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EXTERNAL ENFORCEMENT

BY

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Mikhail Klimenko, Garey Ramey and Joel Watson*

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Abstract

This paper presents a theory of dynamic trade agreements in which external institutions, such as the WTO, play a central role in supporting credible enforcement. In our model, countries engage in ongoing negotiations, and as a consequence cooperative agreements become unsustainable in the absence of external enforcement institutions. By using mechanisms such as delays in dispute resolution and direct penalties, enforcement institutions can restore incentives for cooperation, despite the lack of any coercive power. The occurrence of costly trade disputes, and the feasibility of mechanisms such as escape clauses, depend on the adaptability of enforcement institutions in their use of information.

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1 Introduction

The postwar history of international economic relations has been characterized by a growing reliance on international legal systems to resolve conflicts that arise within the context of bilateral and multilateral trade agreements. The GATT/WTO dispute resolution system, for example, has seen a large increase in the number of dispute cases reviewed annually over this period, and these cases often lead to reversal of trade-inhibiting actions.¹ In many instances, trade disputes trigger aggressive battles between countries to influence the findings of dispute resolution panels, as well as efforts to avoid compliance with rulings.

Although official institutions for enforcement of international trade agreements are obviously important empirically, they are little understood from the theoretical standpoint. Trade agreements have been modeled as subgame perfect equilibria of repeated games, in which violations are punished by reversion to an unfavorable market-access equilibrium. Since such agreements are completely self-enforcing, countries have no need to appeal to any external legal system when a violation occurs. Thus, international legal systems are theoretically redundant, and their empirical predominance remains a puzzle.²

This paper proposes a theory of trade agreements in which external legal institutions play a central role in sustaining trade cooperation. Our point of departure is the observation that actual trade relationships are characterized by ongoing negotiations

¹According to Brewer and Young (1999), the mean number of dispute cases reviewed annually by GATT/WTO dispute-settlement panels have increased from 5.2 during the period of 1948-1959 to 41 in 1998. This increase is not only due to the growing membership of the GATT/WTO. The mean number of filings per year per member has risen from 0.208 during the period of 1948-1959 to 0.307 in 1998. According to Hudec (1993), 88 percent of 139 dispute settlement complaints with a valid legal claim filed in the years 1942-1990 led to full or partial reversal of the trade-inhibiting measures.

²Repeated non-cooperative game models of trade agreements have been considered by McMillan (1986, 1989), Dixit (1987), Bagwell and Staiger (1990, 1997a,b), Riezman (1991), Kovenock and Thursby (1992) and Maggi (1999). Maggi's paper suggests that institutions such as the WTO may play a role in assisting self-enforcement by disseminating information about violations of agreements.

between countries over the terms of agreement.³ We consider a two-country tariff choice model in which negotiations occur in every period, prior to the countries' tariff selections. Negotiations are modeled using the Nash bargaining solution, and for simplicity we allow countries to make transfers to one another as part of bargaining.

A *recurrent agreement* is a subgame perfect equilibrium in which the continuation equilibria are determined according to the Nash bargaining solution in every period. Thus, recurrent agreements satisfy intertemporal consistency of negotiations in the same manner that subgame perfect equilibria satisfy intertemporal consistency of individual incentives. We show that in the absence of external legal systems, cooperation becomes *unsustainable* in a recurrent agreement, since any punishments for deviations from the equilibrium do not survive under subsequent negotiations. In other words, *cooperative agreements cannot be self-enforcing in the presence of ongoing negotiation*.

To support credible punishments, countries must rely on an external legal institution whose value depends on keeping some facets of enforcement out of countries' hands. We demonstrate that institutions having the characteristics of the GATT/WTO legal system suffice to make cooperation possible. To establish these points, we develop a simple model of a dispute settlement institution (DSI) that designates when countries are in a dispute and carries out dispute resolution when countries violate their tariff agreements. Dispute resolution entails only restoration of the balance of market-access concessions that existed before the dispute, with no additional sanctions. The DSI is assumed to have no coercive power; countries can freely choose whether to submit to the DSI or ignore it.

The key feature of the DSI is that dispute resolution occurs with *delay*, and the countries cannot affect the amount of delay, since the operation of the dispute resolution process is external to the countries. As long as the countries value cooperation and utilize the DSI, they realize that triggering a dispute will impose a cost in terms

³The history of GATT and its successor, the WTO agreement, includes not only regular rounds of multilateral trade negotiations, but also "local episodes" of renegotiations between the rounds when individual members states try to alter their obligations on specific trade issues. Such renegotiations of market-access concessions are permitted by the Article XXVIII of the GATT.

of delay in restoring cooperation. This cost, in turn, supports incentives to cooperate and makes cooperation valuable. Thus, although the DSI has no direct sway over the countries, its ability to delay dispute resolution serves indirectly as a source of credible punishments. Importantly, the countries could not duplicate such a dispute resolution process on their own, since they would always renegotiate to reduce the amount of delay and restore cooperation more quickly. *External enforcement is valuable precisely because the countries are unable to manipulate the parameters of the enforcement process.*

As an alternative to delay, the DSI can rely on *direct penalties*, going beyond reciprocal withdrawal of concessions, that are imposed on countries that unilaterally violate trade agreements. We show that direct penalties can substitute for delays in providing credible enforcement, allowing enforcement agencies to reduce delays without undermining incentives. In our setting, penalties are effective even though the DSI has no coercive power. Offending countries are willing to pay penalties in order to restore cooperation, since they share in the benefits.

We extend our model by introducing a noise term that alters incentives to adhere to agreements, in a manner similar to the model of Bagwell and Staiger (1990). When the DSI is *nonadaptable* in using information to enforce agreements, trade disputes are shown to arise with positive probability on the equilibrium path. These disputes have a number of features in common with actual disputes: the onset of the dispute leads to a mutual suspension of concessions between the countries involved, rather than a one-sided violation that does not elicit rapid retaliation; the DSI intervenes to resolve the dispute, which occurs with delay; and dispute resolution entails reversal of the offending actions.⁴ Moreover, in this case the countries never negotiate a zero-

⁴Riezman (1991) proposes an alternative theory of trade agreements in which countries periodically depart from cooperative tariff levels. In Riezman's model, countries cannot directly observe one another's tariff choices, and must instead rely on a noisy signal of tariff choices. Countries agree to select the static Nash outcome for some number of periods when certain values of the signal are observed. This serves to deter deviations, since deviations raise the probability of triggering the Nash equilibrium tariff levels. Departures from cooperation in Riezman's model can be viewed as representing a cooperative mechanism for sustaining incentives, rather than as disputes.

tariff agreement, since a small increase in tariffs would reduce welfare only slightly, while providing greater benefits by reducing the probability of costly disputes.

When the DSI is *fully adaptable* in using information, in contrast, countries can completely avoid disputes by altering tariff agreements after the noise variable is realized; this can be interpreted as a complete state-contingent escape clause. The important point is that the feasibility of such beneficial mechanisms hinges on the adaptability of enforcement institutions in using information. Institutional rigidity can serve as a barrier to otherwise desirable arrangements.⁵

Section 2 reviews the standard repeated tariff model, and Section 3 introduces our notion of recurrent agreements and applies the concept to the standard model without external enforcement. The DSI is introduced in Section 4, where the value of delays and direct penalties in providing credible enforcement is discussed. Section 5 considers adaptability and periodic trade disputes, and Section 6 concludes.

2 Standard Repeated Tariff Model

2.1 Stage Game

The stage game is derived from the basic two-country, two-good framework previously considered by Johnson (1953/54), Mayer (1981) and Dixit (1987). We provide only a terse review of the main elements of this framework. The countries, labeled $i = 1, 2$, exchange two similarly labeled goods. Country 1 exports good 1 in exchange for imports of good 2 from Country 2. Both countries are large enough to affect the terms of trade through the import tariff which is the only policy instrument available to the countries' governments. The countries are assumed to have symmetric single-period welfare functions. The welfare of Country i , given tariff choices τ_i and τ_j , is written $W(\tau_i, \tau_j)$. We make a number of common assumptions on $W(\tau_i, \tau_j)$ to ensure the existence of static best response functions that generate a unique non-autarkic

⁵Bagwell and Staiger (1990) and Milner and Rosendorff (1998) argue that flexibility in choosing tariff levels is important for achieving valuable agreements. Our results demonstrate that the scope for such flexibility depends in turn on the characteristics of external enforcement institutions.

Nash equilibrium in tariffs.⁶ Very large levels of τ_1 or τ_2 lead to the autarky outcome, in which welfare levels are taken to be zero. For lower levels of τ_1 and τ_2 , trade volume is positive, and the welfare function of Country i is strictly positive, differentiable and strictly quasi-concave in τ_i . Let $\tau^R(\tau_j)$ be the value of τ_i that maximizes $W(\tau_i, \tau_j)$ in this case. The unique Nash equilibrium with non-prohibitive tariffs is characterized by $\tau_1 = \tau_2 = \tau^N > 0$. The Nash equilibrium welfare level is $W^N \equiv W(\tau^N, \tau^N) > 0$.

The joint welfare of the two countries is given by $V(\tau_1, \tau_2) \equiv W(\tau_1, \tau_2) + W(\tau_2, \tau_1)$. Assume $V_{\tau_i} < 0$, so that the free trade outcome $\tau_1 = \tau_2 = 0$ maximizes joint welfare. Define $V^N \equiv V(\tau^N, \tau^N) = 2W^N$.

2.2 Repeated Game

The static model is assumed to be repeated over periods $t = 0, 1, 2, \dots$. The tariff choices in each period generate a path (τ_{1t}, τ_{2t}) , $t = 0, 1, 2, \dots$. Country i 's payoff from period t of the repeated game is the discounted sum of welfare levels from the static model:

$$g_i = \sum_{s=t}^{\infty} \delta^{s-t} W(\tau_{is}, \tau_{js}),$$

where $\delta < 1$ is the discount factor. Payoff profiles for the two countries are given by vectors (g_1, g_2) .

