, 1]. \tag{21}$$

Proof of Claim 2. See Proof of Claim 2, Theorem 1, Schwartz (2000). □

Step 3

Claim 3 *In the subgame of the game* Γ^i *that starts after* $x^i \in [0, x^i_m)$ *at most one equilibrium with* $r^{i*} > 0$ *exists. Let* $(r^{i*}(x^i), s^{j*}(x^i), \mathbf{q}^{j*}(x^i))$*, where* $\mathbf{q}^{j*}(x^i) = (q^{j*}(x^i), \dots, q^{j*}(x^i))$*, and* $q^{j*}(x^i) = \frac{Q^{j*}(x^i)}{K^j}$*, be equilibrium.*
Then, $(r^{i*}(x^i), s^{j*}(x^i), Q^{j*}(x^i))$ *is a solution of the system of equations (7) - (10) for* $x^i \in [0, x^i_h)$ *and a solution of (16) - (19) for* $x^i \in [x^i_h, x^i_m)$*.*

Proof of Claim 3: Government *ex post* first order conditions for the actions r^i and s^j respectively coincide with equations (7) and (8) for $x^i \in [0, x^i_h)$, and with equations (16) and (17) for $x^i \in [x^i_h, x^i_m)$. The solutions of these equations ($r^{iQ}(x^i)$ and $s^{jQ}(x^i)$) give best responses r^{i*} and s^{j*} to fixed x^i and Q, where

$$Q = \sum_{k=1}^{K} q_k.$$

From Claims 1 and 1.1, when $r^{i*} > 0$, there exist a unique $r^{iQ*}(x^i) > 0$ and a unique $s^{jQ*}(x^i) \geq 0$ for any $x^i \in [0, x^i_m)$ and $Q \in (Q^j_m, \infty)$:

$$W^i_{\Gamma^i}(x^i, r^{iQ}(x^i), s^{jQ}(x^i), \mathbf{q}^j) = \max_{r^i > 0} W^i_{\Gamma^i}(\mathbf{e}^{ij}),$$
$$W^i_{\Gamma^i}(x^i, r^{iQ}(x^i), s^{jQ}(x^i), \mathbf{q}^j) = \max_{s} W^i_{\Gamma^i}(\mathbf{e}^{ij}),$$

From Claims 1 and 1.1, there exists a unique solution of (7) - (10) for $x^i \in [0, x^i_h)$, and of (16) - (19) for $x^i \in [x^i_h, x^i_m)$. From Schwartz (2000), when $r^i > 0$ and investor actions are symmetric, there exists a unique profit maximizing vector $\mathbf{q}^{j*}(x^i) = (q^{j*}(x^i), \ldots, q^{j*}(x^i))$, with $q^{j*}(x^i) = \frac{Q^{j*}(x^i)}{K^j}$. The functions q^{j*} and Q^{j*} are decreasing with x for $x^i \in [0, x^i_h)$, continuous, and twice continuously differentiable for $x^i \in [0, x^i_m)$ except $x^i = x^i_h$:

$$q^{j\prime*}(x^i) < 0 \quad \text{and} \quad Q^{j\prime*}(x^i) < 0 : x^i \in [0, x^i_m) \quad \text{and} \quad x^i \neq x^i_h. \tag{22}$$

Thus, when $r^i(x^i) > 0$ the solutions $(r^i(x^i), s^j(x^i), Q^j(x^i))$ of the systems of equations (7) - (10) for $x^i \in [0, x^i_h)$ and (16) - (19) for $x^i \in [x^i_h, x^i_m)$ provide unique $r^i(x^i)$, $s^j(x^i)$ and $\mathbf{q}^j(x^i)$ at which player payoffs are maximized. $\square$

Step 4

Let $G^i(x^i)$ be equal to:

$$G^i(x^i) = (r^i(x^i) - s^j(x^i))\alpha^j P(Q^j(x^i)) - \beta^i B(r^i(x^i)). \tag{23}$$

Claim 4 *In the game Γ^i, if*

$$G^i(0) < 0,$$

government i best response r^i to $x^i \in [0, 1]$ is $r^i = 0$. If

$$G^i(x^i) = 0 \tag{24}$$

for some $\bar{x}^i$, such $\bar{x}^i \in [0, x^i_m)$ and is unique. Let $\bar{x}^i$ denote the highest x^i for which r^i is non-unique. Then, $r^i = 0$ for $x^i \in (\bar{x}^i, 1]$.

Proof of Claim 4: Differentiation of equation (23) provides that for $x^i \neq x^i_h$

$$G^{i\prime}(x^i) = \left(r^i(x^i) - s^j(x^i)\right) P^{j\prime}(Q^j) Q^{j\prime}(x^i) < 0 : x^i \neq x^i_h.$$

Thus, the function G^i decreases in x, and and continuous and twice continuously differentiable for $x^i \neq x^i_h$. When $G^i(0) < 0$ we have $G^i(x) < 0$ for $x \in [0, 1]$, in which case $r^i = 0$ is a unique best response. If

$$\lim_{v \to 0} B(v) = 0 \quad \text{and} \quad \lim_{v \to 0} B'(v) = 0,$$

equation (24) has no solution for $x \in (0, 1)$, because in this case $G^i(x) > 0$ for all $x \in (0, 1)$. If

$$\lim_{v \to 0} B(v) \neq 0 \quad \text{or} \quad \lim_{v \to 0} B'(v) \neq 0.$$

and $G^i(0) > 0$, from $G^{i\prime} < 0$ and the properties of the functions P and B, equation (24) has a unique solution, which we denote by $\bar{x}^i$. When m defined by equation (20) is positive, there always exists $\varepsilon > 0$ and $\tilde{x}^i = x^i_m - \varepsilon$ such that the first term of equation (23) is smaller than m:

$$(r^i(x^i) - s^j(x^i))\alpha^j P(Q^j(x^i)) < m.$$

Then, $G^i(\tilde{x}^i) < 0$ and $r^i = 0$ is the only best response for $x^i \in [\tilde{x}^i, 1]$. Therefore,

$$\bar{x}^i < \tilde{x}^i = x^i_m - \varepsilon < x^i_m.$$

Clearly, for $x^i \in (\bar{x}^i, 1]$ we have $G^i(x^i) < 0$ and thus, $r^i = 0$. When $x^i = \bar{x}^i$ we have $G^i(\bar{x}^i) = 0$, and government i has two optimal actions ($r^i(\bar{x}^i) > 0$ and $r^i(\bar{x}^i) = 0$):

$$W^i_{\Gamma^i}(\bar{x}^i) = W^i_{\Gamma^i}(\bar{x}^i, r^i(\bar{x}^i), s^j(\bar{x}^i), \mathbf{q}^j(\bar{x}^i)) = W^i_{\Gamma^i}(\bar{x}^i, 0, 0, \mathbf{q}^j(\bar{x}^i)),$$

and Claim 4 is proven. □

Step 5

Let $G^i(0) \geq 0$. Then, from Claim 4, there exists $\bar{x}$, such that for $x \in (\bar{x}, 1]$ government i best response is $r = 0$. Let $\bar{q}$ denote $\hat{q}(\bar{x})$:

$$\bar{\mathbf{q}} = (\bar{q}, \dots, \bar{q}) = \hat{\mathbf{q}}(\bar{x}) = (\hat{q}(\bar{x}), \dots, \hat{q}(\bar{x})).$$

