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NON-TARIFF BARRIERS AND TRADE LIBERALIZATION

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Abstract

This paper shows that governments have no incentive to introduce non-tariff barriers when they are free to set tariffs but they do when tariffs are determined cooperatively. We then show three results. First, with trade liberalization, there is a progression from using tariffs only to quotas, and to antidumping constraints (when quotas are jointly eliminated). Second, there is a narrowing of the range of industries in which each instrument is used. Third, the degree of tariff liberalization and of replacement of tariffs by NTBs depend on industry characteristics. These results are roughly in line with the empirical evidence.

Keywords: Tariffs, trade policy, reciprocal dumping, quotas, antidumping

JEL Classification: F12, F13, L13

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1. Introduction

It is commonplace to recognize that the use of tariffs has gradually been replaced by the use of non-tariff barriers (hereafter, NTBs). Some authors go even further and argue there is a "Law of Constant Protection" (an expression used by Bhagwati (1988) mainly to dismiss the idea). Baldwin (1984) for instance writes: "Not only have these measures become more visible as tariffs have declined significantly through successive multilateral trade negotiations but they have been used more extensively by governments to attain the protectionist goals formerly achieved with tariffs"(p. 600).

The purpose of this paper is to set up a model in which the effect of trade liberalization on the use of quotas and antidumping laws can be investigated directly. We analyze two types of bilateral trade liberalization: tariff reductions and quota elimination. The model is a two-country model with two-way trade. We show three results. First, the model exhibits a clear *progression* from the use of tariffs only to the use of quotas (following tariff liberalization), to the use of antidumping laws (when quotas have been jointly tarrified). Second, there is a *narrowing* of the range of industries in which each of these instruments is used. Third, the extent of bilateral tariff liberalization and the ensuing *degree of replacement* of tariffs by NTBs are determined by the combination of two industry-specific characteristics: the government's preferences for domestic firm profits and the importance of international transport cost in the industry. Overall, our results support the view that treaties that remove or reduce one type of distortion may lead to the use of other policies that are even worse, but, despite the use of NTBs, overall trade is more liberal.

We believe that these results track well three separate sets of empirical facts. First, evidence shows that there is a clear emergence of quantitative restrictions in the 1960s in manufacturing sectors and in developed economies followed by an explosion in the use of antidumping constraints since the 1980s. The emergence of these two NTBs can be linked to preceding multilateral trade rounds. Second, despite a large number of antidumping cases, it appears that the number of sectors affected is small compared to those that were affected by quantitative restrictions that in turn is smaller than the number affected by tariffs. Finally, the results of this paper can be linked to the empirical literature on tariff liberalization and the emergence of NTBs. In particular, Marvel and Ray (1983) and Ray (1981, 1987) have shown that, in some sectors, a net increase in protection has resulted from the emergence of NTBs, and that the degree of replacement, as well as the extent of tariff liberalization, critically depend on the characteristics of the industry.

There is an abundant theoretical literature on NTBs. Papers investigating why, for instance, a government might prefer quantitative restrictions to tariffs include Cassing and Hillman (1985), Deardorff (1987), Falvey and Lloyd (1991), Kaempfer et al. (1988). As pointed out by McCulloch (1987), these papers do not explain the *changes* from tariffs to quotas, let alone the changes to other forms of NTBs such as antidumping restrictions. Recently, Anderson (1992, 1993) and Rosendorf (1996) have argued that antidumping constraints and quantitative restrictions might go hand in hand. For instance, Rosendorf proposes a model where a VER replaces a tariff when a government cares about electoral returns and the influence of firms' profits on these returns is strong enough. Antidumping actions may then be used to signal to foreign firms this desire to trade VER and tariff. Although this mechanism is interesting, this approach implies that the substitution toward NTBs necessarily increases net protection and that the multilateral trading arrangement has less to do with this substitution than with a change in electoral returns. The empirical literature mentioned above suggests there is a link between NTBs and tariff liberalization and that the net protection resulting from it might increase or decrease.[1] It is this link we wish to investigate and in particular the combination of industry-specific characteristics which is associated with it.

Several recent articles have argued that protection is counter-cyclical and that temporary protection may be used to sustain low cooperative tariff rates (Bagwell and Staiger (1990, 1995)). The present paper takes a more structural (or long-term) view, but it rests on the same economic principles as that of Bagwell and Staiger. It is the desire to have reciprocal trade agreements as well as the unilateral incentive to restrict trade that explains the emergence of NTBs. Due to terms of trade effects, countries gain by unilaterally restricting trade. When all countries act in this fashion, they get stuck in a prisoners' dilemma. A reciprocal agreement allows them to escape from this trap. Whereas Bagwell and Staiger use this argument to investigate a country's incentive over the business cycle, we use it to understand the combination of industry characteristics under which a particular NTB emerges and whether, given these characteristics, net protection increases or decreases.

To investigate the link between industry characteristics and NTBs, we simplify two aspects developed recently by others: the way governments choose trade protection and the way international cooperation is modeled. This allows us to develop how government preferences for domestic industries and other industry-specific variables such as international transport cost determine both the extent of tariff liberalization and the use of specific NTBs.

The paper is organized as follows. Some facts about quotas and antidumping are discussed in the next Section. In Section 3, we present the theoretical model we shall use to track these observations. In Section 4, we derive the non-cooperative tariff equilibrium and show that NTBs will not be used. However, countries can gain by bilateral tariff reductions. In Section 5, we analyze the cooperative tariff and we characterize industries for which tariff reductions are large or small. Tariff reductions create unilateral incentives to alter the terms of trade via NTBs. In Section 6, we show that the NTB of choice is a quota (rather than antidumping), and we analyze the ensuing quota equilibrium. We show that the set of industries affected by quotas is a subset of those affected by tariffs. Moreover, depending on the industry characteristics, the use of quotas may result in a net increase or decrease in protection. In Section 7, we suppose that quotas are negotiated away and investigate whether there is subsequent scope for antidumping laws. The set of industries in which antidumping constraints are invoked is a subset of those affected by quotas. Section 8 summarizes the main points of the analysis.

[1] Copeland (1990) makes some progress in this direction with a model in which two countries bargain over the level of a 'negotiable' trade instrument, anticipating the subsequent use of a non-negotiable instrument. He shows that there is some substitution into the less efficient non-negotiable instrument as a result of this negotiation. However, net protection decreases.

2. Some Facts

Trade liberalization has been impressive since World War II. In the United States, for example, the average tariff declined by nearly 92% between the First GATT Round of 1947 and the Tokyo Round of 1979 (Bhagwati (1988)). In 1987, the estimates of the Post-Tokyo Round average tariff rates were 3.3% in the United States, 4.6% in Canada, 4.9% in France and 6.2% in Japan (Deardorff and Stern (1989)). Impressive as it is, the success of GATT primarily occurred in developed countries and for manufacturing products. Until recent years, developing countries have largely eschewed trade liberalization. Similarly, sectors like agriculture have been mainly outside the scope of the various rounds of trade liberalization.

To link the use of NTBs to trade liberalization in manufacturing, one should look at the timing of their introduction. Renner (1971) shows that the number of manufacturing product classes affected by quantitative restrictions more than doubled in Canada and in the UK between 1963 and 1970, while it increased tenfold in the US. (However, the EC and Japan registered a decrease in the number of protected product classes.) Even though antidumping laws have been around for a long time,[2] for the period 1980-1986, the number of antidumping investigations in the world was almost triple that for 1970-1978 and the number of positive decisions more than tripled (Dale (1980), Table III.1; Finger and Olechowski (1987), Table A8.3).

Overall, NTBs have replaced tariff barriers in manufacturing sectors. Moreover, quantitative restrictions (which emerged during the 1960s) have been gradually replaced by antidumping measures since the 1980s.[3] This shift corresponds roughly to the completion of the Kennedy Round. Today, GATT (1990) notes that "[d]espite a recent decline in the number of anti-dumping investigations initiated in the United States and the European Communities, anti-dumping remains (after tariffs) the most frequently invoked trade policies in these countries" (p.10). According to GATT (1995), there were 764 antidumping measures in force by GATT members in 1994, the highest number ever reported (against 540 measures in force in 1991). Antidumping measures are now spreading to developing countries. For instance, most Latin American countries have introduced antidumping legislation or are in the process of doing so (Nogués (1993)). In the meantime, quantitative restrictions are on the decline: GATT (1993a) documents (on a country-by-country basis) specific import quotas, import licensing restrictions and items subject to import prohibition which have been eliminated in recent years. It has also been noted that antidumping actions have followed soon after the expiration of many restraint arrangements involving the US (GATT (1993a)). Signatories of the Uruguay Round agreement are now required to 'tariffy' existing quotas and put constraints on their future use.

[2] The first antidumping law was introduced in Canada in 1904. New Zealand and Australia soon followed suit. The US adopted its first antidumping law in 1916. By 1921, Great Britain and France also had laws in place (Finger (1993)).

[3] This excludes Voluntary Export Arrangements (VEA). According to some estimates, 2/3 of the VEAs negotiated during the 1980s were installed in response to antidumping actions (The Economist (1991)). On the relationship between these arrangements and antidumping, see Anderson (1992, 1993) and Rosendorff (1996).