Histories of past tariff choices are assumed to be publicly observable when choices are made in the current period. Tariff choice strategies are given by mappings from histories of past tariff choices to current choices. We focus on the set of payoff profiles (g_1, g_2) that can arise in subgame perfect equilibria (SGPE). Let G^P denote the set of all SGPE payoff profiles. G^P can be characterized as follows (see Abreu (1988)):

Definition 1. The set of SGPE payoff profiles G^P is the largest set with the following property. $(g_1, g_2) \in G^P$ if and only if there exist tariffs $\hat{\tau}_1, \hat{\tau}_2$ and profiles (\hat{g}_1, \hat{g}_2) ,

⁶For example, following Dixit (1987) we assume that balanced-trade and Marshall-Lerner conditions are satisfied. This ensures that one country's unilaterally-optimal tariff creates a negative terms-of-trade externality for the other country.

$(g_1^1, g_2^1), (g_1^2, g_2^2) \in G^P$ such that, for $i = 1, 2$:

$$g_i = W(\hat{\tau}_i, \hat{\tau}_j) + \delta \hat{g}_i \geq W(\tau^R(\hat{\tau}_j), \hat{\tau}_j) + \delta g_i^i. \quad (1)$$

Condition (1) contains two parts. The first part states that the payoff g_i is equal to the static welfare generated by equilibrium path choices $\hat{\tau}_i$ and $\hat{\tau}_j$, followed by the discounted payoff \hat{g}_i arising in the continuation. The second part requires g_i to exceed the payoff that Country i could obtain by deviating to $\tau^R(\hat{\tau}_j)$ in the current period, where the deviation leads to a continuation payoff g_i^i that “punishes” Country i for the deviation. The continuation payoffs are credible in that they are themselves SGPE payoffs.

3 Recurrent Agreements

The set G^P represents the set of feasible trade agreements, in that the countries have private incentives to adhere to the agreement following any history. Trade negotiations may then be regarded in terms of making a selection from G^P . Standard approaches to trade negotiation, such as Riezman (1982), Bagwell and Staiger (1990, 1997a,b), Maggi (1999), and others, posit that countries make their selection in a jointly efficient manner.

The Nash bargaining solution, discussed by Riezman (1982), exemplifies the idea of efficient negotiation. Riezman’s analysis can be adapted to the current dynamic setting in the following way. The set G^P is indicated by the shaded area in Figure 1. Point O in the figure emerges from infinite repetition of the autarchy outcome (which is a Nash equilibrium of the static model), while the other points in G^P may be sustained by the credible threat of reversion to autarchy.

Point N corresponds to infinite repetition of the positive trade Nash equilibrium (τ^N, τ^N) . Assume that if the countries are unable to agree in the current period, then the countries select the SGPE consisting of infinite repetition of this Nash equilibrium; i.e., point N is the disagreement point. Then the bargaining set consists of the subset

of G^P that lies above point N , and the Nash solution selects the outcome at point A . Thus, point A constitutes the trade agreement.

This analysis explains the selection of a SGPE at period $t = 0$. An important further consideration, however, is that the agreement itself should be intertemporally consistent. Since negotiation between countries is ongoing, agreement must be reached in each period in the same manner as it was reached in period zero.

A *recurrent agreement* is a selection of a SGPE that satisfies the Nash bargaining solution in *every* period. We shall let G^A denote the set of payoff profiles that can arise in recurrent agreements. Since the countries have an opportunity to negotiate anew in each period, disagreement now determines tariff choices only in the current period, rather than for the entire game, as in the preceding example. Thus, when agreement is recurrent, the disagreement point consists of the choice of (τ^N, τ^N) in the current period, followed by new negotiations in the following period. Disagreement means that Country i obtains a payoff of $W^N + \delta g'_i$, where $(g'_1, g'_2) \in G^A$ indicates the payoff profile from the agreement that is reached in the next period.

To keep the analysis simple, we will allow the countries to make transfers to one another as part of Nash bargaining. This serves to modify the original repeated game in an inessential way (in particular, with transfers the countries are able to obtain payoff profiles that are not in the original G^P set when this set is not convex). However, the bargaining analysis becomes much more transparent in the presence of transfers. Moreover, this assumption can be motivated by the fact that trade negotiations frequently involve cross-country linkages amongst a large number of issues. In such cases, it is appropriate to assume that countries use these linkages to effectively make transfers.⁷

Because agreement is recurrent, future payoff profiles must be elements of G^A no matter what tariffs are chosen in the current period.

Definition 2. Given a set of payoff profiles G^A , the payoff profile (g_1, g_2) is *sup-*

⁷Hoekman (1993), for example, points out that negotiating countries exchange concessions both within and across issues. Cross-issue linkages may allow agreement even if within-issue exchange of concessions proves insufficient to generate an improvement on the status quo for all concerned.

portable if there exist tariffs $\hat{\tau}_1, \hat{\tau}_2$ and profiles $(\hat{g}_1, \hat{g}_2), (g_1^1, g_2^1), (g_1^2, g_2^2) \in G^A$ such that

$$g_1 + g_2 = V(\hat{\tau}_1, \hat{\tau}_2) + \delta(\hat{g}_1 + \hat{g}_2), \quad (2)$$

and, for $i = 1, 2$,

$$W(\hat{\tau}_i, \hat{\tau}_j) + \delta\hat{g}_i \geq W(\tau^R(\hat{\tau}_j), \hat{\tau}_j) + \delta g_i^i. \quad (3)$$

Let the set of supportable payoff profiles be denoted by S^A .

Supportable payoff profiles are similar to SGPE profiles, except that continuation payoffs must be drawn from the given set G^A , rather than from the full set of SGPE payoffs G^P . This reflects the fact that the countries will negotiate a new agreement in the following period (represented by points in G^A). Further, note that the equality in (1) has been replaced by condition (2). Since transfers between the countries are allowed during bargaining, any division of the joint payoff is possible, and so the definition of supportable payoffs determines only the joint payoff.

Ongoing negotiation means that each period the countries select an element from S^A that is consistent with the Nash bargaining solution. This idea completes our notion of recurrent agreement, which is formalized as follows.

Definition 3. G^A constitutes a *set of recurrent agreements* if the following is true for each $(g_1, g_2) \in G^A$:

- I. (g_1, g_2) maximizes the sum of the countries' payoffs on the set S^A ; and
- II. There exists $(g_1', g_2') \in G^A$ such that the following holds for $i = 1, 2$:

$$g_i = \frac{1}{2}[g_1 + g_2 - (V^N + \delta(g_1' + g_2'))] + W^N + \delta g_i'. \quad (4)$$

Condition I is equivalent to the usual requirement of joint efficiency in the presence of transfers. Condition II states that each country obtains an even share of the joint surplus, where surplus is defined relative to a disagreement point that is consistent with agreement in the following period.

Consider now any particular set of recurrent agreements, G^A , along with the associated set of supportable payoff profiles, S^A . It is important to note that neither

the set G^A nor the bargaining solution is affected by the history of past tariff choices. This property gives rise to the following strong result. Let

$$g^A = \max\{g_1 + g_2 | (g_1, g_2) \in S^A\};$$

i.e., g^A is the value of the joint payoff that satisfies the maximization problem in condition I.

Lemma 1. If $(g_1, g_2) \in G^A$, then $g_1 = g_2 = g^A/2$.

Proof in Appendix.

The lemma follows from the fact that when agreement is recurrent, the countries evenly divide the surplus in the current and future periods, irrespective of the history of past tariff choices. In particular, in (3) we must have $\hat{g}_i = g_i^i = g^A/2$, and thus (3) becomes:

$$W(\hat{\tau}_i, \hat{\tau}_j) + \delta \frac{g^A}{2} \geq W(\tau^R(\hat{\tau}_j), \hat{\tau}_j) + \delta \frac{g^A}{2}. \quad (5)$$

Only $\hat{\tau}_i = \hat{\tau}_j = \tau^N$ can satisfy (5) for $i = 1, 2$. This proves:

Proposition 1. There is a unique set of recurrent agreements in the standard repeated tariff game with transfers. This set contains only the SGPE in which the static Nash equilibrium (τ^N, τ^N) is chosen in every period.

In other words, when countries negotiate recurrently, cooperative tariff agreements become unsustainable in the standard model. This is because imposing intertemporal consistency on negotiation procedures undercuts the countries' ability to punish defections from cooperative agreements. The intuition for this result is illustrated in Figure 2. The figure posits, contrary to Proposition 1, that the supportable set S^A , shown as the shaded area, admits payoff profiles that improve on the static Nash outcome N . Because of recurrent agreement, however, in each period the countries are lead to select a jointly efficient element of S^A , at point A , irrespective of tariff history. Since recurrent agreement undercuts the ability to punish defections from the agreement, payoff profiles that improve on N cannot actually be elements of S^A .

Our result differs from alternative approaches to “renegotiation proof” equilibria that have been considered in the literature. Under these approaches, cooperative outcomes can survive renegotiation because negotiation procedures are explicitly linked to the history of tariff choices. In Ludema (1990), for example, defections from a cooperative agreement imply that the countries are assumed to choose from a smaller set of agreements (e.g., the static Nash equilibrium must be selected for some number of periods). It is unclear, however, why the countries would impose such an inefficiency on themselves, given that they have the ability to restore cooperation immediately.

In a related model of dynamic sovereign debt, Kletzer and Wright (2000) posit that defections do not alter the set of feasible agreements, but rather the defecting country has reduced bargaining power in future negotiations. But no mechanism is proposed that links the history of past decisions to bargaining institutions. Why would a defecting country relinquish bargaining power in the absence of external coercion?

Our view is that, in the absence of external enforcement institutions, past tariff choices should not affect negotiation procedures. In particular, the bargaining set and bargaining solution should be history invariant. As Proposition 1 shows, each country’s bargaining power and ability to hold up the relationship undermines the credibility of standard repeated-game punishments.

