Adjustment Costs and Gradual Trade Liberalization*

by

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Abstract

This paper analyzes dynamic bilateral trade liberalization between two large countries. Trade liberalization causes the importable sector of each country to shrink and thereby causes reallocation of labor between sectors. Assuming that each moving worker must pay a fixed adjustment cost, a country has to bear a total adjustment cost which is linear in the amount of moving workers. We derive the most-cooperative, self-enforcing trade liberalization path, and find that in general trade liberalization is gradual. We also find that trade adjustment assistance that compensates workers for relocation out of the protected sector will accelerate the pace of trade liberalization.

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1 Introduction

It is well understood that large countries have some market power in world commerce even in markets that are perfectly competitive. Their governments can increase domestic welfare by erecting trade barriers. When several countries try to exploit this advantage at the same time, they tend to act strategically. Such strategic interaction between, say, two countries can result in a trade war, the outcome of a prisoners' dilemma game, where each country protects its inefficient importable industry by import tariffs or other trade policies. There is, however, no cause for pessimism since when the game is repeated for many periods, countries would be willing to cooperate and cut tariffs below the static 'optimum tariff' level. The Folk Theorem tells us that if the future is sufficiently important to both countries, even free trade can be supported as an equilibrium in a repeated game setting. The two countries will be willing to cooperate immediately and thereafter.[1]

If one examines the evolution of openness to trade of the major industrial countries in the post-war era, it is clear that tariff barriers have fallen gradually, not immediately. Successive rounds of the General Agreement on Tariffs and Trade have delivered lower and lower trade barriers among countries, especially between the major industrialized countries (Bhagwati, 1988). This paper provides a theory to explain gradualism in bilateral trade liberalization between large countries. The theory we develop is based on two assumptions that we believe are essential. First, because of the lack of a world law enforcement agency, multilateral trade agreements should be self-enforceable, otherwise agents may strategically defect from an agreement. Second, factors of production need to pay costs of adjustment as they relocate between sectors.

The literature on trade liberalization has mainly focused on the analysis of unilateral liberalization with costs of adjustment. The results are typically the outcome of unilateral dynamic optimization. In such models, the optimal liberalization path can be gradual only when adjustment costs are convex with respect to the magnitude of tariff reduction. For example, in a model of liberalization of a small country where unemployment is the primary source of adjustment costs, Mussa (1986) finds that optimal unilateral trade liberalization

[1] See, for example, Dixit (1987).

will be gradual if "the rate of resource reallocation relative to the level of unemployment becomes large at low levels of unemployment" (p.71), which is essentially an assumption of convex adjustment cost. However, besides failing to address the enforceability issue, which becomes relevant in the case of large countries, this approach cannot explain gradualism unless the adjustment cost is convex, which is a rather restrictive assumption. On the contrary, the theory we develop below is robust to changes in the structure of adjustment costs.

Other models of unilateral liberalization suggest that gradualism can be justified for income distribution reasons. Mussa (1986) finds that gradual liberalization may be necessary to limit the income and wealth losses sustained by owners of resources initially employed in the protected sectors (p.70). Leamer (1980) considers unilateral tariff reduction of a country in a two-good, two-period model with only one mobile factor (labor) and the cost of inter-sectoral labor transfer. He finds that a staged (rather than immediate) reduction of tariffs not only eases the pain of the workers in the protected sector, but may also be preferred by all workers.

There are also models of (unilateral) endogenous gradual tariff reduction based on political economy arguments. Cassing and Hillman (1986) model that lower domestic output of an industry translates into lower net domestic benefits from protection. Instead of the presence of adjustment costs, what holds back the immediate 'collapse' of an industry (in the initial phase of trade liberalization) is an assumed positive relationship between tariff levels and industry size (based on lobbying theory). Drawing partially from Cassing and Hillman, but explicitly incorporating lobbying and convex adjustment costs, Brainard and Verdier (1994) model that greater current protection, in the form of higher import tariffs, implies greater current output, which in turn leads to more resources devoted to lobbying. Since industry adjustment and lobbying are substitutes — the more an industry lobbies, the greater the protection it receives and the less it adjusts — the lobbying feedback effect leads to a slow reduction of tariffs. Thus declining industries contract slowly over time.

Devereux (1997) examines a two-way interaction between bilateral trade liberalization and economic growth. Through dynamic increasing returns to specialization, international trade can increase world growth rates. But growth, through specialization, alters the pattern of comparative advantage, and increases the gains from trade. In one type of equilibrium in the dynamic tariff game, such interaction gradually raises the costs of punishment, and provides incentives for governments to lower tariffs gradually. Staiger (1995) also attributes gradualism in trade liberalization to self-enforceability of agreements. He assumes that import-competing workers have special rent-earning skills specific to the sector. If an initial "round" of liberalization can induce at least a portion of these workers to relocate to the rest of the economy, and if by not using their sector-specific skills these workers stand to lose them, then the enforcement problem associated with their presence will also diminish over time, and further rounds of liberalization are made possible. He does not, however, address the issue of adjustment costs of liberalization (such as re-training, physical relocation and temporary unemployment of displaced workers), which is a major concern for most countries facing the prospect of trade liberalization.

In this paper, we consider two large countries seeking a bilateral trade liberalization agreement.[2] We assume that each worker has to pay a fixed adjustment cost whenever he switches between sectors. We find that the most-cooperative liberalization path is gradual under a wide range of parametric values. In the course of bilateral trade liberalization, each country gains from a mutual tariff reduction, while incurring the cost of industrial adjustment accompanied by the liberalization. If a country deviates from the liberalization agreement, it would enjoy temporary benefits from setting an optimum tariff, which is followed by a trade war — both countries setting the optimum tariff — which we assume to last forever. Moreover, in this deviation-punishment phase, the deviating country would have to incur adjustment costs for expanding the importable sector. In each period along the most-cooperative trade liberalization path, the tariffs are mutually cut as much as possible, while keeping each country's incentive to stay in the agreement. However, after the resulting adjustment costs have been paid and the country has adjusted toward a smaller importable sector, the value of staying in the agreement is increased while the gains from deviation are decreased. These factors relax the incentive constraint, making it possible to cut tariffs further in the following period. In short, gradualism results both from self-enforceability and from the presence of costs of adjustment. With only self-enforceability and no adjustment costs, liberalization will be immediate. With only adjustment costs and no requirement of self-enforceability, liberalization will be gradual only when the adjustment cost is strictly convex.

We also examine the validity of the 'bicycle theory' of multilateral trade liberalization: unless you keep pedalling, you will fall off. This theory, which is first introduced by Bhagwati (1988), and later found its support in Staiger's (1995) model, suggests that a failure to

[2] At the cost of complexity, we could extend our analysis to *multilateral* trade liberalization and would obtain the same qualitative results.

conclude a round of GATT negotiation does not simply mean a continuation of the status quo, but rather a retreat from existing levels of international cooperation in trade policy. We find that the 'bicycle theory' is not supported in our model because, upon termination of cooperation, the foregone benefits from future cooperation, which tend to tighten the incentive constraint, are outweighed by saving of current adjustment costs, which tend to relax the constraint.

Then, we ask how trade adjustment assistance affects the pace of such liberalization. We find that an increase in the level of trade adjustment assistance granted to workers displaced from the importable sector would accelerate the pace of liberalization. The reason for it is that an increase in trade adjustment assistance reduces the distortion in the importable sector caused by the presence of adjustment costs, raising the benefits from cooperation. This intuitive result contrasts with Fung and Staiger (1996), who find an ambiguous result, and Brecher and Choudhri (1994), who find a quite different result from ours.[3]

Section 2 describes the preliminaries of the paper. In Section 3, we compute as the benchmark cases the liberalization paths with both linear and strictly convex adjustment costs when countries can commit to their agreed-upon tariffs. Noting that self-enforceability is crucial in a world without a central planner, we show in Section 4 a model of self-enforcing bilateral trade liberalization with linear (and more general) adjustment cost. In Section 5, we examine the 'bicycle theory' in light of our model. Section 6 evaluates the impacts of trade adjustment assistance on the liberalization path. Section 7 concludes the paper.

2 Preliminaries

In this section, we describe the basic setup of the models in Sections 3, 4 and 5.

2.1 Production Technologies

Consider two large countries, A and B, each of which can produce three competitively-produced goods, Goods 1 and 2, and a numeraire good. The only factor of production is labor. The two countries are symmetrical in all aspects except that Country A has a

[3]Brecher and Choudhri (1994) find that when there is compensation to maintain the pre-liberalization levels of welfare of displaced workers, the likelihood of Pareto gain from trade is reduced, since it weakens the incentive to work efficiently.

comparative advantage in Good 1 and Country B in Good 2, in the Ricardian sense described below. Consequently, in equilibrium, Good 1 is Country A's exportable and Country B's importable; Good 2 is Country A's importable and Country B's exportable.

In each country, there are two types of workers. The first type is skilled labor. They have special skills in the production of the exportable. Their productivity in the exportable sector is greater than one.[4] In each period they can produce $2E$ units of the exportable, sufficient for export as well as domestic consumption, if they all work in the exportable sector. Although they can also work in the importable sector or the numeraire good sector with productivity one, we assume that their productivity in the exportable sector is so high that all such workers prefer to work there in any event, attracted by higher wages. Workers of the second type are unskilled workers. They have no special skills in the production of the exportable. They can produce any of the three goods with productivity one. As we see later, their wage in the exportable sector equals one minus the other country's specific import tariff, whereas they can earn a wage of one in the other sectors. Thus, no worker of the second type works in the exportable sector. In summary, despite the assumption that the labor markets are perfectly competitive, there is no movement of workers in and out of each country's exportable industry in any event. This last feature allows us to focus on the allocation of the second type of labor between the importable and numeraire good sector whenever the industrial structure changes. Hereinafter, 'labor' or 'worker' refers to this second type of labor, unless otherwise specified.

