Protection and the Business Cycle

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Abstract: Empirical studies have repeatedly documented the countercyclical nature of trade barriers. In this paper, we propose a simple theoretical framework that is consistent with this and other empirical regularities in the relationship between protection and the business cycle. We examine the ability of countries to maintain efficiency-enhancing reciprocal trade agreements that control their temptation to resort to beggar-thy-neighbor policies, under the requirement that such agreements are self-enforcing. We find theoretical support for countercyclical movements in protection levels, as the fast growth in trade volume that is associated with a boom phase facilitates the maintenance of more liberal trade policies than can be sustained during a recession phase in which growth is slow. However, we also find that acyclical increases in the level of trade volume give rise to protection, implying that whether rising imports are met with greater liberalization or increased protection depends on whether they are part of a cyclic upward trend in trade volume or an acyclical increase in import levels.

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I. INTRODUCTION

Empirical studies have repeatedly documented the countercylical nature of trade barriers. McKeown (1984), Gallarotti (1985), Coneybeare (1987), Corden (1987), Ray (1987), Grilli (1988), Hansen (1990) and Bohara and Kaempfer (1991) all conclude that the average level of protection tends to rise in recessions and fall in booms.[1] What can account for these movements in protection over the business cycle? In this paper, we propose a simple theoretical framework that can account for these and other empirical regularities in the relationship between protection and the business cycle.

If governments turn to trade policy intervention primarily to pursue distributive goals, two logical possibilities suggest themselves as providing answers to this question. One possibility is associated with the impact of tariffs on the distribution of income among domestic residents (domestic political economy). If this approach is to deliver a countercyclical theory of protection, it must explain why governments adopt trade policies that serve the interests of import-competing sectors at the expense of export sectors during recessions but do not do so during booms. The other possibility is associated with the impact of tariffs on the distribution of income between domestic residents and the rest of the world (beggar-thy-neighbor effects). If this approach is to deliver a countercyclical theory of protection, it must explain why governments have more difficulty controlling beggar-thy-neighbor tendencies during recessions than booms.

With regard to the first of these possibilities, Cassing, McKeown and Ochs (1986) draw a distinction between "old" and "new" regions, hypothesizing that old regions are experiencing secular decline and dominated by import-competing industries while new regions are experiencing secular growth and dominated by export industries. In this setting, they argue that export interests may dominate the political process during booms, since further expansion is then only possible in new regions. By contrast, during recessions, excess capacity develops in the import-competing industries, and so the payoff to securing protection is high for import-competing industries in the old region. In this way, Cassing, McKeown and Ochs (1986)

[1]These findings apply to various countries, time periods and measures of protection. For example, McKeown (1984), Gallarotti (1985) and Hansen (1990) relate legislated tariff changes to business cycle conditions over various historical periods for the U.K., U.S. and Germany. Grilli (1988) examines the cyclical behavior of non-tariff barriers in the U.S. and E.C. over the period 1969-1986, while Bohara and Kaempfer (1991) focus on the U.S. for the period 1895-1970 and measure average protection by total tariff revenue as a fraction of dutiable

argue that domestic political economy considerations can generate countercyclical movements in protection.[2]

Our goal in this paper is to adopt the second approach noted above, and to develop a business cycle theory of protection that reflects cyclical variations in the effectiveness with which countries can control their beggar-thy-neighbor tendencies. We do so in a model in which countries are tempted to exploit the terms-of-trade effects of protection. This provides a consistent formulation of the basic Prisoners' Dilemma which countries face in their trade policy choices, and it is this Prisoners' Dilemma flavor of the trade policy environment that is crucial for our results. It is our contention that the countercyclical behavior of protection can be best understood with reference to the imperfect attempt by countries to control the temptation to utilize protection for beggar-thy-neighbor purposes when economic times are hard. The constraints placed on the ability of countries to control these tendencies in turn can be traced to weak enforcement mechanisms at the international level.

Our focus on enforcement difficulties at the international level is shared by a growing trade policy literature (early contributions include Jensen and Thursby, 1984; Dixit, 1987; and Bagwell and Staiger, 1990) and reflects the view that international trade agreements such as the General Agreement on Tariffs and Trade (GATT) and its successor, the World Trade Organization (WTO), will be honored only if the incentives created by the agreement are compatible with the desired behavior. That is, since no external enforcement mechanism exists to punish violations, meaningful international commitments in trade policy must be self-enforcing, with violations deterred by the credible threat of subsequent retaliation. Dam (1970) states the need to view international trade agreements as necessarily self-enforcing:[3]

The best guarantee that a commitment of any kind will be kept (particularly in an international setting where courts are of limited importance and, even more important, marshals and jails are nonexistent) is that parties continue to view adherence to their agreement in their mutual interest...

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imports. Finally, Coneybeare (1987) examines trade wars throughout history, from medieval Anglo-Hanseatic conflicts to current trade disputes, and argues that trade wars tend to erupt during recessions.

[2] See also Magee, Brock and Young (1989).

[3] The WTO represents a significant step forward from GATT, but must ultimately still rely on the voluntary actions of member countries to punish violators of the agreement. For an evaluation of the advances embodied in the WTO over GATT, see Jackson (1995).

Thus, the GATT system, unlike most legal systems,.... is not designed to exclude self-help in the form of retaliation. Rather, retaliation, subjected to established procedures and kept within prescribed bounds, is made the heart of the GATT system. (Dam, 1970, pp. 80-81)

In what follows, we model international trade agreements as self-enforcing and thus requiring a constant balance between the gains from deviating unilaterally from the agreement and the discounted expected future benefits of maintaining the integrity of the agreement, with the understanding that the latter would be forfeited in the trade war which followed a unilateral defection in pursuit of the former. In this setting, changes in current conditions or in expected future conditions can upset this balance, requiring changes in existing trade policy to bring incentives back into line. We explore here the way in which changes in trade volumes associated with the business cycle can upset this balance, and determine the trade policy responses required to reestablish balance as the business cycle progresses.[4]

As in our related work on collusion (Bagwell and Staiger, 1994), we follow Hamilton (1989) in modeling the business cycle as the outcome of a Markov process that switches between two distinct states, one representing expansions and the other contractions. With regard to the degree of interdependence of the business cycles across the two countries of our model, we consider two extremes: At one extreme, which we refer to as the *international business cycle* case, countries move together between booms and recessions; at the other extreme, which we refer to as the *national business cycle* case, countries move between booms and recessions independently.[5] We focus on movements in trade volume over the business cycle, and model business cycle fluctuations in trade volumes as procyclical, exhibiting fast

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[4]Jackson (1969, p. 170) quotes a statement made by a draftsman of GATT's Article XXIII, the main enforcement provision of GATT, which reflects the delicate balance that must be maintained through the life of a trade agreement. We reproduce the quote here:

We shall achieve, under the Charter, if our negotiations are successful, a careful balance of the interests of the contracting states. This balance rests upon certain assumptions as to the character of the underlying situation in the years to come. And it involves a mutuality of obligations and benefits. If, with the passage of time, the underlying situation should change or the benefits accorded any member should be impaired, the balance would be destroyed. It is the purpose of Article 35 [corresponding to GATT Article XXIII] to restore this balance by providing for compensatory adjustment in the obligations which the Member has assumed. This adjustment will not be made unless the Member has asked that it be made. And it is then the function of the Organization to insure that compensatory action will not be carried out to such a level that balance would be tipped the other way. What we have really provided, in the last analysis, is not that retaliation should be invited or sanctions invoked, but that a balance of interests once established, shall be maintained. [U.N. Doc. EPCT/A/PV.6 at 5 (1947)].

[5]The empirical evidence suggests that output is positively correlated across countries, but with a few exceptions the correlations are not particularly strong (see, for example, Danthine and Donaldson, 1993).

growth during boom periods and slow growth during periods of recession. That trade volumes and trade deficits are strongly procyclical has been well-documented empirically (see, for example, Dornbusch and Frankel, 1987; Danthine and Donaldson, 1993; and Backus, Kehoe and Kydland, 1994). We also allow trade volumes to fluctuate around their high-growth and slow-growth trends.

We first consider the case of an international business cycle. Here we show that the procyclical movements in import volumes lead to countercyclical movements in protection provided that trade volume growth rates are positively correlated through time, i.e., provided that the phases of the business cycle and the accompanying changes in the growth of import flows are sufficiently *persistent*. As positive correlation seems the natural presumption for business cycle aggregates, our theory yields a prediction of countercyclical protection, in line with the empirical studies of the cyclical properties of protection noted above.[6] We also generalize our earlier model of "managed trade" (Bagwell and Staiger, 1990) to a business cycle setting and show that transitory increases in import *levels* lead to increased protection regardless of the phase of the business cycle. Thus, whether rising imports are met with greater liberalization or increased protection depends on whether they are part of a cyclical upward trend in trade volume or a transitory increase in import levels. In this way, our theory can help reconcile the stylized facts noted above - that protection is countercyclical while trade volumes are procyclical - with the seemingly contradictory evidence that protection rises with rising import levels or import penetration (Trefler, 1993).

We next consider the case of national business cycles, in which each country's business cycle operates independently of the other's. In this setting, there are now three growth states for trade volume: High growth when both countries are in expansion, medium growth when one country is in a boom and the other is in a recession, and low growth when both countries are in a recession. We first establish that the international business cycle results extend to the case of national business cycles. That is, with sufficient persistence in the phases of each country's business cycle, protection will be countercyclical, rising when either country moves from boom to recession and falling when either country recovers. However, each country's

[6]On estimates of transition probabilities for business cycle phases, see Hamilton (1989), who finds positive correlation in growth rates of quarterly GDP for the United States.

protection level now depends countercyclically not only on the state of its own business cycle, but also on the state of the business cycle in the rest of the world.

The remainder of the paper proceeds as follows. The static model of trade and protection is developed in Section II, and it is here that the Prisoners' Dilemma problem confronting countries is presented. In Section III, we develop and analyze the model of international business cycles. The national business cycle model is presented in Section IV. Section V concludes. Remaining proofs are contained in an Appendix section.

II. STATIC MODEL

In this section, we develop the basic static model of trade between two countries. With this model in place, we draw a formal distinction between domestic political economy and beggar-thy-neighbor arguments for countercyclical tariff policy. We also demonstrate that the Prisoners' Dilemma problem that underlies the latter argument is robust, arising whether or not political economy effects are present.

A. The Static Tariff Game

We consider a world comprised of two countries, with foreign country variables distinguished by an "*." Each country is endowed with an infinite number of locally abundant goods, where each locally abundant good in one country is distinct from every locally abundant good in the other country. A country is endowed with 3/2 units of each of its locally abundant goods. The domestic country's demand for each of its locally abundant goods is given by $D(P) = 3/2 - P$, where P is the local price of the good in the domestic economy. Similarly, the foreign country's demand for each of its locally abundant goods is represented as $D(P^*) = 3/2 - P^*$, where P^* is the local price of the good in the foreign economy.

Each country also has symmetric demand for and a small endowment of a number of the goods that are available abundantly in the other country, and this forms the basis for trade between the two countries. In particular, the domestic country has demand $D(P) = 3/2 - P$ for G of the goods available abundantly in the foreign country, and the domestic country is also endowed with 1/2 unit of each of these G goods. Each of the G goods is thus a potential import (export) good for the domestic (foreign) country. Similarly, the foreign country has demand $D(P^*) = 3/2 - P^*$ for G^* of the goods available abundantly in the domestic economy, and the foreign country is also endowed with 1/2 unit of each of these G^* goods. Accordingly, each of the G^* goods is a potential import (export) good for the foreign (domestic) country. Notice further that G (G^*) gives the number of import-competing sectors in the domestic (foreign) economy. For now, we fix G and G^*.

The government in each country can restrict or promote trade volume through the choice of specific import and export taxes or subsidies. Let τ_m and τ_x represent the domestic country's tariff policy, where τ_m denotes the import policy (tax if positive, subsidy if negative) applied to each of its G import goods and τ_x designates the export policy (tax if positive, subsidy if negative) applied to each of its G^* export goods. Similarly, the foreign country chooses an import tariff, τ_m^*, and an export tariff, τ_x^*, on the G^* goods that it imports and the G goods that it exports, respectively.[7]

For each of the G^* goods that the foreign country imports, let P_m^* and P_x represent the price of the good in the foreign and domestic markets, respectively. Likewise, for each of the G goods that are imported by the domestic country, we may denote the domestic and foreign prices as P_m and P_x^*, respectively. We have now that

(1). $P_m^* = P_x + \tau_x + \tau_m^*$

(2). $P_m = P_x^* + \tau_x^* + \tau_m$.

The structure of the basic model is completed with the further requirement of market clearing for each product. This requirement may be expressed as

(3). $2 = [3/2 - P_x] + [3/2 - P_m^*]$

(4). $2 = [3/2 - P_x^*] + [3/2 - P_m]$.

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[7]Given the symmetry across each of the G domestic import goods and across each of the G^* export goods, we consider a single import (export) policy applied symmetrically to all goods imported (exported) by the domestic country, and similarly for the foreign country trade policy.

Using a "^" to denote market-clearing values, we solve (1) - (4) for market-clearing prices and import volumes, $M(\hat{P}_m) \equiv D(\hat{P}_m) - 1/2$ and $M^*(\hat{P}^*_m) \equiv D(\hat{P}^*_m) - 1/2$, which are:

(5). $\hat{P}_x = [1 - (\tau_x + \tau^*_m)]/2;$ $\hat{P}^*_m = [1 + (\tau_x + \tau^*_m)]/2$

(6). $\hat{P}^*_x = [1 - (\tau^*_x + \tau_m)]/2;$ $\hat{P}_m = [1 + (\tau^*_x + \tau_m)]/2.$

(7). $M(\hat{P}_m) = [1 - (\tau^*_x + \tau_m)]/2;$ $M^*(\hat{P}^*_m) = [1 - (\tau_x + \tau^*_m)]/2$

Thus, under free trade, each good is sold at the price of 1/2 in both countries, and the per-good import volume is also 1/2, so that consumption is identical across countries. When taxes are imposed, however, the volume of trade is reduced, and consumers in the importing (exporting) country pay a price above (below) 1/2. Observe that trade is prohibited for the G (G*) goods potentially imported (exported) by the domestic country when $\tau^*_x + \tau_m \geq 1$ ($\tau_x + \tau^*_m \geq 1$).