4 External Enforcement

4.1 Dispute Settlement Institution

We have shown that because countries can exercise bargaining power in their ongoing negotiation, they are unable to achieve cooperative agreements on their own. External enforcement institutions therefore become important for sustaining credible enforcement. This section extends the standard repeated tariff model by adding a simple dispute settlement institution (DSI) modeled after the operations of the GATT and WTO legal systems. The countries are free to completely ignore the DSI if they choose; nevertheless, its existence makes cooperative agreements possible when

negotiation is ongoing.

Actual trade disputes brought to the GATT and WTO vary greatly in their particulars, but three features are commonly observed. First, countries rarely wait for the DSI to authorize retaliation. Offended countries typically pursue official grievance proceedings and simultaneously retaliate without WTO authorization, or else disguise retaliation as an unfair trade remedy (under GATT Article VI) or as a safeguard measure (Article XIX). Further, retaliation often triggers a counter-lawsuit from the country that started the conflict. Thus, disputes often involve bilateral suspension of concessions almost from the start.⁸

Second, settlement of disputes entails lengthy delays, often lasting many years, during which countries incur costs due to lost benefits of trade.⁹ Third, the settlement of disputes generally involves simple reversal of the actions that generated the claims. Sanctions aimed at punishing transgressor countries beyond reciprocal withdrawal of concessions, such as strongly asymmetric concessions or financial indemnities, are seldom specified.¹⁰ Another key property of trade disputes is that the enforcement

⁸The history of GATT is replete with episodes of such “tit-for-tat” exchanges of trade-inhibiting measures and lawsuits. For example, in 1988, within the same day Canada and the U.S. filed complaints accusing each other of illegal quantitative restrictions on import of ice cream and yogurt (see Hudec (1993)). Valles and McGivern (2000) discuss the dispute between Canada and Brazil involving mutual accusations regarding export subsidies for aircraft manufacturers. Hudec (1993) describes tit-for-tat exchanges of retaliatory measures and lawsuits between the U.S. and E.C. concerning citrus fruits in the 1980’s and bananas in the 1990’s. Prusa (1999) documents a tit-for-tat pattern in the way countries launch antidumping investigations.

⁹Under WTO rules, for example, if proceedings result in granting an offending party “a reasonable period of time” during which to comply with WTO decisions, a total of 31 or 32 months would elapse before the complainant receives authorization to suspend benefits. Importantly, changes under the Uruguay Round’s Understanding on Rules and Procedures Governing the Settlement of Disputes seem to have merely shifted delays from panel deliberation and appeal to the compliance stage.

¹⁰While proposals for the adoption of additional punitive sanctions, such as financial indemnities, have been discussed at different rounds of multilateral trade negotiations, they have never been formally incorporated in the GATT/WTO dispute settlement mechanism. The only direct sanction for a violation of trade agreements known to us exists under NAFTA’s environmental side agreement. For violations of this form, a dispute settlement panel may impose a fine on the offending state

authority has no direct coercive power over the countries involved, other than the ability to deny violators their membership.¹¹

To capture these salient features of trade disputes and enforcement activities, we propose the following simple extension of the standard repeated tariff model. Apart from the two countries, we assume that there exists a DSI whose purpose is to register agreements that the countries negotiate, and also to settle disputes when agreements are violated. At the start of any period, it is assumed that either there is no dispute pending, or else the DSI is in the process of resolving a dispute triggered by a violation in some prior period. We refer to the former situation as the “cooperative state,” or state C . If a dispute is pending, then the period begins in the “dispute state,” or state D . When a tariff agreement is violated, the DSI switches the state from C to D , and a dispute resolution process (DSP) begins, as described below. When settlement is achieved, the DSI switches the state from D back to C . Countries continue to negotiate agreements and choose tariffs, as before, under either the C or D state.¹²

Rather than developing a detailed model of the DSP, it suffices for our purposes to treat the DSP as a “black box,” where the key feature is that settlement occurs with delay. For a period that begins in the D state, the dispute is resolved, and the state is switched to C , with probability p . This probability is exogenous and is meant to capture the idea that dispute resolution may entail costs including delay. Importantly, the countries cannot take actions to raise p and hasten dispute resolution; this is the sense in which the DSP is external to the countries. Dispute resolution occurs at the very start of the period, prior to negotiation by the countries.

The timing of actions is illustrated in Figure 3. If the countries are in state C at the start of period t , they choose an agreement from a feasible set G^C and communicate the agreement to the DSI. As long as their tariff choices adhere to the agreement,

by making it pay a “Monetary Enforcement Award” to the complaining state (see Reisman and Wiedman (1995)).

¹¹Our model does not include an expulsion possibility, which itself may fail to hold up under ongoing negotiation.

¹²The model could allow for multiple dispute states, reflecting violations that occur while a prior dispute is pending. We focus on a single dispute state in the interest of simplicity.

they remain in state C at the start of period $t + 1$. If one or both countries defect from the agreement, however, a dispute arises, and the state is switched to D at the start of period $t + 1$.

If the countries are in state D at the start period t , then dispute settlement may occur at the start of the period. With probability p , the dispute is settled and the state switches back to C . In this case, the countries immediately negotiate a selection from G^C and communicate it to the DSI. With probability $1 - p$, the dispute is unresolved and the state remains D through the start of period $t + 1$, irrespective of what tariffs the countries select in the current period. In this event, the countries choose an agreement from a feasible set G^D . In principle, G^D can be identical to G^C , since the countries are free to ignore the DSI when negotiating agreements and selecting tariffs.

The definitions from the preceding section will now be extended to incorporate the DSI. For given sets G^C and G^D , define the following set of expected payoff profiles:

$$G^E = \{p(g_1, g_2) + (1 - p)(g'_1, g'_2) | (g_1, g_2) \in G^C, (g'_1, g'_2) \in G^D\}.$$

This is the set of possible expected continuation payoff profiles, conditional entering the following period in the D state. With probability p , the dispute is resolved and (g_1, g_2) is selected from G^C in the next period; with probability $1 - p$, the dispute is not resolved and (g'_1, g'_2) is selected from G^D .

Definition 4. Given sets of payoff profiles G^C and G^D , the payoff profile (g_1, g_2) is *supportable in state s* , $s = C, D$, if there exist tariffs $\hat{\tau}_1, \hat{\tau}_2$ and profiles (\hat{g}_1, \hat{g}_2) , (g_1^1, g_2^1) , (g_1^2, g_2^2) such that (2) and (3) are satisfied, where:

for $s = C$: $(\hat{g}_1, \hat{g}_2) \in G^C$, and $(g_1^1, g_2^1), (g_1^2, g_2^2) \in G^E$; and

for $s = D$: $(\hat{g}_1, \hat{g}_2), (g_1^1, g_2^1), (g_1^2, g_2^2) \in G^E$.

Let the set of payoff profiles that are supportable in state s be denoted by S^s .

Intuitively, in state C any defection from the agreed tariffs $\hat{\tau}_1$ and $\hat{\tau}_2$ triggers the dispute state. Continuation payoffs are then elements of G^E , which builds in the probability of dispute settlement at the start of the following period. State D indicates an ongoing dispute, and all continuation payoffs in state D are drawn from G^E .

Definition 5. G^C and G^D constitute *state-dependent sets of recurrent agreements* if, for $s = C, D$, the following is true for each $(g_1, g_2) \in G^s$:

- I. (g_1, g_2) maximizes the sum of the countries' payoffs on the set S^s ; and
- II. There exists (g'_1, g'_2) such that (4) holds for $i = 1, 2$, where:
 - for $s = C$: $(g'_1, g'_2) \in G^C$; and
 - for $s = D$: $(g'_1, g'_2) \in G^E$.

According to condition I, countries agree to do as well as possible in each state. Agreement is recurrent, in that continuation payoffs are always drawn from G^C or G^D , but the countries are unable to alter the state as part of their agreement.¹³

4.2 Recurrent Agreements With External Enforcement

We now demonstrate that cooperative outcomes become sustainable as recurrent agreements once the DSI is added to the model. Let the maximized value of the joint payoff for $s = C, D$ be written

$$g^s = \max\{g_1 + g_2 | (g_1, g_2) \in S^s\}.$$

Lemma 2. If $(g_1, g_2) \in G^s$, then $g_1 = g_2 = g^s/2$.

Proof in Appendix.

We may now derive the tariff choices in a recurrent agreement with external enforcement. For $s = D$, applying Lemma 2 to the supportability condition (3) gives

$$W(\hat{\tau}_i, \hat{\tau}_j) + \delta \left(p \frac{g^C}{2} + (1-p) \frac{g^D}{2} \right) \geq W(\tau^R(\hat{\tau}_j), \hat{\tau}_j) + \delta \left(p \frac{g^C}{2} + (1-p) \frac{g^D}{2} \right). \quad (6)$$

Thus, $\hat{\tau}_i = \hat{\tau}_j = \tau^N$ must be selected when $s = D$. As long as a dispute is pending, the disposition of the DSI is not affected by current tariff choices, and only the static Nash outcome can be sustained.

¹³As condition II is stated, if there is disagreement in state C , the state remains C , since we have assumed that in this event the countries do not communicate any agreement to the DSI. The results would not be affected if the model instead specified that disagreement triggered state D .

For $s = C$, the supportability condition (3) becomes:

$$W(\hat{\tau}_i, \hat{\tau}_j) + \delta \frac{g^C}{2} \geq W(\tau^R(\hat{\tau}_j), \hat{\tau}_j) + \delta \left(p \frac{g^C}{2} + (1-p) \frac{g^D}{2} \right), \quad (7)$$

which may be rewritten as

$$\Omega(\hat{\tau}_i, \hat{\tau}_j) \equiv W(\tau^R(\hat{\tau}_j), \hat{\tau}_j) - W(\hat{\tau}_i, \hat{\tau}_j) \leq \frac{\delta(1-p)}{2} (g^C - g^D). \quad (8)$$

The function $\Omega(\hat{\tau}_i, \hat{\tau}_j)$ indicates Country i 's within-period gain when it defects from the tariff agreement $(\hat{\tau}_i, \hat{\tau}_j)$. This gain is strictly positive for at least one of the countries whenever the agreement improves on the static Nash outcome. The right-hand side of (8) indicates the punishment that derives from delays induced by the DSP. As long as $p < 1$, defection initiates a dispute that may take time to resolve. The term $g^C - g^D$ gives the loss in joint surplus that the countries endure while the dispute is being resolved.