Claim 5 *In the game Γ^i, there exists at most a single $\underline{x}^i$, investor best response to which is non-unique. If $\underline{x}^i$ exists, $\underline{x}^i \leq \bar{x}^i$ and we have:*
(1) for $x^i \in [0, \underline{x}^i) \cup (\bar{x}^i, 1]$ a unique equilibrium exists in the subgame that starts after x^i, in which $r^i > 0$ if $x^i \in [0, \underline{x}^i)$ and $r^i = 0$ if $x^i \in (\bar{x}^i, 1]$.
(2) for $x^i \in (\underline{x}^i, \bar{x}^i)$ best response $\mathbf{q}^j(\bar{x}^i)$ is unique and $\mathbf{q}^j(\bar{x}^i) = \bar{\mathbf{q}}$.

Proof of Claim 5: To simplify, we drop the indexes i and j. First, let $G^i(0) < 0$. Then, investor best response is always unique, and Claim 5 holds. Second, let $G^i(0) \geq 0$. Then, from equations (8) and (21):

$$q(x) = \hat{q}(x + r(x) - s(x)) < \hat{q}(x) : x \in [0, x_m), \tag{25}$$

where $\underline{x} \leq \bar{x} < x_m$. From Claim 4, if $x \in (\bar{x}, 1]$, $r = 0$ is optimal. If $x \in [0, \bar{x})$ and $q > \bar{q}$ we have $r > 0$. If $x \in [0, \bar{x})$ from our definition of $\bar{\mathbf{q}}$ and equation (21) we have we $\hat{q}(x) > \bar{q}$. Then:

$$\Pi(x, 0, 0, \mathbf{q}^{r=0}) = \hat{\Pi}(x, \mathbf{q}^{r=0}) \leq \hat{\Pi}(x, \bar{\mathbf{q}}) : x \in [0, \bar{x}),$$

where $\mathbf{q}^{r=0} = (q, \dots, q)$, and the inequality is non-strict for any $q < \bar{q}$. Thus, if $x \in [0, \bar{x})$ and $r = 0$, only $q = \bar{q}$ is optimal for investors.

The remainder of the proof of Claim 5 is by contradiction. Let investor best responses to x_1 and x_2, $(x_1 < x_2)$, and $x_{1,2} \in [0, \bar{x})$ be nonunique:

$$\Pi(x_{1,2}, r(x_{1,2}), s(x_{1,2}), \mathbf{q}_{1,2}^{r_{1,2}>0}) = \Pi(x_{1,2}, 0, 0, \mathbf{q}_{1,2}^{r=0}) \tag{26}$$

Here $\mathbf{q}_{1,2}^{r_{1,2}>0} = (q(x_{1,2}), \ldots, q(x_{1,2}))$, and $\mathbf{q}_{1,2}^{r=0} = (\bar{q}, \ldots, \bar{q})$, because $x_{1,2} \in [0, \bar{x})$. From equations (21), (22) and (25) we have

$$\bar{q} < q^{r_2>0}(x_2) < q^{r_1>0}(x_1),$$

and from comparing profits using equation (26), the difference between investor profits from $\mathbf{q}^{r_1>0}(x_1)$ and $\mathbf{q}^{r=0}(x_1)$ is positive:

$$\begin{aligned} &\Pi(x_1, r^{Q_1}(x_1), s^{Q_1}(x_1), \mathbf{q}_1^{r_1>0}) - \Pi(x_1, 0, 0, \bar{\mathbf{q}}) > \\ &\Pi(x_1, r^{Q_2}(x_1), s^{Q_2}(x_1), \mathbf{q}_2^{r_2>0}) - \Pi(x_1, 0, 0, \bar{\mathbf{q}}) = \\ &\qquad (x_2 - x_1)[P(Q_2) - P(K\bar{q})] > \quad 0, \end{aligned} \tag{27}$$

where $Q_2 = Kq\,(x_2)$, and $(r^{Q_2}\,(x_1)\,, s^{Q_2}(x_1))$ is the solution of the system of equations (7) – (8) if $Q_2 > Q_h$, and of the system of equations (16) – (17) if $Q_2 < Q_h$. Equation (27) contradicts the nonuniqueness of investor best response at x_1. Therefore, the action $\underline{x}$ is either unique or does not exist.

Assume that $\underline{x}$ exists and let $x_2 = \underline{x}$. Then, from equation (27) for $x \in [0, \underline{x})$ investor best response is unique and $r^i > 0$.

Since $\bar{q}$ is sustainable at $\bar{x}$, $\bar{q}$ is, obviously sustainable at any $x \in (\underline{x}, \bar{x})$. Next, we compare x_2 and x_3, with $\underline{x} = x_2 < x_3 < \bar{x}$. Analogous to equation(27):

$$\Pi(x_3, 0, 0, \bar{\mathbf{q}}) - \Pi(x_3, r(x_3), s(x_3), \mathbf{q}_3^{r>0}) > (x_3 - x_2)[P(Kq(x_3)) - P(K\bar{q})] > 0,$$

from which investor profit at x_3 is higher if $r^i = 0$ than if $r^i > 0$. Thus, for $x \in (\underline{x}, \bar{x})$ investor best response is unique and equals $\bar{q}$, and Claim 5 is proven
□

Step 6

Claim 6 *There exists a unique equilibrium in the subgame of the game Γ^i that starts after $x^i \in [0, \underline{x}^i] \cup [\bar{x}^i, 1]$.*

Proof of Claim 6: Let $r^i(x^i)$, $s^j(x^i)$ and $f^j(x^i)$ denote *player equilibrium actions* , then

$$r^i(x^i) = \begin{cases} r^i(x^i) : x^i \in [0, \underline{x}^i] \\ 0 : x^i \in [\bar{x}^i, 1] \end{cases}, \quad s^j(x^i) = \begin{cases} s^j(x^i) : x^i \in [0, \underline{x}^i] \\ 0 : x^i \in [\bar{x}^i, 1] \end{cases},$$
$$f^j(x^i) = \begin{cases} q^j(x^i) : x^i \in [0, \underline{x}^i] \\ \hat{q}^j(x^i) : x^i \in [\bar{x}^i, 1] \end{cases}. \tag{28}$$

From the continuity and differentiability of the underlying functions, the functions r^i, s^j and f^j are continuous and twice continuously differentiable for $x^i \in [0, \underline{x}^i] \cup [\bar{x}^i, 1]$, and from equations (21), (22) and (28)

$$f^{j\prime}(x^i) < 0 : x^i \in [0, \underline{x}^i] \cup [\bar{x}^i, 1] \quad \text{and} \quad x^i \neq x^i_h.$$