Importantly, the gradual replacement of trade tools has also been accompanied by a reduction of the number of sectors affected by NTBs. Whereas very few products were traded without levy before the various GATT rounds, Renner (1971) finds that 7% of the (4 digit) product classes were affected by quantitative restrictions in the US and in the EC in 1970. The number of antidumping cases in the EC (initiated and/or ending up with a positive decision) represents a fraction of this number (see GATT (1993b)). Of course, it is not because a smaller number of sectors are affected by NTBs that overall protection necessarily decreases. However, given the high rates of growth in world trade, it seems likely that, despite this substitution, the overall level of protection has decreased through time.

The links between tariff liberalization and the emergence of NTBs have been investigated empirically with interesting results with respect to industry characteristics. Marvel and Ray (1983), in particular, show that tariff liberalization is stronger (on average) in industries that are more competitive and that enjoy higher growth rates. Moreover, Ray (1981) and Marvel and Ray (1983) argue that NTBs are found predominantly in more competitive industries because NTBs are better than tariffs at shielding rents among existing firms when barriers to entry are low. There is much less use of NTBs in less competitive industries as tariff liberalization has been more modest. Marvel and Ray also argue that there are some sectors (in both types of industry) in which overall protection has increased as a result of the emergence of NTBs.

In the next Sections, we investigate the case of quotas and antidumping as devices to maintain protection when tariffs are negotiated away or when international transport costs get lower. We are interested in developing a model (i) which is consistent with the sequential introduction of quantitative restrictions and antidumping measures; (ii) where the range of sectors affected by these tools gets smaller, and (iii) where the degree of tariff liberalization and the use of NTBs depend on industry characteristics.

3. The Model

In this Section, we describe the various trade policy tools we consider in the sequel, namely tariffs, quotas, and antidumping restrictions, and discuss our modeling strategy.

The interaction between firms follows the simple reciprocal dumping model of Brander (1981). There are two firms, one in each country, selling the same good. Competition between firms within each country is described by the Cournot model. The reasons for this choice of modeling strategy are as follows. In a perfectly competitive world, firms would never dump so there would be no role for antidumping measures (see Ethier (1982) for an exception when uncertainty is introduced). Furthermore, there would be no incentive to use quotas if the foreigners get the rents from them (see for example Helpman and Krugman (1989), p.14). Hence to explain the use of quotas and antidumping restrictions in a simple static framework, we should look for some market imperfection. The most natural one is market power, which is also the relevant market structure for many manufacturing industries. The basic choices to model oligopolistic interaction are the Cournot and Bertrand descriptions. The Bertrand model requires one to consider differentiated products otherwise there would be neither imports nor exports. Under quotas, the price equilibria are typically in mixed strategies (see for example Krishna (1989)), which are both cumbersome to deal with analytically, as well as being unappealing to some critics. Therefore we use the Cournot model, which as we show, is generally manageable, as well as tracking to a fair degree the stylized facts of Section 2. For simplicity we do not allow for entry, and consider only a two-country, two-firm case.

Firm 1 is domiciled in country A, in which it sells x_1 units of output, while it sells y_1 in country B. Firm 2, domiciled in B, sells x_2 in A and y_2 in B. There are no marginal production costs, but the cost of shipping one unit of output abroad is t per unit.

The inverse demands in market A and B are, respectively

$$p_A = 1 - X; \qquad \text{and} \qquad p_B = 1 - Y, \tag{3.1}$$

where $X = x_1 + x_2$ and $Y = y_1 + y_2$. If a tariff τ_A is imposed by government A, the foreign firm's marginal cost for its exports is $T_A = t + \tau_A$; T_B and τ_B are analogously defined. The standard linear-demand Cournot model then yields equilibrium outputs as

$$\hat{x}_1 = \frac{1+T_A}{3}; \qquad \hat{x}_2 = \frac{1-2T_A}{3}; \qquad \hat{y}_1 = \frac{1-2T_B}{3}; \qquad \hat{y}_2 = \frac{1+T_B}{3}. \tag{3.2}$$

These solutions are valid for $T_i \,\epsilon\, [-1, \frac{1}{2}]$, $(i = A, B)$. If $T_i \geq \frac{1}{2}$, there is a domestic monopoly in country i with the rival firm excluded by too high export cost (and thus the solution is that of $T_i = \frac{1}{2}$). If $T_i \leq -1$, the foreign firm is a monopolist in the domestic firm's market.

The equilibrium profits are simply $\pi_j = \hat{x}_j^2 + \hat{y}_j^2$, $(j = 1, 2)$, or for Firm 1,

$$\pi_1 = \left(\frac{1+T_A}{3}\right)^2 + \left(\frac{1-2T_B}{3}\right)^2. \tag{3.3}$$

This model produces reciprocal dumping (Brander and Krugman (1983)) since $p_A - T_A \leq p_B$ and $p_B - T_B \leq p_A$. That is, each firm uses third-degree international price discrimination.

Consumer surplus in A is simply $\frac{\hat{X}^2}{2}$. We assume that tariff revenues are redistributed to consumers. Hence consumer benefits, β_A, are the sum of consumer surplus and tariff revenue:

$$\beta_A = \frac{1}{2}\left(\frac{2-T_A}{3}\right)^2 + \tau_A\left(\frac{1-2T_A}{3}\right). \tag{3.4}$$

A similar expression applies to market B.

The expressions given above will be used in the next two sections to describe the non-cooperative tariff equilibrium and the cooperative tariff. We show that NTBs will not be used when tariffs are freely chosen, but may be unilaterally desirable when the cooperative tariff is in place. The two NTBs we consider are quotas and antidumping restrictions.

Suppose then that Government A imposes a quota, $\bar{x}_2 \geq 0$, on the foreign firm. This quota is binding if it is less than the Cournot output (see (3.2)) of the foreign firm in the domestic market, i.e. if $\bar{x}_2 < \frac{1-2T_A}{3}$, where T_A is the sum of transport cost and whatever tariff is currently in effect. The domestic firm then chooses its Cournot best reply to $\bar{x}_2$,

$$\hat{x}_1 = \frac{1-\bar{x}_2}{2}. \tag{3.5}$$

Note that a quota in the domestic market has no effect in the foreign market.

The third tool available to each government is an antidumping constraint. Following Anderson, Schmitt, and Thisse (1995), we model antidumping measures as a binding constraint on the affected firm's outputs to eliminate the dumping margin, which is the difference between the price received on each domestic unit sold and the net price received on each unit exported. Hence, if Government A imposes an antidumping restriction on the foreign firm, then Firm 2's outputs must ensure that

$$p_A \geq p_B + T_A, \tag{3.6}$$

if Firm 2 is to sell in market A (it may prefer giving up market A and selling only in market B). The concavity of the profit functions ensures that (3.6) will hold with equality whenever Firm 2 opts to still serve market A under an antidumping restriction. We assume that evidence of dumping is determined by a price-based method, which "in the US [...] is generally based on a foreign firm's own home market sale price" (Gallaway, Blonigen and Flynn (1999)).[4]

An equilibrium with the restricted firm (say, Firm 2) serving both markets entails first finding the x's and the y's to the problem

$$\max_{x_2, y_2} \pi_2 = (1 - y_1 - y_2)y_2 + (1 - x_1 - x_2 - T_B)x_2, \tag{3.7}$$

subject to the antidumping constraint $(1 - y_1 - y_2) \leq (1 - x_1 - x_2 - T_B)$ and the standard non-negativity constraints, given that Firm 1's problem is the standard Cournot one. We show in Appendix 1 that the effect of an antidumping restriction on Firm 2 is to reduce its equilibrium output in market A and to increase it in B (Firm 1's outputs go the other way). As expected, the equilibrium price rises in A and falls in B.

The final ingredient of the model is the description of how trade policies are determined. We posit a policy-maker's objective function over consumer benefits (β) and profit (π), $U(\beta, \pi)$, which is strictly increasing in each argument and quasiconcave so the indifference curves have the standard shape (downward sloping with diminishing marginal rate of substitution). The standard case of total surplus ($\beta + \pi$) maximization is a particular case of the above. We also assume that this objective function is applied to each industry separately. This assumption is a simple way to allow for different trade-offs between consumer benefits and profits in different industries. As we show below, our approach can explain the observed fact of binding but non-prohibitive quotas, whereas this observation rejects the simple surplus maximization approach. For the most part, we shall think of a strictly quasi-concave objective function (and strictly diminishing marginal rate of substitution). In what follows, we shall make extensive use of a Cobb-Douglas form for the policymaker's objective function, $U = \beta^{1-\alpha}\pi^{\alpha}$, where α denotes the relative weight on profit, or the importance of the domestic firm to the policymaker.