With (5)-(7) in place, we are now ready to define the welfare functions that governments maximize. We assume that each government seeks to maximize the sum of producer surplus, consumer surplus and net tariff revenue on traded goods for its country, with weights $\gamma_x \geq 1$ and $\gamma_m \geq 1$ attached to the producer surplus of the import-competing and export sectors, respectively. We follow Baldwin (1987) and interpret weights on producer surplus that exceed unity as signifying domestic political economy forces.[8] Specifically, letting $W_x(\tau_x,\tau^*_m)$ and $W_m(\tau_m,\tau^*_x)$ represent the domestic-country welfare (inclusive of domestic political economy considerations) received on each of its G* export and G import goods, respectively, we have that

(8). $$W_x(\tau_x,\tau^*_m) = \int_{\hat{P}_x}^{3/2} D(P)dP + \gamma_x(3/2)\hat{P}_x + \tau_x M^*(\hat{P}^*_m)$$

(9). $$W_m(\tau_m,\tau^*_x) = \int_{\hat{P}_m}^{3/2} D(P)dP + \gamma_m(1/2)\hat{P}_m + \tau_m M(\hat{P}_m),$$

so that total domestic-country welfare, $W(\tau_m,\tau_x,\tau^*_m,\tau^*_x;G,G^*)$, is given by

[8]While Baldwin (1987) adopts a reduced-form representation of domestic political economy influences, Grossman and Helpman (1993) have provided micro-analytic foundations for such a representation in the context of a model of lobbying.

$$W(\tau_m,\tau_x,\tau_m^*,\tau_x^*; G,G^*) = G^*W_x(\tau_x, \tau_m^*) + GW_m(\tau_m, \tau_x^*).$$

In an exactly analogous manner, we may define the foreign-country welfare received on each export and import good as $W_x^*(\tau_x^*,\tau_m)$ and $W_m^*(\tau_m^*,\tau_x)$, respectively, with total foreign-country welfare then expressed as $W^*(\tau_m^*,\tau_x^*,\tau_m,\tau_x; G,G^*) = GW_x^*(\tau_x^*,\tau_m) + G^*W_m^*(\tau_m^*,\tau_x)$.

We now define the *static tariff game* as the game in which both governments simultaneously select import and export tariffs, where the domestic government chooses its tariff policy (τ_m,τ_x) to maximize $W(\tau_m,\tau_x,\tau_m^*,\tau_x^*; G,G^*)$, and the foreign government selects it tariff policy (τ_m^*,τ_x^*) to maximize $W^*(\tau_m^*,\tau_x^*,\tau_m,\tau_x; G,G^*)$.

B. Nash Equilibria of the Static Tariff Game

Before characterizing the Nash equilibria of the static tariff game, it is instructive to identify three effects of trade policy for this game. First, by altering the domestic price, trade policy redistributes surplus between domestic producers and domestic consumers or tariff revenue; we refer to this as the *domestic political economy effect*. Second, a country's trade policy also affects the terms-of-trade, and it is through this *terms-of-trade effect* that a country can redistribute surplus from its trading partner to itself. Finally, taxes on trade have an *efficiency effect*, as they restrict the volume of trade and thereby reduce welfare. We argue below that the terms-of-trade effect leads governments to restrict trade more than they would were they each motivated only by domestic political economy redistributive goals. This restriction in trade in turn leads to efficiency losses, implying that countries face a Prisoners' Dilemma problem when trade policy is the outcome of a noncooperative process.

To develop this argument formally, we maximize W with respect to τ_x and τ_m, finding that the best-response tariffs for the domestic government are defined implicitly by

(10). $(\gamma_m - 1)/2 + M(\hat{P}_m) = \tau_m$

(11). $M^*(\hat{P}_m^*) = 3(\gamma_x - 1)/2 + \tau_x$.

On the LHS of (10), we have the benefits to the domestic country from a slight increase in its import tariff, holding fixed the level of import volume. The first term, $(\gamma_m - 1)/2$, measures the net effect on consumer surplus and import-competing producer surplus when the 1/2 units of endowed goods are exchanged domestically at a higher price. This domestic political economy effect is positive when the implied redistribution is desirable (i.e., when $\gamma_m > 1$). The second term, $M(\hat{P}_m)$, corresponds to the net effect on tariff revenue and consumer surplus for the $M(\hat{P}_m)$ units of traded goods following a slight increase in the import tariff; this is the terms-of-trade effect, and it reflects a redistribution of surplus from the foreign exporters to the domestic country. Finally, the RHS of (10) gives the cost to the domestic country when its import tariff is raised slightly. A higher import tariff results in lower import volume, and this efficiency effect in turn diminishes the tariff revenue earned by the domestic government.

The export tariff condition (11) admits a similar interpretation. For fixed export volume, a higher export tariff redistributes a portion of foreign consumer surplus into greater domestic tariff revenue; this terms-of-trade benefit is represented in the LHS of (11) by the term $M^*(\hat{P}^*_m)$. A higher export tariff also has costs, however, and these are captured in the RHS of (11). A higher export tariff reduces the domestic price and therefore lowers export-sector producer surplus on the endowed 3/2 units. This loss is balanced against a corresponding gain in tariff revenue on the $M^*(\hat{P}^*_m)$ traded units and in consumer surplus on the $3/2 - M^*(\hat{P}^*_m)$ domestically-consumed units. The net loss then corresponds to the domestic political economy effect of a higher export tariff, and this is represented in (11) by the term $3(\gamma_x - 1)/2$. Finally, a higher export tariff reduces export volume, and this efficiency loss results in less tariff revenue; the efficiency cost of a slightly higher export tariff is given in the RHS of (11) by the term τ_x.[9]

Having identified the three separate effects that each country balances in its unilateral choice of trade policy, we turn next to a characterization of the Nash equilibria of the static tariff game. There is an interior equilibrium to this game in which positive trade takes place, and an autarky equilibrium also exists. Solving for the interior Nash equilibrium trade tariffs yields

$$\hat{\tau}^n_x = [12 - 9\gamma_x - \gamma_m]/8; \qquad \hat{\tau}^n_m = [3(\gamma_x + \gamma_m) - 4]/8,$$

[9]Solving (10) and (11), we find that the best-response tariffs for the domestic government take the explicit forms: $\tau_{xr}(\tau^*_m) = [4 - 3\gamma_x - \tau^*_m]/3$ and $\tau_{mr}(\tau^*_x) = [\gamma_m - \tau^*_x]/3$.

where $\hat{\tau}_x^n$ and $\hat{\tau}_m^n$ are the Nash export and import tariffs, respectively, imposed by the domestic and foreign governments. Nash export tariffs are therefore lower when governments are more sensitive to political economy considerations, and in fact export subsidies occur in the Nash equilibrium if producer-surplus welfare weights are sufficiently large (i.e., if $12 < 9\gamma_x + \gamma_m$). On the other hand, Nash import tariffs are always positive, and they are higher when governments are more responsive to political economy influences. Note also that

$$\hat{\tau}_x^n + \hat{\tau}_m^n = 1 - (3\gamma_x - \gamma_m)/4.$$

Thus, interior Nash tariffs do not prohibit trade under the further assumption that $3\gamma_x - \gamma_m > 0$. The autarky Nash equilibrium has all export tariffs set at or higher than $\hat{\tau}_x^a \equiv (3 - \gamma_m)/2$ and all import tariffs set at or higher than $\hat{\tau}_m^a \equiv (3\gamma_x - 1)/2$. In this case, no unilateral incentive to reduce tariffs exists, as the tariff rates in the other country ensure that a trade subsidy sufficient to induce trade would lead to a lower welfare level than that achieved under autarky.

C. Efficient Trade Policies and the Prisoners' Dilemma Problem

We next characterize the efficient trade policies, which are the trade policies that maximize joint welfare, W + W*. Efficient export and import policies, (τ_x^e, τ_m^e), satisfy

$$(12). \quad (\gamma_m - 1)/2 - \tau_m^e = 3(\gamma_x - 1)/2 + \tau_x^e,$$

which would be satisfied if each country ignored the terms-of-trade effects of its trade policy choices (see (10) and (11) above). Rewriting this condition yields

$$\tau_x^e + \tau_m^e = 1 - (3\gamma_x - \gamma_m)/2 < \hat{\tau}_x^n + \hat{\tau}_m^n.$$

Thus, Nash trade policies result in too little trade relative to efficient trade policies. This inefficiency is depicted in Figure 1, which represents the Nash and efficient tariffs for a domestic import good and a positive Nash export tariff.[10]

The static tariff game illustrates the Prisoners' Dilemma problem that confronts countries. Joint welfare is maximized when countries ignore their ability to alter the terms-of-trade and set trade policy solely to achieve domestic redistributive objectives. But the efficient trade policy does not constitute a Nash equilibrium: each country does even better when it unilaterally exploits the terms-of-trade consequences of its policy choices, as in this way it redistributes surplus from its trading partner to itself. In the static tariff game, both countries are tempted by such "beggar-thy-neighbor" policies, and as a consequence joint welfare in the interior Nash equilibrium is inefficient. The autarky equilibrium is even worse in this respect, as welfare is reduced further.

D. Sources of Countercyclical Tariff Policies

While the static tariff game identifies the sources of potential gain from an international trade agreement, it also provides a useful starting point for understanding why protection might be countercyclical. Two possibilities suggest themselves. First, countercyclical movements in political pressure for trade policy intervention might induce countercyclical movements in protection. This possibility could be captured by countercyclical movements in γ_m and γ_x. Note, however, that it is not enough to posit an overall rise in political pressure during downturns, since if pressures for both restrictions on imports and promotion of exports increased, then it is not obvious which force would prevail. In fact, for cyclical movements in political pressure to deliver a countercyclical theory of protection, pressures for trade restriction must dominate those for trade promotion during recessions but fail to do so during booms. In terms of the notation above, and regardless of whether equilibrium trade policies are best

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[10]In Figure 1, note that the Nash iso-total-tariff line, $\tau_x^* + \tau_m = \hat{\tau}_x^n + \hat{\tau}_m^n$, involves higher tariffs than (lies Northwest of) the efficiency iso-total-tariff line, $\tau_x^* + \tau_m = \tau_x^e + \tau_m^e$. The latter line may cross the 45 degree line above, on or below the origin; the three cases are depicted in Figure 1. A similar figure applies when the Nash export tariff is negative, corresponding to an export subsidy. In that case, the two reaction curves cross left of the τ_m axis, and efficiency can be associated with lower import taxes and higher export subsidies. For further elaboration on these points, see Bagwell and Staiger (1995).

characterized by the interior Nash equilibrium or the efficient trade agreement, countercyclical protection would require that γ_m rise relative to $3\gamma_x$ during recessions and fall during booms.[11]

A second possibility is that the degree to which efficient trade policies can be maintained varies with the business cycle. That is, since the efficient trade agreement involves lower trade barriers and greater trade volume than the Nash equilibrium outcomes, procyclical variation in the effectiveness with which countries can implement more efficient trade policies will result in countercyclical protection.[12] It is this possibility that we pursue here.

Finally, a comparison of (10) and (11) with (12) reveals that political economy plays no essential role in distinguishing between the policies that would be implemented under an efficient trade agreement and those that would be implemented in the Nash equilibrium. The Nash equilibrium and efficient trade policy choices differ solely because of the terms-of-trade effect of trade policy: this effect contributes to the determination of the interior Nash equilibrium tariff, but it does not play a role in the characterization of the efficient tariffs. Since our focus on the effectiveness with which countries can implement more efficient trade policies centers on the distinction between the efficient trade agreement and the inefficient Nash policies, and since the domestic political economy effect is not part of this distinction, we abstract from political economy considerations in the remainder of the paper and set $\gamma_x = \gamma_m = 1$.

With this simplification, the domestic country's welfare-maximizing tariff responses corresponding to (10) and (11) reduce to

(13). $\tau_{xr}(\tau_m^*) = [1 - \tau_m^*]/3$

(14) $\tau_{mr}(\tau_x^*) = [1 - \tau_x^*]/3.$

Thus, the domestic country's optimal tariffs are positive, provided that the foreign-country tariffs do not already prohibit all trade. Foreign-country welfare-maximizing tariff responses may be derived analogously. The interior Nash equilibrium has every tariff set equal to $\hat{\tau}^n$ =

[11]An exploration along these lines is contained in Cassing, McKeown and Ochs (1986).
[12]This view conforms with the features of international trade cooperation described by Coneybeare (1987), who studies trade wars throughout history and argues that international trade policy cooperation tends to break down during periods of cyclical downturn.

1/4, and the autarky Nash equilibrium has tariffs set at or higher than $\hat{\tau}^a = 1$. The efficient trade policy is free trade.

III. Protection and International Business Cycles

With the static tariff game now presented, we turn next to a dynamic model of tariff determination and develop our theory of countercyclical protection. A dynamic model provides scope for more efficient trade agreements, since a country then encounters a tradeoff when considering a tariff increase: on the one hand, a higher tariff continues to enhance the country's welfare in the short term, but, on the other hand, opportunistic behavior of this kind could trigger a painful tariff war in the long term. Clearly, this tradeoff is influenced by the rate at which the country discounts the future as well as the rate at which each country's demand for products of the other is expected to grow. This suggests that the level of tariff-policy cooperation may vary through time, along with the underlying business-cycle conditions that determine the expected growth rates for import demand.