2.2 Preferences and Demand for Goods

The preferences of a representative consumer of each country in each period of discrete time are represented by a quasi-linear utility function

$$U(x_1, x_2, y) = u(x_1) + u(x_2) + y,$$

where x_1, x_2, and y are respectively the consumption of Good 1, Good 2, and the numeraire good. As is well-known, preferences of this type implies that consumers' utility can be measured by the total surplus derived from the markets of Good 1 and Good 2. Consequently, the analysis may proceed in a partial equilibrium framework.

To simplify our calculation, we assume that the sub-utility function u has a form which makes each country's demand function for either Good 1 or Good 2 linear. Specifically, we

[4]Productivity is measured by the amount of good produced by each unit of labor.

define u in such a way that the per-period inverse demand function for either Good 1 or Good 2 can be written as $p = a - bq$, where $a \in [1 + bE,\ 1 + 2bE)$ and $b > 0$ are parameters; p and q are the price and quantity of the good. From the assumption that $2E$ units of Good 1 (Good 2) are produced in Country A (Country B), the inverse export supply function is given by $p = a - 2bE + bq$ for either country. Thus, the demand for the importable equals the export supply from abroad at the price $a - bE$. Since the importable can be supplied infinitely elastically at the price of one, the restriction on 'a' stated above, which can be rewritten as $a - 2bE < 1 \leq a - bE$, means that in free trade each country also produces the importable domestically. As Figure 1 shows, Country A (Country B) is the exporter of Good 1 (Good 2) in free trade, with the equilibrium world price equal to one.

2.3 One-Shot Payoffs for Each Government

As a benchmark scenario, we assume in Sections 3 and 4 that each government fully compensates workers for all the costs of adjustment if trade liberalization indeed takes place.[5] In such a case, even during trade liberalization, workers in the importable sector are always indifferent between staying and leaving the importable sector at the wage rate of one. This implies that the domestic price of the importable is always equal to one.

The one-shot social welfare is defined as the benefits minus the adjustment costs, which we shall specify in the next subsection. The benefits are defined as the sum of the total surpluses in the exportable and importable sectors. The total surplus in the importable sector in each country is the sum of the consumer surplus, producer surplus, and tariff revenue. Since the domestic supply of the importable is perfectly elastic at a price of one, and as a consequence the domestic price is always equal to one, the consumer surplus is equal to $(a-1)^2/(2b)$ and the producer surplus in the importable sector is equal to zero regardless of the level of the tariff. Since the amount of imports is equal to $(1 - a + 2bE - \tau)/b$ when the tariff level is τ, the tariff revenue is given by $\tau(1 - a + 2bE - \tau)/b$. Thus, letting $M(\tau)$ denote the benefit derived from the importable sector as a function of the country's tariff against its imports, we have:

$$M(\tau) = \frac{(a-1)^2}{2b} + \frac{\tau(1 - a + 2bE - \tau)}{b}. \tag{1}$$

[5]In Sections 3 and 4, with full government's compensation, the adjustment costs arising from the relocation of workers are in effect transferred from displaced workers to the governments. As we shall see, this simplified model is sufficient to make the main point of our argument.

The function $M(\tau)$ is concave and attains its maximum at $\tau = (1-a+2bE)/2$.

The total surplus in each country derived from the exportable sector can similarly be calculated from the fact that the price of the exportable in the exporting country is equal to $1-\tau$ when a tariff at the level of τ is imposed by the importing country. From Figure 1, it is easy to see that the surplus from export to the foreign country, denoted by X, expressed as a function of the importing country's tariff level τ, is given by

$$X(\tau) = \frac{(1-a+2bE-\tau)^2}{2b}.$$

The function $X(\tau)$ is decreasing and convex. In fact, the sum of producer surplus and consumer surplus from the sales of the exportable in both the home and foreign country is equal to $X(\tau) + 2E(a-bE)$.[6] Since adding a constant to the payoff would not change the analysis, we drop $2E(a-bE)$ from the expression of social welfare in the rest of the paper.

Let τ^j, $j = A, B$, denote the tariff level of Country j in a certain period. Country j's benefit in that period is given by $M(\tau^j) + X(\tau^k)$, where $k \neq j$. If the countries set a common tariff level of τ, the one-shot benefit to each country, expressed by $W(\tau)$, is given by $M(\tau) + X(\tau)$. That is,

$$\begin{aligned} W(\tau) &\equiv M(\tau) + X(\tau) \\ &= \tfrac{(a-1)^2+(1-a+2bE)^2-\tau^2}{2b}, \end{aligned} \tag{2}$$

where W is concave and decreasing.[7]

2.4 Re-allocation of Labor and Adjustment Costs

At the beginning of each period, the two governments simultaneously set the tariff levels, followed by each worker's choice of the industry in which to work in that period. Production and consumption take place after those decisions. Employment in the importable sector in any period is given by the difference between the domestic demand for the importable and the export supply of the same good from the foreign country at a going domestic market price. This employment level shrinks when the country cuts import tariff during each stage of mutual trade liberalization. Some workers in the importable sector are displaced and are assumed to switch immediately to the numeraire good sector after paying some adjustment

[6] To derive the producer surplus, we treat the exportable as an endowment. The producer surplus equals $2E(1-\tau)$ as a consequence.

[7] Note that adjustment costs have not been taken into account in $W(\tau)$.

costs.[8] These adjustment costs arise from frictional losses associated with inter-sectoral reallocation of labor. They can be interpreted as such things as the costs of training, physical relocation and temporary unemployment.

Frictional losses associated with reallocation are also present as workers switch from the numeraire good sector to the importable sector, which would happen if the tariff rate is raised. The adjustment cost of switching from the numeraire good sector to the importable sector need not be equal to that of switching in the opposite direction. To allow for this possibility, we assume that a switching worker needs to purchase α units of the numeraire good when switching from the importable to the numeraire good industry, while one needs to purchase β units of the numeraire good when switching in the opposite direction. Although the wage rate in the exportable sector is lower than that in other sectors, as we assumed, workers might relocate from the importable sector to the exportable sector if the corresponding adjustment cost is small relative to that of relocating to the numeraire sector. However, for the sake of simplifying the analysis, we assume that the adjustment cost of each worker who switches from the importable to the exportable industry is sufficiently large that no worker moves into the exportable sector in equilibrium.

The assumption that each switching worker has to pay an adjustment cost implies that the total adjustment costs the country bears are proportional to the number of switching workers, which is in turn proportional to the magnitude of the change in tariff, due to the linearity of the export supply, domestic supply, and domestic demand curves. As Figure 1 suggests, the number of switching workers is given by the magnitude of the tariff change divided by b.

2.5 Deviation Path and Deviation Payoffs

We assume that if a country does not honor the trade liberalization agreement, the other country will punish it by reverting to the optimum tariff forever starting from the period after the defection.[9] In the presence of adjustment costs, however, the level of this optimum tariff in a certain period depends on the country's tariff level at the beginning of that period,

[8] In the context of our model, this amounts to the assumption that each switching worker must purchase a certain amount of the numeraire good, yet this purchase *per se* does not increase the workers' utility.

[9] Most trade retaliations in reality ended in a finite period of time. However, the adoption of other punishment strategies, such as finite Nash reversion, would only complicate the analysis without altering the basic results of this paper.

which has been carried over from the last period.[10]

It is easy to see that on the optimal deviation path, the tariff level would not decrease at any time. In such a case, a country, say Country j, which deviates in period i would choose a sequence of tariff levels to solve

$$\max_{\{\tau^j(i+s)\}_{s=0}^{\infty}} (1-\delta)\sum_{s=0}^{\infty}\delta^s\left\{M(\tau^j(i+s)) + X(\tau^k(i+s)) - \frac{\beta[\tau^j(i+s)-\tau^j(i+s-1)]}{b}\right\},$$

(where $j \neq k$) for a given $\tau^j(i-1)$ and a given sequence of foreign tariff levels $\{\tau^k(i+s)\}_{s=0}^{\infty}$, where $\tau^j(i)$ denotes the tariff level of country j in period i.

It is straightforward to show that the first order condition is:

$$M'(\tau^j(i+s)) - \frac{\beta(1-\delta)}{b} = 0$$

for any $s = 0, 1, \cdots$. Using (1), this implies that the optimal deviation path satisfies $\tau^j(i+s) = [1-a+2bE-\beta(1-\delta)]/2$ for any $s = 0, 1, \cdots$. That is, the deviating country would increase its tariff level to $[1-a+2bE-\beta(1-\delta)]/2$ and maintain this level thereafter. Call this level τ^N. It is obvious that Country j would not change the tariff level from $\tau^j(i-1)$ if $\tau^N \leq \tau^j(i-1) \leq (1-a+2bE)/2$.

For simplicity, we assume that the tariff level at the beginning of period 1, call it τ_0, is less than or equal to τ^N for either country so that a country would always revert to τ^N if it deviates at all. Therefore, the one-shot benefit from deviation from the agreed-upon tariff level of τ is given by $M(\tau^N) + X(\tau)$. We define the function $\hat{W}(\tau)$ representing this one-shot deviation benefit (with adjustment costs not accounted for) as:

$$\begin{aligned} \hat{W}(\tau) &\equiv M(\tau^N) + X(\tau) \\ &= \tfrac{(a-1)^2}{2b} + \tfrac{(1-a+2bE)^2-\beta^2(1-\delta)^2}{4b} + \tfrac{(1-a+2bE-\tau)^2}{2b}. \end{aligned}$$

Since X is decreasing and convex, $\hat{W}$ is also decreasing and convex.