There are several justifications for such a form. For example, following Stigler (1971) and Peltzman (1976), we could think of governments that care about consumer welfare (with

[4] See Boltuck and Litan (1991) for a detailed description of the implementation of the US antidumping law.

tariff revenues spent, say, on public goods) because consumers vote, and they care about profit because legislators get perks from lobbyists (and there are diminishing returns to each argument). In a similar vein, we could imagine, as in Becker (1983), that government policy is determined by costly lobbying from interested parties. Insofar as greater concessions are only achieved at the cost of larger lobbying expenditures, a balance will be struck between the lobbying parties, just as the Cobb-Douglas function tends to select outcomes that are 'in the middle' (whereas a linear utility function tends to select more extreme outcomes, especially under convex constraints). We can think of the outcome of the lobbying game as the solution to the simpler maximization problem. In adopting $U(\beta, \pi)$ to investigate the choice and the level of the three trade tools available to policymakers, we assume they have as much freedom in choosing antidumping constraints on an industry-by-industry basis as they have over tariffs and quotas.[5]

In the sequel, we model a progression through different types of policy, with noncooperative phases interspersed with trade negotiations which lead to cooperative policies. However, we assume a certain degree of myopia in the cooperative phases. In particular, the trade negotiators do not consider how governments may later resort to other policies that are within the letter of the trade agreement (but contrary to its spirit). For example, when setting cooperative tariffs, negotiators do not anticipate that countries may afterwards resort to antidumping measures to unilaterally improve their positions. While this approach is contrary to the spirit of subgame perfection, it does capture the realistic aspect that laws and agreements typically do not foresee all contingencies. Such loopholes in practice are typically only closed in later negotiations and once there have been significant violations.

There is some evidence that negotiators may be myopic in the above sense. For example, Marvel and Ray (1983, p.196) note that their empirical findings "support the view that the NTBs actually augmented protection in favored industries". If a higher level of protection were unilaterally desirable, it could have been attained through tariffs in the initial non-cooperative equilibrium. Therefore, tariff negotiations would not ultimately lead to higher protection unless negotiators did not foresee the subsequent use of NTBs. One might also argue that, if negotiators are aware that countries would want to change say quotas following tariff negotiations, then these quotas should themselves be part of the negotiations. Historically, tariffs were negotiated first, without explicit consideration of quotas or other NTBs. Only in later rounds of negotiation, once quotas had actually proliferated, did attention turn to them. When the issue of quotas was brought to the negotiating table, it is unlikely that the parties anticipated the ensuing rise in the use of other NTBs such as antidumping measures.[6]

[5] For instance, the application of antidumping laws are subject to political influence. Moore (1992) finds empirical evidence that decisions on antidumping cases in the US are partly determined by political variables. Baldwin and Steagall (1994) reach less strong conclusions but note that commissioners do not have a very strict interpretation of the law.

[6] The Economist (1999) underlines this point well: 'Countries agreed to lower their blatant barriers to trade [..] while intervening at will [..] in their domestic economies. [B]y the 1970s, problems began to emerge. As border barriers fell, it became clear that domestic regulations were also a big impediment to trade [..]. Moreover, governments began to abuse these loopholes for protectionist ends: antidumping cases

4. The Non-Cooperative Tariff Game

In this Section we describe the Nash equilibrium outcome of the tariff game and the properties of the equilibrium tariff. We begin by deriving this equilibrium because we want to establish that NTBs are not used in the non-cooperative tariff equilibrium and because we will use it as our benchmark equilibrium.

Consider the problem facing the government in A. It has to choose a tariff, τ_A, to maximize $U(\beta_A, \pi_1)$ where β_A, the sum of domestic consumer surplus and tariff revenue, is given by (3.4), and π_1, which is the total profit earned by the domestic firm in both countries, is given by (3.3). The solution is described by a tangency condition between an indifference curve in (π_1, β_A) space and the constraint defined by the set of (π_1, β_A) pairs attainable via different levels of the tariff. There is also a possible corner solution corresponding to $T_A = \frac{1}{2}$, where profit attains its maximum value since the foreign presence is eliminated. The constraint slope is described by

$$\frac{d\pi_1}{d\beta_A} = \frac{\pi_1'}{\beta_A'} = \frac{2(1+T_A)}{1-5T_A-6\tau_A} = \frac{2(1+t+\tau_A)}{1-5t-11\tau_A}, \tag{4.1}$$

where a prime denotes a partial derivative with respect to τ_A. From (4.1), the constraint locus slopes up for $\tau_A < \frac{1-5t}{11}$, so there can never be a maximum of U on this portion. This is because higher tariffs here increase β_A, while they increase π_1 throughout. Hence the relevant part of the locus involves

$$\tau_A > \frac{1-5t}{11} \tag{4.2}$$

or, equivalently (recalling $T_A = \tau_A + t$),

$$T_A > \frac{1+6t}{11}, \tag{4.3}$$

in which case there is a trade-off between higher profit and higher consumer benefits (a higher τ_A increases profit by squeezing out the rival firm while decreasing consumer benefits since consumers pay through higher prices). It is useful to note for what follows that (4.3) implies that the effective trade barrier $T_A > \frac{1}{11}$, while T_A can be effectively bounded above by $\frac{1}{2}$, the value at which the foreign firm is excluded from the domestic market.[7] The solution to the government's problem is illustrated in Figure 1, where τ_A is monotonically increasing as we move counter-clockwise around the constraint locus. It is readily shown that the constraint locus is necessarily concave in the relevant range, so the solution obtained from the tangency condition of the indifference curve to the constraint is a maximum (and the corresponding second-order condition holds).

[Insert Figure 1 about here]

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and import restricting regulations proliferated. So the focus of trade policy turned to limiting such abuses.'

[7] It also follows from (4.2) that τ_A is necessarily non-negative for $t \leq \frac{1}{5}$.

The tangency condition is described by the first-order condition to the government's problem, $U_\beta \beta'_A + U_\pi \pi'_1 = 0$, or

$$f(\tau_A, \tau_B, t) \equiv (1 - 11\tau_A - 5t)U_\beta + 2(1 + t + \tau_A)U_\pi = 0. \tag{4.4}$$

Let τ_A^* denote the tariff rate solving (4.4); the slope of government A's reaction function is

$$\frac{d\tau_A^*}{d\tau_B} = -\frac{\partial f/\partial \tau_B}{\partial f/\partial \tau_A}, \tag{4.5}$$

where the denominator is negative by the second-order condition, and $\partial f/\partial \tau_B$ is positive (see Appendix 2(i)). Hence the reaction functions slope up: tariffs are strategic complements in the non-cooperative game between governments.

The reaction functions are also continuous since the constraint locus is strictly concave in the relevant region and varies continuously with the other government's tariff rate, while the indifference curves are convex. A non-cooperative tariff equilibrium then exists by Brouwer's fixed point theorem since tariffs must be effectively chosen from the compact set $[\frac{1}{11} - t, \frac{1}{2} - t]$ (which stems from the fact that $T \,\epsilon\, [\frac{1}{11}, \frac{1}{2}]$).[8]

It is worthwhile at this juncture to point out how the introduction of a quasiconcave government objective function U is instrumental to the strategic complementarity result. If instead we assumed that governments maximized the sum of consumer benefits and firm profits, the tariff reaction function would be independent of the rival's choice (there is a dominant strategy).[9] Although the *level* of social welfare then depends on the rival's tariff (through the domestic firm's profit abroad), the optimal tariff does not. However, if the government trades off consumer benefits with profit in a non-linear fashion, as we are assuming, the higher the rival government's tariff, the lower will be the domestic firm's profit, ceteris paribus. At the margin, the government now wishes to redress the balance in favor of the firm and at the expense of consumers, resulting in a higher tariff best reply.

So far we have shown that tariff reaction functions are continuous, upward sloping, and that they must cross. The symmetry of the governments' problems then implies that any equilibrium must be symmetric. We can further show under some further restrictions that the equilibrium is stable ($\frac{d\tau_A^*}{d\tau_B} < 1$ at $\tau_A^* = \tau_B^* = \tau^*$, or $\frac{\partial f}{\partial \tau_B} < -\frac{\partial f}{\partial \tau_A}$), and hence unique. The sufficient restrictions we use are that the government preference function is given by the Cobb-Douglas function, $U = \beta^{1-\alpha}\pi^\alpha$, and $\alpha \,\epsilon\, [\frac{1}{3}, \frac{11}{16}]$ so that preference weights are not too extreme. The stability proof under these conditions is given in Appendix 2(ii).[10]

The reaction functions are sketched in Figure 2, in which we also represent some government indifference curves.

[Insert Figure 2 about here]

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[8] Equilibrium existence still holds if tariffs are constrained to be non-negative: the relevant compact set for τ is then $[0, \frac{1}{2} - t]$.

[9] In this case, $U_\beta = U_\pi = 1$ and, from (4.4), $(1 - 5t - 11\tau_A) + 2(1 + t + \tau_A) = 0$, so $\tau_A^* = \frac{1-t}{3}$.

[10] The stability condition holds generally for $t \geq \frac{1}{5}$; the other restrictions are only used for $t < \frac{1}{5}$ (see Appendix 2).

From Figure 1, a relatively higher weight on firms in the government objective function (an increase in α in the Cobb-Douglas formulation) corresponds to an indifference curve that tilts more towards the π-axis, and a greater best reply value of π (and lower β). This is achieved by a higher tariff so tariff reaction functions shift up, resulting in a higher equilibrium tariff (see also Rosendorff (1996)).