To explore this possibility, we construct dynamic tariff models in which import demand fluctuates through time. Our approach is to model growth in aggregate demand as evolving cyclically and to highlight the implications of these cyclical movements for import volume. Specifically, we model cyclical movements in aggregate demand in terms of growth in the number of new goods demanded.[13] In other words, we let G_t give the number of foreign export goods demanded by the domestic country at date t, while G_t^* denotes the number of domestic export goods demanded by the foreign country at date t. With this, the business-cycle conditions transpiring in the domestic (foreign) country can be interpreted in terms of the evolution of G_t (G_t^*), and the evolution of the number of goods traded in total can be determined as $G_t^W \equiv G_t + G_t^*$. Business cycles are then "international" in nature if G_t and G_t^* are perfectly correlated through time, while domestic- and foreign-country business cycles are "national" and sometimes "out of sync" with one another when these variables are imperfectly

[13]We let growth in the number of new goods supplied vary procyclically as well, but the endowment of each new good is small relative to the demand. This ensures that cyclical movements in import volume are driven by cyclical movements in demand and delivers procyclical trade deficits. In focusing on new goods, we recognize that growth in trade for existing goods is also an important ingredient in accounting for overall growth in import demand. Our association between growth in the number of traded goods and growth in import demand seems a plausible abstraction, however, and particularly so in light of the technical simplifications that this approach affords. In the symmetric model of trade presented here, the number of traded goods enters welfare in a

correlated. We consider the case of international business cycles in the present section, leaving the analysis of national business cycles for the next section.

A. The Incentive to Cheat

Before developing any particular model of the business cycle, we first characterize the domestic country's short-term or single-period incentive to cheat on a proposed tariff policy agreement. To this end, suppose that the agreement calls for a set of tariffs $\{\tau_m, \tau_x, \tau_m^*, \tau_x^*\}$ at date t, and consider the gain to the domestic country from violating the agreement and defecting to its optimal response tariffs, $\tau_{mr}(\tau_x^*)$ and $\tau_{xr}(\tau_m^*)$. On each of its G_t^* export goods, the domestic country gains welfare in amount $\Omega_x(\tau_x, \tau_m^*)$, while for each of its G_t import goods the domestic-country welfare gain is $\Omega_m(\tau_m, \tau_x^*)$, where

$$(15). \quad \Omega_x(\tau_x, \tau_m^*) \equiv W_x(\tau_{xr}(\tau_m^*), \tau_m^*) - W_x(\tau_x, \tau_m^*)$$

$$(16). \quad \Omega_m(\tau_m, \tau_x^*) \equiv W_m(\tau_{mr}(\tau_x^*), \tau_x^*) - W_m(\tau_m, \tau_x^*),$$

so that the domestic country's total *incentive to cheat* is defined by $G_t^*\Omega_x(\tau_x, \tau_m^*) + G_t\Omega_m(\tau_m, \tau_x^*)$. The incentive to cheat for the foreign country can be defined similarly.

To better understand the incentive-to-cheat function, we next exploit the symmetry present in the model. As (13) and (14) suggest, a country's welfare function is symmetric across import and export sectors. In fact, it is easy to confirm that $W_x(\tau, \tau^*) \equiv W_m(\tau, \tau^*) + 1/2$, with the difference corresponding to the different autarky payoffs for export and import markets. For any fixed good and foreign-country tariff, it follows that the domestic country's incentives associated with a particular domestic tariff level are independent of whether the given good is imported or exported. When both import and export tariffs are feasible, it is thus natural to model a country as selecting a single tariff that applies to both exports and imports. Furthermore, given that the countries are also symmetric, it is natural as well to consider the case in which the domestic and foreign countries select the same tariff. Let us therefore set τ_m

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proportional fashion, and so simple characterizations of expected discounted welfare over the business cycle can be derived. Consequently, incentive constraints for the dynamic tariff games can be captured in a tractable form.

$= \tau_x = \tau_m^* = \tau_x^* \equiv \tau$, and evaluate the incentive that a country has to cheat at date t on an agreement that calls for all tariffs to be set at level τ.

For this symmetric environment, straightforward calculations reveal that

(17). $\Omega_x(\tau,\tau) = \Omega_m(\tau,\tau) = (2/3)\,[\hat{\tau}^n - \tau]^2.$

Using (17), it is apparent that a country's total incentive to cheat now be written simply as

(18). $G_t^w\Omega(\tau) \equiv G_t^*\Omega_x(\tau,\tau) + G_t\Omega_m(\tau,\tau) \equiv G_t^w\,(2/3)\,[\hat{\tau}^n - \tau]^2,$

where $\Omega(\tau)$ measures the incentive to cheat on any one export or import good. It is now easy to verify that $G_t^w\Omega(\tau)$ is positive, decreasing and convex in τ, and increasing in G_t^w for $\tau \in [0,\hat{\tau}^n)$.

Intuitively, the incentive to cheat depends only upon the total number of goods traded, as opposed to the distribution of those goods across countries, since export and import sectors are symmetric. The incentive to cheat is thus high when the total number of traded goods is large, since the optimal response tariff then can be applied to a larger volume of trade. On the other hand, a higher agreed-upon tariff, τ, acts to reduce the incentive to cheat, because the tariff is then already close to its optimal response level. Indeed, when $\tau = \hat{\tau}^n = 1/4$, the incentive to cheat is zero. Figure 2 illustrates.

B. The Dynamic Tariff Game with International Business Cycles

With the short-term benefits from cheating now characterized, let us next specify a model of the business cycle, so that the long-term welfare costs of a trade war can be evaluated. Motivated by the empirical analysis performed by Hamilton (1989), we assume that the business cycle within any given country is described by fast- and slow-growth demand phases, where the transition between phases is determined by a Markov process. We assume further that the business cycle is international, in that a single unifying business cycle operates on the economies of both the domestic and foreign countries.

Given the symmetry between export and import sectors, the possible consequences of business-cycle fluctuations for tariff cooperation are completely summarized by the manner in which the total number of traded goods, G_t^W, fluctuates through time. We therefore describe the business-cycle model in terms of this variable. In particular, we assume G_t^W obeys the following nonstationary process:

$$(19).\quad G_t^W = g_t(G_{t-1}^W/\varepsilon_{t-1})\varepsilon_t,$$

where $g_t \in \{b,r\}$ is the period-t growth rate, which is stochastic and determined by a Markov process, as described below. Letting $b > r > 0$, we say that period t is a *boom (recession) period* when $g_t = b$ ($g_t = r$). With regard to ε_t, we assume that it is iid through time with full support over $[\underline{\varepsilon},\bar{\varepsilon}]$ where $E\{\varepsilon_t\} = 1 \in (\underline{\varepsilon},\bar{\varepsilon})$ and $\underline{\varepsilon} > 0$.

Intuitively, the total number of traded goods fluctuates between fast- and slow-growth periods, with b indicating the growth rate in boom periods and r representing the growth rate in recession periods. In addition, the number of traded goods in period t is affected by a period-t transitory shock, which alters the number of traded goods in period t but leaves unaffected the number of traded goods in future periods. The period t transitory shock is represented in (19) with the variable ε_t, and notice there that past shocks are indeed transitory as the period t-1 shock is eliminated from the base from which all future growth occurs. Thus, ε_t may be appropriately interpreted in terms of the transitory shocks to trade volume that occur within broader business cycle phases. Given the iid manner in which ε_t is distributed, we will sometimes drop the time subscript when no confusion is created.

The transition between boom and recession periods is assumed to be governed by a Markov process, in which

$$(20).\quad \rho \equiv \text{Prob}(g_t = r \mid g_{t-1} = b) \in [0,1]$$

$$\lambda \equiv \text{Prob}(g_t = b \mid g_{t-1} = r) \in [0,1]$$

$$\mu \equiv \text{Prob}(g_1 = b) \in [0,1]$$

Thus, ρ is the transition probability associated with moving from a boom to a recession, while λ is the transition probability corresponding to moves from recessions to booms. Assuming that time runs from $t = 1$ to infinity, the parameter μ describes how the system begins. Assume further that $G_0^W > 0$, so that trade volume is always positive.

The parameters ρ and λ play important roles in two key measures associated with the business cycle. First, ρ and λ may be interpreted in terms of the expected duration of boom and recession phases, respectively. Suppose that $g_{t-1} = r$ and $g_t = b$, so that a switch to a boom period occurs at period t, and define $t^* \equiv \min\{\tau > t \mid g_\tau = r\}$. We then define a *boom phase* as a sequence of boom periods, $\{t, \ldots, t^*-1\}$, and the *expected duration of a boom phase* is given by

$$\sum_{z=1}^{\infty} z\rho(1-\rho)^{z-1} = 1/\rho$$

In the same manner, we may define a *recession phase* and derive that the *expected duration of a recession phase* is $1/\lambda$.

A second important measure for the business cycle concerns the correlation in growth rates through time. Observe that

$$E(g_{t+1} \mid g_t = b) - E(g_{t+1} \mid g_t = r) = [1 - \lambda - \rho][b - r],$$

and so the expected growth rate is higher in period t+1 when period t is a boom period if and only if $1 - \lambda - \rho > 0$. Accordingly, we say that business cycle growth rates are *positively correlated* through time when $1 - \lambda - \rho > 0$, and that they are *negatively correlated* through time when $1 - \lambda - \rho < 0$. Finally, business-cycle growth rates are said to exhibit *zero correlation* when $1 - \lambda - \rho = 0$.

With the business-cycle model now developed, we return to our original focus and examine the possibilities for cooperation between countries in the setting of tariffs. In particular, suppose that the static tariff game is repeated infinitely often, where in any period t governments are fully informed of (i). all past tariff choices, (ii). the current value of g_t and ε_t

as well as all past values, and (iii). the stochastic process that governs the future evolution of G_t^W.[14] We define this game as the *dynamic tariff game with international business cycles.*

We select among the set of subgame perfect Nash equilibria with two additional requirements. First, we assume that equilibrium tariff strategies are symmetric across countries and sectors, so that at any date t a single tariff is selected by both countries for both imports and exports. Second, we characterize *the most-cooperative tariffs*, which we define as the lowest tariffs that can be supported in a symmetric subgame perfect equilibrium. Following the general arguments of Abreu (1986), we find such tariffs by supposing that a deviation induces a maximal punishment. In the context of our tariff model, this is accomplished with the requirement that, if a deviation from equilibrium tariff policy occurs, then in the next period and forever thereafter the countries revert to the autarky Nash equilibrium of the static tariff game.[15]

C. The Cost of a Trade War

It is now apparent that countries encounter a tradeoff when making their respective tariff selections, as each must balance the one-time benefit of cheating with a deviant high tariff against the future value of maintaining a cooperative trading relationship. In other words, a tariff policy can then be supported in equilibrium only if the incentive to cheat is no higher than the expected discounted cost of a trade war. Having already characterized the incentive to cheat, we turn now to a formal representation of the cost of a trade war. Combining this with the business-cycle model developed above, we then characterize the incentive constraints that equilibrium tariffs must satisfy.

For a given tariff τ and number of traded goods G_t^W, the per-period cost of a trade war, $G_t^W\omega(\tau)$, may be defined as

$$(21). \quad G_t^W\omega(\tau) \equiv W(\tau;G_t,G_t^*) - W(\hat{\tau}^a;G_t,G_t^*) \equiv G_t^W\,(1/2)\,[\hat{\tau}^n - \tau^2],$$

[14]Tariff cooperation is also possible in a finite-horizon game, since the static game admits two Nash equilibria. In this case, defection would trigger a reversion to the "bad" (i.e., autarky) equilibrium in the future.

[15]The autarky punishment is convenient because it delivers the most-cooperative equilibrium outcome. Less-severe punishments might also be considered. Our main conclusions also can be supported in equilibria with milder punishments, although the overall level of tariffs then would be somewhat higher.

where $\omega(\tau)$ measures the cost of a trade war per period and per export or import good.[16] Provided that the tariff τ is not so high as to prohibit trade, therefore, the per-period cost of a trade war is positive, larger when more goods are traded, and concave and decreasing in τ. Intuitively, the cost of a trade war is greater when more goods otherwise would be traded at cooperative tariff levels. Figure 3 illustrates.

As the cost of a trade war is experienced in future periods, it is important to specify the manner in which countries discount the future and the relationships between growth rates and the discount factor. We assume only that countries employ the same discount factor, δ, and that $0 < \delta r < \delta b < 1$. These assumptions allow $b > 1 > r$ as one possibility, in which case booms are periods of positive growth and recessions entail negative growth; another possibility is that growth is positive in either state and faster in booms.

We now follow the methods presented in Bagwell and Staiger (1994) and derive the incentive constraints that equilibrium tariffs must satisfy. The Markov structure of the growth process is particularly helpful in this regard. When growth rates follow a Markov process, the expected cost of a trade war is the same in any one boom period as any other, holding fixed the level of the transitory shock ε, and likewise recession periods are equivalent with one another in this sense. Equilibrium tariff functions thus may be represented as $\tau_b(\varepsilon)$ and $\tau_r(\varepsilon)$, where these functions indicate the equilibrium tariffs to be charged in boom and recession periods, respectively, when the current period within-phase demand shock is given by ε.[17]

An additional benefit of the Markov structure is its recursive nature, which permits an explicit calculation of the expected discounted cost of a trade war, once the appropriate definitions are put forth. To this end, let us define $\bar{\omega}_b(\tau_b(\varepsilon),\tau_r(\varepsilon))$ as the per-good expected discounted cost of a trade war in period t+1 and thereafter, if $g_{t+1} = b$, $\tau_b(\varepsilon)$ and $\tau_r(\varepsilon)$ are the tariff functions, and the value for ε in period t+1 has not yet been determined. Analogously, we may define $\bar{\omega}_r(\tau_b(\varepsilon),\tau_r(\varepsilon))$ when $g_{t+1} = r$. Both functions are evaluated in period t+1 dollars.

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[16]In making this calculation, we have used the fact that autarky payoffs are 9/8 per export good and 5/8 per import good.

[17]As will become clear below, equilibrium tariffs do not depend upon G_t^W, since it enters as a proportional constant in both the incentive to cheat and the expected discounted cost of a trade war.