Since the outcome is (τ^N, τ^N) when $s = D$, we may apply supportability condition (2) in state D , along with the definition of G^E , to obtain

$$g^D = V^N + \delta(pg^C + (1-p)g^D). \quad (9)$$

Combining (8) and (9) gives

$$\Omega(\hat{\tau}_i, \hat{\tau}_j) \leq \frac{\delta(1-p)}{1-\delta(1-p)} \left(\frac{(1-\delta)g^C}{2} - W^N \right). \quad (10)$$

Further, condition (2) in state C implies

$$g_1 + g_2 = V(\hat{\tau}_1, \hat{\tau}_2) + \delta g^C. \quad (11)$$

Condition I of the definition of a recurrent agreement indicates that $\hat{\tau}_1$ and $\hat{\tau}_2$ are chosen to maximize $g_1 + g_2$ subject to (2) and (3). Based on (11), this is equivalent to maximizing $V(\tau_1, \tau_2)$ subject to (10). The maximized joint payoff is thus given by

$$\psi(g^C) \equiv \max_{\hat{\tau}_1, \hat{\tau}_2} \frac{V(\hat{\tau}_1, \hat{\tau}_2)}{1-\delta} \text{ subject to (10)}. \quad (12)$$

It follows that we have a recurrent agreement at any point where $g^C = \psi(g^C)$. This proves the following proposition.

Proposition 2. G^C and G^D give state-dependent sets of recurrent agreements if and only if the following are true.

- a. For $s = C, D$, the set G^s consists of a single element $(g^s/2, g^s/2)$.
- b. The value g^C satisfies $g^C = \psi(g^C)$, and tariff choices in state C are solutions to problem (12) for this value of g^C .
- c. The value of g^D satisfies (9), and tariff choices in state D are $\hat{\tau}_1 = \hat{\tau}_2 = \tau^N$.

The workings of a recurrent agreement in the presence of the DSI are depicted in Figure 4. The set S^D of supportable payoffs in state D contains only the point D , which lies above point N as long as $p > 0$ and cooperation occurs in state C . The shaded area indicates the set S^C of supportable payoffs in state C , given the values g^C and g^D . The bargaining solution selects point C in state C , which corresponds to the joint value g^C .

It is possible that (12) is satisfied by multiple values of g^C , with each solution supporting a recurrent agreement. For concreteness, we focus on the *maximal recurrent agreement*, which is the recurrent agreement giving the highest value of g^C . Let \bar{g}^C denote this highest value. The following proposition characterizes \bar{g}^C .

Proposition 3. There exists a maximal recurrent agreement, whose value \bar{g}^C is determined by

$$\bar{g}^C = \max_{\hat{\tau}_1, \hat{\tau}_2} \frac{V(\hat{\tau}_1, \hat{\tau}_2)}{1 - \delta} \text{ subject to} \quad (13)$$

$$\Omega(\hat{\tau}_i, \hat{\tau}_j) \leq \frac{\delta(1-p)}{1 - \delta(1-p)} \left(\frac{V(\hat{\tau}_i, \hat{\tau}_j)}{2} - W^N \right). \quad (14)$$

Proof in Appendix.

From (13) and (14), it may be seen that the maximal recurrent agreement maximizes the discounted value of the equilibrium path joint payoff subject to the supportability conditions. Using Proposition 3, we may easily relate the value of the maximal recurrent agreement to the delay induced by the DSP.

Proposition 4. The value \bar{g}^C is strictly decreasing in p , and $\bar{g}^C = V^N/(1 - \delta)$ when $p = 1$.

Proof in Appendix.

When $p = 1$, all disputes are resolved immediately, so that any cooperative agreement could be reinstated without delay. This undermines incentives to maintain cooperation, in the same manner as in the model with no DSI, and repetition of the static Nash equilibrium is the unique outcome. When $p = 0$, in contrast, the DSI never resolves disputes, and cooperative agreements cannot be restored. This corresponds to the “grim trigger” specification that imposes the positive-trade static Nash outcome in every period following defection. Intermediate cases are reflected by values of p between zero and one.

Proposition 4 assures that $\bar{g}^C > V^N/(1-\delta)$ whenever $p < 1$, and thus cooperation is attained in the maximal recurrent agreement. These outcomes capture the three features of actual trade disputes discussed above: a dispute leads to the static Nash equilibrium, reflecting violations by both countries and a mutual suspension of cooperative policies; delays in dispute resolution are built into the DSP; and settlement involves restoration of the cooperative tariff levels.¹⁴

Cooperation is sustained despite the fact that the DSI has no coercive powers. The key point is that when a dispute is triggered, the countries cannot avoid delays in restoring the cooperative state, since the DSP operates externally. This makes the cooperative state valuable, which in turn provides the incentive to preserve cooperation. It is important to note that the countries could not implement the DSP internally through an implicit agreement: whenever the D state arose, the countries would mutually benefit by redesigning the DSP to set $p = 1$, thereby undercutting the enforcement mechanism. External mechanisms are critical for credible enforcement because countries cannot manipulate the DSP in this way.

¹⁴Disputes do not actually occur in equilibrium, however, since countries negotiate agreements that satisfy the supportability conditions. In Section 5 we introduce a noise term that affects countries’ incentives, and we show that disputes arise with positive probability on the equilibrium path when the DSI is inflexible in using information.

4.3 Direct Penalties

Although not often used in practice, direct penalties imposed on unilateral violators represent a potentially useful mechanism for sustaining cooperation. In this section we show that direct penalties can substitute for delays, making it possible to expedite dispute resolution without undercutting incentives. Further, enforcement institutions can require direct penalties even though they have no coercive power.

We introduce direct penalties into the model in the following way. Suppose Country 1 unilaterally deviates from an agreement; i.e., following an agreement in state C , Country 1 chooses $\tau_1 \neq \hat{\tau}_1$, while Country 2 selects $\tau_2 = \hat{\tau}_2$. In this case, we assume that the DSI requires Country 1 to pay a penalty of $m > 0$ to Country 2 at the point of dispute resolution, as a condition for resolving the dispute and returning the state to C . Payment of this penalty is voluntary, but if the transgressor fails to pay it, then the DSI refuses to switch the state back to C . Thus, if state D has been triggered by a unilateral deviation by Country 1, then the set of expected continuation payoffs becomes

$$G_1^E = \{p(g_1 - m, g_2 + m) + (1 - p)(g'_1, g'_2) | (g_1, g_2) \in G^C, (g'_1, g'_2) \in G^D\}.$$

Similarly, expected continuation payoffs in state D following a unilateral deviation by Country 2 are given by

$$G_2^E = \{p(g_1 + m, g_2 - m) + (1 - p)(g'_1, g'_2) | (g_1, g_2) \in G^C, (g'_1, g'_2) \in G^D\}.$$

Assume that no penalties are imposed if the countries deviate simultaneously from a cooperative agreement (such joint deviations are never relevant for assessing the supportability of payoff profiles, however).

With the addition of direct penalties, Lemma 2 is modified as follows.

Lemma 3. a. If $(g_1, g_2) \in G^C$, then $g_1 = g_2 = g^C/2$.

b. If $(g_1, g_2) \in G^D$ and the dispute was triggered by unilateral deviation by Country i , then

$$g_i = \frac{g^D}{2} - \frac{\delta pm}{1 - \delta(1 - p)}, \quad (15)$$

$$g_j = \frac{g^D}{2} + \frac{\delta pm}{1 - \delta(1 - p)}. \quad (16)$$

Proof in Appendix.

With direct penalties, dispute settlement implies that Country i must pay a penalty to Country j before a new cooperative agreement is negotiated. This lowers the value of the disagreement point for Country i in state D . Thus, although the bargaining procedures are unchanged following its deviation, Country i obtains a lower payoff than does Country j .

Next consider the tariff choices in recurrent agreements with direct penalties. As before, only the choices $\hat{\tau}_1 = \hat{\tau}_2 = \tau^N$ are possible in state D . Tariff choices in state C are altered, however. Treating Country i as the unilateral deviator, the supportability condition (3) becomes, using (15):

$$W(\hat{\tau}_i, \hat{\tau}_j) + \delta \frac{g^C}{2} \geq W(\tau^R(\hat{\tau}_j), \hat{\tau}_j) + \delta \left[p \left(\frac{g^C}{2} - m \right) + (1 - p) \left(\frac{g^D}{2} - \frac{\delta pm}{1 - \delta(1 - p)} \right) \right],$$

or

$$\Omega(\hat{\tau}_i, \hat{\tau}_j) \leq \frac{\delta(1 - p)}{2} (g^C - g^D) + \frac{\delta pm}{1 - \delta(1 - p)}. \quad (17)$$

Combining (17) with (9) yields

$$\Omega(\hat{\tau}_i, \hat{\tau}_j) \leq \frac{\delta(1 - p)}{1 - \delta(1 - p)} \left(\frac{(1 - \delta)g^C}{2} - W^N \right) + \frac{\delta pm}{1 - \delta(1 - p)}. \quad (18)$$

Comparing (18) with (10), it may be seen that when $p > 0$, direct penalties serve to weaken the incentive constraints, thereby expanding the set of supportable payoff profiles. Thus, for any g^C , the value of $\psi(g^C)$ is strictly greater. This proves:

Proposition 5. If $p > 0$, then the use of direct penalties raises the value of the maximal recurrent agreement.

From this it follows that direct penalties can potentially substitute for delays in sustaining cooperative agreements. We must still check, however, that countries are willing to comply with the penalties, since the DSI has no coercive power. Voluntary compliance occurs when restoration of cooperation conveys benefits that exceed the

penalty. Thus, the size of the direct penalty is constrained by the following “voluntary compliance” condition:

$$\frac{g^C}{2} - m \geq \frac{g^D}{2} - \frac{\delta pm}{1 - \delta(1 - p)}.$$

Taking the largest value of m that satisfies this condition, and combining this value with (17) and (9), yields:

$$\Omega(\hat{\tau}_i, \hat{\tau}_j) \leq \delta \left(\frac{g^C}{2} - \frac{W^N}{1 - \delta} \right). \quad (19)$$

The right-hand side of (19) indicates the largest punishment that can be imposed in a recurrent agreement with direct penalties that satisfy the voluntary compliance condition. Observe that the punishment value is equivalent to the grim trigger strategy that uses infinite repetition of the static Nash tariffs (τ^N, τ^N) to punish deviations. Thus, we have proven the following proposition.