Real transportation costs have declined over the years. The effect of lower transport costs is to shift the reaction functions up and so to raise equilibrium tariffs. A lower transport cost implies a greater foreign presence, ceteris paribus, and thus higher consumer benefits. Given the trade off between consumer benefits and profits, each government wants to increase protection and to exploit the monopoly power of the home market. Moreover, as we show in Appendix 2(iv), lower real barriers to trade lead to lower effective barriers (and hence more trade in equilibrium) despite the offsetting effects of the tariff increase. As we will see, the effect of a change in t has very different effects on the cooperative tariff rate. To summarize (in the sequel, Results apply to the Cobb-Douglas form, while Propositions do not depend on it):

Result 1:

(i) The more governments weigh profits (higher α), the higher are non-cooperative tariffs.

(ii) Lower transport costs bring higher non-cooperative tariffs but lower overall trade barriers.

We now show that neither government will further curtail trade on top of the non-cooperative tariff.

Proposition 1: *There is no incentive for a government to use quotas or antidumping constraints if there is no restriction on tariff use.*

Proof: An antidumping constraint or a prohibitive quota may cause the foreign firm to stop selling in the home market. A government imposing a prohibitive quota or an antidumping constraint which eliminates trade cannot prefer this outcome to the optimal tariff because the tariff could have originally been chosen to be prohibitive. So consider the case where NTBs do not eliminate trade. Consider first a combination of tariff τ^0 and a non-prohibitive binding quota, $\bar{x}_2$. The key point is that any quota can be 'tariffied' to yield a revenue gain: any quota output can be attained via a tariff $\tau^1(\bar{x}_2)$ with $\tau^1 > \tau^0$ (see (3.2)). Imposing τ^1 leaves both profit and consumer surplus unchanged from their values at the pair $(\tau^0, \bar{x}_2)$, but tariff revenue must rise since $\tau^1 > \tau^0$.[11] Since τ^* maximizes $U(.)$, then no other tariff can be better, and therefore (from the above argument) no tariff-cum-quota can be preferred.

The argument for the antidumping restriction follows the same lines. The only added element is that an antidumping constraint also changes the profit of the domestic firm in the foreign market. As we noted in the previous Section, and as is shown in Appendix 1, the output of the restricted firm rises in its own market. Since a firm's profit is decreasing in its rival's output in any market, the profit of the domestic firm abroad must fall whenever an antidumping restriction is imposed on top of any tariff. Consider then a combination of tariff τ^0 and an antidumping constraint on Firm 2. An antidumping constraint can be

[11] This result relies on the equivalence of tariff and quota in a Cournot game (see Hwang and Mai (1988)). This also implies that quotas would be as efficient as tariffs if quota rights were auctioned off by the government.

replaced by a quota, $\bar{x}_2$, leading to the same outcome in the domestic market, as well as the same profit and consumer surplus there. Since we have just argued that an antidumping constraint lowers a firm's profit abroad, Firm 1's overall profit must rise when an antidumping constraint is replaced by a quota yielding the same level of imports. Since a quota can be tariffied to yield a revenue gain, the same argument used above applies here. Hence no tariff-cum-antidumping constraint can be preferred to τ^* and there is no combination of tariff, quota and antidumping constraint that is unilaterally preferred to τ^*. ■

This proof showcases an important property of the model: tariffs are more efficient trade policy tools than quotas, and quotas are more efficient than antidumping restrictions.[12] We now turn to the properties of the cooperative tariff rate.

5. Cooperative Tariffs

The Nash equilibrium tariffs just derived leave room for negotiation. This is readily seen from Figure 2. Both countries can be better off with lower tariffs that increase the volume of trade and reduce local market power. Tariff negotiation, as in the GATT, is the manifestation of the realization that lower tariffs are better if they are bilaterally binding.

In this Section we look at the common tariff rate that maximizes joint welfare (and can equivalently be attained through a Nash bargaining solution). The key difference from the non-cooperative problem is that the cooperative tariff explicitly accounts for profits earned abroad. This is the reason it is lower than the non-cooperative tariff rate – a lower tariff increases profit earned from the foreign market. The common tariff τ^{**} is given by maximizing the policymaker's utility function where the tariff determines β and π (we can drop the subscripts since the problem is the same for both governments). The first-order condition is

$$U_\beta \beta' + U_\pi \pi' = 0. \tag{5.1}$$

The trade-off between β and π is determined from the relations (3.4) and (3.3) where $T = T_A = T_B$ and $\tau = \tau_A = \tau_B$. The corresponding derivative expressions are

$$\beta' = \frac{1 - 5T - 6\tau}{9}, \tag{5.2}$$

and

$$\pi' = \frac{2(5T - 1)}{9}, \tag{5.3}$$

while $\beta'' < 0$ and $\pi'' > 0$.

Profit is a $\bigcup$-shaped function of τ. For τ high enough (such that $T \geq \frac{1}{2}$), the domestic firm is a monopolist in its own market. As τ falls below $\frac{1}{2}$, the domestic firm loses out increasingly through competition from the foreign rival, but also becomes more competitive in the foreign market. For τ low enough, the latter effect dominates, and profit rises as τ falls: the domestic firm is effectively subsidized to produce in the foreign market and eventually

[12] Cassing and Hillman (1985) show that a quota may be preferred if revenue enters the objective function as a separate argument, and when a domestic monopolist faces a foreign competitive fringe.

drives the foreign firm out of the foreign market (when $T \leq -1$). Conversely, β (consumer surplus plus tariff revenues) is a $\bigcap$-shaped of τ, which is lowest at its extremes. A high tariff implies a small volume of trade, low tariff revenue and low consumer surplus, while, for τ low enough, consumer surplus is high but the cost of subsidizing trade dominates. The construction of the locus of feasible (π, β) combinations (that determines the cooperative tariff) is rather intricate and is described in Appendix 3.

The cooperative tariff rate for the Cobb-Douglas example is found by solving (5.1), or

$$\left(\frac{1-\alpha}{\alpha}\right)\frac{\pi}{\beta} = \frac{\pi'}{\beta'}, \tag{5.4}$$

(marginal rate of substitution equals marginal rate of transformation along the feasible locus). Substituting (3.4), (3.3) (with $T = T_A = T_B$ and $\tau = \tau_A$), (5.2), and (5.3), we find the following implicit cubic equation

$$\tau^{**} = \left(\frac{1-5T}{6}\right)\left(\frac{(1-\alpha)(2-2T+5T^2)-\alpha(2-T)^2}{(1-\alpha)(2-2T+5T^2)-\alpha(5T-1)(1-2T)}\right). \tag{5.5}$$

It is helpful to find where $\tau^{**} = 0$. From (5.5), there is clearly a solution $\tau^{**} = 0$ for $t = \frac{1}{5}$. However, for $\alpha > \frac{11}{20}$, this is a minimum. The other root to $\tau^{**} = 0$ is given from (5.5) as the solution to $(1-\alpha)(2-2t+5t^2) = \alpha(2-t)^2$, or

$$\alpha = \frac{2-2t+5t^2}{6(1-t+t^2)}, \tag{5.6}$$

which determines a unique positive relationship between α and t. Both loci where $\tau^{**} = 0$ are depicted in Figure 3. The sign of τ^{**} for any parameter combination is then determined by considering on which side of the loci $t = \frac{1}{5}$ and (5.6) we are (see (5.5)). Below the locus (5.6), $\tau^{**} > 0$ when $t < \frac{1}{5}$, and above the locus (5.6), $\tau^{**} > 0$ when $t > \frac{1}{5}$. The theoretical result of $\tau^{**} < 0$ for some parameter values seems unrealistic. In practice, such negative tariffs might be undone by arbitrage: individuals could cross and recross the frontier and keep collecting subsidies.[13] In the sequel, we therefore restrict tariffs to be non-negative.[14]

[Insert Figure 3 about here]

The other feature of Figure 3 that needs some explanation is the locus such that $T = \frac{1}{2}$, which is the right most curve in the Figure and which corresponds to a cooperative tariff

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[13] Similar stories are told about trucks crossing borders between EC countries, driving round the roundabout, collecting agricultural subsidies under the Common Agricultural Policy, and recrossing the border. Between Northern Ireland and Eire, this is known as the 'turnaround pig'.

[14] This is actually a little more complex than simply replacing $\tau^{**} < 0$ by a zero tariff since, given the shape of the locus of feasible (π, β) combinations, the local maximum positive value of τ^{**} might be preferred to free trade. However this happens only when the two sides of the constraint locus are very close. As a result, the constraint τ^{**} is zero when the unconstrained τ^{**} is negative except for a small range of parameters ($\alpha > .55$ and $.12 < t < .2$; see Figure 3) where τ^{**} is strictly positive.

that eliminates trade, and hence to monopoly in each country. From (5.5), and using $\tau^{**} = \frac{1}{2} - t \geq 0$, this locus for $t > \frac{1}{5}$ is given by

$$\tilde{t} = \text{Min}\left\{\frac{3-4\alpha}{4(1-\alpha)}; \frac{1}{2}\right\}. \tag{5.7}$$

Comparing the cooperative and the non-cooperative tariff rates enables us to define three types of regions consistent with two-way trade.[15] They are defined in Figure 3 by the pair (τ^*, τ^{**}). In the first region, τ^* is positive but τ^{**} is zero; in the second region, both τ^* and τ^{**} are positive, and in the third region, both τ^* and τ^{**} are zero. It is also instructive to consider the degree of tariff liberalization defined as $s = (\frac{\tau^*-\tau^{**}}{\tau^*})100$. In Figure 3, we have added the degree of tariff liberalization to the pair (τ^*, τ^{**}), and we have included a few points where the triple (τ^*, τ^{**}, s) has been computed.