To fix ideas, consider now the incentive constraint facing a country in period t, when period t is a boom period and the period-t within-phase shock is given by $\varepsilon_t = \varepsilon$. Simplifying notation slightly, we may represent this incentive constraint as

$$G_t^W \Omega(\tau_b(\varepsilon)) \leq \delta\{\rho(rG_t^W/\varepsilon)\bar{\omega}_r + (1-\rho)(bG_t^W/\varepsilon)\bar{\omega}_b\},$$

or more simply

$$\varepsilon\Omega(\tau_b(\varepsilon)) \leq \delta\{\rho r\bar{\omega}_r + (1-\rho)b\bar{\omega}_b\}.$$

Thus, the current-period "base" level of trading volume, G_t^W, cancels, since all future trading volume growth will be in any event proportional to this base, but the current-period within-phase shock, ε, is not represented in future growth, and its value remains in the incentive constraint, with higher values for ε having the effect of raising the incentive to cheat.

Building on these insights, we now represent the complete incentive system as

(22). $\varepsilon\Omega(\tau_b(\varepsilon)) \leq \delta\{\rho r\bar{\omega}_r + (1-\rho)b\bar{\omega}_b\}$

(23). $\varepsilon\Omega(\tau_r(\varepsilon)) \leq \delta\{\lambda b\bar{\omega}_b + (1-\lambda)r\bar{\omega}_r\}$,

where

(24). $\bar{\omega}_b = E\{\omega(\tau_b(\varepsilon))\varepsilon\} + \delta\{\rho r\bar{\omega}_r + (1-\rho)b\bar{\omega}_b\}$

(25). $\bar{\omega}_r = E\{\omega(\tau_r(\varepsilon))\varepsilon\} + \delta\{\lambda b\bar{\omega}_b + (1-\lambda)r\bar{\omega}_r\}$.

We may now solve (24) and (25) for $\bar{\omega}_b$ and $\bar{\omega}_r$ and substitute these values back into (22) and (23). This yields the following representation of the incentive constraints:

(26). $\varepsilon\Omega(\tau_b(\varepsilon)) \leq E\{\omega(\tau_r(\varepsilon))\varepsilon\}\rho r\Delta + E\{\omega(\tau_b(\varepsilon))\varepsilon\}\beta\Delta$

(27). $\varepsilon\Omega(\tau_r(\varepsilon)) \leq E\{\omega(\tau_b(\varepsilon))\varepsilon\}\lambda b\Delta + E\{\omega(\tau_r(\varepsilon))\varepsilon\}\sigma\Delta$, where

(28). $\Delta = \delta/\{[1-(1-\lambda)\delta r][1-(1-\rho)\delta b] - \delta^2\lambda b\rho r\}$

(29). $\beta = b[1-\rho-\delta r(1-\lambda-\rho)]$

(30). $\sigma = r[1-\lambda-\delta b(1-\lambda-\rho)]$.

Clearly, $\beta > 0$ and $\sigma > 0$. We also have that $\Delta > 0$ and that Δ increases in δ for $\delta \in (0,1/b)$.[18]

D. Solution Method

With the incentive constraints now fully captured by (26) and (27), the next task is to solve for the most-cooperative tariff functions, $\tau_b^c(\varepsilon)$ and $\tau_r^c(\varepsilon)$. These functions maximize welfare over the set of all tariff functions that satisfy (26) and (27). One difficulty in approaching this problem is that tariff functions affect both the incentive to cheat as well as the expected discounted cost of a trade war. Here, we follow Rotemberg and Saloner (1986) and Bagwell and Staiger (1994) and exploit a two-step solution process, in which the expected discounted cost of a trade war is initially regarded as a constant.

Specifically, in the first step of the solution process, we view the right hand sides of (26) and (27) as fixed values, defined as

(31). $\tilde{\omega}_b \equiv E\{\omega(\tau_r(\varepsilon))\varepsilon\}\rho r\Delta + E\{\omega(\tau_b(\varepsilon))\varepsilon\}\beta\Delta$

(32). $\tilde{\omega}_r \equiv E\{\omega(\tau_b(\varepsilon))\varepsilon\}\lambda b\Delta + E\{\omega(\tau_r(\varepsilon))\varepsilon\}\sigma\Delta$.

Using (26) - (27) and (31) - (32), the incentive constraints now appear as

(33). $\varepsilon\Omega(\tau_b(\varepsilon)) \leq \tilde{\omega}_b$

[18] Let $\Delta \equiv \delta/D(\delta)$, where D is the denominator of the expression in (28). Simple calculations reveal that $D(0) = 1$, $D'(0) \leq 0$, $D(1/b) \geq 0$ and $\text{sign}\{D''(\delta)\} = \text{sign}\{1-\lambda-\rho\}$. Thus, if $1-\lambda-\rho \leq 0$, then $D''(\delta) \leq 0$ over $(0,1/b)$ and so $D(\delta) > 0$ follows necessarily. Consider next the case in which $1-\lambda-\rho > 0$, implying that $D''(\delta) > 0$. Observe that $D(1/r) \leq 0$, where $1/r > 1/b$. Given the convexity of $D(\delta)$ and the fact that $D(1/b) \geq 0$, it follows that $D'(\delta) < 0$ for $\delta \in [0,1/b]$. This in turn implies that $D(\delta) > 0$ over $(0,1/b)$.

(34). $\varepsilon\Omega(\tau_r(\varepsilon)) \leq \tilde{\omega}_r$.

We may now define $\tau_b^*(\tilde{\omega}_b/\varepsilon)$ and $\tau_r^*(\tilde{\omega}_r/\varepsilon)$ as the most-cooperative tariffs when $\tilde{\omega}_b$ and $\tilde{\omega}_r$ are taken as fixed values: i.e. $\tau_b^*(\tilde{\omega}_b/\varepsilon)$ is the lowest tariff satisfying (33) and $\tau_r^*(\tilde{\omega}_r/\varepsilon)$ is defined analogously for (34). Using (18), these tariffs can be represented as follows:

(35). $\tau_b^*(\tilde{\omega}_b/\varepsilon) = \max\{\hat{\tau}^n - \dfrac{(6\tilde{\omega}_b/\varepsilon)^{1/2}}{2}, 0\}$

(36). $\tau_r^*(\tilde{\omega}_r/\varepsilon) = \max\{\hat{\tau}^n - \dfrac{(6\tilde{\omega}_r/\varepsilon)^{1/2}}{2}, 0\}$.

In short, each tariff is set as close to free trade as possible, while still being consistent with the corresponding incentive constraint.

We now proceed to the next step in this process, and present a fixed point technique through which the most-cooperative values for $\tilde{\omega}_b$ and $\tilde{\omega}_r$ may be endogenously determined. Specifically, consistency requires that the most-cooperative values for $\tilde{\omega}_b$ and $\tilde{\omega}_r$ lead through (35) and (36) to tariffs which in turn generate through (31) and (32) the originally specified values for $\tilde{\omega}_b$ and $\tilde{\omega}_r$. This requirement is captured by the following fixed-point equations:

(37). $\tilde{\omega}_b = E\{\omega(\tau_r^*(\tilde{\omega}_r/\varepsilon))\varepsilon\}\rho r\Delta + E\{\omega(\tau_b^*(\tilde{\omega}_b/\varepsilon))\varepsilon\}\beta\Delta$

(38). $\tilde{\omega}_r = E\{\omega(\tau_b^*(\tilde{\omega}_b/\varepsilon))\varepsilon\}\lambda b\Delta + E\{\omega(\tau_r^*(\tilde{\omega}_r/\varepsilon))\varepsilon\}\sigma\Delta$.

We show in the Appendix that these fixed-point equations admit a unique solution, $(\hat{\omega}_b, \hat{\omega}_r)$. Once these values are determined, the most-cooperative tariffs are then defined by

(39). $\tau_b^c(\varepsilon) \equiv \tau_b^*(\hat{\omega}_b/\varepsilon)$

(40). $\tau_r^c(\varepsilon) \equiv \tau_r^*(\hat{\omega}_r/\varepsilon)$.

In this way, the problem of solving for the most-cooperative tariff functions is reduced to the alternative task of solving for two fixed point values.[19]

E. The Most-Cooperative Tariffs

The most-cooperative tariffs are set to balance the current incentive to cheat against the long-term cost of a trade war. Viewed from this perspective, it may be anticipated that cooperation will be easier in periods in which the expected rate of future trade growth is large, since the cost of a trade war is then also large. This suggests that tariffs can be pushed to lower levels in such periods, even though the incentive to cheat is thereby raised. Transitory within-phase shocks represent an additional influence on the most-cooperative tariff functions. Drawing on the structure developed above, it is natural to anticipate that attempts to liberalize trade will be frustrated by high transitory shocks, as a period of unusually high trade volume exacerbates the short-term incentive to cheat without raising commensurably the cost of a trade war. We develop and elaborate upon these ideas in this subsection.

In characterizing the most-cooperative tariffs, it is interesting to determine those environments in which countries achieve free trade in all possible states, $\tau_b^c(\varepsilon) \equiv \tau_r^c(\varepsilon) \equiv 0$. Of course, complete liberalization is sure to fail if $\bar{\varepsilon}$ is sufficiently big, as the temptation to cheat is then irresistible when the within-phase shock is near its upper bound. To create the possibility of complete liberalization, we thus restrict the size of $\bar{\varepsilon}$ with the following assumption:

(41). $\delta b > \bar{\varepsilon}/[3+\bar{\varepsilon}]$.

This assumption admits a simple interpretation. It implies that even a maximal transitory shock is insufficient to disrupt free trade, when the business cycle is described by maximal growth (i.e., $g_t = b$ with probability one at all dates).

It is also interesting to characterize those environments in which some protection is required in the most-cooperative equilibrium. This motivates the following assumption:

[19]The approach pursued here presumes that the most-cooperative tariffs are found by lowering tariffs as much as possible in each state, as is evident from (35) and (36). This presumption is appropriate in the present model, because incentive constraints are complementary, with more cooperation in any one state fostering greater cooperation in the other as well.

(42). $\bar{\varepsilon}/[3+\bar{\varepsilon}] > \delta r$.

This inequality implies that a maximal transitory shock would be incompatible with free trade, were the business cycle one of minimal growth (i.e., $g_t = r$ with probability one at all dates). Together, as will become clear, inequalities (41) and (42) describe an international business cycle in which complete liberalization is possible if and only if the expected duration of a boom (recession) phase is sufficiently long (short).

With these assumptions in place, we are now prepared to describe the conditions under which free trade can be achieved in all states. To this end, we define the following functions:

(43). $\hat{\lambda}(\rho,\bar{\varepsilon}) = [1-(1-\rho)\delta b]/[1/\lambda^*(\bar{\varepsilon}) - \delta b]$

(44). $\tilde{\rho}(\lambda,\bar{\varepsilon}) = [1-(1-\lambda)\delta r]/[1/\rho^*(\bar{\varepsilon}) - \delta r]$,

where $\lambda^*(\bar{\varepsilon}) = 1 - \rho^*(\bar{\varepsilon})$ and

(45). $\lambda^*(\bar{\varepsilon}) = \{\bar{\varepsilon}/[3+\bar{\varepsilon}] - \delta r\}/[\delta(b-r)]$

(46). $\rho^*(\bar{\varepsilon}) = \{\delta b - \bar{\varepsilon}/[3+\bar{\varepsilon}]\}/[\delta(b-r)]$.

Under assumptions (41) and (42), we find that $\lambda^*(\bar{\varepsilon}) \in (0,1)$ and $\rho^*(\bar{\varepsilon}) \in (0,1)$. We also have that $\hat{\lambda}(0,\bar{\varepsilon}) \in (0,1)$ and $\tilde{\rho}(0,\bar{\varepsilon}) \in (0,1)$. These properties are illustrated in Figure 4.

As we show formally in the Appendix, when $\lambda \geq \hat{\lambda}(\rho,\bar{\varepsilon})$ and $\rho \leq \tilde{\rho}(\lambda,\bar{\varepsilon})$, then the most-cooperative tariffs support free trade in all states, i.e., $\tau_b^c(\varepsilon) \equiv \tau_r^c(\varepsilon) \equiv 0$. This free-trade region of the parameter space is marked as Region I in the parameter box represented in Figure 4. The essential point is intuitive. When λ is large and ρ is small, the expected duration of a recession is brief and the expected duration of a boom is long. Thus, the expected growth rate in the future is close to the boom level, b, regardless of whether the current period is a boom or a recession period. In this situation, under assumption (41), free trade can be supported even when a maximal transitory shock is encountered. Notice that the free trade region expands as the difference between $\bar{\varepsilon}/[3+\bar{\varepsilon}]$ and δr shrinks, since then free trade becomes possible in all states even for a business cycle that has long exposures to recessions.

Free trade is no longer possible in all states when $\lambda < \hat{\lambda}(\rho,\bar{\varepsilon})$ or $\rho > \tilde{\rho}(\lambda,\bar{\varepsilon})$. Some protection is then required and a central issue is whether protection is greater in boom or recession periods. As we show formally in the Appendix, the cyclical properties of protection are determined entirely by the correlation in growth rates. Growth rates are positively correlated in Region II of Figure 4, and in this case expected future growth is higher when the current period is a boom period. This means in turn that the expected discounted cost of a trade war is higher when the current period is a boom, since cheating today would result in the sacrifice of a high level of expected gains from trade in the future. Consequently, a higher incentive to cheat can be tolerated in boom periods, and so the most-cooperative tariffs are (weakly) lower in boom than recession periods, given the level of transitory shock. In other words, when growth rates are positively correlated, the most-cooperative tariffs are *countercyclical* ($\tau_b^c(\varepsilon) \le \tau_r^c(\varepsilon)$).

While free trade cannot be supported in all states in Region II, it may be possible in some states. Figure 5a illustrates one possibility. Here, free trade can be achieved in both boom and recession periods provided that the level of transitory shock is small. When higher shocks arrive, however, free trade is possible only in boom periods. Finally, if the transitory shock is higher yet, then the most-cooperative tariff must be positive for both boom and recession periods, although the recession-period tariff remains higher. In sum, if international business cycles exhibit persistence, as captured in our model by the specification of positively correlated growth rates, then protection is countercyclical with respect to business cycle phases, and high transitory shocks to trade volume may require that protection be temporarily increased.