Proposition 6. Suppose the DSI imposes the largest direct penalty consistent with voluntary compliance. Then the punishment for deviation is equivalent to the use of a grim trigger strategy in which deviation leads to infinite repetition of the positive-trade static Nash equilibrium.

As may be seen from (19) and (10), use of the largest direct penalty yields the same incentive constraint as does setting $p = 0$ in the absence of direct penalties. In particular, penalties make possible the same level of punishment as would be the case with grim trigger strategies, but with no delay in dispute resolution.

5 Adaptability and Periodic Trade Disputes

5.1 Standard Tariff Model with Noise

In the preceding analysis of external enforcement, trade disputes never actually arise on the equilibrium path, since countries negotiate agreements that satisfy the supportability conditions. In this section we extend the model to incorporate a noise

term that alters the countries' incentives to adhere to their agreements, similar to the specification considered by Bagwell and Staiger (1990). If the DSI is uninformed about realizations of this random variable, or is unable to use this information in adjudicating disputes, then trade disputes occur periodically on the equilibrium path.¹⁵

Let the random element be denoted by θ . Fluctuations in θ may represent factors that lead to variations in trade volume, for example. We assume that countries are able to observe past and current realizations of θ when they make their tariff choices in a given period. The payoff of Country i is now given by $W(\tau_i, \tau_j, \theta)$. Assume $W_{\tau_i \theta} > 0$, so that higher θ raises the incentive to choose high tariffs. To simplify the technical arguments, we assume further that

$$\lim_{\theta \rightarrow \infty} W_{\tau_i}(\tau_i, \tau_j, \theta) = \infty$$

for any τ_i, τ_j, θ such that $W(\tau_i, \tau_j, \theta) > 0$; i.e., the incentive to choose higher tariffs may be made as large as desired by taking large enough θ .

The reaction function and Nash equilibrium now depend on θ ; let these be denoted by $\tau^R(\tau_j, \theta)$ and $\tau^N(\theta)$, respectively. Let $W^N(\theta) \equiv W(\tau^N(\theta), \tau^N(\theta), \theta)$ and $V^N(\theta) \equiv V(\tau^N(\theta), \tau^N(\theta), \theta) = 2W^N(\theta)$. Moreover, in this section we will invoke two other assumptions that are standard in the literature. First, assume $W_{\tau_i, \tau_j} < 0$; i.e., the two countries' tariffs are strategic substitutes. Second, assume $V_{\tau_i}(0, 0, \theta) = 0$; i.e., the marginal effect of tariffs on the joint payoff is zero at the free trade point.

In the repeated game, θ is drawn independently in each period according to the density function $f(\theta)$. Assume $f(\theta) = 0$ for $\theta < 0$ and $f(\theta) > 0$ for $\theta \geq 0$. Repeated game payoffs from period t are now given by

$$W(\tau_{it}, \tau_{jt}, \theta_t) + E\left[\sum_{s=t+1}^{\infty} \delta^{s-t} W(\tau_{is}, \tau_{js}, \theta_s)\right],$$

where expectation is taken with respect to the future path of θ realizations and tariff choices.

¹⁵Hungerford (1991) considers a model in which the offended party can conduct a costly and imperfectly informative investigation during the trade dispute. In an environment with unobservable non-tariff barriers and stochastic terms of trade, such an investigation can reduce the probability of trade wars.

Let G^P now denote the set of *expected* payoff profiles that may arise in SGPE of the extended model.

Definition 6. The set of SGPE expected payoff profiles G^P is the largest set with the following property: $(g_1, g_2) \in G^P$ if and only if there exist mappings $(\hat{\tau}_1(\theta), \hat{\tau}_2(\theta))$ and $(\hat{g}_1(\theta), \hat{g}_2(\theta))$, where $(\hat{g}_1(\theta), \hat{g}_2(\theta)) \in G^P$ for each θ , such that, for $i = 1, 2$:

$$g_i = \int_0^\infty [W(\hat{\tau}_i(\theta), \hat{\tau}_j(\theta), \theta) + \delta \hat{g}_i(\theta)] f(\theta) d\theta. \quad (20)$$

Moreover, for each θ and for $i = 1, 2$, there exists $(g_1^i(\theta), g_2^i(\theta)) \in G^P$ such that

$$W(\hat{\tau}_i(\theta), \hat{\tau}_j(\theta), \theta) + \delta \hat{g}_i(\theta) \geq W(\tau^R(\hat{\tau}_j(\theta), \theta), \hat{\tau}_j(\theta), \theta) + \delta g_2^i(\theta). \quad (21)$$

This definition extends Definition 1 by requiring that the incentive compatibility condition hold for each θ .

5.2 Nonadaptable DSI

As before, countries can make use of the DSI by communicating tariff agreements to the DSI when they are in state C . We first consider the case in which the DSI is *nonadaptable*, meaning that it cannot make use of the current period realization of θ in adjudicating a dispute. Thus, for periods in which the countries begin in state C , the timing is as follows. First, the countries negotiate a selection from G^C at the beginning of the period, prior to realization of θ , and communicate the agreed tariff bindings to the DSI. Let τ_1^* and τ_2^* denote the agreed tariff bindings in this case. Second, θ is realized. Finally, the countries observe θ and make their actual tariff choices. As long as the tariff choices satisfy $\hat{\tau}_i \leq \tau_i^*$ for both countries, the state remains C , while $\hat{\tau}_i > \tau_i^*$ for either i triggers state D . For periods beginning in state D , the model works as before: with probability p , the DSI resolves the dispute, and the countries immediately select an agreement from G^C , involving choices of τ_1^* and τ_2^* , as discussed. With probability $1 - p$, the dispute remains unresolved, and the

countries select their agreement from G^D . To avoid complications, we do not consider direct penalties in the extended model.

The earlier definitions are extended as follows.

Definition 7. Take as given sets of payoff profiles G^C and G^D . For the noise model with nonadaptable DSI, the payoff profile (g_1, g_2) is *supportable in state s* , $s = C, D$, if there exist tariffs τ_1^*, τ_2^* , tariff mappings $\hat{\tau}_1(\theta), \hat{\tau}_2(\theta)$, and a payoff profile mapping $(\hat{g}_1(\theta), \hat{g}_2(\theta))$, such that

$$g_1 + g_2 = \int_0^{\infty} [V(\hat{\tau}_1(\theta), \hat{\tau}_2(\theta), \theta) + \delta(\hat{g}_1(\theta) + \hat{g}_2(\theta))] f(\theta) d\theta, \quad (22)$$

and, in addition, there exist mappings $(g_1^i(\theta, \tau_i), g_2^i(\theta, \tau_i))$ for $i = 1, 2$ such that, for each θ and each deviation τ_i of Country i , the following holds:

$$W(\hat{\tau}_i(\theta), \hat{\tau}_j(\theta), \theta) + \delta \hat{g}_i(\theta) \geq W(\tau_i, \hat{\tau}_j(\theta), \theta) + \delta g_i^i(\theta, \tau_i), \quad (23)$$

where

for $s = C$: (a) $(\hat{g}_1(\theta), \hat{g}_2(\theta)) \in G^C$ for θ such that $\hat{\tau}_i(\theta) \leq \tau_i^*$ for both i , and otherwise $(\hat{g}_1(\theta), \hat{g}_2(\theta)) \in G^E$; (b) $(g_1^i(\theta, \tau_i), g_2^i(\theta, \tau_i)) \in G^C$ if $\tau_i \leq \tau_i^*$, and otherwise $(g_1^i(\theta, \tau_i), g_2^i(\theta, \tau_i)) \in G^E$; and

for $s = D$: $(\hat{g}_1(\theta), \hat{g}_2(\theta)) \in G^E$ and $(g_1^i(\theta, \tau_i), g_2^i(\theta, \tau_i)) \in G^E$ for all θ and τ_i , $i = 1, 2$.

Let S^s denote the set of payoff profiles that are supportable in state s .

The extended definition of supportable payoff profiles allows for a switch to state D only for equilibrium path choices and deviations that involve *increases* in tariffs above the agreed bindings τ_1^* and τ_2^* . No dispute is triggered if the countries depart from their agreement by lowering tariffs.

Definition 8. For the noise model with nonadaptable DSI, G^s constitutes a *state-dependent set of recurrent agreements* if, for $s = C, D$, the following is true for each $(g_1, g_2) \in G^s$:

- I. (g_1, g_2) maximizes $g_1 + g_2$ on S^s ; and

II. There exists a mapping $(g'_1(\theta), g'_2(\theta))$ such that

$$g_i = \frac{1}{2}(g_1 + g_2 - \int_0^\infty [V^N(\theta) + \delta(g'_1(\theta) + g'_2(\theta))]f(\theta)d\theta + \int_0^\infty [W^N(\theta) + \delta g'_i(\theta)]f(\theta)d\theta), \quad (24)$$

where

for $s = C$: $(g'_1(\theta), g'_2(\theta)) \in G^C$ for all θ ; and
for $s = D$: $(g'_1(\theta), g'_2(\theta)) \in G^E$ for all θ .

Observe that disagreement leads to the static Nash equilibrium contingent on θ , followed by a selection from the from the appropriate set of recurrent agreements in the following period.