The intuition for the tariff patterns shown in Figure 3 is the following. The model has two distortions: imperfect competition and relative inefficiency of trade due to the presence of international transport costs. The first distortion induces countries to jointly subsidize trade, while the second one induces them to tax trade. At $t = \frac{1}{5}$, the two forces just balance resulting in $\tau^{**} = 0$. Consider now a marginal increase in t from $\frac{1}{5}$. Consumer benefits decrease since the equilibrium price increases with less trade. Governments that care about consumers (low α) then have a tendency to decrease τ^{**}, and thus to subsidize trade (or retain a zero tariff under a non-negativity constraint). Less trade, however, implies higher firm profits. If governments like firms (high α) they are induced to tax trade. When $t < \frac{1}{5}$, governments jointly want to subsidize trade and this helps firms (since π is convex in τ). It is only when governments care about consumers (low α) that they tax trade.

Note that there is very little tariff liberalization close to the boundary where the cooperative tariff eliminates trade. Indeed, the boundary condition at which trade is eliminated under cooperative tariff (see (5.7)) is the same as that for the non-cooperative tariff.[16] We also know that every point inside the boundary involves trade under the non-cooperative tariff equilibrium since we showed in the previous section that the equilibrium total barrier to trade ($T^* = t + \tau^*$) is falling with t for the Cobb-Douglas example with $\alpha \geq \frac{1}{3}$. Each such point also involves trade under the cooperative tariff.[17] The reason that the boundaries

[15] The non-cooperative tariff for the Cobb-Douglas example is given by solving (4.4) to give $(\frac{1-\alpha}{\alpha})\frac{\pi_1}{\beta_A} = \frac{d\pi_1}{d\beta_A}$, where the RHS is given by (4.1) and β_A and π_1 are given by (3.4) and (3.3). Using symmetry yields an implicit formula

$$\tau^* = \frac{(1-\alpha)(1-5T)(2-2T+5T^2)+\alpha(1+T)(2-T)^2}{6\{(1-\alpha)(2-2T+5T^2)-\alpha(1+T)(1-2T)\}}. \tag{5.8}$$

In Figure 3, we have constrained $\tau^* \geq 0$.

[16] This can be seen by setting $\tau = \frac{1}{2} - t \geq 0$, $U = \beta^{1-\alpha}\pi^{\alpha}$, $\beta = \frac{1}{8}$ and $\pi = \frac{1}{4}$ in (4.4).

[17] To see this, let $\tilde{U}(\tau_A, \tau_B)$ denote country A's payoffs under tariffs τ_A and τ_B. Then note that $\tilde{U}(\tau^{**}, \tau^{**}) \geq \tilde{U}(\tau_A^*, \tau_B^*) \geq \tilde{U}(\frac{1}{2} - t, \tau_B^*) > \tilde{U}(\frac{1}{2} - t, \frac{1}{2} - t)$ where the first inequality holds by the optimality of the cooperative tariff, the second since τ_A^* is preferred at the non-cooperative equilibrium to a prohibitive tariff, and the third since A's payoff is strictly decreasing in B's tariff. Hence the cooperative tariff involves trade if the non-cooperative equilibrium tariff entails trade.

are the same for the non-cooperative and the cooperative tariff equilibria is that, with a prohibitive tariff ($\tau = \frac{1}{2} - t$), a slight bilateral reduction in τ has only a second-order effect on the profits of the domestic firm abroad. The incentive to cut tariffs marginally is then the same in the two equilibria. We summarize this discussion with

Result 2: *Tariff negotiation does not change the range of trading industries.*

Inspection of Figure 3 reveals a number of additional results. The degree of bilateral tariff liberalization depends on whether $t \gtrless \frac{1}{5}$ and how close we are to the boundary at which trade is eliminated. We can determine the following properties from Figure 3, which indicate the degree of trade liberalization by industry type (i.e., (α, t) pair).

Result 3:

(i) A high degree of tariff occurs when governments weigh profits highly and transport cost is low (high α and low t).

(ii) A low degree of tariff liberalization despite high non-cooperative tariffs occurs when governments weigh profits highly and transport cost is high (high α and t).

(iii) A low degree of tariff liberalization from low non-cooperative tariffs occurs when governments weigh consumers highly and transport cost is high (low α and high t).

The parameter α is a policymaker's taste parameter that can be related to several broader indices. For example, one might expect higher α in sectors where economic activity is geographically concentrated, so the industry is important to politicians. Likewise, sectors in decline might be represented by higher α's in the sense that politicians might be more sensitive to their continuing prospects; and similarly for more labor intensive industries insofar as workers vote for politicians. The parameter t is the international transport cost (as a fraction of the demand intercept), and so high t corresponds to industries for which the domestic market is much more important than foreign markets. Hence, t is inversely related to the degree of import penetration in an industry and thus, in this model, with effective competition.[18] Under this interpretation, the results on tariffs are in line with the empirical results discussed in Section 2. In particular, the higher the competition between firms (low t), the higher the degree of tariff liberalization. It remains now to see whether the predictions of the model are also consistent with the use of NTBs.

6. Quotas

Having negotiated the cooperative tariff τ^{**}, and under the understanding that countries can no longer deviate from this tariff rate, they are likely to look for alternative ways to influence the pattern of trade to their own advantage. We restrict the set of possible instruments to quotas and antidumping restrictions. The following result is a corollary of the proof of Proposition 1:

[18] We have also looked at a model with n domestic and n foreign firms and calculated equilibrium and cooperative tariff rates under the assumption that the maximand is social surplus. Results are mixed. The equilibrium tariff decreases with n while the cooperative one increases, so that the degree of liberalization falls with domestic concentration. However, it rises with import penetration so that industries with more competition from imports in the non-cooperative equilibrium would expect more tariff liberalization.

Proposition 2: *Given the cooperative tariff, τ^{**}, if governments can use both quotas and antidumping restrictions, they will only use quotas or else no NTBs at all.*

The idea behind the result is that an antidumping restriction has the same effect as a particular quota on the domestic market, but has an additional deleterious effect on the home firm's profit in the foreign market. As we noted in Section 2, quotas were the trade restriction of choice prior to the completion of the Kennedy Round.

The quota game is of interest in its own right outside the general points we make about the progression of trade policies. In particular, our policymaker's objective function approach yields more appealing results than does a simple social surplus maximization approach. The latter yields either completely prohibitive quotas or else no quota at all; the reason being that the locus of $(\pi,\ \beta)$ combinations attainable through quotas is convex.

To see this convexity result, we first characterize the Cournot equilibrium in the presence of a quota. If the quota on Firm 2 is binding, $\bar{x}_2\ \epsilon\ [0, \frac{1-2T^{**}}{3}]$ (where $T^{**} = t + \tau^{**}$) and Firm 1's best reply is $\hat{x}_1 = \frac{1-\bar{x}_2}{2}$ (which is also the domestic market price, from Firm 1's first-order condition). Hence total output in market A is $\hat{X} = \frac{1+\bar{x}_2}{2}$ and Firm 1's equilibrium profit, if it faces a binding quota $\bar{y}_1$ in market B, is

$$\tilde{\pi}_1 = \frac{(1-\bar{x}_2)^2}{4} + \bar{y}_1(\frac{1-\bar{y}_1}{2} - T^{**}), \tag{6.1}$$

while consumer benefit in A is $\hat{X}^2/2$ plus tariff revenue, i.e.,

$$\tilde{\beta}_A = \frac{1}{2}\left(\frac{1+\bar{x}_2}{2}\right)^2 + \tau^{**}\bar{x}_2. \tag{6.2}$$

These equations describe a parameterized curve (the parameter being $\bar{x}_2$) in $(\pi,\ \beta)$ space. To describe the curve, first note that $\frac{\partial\tilde{\pi}_1}{\partial\bar{x}_2} = -(\frac{1-\bar{x}_2}{2}) < 0$ and $\frac{\partial\tilde{\beta}_A}{\partial\bar{x}_2} = (\frac{1+\bar{x}_2}{4}) + \tau^{**}$, which is necessarily positive for $\tau^{**} > -\frac{1}{4}$. Since we concentrate on non-negative tariffs, the feasible locus slopes down in $(\pi,\ \beta)$ space. It is also strictly convex since

$$\frac{\partial^2\pi_1}{\partial\tilde{\beta}_A^2} = \left(\frac{1}{\frac{\partial\tilde{\beta}_A}{\partial\bar{x}_2}}\right)\frac{\partial\left(\frac{\partial\tilde{\pi}_1}{\partial\bar{x}_2}/\frac{\partial\tilde{\beta}_A}{\partial\bar{x}_2}\right)}{\partial\bar{x}_2} > 0. \tag{6.3}$$

Under the standard social surplus maximization, the convex locus necessarily implies either completely prohibitive quotas or none at all. This is true irrespective of the weight chosen by the government between consumer benefits and firm profits.