The next region to consider is the region marked as Region III in Figure 4. Here, growth rates are negatively correlated, indicating that the prospects for cooperation are most favorable now in recession periods. Accordingly, we find that protection is *procyclical* ($\tau_b^c(\varepsilon) \ge \tau_r^c(\varepsilon)$) when growth rates are negatively correlated through time. As before, high transitory shocks raise the short term incentive to cheat, forcing a temporary retreat from liberalization. Figure 5b illustrates the negative-correlation case.[20]

[20] A final possibility is that growth rates exhibit zero correlation, in which case $1 = \lambda + \rho$. In this event, expected trade volume growth in the future is independent of whether the current period is a boom or a recession, and so the most-cooperative tariffs are *acyclic* ($\tau_b^c(\varepsilon) = \tau_r^c(\varepsilon)$) when growth rates exhibit zero correlation

The main points may now be summarized as follows:

Theorem 1: In the dynamic tariff game with international business cycles,

(i). The most-cooperative tariffs involve free trade in all states if and only if the expected duration of a boom phase is sufficiently long and the expected duration of recession phase is sufficiently short.

(ii). The most-cooperative tariffs are countercyclical (procyclical) when growth rates are positively (negatively) correlated through time.

(iii). Regardless of the nature of correlation in growth rates, a higher transitory shock to trade volume results in a (weakly) higher most-cooperative tariff.

To the extent that international business cycles are well described by positively correlated growth rates, therefore, the theory developed here suggests that tariffs will be higher in recessions and in periods in which the trade volume experiences a transitory surge. These findings are consistent with the empirical analyses of protection noted in the Introduction. In particular, the model predicts countercyclical movements in protection in the presence of procyclical movements in trade volume, consistent with the large empirical literature relating to cyclical properties of protection and imports. But for a given phase of the business cycle the model also predicts that protection levels rise in response to increases in trade volume, and this finding is consistent with Trefler's (1993) observation that protection rises with increases in import penetration, even after controlling for business cycle measures.[21]

The results developed here also generalize an earlier finding of ours (Bagwell and Staiger, 1990), in which we model transitory surges only and offer an equilibrium interpretation of "managed trade" practices. According to this interpretation, high transitory shocks to the volume of trade necessitate an increase in protection above the relevant "baseline" level, if the cooperative agreement is to be credibly enforced. Managed trade practices thus can be interpreted as temporary retreats from liberalization, brought about by unusual surges in trade volumes and serving to maintain the credibility of the cooperative trade agreement. From this

[21]Trefler's (1993) analysis is based on cross sectional data for 1983 and controls for industry growth and unemployment.

perspective, the results developed here indicate that managed trade practices arise in response to transitory trade volume surges that occur within broader business cycle phases.[22]

IV. PROTECTION AND NATIONAL BUSINESS CYCLES

We now relax the assumption of an international business cycle and suppose instead that each country's business cycle evolves independently of the other's. After defining the national business cycle model, we derive the corresponding incentive constraints and show that the main qualitative conclusions developed above continue to hold. However, we now find that a country's tariff policy depends not only on the state of its own business cycle, but also on the state of its trading partner's business cycle.

A. The Dynamic Tariff Game with National Business Cycles

We begin by developing the national business cycle model. Our approach is to specify directly a multi-state Markov-growth process for the total volume of trade, G_t^W, and then to interpret the associated trade volume growth states in terms of the respective national business cycles. Under this approach, national business cycle fluctuations are summarized entirely by various growth rates for G_t^W, and so the modeling framework developed above can be extended in order to characterize the associated most-cooperative tariffs.[23]

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[22]The model also can be generalized to allow for within-phase shocks that are of intermediate duration. This can be formalized with the assumption that the within-phase shock is transitory with probability $\theta \in [0,1]$ and permanent with probability $1 - \theta$. Specifically, let

$$G_t^W = g_t(\theta G_{t-1}^W/\varepsilon_{t-1} + (1-\theta)G_{t-1}^W)\varepsilon_t,$$

where g_t obeys (20) and ε_t is iid. Assuming that governments don't know when setting tariff policy in period t-1 whether the period t-1 shock is in fact transitory or permanent, the incentive constraints can be derived as before, except that $\varepsilon_{t-1}/(\theta + (1-\theta)\varepsilon_{t-1})$ now replaces ε_{t-1}. In the pure case of permanent shocks ($\theta = 0$), we find that within-phase shocks have no effect on the most-cooperative tariffs whatsoever, since the shock affects the incentive to cheat and the cost of a trade war in the same proportion. More generally, the most-cooperative tariffs are more responsive upward to within-phase shocks when the shocks are expected to be more transitory in nature (i.e., when θ is higher).

[23]An alternative approach is to directly specify independent Markov-growth processes for the domestic and foreign business cycles, and then to examine the implied cyclical behavior for G_t^W between the two countries. While this approach is conceptually attractive, it does introduce significant technical complexities. The most-cooperative tariffs may then also depend on the current levels G_t and G_t^*, representing an increase in the dimensionality of the state space.

In particular, our first assumption is that the total volume of trade alternates stochastically between three possible growth rates: g_{bb}, g_{br} and g_{rr}, where $g_{bb} > g_{br} > g_{rr}$, $\delta g_{bb} < 1$ and $g_{rr} > 0$. The interpretation is that total trade volume grows at the fast rate g_{bb} when both national economies are experiencing a boom, while the total trade volume grows at the slower rate g_{rr} when the national economies are each in a recession. An intermediate growth rate, g_{br}, arises when one economy is in a boom and the other is in a recession.

Our second assumption specifies the Markov transition probabilities associated with the three states for total trade volume. The specification is motivated by the interpretation that domestic and foreign national business cycles evolve independently but are described by the same underlying set of transition probabilities. To this end, let S_t be a two-dimensional vector with elements (s, s_t^*), where $s_t \in \{B,R\}$ and $s_t^* \in \{B,R\}$ represent the general state of the business cycle in period t in the domestic and foreign countries, respectively. Then the transition probabilities for the total trade volume are fully specified under the assumption that

(48). $\mathrm{Prob}(s_t = R \mid s_{t-1} = B) \equiv \rho \equiv \mathrm{Prob}(s_t^* = R \mid s_{t-1}^* = B)$

$\mathrm{Prob}(s_t = B \mid s_{t-1} = R) \equiv \lambda \equiv \mathrm{Prob}(s_t^* = B \mid s_{t-1}^* = R)$,

where $g_t = g_{bb}$ if $S_t = (B,B)$, $g_t = g_{br}$ if $S_t \in \{(B,R), (R,B)\}$ and $g_t = g_{rr}$ if $S_t = (R,R)$. With this structure in place, the transition probabilities associated with the three states for total trade volume are easily calculated. For example, the probability of moving from the "boom, boom" state with growth rate g_{bb} to the "recession, recession" state with growth rate g_{rr} is ρ^2.

We may now define the nonstationary process that G_t^W is assumed to follow as

(49). $G_t^W = g_t(G_{t-1}^W/\varepsilon_{t-1})\varepsilon_t$,

which is the same as (19), except that the period-t growth rate g_t now assumes one of three possible rates, $g_t \in \{g_{bb}, g_{rr}, g_{br}\}$, with the associated transition probabilities now defined by

(48). As before, we assume that ε_t is iid through time with full support over $[\underline{\varepsilon},\bar{\varepsilon}]$ where $E\{\varepsilon_t\} = 1 \in (\underline{\varepsilon},\bar{\varepsilon})$ and $\underline{\varepsilon} > 0$.

With the national business cycle model now fully specified, we may define the *dynamic tariff game with national business cycles* in terms the infinite repetition of the static tariff game, in which in any period t all governments are fully informed of (i). all past tariff choices, (ii). the current value of g_t and ε_t as well as all past values, and (iii). the stochastic process given in (48) - (49) that governs the future evolution of G_t^W.

B. The Most-Cooperative Tariffs

We turn now to a representation of the incentive constraints associated with the dynamic tariff game with national business cycles. As in the international business cycle model, the equilibrium tariff in period t may be expressed as a function of the period-t growth rate for total trade volume, which is now either g_{bb}, g_{br} or g_{rr}, and the period-t transitory shock, ε. We thus write the equilibrium tariff functions in the form $\tau_{bb}(\varepsilon)$, $\tau_{br}(\varepsilon)$ and $\tau_{rr}(\varepsilon)$. The most-cooperative tariffs are the lowest such tariffs, and they are denoted as $\tau_{bb}^c(\varepsilon)$, $\tau_{br}^c(\varepsilon)$ and $\tau_{rr}^c(\varepsilon)$.

In analogy with (22) - (25), the incentive constraints may now be represented as:

(50). $\varepsilon\Omega(\tau_{bb}(\varepsilon)) \leq \delta\{\rho^2 g_{rr}\bar{\omega}_{rr} + 2(1-\rho)\rho g_{br}\bar{\omega}_{br} + (1-\rho)^2 g_{bb}\bar{\omega}_{bb}\}$

(51). $\varepsilon\Omega(\tau_{br}(\varepsilon)) \leq \delta\{(1-\lambda)\rho g_{rr}\bar{\omega}_{rr} + [(1-\lambda)(1-\rho) + \rho\lambda]g_{br}\bar{\omega}_{br} + \lambda(1-\rho)g_{bb}\bar{\omega}_{bb}\}$

(52). $\varepsilon\Omega(\tau_{rr}(\varepsilon)) \leq \delta\{\lambda^2 g_{bb}\bar{\omega}_{bb} + 2(1-\lambda)\lambda g_{br}\bar{\omega}_{br} + (1-\lambda)^2 g_{rr}\bar{\omega}_{rr}\}$

where

(53). $\bar{\omega}_{bb} = E\{\omega(\tau_{bb}(\varepsilon))\varepsilon\} + \delta\{\rho^2 g_{rr}\bar{\omega}_{rr} + 2(1-\rho)\rho g_{br}\bar{\omega}_{br} + (1-\rho)^2 g_{bb}\bar{\omega}_{bb}\}\}$

(54). $\bar{\omega}_{br} = E\{\omega(\tau_{br}(\varepsilon))\varepsilon\} + \delta\{(1-\lambda)\rho g_{rr}\bar{\omega}_{rr} + [(1-\lambda)(1-\rho) + \rho\lambda]g_{br}\bar{\omega}_{br} + \lambda(1-\rho)g_{bb}\bar{\omega}_{bb}\}$

(55). $\bar{\omega}_{rr} = E\{\omega(\tau_{rr}(\varepsilon))\varepsilon\} + \delta\{\lambda^2 g_{bb}\bar{\omega}_{bb} + 2(1-\lambda)\lambda g_{br}\bar{\omega}_{br} + (1-\lambda)^2 g_{rr}\bar{\omega}_{rr}\}$.

As before, for any given total trade volume growth rate and transitory shock, the short-term incentive to cheat cannot exceed the long-term cost of a trade war. In representing the cost of a trade war for each of the three possible period-t growth rates, we define $\bar{\omega}_{bb}$ as the per-good expected discounted cost of a trade war in period t+1 and thereafter, if $g_{t+1} = g_{bb}$, $\tau_{bb}(\varepsilon)$, $\tau_{br}(\varepsilon)$ and $\tau_{rr}(\varepsilon)$ are the tariff functions, and the value for ε in period t+1 has not yet been determined. Analogous interpretations apply for $\bar{\omega}_{br}$ and $\bar{\omega}_{rr}$.

With the national business cycle model defined and the incentive constraints represented, the analysis now proceeds similarly to that presented above for the international business cycle model. We thus relegate additional derivations to the Appendix and describe here the main findings. In analogy with analysis above, we say that a national business cycle growth rate is *positively correlated* (*negatively correlated*) through time if $1-\lambda-\rho > 0$ ($1-\lambda-\rho < 0$), while *zero correlation* occurs when $1-\lambda-\rho = 0$. Similarly, we say that the most-cooperative tariffs are *countercyclical* when $\tau^c_{bb}(\varepsilon) \leq \tau^c_{br}(\varepsilon) \leq \tau^c_{rr}(\varepsilon)$, while they are said to be *procyclical* when $\tau^c_{bb}(\varepsilon) \geq \tau^c_{br}(\varepsilon) \geq \tau^c_{rr}(\varepsilon)$. With these definitions made, our main findings can be reported:

Theorem 2: In the dynamic tariff game with national business cycles,

(i). The most-cooperative tariffs are countercyclical (procyclical) when growth rates are positively (negatively) correlated through time.

(ii). Regardless of the nature of correlation in growth rates, a higher transitory shock to trade volume results in a (weakly) higher most-cooperative tariff.

This theorem is proved in the Appendix.

Two main lessons emerge from this theorem. A first point is that the central results reported above in Theorem 1 for the case of international business cycles carry over to the situation in which countries experience independent national business cycles. The most-cooperative tariffs are again lower when the growth rate for total trade volume is higher, provided that business cycles are described by positive correlation, and higher transitory shocks to total trade volume continue to require higher most-cooperative tariffs.[24] A second lesson concerns the determinants of a country's tariff policy. A country's most-cooperative tariff is fundamentally determined by the growth rate of total trade volume, but this rate is in turn determined by the combination of business cycle states experienced in the domestic and foreign

[24]It is also possible to derive the region over which free trade occurs in all states. As in the case of international business cycles, this region is described by low values for ρ (i.e., a large expected duration for a boom phase) and high values for λ (i.e., a small expected duration for a recession phase).

national economies. In other words, the most-cooperative tariff selected by a country at a point in time is a function of the current states of the business cycle both at home and abroad.

V. Conclusion

Adopting the view that trade agreements must be self-enforcing, we explore the ability of countries to overcome their beggar-thy-neighbor incentives and enforce liberal trade policies. Cooperative trade policies can be enforced when countries recognize the ongoing nature of their relationship, since each country's short-term incentive to pursue beggar-thy-neighbor policies is then balanced against the long-term costs of a consequent trade war. Business cycle fluctuations result in an initial imbalance between these short- and long-term considerations, requiring an adjustment in the equilibrium tariff level in order to maintain some measure of cooperation. In this general fashion, we forge a link between the state of the business cycle and the level of protection.