Lemma 2 extends to this case, and it remains true that only the static Nash outcome may be supported in state D ; i.e., $\hat{\tau}_1(\theta) = \hat{\tau}_2(\theta) = \tau^N$ for all θ in state D . Let the expected private and joint payoffs be written:

$$\bar{W}^N \equiv \int_0^\infty W^N(\theta)f(\theta)d\theta, \quad \bar{V}^N \equiv \int_0^\infty V^N(\theta)f(\theta)d\theta.$$

Next consider tariff choices in state C . For simplicity, we focus on symmetric agreements, having $\tau_1^* = \tau_2^* = \tau^*$; the results may be straightforwardly extended to the asymmetric case. Determination of equilibrium tariff choices is illustrated in Figure 5. For low values of θ , such as θ^a in the figure, we have $\tau^a = \tau^R(\tau^*, \theta) < \tau^*$, and (23) is violated as a consequence of the desirability of low tariffs. In this case, the static Nash tariff levels are chosen, at point a . A dispute is not triggered, however, since the tariff choices lie below the agreed level τ^* . For larger θ , such as θ^b , we have $\tau^b = \tau^R(\tau^*, \theta^b) > \tau^*$, and thus defections from the agreement involve tariff increases. Since τ^b is close to τ^* , however, (23) holds and the tariff choices adhere to the agreement, at point b . Finally, very large values of θ , such as θ^c , give rise to a large value $\tau^c = \tau^R(\tau^*, \theta^c) > \tau^*$, and (23) is violated at $\tau_i = \tau^c$. In this case, the tariff choices correspond to the static Nash outcome, this time at point c . A dispute is triggered in this last case.

The ranges of θ that support these three outcomes may be characterized as follows. First, the upper bound of the lower range, denoted by $\underline{\theta} \geq 0$, satisfies $\tau^N(\underline{\theta}) = \tau^*$. As for the lower bound of the upper range, denoted by $\bar{\theta}$, we have, using (23) and Lemma 2:

$$\Omega(\tau^*, \tau^*, \bar{\theta}) = \frac{\delta(1-p)}{2}(g^C - g^D), \quad (25)$$

where

$$\Omega(\hat{\tau}_i, \hat{\tau}_j, \theta) \equiv W(\tau^R(\hat{\tau}_j), \hat{\tau}_j, \theta) - W(\hat{\tau}_i, \hat{\tau}_j, \theta).$$

Note that under our assumptions, $\Omega(\tau^*, \tau^*, \theta)$ may be made unboundedly large for sufficiently large θ . Thus, for any τ^* , g^C , and g^D , there will be a nonempty upper range of θ such that $\Omega(\tau^*, \tau^*, \theta)$ exceeds the right hand side of (25). If this is true for every θ (i.e., if equality never holds in (25)), then for convenience we set $\bar{\theta} = -1$. It follows that the equilibrium tariff choices for given values of τ^* , g^C and g^D satisfy

$$\hat{\tau}_i(\theta) = \begin{cases} \tau^N(\theta), & \theta < \underline{\theta}, \\ \tau^*, & \underline{\theta} \leq \theta \leq \bar{\theta}, \\ \tau^N(\theta), & \theta > \bar{\theta}. \end{cases} \quad (26)$$

Since the outcome is $(\tau^N(\theta), \tau^N(\theta))$ when $s = D$, we have

$$g^D = \bar{V}^N + \delta(pg^C + (1-p)g^D). \quad (27)$$

Combining (25) and (27) gives

$$\Omega(\tau^*, \tau^*, \bar{\theta}) = \frac{\delta(1-p)}{1-\delta(1-p)} \left(\frac{(1-\delta)g^C}{2} - \bar{W}^N \right). \quad (28)$$

Further, making use of (26), the equality (22) for state C may be written

$$\begin{aligned} g_1 + g_2 &= \int_0^{\underline{\theta}} V^N(\theta) f(\theta) d\theta + \int_{\underline{\theta}}^{\bar{\theta}} V(\tau^*, \tau^*, \theta) f(\theta) d\theta \\ &+ \int_{\bar{\theta}}^{\infty} V^N(\theta) f(\theta) d\theta + \delta[g^C F(\bar{\theta}) + (pg^C + (1-p)g^D)(1 - F(\bar{\theta}))], \end{aligned} \quad (29)$$

where $F(\theta)$ indicates the cumulative distribution function. Thus, condition I of the definition of a recurrent agreement requires that τ^* be chosen to solve the following

problem (using (27)):

$$\begin{aligned} \psi(g^C) = \max_{\tau^*} & \left\{ \int_0^{\underline{\theta}} V^N(\theta) f(\theta) d\theta + \int_{\underline{\theta}}^{\bar{\theta}} V(\tau^*, \tau^*, \theta) f(\theta) d\theta \right. \\ & \left. + \int_{\bar{\theta}}^{\infty} V^N(\theta) f(\theta) d\theta + \frac{\delta(1-p)((1-\delta)g^C - \bar{V}^N)}{1-\delta(1-p)} F(\bar{\theta}) \right\}, \\ & \text{subject to (28) and } \tau^N(\underline{\theta}) = \tau^*. \end{aligned} \quad (30)$$

As before, a recurrent agreement must satisfy $g^C = \psi(g^C)$. We summarize with

Proposition 7. G^C and G^D give sets of recurrent agreements of the noise model with nonadaptable DSI if and only if the following are true.

- a. For $s = C, D$, G^s consists of a single element $(g^s/2, g^s/2)$.
- b. The value of g^C satisfies $g^C = \psi(g^C)$, the tariff agreement in state C is the solution to problem (30) for this value of g^C , and the realized tariff choices are given by (26).
- c. The value of g^D satisfies (27), and tariff choices in state D are $\hat{\tau}_1(\theta) = \hat{\tau}_2(\theta) = \tau^N(\theta)$.

Observe from (29) that in state C of the recurrent agreement, the countries raise tariffs and trigger a dispute with strictly positive probability. Equivalently, the term $F(\bar{\theta})$ in the objective of problem (30) is strictly positive. Thus, even in environments where countries can renegotiate their agreements every period, trade wars occur periodically if the DSI is not sufficiently adaptable to new information.

Moreover, the prospect for such trade wars serves as a check on the countries' desired tariff agreements. Using (28), we obtain:

$$\frac{\partial \bar{\theta}}{\partial \tau^*} = \frac{- \int_{\tau^*}^{\tau^R(\tau^*)} W_{\tau_i \tau_j}(\tau, \tau^*, \bar{\theta}) d\tau + W_{\tau_i}(\tau^*, \tau^*, \bar{\theta})}{\int_{\tau^*}^{\tau^R(\tau^*)} W_{\tau_i \theta}(\tau, \tau^*, \bar{\theta}) d\tau} > 0,$$

where we invoke the assumptions $W_{\tau_i \theta} > 0$, $W_{\tau_i \tau_j} < 0$ and W strictly quasi-concave in τ_i . It follows that as the countries seek a more beneficial agreement by lowering τ^* , they also reduce $\bar{\theta}$ and thus raise the probability that a trade war is triggered.

The solution to (30) for given g^C represents a tradeoff between beneficial agreement and costly trade war. The first-order condition for maximization may be written

$$\int_{\underline{\theta}}^{\bar{\theta}} \frac{d}{d\tau^*} V(\tau^*, \tau^*, \theta) f(\theta) d\theta = - \left[V(\tau^*, \tau^*, \bar{\theta}) - V^N(\bar{\theta}) + \frac{\delta(1-p)((1-\delta)g^C + \bar{V}^N)}{1-\delta(1-p)} \right] f(\bar{\theta}) \frac{\partial \bar{\theta}}{\partial \tau^*}. \quad (31)$$

The left-hand side of (31) is strictly negative for $\bar{\theta} > 0$ and $\tau^* > 0$, indicating the joint benefits of an agreement to lower tariffs. The right-hand side is strictly negative for $\bar{\theta} > 0$ and *any* τ^* , reflecting the fact that a small reduction in the agreed tariff must necessarily raise the probability of a trade war that reduces both the current and future joint payoffs. Note further that the left-hand side will be zero when $\tau^* = 0$, based on the assumption $V_{\tau_i}(0, 0, \theta) = 0$, while the right-hand side remains strictly negative. Thus, with a nonadaptable DSI the free trade outcome can never be supported as a recurrent agreement.

This completes the proof of the following proposition.

Proposition 8. In any recurrent agreement of the noise model with nonadaptable DSI, the following is true.

- a. When the state is C , the countries violate their tariff agreement and trigger a dispute with strictly positive probability.
- b. A reduction in τ^* raises the probability of triggering a dispute.
- c. The agreement $\tau^* = 0$ is never selected.

Intuitively, when the DSI is nonadaptable, countries realize that trade disputes become unavoidable under certain circumstances. Since the marginal loss from a tariff increase is zero at the free trade point, countries find it beneficial to give up some benefits of free trade in order to reduce the probability of trade disputes.

5.3 Fully Adaptable DSI

We now consider the case of a *fully adaptable* DSI, which can freely utilize all available information. In this case, the countries can communicate an entire mapping

$(\hat{\tau}_1(\theta), \hat{\tau}_2(\theta))$ to the DSI. It is not necessary to distinguish between upward and downward tariff deviations, and so we specify that the dispute state is triggered if and only if $\tau_i \neq \hat{\tau}_i(\theta)$ for some i when θ is realized. The definition of supportable payoffs is now altered: for $s = C$, we have $(\hat{g}_1(\theta), \hat{g}_2(\theta)) \in G^C$ for *every* θ , reflecting the fact that the agreement itself may be tailored to the circumstances that arise ex post.

The analysis of this case proceeds in a manner analogous to that of the original model. Restricting attention to symmetric agreements, problem (30) becomes:

$$\psi(g^C) = \int_0^\infty \left(\max_{\hat{\tau}(\theta)} V(\hat{\tau}(\theta), \hat{\tau}(\theta), \theta) + \delta g^C \right) f(\theta) d\theta,$$

$$\text{subject to } \Omega(\hat{\tau}(\theta), \hat{\tau}(\theta), \theta) \leq \frac{\delta(1-p)}{1-\delta(1-p)} \left(\frac{(1-\delta)g^C}{2} - \bar{W}^N \right) \text{ for all } \theta. \quad (32)$$

It is easy to verify that (32) gives a strictly higher maximized value than does (30) for all g^C such that the solution to (30) satisfies $\psi(g^C) > \bar{V}^N$; i.e., such that the solution improves on the static Nash outcome (note that (26) satisfies the constraints in (32)). Further, tariffs in the fully adaptable case will always be adjusted to avoid costly disputes. Thus, we have proven the following:

Proposition 9. In any recurrent agreement of the noise model with fully adaptable DSI, the following is true.

a. In equilibrium, the countries do not violate their tariff agreement in any contingency, so the dispute state is never triggered.

b. The maximal recurrent agreement with a fully adaptable DSI gives a strictly higher joint payoff than does the maximal recurrent agreement with a nonadaptable DSI.