Clearly, a quasi-concave policymakers' objective function over consumer benefits and firm profits might alleviate this problem by generating non-prohibitive quotas in addition to prohibitive quotas and no quotas at all. We now show that there exists an equilibrium to the quota game and, furthermore, that any equilibrium is symmetric.

To see this, note first that the strategy space for each government is $[0, \hat{x}(\tau^{**})]$. It suffices then to show that the quota reaction functions slope up (strategic complementarity) and that any jump is a jump up (the game is supermodular). This means that the reaction function for a government must cross the 45^0 degree line, and by symmetry of the reaction functions around the 45^0 line, the only possible equilibria are symmetric. Strategic complementarity follows if $\frac{\partial^2 U}{\partial \bar{x}_2 \partial \bar{y}_1} \geq 0$. Given the Cobb-Douglas government's payoff function,

$$\frac{\partial U}{\partial \bar{y}_1} = \alpha \left(\frac{\tilde{\beta}_A}{\tilde{\pi}_2} \right)^{1-\alpha} \left(\frac{1 - 2\bar{y}_1}{2} - T^{**} \right), \tag{6.4}$$

and so,

$$\frac{\partial^2 U}{\partial \bar{x}_2 \partial \bar{y}_1} \propto \left[\tilde{\pi}_1 \frac{\partial \tilde{\beta}_A}{\partial \bar{x}_2} - \tilde{\beta}_A \frac{\partial \tilde{\pi}_1}{\partial \bar{x}_2} \right] \left(\frac{1 - 2\bar{y}_1}{2} - T^{**} \right). \tag{6.5}$$

The first expression on the RHS is positive since $\frac{\partial \tilde{\beta}_A}{\partial \bar{x}_2} > 0$ and $\frac{\partial \tilde{\pi}_1}{\partial \bar{x}_2} < 0$ (for $\tau^{**} > -\frac{1}{4}$). The second is positive since it is smallest at $\bar{y}_1 = \hat{x}_2 = \frac{1-2T^{**}}{3}$, at which value it is equal to $\frac{1}{6}(1 - 2T^{**})$ which is positive since $T^{**} < \frac{1}{2}$, or else there is no trade in the first place.

A candidate symmetric interior binding quota equilibrium is found by solving

$$\frac{\partial U}{\partial \tilde{\beta}_A} \frac{\partial \tilde{\beta}_A}{\partial \bar{x}_2} + \frac{\partial U}{\partial \tilde{\pi}_1} \frac{\partial \tilde{\pi}_1}{\partial \bar{x}_2} = 0, \tag{6.6}$$

when this derivative is evaluated at $\bar{x}_2 = \bar{y}_1 = \bar{q}$. For the Cobb-Douglas government payoff function, the resulting equation is

$$(1-\alpha)(1+\bar{q}+4\tau^{**})[1-\bar{q}^2 - 4(t+\tau^{**})\bar{q}] - \alpha[(1+\bar{q})^2 + 8\tau^{**}\bar{q}](1-\bar{q}) = 0, \tag{6.7}$$

which is a cubic with at most three real roots. Any root outside $[0, \hat{x}_2(\tau^{**})]$ is irrelevant. Hence, the candidate symmetric equilibrium is any relevant root or else one of the endpoints. We only ever found one interior solution, if any.[19] Figure 4 illustrates the findings for the equilibrium quota given the cooperative tariff τ^{**} (constrained to be non-negative). As expected, depending on parameter values, there are three types of symmetric equilibria: no quantitative restrictions ($\bar{q} = \hat{x}$); binding quotas ($0 < \bar{q} < \hat{x}$), and prohibitive quotas ($\bar{q} = 0$).

[Insert Figure 4 about here]

Clearly, given t, tighter quotas are associated with higher values of α. However the interaction between α and t also plays an important role. In particular, high values of t are associated with lower degrees of tariff liberalization which decreases the need for quotas even if α is high. Comparing Figures 3 and 4, interesting patterns emerge.

Result 4: *Quotas are not necessarily linked to high degrees of tariff liberalization.*

[19] To check that any candidate solution is a symmetric equilibrium, we used the solution to calculate the equation of the indifference curve $\beta^I = \left(\frac{U}{\pi^\alpha}\right)^{\frac{1}{1-\alpha}}$ with U evaluated at the candidate symmetric solution. We next calculated the equation for the feasible quota locus, $\beta^C(\pi)$. We then subtracted β^C from β^I for all possible π consistent with choice of any quota between 0 and $\hat{x}_2$. In order for $\bar{q}^*$ to be an equilibrium, then $\beta^I - \beta^C \geq 0$ for all possible values of π (corresponding to alternative quota choices by Government A). The same procedure was used to check whether $(0, 0)$ or $(\hat{x}_2, \hat{x}_2)$ is an equilibrium.

Large declines in tariffs clearly bring quotas (for instance, when t is low and α is high). But small declines in tariffs can also lead to the use of quotas. This is the case when t is not too high near the locus that eliminates trade, where little tariff liberalization occurs.

Result 5: *Quotas applied on top of the cooperative tariff, τ^{**}, can lead to a net trade expansion effect or to a net decline in trade as compared to the non-cooperative tariff equilibrium.*

Indeed there exist industries (i.e., (α, t) combinations) where no quotas are used even though $\tau^{**} < \tau^{*}$. In such sectors, trade liberalization leads to trade expansion. For this to happen, low α is a sufficient but not a necessary condition. In particular, high feasible values of α and t may imply no quotas as well. In other industries (high α and low t), quotas are prohibitive, increasing protection with respect to τ^{*}.[20] When quotas are binding, it can be easily shown that, for most $(\alpha,\ t)$ pairs, the combined effect of $\bar{q}$ and τ^{**} results in an increase in trade as compared to τ^{*}. It is only near the border separating the prohibitive from the binding quotas that protection increases with quotas.

Figure 4 also has something to say about decreases in transport cost t.

Result 6: *Lower t not only may lead to quotas but may also lead to stricter quotas under the cooperative tariff equilibrium.*

Result 6 is immediate from inspection of Figure 4. If α and t are high, the equilibrium involves no quotas. Lower t, however, may bring binding, and even prohibitive, quotas. This contrasts with the non-cooperative tariff equilibrium where lower t never leads to quotas.

Result 7: *The set of industries in which a quota is used is a subset of the industries in which the non-cooperative tariff was positive.*

Although positive non-cooperative tariffs are used over much of the parameter space, once they are reduced through cooperative agreements, quotas will be applied to a substantially smaller set of industries. Hence, tariff liberalization, even though it may bring quotas for some industries, will be effective over most of the parameter space. This result depends on our assumption that quota rents are lost to foreign firms. If instead quotas were licensed off, using the logic of Hwang and Mai (1988), then quotas would be set so as to return to the effective tariff rate τ^{*} and the set of industries affected would be unchanged. We now investigate how antidumping measures may be applied after quantitative restrictions.

7. Antidumping Measures

Quotas have been used less frequently over the recent years. In large part this is due to constraints placed by GATT. As shown in the previous Section, a government would always prefer quotas to antidumping constraints. In this Section, we investigate whether the government would choose antidumping constraints if quotas were no longer available as a policy tool. One restriction on the use of quotas is a bilateral agreement not to use them, and return to the cooperative tariff alone. We consider here whether antidumping measures are imposed when τ^{**} is in place. We assume that antidumping restrictions are never violated if

[20] The Italian quota on Japanese automobiles (2,000 cars per year), and the prohibition to import certain types of vessels in the US are well-known examples of (quasi) prohibitive quotas.

imposed.[21] One interpretation is that violation of such a constraint would incur prohibitive penalties.[22]

Under an antidumping constraint, the restricted firm may either want to withdraw from its export market or else serve it without dumping. As shown in Appendix 1, the equilibrium involves the restricted firm selling in both markets when T^{**} is low enough. When T^{**} is large, the equilibrium involves the restricted firm selling only in its domestic market competing there with the other firm (the other firm being a monopolist at home).[23]

We begin by establishing two important implications of the model. If the quota equilibrium involves no quotas, then the best reply to no quota is no quota. This means that no quota is preferred to any binding quota, and we showed in Proposition 1 that an antidumping constraint is equivalent to a quota plus a loss to domestic firms in the foreign market. Thus, antidumping will never be used in response to no antidumping and no antidumping will be used if quotas were not optimal when they could be used. Hence, we can state that if the quota equilibrium involves no quotas, then no antidumping constraint will be used. The contra-positive to this last statement is:

Proposition 3: *If an antidumping constraint is desired, then the equilibrium to the quota game must involve binding quotas.*

This last proposition is important since it implies that the use of antidumping measures necessarily occurs for a *subset* of the parameter values (α, t) (for the Cobb-Douglas example) where a binding quota is used. Hence, the model exhibits not only a progression from tariffs to quotas and to antidumping, but the implication of this progression is that *the set of $(\alpha$, $t)$ over which a particular trade tool will be used will shrink with this progression.*

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21 We have not explicitly considered the implications of the foreign firm violating the antidumping constraint. In our equilibrium, the constraint is binding with equality so that the domestic firm could, if it wished, increase its home output slightly, reducing the domestic price and leading to a violation. And the domestic firm would wish to do this if it could thereby gain (as in Fischer (1992)). On the other hand, if there is no *direct* benefit to the domestic firm (for example, the foreign violator is fined or an antidumping duty kicks in) then there is no incentive to deviate from the equilibrium strategies described in the text.