3 Bilateral Trade Liberalization with Commitment

In this section, we compute the liberalization path when two large countries can commit themselves to all future tariffs stipulated in an agreement. In other words, the countries are

[10]Without the adjustment costs, Country j's optimum tariff is always $bE/2$, at which $M(\tau^j)$ is maximized.

not allowed to deviate from the agreed-upon tariff levels in all periods. This case would arise, for example, if there were an international law enforcement agency to ensure that agreements are honored.

Given the above environment, the two governments cooperatively maximize each government's net payoff without any constraint. That is, they solve the following problem for each country:

$$\max_{\{\tau(t)\}_{t=1}^{\infty}} (1-\delta)\sum_{t=1}^{\infty}\delta^{t-1}\left\{W(\tau(t)) - \frac{\alpha[\tau(t-1)-\tau(t)]}{b}\right\},$$

for a given $\tau(0)$, where $\tau(t)$ denotes the tariff level in period t, which is common to both countries because of the symmetry.

The first order condition for this problem is:

$$W'(\tau(t)) + \frac{\alpha(1-\delta)}{b} = 0,$$

for any $t = 1, 2, \cdots$. From (2), we find that $\tau(t) = \alpha(1-\delta)$ for any $t = 1, 2, \cdots$. Thus, we have shown that the trade liberalization is once-and-for-all in our model if the countries can commit themselves to such a liberalization path. Let us define τ^* as this steady state tariff, i.e., $\tau^* = \alpha(1-\delta)$.[11]

On the contrary, we show in the Appendix that even if the countries can commit themselves to a trade liberalization path, when the adjustment cost is convex, there is an incentive for the countries to spread liberalization over many periods so as to lower the marginal adjustment cost in each period. Thus, we have

Proposition 1 *When symmetric countries can commit themselves to bilateral trade liberalization agreements, the most-efficient liberalization will be immediate rather than gradual if the adjustment cost is linear in the magnitude of tariff reduction. However, it will be gradual if the adjustment cost is strictly convex.*

We can think of the case in this section as one in which there is a central planner in the world to enforce the tariff agreement in each country. We argue that if there does not exist such a world law enforcement agency, tariff agreements have to be self-enforcing. In the next section, we shall show that the requirement of self-enforceability, even with linear

[11]For there to be any liberalization, it is obvious that we need to assume $\tau(0) > \alpha(1-\delta)$ as we later discuss more.

adjustment costs, implies that liberalization will be gradual rather than immediate within certain ranges of the parameters. In other words, convexity of the adjustment cost need not play any role in gradual trade liberalization. Since the faster the pace of liberalization, the higher each country's social welfare, this means that the self-enforcing trade liberalization is Pareto-inferior to the central planner's solution.

4 Self-Enforcing Bilateral Trade Liberalization

In this section, we derive a model of a non-cooperative, infinite-horizon, dynamic trade liberalization game played by two large countries. We assume that the countries agree to select the most-efficient trade liberalization path and that this agreement must be self-enforcing. The main result in this section is that such trade liberalization will be gradual under a wide range of parametric values, even when the adjustment cost is linear. To show this, we first present the condition under which trade liberalization will occur and will take more than one period to complete if the initial tariff level is high enough. Then we show that there exists a unique, symmetric, most-cooperative (and also most-efficient), self-enforcing liberalization path along which liberalization always takes a finite number of periods to complete. In each period, each government sets the lowest common tariff level that is incentive-compatible.

In each period, the following sequence of events will occur: (i) The governments set tariffs. (ii) If the tariff is lowered in a country, some import-competing workers are displaced from the importable sector, and switch to the numeraire good sector. If the tariff is raised in a country, some workers would move from the numeraire good sector to the importable sector. (iii) Workers who switch sectors pay adjustment costs and the governments pay full trade adjustment compensation to workers. (iv) All goods are produced and consumed.

The action space of each country is $\{\tau(t)\}_{t=1}^{\infty}$ where $\tau(t) \in \mathbf{R}$. Here, $\tau(t)$ is the import tariff of the country in period t. The initial tariff, τ_0 ($\leq \tau^N$), is exogenous. We assume that if a country does not honor the trade liberalization agreement, the other country will punish it by reverting to τ^N forever starting from the period after the defection. Therefore, the equilibrium strategy of each country is: Cooperate (according to the agreement) in this period if both countries have cooperated in the last period, but set the tariff at τ^N forever after if one of the countries did not cooperate in the last period. Consequently, the subgame perfect equilibrium outcome is: Each country will set the agreed-upon, most-cooperative (lowest possible) tariffs consistent with incentive in each period.

As we argued in Section 2, short of any punishment, each country is tempted to set its tariff level at τ^N during the trade liberalization. However, such a deviation may be deterred by the threat of the other country also reverting to τ^N forever after the deviation. Therefore, the liberalization path is self-enforcing if and only if the sequence of common tariff levels from period i onwards, $\{\tau(i+s)\}_{s=0}^{\infty}$, satisfies the following incentive constraint for all i:

$$\begin{aligned}(1-\delta)\textstyle\sum_{s=0}^{\infty}\delta^s\left\{W(\tau(i+s))-\frac{\alpha[\tau(i+s-1)-\tau(i+s)]}{b}\right\}\\ \geq(1-\delta)\hat{W}(\tau(i))+\delta W(\tau^N)-\frac{\beta(1-\delta)[\tau^N-\tau(i-1)]}{b}.\end{aligned} \tag{3}$$

The left-hand side shows the average discounted net payoff from perpetual cooperation from period i onwards, whereas the right-hand side represents the average discounted net payoff from deviation. The first two terms on the right-hand side together show the average discounted benefit to the country when it deviates, since the two countries would set τ^N every period in the punishment phase. The last term on the right-hand side shows the one-time adjustment costs the deviating country would incur. Since deviation means that the deviating country sets her tariff at τ^N instead of $\tau(i)$ in period i, the number of workers switching from the numeraire good sector to the importable sector is $\frac{\tau^N-\tau(i-1)}{b}$. There will be no incentive to deviate in any period if the incentive constraints in all periods are satisfied. To simplify the expressions, define $G(\tau,\delta)$ as the average discounted payoff from deviation:

$$G(\tau,\delta)\equiv(1-\delta)\hat{W}(\tau)+\delta W(\tau^N).$$

The function $G(\tau,\delta)$ is convex and decreasing with respect to τ due to the same properties of $\hat{W}(\tau)$.

Recall that τ^* is the steady state tariff level (or cooperative long-run optimal tariff level) in the case of bilateral trade liberalization with commitment (i.e. the first best). It is obvious that neither country has an incentive to cut the tariff below τ^*, at which the marginal cost of tariff reduction is equal to the marginal benefit from cooperation.

Now, let us derive the condition under which trade liberalization will occur and will take more than one period to complete. First, for trade liberalization to be welfare-improving for both countries, the long-run optimal tariff level τ^* must be less than τ_0, which in turn is less than or equal to τ^N. Since $\tau^*=\alpha(1-\delta)$ and $\tau^N=[1-a+2bE-\beta(1-\delta)]/2$, it is necessary that

$$(1-\delta)(2\alpha+\beta)<1-a+2bE. \tag{4}$$

That is, the adjustment costs should be sufficiently small to make trade liberalization welfare-improving. Second, it follows from (3) that setting τ^* is incentive compatible for both governments after τ^* has been reached, if

$$W(\tau^*) \geq G(\tau^*, \delta) - \frac{\beta(1-\delta)(\tau^N - \tau^*)}{b}. \tag{5}$$

Finally, liberalization will take more than one period if the countries have no incentive to cut the tariff level from τ_0 to τ^* in one period. Liberalization will take more than one period, for $\tau_0 \leq \tau^N$, if

$$W(\tau^*) - \frac{\alpha(1-\delta)(\tau^N - \tau^*)}{b} < G(\tau^*, \delta). \tag{6}$$

Notice that satisfying this condition would not preclude the possibility that liberalization takes multiple periods even if τ_0 is strictly less than τ^N. We will henceforth assume that

$$-\frac{\beta(1-\delta)(\tau^N - \tau^*)}{b} < W(\tau^*) - G(\tau^*, \delta) < \frac{\alpha(1-\delta)(\tau^N - \tau^*)}{b}, \tag{7}$$

a condition which is slightly stronger than the combination of (5) and (6). A gradual trade liberalization is supported by a subgame perfect equilibrium under this condition.

Since a violation of (4) means that the adjustment costs are too large to start the trade liberalization and hence $\tau^* \geq \tau^N$, it is clear that (7) implies (4). Basically, condition (7) is satisfied if the discount factor is moderately large such that setting τ^* is just about incentive compatible to both governments in the absence of adjustment costs. The existence of α, β, and δ which satisfy (7) is proved in the Appendix.

Now, let us derive the self-enforcing trade liberalization path. Our goal here is to construct the function θ such that $\theta(\tau)$, for $\tau^* \leq \tau \leq \tau^N$, represents the common tariff level both governments will set for a period along the equilibrium liberalization path, given that they have set the tariff levels at τ in the last period. Figure 2 shows an example of the graph of θ we will derive. The figure describes the situation where the governments set τ_1 in the first period, τ_2 in the second period, and τ^* in the third period onward. We will henceforth use τ_i $(i = 1, 2, \cdots)$ to represent the equilibrium tariff level in period i. In the Appendix, we show that the trade liberalization ends in a finite number of periods. In deriving function θ for the entire domain $[\tau^*, \tau^N]$, we tentatively assume that liberalization begins with $\tau_0 = \tau^N$. Under this assumption, the last period of trade liberalization is defined as period n. When $\tau_0 \neq \tau^N$, the actual number of rounds of trade liberalization depends on the level of τ_0 and may be smaller than n.