We demonstrate the usefulness of this general approach with two main predictions. First, we find that the most-cooperative tariffs are countercyclical, as countries are able to sustain low tariffs in a persistent boom phase characterized by fast growth in the volume of trade. A second finding concerns the implications of transitory or acyclic increases in the level of trade volume. We show that transitory shocks to the trade volume level result in more protection. As we discuss in the Introduction, these predictions are consistent with empirical regularities observed in the relationship between protection and the business cycle. The findings also offer an interpretation of managed trade practices as responses to transitory trade volume surges that occur within broader business cycle phases. Finally, we demonstrate that our predictions are robust, arising whether business cycles are international or national in nature, and we also argue that our basic conclusions are maintained when domestic political economy variables are included.

Future research might consider alternative representations of export policy. In practice, export taxes are rarely employed, and GATT members have agreed to eliminate export subsidies for most products. This behavior contrasts with the predictions of our model, where cooperative trade agreements yield benefits by reducing export taxes.[25] One interesting

[25] If exporters have sufficient political weight, cooperation actually may involve increasing export subsidies.

possibility is that export policy is special, since a country's level of intervention in the export market is difficult for trading partners to observe. If the act of intervention in the export market is verifiable to partners, however, then cooperation may involve a prohibition against export taxes and subsidies.

If export taxes and subsidies are successfully eliminated, then additional implications arise. A key point is that cooperative import tariffs then may be sensitive to trade balances. In the context of the national business cycle model, if trade deficits are procyclical so that a country runs a trade deficit when it is in a boom and its trading partner is in a recession, then the country in a boom imports a disproportionate share of the existing trade volume and thus finds it especially tempting to cheat with a high import tariff. A cooperative trade agreement thus may require that deficit countries be allowed to select higher import tariffs, in order to reduce the import volume and quell the incentive to cheat. The surplus country, by contrast, imports relatively little and so has little incentive to cheat with a high import tariff. This suggests that surplus countries may select lower import tariffs in the cooperative agreement, providing a possible association of Voluntary Import Expansions (VIE's) and surplus countries. Similarly, if non-tariff barriers are feasible in the export market, then a surplus country may employ a Voluntary Export Restraint (VER), in order to slow the volume of trade and enable the deficit country to reduce its import tariff. We hope to explore these interesting implications of our modeling framework in future work.

Appendix

Lemma 1: In the dynamic tariff game with international business cycles, the fixed point values $(\hat{\omega}_b, \hat{\omega}_r)$ satisfying (37) and (38) exist uniquely and satisfy

(i). $(\hat{\omega}_b, \hat{\omega}_r) > 0$

(ii). $\text{sign}\{\hat{\omega}_b - \hat{\omega}_r\} = \text{sign}\{1-\lambda-\rho\}$.

Proof: We begin by characterizing the function

(A1). $E(\tilde{\omega}) \equiv E\{\omega(\tau^*(\tilde{\omega}/\varepsilon))\varepsilon\}$, where

(A2). $\tau^*(\tilde{\omega}/\varepsilon) = \max\{\hat{\tau}^n - \dfrac{(6\tilde{\omega}/\varepsilon)^{1/2}}{2}, 0\}$.

Using (21), calculations reveal that

(A3). $E(\tilde{\omega}) = 1/8$, if $\tilde{\omega}/\underline{\varepsilon} \geq 1/24$

(A4). $E(\tilde{\omega}) = 3/32 + (1/8)(6\tilde{\omega})^{1/2}E(\varepsilon^{1/2}) - 3\tilde{\omega}/4$, if $\tilde{\omega}/\underline{\varepsilon} \leq 1/24$

(A5). $E(\tilde{\omega}) = 1/8 - (1/32)\displaystyle\int_{24\tilde{\omega}}^{\bar{\varepsilon}} \varepsilon dF(\varepsilon) + [(6\tilde{\omega})^{1/2}/8]\int_{24\tilde{\omega}}^{\bar{\varepsilon}} (\varepsilon)^{1/2}dF(\varepsilon) - (3\tilde{\omega}/4)\int_{24\tilde{\omega}}^{\bar{\varepsilon}} dF(\varepsilon)$, otherwise

where F is the distribution function for ε and $E(\varepsilon^{1/2})$ is the expected value of $\varepsilon^{1/2}$. It may now be confirmed that $E(\tilde{\omega})$ is continuous and positive for $\tilde{\omega} \geq 0$, and has infinite slope when $\tilde{\omega} = 0$. In addition, $E(\tilde{\omega})$ is increasing and concave for $\tilde{\omega} \in [0, \bar{\varepsilon}/24)$ and constant for $\tilde{\omega} \geq \bar{\varepsilon}/24$.

With this notation in place, the fixed point equations (37) and (38) may be rewritten as

(A6). $\tilde{\omega}_b = E\{\tilde{\omega}_r\}\rho r\Delta + E\{\tilde{\omega}_b\}\beta\Delta$

(A7). $\tilde{\omega}_r = E\{\tilde{\omega}_b\}\lambda b\Delta + E\{\tilde{\omega}_r\}\sigma\Delta$.

Notice that neither constraint is satisfied at the origin. In correspondence with (A6) and (A7) when $\tilde{\omega}_b = \tilde{\omega}_r$, we may define

(A8) $f_b(\tilde{\omega}) \equiv E(\tilde{\omega})[\rho r + \beta]\Delta - \tilde{\omega}$

(A9) $f_r(\tilde{\omega}) \equiv E(\tilde{\omega})[\lambda b + \sigma]\Delta - \tilde{\omega}$.

Thus, e.g., when $f_b(\tilde{\omega}) = 0$, it follows that the boom-period incentive constraint (A6) is satisfied on the 45 degree line at $\tilde{\omega}_b = \tilde{\omega}_r = \tilde{\omega}$. Observe that $f_b(\tilde{\omega})$ and $f_r(\tilde{\omega})$ are positive with an infinite derivative when $\tilde{\omega} = 0$. These functions are also concave for $\tilde{\omega} \leq \bar{\varepsilon}/24$, decrease linearly at higher values for $\tilde{\omega}$, and become negative when $\tilde{\omega}$ is sufficiently large.

Let $\bar{\omega}_b$ be the unique root satisfying $f_b(\bar{\omega}_b) = 0$, and let $\bar{\omega}_r$ be the unique root satisfying $f_r(\bar{\omega}_r) = 0$. Clearly, $(\bar{\omega}_b, \bar{\omega}_r) > 0$, $f_b'(\bar{\omega}_b) < 0$, and $f_r'(\bar{\omega}_r) < 0$. Observe next that

(A10) $\{(\rho r+\beta) - (\lambda b+\sigma)\}\Delta = (b-r)(1-\lambda-\rho)\Delta.$

We thus have that

(A11) $f_b(\bar{\omega}_r) = f_b(\bar{\omega}_r) - f_r(\bar{\omega}_r) = E(\bar{\omega}_r)(b-r)(1-\lambda-\rho)\Delta,$

which with $E(\bar{\omega}_r) > 0$ implies that

(A12) $\text{sign}\{\bar{\omega}_b - \bar{\omega}_r\} = \text{sign}\{1-\lambda-\rho\}.$

The function f_b thus has a larger root than does the function f_r under positive correlation.

We next differentiate the boom-period fixed point equation (A6) to get

(A13) $\dfrac{\partial\tilde{\omega}_b}{\partial\tilde{\omega}_r}\Big|_b = E'(\tilde{\omega}_r)\rho r\Delta/[1 - E'(\tilde{\omega}_b)\beta\Delta] = E'(\tilde{\omega}_r)\rho r\Delta/[E'(\tilde{\omega}_b)\rho r\Delta - f_b'(\tilde{\omega}_b)]$

Similarly, the recession-period fixed point equation (A7) satisfies

(A14) $\dfrac{\partial\tilde{\omega}_b}{\partial\tilde{\omega}_r}\Big|_r = [1 - E'(\tilde{\omega}_r)\sigma\Delta]/[E'(\tilde{\omega}_b)\lambda b\Delta] = [E'(\tilde{\omega}_r)\lambda b\Delta - f_r'(\tilde{\omega}_r)]/[E'(\tilde{\omega}_b)\lambda b\Delta]$

Differentiating once more, we have that

(A15) $\dfrac{\partial^2\tilde{\omega}_b}{\partial\tilde{\omega}_r^2}\Big|_b = \{E''(\tilde{\omega}_r)\rho r\Delta + E''(\tilde{\omega}_b)\beta\Delta[\dfrac{\partial\tilde{\omega}_b}{\partial\tilde{\omega}_r}\Big|_b]^2\} / [1 - E'(\tilde{\omega}_b)\beta\Delta]$

(A16) $\dfrac{\partial^2\tilde{\omega}_b}{\partial\tilde{\omega}_r^2}\Big|_r = -\{E''(\tilde{\omega}_r)\sigma\Delta + E''(\tilde{\omega}_b)\lambda b\Delta[\dfrac{\partial\tilde{\omega}_b}{\partial\tilde{\omega}_r}\Big|_r]^2\} / [E'(\tilde{\omega}_b)\lambda b\Delta].$

Observe from (A13) and (A15) that the boom-period incentive constraint is concave if it is positively sloped. Using (A16), we see that the recession-period incentive constraint is convex.

Using (A13), (A14), $f_b'(\bar{\omega}_b) < 0$ and $f_r'(\bar{\omega}_r) < 0$, it is now a simple matter to see that

(A17) $\dfrac{\partial\tilde{\omega}_b}{\partial\tilde{\omega}_r}\Big|_b \in [0,1)$ at $\tilde{\omega}_b = \tilde{\omega}_r = \bar{\omega}_b$

(A18) $\dfrac{\partial\tilde{\omega}_b}{\partial\tilde{\omega}_r}\Big|_r > 1$ at $\tilde{\omega}_b = \tilde{\omega}_r = \bar{\omega}_r$.

It follows that the respective fixed point curves eventually slope upward through their respective 45 degree line crossings. In particular, there must exist values $\underline{\omega}_b$ and $\underline{\omega}_r$ with $0 < \underline{\omega}_b \leq \bar{\omega}_b$

and $0 < \underline{\omega}_r \leq \bar{\omega}_r$ such that (A6) is satisfied at $(\tilde{\omega}_b, \tilde{\omega}_r) = (\underline{\omega}_b, 0)$ and slopes upward from $(\underline{\omega}_b, 0)$ through $(\bar{\omega}_b, \bar{\omega}_b)$ and on, while (A7) holds at $(\tilde{\omega}_b, \tilde{\omega}_r) = (0, \underline{\omega}_r)$ and slopes upward from $(0, \underline{\omega}_r)$ through $(\bar{\omega}_r, \bar{\omega}_r)$ and on. With $\tilde{\omega}_b$ on the y axis, the boom-period fixed point equation thus crosses the 45 degree line at $(\bar{\omega}_b, \bar{\omega}_b)$ from above, while the recession-period fixed point equation crosses at $(\bar{\omega}_r, \bar{\omega}_r)$ from below. Neither crosses the 45 degree line at any other point.

Given these properties, the two incentive constraints must cross at exactly one point, with the recession-period constraint being steeper at that point. Furthermore, the intersection point, $(\hat{\omega}_b, \hat{\omega}_r)$, must satisfy $(\hat{\omega}_b, \hat{\omega}_r) > 0$ and $\text{sign}\{\hat{\omega}_b - \hat{\omega}_r\} = \text{sign}\{\bar{\omega}_b - \bar{\omega}_r\} = \text{sign}\{1-\lambda-\rho\}$.

Lemma 2: In the dynamic tariff game with international business cycles, the most-cooperative tariffs support free trade in all states $(\tau_b^c(\varepsilon) \equiv \tau_r^c(\varepsilon) \equiv 0)$ if and only if $\min\{\rho r+\beta, \lambda b+\sigma\}\Delta \geq \bar{\varepsilon}/3$.

Proof: Observe that $\min\{\rho r+\beta, \lambda b+\sigma\}\Delta \geq \bar{\varepsilon}/3$ is equivalent to $(\rho r+\beta)\Delta/8 \geq \bar{\varepsilon}/24$ and $(\lambda b+\sigma)\Delta/8 \geq \bar{\varepsilon}/24$, and consider the solution candidate $(\hat{\omega}_b, \hat{\omega}_r) = ((\rho r+\beta)\Delta/8, (\lambda b+\sigma)\Delta/8)$. Given that (35) implies $\tau_b^*(\tilde{\omega}_b/\varepsilon) = 0$ for $\tilde{\omega}_b \geq \varepsilon/24$, with (36) yielding the analogous conclusion for $\tau_r^*(\tilde{\omega}_r/\varepsilon)$, it follows that $\tau_b^*(\hat{\omega}_b/\varepsilon) \equiv 0$ and $\tau_r^*(\hat{\omega}_r/\varepsilon) \equiv 0$. Substitution of these free-trade values into the fixed-point equations (37) and (38) yields $(\rho r+\beta)\Delta/8$ and $(\lambda b+\sigma)\Delta/8$ on the respective RHS's, confirming that the proposed solution is indeed a fixed-point solution. Next, suppose a fixed-point solution exists and $\tau_b^c(\varepsilon) \equiv \tau_r^c(\varepsilon) \equiv 0$. Using (35)-(38), it is then necessary that $\tau_b^*(\hat{\omega}_b/\varepsilon) = 0 = \tau_r^*(\hat{\omega}_r/\varepsilon)$, $\hat{\omega}_b \geq \bar{\varepsilon}/24$ and $\hat{\omega}_r \geq \bar{\varepsilon}/24$, and $\hat{\omega}_b = (\rho r+\beta)\Delta/8$ and $\hat{\omega}_r = (\lambda b+\sigma)\Delta/8$. It thus must be that $(\rho r+\beta)\Delta/8 \geq \bar{\varepsilon}/24$ and $(\lambda b+\sigma)\Delta/8 \geq \bar{\varepsilon}/24$, or equivalently $\min\{\rho r+\beta, \lambda b+\sigma\}\Delta \geq \bar{\varepsilon}/3$.