First, let $x^i \in [\bar{x}^i, 1]$. From Claim 5 we have $r^i = 0$ for $x^i \in (\bar{x}^i, 1]$. When the game Γ^i starts with an action $x^i = \bar{x}^i$, only $r^i = 0$ is government i equilibrium action, because country j investors strictly prefer this action. By investing $\bar{q}^j - \epsilon$, with $\epsilon > 0$, they secure for themselves a profit arbitrarily close to their profit at their preferred outcome ($r^i = 0$). Thus, for $x^i \in [\bar{x}^i, 1]$ player maximization problems coincide with their optimization in the game $\hat{\Gamma}^i$. Then, each investor best response is $\hat{q}^j(x^i)$ (exactly as our definition of the functions r^i, s^j and f^j provide for $x^i \in [\bar{x}^i, 1]$). The proof for $x^i \in [0, \underline{x}^i]$ is analogous. Thus, Claim 6 is proven. $\square$

Step 7

Claim 7 *An equilibrium of the game Γ^i exists, and x^{i*} belongs to $[0, \underline{x}^i]$ or $[\bar{x}^i, 1]$.*

Proof of Claim 7: Since to any $x^i \in (\underline{x}^i, \bar{x}^i)$ government i strictly prefers $\bar{x}^i$, $(\underline{x}^i, \bar{x}^i)$ cannot be government i equilibrium actions. Let W^i_f and W^j_f denote:

$$W^j_f(x^i) = W^i_{\Gamma^i}(x^i, r^i(x^i), s^j(x^i), \mathbf{f}^j(x^i)), \quad W^j_f(x^i) = W^i_{\Gamma^i}(x^i, r^i(x^i), s^j(x^i), \mathbf{f}^j(x^i)),$$

for $x^i \in [0, \underline{x}^i] \cup [\bar{x}^i, 1]$, except x^i_h. Here $\mathbf{f}^j(x^i) = (f^j(x^i), \ldots, f^j(x^i))$ and the functions r^i, s^j and f^j are given by equation (28). The functions W^i_f and W^j_f are continuous and two times continuously differentiable.

From Claim 6 government i equilibrium payoff in the subgame of the game Γ^i that starts after $x^i \in [0, \underline{x}^i] \cup [\bar{x}^i, 1]$ is given by the function W^i_f. The government i payoff W^i_f is continuous on the compact intervals $[0, \underline{x}^i] \cup [\bar{x}^i, 1]$ and bounded from below and above by $[0, P^{j\max}]$, where $P^{j\max} = P(\hat{Q}^j(0))$. Thus, there exists at least one maximizer of the function W^i_f on each interval, and at least one global maximizer of the function W^i_f. Let X^{i*} denote the set of maximizers of the function W^i_f. From Claim 6, there exists a unique equilibrium in each subgame originating at $x^i \in [0, \underline{x}^i] \cup [\bar{x}^i, 1]$, and, thus, a unique equilibrium in each subgame that starts after $x^{i*} \in X^{i*}$. Since we have proven that the set X^{i*} is non-empty, an equilibrium of the game Γ^i exists.□

Step 8

Claim 8 *An equilibrium of the game $\mathcal{T}$ exists, and each player payoff is a sum of his equilibrium payoffs in the games Γ^i and Γ^j:*

$$\Pi^j(\mathbf{a}) = \Pi^j_{\Gamma^i}(\mathbf{e}^{ij}) \quad \textit{and} \quad W^i(\mathbf{a}) = W^i_{\Gamma^i}(\mathbf{e}^{ij}) + W^i_{\Gamma^j}(\mathbf{e}^{ji}),$$

Proof of Claim 8. Equation (21) holds from construction.

Finding the equilibria of the game $\mathcal{T}$ is equivalent to finding the equilibria of two games Γ^i. From Claim 7, there exists an equilibrium in each game Γ^i, and, thus, in the game $\mathcal{T}$, and Theorem 1 is proven. □

Proof of Proposition 1: Let $(\breve{x}^{i*}, \breve{r}^{i*}, \breve{s}^{i*}, \breve{\mathbf{q}}^{i*})$ and $(\tilde{x}^{i*}, \tilde{r}^{i*}, \tilde{s}^{i*}, \tilde{\mathbf{q}}^{i*})$ denote player actions in the equilibria under consideration. When $\breve{Q}^{i*} > \tilde{Q}^{i*}$, where $Q^{i*} = K^i q^{i*}$ from equations (16) or (21), we have

$$\breve{x}^{j*} < \tilde{x}^{j*}. \tag{29}$$

Differentiation of equations (9) or (18) with respect to x provides:

$$A' \frac{dQ(x)}{dx} = \frac{\xi}{(1-t)^2} \frac{dt(x)}{dx},$$

which implies:

$$\frac{dt^j(x^j)}{dx^j} \geq 0, \tag{30}$$

and from equation (29):

$$\breve{t}^{j*} < \tilde{t}^{j*}.$$

From equation (30), in the subgame of the game Γ^j that starts after x^j, equilibrium profit decreases with x^j:

$$\frac{d\Pi^i_{k\Gamma^i}(x^j, \mathbf{q}^i)}{dx^j} = -\frac{dt^j(x^j)}{dx^j} \alpha^i P(Q^i) \frac{q^i_k}{Q^i} < 0.$$

Thus, in the game Γ^j investor preferred equilibrium has the lowest t^{j*} and highest q^{i*} within the set of their equilibrium values. Government i payoff in the game Γ^i is the same in all equilibria, and government j strictly prefers the same equilibrium as its investors. Thus, investor preferred equilibrium is a Pareto-dominant equilibrium of the game Γ^i. Since government j payoff in the game $\mathcal{T}$ is equal to a sum of its payoffs in the games Γ^i and Γ^j, government j strictly prefers the same equilibrium of the game $\mathcal{T}$ as its investors. Country i investor profit in the game $\mathcal{T}$ does not depend on the equilibrium of the game Γ^i. Hence, there exists a Pareto-dominant equilibrium in the game $\mathcal{T}$. From equations (29) and (30), in the Pareto dominant equilibrium tariffs are the lowest and investments the highest within the set of the equilibrium values.$\square$