For simplicity of notation, we shall suppress the argument δ in the function G in the following analysis. This abbreviation is justified since the analysis proceeds with fixed α, β, and δ which satisfy (7). Now, we are ready to solve for the most-cooperative bilateral liberalization path by backward induction.

Assuming $\tau_0 = \tau^N$, the countries cut the common tariff level from τ_{n-1} to τ^* in period n, i.e., $\tau_n = \tau^*$. It follows from (3) that the incentive constraint is given by

$$W(\tau^*) - \frac{\alpha(1-\delta)(\tau_{n-1}-\tau^*)}{b} \geq G(\tau^*) - \frac{\beta(1-\delta)(\tau^N-\tau_{n-1})}{b}.$$

That is, self-enforceability can be sustained if and only if the magnitude of tariff reduction in the last period of liberalization (from τ_{n-1} to τ^*) must be sufficiently small that the net payoff from cooperation (at a common tariff of τ^* thereafter) is at least as large as the net payoff from deviating to τ^N.

Rewrite the incentive constraint as

$$W(\tau^*) - G(\tau^*) + \frac{\beta(1-\delta)(\tau^N-\tau^*)}{b} \geq \frac{(1-\delta)(\alpha+\beta)(\tau_{n-1}-\tau^*)}{b}. \tag{8}$$

Lemma 1 $W(\tau) - G(\tau) + \frac{\beta(1-\delta)(\tau^N-\tau)}{b} > 0$ *for any* $\tau^* \leq \tau < \tau^N$. *Moreover, this expression is concave in* τ.

Proof. See Appendix D.

Since Lemma 1 shows that the left-hand side of (8) is positive, there exists a unique tariff level for τ_{n-1}, call it $\overline{\tau_{n-1}}$, which satisfies (8) with equality. The tariff level $\overline{\tau_{n-1}}$ is the critical level such that the most-cooperative symmetric tariff in the next period will be τ^* if the current tariff level is below $\overline{\tau_{n-1}}$. It is obvious that setting τ^* is incentive compatible to both governments, if and only if $\tau^* \leq \tau_{n-1} \leq \overline{\tau_{n-1}}$. We have thus identified the function $\theta(\tau)$ for $\tau \in [\tau^*, \overline{\tau_{n-1}}]$ in the domain (see Figure 2).

We now turn to the next step of the backward induction process. Since we are deriving the most-cooperative trade liberalization path, the incentive constraint in period $n-1$ should be binding, i.e.,

$$\begin{aligned}(1-\delta)W(\tau_{n-1}) + \delta W(\tau^*) - (1-\delta)\left[\tfrac{\alpha(\tau_{n-2}-\tau_{n-1})}{b} + \delta\tfrac{\alpha(\tau_{n-1}-\tau^*)}{b}\right] \\ = G(\tau_{n-1}) - \tfrac{\beta(1-\delta)(\tau^N-\tau_{n-2})}{b}.\end{aligned} \tag{9}$$

Given any $\tau_{n-1} \in (\tau^*, \overline{\tau_{n-1}}]$ and consequently $\tau_n = \tau^*$, this equality gives τ_{n-2} such that $\tau_{n-1} = \theta(\tau_{n-2})$.

To see that such a τ_{n-2} indeed exists and is greater than τ_{n-1}, we will explicitly use the fact that the incentive constraint is satisfied in period n as well as in period $n-1$. Since the incentive constraint for period n may not be binding, we define the function $\gamma(\tau_{n-1})$ representing the slack. Then, the incentive constraint for period n can be rewritten as

$$W(\tau^*) - \frac{\alpha(1-\delta)(\tau_{n-1}-\tau^*)}{b} = G(\tau^*) - \frac{\beta(1-\delta)(\tau^N-\tau_{n-1})}{b} + \gamma(\tau_{n-1}). \tag{10}$$

It follows from the definition of $\overline{\tau_{n-1}}$ (i.e. the value of τ_{n-1} when (8) is satisfied with equality) that γ is decreasing at a rate of $\frac{(1-\delta)(\alpha+\beta)}{b}$ and that $\gamma(\overline{\tau_{n-1}}) = 0$. To take into account the incentive constraint for period n, we multiply (10) by δ and subtract the resulting equation from (9). After some rearrangement, we obtain

$$\begin{aligned}(1-\delta)\left[W(\tau_{n-1}) - G(\tau_{n-1}) + \tfrac{\beta(1-\delta)(\tau^N-\tau_{n-1})}{b}\right] + \delta[G(\tau^*) - G(\tau_{n-1})] + \delta\gamma(\tau_{n-1}) \\ = \tfrac{(1-\delta)(\alpha+\beta)(\tau_{n-2}-\tau_{n-1})}{b}.\end{aligned} \tag{11}$$

Lemma 2 *For a given $\tau' \geq \tau^*$, $(1-\delta)\left[W(\tau) - G(\tau) + \frac{\beta(1-\delta)(\tau^N-\tau)}{b}\right] + \delta[G(\tau') - G(\tau)] > 0$ for any $\tau' \leq \tau < \tau^N$. Moreover, this expression is concave in τ.*

Proof. See Appendix D.

Together with the fact that $\gamma(\tau_{n-1})$ is linear and that $\gamma(\tau_{n-1}) \geq 0$ for $\tau^* < \tau_{n-1} \leq \overline{\tau_{n-1}}$, Lemma 2 implies that the left-hand side of (11) is positive for any $\tau_{n-1} \in (\tau^*, \overline{\tau_{n-1}}]$. Given $\tau_{n-1} \in (\tau^*, \overline{\tau_{n-1}}]$, therefore, there exists a unique τ_{n-2} which satisfies (11). Defining $\overline{\tau_{n-2}}$ as the level of τ_{n-2} which satisfies (11) when $\tau_{n-1} = \overline{\tau_{n-1}}$, we have thus found the function $\theta(\tau)$ for $\tau \in (\overline{\tau_{n-1}}, \overline{\tau_{n-2}}]$. As Figure 2 shows, it can be shown that θ is upward sloping for this part, i.e., the smaller τ_{n-2} is, the smaller τ_{n-1}.

We can now extend backward the above procedure of determining the function θ to earlier periods of trade liberalization. Given that we have constructed θ for $[\tau^*, \overline{\tau_i}]$, we shall find τ_{i-1} for a given $\tau_i \in (\overline{\tau_{i+1}}, \overline{\tau_i}]$, from the incentive constraint for period i. This procedure determines θ for $(\overline{\tau_i}, \overline{\tau_{i-1}}]$.

Using the same technique as for period $n-1$, the incentive constraint for period i ($i = 1, 2, \cdots, n-2$) can be written as:

$$\begin{aligned}(1-\delta)\left[W(\tau_i) - G(\tau_i) + \tfrac{\beta(1-\delta)(\tau^N-\tau_i)}{b}\right] + \delta[G(\tau_{i+1}) - G(\tau_i)] \\ = \tfrac{(1-\delta)(\alpha+\beta)(\tau_{i-1}-\tau_i)}{b}.\end{aligned} \tag{12}$$

Given the function θ for $[\tau^*, \overline{\tau_i}]$, selecting a τ_i from $(\overline{\tau_{i+1}}, \overline{\tau_i}]$ determines τ_{i+1} as well. Hence, Lemma 2 implies that the left-hand side of (12) is a positive number. Since the right-hand side increases linearly from 0 as τ_{i-1} increases from τ_i, there exist a unique τ_{i-1} which satisfies (12). Again, the critical tariff level $\overline{\tau_{i-1}}$ is determined as a level of τ_{i-1} which satisfies (12) when $\tau_i = \overline{\tau_i}$.

The above procedure determines the function θ for its entire domain. Trade liberalization takes m $(\leq n)$ periods if the initial tariff level τ_0 lies in $(\overline{\tau_{n-m+1}}, \overline{\tau_{n-m}}]$, where we define $\overline{\tau_n} \equiv \tau^*$ and $\overline{\tau_0} \equiv \tau^N$. As Figure 2 shows, the higher the initial tariff, the (weakly) longer liberalization takes.[12]

We can also appeal to a graphical method for determining the most-cooperative path. Figure 3 indicates how the most-cooperative liberalization path starting at τ_0 is determined. It demonstrates clearly how gradualism is determined simultaneously by the presence of adjustment costs and self-enforceability. The bold curve in the figure shows the left-hand side of the corresponding incentive constraint such as (8), (11) or (12), with $\theta(\tau_i)$ substituted for τ_{i+1}, in (12). It is clear from the diagram that the most-cooperative path is unique. In the case described by Figure 3, the implied θ curve can be divided into three segments, corresponding to $\tau \in [\tau^*, \overline{\tau_2}]$, $\tau \in [\overline{\tau_2}, \overline{\tau_1}]$, and $\tau \in [\overline{\tau_1}, \tau^N]$, and the trade liberalization takes three periods starting from τ_0, which is shown to lie in $[\overline{\tau_1}, \tau^N]$ in the figure.