22 See Fischer (1992) for an analysis of antidumping penalties when violation is only imperfectly observable. An alternative interpretation of the antidumping constraint is that a firm that violates (3.6) is hit with an antidumping duty to bring its price into line. Then the firm would face a duty (D) equal to the dumping margin $p_A - p_B - T_A$ and it would then be able to set the duty to zero by driving the dumping margin to zero. It would always want to do this (conditional on still selling in A) because its profit is $\pi_2 = (p_A - D - T_A)x_2 + p_B y_2$, with the $D = p_A - p_B - T_A \geq 0$. Substituting the equation determining D into π_2 yields $\pi_2 = p_B(x_2 + y_2)$. Since this expression is increasing in x_2 (p_B being independent of x_2), then Firm 2 would always want to increase x_2 so far as to render D equal to zero. But this is equivalent to facing the antidumping constraint.

23 There is a small gap between the values of T^{**} for which the equilibrium entails the restricted firm trading and not trading (i.e., $T_u < T^{**} < T_l$; see Appendix 1). In this range, there is no pure strategy equilibrium for firms. This is because when $T^{**} < T_l$, the restricted firm wants to export to market A if we start from a situation in which Firm 1 is a monopolist in A and there is duopoly competition in B. However, to satisfy the antidumping constraint, Firm 2 must increase its domestic output to lower the price in B. In a Cournot game, Firm 1 responds by reducing y_1 and the equilibrium, conditional on Firm 2 selling in both markets, has lower y_1. When $T^{**} > T_u$, it then pays Firm 2 to give up its export market and sell only at home. There is, of course, a mixed strategy equilibrium for $T^{**} \epsilon (T_u, T_l)$. However, since this range is very small with respect to the entire parameter space, and since there are more interesting features of the model, we shall ignore this range.

We now determine the set of parameter values in the Cobb-Douglas example for which one country wishes to impose an antidumping constraint given the presence of the cooperative tariff τ^{**}. We show in Appendix 1 that an antidumping constraint either causes the foreign firm to abandon its export market (if $T^{**} > T_l \approx 0.175$), or to still serve both markets (for $T^{**} < T_u \approx 0.168$). In the latter case there are still imports in the protected market but at a much lower level since $p^* = p - T^{**}$.

The regions of the parameter space for which either country prefers to invoke an antidumping constraint (given the other does not) are shown by regions I and II in Figure 4: in region II, the constraint still involves bilateral trade, while the foreign firm is effectively debarred in region I.[24] These two regions depend on T^{**} and thus on τ^{**}. In region II, $\tau^{**} = 0$, whereas τ^{**} is either zero or takes a low positive value in region I. The incentive to introduce antidumping measures is thus only consistent with intermediate values of T^{**}. When T^{**} is low, the dumping margin is too low to compensate for the distortionary effect of an antidumping constraint. When T^{**} is high (for high t), the foreign firm responds by discontinuing exports. This creates a monopoly at home and a significant loss in consumer benefits that for intermediate values of α cannot be offset by the resulting increase in domestic firm profit. Given these individual incentives, there is clearly an equilibrium *without* antidumping measures outside these two regions (subject to the caveat of note 23). Inside the regions, equilibrium involves one or both countries using the constraint, or else a mixed strategy equilibrium in constraints.[25] Whatever the outcome, trade is significantly curtailed. Inspection of Figure 4 yields the following results:

Result 8:

(i) Antidumping measures may be not used even when quotas would be prohibitive.

(ii) Antidumping measures that eliminate trade may be used when the quota equilibrium involves positive binding quotas, or prohibitive quotas.

Obviously, the desire to introduce antidumping constraints is present over a small subset of the parameter space as compared to quotas. This is due to the fact that antidumping restrictions have a strong negative effect on the domestic firm's profit from export. This lowers significantly the domestic authorities' incentive to introduce such a constraint.

8. Conclusions

In this paper we have taken a simple view of how the pattern and the degree of protectionism have evolved. The analysis is based on a model of governments that resolve trade-offs between surpluses of various interest groups. We have taken a broad view that clearly neglects many of the details of particular industries. The model still affords a characterization

[24] Cases where antidumping constraints eliminate trade have been noted in the literature. Hansen and Prusa (1995) cite the case of imports of Mexican fresh-cut flowers in the United States decreasing by 98% following antidumping action and Braga and Silber (1993) discusses the case of imports of Brazilian frozen concentrated orange juice in Australia.

[25] For example, it is straightforward (but lengthy) to show that the equilibrium in region I involves both countries imposing antidumping constraints. Note also that, in region II, there cannot exist an equilibrium in pure strategies at which both countries impose a constraint and both firms trade.

of how different industries are affected by the various waves of protectionism. This allowed us to track the stylized facts quite well.

First, governments have no incentive to use quotas or antidumping restrictions when they unilaterally choose from a menu of trade policies that includes tariffs. However, once tariffs are set cooperatively, governments may then wish to introduce NTBs. Second, if they have the choice, policymakers prefer quotas to antidumping restrictions. Antidumping constraints may be used only when the use of quotas is sufficiently restricted. Third, the set of parameter values over which non-cooperative tariffs are positive is wider than that where quotas are used which, in turn, is wider than for antidumping restrictions. Hence, the model exhibits both a progression from non-cooperative tariffs to quotas and antidumping restrictions, and a convergence to freer trade as each trade tool is associated with a smaller set of parameter values where it will be used. Fourth, as shown in the empirical literature, net protection may increase in some sectors and decrease in others.

Clearly, without knowledge of the empirical distribution of industries over the parameter space, the model cannot predict whether tariff liberalization will ultimately lead to a net expansion or a net contraction in aggregate trade. However, the model suggests that tariff liberalization will be associated with an overall trade expansion despite the endogenous emergence of NTBs for a relatively even distribution of industries over the parameter space (α, t). There is thus no law of constant protection in this model.

Interesting results at the industry level have also been obtained about the links between the degree of tariff liberalization and the use of NTBs. In particular, the highest degrees of tariff liberalization are associated with low values of t and high values of α. It is also in this region that the endogenous replacement by NTBs is the strongest, particularly with quotas. If one interprets low t as reflecting high competition especially from abroad, the model predicts a strong degree of replacement, and even overshooting, between NTBs and tariffs for more competitive industries (that governments are sensitive about). By contrast, when competition within an industry is lower (t is higher), tariff liberalization is lower, and the endogenous response of NTBs is in general more modest and even nonexistent with antidumping: NTBs serve to partially offset tariff liberalization and, in some cases to increase net protection. These predictions are in line with the empirical evidence, especially that of Marvel and Ray (1983). These authors also find that NTBs are predominantly found in more competitive industries. Our explanation for this result is that trade is efficient in such industries, which induces governments to jointly set a low cooperative rate. This creates a strong incentive for individual countries to use NTBs, especially if governments weigh firm profits quite heavily.

The model is simple and some of its features are instrumental to the results while others are not. The international duopoly framework simplifies the analysis. While there are many highly concentrated industries where NTBs have been used (steel, semi-conductors, tapered roller bearings; see Nieberding (1999) for an analysis at the firm level for some of these industries), our main results do not depend on a duopoly market structure. In particular, both the progression of trade instruments and the narrowing of affected industries should hold with an arbitrary number of domestic and foreign firms since, for a Cournot game among firms, these results depend only on the nature of the trade instruments. However, the results may be sensitive to the model of strategic interaction among firms. Cournot rivalry implies that quotas are equivalent to tariffs and this is helpful to get the progression of trade tools. Had we assumed Bertrand rivalry, the equivalence of tariffs and quotas would no longer hold and it is possible that quotas would be used in addition to tariffs at a non-cooperative equilibrium; however antidumping would still be less efficient than quotas. A possible extension of the present model would be to work with a more elaborate model of government preferences and in particular with one involving trade offs in consumer surplus across industries. Still, the present model provides a useful benchmark which allows for interior solutions with NTBs and that captures well the stylized facts reviewed in Section 2. Our analysis also suggests that, even if future rounds of negotiations succeed in curbing the use of antidumping measures, other tools, possibly even less efficient than antidumping restrictions, are likely to emerge.