Proof of Corollary 1: Let E^{j*} denote equilibrium expenses of both governments on negotiations of country j tariff:

$$E^{j*} = \beta^j B(r^{j*}) + \gamma^i B(s^{i*}).$$

From Theorem 1 and *ex post* optimization in the game $\Gamma^j = \Gamma^j(x^j, r^j, s^i, \mathbf{q}^i)$:

$$\alpha^i P(Q^{i*}) = \gamma^i B'(s^{i*}), \quad \text{when} \quad s^{i*} \neq 0, \quad \text{and} \quad \alpha^i P(Q^{i*}) = \beta^j B'(r^{j*}),$$

where $Q^{i*} = K^i q^{i*}$. Thus, when $\breve{Q}^{i*} > \tilde{Q}^{i*}$ we have:

$$\tilde{r}^{j*} < \breve{r}^{j*} \quad \text{and} \quad \tilde{s}^{i*} \leq \breve{s}^{i*},$$

and from the properties of the function B:

$$\tilde{E}^{j*} \leq \breve{E}^{j*}.$$

$\square$

Proof of Proposition 2: Let $(\breve{x}^{i*}, \breve{r}^{i*}, \breve{s}^{i*}, \breve{\mathbf{q}}^{i*})$ and $(\tilde{x}^{i*}, \tilde{r}^{i*}, \tilde{s}^{i*}, \tilde{\mathbf{q}}^{i*})$ denote player actions in the equilibria of the games $\mathcal{T}(\breve{\mathbf{o}})$ and $\mathcal{T}(\tilde{\mathbf{o}})$. From Theorem 1 and investor optimization:

$$\alpha^i A(Q^i(x^j)) = \frac{\xi^i}{(1 - t^j(x^j))}, \tag{31}$$

where $t^j(x^j)$ is best response *ex post* tariff, which from equation (1) and Theorem 1 is equal to

$$t^j(x^j) = x^j + r^j(x^j) - s^i(x^j), \tag{32}$$

and from equation (31)

$$\breve{t}^j(\breve{x}^j) = \tilde{t}^j(\tilde{x}^j) \quad \text{if} \quad \breve{Q}^i(\breve{x}^j) = \tilde{Q}^i(\tilde{x}^j), \tag{33}$$

where decorations "˘" and "˜" designate the games $\mathcal{T}(\breve{\mathbf{o}})$ and $\mathcal{T}(\tilde{\mathbf{o}})$, respectively. To ease notation, we drop the decorations when possible. From Theorem

1, in any subgame of the game Γ^j that starts after action x^j government *ex post* optimization results in:

$$\alpha^i P(Q^i(x^j)) = \beta^j B'(r^j(x^j)) = \gamma^i B'(s^i(x^j)), \tag{34}$$

when $s^i(x^j) > 0$, or $s^i(x^j) = 0$, or both, *ex post* best responses are zero, $s^i(x^j) = r^j(x^j) = 0$. In all cases $r^i(x^j) \geq s^j(x^j)$, and from $\breve{\gamma}^i > \tilde{\gamma}^i$ we have:

$$\breve{r}^j(\breve{x}^j) = \tilde{r}^j(\tilde{x}^j), \quad \breve{s}^i(\breve{x}^j) \leq \tilde{s}^i(\tilde{x}^j) \quad \text{if} \quad \breve{Q}^i(\breve{x}^j) = \tilde{Q}^i(\tilde{x}^j), \tag{35}$$

and from equations (33) and (35):

$$\breve{x}^j > \tilde{x}^j \quad \text{if} \quad \breve{Q}^i(\breve{x}^j) = \tilde{Q}^i(\tilde{x}^j).$$

From Theorem 1, government j *ex ante* optimization:

$$\left.\frac{dW_f^j(x^j)}{dx^j}\right|_{x^j = x^{j*}} = 0, \tag{36}$$

and the use of equation (34) and its derivative

$$\frac{ds^i(x^j)}{dx^j} = \frac{\alpha^i P'(Q^i)}{\gamma^i B''(s^i)} \frac{dQ^i(x^j)}{dx^j}$$

provides:

$$\left[t^j - \frac{\alpha^i P(Q^i)}{\gamma^i B''(s^i)}\right] \frac{dQ^i(x^j)}{dx^j} + \frac{P(Q^i)}{P'(Q^i)} = 0. \tag{37}$$

The derivative $\frac{dQ^i(x^j)}{dx^j}$, (equation (15)), is higher in $\mathcal{T}(\breve{\mathbf{o}})$ than in $\mathcal{T}(\tilde{\mathbf{o}})$:

$$\frac{d\breve{Q}^i(\breve{x}^j)}{d\breve{x}^j} > \frac{d\tilde{Q}^i(\tilde{x}^j)}{d\tilde{x}^j} \quad \text{if} \quad \breve{Q}^i(\breve{x}^j) = \tilde{Q}^i(\tilde{x}^j), \tag{38}$$

because from $\breve{\gamma}^i > \tilde{\gamma}^i$, equation (35) and properties of the function B:

$$\frac{1}{\beta^j B''(\breve{r}^j)} - \frac{1}{\breve{\gamma}^i B''(\breve{s}^i)} \geq \frac{1}{\beta^j B''(\tilde{r}^j)} - \frac{1}{\tilde{\gamma}^i B''(\tilde{s}^j)}.$$

Therefore, when in the game $\mathcal{T}(\breve{\mathbf{o}})$ the *ex ante* action $\tilde{x}_0^j$ is such that $\tilde{Q}^i(\tilde{x}_0^j) = \breve{Q}^{i*}$ we have:

$$\left.\frac{d\tilde{W}_f^j(\tilde{x}^j)}{d\tilde{x}^j}\right|_{\tilde{x}^j = \tilde{x}_0^j} < 0, \tag{39}$$

because equation (36) holds in the equilibrium of the game $\mathcal{T}(\breve{\mathbf{o}})$ and, from equations (35) and (38), both terms of equation (37) are smaller in $\mathcal{T}(\tilde{\mathbf{o}})$ than in $\mathcal{T}(\breve{\mathbf{o}})$. If equation (4) holds, the function $W_f^j(x^j)$ is single peaked: it is increasing for any $x^j < x^{j*}$, and decreasing for any $x^j < x^{j*}$. Equation (39) provides that $\tilde{x}^{j*} < \tilde{x}_0^j$, and from $\frac{dQ(x)}{dx} < 0$ we have:

$$\tilde{Q}^{i*} = \tilde{Q}^i(\tilde{x}^{j*}) > \tilde{Q}^i(\tilde{x}_0^j) = \breve{Q}^{i*},$$

in which case, from equation (34) $\breve{s}^i(\breve{x}^j) \leq \tilde{s}^i(\tilde{x}^j)$, and from equation (31)

$$\tilde{t}^{j*} \leq \breve{t}^{j*},$$

Equation (34) and properties of the function B imply:

$$\breve{\gamma}^i B(\breve{s}^{i*}) \leq \tilde{\gamma}^i B(\tilde{s}^{i*}), \quad \breve{\beta}^j B(\breve{r}^{j*}) \leq \tilde{\beta}^j B(\tilde{r}^{j*}) \quad \text{if} \quad \tilde{Q}^{i*} > \breve{Q}^{i*},$$

where the inequality is strict if the relevant renegotiation expenses are nonzero. Thus, renegotiation expenses are higher in $\mathcal{T}(\tilde{\mathbf{o}})$ than in $\mathcal{T}(\breve{\mathbf{o}})$. $\square$