Proposition 2 *There is a unique most-cooperative bilateral trade liberalization path with any initial tariff level $\tau_0 \in [\tau^*, \tau^N]$. Moreover, the trade liberalization takes more than one period if τ_0 is large enough.*

As is well-known, mutual trade liberalization is beneficial as a whole to both countries through exchange of market access, though it harms the importable sector and burdens each country with some adjustment costs. On the other hand, each country is tempted to deviate from the agreement by exercising the market power in its importable sector in the world market. In each round of liberalization on the most-cooperative bilateral liberalization path, tariffs are cut to the extent that the present discounted net payoffs to each country of staying in the ongoing liberalization just offsets the net payoffs from deviating from the agreement. However, after a round of bilateral tariff reduction is completed and the necessary adjustment costs have been paid, the present discounted sum of social welfare from

[12]The assumption expressed by (7) ensures that the trade liberalization takes more than one period if the initial tariff level is large enough.

cooperation rises. Therefore, each country will find its own incentive constraint slackened. Moreover, each country has adjusted its industrial structure to a smaller importable sector after a round of tariff reduction. This industrial adjustment makes a deviation more costly, further relaxing the incentive constraint. These two factors enable the countries to engage in the next round of trade liberalization. Consequently, trade liberalization will be gradual, though the adjustment cost is linear in the magnitude of tariff reduction.

It is important to point out that, although our formal analysis is based on linear adjustment costs, the result that gradualism is optimal continues to hold under a wide variety of non-linear adjustment costs. This claim can be seen from the fact that the left-hand side of (12), for example, can remain positive even when the term representing the adjustment cost is replaced by an increasing but non-linear function of $\tau_{i-1} - \tau_i$. When translated into Figure 3, this amounts to shifting the bold curve while keeping it in the positive quadrant, and then replacing the downward sloping straight lines by some non-linear curves. It is clear that the optimal liberalization involves multiple rounds of tariff reduction as long as the *average* slopes of these curves are not too flat.

5 The Bicycle Theory

Suppose that the trade liberalization is terminated abruptly in the middle of the process and that this termination is announced at the beginning of period $i+1$. Of course, if the trade liberalization process ended as a consequence of a country's deviation, both countries would retreat from cooperation and would set τ^N thereafter. However, we shall consider a different case, in which the government(s) of one or both countries are suddenly forced to stop any further tariff reduction due to, say, a change in the political environment. The 'bicycle theory' says that if such a termination happens, not only are the countries unable to cut the tariff levels further, but they cannot even sustain the current tariff level they have achieved in the previous round of liberalization.

To see whether the bicycle theory holds in our model, we need only examine whether setting the current tariff level τ_i is incentive compatible to both governments. Since, at the beginning of period $i+1$, the industries have already adjusted themselves to the tariff level of τ_i, the incentive constraint can be written as:

$$W(\tau_i) \geq G(\tau_i) - \frac{\beta(1-\delta)(\tau^N - \tau_i)}{b}.$$

However, this holds from Lemma 1. Therefore, the countries need not retreat from the current level of cooperation. In fact, tariffs will stay at the level where the liberalization stops. The intuition is as follows: Compared with the incentive constraint for the period just before termination, the incentive constraint at the termination date is tightened by the amount of forgone benefits of future cooperation. If this effect is dominant, then countries would retreat from the status quo as predicted by the bicycle theory. However, the incentive constraint at the termination date is relaxed by the amount of saving in the current and future adjustment costs that the countries were supposed to bear if liberalization were to be continued till completion. Reallocation of workers in the period before termination also contributes to further relaxation of the incentive constraint. It turns out that the last two effects outweigh the first in our model, making the current tariff levels sustainable.

This result contrasts sharply with the bicycle theory conjectured by Bhagwati (1988) and later found its support in Staiger's (1995) model in which industrial adjustments are not costly. The incentive constraint for the most-cooperative liberalization path exactly balances the discounted benefits (i.e. total surpluses) from cooperation against the discounted benefits from deviation. The cause of the bicycle theory in Staiger's model lies in the fact that the continuation benefits on the most-cooperative gradual liberalization path are always higher than those on a stationary cooperation path where the countries keep the current tariff level forever. When liberalization breaks down, the discounted benefits from cooperation decrease, while the discounted benefits from deviation stay unchanged. Therefore, the incentive constraint is violated. Consequently, the countries cannot sustain the current cooperation level once trade liberalization terminates prematurely.

Therefore, the combination of tariff-liberalization-induced resource reallocation and "use-it-or-lose-it" sector-specific skills in Staiger (1995) delivers a prediction of gradualism that confirms the bicycle theory, while the combination of tariff-liberalization-induced resource reallocation and adjustment costs in our paper delivers a prediction of gradualism without the associated bicycle prediction. Consequently, whether or not a bicycle phenomenon is present may depend critically on the nature of the factors that give rise to gradualism, as a comparison across the two papers indicates.

Proposition 3 *When the existence of adjustment costs causes gradualism, if the trade liberalization process is terminated before completion (without any country's deviation), the terminal (common) tariff level can be supported as a subgame perfect equilibrium of the dynamic game from the termination period onwards.*

6 Imperfect Trade Adjustment Compensation

In this section we shall evaluate the impact of the government's trade adjustment assistance given to workers who switch between the importable sector and the numeraire good sector. Instead of assuming that the government bears the entire adjustment cost, we assume now that the government only partially compensates the workers for these costs. We then examine the impact of a change in this compensation on the pace of the trade liberalization.

Assume that before they engage in trade liberalization, the countries have been setting the common tariff level τ_0. Assume further that until the beginning of period 1, the period in which trade liberalization begins, there has been no expectation of trade liberalization, and the perceived chance of losing a job has been zero in any sector. Hence, workers have randomly chosen between working in the importable sector and the numeraire good sector. At the beginning of period 1, therefore, the wage rates in the two sectors must be both equal to one, the productivity of workers in the numeraire good as well as the importable sector.

In the trade liberalization phase of the subgame perfect equilibrium, all workers in the importable sector must be indifferent between staying in and moving out of that sector. This implies that the wage rate in the importable sector must be less than one since switching workers must bear part of the adjustment costs. Similarly, in case a country deviates, the wage rate in its importable sector must be greater than one in order to induce workers to move from the numeraire good sector to the importable sector. In both cases, therefore, the wage rates in the importable sector are no longer equal to one. Consequently, social welfare as a function of tariff level is different from that under perfect adjustment compensation, and so is the equilibrium pace of trade liberalization.

Let α' and β' $(0 < \alpha' < \alpha,\ 0 < \beta' < \beta)$ be the adjustment costs borne by a worker moving out of the importable sector and into the importable sector, respectively. Then, during trade liberalization, the average discounted wage rate each switching worker faces equals $1-\alpha'(1-\delta)$, which should in turn be equal to the wage rate in the importable sector. Call this wage rate $\underline{w}$. The wage rate continues to be $\underline{w}$ even after the trade liberalization process is completed.[13] Similarly, at any point in the deviation-punishment phase, the wage

[13]In equilibrium, workers must weakly prefer staying in their current sector to moving out to the other. This situation occurs if the wage rate in the importable sector lies in between $\underline{w}$ and 1. However, if the wage rate and hence the price of the importable is strictly higher than $\underline{w}$ after the trade liberalization process is completed, the domestic production must shrink from the level realized in the last round of the trade liberalization in order to clear the market. But it is impossible since any worker in the importable sector

rate in the importable sector is equal to $\overline{w} \equiv 1 + \beta'(1-\delta)$, the average discounted wage rate each switching worker faces.

During cooperation, the surplus from imports amounts to the sum of the consumer surplus and the tariff revenue minus the "forgone" wages all workers in the importable sector would have earned if the government had fully compensated switching workers for the adjustment costs. This surplus is indicated by the shaded area in Figure 4. From Figure 4 and the definition of W, it is easy to see that the total surplus can be expressed as $W(\tau + (1-\underline{w})) - \frac{(1-\underline{w})^2}{2b}$. Consequently, the cooperative long-run optimal tariff becomes $\tau^* - (1-\underline{w})$.

In case a country deviates, the surplus from imports is shown by the shaded area in Figure 5, and is given by $M(\tau - (\overline{w}-1)) - \frac{(\overline{w}-1)^2}{2b}$, which implies that the tariff level which maximizes the surplus from imports is $\tau^N + (\overline{w}-1)$. As for the surplus from exports, we should consider the period in which a country deviates and the subsequent punishment periods separately. In the period when a country deviates, its rival continues to cut tariff to the cooperative level and have some workers displaced from the importable sector. Therefore, the wage rate equals $\underline{w}$ in the rival's country. Consequently, the deviating country would obtain $X(\tau + (1-\underline{w}))$ from exports as seen from Figure 4. In subsequent punishment periods, on the other hand, the wage rate in the importable sector in both countries equals $\overline{w}$, and hence each country would obtain a surplus $X(\tau - (\overline{w}-1))$ from exports as shown in Figure 5. It follows that the one-shot payoff from deviation is given by $M(\tau^N) - \frac{(\overline{w}-1)^2}{2b} + X(\tau + (1-\underline{w}))$, which equals $\hat{W}(\tau + (1-\underline{w})) - \frac{(\overline{w}-1)^2}{2b}$. Moreover, the payoff in each subsequent punishment period is given by $W(\tau^N) - \frac{(\overline{w}-1)^2}{2b}$.