Lemma 3: In the dynamic tariff game with international business cycles, the most-cooperative tariffs support free trade in all states $(\tau_b^c(\varepsilon) \equiv \tau_r^c(\varepsilon) \equiv 0)$ if and only if $\lambda \geq \hat{\lambda}(\rho, \bar{\varepsilon})$ and $\rho \leq \tilde{\rho}(\lambda, \bar{\varepsilon})$.

Proof: Using (A10), $\min\{\rho r+\beta, \lambda b+\sigma\}\Delta = (\lambda b+\sigma)\Delta$ if and only if $1-\lambda-\rho \geq 0$. Lemma 2 thus implies that the most-cooperative tariffs involve free trade in all states under positive correlation if and only if $(\lambda b+\sigma)\Delta \geq \bar{\varepsilon}/3$. But calculations reveal that this occurs if and only if $\lambda \geq \hat{\lambda}(\rho, \bar{\varepsilon})$, where $\hat{\lambda}(\rho, \bar{\varepsilon})$ is defined in (43). Similarly, free trade occurs in all states under negative correlation if and only if $(\rho r+\beta)\Delta \geq \bar{\varepsilon}/3$, which is true if and only if $\rho \leq \tilde{\rho}(\lambda,\bar{\varepsilon})$, where $\tilde{\rho}(\lambda,\bar{\varepsilon})$ is defined in (44). Finally, as illustrated in Figure 4, under positive correlation, $\lambda \geq \hat{\lambda}(\rho,\bar{\varepsilon})$ implies $\rho \leq \tilde{\rho}(\lambda,\bar{\varepsilon})$, while under negative correlation the reverse implication holds.

Lemma 4: In the dynamic tariff game with international business cycles,

(i). under positive correlation when $\lambda < \hat{\lambda}(\rho,\bar{\varepsilon})$, the most-cooperative tariffs are countercyclical ($\tau_b^c(\varepsilon) \leq \tau_r^c(\varepsilon)$) and nonincreasing in the level of transitory shock, ε.

(ii). under negative correlation when $\rho > \tilde{\rho}(\lambda,\bar{\varepsilon})$, the most-cooperative tariffs are procyclical ($\tau_b^c(\varepsilon) \geq \tau_r^c(\varepsilon)$) and nonincreasing in the level of transitory shock, ε.

(iii). under zero correlation when $\lambda < \hat{\lambda}(\rho,\bar{\varepsilon})$, the most-cooperative tariffs are acyclic ($\tau_b^c(\varepsilon) = \tau_r^c(\varepsilon)$) and nonincreasing in the level of transitory shock, ε.

Proof: We prove here part (i); the other cases are similar. Under Lemma 1, we have that $\hat{\omega}_b > \hat{\omega}_r$. Furthermore, given that $\lambda < \hat{\lambda}(\rho,\bar{\varepsilon})$, it follows from Lemma 3 that the most-cooperative tariffs are sometimes positive, and so it must be that $\hat{\omega}_r < \bar{\varepsilon}/24$. With τ^* defined by (A2) and (weakly) decreasing in $\tilde{\omega}/\varepsilon$, we thus have that $\tau_b^c(\varepsilon) = \tau^*(\hat{\omega}_b/\varepsilon) \leq \tau^*(\hat{\omega}_r/\varepsilon) = \tau_r^c(\varepsilon)$, with the inequality being strict at $\bar{\varepsilon}$. It also follows that higher values for ε cannot lower the most-cooperative tariff; in fact, in a recession phase, and if ε is near its upper bound, a higher value for ε is sure to raise the most-cooperative tariff. Together, Lemmas 1-4 prove Theorem 1.

Solution method for the national business cycle model:

We begin by deriving the incentive constraints for the national business cycle model. In analogy to (26)-(27), the incentive constraints given in (50)-(55) may be written as:

(A19). $$\varepsilon\Omega(\tau_{bb}(\varepsilon)) \leq C_{bb}^{bb}E\{\omega(\tau_{bb}(\varepsilon))\varepsilon\} + C_{bb}^{br}E\{\omega(\tau_{br}(\varepsilon))\varepsilon\} + C_{bb}^{rr}E\{\omega(\tau_{rr}(\varepsilon))\varepsilon\}$$

(A20). $$\varepsilon\Omega(\tau_{br}(\varepsilon)) \leq C_{br}^{bb}E\{\omega(\tau_{bb}(\varepsilon))\varepsilon\} + C_{br}^{br}E\{\omega(\tau_{br}(\varepsilon))\varepsilon\} + C_{br}^{rr}E\{\omega(\tau_{rr}(\varepsilon))\varepsilon\}$$

(A21). $$\varepsilon\Omega(\tau_{rr}(\varepsilon)) \leq C_{rr}^{bb}E\{\omega(\tau_{bb}(\varepsilon))\varepsilon\} + C_{rr}^{br}E\{\omega(\tau_{br}(\varepsilon))\varepsilon\} + C_{rr}^{rr}E\{\omega(\tau_{rr}(\varepsilon))\varepsilon\},$$

where $C_{ij}^{kl} > 0$ are constants determined as functions of parameters of the model. To solve for the most-cooperative tariffs, we first treat the right-hand-sides of (A19)-(A21) as constants and rewrite the incentive constraints as

(A22). $\quad \varepsilon\Omega(\tau_{bb}(\varepsilon)) \leq \tilde{\omega}_{bb}$

(A23). $\quad \varepsilon\Omega(\tau_{br}(\varepsilon)) \leq \tilde{\omega}_{br}$

(A24). $\quad \varepsilon\Omega(\tau_{rr}(\varepsilon)) \leq \tilde{\omega}_{rr}$.

Solving for the lowest tariffs consistent with (A22)-(A24) and using the definitions given in (A1) and (A2), we now describe the fixed-point equations as

(A25). $\quad \tilde{\omega}_{bb} = C_{bb}^{bb}E\{\tilde{\omega}_{bb}\} + C_{bb}^{br}E\{\tilde{\omega}_{br}\} + C_{bb}^{rr}E\{\tilde{\omega}_{rr}\}$

(A26). $\quad \tilde{\omega}_{br} = C_{br}^{bb}E\{\tilde{\omega}_{bb}\} + C_{br}^{br}E\{\tilde{\omega}_{br}\} + C_{br}^{rr}E\{\tilde{\omega}_{rr}\}$

(A27). $\quad \tilde{\omega}_{rr} = C_{rr}^{bb}E\{\tilde{\omega}_{bb}\} + C_{rr}^{br}E\{\tilde{\omega}_{br}\} + C_{rr}^{rr}E\{\tilde{\omega}_{rr}\}$.

We argue below that the fixed-point equations admit a unique solution, $(\hat{\omega}_{bb}, \hat{\omega}_{br}, \hat{\omega}_{rr})$. Once these values are determined, the most-cooperative tariffs are then defined by

(A28). $\quad \tau_{bb}^{c}(\varepsilon) \equiv \tau^{*}(\hat{\omega}_{bb}/\varepsilon)$

(A29). $\quad \tau_{br}^{c}(\varepsilon) \equiv \tau^{*}(\hat{\omega}_{br}/\varepsilon)$

(A30). $\quad \tau_{rr}^{c}(\varepsilon) \equiv \tau^{*}(\hat{\omega}_{rr}/\varepsilon)$,

which completes the description of the solution technique for the national business cycle model.

Lemma 5: In the dynamic tariff game with national business cycles, the fixed point values $(\hat{\omega}_{bb}, \hat{\omega}_{br}, \hat{\omega}_{rr})$ satisfying (A25)-(A27) exist uniquely and satisfy

(i). $\quad (\hat{\omega}_{bb}, \hat{\omega}_{br}, \hat{\omega}_{rr}) > 0$

(ii). $\quad \text{sign}\{\hat{\omega}_{bb} - \hat{\omega}_{br}\} = \text{sign}\{\hat{\omega}_{br} - \hat{\omega}_{rr}\} = \text{sign}\{1-\lambda-\rho\}$.

Proof: In examining the fixed-point equations (A25)-(A27), we first relate the magnitudes of the associated constants to the sign of correlation. Calculations reveal that

(A31). $\quad \text{sign}\{C_{bb}^{ij} - C_{br}^{ij}\} = \text{sign}\{C_{br}^{ij} - C_{rr}^{ij}\} = \text{sign}\{1-\lambda-\rho\}$

for any $(i,j) \in \{(b,b), (b,r), (r,r)\}$. Next, we fix $\tilde{\omega}_{br}$ at a constant level $\bar{\omega}_{br} \geq 0$ and focus on the fixed-point equations for the boom-boom and recession-recession states. Define

(A32). $\quad f_{kl}(\tilde{\omega}) \equiv E(\tilde{\omega})[C_{kl}^{bb} + C_{kl}^{rr}] + E(\bar{\omega}_{br})C_{kl}^{br} - \tilde{\omega}$

for $(k,l) \in \{(b,b), (r,r)\}$. Each function is positive with infinite derivative at $\tilde{\omega} = 0$ and has a unique root. Let $\bar{\omega}_{kl} = \bar{\omega}_{kl}(\bar{\tilde{\omega}}_{br})$ be the unique root satisfying $f_{kl}(\bar{\omega}_{kl}) = 0$. We have $\bar{\omega}_{kl} > 0 > f'_{kl}(\bar{\omega}_{kl})$. Using (A31), we find that

(A33). $$\text{sign}\{\bar{\omega}_{bb} - \bar{\omega}_{rr}\} = \text{sign}\{1-\lambda-\rho\},$$

which is analogous to (A12). Thus, for any given value of $\tilde{\omega}_{br}$ and under positive correlation, the function f_{bb} has a larger root than does the function f_{rr}.

Continuing to hold $\tilde{\omega}_{br}$ fixed at $\bar{\tilde{\omega}}_{br}$, we may proceed as in (A13) and (A15) and differentiate the boom-period fixed-point equation (A25), finding that $\tilde{\omega}_{bb}$ is concave in $\tilde{\omega}_{rr}$ when it is increasing. Similarly, as in (A14) and (A16), we may differentiate the recession-period fixed-point equation (A26), discovering that $\tilde{\omega}_{bb}$ is convex in $\tilde{\omega}_{rr}$. Following (A17) and (A18), we may then exploit that $f'_{kl}(\bar{\omega}_{kl}) < 0$ in order to conclude that the boom-period (recession-period) fixed-point equation crosses the 45 degree line with a nonnegative slope that is less then one (greater than one). Given $\tilde{\omega}_{br} = \bar{\tilde{\omega}}_{br}$ and (A33), the two fixed-point equations are uniquely satisfied at positive values $\hat{\omega}_{bb}(\bar{\tilde{\omega}}_{br})$ and $\hat{\omega}_{rr}(\bar{\tilde{\omega}}_{br})$ where

(A34). $$\text{sign}\{\hat{\omega}_{bb}(\bar{\tilde{\omega}}_{br}) - \hat{\omega}_{rr}(\bar{\tilde{\omega}}_{br})\} = \text{sign}\{1-\lambda-\rho\}.$$

Straightforward differentiation reveals that $\hat{\omega}_{bb}(\bar{\tilde{\omega}}_{br})$ and $\hat{\omega}_{rr}(\bar{\tilde{\omega}}_{br})$ are nondecreasing functions.

We return now to the boom-recession fixed-point equation (A26), now written as

(A35). $$\tilde{\omega}_{br} = C^{bb}_{br}E\{\hat{\omega}_{bb}(\tilde{\omega}_{br})\} + C^{br}_{br}E\{\tilde{\omega}_{br}\} + C^{rr}_{br}E\{\hat{\omega}_{rr}(\tilde{\omega}_{br})\}.$$

It is direct to verify that the right-hand-side is nondecreasing, positive at $\tilde{\omega}_{br} = 0$, and constant for sufficiently large $\tilde{\omega}_{br}$. Thus, there exists a positive value $\hat{\omega}_{br}$ satisfying (A35), and so the unique fixed-point solutions are given by the positive values $\hat{\omega}_{bb} = \hat{\omega}_{bb}(\hat{\omega}_{br})$, $\hat{\omega}_{rr} = \hat{\omega}_{rr}(\hat{\omega}_{br})$ and $\hat{\omega}_{br}$. We then have that (A34) yields

(A36). $$\text{sign}\{\hat{\omega}_{bb} - \hat{\omega}_{rr}\} = \text{sign}\{1-\lambda-\rho\}.$$

Finally, we may fix $\tilde{\omega}_{rr} = \hat{\omega}_{rr}$ and then $\tilde{\omega}_{bb} = \hat{\omega}_{bb}$ and establish by related arguments that

(A37). $$\text{sign}\{\hat{\omega}_{bb} - \hat{\omega}_{br}\} = \text{sign}\{1-\lambda-\rho\},$$

(A38). $$\text{sign}\{\hat{\omega}_{br} - \hat{\omega}_{rr}\} = \text{sign}\{1-\lambda-\rho\}.$$

The proof of Theorem 2 now follows directly from (A2), (A28)-(A30), and (A36)-(A38).