Proof of Corollary 2: From equation (34)

$$\beta^i B'(r^{i*}) = \gamma^j B'(s^{j*}),$$

hence, when $\beta^i = \gamma^j$ we have $r^{i*} = s^{j*}$. $\square$

Notation and Preliminaries for the Proofs of Propositions 3 – 6: Let $(\breve{x}^{i*}, \breve{r}^{i*}, \breve{s}^{i*}, \breve{q}^{i*})$ and $(\tilde{x}^{i*}, \tilde{r}^{i*}, \tilde{s}^{i*}, \tilde{q}^{i*})$ denote player actions in the equilibria of $\mathcal{T}(\breve{\mathbf{o}})$ and $\mathcal{T}(\tilde{\mathbf{o}})$. As above, the decorations "$\breve{}$" and "$\tilde{}$"designate the respective games, and to ease notation, we drop the decorations when possible. In the equilibrium of any subgame that starts after x^j we have:

$$r^j(x^j) = s^i(x^j), \quad t^j(x^j) = x^j + r^j(x^j) - s^i(x^j) = x^j \quad \text{if} \quad \beta^i = \gamma^j. \tag{40}$$

Proof of Proposition 3: When $\breve{\alpha}^i > \tilde{\alpha}^i$, from equation (31) we have:

$$\breve{x}^j > \tilde{x}^j \quad \text{if} \quad \breve{Q}^i(\breve{x}^j) = \tilde{Q}^i(\tilde{x}^j), \tag{41}$$

or, when *ex ante* tariff rates are the same in both games:

$$\breve{Q}^i(x^j) > \tilde{Q}^i(x^j). \tag{42}$$

When $\beta^i = \gamma^j$, equation (36) can be rearranged as

$$\frac{\xi^i}{(1-x^j)^2}\left[\frac{P(Q^i)}{\gamma^i B''(s^i)} - \frac{x^j}{\alpha^i}\right] + \frac{P(Q^i)(-A'(Q^i))}{P'(Q^i)} = 0, \tag{43}$$

where equations (15) and (40) were used. When in the game $\mathcal{T}(\tilde{\mathbf{o}})$ *ex ante* tariff rate $\tilde{x}^j$ is equal to $\breve{x}^{j*}$

$$\left.\frac{d\tilde{W}_f^j(\tilde{x}^j)}{d\tilde{x}^j}\right|_{\tilde{x}^j=\breve{x}^{j*}} < 0,$$

because equation (36) holds in the equilibrium of the game $\mathcal{T}(\breve{\mathbf{o}})$ and, from equation (42), both terms of equation (43) are smaller in $\mathcal{T}(\tilde{\mathbf{o}})$ than $\mathcal{T}(\breve{\mathbf{o}})$. Thus,

$$\tilde{x}^{j*} < \breve{x}^{j*}, \tag{44}$$

and from equation (40) we have:

$$\tilde{t}^{j*} < \breve{t}^{j*}.$$

Next, we show that when in the game $\mathcal{T}(\tilde{\mathbf{o}})$ the *ex ante* tariff rate $\tilde{x}_0^j$ is such that $\tilde{Q}^i(\tilde{x}_0^j) = \hat{Q}^{i*}$ we have:

$$\left.\frac{d\tilde{W}_f^j(\tilde{x}^j)}{d\tilde{x}^j}\right|_{\tilde{x}^j=\tilde{x}_0^j} < 0,$$

because equation (36) holds in the equilibrium of the game $\mathcal{T}(\breve{\mathbf{o}})$ and, from equation (41), the first term of equation (43) is smaller in $\mathcal{T}(\tilde{\mathbf{o}})$ than in $\mathcal{T}(\breve{\mathbf{o}})$, and the second term is the same in both games. Thus,

$$\tilde{x}^{j*} < \tilde{x}_0^j,$$

and from $\frac{dQ(x)}{dx} < 0$ we have:

$$\tilde{Q}^{i*} = \tilde{Q}^i(\tilde{x}^{j*}) > \tilde{Q}^i(\tilde{x}_0^j) = \breve{Q}^{i*}. \tag{45}$$

To show that country i equilibrium exports are higher in $\mathcal{T}(\breve{\mathbf{o}})$ than in $\mathcal{T}(\tilde{\mathbf{o}})$, rewrite equation (43) as

$$-\frac{x^j\xi^i}{(1-x^j)^2}\frac{P'(Q^i)}{(-A'(Q^i))} + \alpha^i P(Q^i)\left[1+\frac{1}{\gamma^i B''(s^i)}\right] = 0. \tag{46}$$

From $P'''(Q) \leq 0$, the function A'' is nonpositive:

$$A''(Q) = \frac{1}{K}P'''(Q) + \left[1-\frac{1}{K}\right]\frac{1}{Q}\left(P''(Q) - \frac{2}{Q}\left[P'(Q) - \frac{P(Q)}{Q}\right]\right) \leq 0, \tag{47}$$

because

$$P''(Q) - \frac{2}{Q}[P'(Q) - \frac{P(Q)}{Q}] \leq 0 \quad \text{if} \quad P'''(Q) \leq 0.$$

From equations (44), (45), (47) and properties of the functions P and B, the absolute value of the negative first term of equation (46) is greater in $\mathcal{T}(\breve{\mathbf{o}})$ than in $\mathcal{T}(\tilde{\mathbf{o}})$. Since equation (46) holds in the equilibrium of both games, the positive second term is greater in $\mathcal{T}(\breve{\mathbf{o}})$ than in $\mathcal{T}(\tilde{\mathbf{o}})$.

From properties of the functions P and B, the second term of equation (46) is higher only if equilibrium exports $\alpha^i P(Q^{i*})$ are higher in $\mathcal{T}(\breve{\mathbf{o}})$ than in $\mathcal{T}(\tilde{\mathbf{o}})$. Hence, equilibrium exports are higher in $\mathcal{T}(\breve{\mathbf{o}})$ than in $\mathcal{T}(\tilde{\mathbf{o}})$. $\square$

Proofs of Propositions 4 - 6 are analogous to Proposition 3. These proofs are attached in provided "Notes for Referees". I would follow the advice on whether these proofs should be included in the final version (if I am lucky and the paper is accepted for publication).