Having established all the relevant expressions for social welfare, it is straightforward to show that the incentive constraint, the counterpart of (3), reduces to

$$\begin{aligned}(1-\delta)\textstyle\sum_{s=0}^{\infty}\delta^s\left\{W(\tau(i+s)+(1-\underline{w})) - \frac{\alpha[\tau(i+s-1)-\tau(i+s)]}{b}\right\} - \frac{(1-\underline{w})^2}{2b} \\ \geq (1-\delta)\hat{W}(\tau(i)+(1-\underline{w})) + \delta W(\tau^N) - \frac{\beta(1-\delta)[\tau^N-\{\tau(i-1)+(1-\underline{w})\}]}{b} - \frac{(\overline{w}-1)^2}{2b},\end{aligned} \tag{13}$$

where the amount of labor inflow to the importable sector, resulting from a deviation, is given by $[\tau^N - \{\tau(i-1) + (1-\underline{w})\}]/b$, while the actual tariff is raised from $\tau(i-1)$ to $\tau^N + (\overline{w}-1)$.

Now, to find how trade adjustment assistance affects the pace of trade liberalization, we define $\tau^{\underline{w}}(t) \equiv \tau(t) + (1-\underline{w})$ for any period t. As seen from Figure 4, a tariff of $\tau^{\underline{w}}(t)$ under perfect adjustment compensation induces the same quantity of imports as does a tariff of

strictly prefer staying in this sector at the going wage rate.

$\tau(t)$ under imperfect adjustment compensation. With this auxiliary variable, we can directly compare equilibrium liberalization paths corresponding to different levels of the adjustment compensation, since the goal of the liberalization now becomes cutting $\tau^{\underline{w}}(t)$ until it equals τ^*, for *any given* $\underline{w}$. Now, substituting $\tau^{\underline{w}}(t)$ in (13) yields

$$\begin{aligned}&(1-\delta)\sum_{s=0}^{\infty}\delta^s\left\{W(\tau^{\underline{w}}(i+s))-\tfrac{\alpha[\tau^{\underline{w}}(i+s-1)-\tau^{\underline{w}}(i+s)]}{b}\right\}-\tfrac{(1-\underline{w})^2}{2b}\\ &\geq(1-\delta)\hat{W}(\tau^{\underline{w}}(i))+\delta W(\tau^N)-\tfrac{\beta(1-\delta)[\tau^N-\tau^{\underline{w}}(i-1)]}{b}-\tfrac{(\overline{w}-1)^2}{2b}.\end{aligned}$$

It is clear that, compared with the corresponding equation (3) under the case of full compensation by the government, the left-hand side of the incentive constraint in period i is lowered by an amount of $\frac{(1-\underline{w})^2}{2b}=\frac{[\alpha'(1-\delta)]^2}{2b}$, while the right-hand side of it is lowered by an amount of $\frac{(\overline{w}-1)^2}{2b}=\frac{[\beta'(1-\delta)]^2}{2b}$. Therefore, we have

Proposition 4 *An increase in trade adjustment assistance given to workers displaced from the importable sector speeds up the pace of liberalization, while an increase in adjustment assistance given to workers switching into the importable sector slows down the pace of liberalization.*

The result is quite intuitive. An increase in compensation to workers moving out of the importable sector reduces the distortion resulting from the fact that the existence of the adjustment costs creates a discrepancy between wage rate and productivity. Therefore, it raises social welfare under cooperation, which in turn speeds up the pace of liberalization. On the contrary, an increase in compensation to workers switching in the opposite direction raises social welfare under defection, and hence slows down the pace of liberalization.

Compared with the case of full government adjustment compensation, the pace of liberalization is speeded up (slowed down) if and only if $\alpha'<\beta'$ ($\alpha'>\beta'$). In fact, the greater $\beta'-\alpha'$ is, the faster will be the pace of liberalization. This unambiguous result contrasts with the one obtained by Fung and Staiger (1996) and Brecher and Choudhri (1994). (See footnote 3.)

7 Conclusion

We have analyzed dynamic bilateral trade liberalization between two large countries. We find that self-enforceability and the presence of adjustment costs (regardless of the shape) are sufficient to induce gradualism. Trade liberalization causes the previously-protected sector of each country to shrink and thereby causes reallocation of workers between industries. Assuming that moving from one industry to another requires each worker to pay a fixed cost resulting from adjustment losses, a country has to bear a total adjustment cost which is linear in the quantity of moving workers. In this framework, we have derived the most-efficient, self-enforcing bilateral trade liberalization agreement from which neither country has incentive to deviate throughout the liberalization process and after. When the discount factor is moderately large, the two countries are willing to cut tariffs gradually to the long-run optimal level.

After each round of bilateral tariff reduction is completed and the necessary adjustment costs have been paid, the present discounted sum of social welfare from cooperation rises. Therefore, each country will find its own incentive constraint slackened. Moreover, each country has adjusted its industrial structure to a smaller importable sector after a round of tariff reduction. This industrial adjustment makes a deviation more costly, further relaxing the incentive constraint. These two factors enable the countries to engage in the next round of trade liberalization. Consequently, trade liberalization will be gradual, though the adjustment cost is linear in the magnitude of tariff reduction.

Although our formal analysis of self-enforceable liberalization has been based on linear adjustment costs, all the relevant propositions continue to hold under a wide variety of non-linear adjustment costs. Thus, the assumption of convex adjustment cost by Mussa (1986) is unnecessarily restrictive for building a theory of gradualism in bilateral trade liberalization.

Finally, it is important to emphasize that gradualism is an intrinsic feature of bilateral trade liberalization whenever there exist trade adjustment costs and the requirement for self-enforceability. Consequently, this main message of the paper would be obtained even without the simplifying assumptions such as linearity of demand functions and identical initial tariff levels.

Appendix

A Convex Adjustment Costs

We assume that the countries can commit themselves to any liberalization path. The convex adjustment costs are described by a (strictly) convex function ϕ which is a function of the amount of tariff reduction. The governments' maximization problem is:

$$\max_{\{\tau(t)\}_{t=1}^{\infty}} (1-\delta)\sum_{t=1}^{\infty} \delta^{t-1}\{W(\tau(t)) - \phi(\tau(t-1)-\tau(t))\},$$

for a given $\tau(0)$. Then, the first order condition is:

$$W'(\tau(t)) + \phi'(\tau(t-1)-\tau(t)) - \delta\phi'(\tau(t)-\tau(t+1)) = 0,$$

for any $t = 1, 2, \cdots$.

Define $\tilde{\tau}$ by $W'(\tilde{\tau}) + (1-\delta)\phi'(0) = 0$. The concavity of W means that $W'(\tau) + (1-\delta)\phi'(0) > 0$ for any $0 \le \tau < \tilde{\tau}$. Since $-W'(\tau) - (1-\delta)\phi'(0)$ shows the gains from an infinitesimal reduction of the tariff level from τ, the above inequality implies that the tariff should not be cut further if the tariff level is already less than $\tilde{\tau}$. Therefore, the governments will not cut the tariff level further than $\tilde{\tau}$.

Next, we claim that the tariff reduction ought to be gradual and last indefinitely. It follows immediately if we can show that from any tariff level $\tau' \in (\tilde{\tau}, \tau^N]$ the governments would prefer setting a tariff level $\tau'' \in (\tilde{\tau}, \tau')$ for one period before reaching $\tilde{\tau}$ to setting $\tilde{\tau}$ immediately.

To see this, notice that the continuation payoff under the second process is given by

$$(1-\delta)W(\tau'') - (1-\delta)\phi(\tau'-\tau'') + \delta W(\tilde{\tau}) - \delta(1-\delta)\phi(\tau''-\tilde{\tau}). \qquad (14)$$

This payoff converges as τ'' goes to $\tilde{\tau}$ to $W(\tilde{\tau}) - (1-\delta)\phi(\tau'-\tilde{\tau})$, the continuation payoff under the first process. Our claim then follows if the payoff in (14) increases as τ'' increases from $\tilde{\tau}$, i.e., if the derivative of (14) with respect to τ'' is positive when evaluated at $\tilde{\tau}$. Now,

$$\begin{aligned}
&(1-\delta)W'(\tilde{\tau}) + (1-\delta)\phi'(\tau'-\tilde{\tau}) - \delta(1-\delta)\phi'(0) \\
&\quad = (1-\delta)[W'(\tilde{\tau}) + \phi'(\tau'-\tilde{\tau}) - \delta\phi'(0)] \\
&\quad > (1-\delta)[W'(\tilde{\tau}) + (1-\delta)\phi'(0)] \\
&\quad = 0,
\end{aligned}$$

where the inequality in the third line follows from the convexity of ϕ. This completes the proof of the last claim, and implies that the trade liberalization is gradual and lasts indefinitely.

B Proof of the Existence of α, β, and δ which Satisfy Inequality (7)

We will derive sufficient conditions on α, β, and δ for (7) to hold. The continuity with respect to these parameters of the functions involved in the analysis implies that (7) also holds at least in the neighborhood of derived values of the parameters.

For any given a, b and E, set $\beta = \alpha$ and pick a value for $\alpha(1-\delta)$ such that $3\alpha(1-\delta) < 1 - a + 2bE$ (see (4)). Since $\tau^* = \alpha(1-\delta)$ and $\tau^N = [1 - a + 2bE - \beta(1-\delta)]/2$, this selection pins down the values of τ^* and τ^N such that $\tau^* < \tau^N$. It also determines the values of the left-hand side of the first inequality and the right-hand side of the second inequality of (7); the former value is negative while the latter is positive.

What remains, therefore, is to find α and δ which make $\alpha(1-\delta)$ equal to the value selected previously and also satisfy (7). Now, $W(\tau^*) - G(\tau^*, \delta)$ does not depend on α (nor β), given $\alpha(1-\delta)$. Furthermore, for any fixed τ^*, it varies continuously from negative values to positive values as δ increases from 0 to 1. Therefore, there exists a δ which satisfies (7). The value of α (and hence β) is determined accordingly.