Thus, the use of information by the DSI is important for sustaining agreements that avoid costly trade disputes and convey higher value. The adjustment of tariff agreements following realizations of θ constitutes a complete, state-contingent escape clause that heads off disputes. Importantly, such an attractive mechanism is feasible only to the extent that enforcement institutions are able to make use of information to adjudicate finely-tuned escape clauses. This suggests that it may be necessary

to overcome rigidities in enforcement institutions before the full benefits of escape clauses can be attained.

6 Conclusion

We have developed a theory of recurrent trade agreements that explains why external enforcement institutions, such as the GATT/WTO legal system, are essential for sustaining cooperative agreements. The key idea is that ongoing negotiations between countries undermine the credibility of repeated game punishments. External legal systems, utilizing mechanisms such as delays and direct penalties, can ensure credibility, since countries cannot manipulate for their mutual benefit the parameters of dispute resolution processes. When enforcement institutions are nonadaptable in using information, the model generates periodic trade disputes that capture important properties of actual disputes. The feasibility of beneficial arrangements to avoid disputes, such as escape clauses and safeguards, is shown to hinge on whether enforcement institutions can make effective use of information.

Our model can be viewed as a first step toward a more complete analysis of trade institutions and policy. In future work, it would be useful to consider the DSP in greater detail. The use of information in dispute resolution, and moral hazard on the part of countries, could be modeled explicitly as part of a multistage DSP, incorporating discovery, settlement and compliance stages. Feedbacks between the structure of the DSP, tariff agreements, and the nature of disputes can be explicitly considered within our framework.

The structure of escape clauses could also be analyzed more fully. Intermediate levels of adaptability, lying between the nonadaptable and fully adaptable DSI cases considered in this paper, would influence the nature of escape clauses available to the countries. We conjecture that as adaptability increases, countries would have available a richer constellation of escape clauses, and the value of trade agreements would rise.

Finally, our concept of recurrent agreement has implications for the theory or

renegotiation in repeated games. Past notions of renegotiation-proofness, developed in Bernheim and Ray (1989), Farrell and Maskin (1989) and Pearce (1987), for example, rely on implicit links between past action choices and current selections of continuation equilibria. Recurrent agreement, which makes the bargaining aspects of renegotiation explicit, could be applied to obtain a more coherent understanding of the problem of renegotiation in general games.

APPENDIX

Proof of Lemma 1. Condition I of Definition 3 implies that $g_1 + g_2 = g^A$ for any $(g_1, g_2) \in G^A$. Also recall that $V^N = 2W^N$. These facts allow us to rewrite (4) as follows:

$$g_i - \frac{g^A}{2} = \delta(g'_i - \frac{g^A}{2}). \quad (33)$$

The stage game and SGPE conditions imply that G^P is bounded from above and below. Since $G^A \subset G^P$, this implies that G^A is also bounded. Thus, the supremum of $|g_i - g^A/2|$ over both i and $(g_1, g_2) \in G^A$ is finite. Combining this with (33) implies that $g_i = g^A/2$ for all $(g_1, g_2) \in G^A$. *Q.E.D.*

Proof of Lemma 2. Note that, from Condition I of Definition 5, $(g'_1, g'_2) \in G^C$ implies $g'_1 + g'_2 = g^C$. From Condition II for the case of $s = C$, we can rewrite (4) as:

$$g_i - \frac{g^C}{2} = \delta(g'_i - \frac{g^C}{2}). \quad (34)$$

Proceeding just as in the proof of Lemma 1, we obtain $g_i = g^C/2$ for all $(g_1, g_2) \in G^C$. As for the case of $s = D$, (4) can be rewritten as

$$g_i - \frac{g^D}{2} = \delta[p(g'_i - \frac{g^C}{2}) + (1-p)(g''_i - \frac{g^D}{2})] = \delta(1-p)(g''_i - \frac{g^D}{2}). \quad (35)$$

Here we have used the fact that $(g'_1, g'_2) \in G^D$ implies $g_1 + g_2 = g^D$. The method employed above can then be applied again, yielding $g_i = g^D/2$ for all $(g_1, g_2) \in G^D$. *Q.E.D.*

Proof of Proposition 3. For any $g^C \geq V^N/(1-\delta)$, the values $\hat{\tau}_i = \hat{\tau}_j = \tau^N$ satisfy (10) for $i = 1, 2$. Thus, $\psi(g^C) \geq V^N/(1-\delta)$ for any $g^C \geq V^N/(1-\delta)$. Further,

$\psi(g^C) \leq V(0,0)/(1-\delta)$ for any g^C . It follows that $g^C = \psi(g^C)$ for at least one g^C , and also there is a largest g^C such that this is true. The constraint (14) is implied by the fact that the constraint (10) is relaxed as $V(\hat{\tau}_i, \hat{\tau}_j)$ rises. *Q.E.D.*

Proof of Proposition 4. The result follows directly from (12): higher p strictly lowers the right-hand side of (10), and the right-hand side is zero for $p = 1$. *Q.E.D.*

Proof of Lemma 3. Part a follows exactly as in Lemma 2. As for part b, note that (4) and the definition of G_i^E imply

$$g_i - \frac{g^D}{2} = \delta[p(g'_i - m - \frac{g^C}{2}) + (1-p)(g''_i - \frac{g^D}{2})] = \delta(1-p)(g''_i - \frac{g^D}{2}) - \delta pm, \quad (36)$$

where $(g'_1, g'_2) \in G^C$, $(g''_1, g''_2) \in G^D$ and $g'_i = g^C/2$ is invoked. Suppose first that

$$g_i < \frac{g^D}{2} - \frac{\delta pm}{1 - \delta(1-p)}. \quad (37)$$

Then using (36) we have that $g''_i < g_i$. Let $g_i^1 = g''_i$. Continuing inductively, we obtain a sequence $(g_1^k, g_2^k) \in G^D$, $k = 1, 2, \dots$, with $g_i^{k+1} < g_i^k$ and

$$g_i^k - \frac{g^D}{2} = \delta(1-p)(g_i^{k+1} - \frac{g^D}{2}) - \delta pm. \quad (38)$$

Further, $g_i^k \geq 0$. But then it is necessary that the sequence have a limit point, in which case (38) is inconsistent with (37) and $g_i^k < g_i$.

Assume next that

$$g_i > \frac{g^D}{2} - \frac{\delta pm}{1 - \delta(1-p)}.$$

In this case, we may construct a sequence $(g_1^k, g_2^k) \in G^D$, $k = 1, 2, \dots$, with $g_i^{k+1} > g_i^k > g_i$. Further, $g_i^k \leq V(0,0)/(1-\delta)$. As above, existence of a limit point then yields a contradiction. This demonstrates that (15) must hold, and (16) then follows from (15) and $g_1 + g_2 = g^D$. *Q.E.D.*

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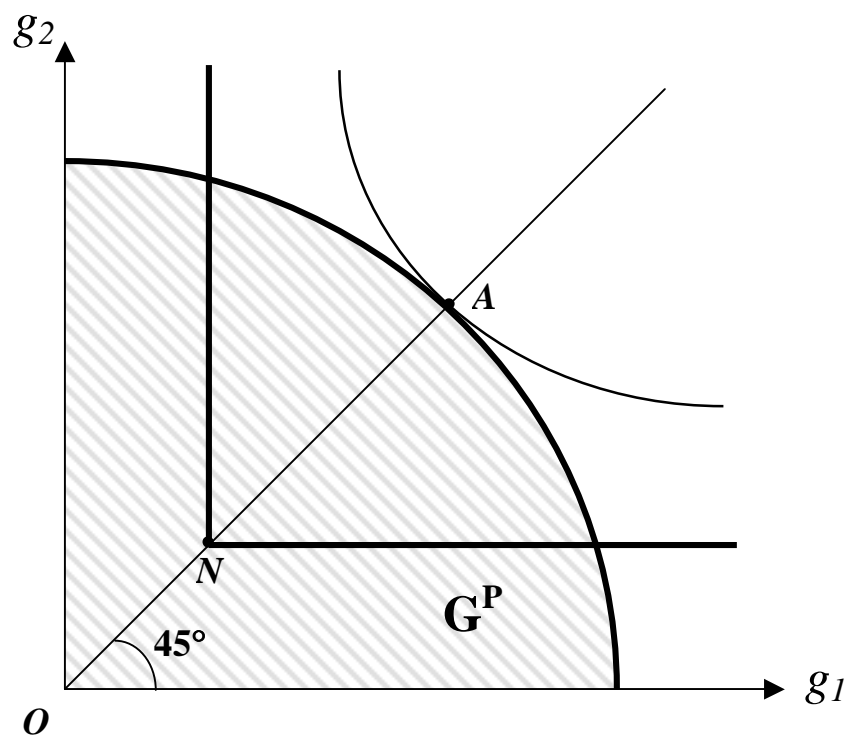


Figure 1.