Consumer Demand

Remark 1 *Let aggregate consumer demand be convex and continuous in aggregate quantity, continuous in investment and let government costs of sustaining its tariffs be insignificant compared with aggregate consumer demand. Then, the function P is concave.*

Proof of Remark 1: Let y denote an aggregate quantity of an import good demanded at the price $D(y^i)$ by country i consumers:

$$y^i = \sum_{i \neq j} y^{ij} = y,$$

From our assumption the function D continuous and convex

$$D' < 0, \quad D'' > 0.$$

For country i consumers, good y imports are perfect substitutes (think of sugar). Without loss of generality we let:

$$K^j = 1.$$

Since government costs of sustaining its tariffs are insignificant relative to aggregate demand, this demand is independent of government costs. Let Q^{ji} denote country j investment in exports to country i:

$$y^{ji} = y^{ji}(Q^{ji}).$$

Obviously, the function y^{ji} is nondecreasing in Q^{ji} :

$$y^{ji\prime} \geq 0, \tag{48}$$

see Figure 1 for supply-demand diagram.[15] Country j investor profit from exports to country i is:

$$\Pi^{ij}(\mathbf{a}_N, y) = (1 - t^{ij})D(y)y^{ji} - \xi^j Q^{ji}, \tag{49}$$

and countries i and j government objectives are:

$$\begin{aligned} V^i(\mathbf{a}_N) &= \sum_j [t^{ij}D(y)y^j - \beta^{ij}B(r^{ij})], \\ \Phi(\mathbf{a}_N) &= \sum_j [(1 - t^{ij})\Pi^{ji}(\mathbf{a}_N, y) - \gamma^{ji}B(s^{ji})]. \end{aligned} \tag{50}$$

With equation (5), government *ex post* first order conditions are:

$$\begin{gathered} D(y)y^{ji} = \beta^{ij}B'(r^{ij}) = \gamma^{ji}B'(s^{ji}), \\ r^{ji} = s^{ji}, \quad t^{ij} = x^{ij} + r^{ij} - s^{ji} = x^{ij}. \end{gathered}$$

From country j investor profit maximization, in equilibrium:

$$\frac{d\Pi^j}{dQ^{ji}} = 0 \quad \text{and} \quad \frac{d^2\Pi^j}{[dQ^{ji}]^2} < 0. \tag{51}$$

Let $P(Q^{ji})$ be defined as $\frac{1}{\alpha^{ji}}D(y)y^{ji}$:

$$P(Q^{ji}) = \frac{1}{\alpha^{ji}}D(y)y^{ji}.$$

From equation (51) the expression $\frac{dD(y)y^{ji}}{dQ^{ij}}$ is positive:

$$\frac{dD(y)y^{ji}}{dQ^{ji}} = \left[y^{ji}\frac{dD(y)}{dy} + D(y)\right]\frac{dy^{ji}}{dQ^{ji}} = \frac{\xi t^{ji}}{(1 - t^{ij})} > 0,$$

thus:

$$\frac{dP(Q^{ji})}{dQ^{ji}} = \frac{1}{\alpha^{ji}}\left[y^{ji}\frac{dD(y)}{dy} + D(y)\right]\frac{dy^{ji}}{dQ^{ji}} = \frac{1}{\alpha^{ji}}\frac{\xi}{(1 - t^{ij})} > 0,$$

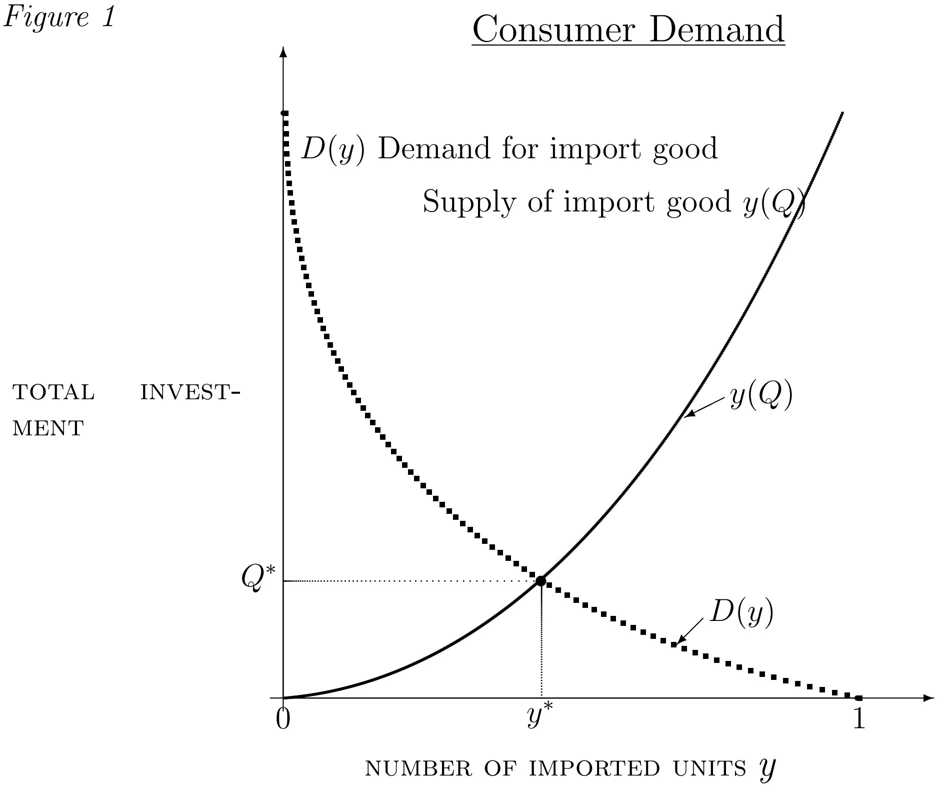
and from $\frac{d^2\Pi^j}{dQ^{ji2}} < 0$:

$$\frac{d^2P(Q^{ji})}{dQ^{ji2}} < 0,$$

which permits to rewrite investor and government objectives (equations (49) and (50)) as functions of Q^{ji}. The resulting equations coincide with equations (2) and (3) . □

[15] The diagram is drawn for the case of decreasing returns in production ($y^{ji\prime\prime} > 0$), which is not used in our derivation. We allows $y^{ji\prime\prime} \leq 0$.

Figure 1



We define $P(Q^{ji})$ *as* $\frac{1}{\alpha^{ji}} D(y) y^{ji}$ *and derive its convexity when the function* D *is convex and the function* y *is nondecreasing in investment. On Figure 1, we assume convex functions* D *and* y.

Notes for Referees

Thanks a lot for refereeing this paper.

I made a last minute change of notation: in the current version, when the games with different parameters are compared, I call the compared games $\mathcal{T}(\breve{\mathbf{o}})$ and $\mathcal{T}(\tilde{\mathbf{o}})$, and the decorations "$\breve{}$" and "$\tilde{}$"designate the respective parameters and variables. Originally, I used to denote these games $\mathcal{T}(\hat{\mathbf{o}})$ and $\mathcal{T}(\tilde{\mathbf{o}})$. I realized that "hat" is overused, and changed it to "$\breve{}$". I bring my apology if in some places the decorations are still a little messed up.