Alternatively, for given α, β, a, b and E, the range of δ that satisfies (7) can be obtained graphically, as shown in Figure A1. It is assumed that $2\alpha + \beta < 1 - a + 2bE$ so that condition (4) holds for $\delta \in [0, 1]$. In the following argument, we explicitly show the dependency of τ^* and τ^N on δ.

Now, one crucial feature is that the $W(\tau^*(\delta)) - G(\tau^*(\delta), \delta)$ curve intersects the curve RHS_7 at $\delta = \bar{\delta}$ where $0 < \bar{\delta} < 1$. It is clear that the second inequality in (7) (i.e. inequality (6)) is satisfied if and only if $\delta < \bar{\delta}$. Another crucial feature is that $W(\tau^*(\delta)) - G(\tau^*(\delta), \delta)$ curve intersects the LHS_7 curve at $\delta = \underline{\delta}$, where $0 < \underline{\delta} < 1$. This is true if $W(\tau^*(0)) - G(\tau^*(0), 0) < LHS_7(0)$. This condition holds because, when $\delta = 0$, we have

$$W(\tau^*(0)) - G(\tau^*(0), 0) = M(\tau^*(0)) - M(\tau^N(0)) = \tfrac{[\tau^N(0) - \tau^*(0)][\tau^N(0) + \tau^*(0) - (1-a+2bE)]}{b},$$
$$LHS_7(0) = -\tfrac{\beta(\tau^N(0) - \tau^*(0))}{b},$$

and thus,

$$
\begin{aligned}
W(\tau^*(0)) - G(\tau^*(0), 0) - LHS_7(0) &= \tfrac{[\tau^N(0)-\tau^*(0)][\tau^N(0)+\tau^*(0)-(1-a+2bE-\beta)]}{b} \\
&= \tfrac{[\tau^N(0)-\tau^*(0)][2\alpha+\beta-(1-a+2bE)]}{b} \\
&< 0,
\end{aligned}
$$

where the last equality is obtained from $\tau^N(0) = (1 - a + 2bE - \beta)/2$ and $\tau^*(0) = \alpha$. As Figure A1 shows, the left inequality of (7) is satisfied if and only if $\delta > \underline{\delta}$.

We have thus found a range $\underline{\delta} < \delta < \bar{\delta}$ that satisfies (7) for any combination of α, β, a, b, and E satisfying $2\alpha + \beta < 1 - a + 2bE$. Moreover, the above analysis implies (i) that the liberalization from τ^N to τ^* takes only one period if $\delta \geq \bar{\delta}$, (ii) that the liberalization from τ^N to τ^* is gradual if $\underline{\delta} \leq \delta < \bar{\delta}$, and (iii) that τ^* cannot be reached if $\delta < \underline{\delta}$.

C The Number of Rounds of Liberalization is Finite

It is clear from Figure 3 that we need only show that the left-hand sides of the incentive constraints, expressed by (8), (11), and (12), are positive on $[\tau^*, \tau_0]$. If $\tau_0 < \tau^N$, however, Lemmas 1 and 2 directly imply that this is indeed the case. If $\tau_0 = \tau^N$, on the other hand, we should carefully investigate whether or not the left-hand side is positive at τ^N, for neither lemma includes the assertion for the case that $\tau = \tau^N$.

Indeed, the first group of the terms on the left-hand side of (12) takes the value of zero when $\tau_0 = \tau^N$ (notice that $i = 0$ at the starting point). To show that the entire left-hand side is positive when $\tau_0 = \tau^N$, therefore, we need to show that $G(\tau_1) - G(\tau_0) > 0$. But this is the case as far as $\tau_1 < \tau_0$. Thus, if a tariff reduction is possible at all, the left-hand side of (12) is positive at τ_0, which in turn implies that a tariff reduction can be done. This self-fulfilling property proves that the left-hand side of the incentive constraints is positive and hence that the trade liberalization ends in finite periods even if the initial tariff levels are τ^N.

D Proof of Lemmas for Proposition 2

Proof of Lemma 1. Since W is concave, G is convex, and the last term is linear in τ, the expression on the left-hand side is concave in τ. Thus, the lemma is proved if we show that $W(\tau^*) - G(\tau^*) + \frac{\beta(1-\delta)(\tau^N - \tau^*)}{b} > 0$ and $W(\tau^N) - G(\tau^N) + \frac{\beta(1-\delta)(\tau^N - \tau^N)}{b} \geq 0$. Now, the first inequality follows from (7). The second inequality is satisfied with equality since $G(\tau^N) = (1-\delta)\hat{W}(\tau^N) + \delta W(\tau^N) = W(\tau^N)$. $\square$

Proof of Lemma 2. Lemma 1 implies that the expression in the first set of squared brackets is concave in τ and takes on a positive value for any $\tau \in [\tau', \tau^N)$. The expression in the second set of squared brackets is concave in τ since G is a convex function. Furthermore, it takes on a nonnegative value for any $\tau \in [\tau', \tau^N)$ since G is a decreasing function. $\square$

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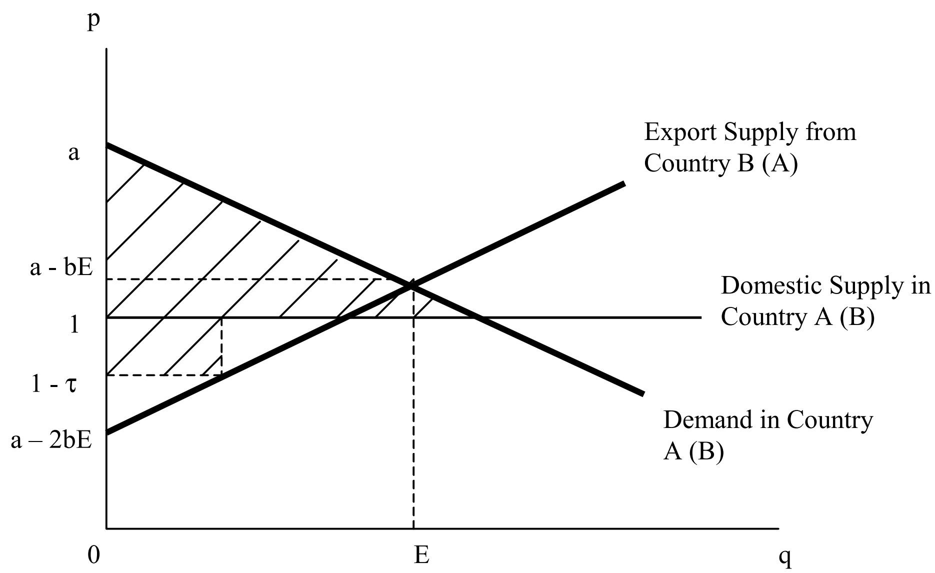

Figure 1. The Market for Good 2 (1) in Country A (B)