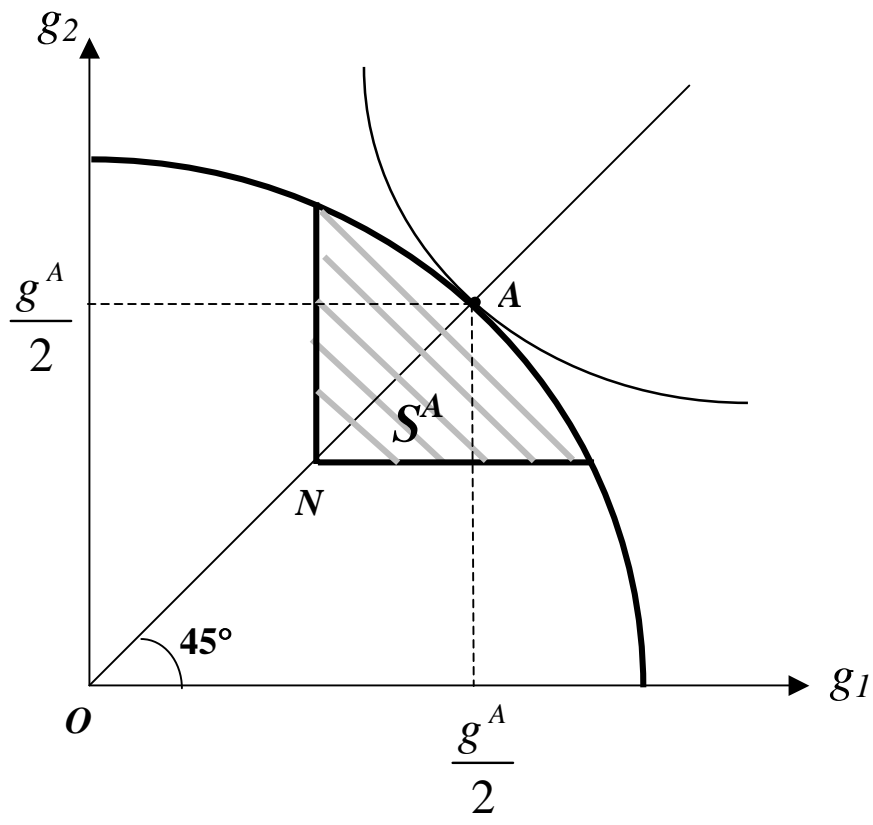


Figure 2.

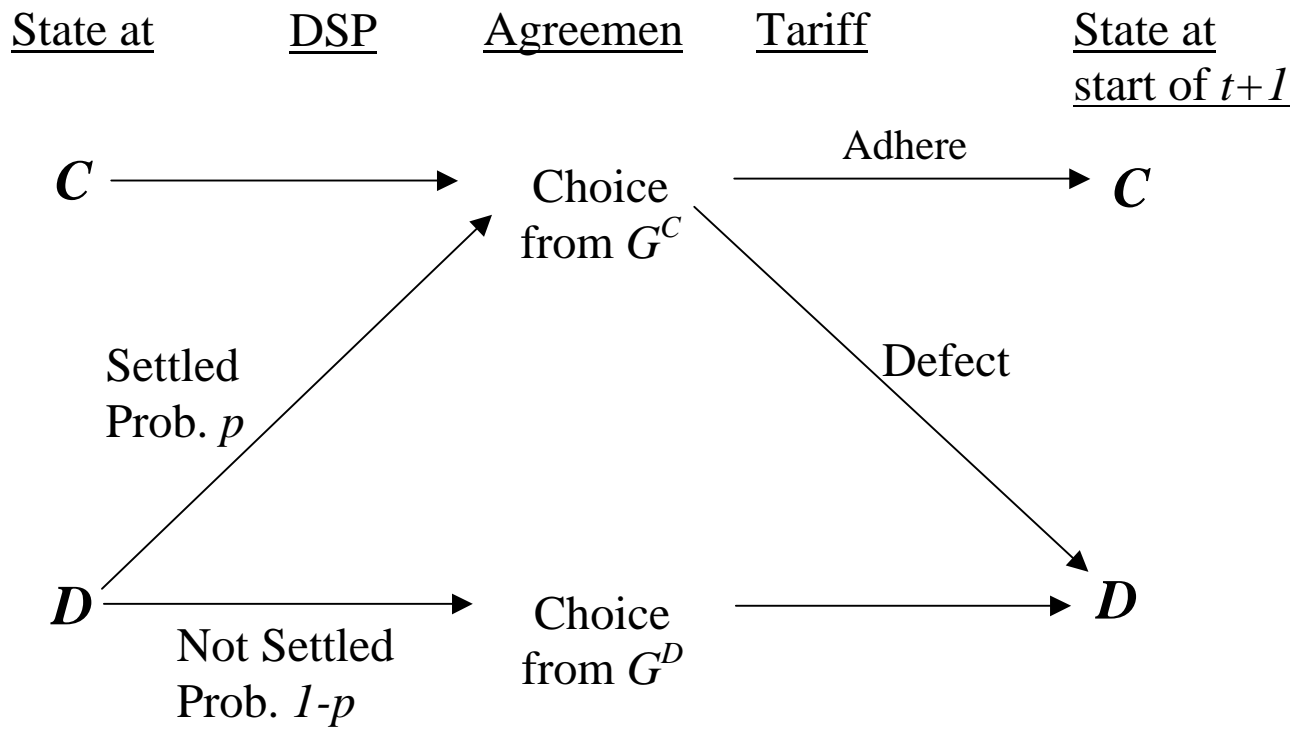


Figure 3.

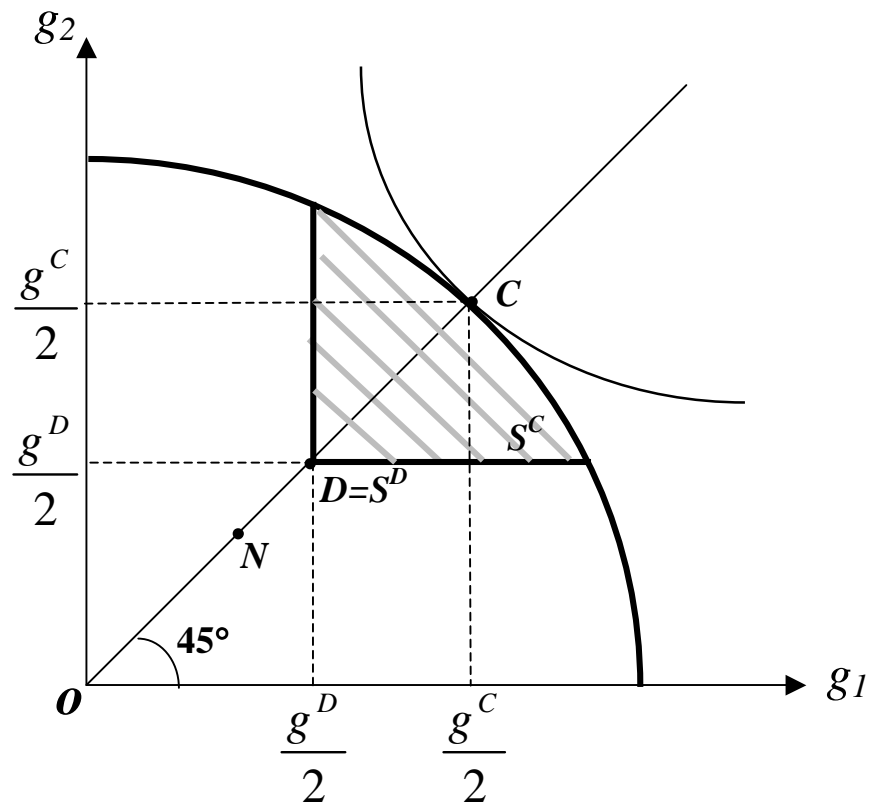


Figure 4.

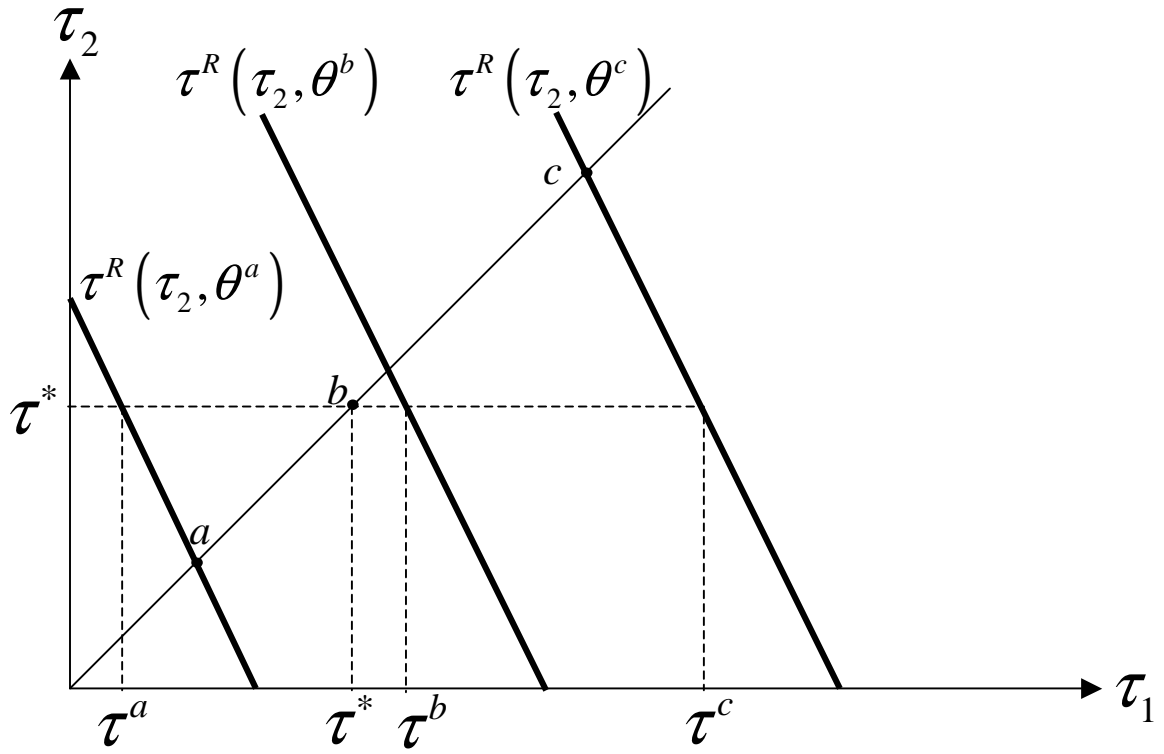


Figure 5.