More details on Section 4

Let $\beta^{ij}B(r^{ij})$ and $\gamma^{ji}B(s^{ji})$ denote government i and j negotiation expenses on t^{ij}, i.e., country i tariff on imports from country j:

$$t^{ij} = x^i + r^{ij} - s^{ji}, \quad i, j = 1, \dots, N,$$

with $j \neq i$, here and below. Let $\mathbf{q}^{ij} = (q_1^{ij}, \dots, q_{K^i}^{ij})$ denote the vector of actions (investments) of country i investors in export good to country j, where the k-th component q_k^{ij} denotes the k-th investor action. Player objectives in the game $\mathcal{T}$ are the generalization of their objectives in the game $\mathcal{T}$. Let

$$Q^{ij} = \sum_{k=1}^{K^i} q_k^{ij}$$

denote country i aggregate investment in exports to country j, and $\Pi^{ij}(\mathbf{a}_N)$ – the respective investor profit:

$$\Pi^{ij}(\mathbf{a}_N) = (1 - t^{ji})\alpha^{ij}P(Q^{ij}) - \xi^i Q^{ij}, \quad \mathbf{a}_N = (x^{ij}, r^{ij}, s^{ij}, \mathbf{q}^{ij}) \in \mathbf{A}_N,$$

where $\mathbf{A}_N$ is the set of action profiles in the game $\mathcal{T}_N$.

More details on Proofs

Theorem 1: Actually, the system of equations is just player FOCs:

$$b = \frac{\beta}{\alpha} \quad \text{and} \quad c = \frac{\gamma}{\alpha}$$

To simplify notation, further we drop the indexes i and j when possible. From *ex post* optimization we have for fixed x and Q, and if $s^Q(x) > 0$

$$\frac{B'((r^Q(x))}{B'(s^Q(x))} = \frac{\gamma}{\beta} > 0, \quad s^Q(x) > 0$$

Lemma 2.1. *There exists a unique solution $\hat{Q}(x)$ of the following equation*

$$(1-x)A(Q)-\xi=0, \tag{52}$$

where A is given by equation (11), $Q \in [0,\infty)$ and $x \in [0,1]$. The function $\hat{Q}$ is continuous, twice continuously differentiable and $\hat{Q}' < 0$.

Proof of Lemma 2.1: We have:

$$(1-x)A'(Q) < 0,$$

where A' is negative from equation (13). Thus, the interior solution $\hat{Q}(x)$ of equation (52) is unique. A boundary point $Q \to \infty$ is never optimal and $Q=0$ is optimal only when $x=1$, in which case no other optimal x exists. Thus, the solution $\hat{Q}(x)$ of equation (52) is unique. From properties of the underlying functions, the function $\hat{Q}(x)$ is continuous and twice continuously differentiable. Differentiate equation (52) with respect to x and use the implicit function theorem to show that the derivative $\hat{Q}'(x)$ is negative:

$$\hat{Q}'(x) = \frac{\xi}{(1-x)^2 A'(\hat{Q}(x))} < 0, \tag{53}$$

because A' is negative from equation (13). □

Lemma 2.2. *There exists a unique symmetric equilibrium $\hat{\mathbf{q}}^j(x^i)$ in subgame of the game $\hat{\Gamma}^i$ that starts after x^i, where $\hat{\mathbf{q}}^j(x^i) = (\hat{q}^j(x^i), \dots, \hat{q}^j(x^i))$, $\hat{q}^j(x^i) = \frac{\hat{Q}^j(x^i)}{K}$, and $\hat{Q}^j(x^i)$ is a solution of equation (52). The function $\hat{q}^j$ is continuous, twice continuously differentiable and $\hat{q}'^j(x^i) < 0$* for all $x^i \in [0,1]$.

Proof of Lemma 2.2: First, we show that investment $\hat{q}(x)$ is optimal for each investor given that the actions of all other investors are equal to $\hat{q}(x)$. Second, we prove that no other vector of investments can be a symmetric investor best response.

1. Let $\hat{\mathbf{q}}(x) = (\frac{\hat{Q}(x)}{K}, \dots, \frac{\hat{Q}(x)}{K})$ be the vector of investments. Then, from Lemma 2.1 the first order conditions of each investor are fulfilled:

$$\frac{d\hat{\Pi}_k(x, \hat{\mathbf{q}}(x))}{dq_k} = (1-x)A(Q) - \xi = 0,$$

where $k = 1, \dots, K$. Thus, $\hat{\mathbf{q}}(x)$ is a critical point of the function $\hat{\Pi}_k$. Since $\hat{\Pi}_k$ is concave in q_k:

$$\frac{d^2\hat{\Pi}_k(x, \hat{\mathbf{q}}(x))}{dq_k^2} = (1-x)A'(Q) < 0,$$

which provides that each investor profit is maximized at $\hat{\mathbf{q}}(x)$.

2. The proof is by contradiction. Let $\tilde{\mathbf{q}}(x) = (\frac{\tilde{Q}(x)}{K}, \dots, \frac{\tilde{Q}(x)}{K})$, with $\tilde{Q}(x) \neq \hat{Q}(x)$, be investor best response. Then, each investor's first order conditions are:

$$\frac{d\hat{\Pi}_k(x, \tilde{\mathbf{q}}(x))}{dq_k} = (1-x)A(\tilde{Q}) - \xi = 0,$$

which contradicts the uniqueness of the solution of equation (52). Thus, the symmetric best response $\hat{q}(x)$ is unique. From Lemma 2.1 and equation (53) the function $\hat{q}$ is continuous, twice continuously differentiable and decreasing in x:

$$\hat{q}'(x) < 0 \tag{54}$$

for all $x \in [0, 1]$. □

Proof of Claim 2: From equation (3) and Lemma 2.2, government i objective in the game $\hat{\Gamma}^i$ is to maximize:

$$\hat{V}(x^i, \mathbf{q}^j) = V(x^i, 0, 0, \mathbf{q}^j) = x^i P(\hat{Q}^j(x^i)),$$

where $\hat{Q}(x) = K\hat{q}(x)$ is aggregate best response investment. Government i payoff is continuous for all $x^i \in [0, 1]$, equal to zero for $x \in [0, 1]$ and bounded by $[0, P^{\max}]$, where $P^{\max} = P(\hat{Q}(0))$. Thus, government i payoff is continuous and bounded on the compact interval $[0, 1]$. Therefore, there exists a non-empty set $\hat{X}$ of maximizers of the function $\hat{V}(x, \mathbf{q})$. From Lemma 2.2 there exists a unique investor best response for any x, and, thus for all $\hat{x} \in \hat{X}$. Therefore, there exists an equilibrium of the game $\hat{\Gamma}$, in which the player actions are $(\hat{x}, \hat{q}(\hat{x}))$ and $\hat{x} \in \hat{X}$. □