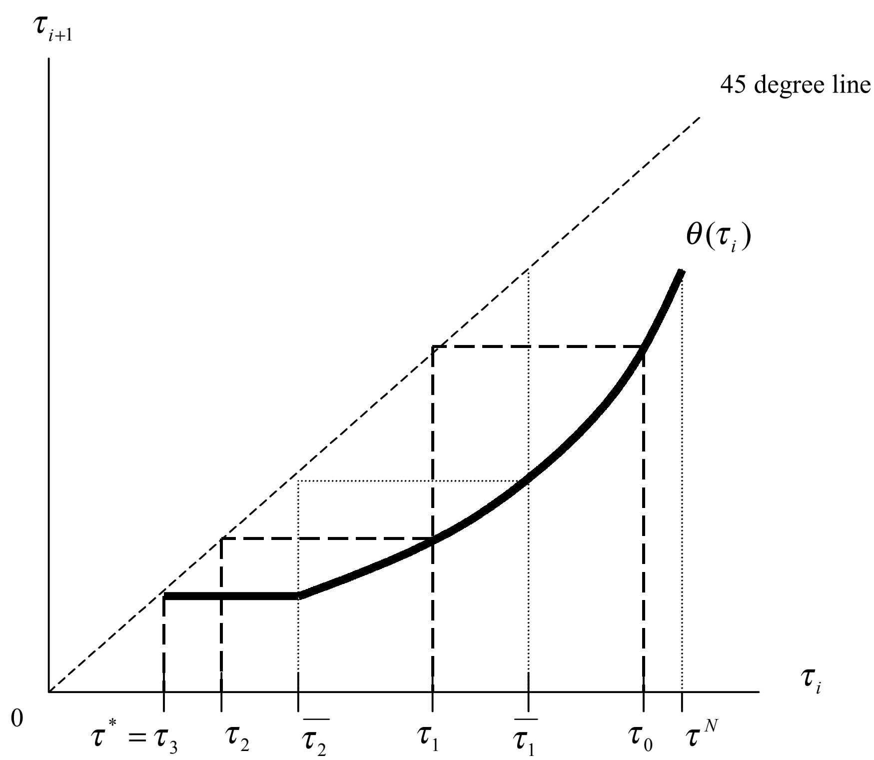

Figure 2. The Equilibrium Trade Liberalization Path

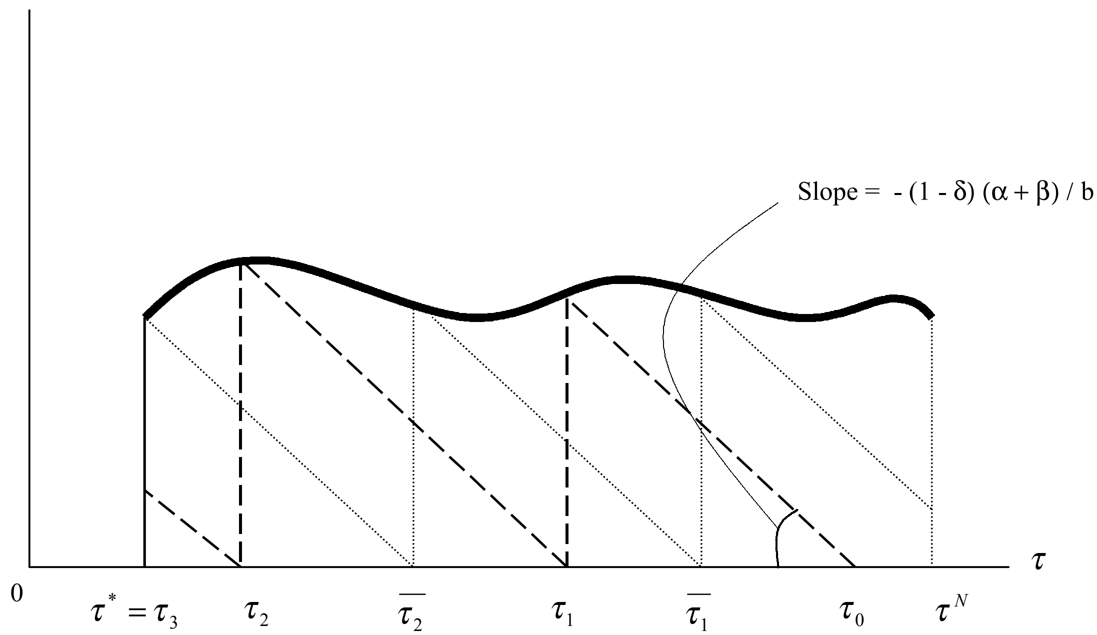

Figure 3. A Graphical Derivation of the Equilibrium Path

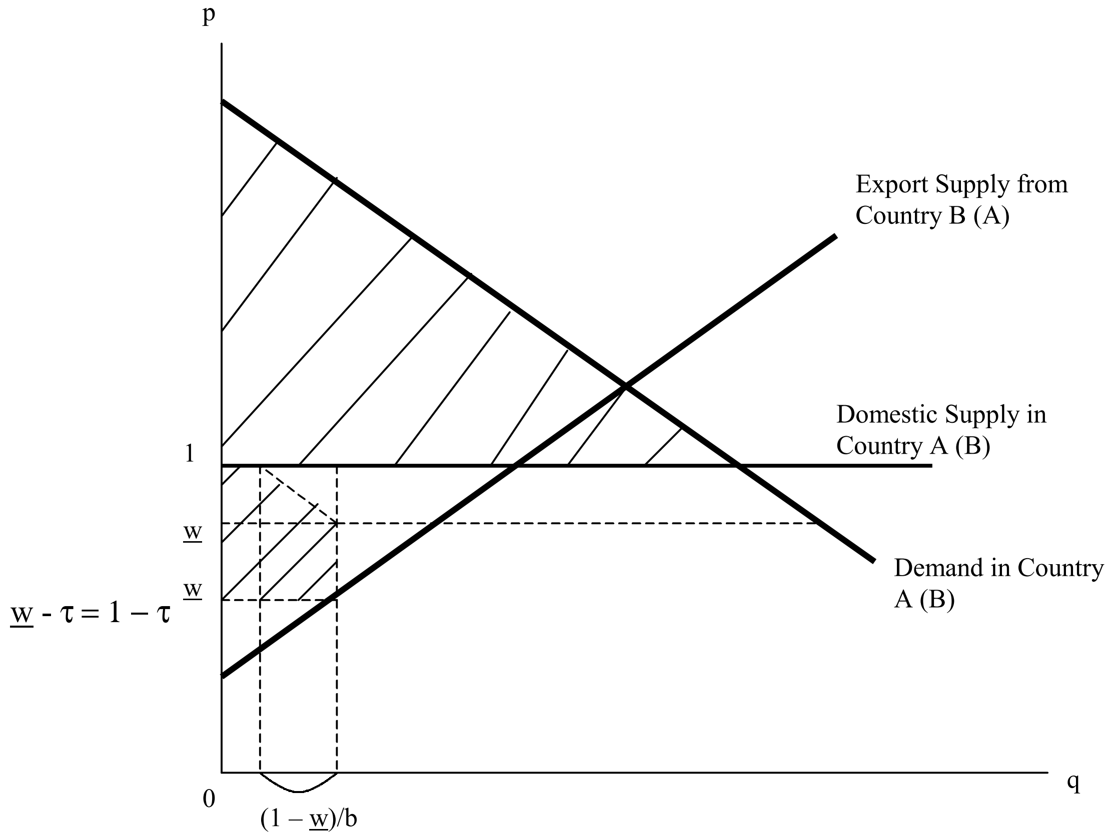

Figure 4. The Surplus in the Importable Sector in the Cooperation Phase

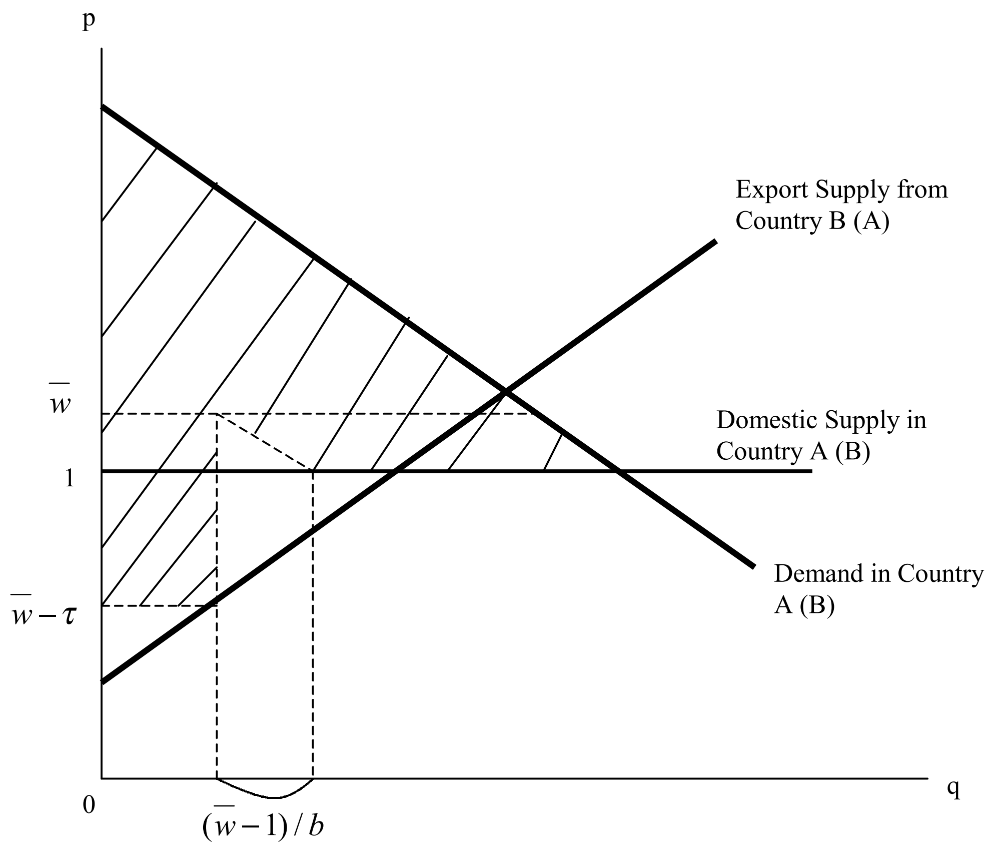

Figure 5. The Surplus in the Importable Sector in the Deviation Phase

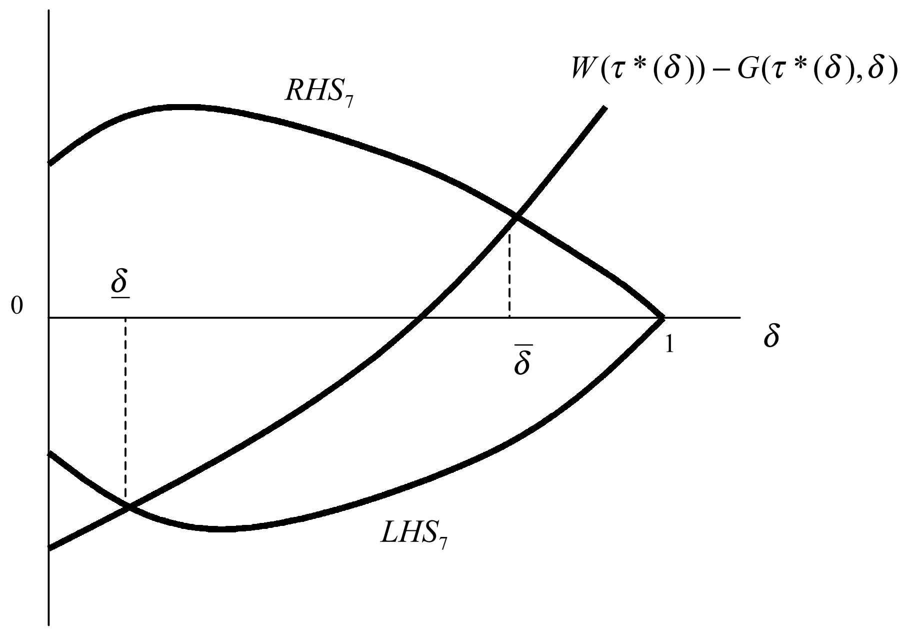

Figure A1. The Range of Discount Factors which Satisfy Inequality (7)