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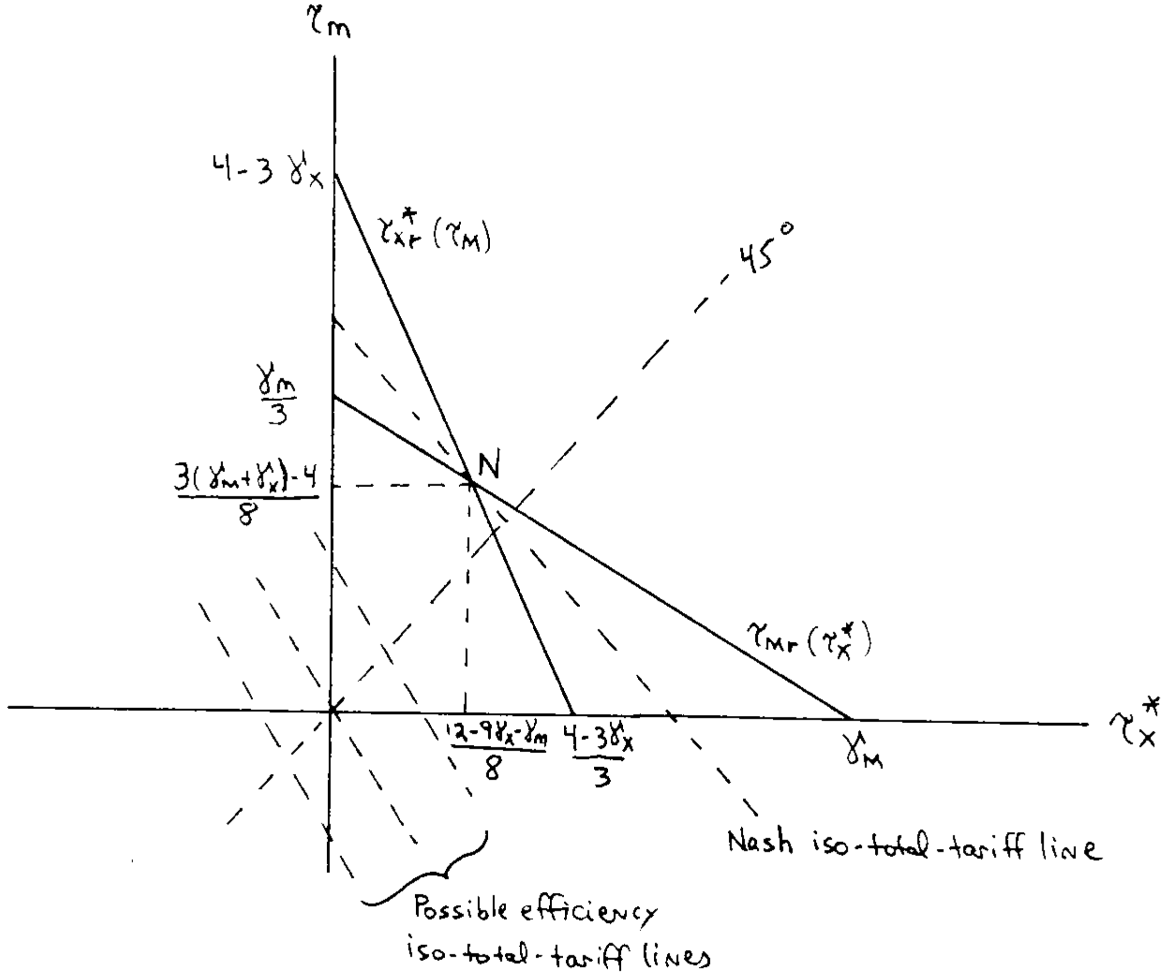

Figure 1

Domestic Import Good

Positive Nash Export Tax: $12-9\gamma_x-\gamma_m>0$

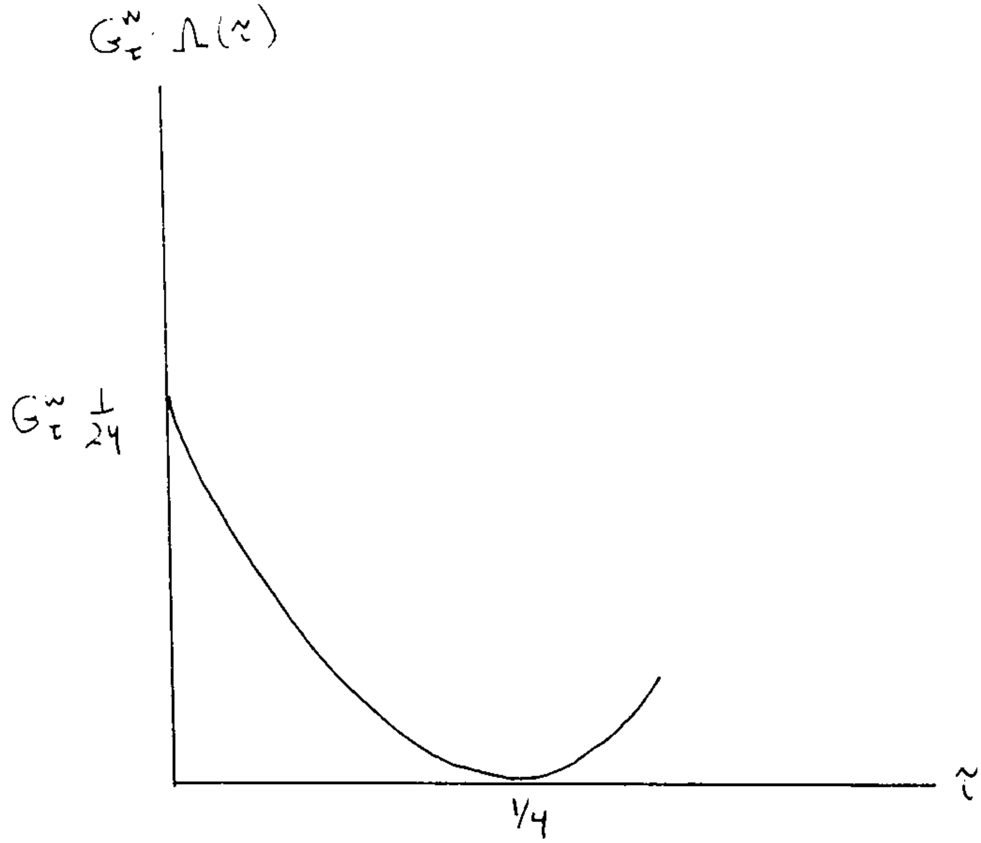

Figure 2

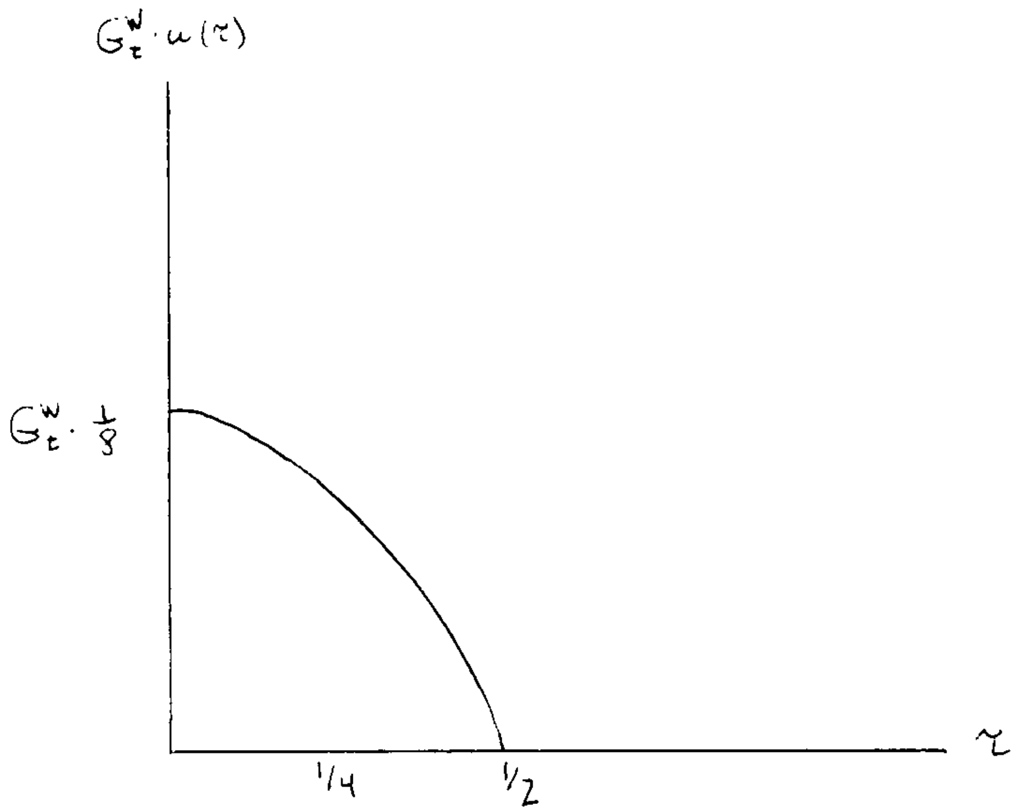

Figure 3

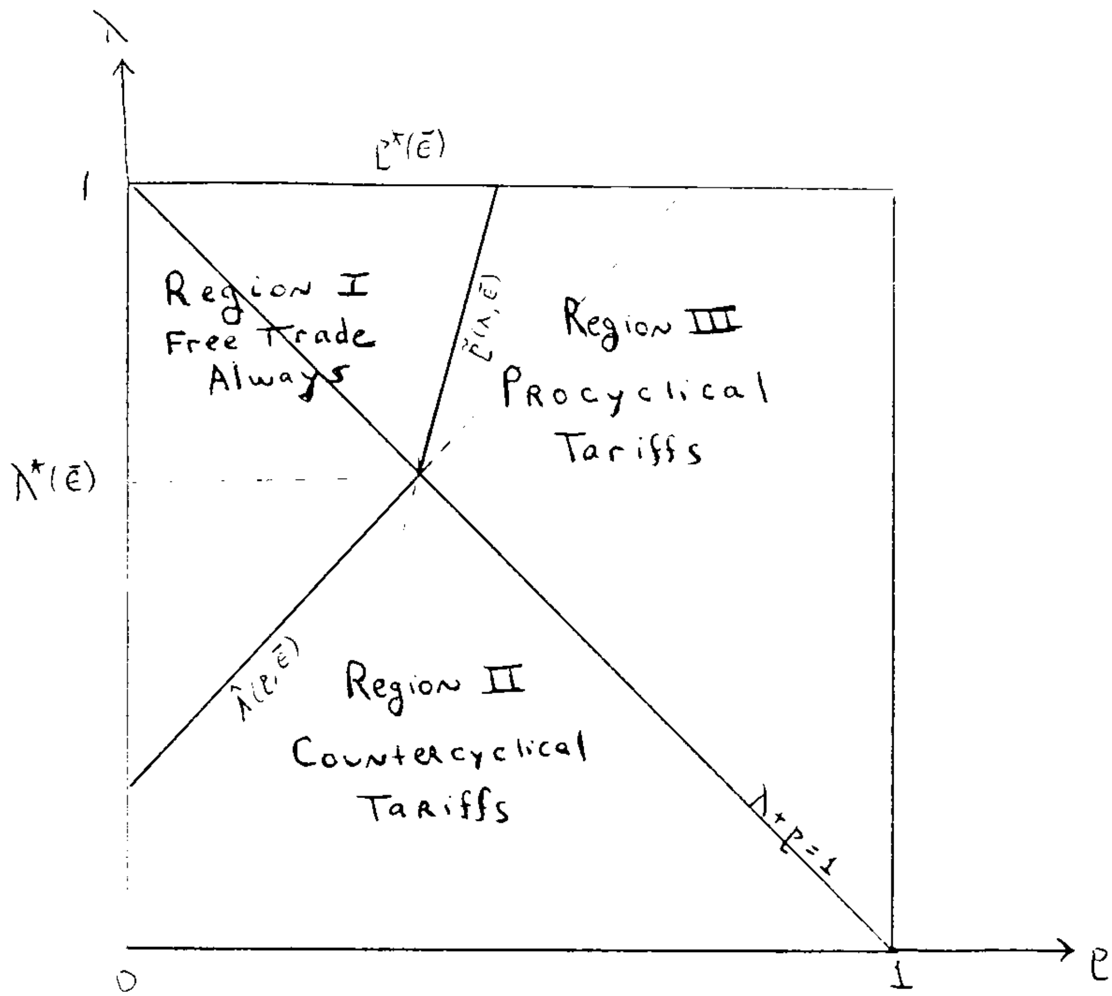

Figure 4

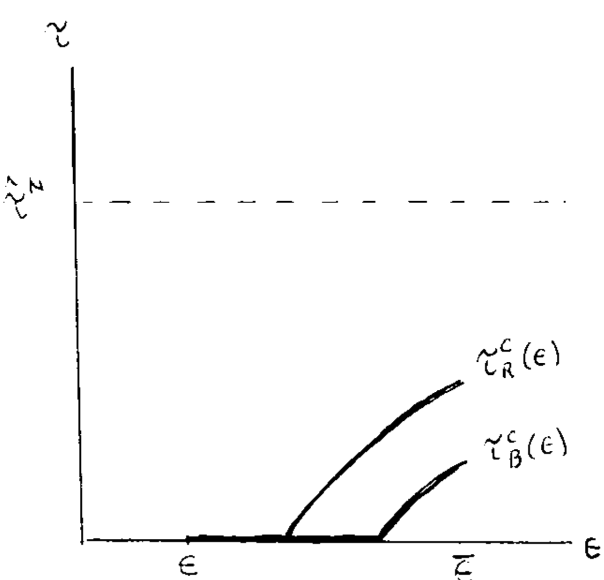

Figure 5a
Positive Correlation

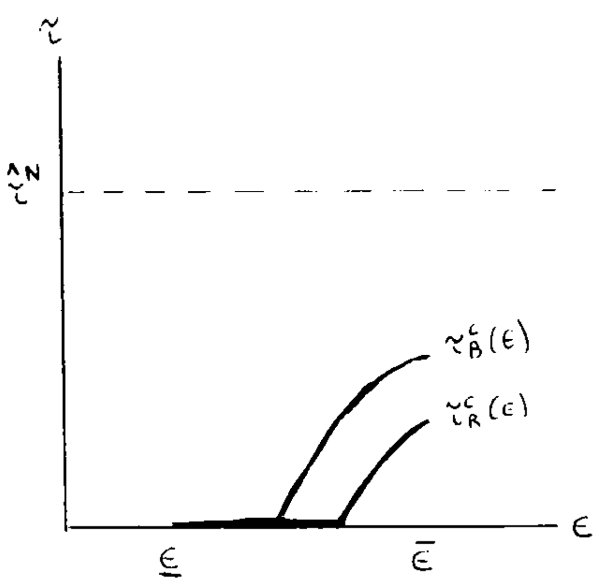

Figure 5b
Negative Correlation