Proof of Proposition 4: From equations (31) and (40) we have:

$$\breve{x}^j < \tilde{x}^j \quad \text{if} \quad \hat{Q}^i(\breve{x}^j) = \tilde{Q}^i(\tilde{x}^j), \tag{55}$$

or, when *ex ante* tariff rate x^j is the same in both games:

$$\hat{Q}^i(x^j) > \tilde{Q}^i(x^j). \tag{56}$$

From properties of the functions P and B, the terms

$$\frac{\alpha^i P(Q^i)}{\gamma^i B''(s^i)} \quad \text{and} \quad \frac{\alpha^i P(Q^i)(-A'(Q^i))}{P'(Q^i)}$$

of equation (43) are increasing in Q When in the game $\mathcal{T}(\tilde{\mathbf{o}})$ *ex ante* tariff rate $\tilde{x}^j$ is equal to $\breve{x}^{j*}$ we have:

$$\left.\frac{d\tilde{W}_f^j(\tilde{x}^j)}{d\tilde{x}^j}\right|_{\tilde{x}^j = \breve{x}^{j*}} < 0,$$

because equation (36) holds in the equilibrium of the game $\mathcal{T}(\breve{\mathbf{o}})$ and, from equation (56), both terms of equation (43) are greater in $\mathcal{T}(\breve{\mathbf{o}})$ than in $\mathcal{T}(\tilde{\mathbf{o}})$. Therefore,

$$\tilde{x}^{j*} < \breve{x}^{j*},$$

and from equation (40) we have

$$\tilde{t}^{j*} < \breve{t}^{j*}.$$

When in the game $\mathcal{T}(\tilde{\mathbf{o}})$ the *ex ante* tariff rate $\tilde{x}_0^j$ is such that $\tilde{Q}^i(\tilde{x}_0^j) = \breve{Q}^{i*}$ we have:

$$\left.\frac{d\tilde{W}_f^j(\tilde{x}^j)}{d\tilde{x}^j}\right|_{\tilde{x}^j=\tilde{x}_0^j} < 0,$$

because equation (36) holds in the equilibrium of the game $\mathcal{T}(\breve{\mathbf{o}})$ and, from equation (55), the first term of equation (43) is smaller in $\mathcal{T}(\tilde{\mathbf{o}})$ than in $\mathcal{T}(\breve{\mathbf{o}})$, and the second term is the same in both games. Thus,

$$\tilde{x}^{j*} < \tilde{x}_0^j,$$

and we have

$$\tilde{Q}^{i*} = \tilde{Q}^i(\tilde{x}^{j*}) > \tilde{Q}^i(\tilde{x}_0^j) = \breve{Q}^{i*},$$

because $\frac{dQ(x)}{dx} < 0$. $\square$

Proof of Proposition 5: The left-hand side of equation (11) is increasing in K for any fixed Q:

$$\breve{A}(Q) - \tilde{A}(Q) > 0.$$

Thus, from equations (31) and (40) we have:

$$\breve{x}^j > \tilde{x}^j \quad \text{if} \quad \breve{Q}^i(\breve{x}^j) = \tilde{Q}^i(\tilde{x}^j), \tag{57}$$

or, when the *ex ante* tariff rate is the same in both games:

$$\breve{Q}^i(x^j) > \tilde{Q}^i(x^j).$$

From equation (43), when in the game $\mathcal{T}(\tilde{\mathbf{o}})$ the *ex ante* tariff rate $\tilde{x}_0^j$ is such that $\tilde{Q}^i(\tilde{x}_0^j) = \breve{Q}^{i*}$, we have :

$$\left.\frac{d\tilde{W}_f^j(\tilde{x}^j)}{d\tilde{x}^j}\right|_{\tilde{x}^j=\tilde{x}_0^j} > 0, \tag{58}$$

because equation (36) holds in the equilibrium of the game $\mathcal{T}(\breve{\mathbf{o}})$ and, from equation (57), both terms of equation (43) are greater in $\mathcal{T}(\tilde{\mathbf{o}})$ than in $\mathcal{T}(\breve{\mathbf{o}})$. The first term is greater because from equation (57)

$$\frac{-\breve{x}^{j*}}{(1-\breve{x}^{j*})} < \frac{-\tilde{x}^j_0}{(1-\tilde{x}^j_0)},$$

and since investments $\hat{Q}^i(\breve{x}^{j*}) = \tilde{Q}^i(\tilde{x}^j_0)$ are equal in both games, best response *ex post* adjustments r^j are also equal, which implies:

$$\frac{1}{\gamma^i B''(\breve{s}^i)} = \frac{1}{\gamma^i B''(\tilde{s}^i)} \quad \text{if} \quad \breve{Q}^i(\breve{x}^j) = \tilde{Q}^i(\tilde{x}^j).$$

The second term of equation (43) is greater in $\mathcal{T}(\tilde{\mathbf{o}})$ than in $\mathcal{T}(\breve{\mathbf{o}})$, because the left-hand side of equation (13) is increasing in K for any fixed Q:

$$-\tilde{A}'(Q) + \hat{A}'(Q) > 0.$$

From equation (58) we have $\tilde{x}^{j*} > \tilde{x}^j_0$ and

$$\tilde{Q}^{i*} = \tilde{Q}(\tilde{x}^{j*}) < \tilde{Q}^i(\tilde{x}^j_0) = \breve{Q}^{i*},$$

due to $\frac{dQ(x)}{dx} < 0$. □

Proof of Proposition 6: When $\hat{\beta}^i > \tilde{\beta}^i$ (and $\hat{\gamma}^j < \tilde{\gamma}^j$), from equation (34) we have:

$$\breve{r}^i(\breve{x}^i) = \breve{s}^j(\breve{x}^i) < \tilde{r}^i(\tilde{x}^i) = \tilde{s}^j(\tilde{x}^i) \quad \text{if} \quad \breve{Q}^j(\breve{x}^i) = \tilde{Q}^j(\tilde{x}^i), \tag{59}$$

and from equations (31) and (40)

$$\breve{x}^i = \tilde{x}^i \quad \text{if} \quad \breve{Q}^j(\breve{x}^i) = \tilde{Q}^j(\tilde{x}^i). \tag{60}$$

From equation (43), when in the game $\mathcal{T}(\tilde{\mathbf{o}})$ *ex ante* tariff rate $\tilde{x}^i$ is equal to $\breve{x}^{i*}$, we have:

$$\left.\frac{d\tilde{W}^i_f(\tilde{x}^i)}{d\tilde{x}^i}\right|_{\tilde{x}^i=\breve{x}^{i*}} > 0,$$

because equation (36) holds in the equilibrium of the game $\mathcal{T}(\breve{\mathbf{o}})$ and, from equations (59) and (60), the first term of equation (43) is smaller in $\mathcal{T}(\tilde{\mathbf{o}})$ than in $\mathcal{T}(\breve{\mathbf{o}})$, and the second term is the same in both games. Therefore,

$$\tilde{x}^{i*} > \breve{x}^{i*},$$

in which case from equation (40) we have:

$$\tilde{t}^{i*} > \breve{t}^{i*},$$

and

$$\tilde{Q}^{j*} = \tilde{Q}^{j}(\tilde{x}^{i*}) < \breve{Q}^{j}(\breve{x}^{i*}) = \hat{Q}^{j*},$$

due to $\frac{dQ(x)}{dx} < 0$. $\square$