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Appendix 1: Antidumping

An antidumping measure by A forces Firm 2 either to satisfy the constraint in order to sell in A, or else to stop exporting to A. We derive the parameter values under which each of these two cases arises.

i) Antidumping with trade: Firm 2's problem is

$$\max_{x_2,y_2} \quad \pi_2 = (1-y_1-y_2)y_2+(1-x_1-x_2-T)x_2 \quad \text{s.t.} \quad 1-y_1-y_2 \leq 1-x_1-x_2-T. \tag{8.1}$$

Firm 1 solves its unconstrained Cournot problem. The solution to this game is $x_2 = \frac{1-5T}{3}$, $y_2 = \frac{1+4T}{3}$, $x_1 = \frac{2+5T}{6}$, $y_1 = \frac{2-7T}{6}$ with $\pi_2 = 2(1-y_1-y_2)^2 = \frac{2}{9}(2-4T-3y_1)^2$. This is an equilibrium if Firm 2 does not prefer to deviate and sell in F only, given Firm 1's outputs x_1 and x_2 above. Firm 2's profit if it sells only in F is $\frac{(1-y_1)^2}{4}$. Given $y_1 = \frac{2-7T}{6}$, Firm 2 finds it more profitable to trade (i.e., $\frac{2}{9}(2-4T-3y_1)^2 > \frac{(1-y_1)^2}{4}$) if $T \leq T_u = \frac{4}{41}(-11+\sqrt{162}) \approx .1685$.

Using (3.2), note that $x_1 + x_2 < \hat{x}_1 + \hat{x}_2 < y_1 + y_2$, so that an antidumping measure introduced by A decreases total output in A and increases total output in B. Moreover, $y_2 > \hat{y}_2$ $(= \hat{x}_1)$ and $x_2 < \hat{x}_2$: an antidumping restriction on Firm 2 reduces its sales to A and increases them in B (Firm 2's domestic market).

ii) Antidumping without trade: Firm 2's problem is to maximize $\pi_2 = (1-y_1-y_2)y_2$ with respect to y_2. (Firm 1's problem is the same as above.) Hence, $y_2 = \frac{1-y_1}{2}$ and $\pi_2 = \frac{(1-y_1)^2}{4} = \frac{(1+T)^2}{9}$ since Firm 1 sells its unconstrained Cournot quantity $y_1 = \frac{1-y_2-T}{2} = \frac{1-2T}{3}$ in B and is a monopolist ($x_1 = \frac{1}{2}$) in A. This is an equilibrium if Firm 2 has no incentive to deviate and satisfy the antidumping constraint given the outputs sold by Firm 1 when Firm 2 does not trade. Solving problem (8.1) given $y_1 = \frac{1-2T}{3}$ and $x_1 = \frac{1}{2}$, $\pi_2 = \frac{(7-2T)^2}{288}$. This is less than $\frac{(1+T)^2}{9}$ if $T > T_l$ where $T_l = \frac{9\sqrt{8}-23}{14} \approx 0.175$.

Appendix 2: Comparative Statics of the Noncooperative Tariff Model

The comparative static properties follow from (4.4).

(i) We first note that

$$\frac{\partial f}{\partial \tau_B} = -\frac{4}{9}(1-2T_B)(\beta_A' U_{\beta\pi} + \pi_1' U_{\pi\pi}), \tag{8.2}$$

which is necessarily positive since $T_B < \frac{1}{2}$, $\beta_A' < 0$, $\pi_1' > 0$, while $U_{\beta\pi} \geq 0$ and $U_{\pi\pi} < 0$. Hence the tariff reaction function slopes up because $\frac{d\tau_A^*}{d\tau_B} = -\frac{\partial f/\partial \tau_B}{\partial f/\partial \tau_A}$ and the denominator is negative by the second-order condition.

(ii) Next, consider the stability of the tariff equilibrium, τ^*. The stability condition holds if the reaction function has slope less than unity at $\tau^* = \tau_A = \tau_B$; that is $-\frac{\partial f/\partial \tau_B}{\partial f/\partial \tau_B} < 1$, or, equivalently, $\frac{\partial f}{\partial \tau_B} + \frac{\partial f}{\partial \tau_A} < 0$. Writing out the latter condition, we have to show that

$$\left[U_\beta \beta_A'' + U_\pi \pi_1''\right] + \left[U_{\beta\beta}(\beta_A')^2 + (\frac{12T}{9})U_{\beta\pi}\beta_A' + (\frac{10T-2}{9})U_{\pi\pi}\pi_1'\right] < 0. \tag{8.3}$$

We shall show that each expression in square brackets is negative. The first one reduces to $-11U_\beta+2U_\pi < 0$. Given the first-order condition (4.4), or $(1-5T^*-6\tau^*)U_\beta+2(1+T^*)U_\pi = 0$, we must show that

$$\frac{11}{2} > \frac{U_\pi}{U_\beta} = -\frac{1-5T^*-6\tau^*}{2(1+T^*)}. \tag{8.4}$$

Cross multiplying, and recalling $T^* = \tau^* + t$, this reduces to $2 + t > 0$, which necessarily holds since $t \geq 0$.

Now consider the second term in square brackets in (8.3). This is clearly negative (recalling the sign pattern given after (8.2), along with $U_{\beta\beta} < 0$) for $T \geq \frac{1}{5}$, and thus for $t \geq \frac{1}{5}$ (see (4.3)). For $t < \frac{1}{5}$, we use the Cobb-Douglas form under the restriction $\alpha \geq \frac{1}{3}$ as a sufficient condition. The condition we wish to prove is then

$$\alpha(1-\alpha)U\left\{-(\frac{\beta_A'}{\beta_A})^2 + (\frac{12T}{9})\frac{\beta_A'}{\pi_1\beta_A} - (\frac{10T-2}{9})\frac{\pi_1'}{\pi_1^2}\right\} < 0. \tag{8.5}$$

Since

$$(1-\alpha)\frac{\beta_A'}{\beta_A} = -\alpha\frac{\pi_1'}{\pi_1} \tag{8.6}$$

from the first-order condition (4.4), we can substitute and take out a factor $\frac{\beta_A'}{9\beta_A\pi_1} < 0$ from (8.5) so it remains to show that the remaining term

$$2(\frac{\alpha}{1-\alpha})(1+T) + 12T + (\frac{1-\alpha}{\alpha})(10T-2) > 0. \tag{8.7}$$

The LHS of (8.7) is increasing in T, so consider the lowest possible value of T, $T = \frac{1}{11}$. The LHS then takes the value $12(2A + 1 - \frac{1}{A})$, where $A \equiv \frac{\alpha}{1-\alpha} > 0$. This expression is non-negative as long as $2A^2 + A - 1 \geq 0$, which clearly holds for $A \geq \frac{1}{2}$, and thus for $\alpha \geq \frac{1}{3}$.

(iii) We now show that $\frac{d\tau^*}{dt} < 0$. Since any equilibrium is necessarily symmetric, (4.4) holds along with $\tau_A - \tau_B = 0$. Totally differentiating gives

$$\begin{bmatrix} \frac{\partial f}{\partial \tau_A} & \frac{\partial f}{\partial \tau_B} \\ 1 & -1 \end{bmatrix} \begin{bmatrix} d\tau_A \\ d\tau_B \end{bmatrix} = \begin{bmatrix} -\frac{\partial f}{\partial t} \\ 0 \end{bmatrix} dt, \tag{8.8}$$

and hence

$$\frac{d\tau^*}{dt} = -\frac{\partial f/\partial t}{\partial f/\partial\tau_A + \partial f/\partial\tau_B}. \tag{8.9}$$

The denominator is negative by (ii) above, so it suffices to show that $\partial f/\partial t < 0$. Evaluating this expression at a symmetric solution,

$$\begin{aligned} \frac{\partial f}{\partial t} &= \frac{1}{9}\left[-5U_\beta + 2U_\pi\right] \\ &+ \left[(\frac{-2+T-6\tau}{9})U_{\beta\beta}\beta_A' + (\frac{10T-2}{9})U_{\pi\pi}\pi_1' + U_{\pi\beta}\left\{(\frac{10T-2}{9})\beta_A' + (\frac{-2+T-6\tau}{9})\pi_1'\right\}\right]. \end{aligned} \tag{8.10}$$

The first square bracketed expression is negative by an argument similar to that used in (ii): we must show that

$$\frac{5}{2} > \frac{U_\pi}{U_\beta} = -\frac{1-5T^*-6\tau^*}{2(1+T^*)}, \tag{8.11}$$

which reduces to $\tau^* < 1$, and holds since $T^* \leq \frac{1}{2}$.

Thus it suffices that the second term in parentheses in (8.10) be non-positive. First note that the term $(-2+T-6\tau) < 0$ since $6\tau \geq 1-5T > -2+T$, where the first inequality follows from the condition $\beta'_A \leq 0$, and the second from the condition that $T \leq \frac{1}{2}$. Hence, for $10T-2 \geq 0$ (or $t \geq \frac{1}{5}$, as in part (ii)), the term is indeed non-positive. Again in parallel to (ii), we invoke the Cobb-Douglas form with $\alpha \geq \frac{1}{3}$ to prove the case $t < \frac{1}{5}$ and $T < \frac{1}{5}$. For the Cobb-Douglas, we have to show

$$\frac{\alpha(1-\alpha)U}{9}\left\{-\frac{\beta'_A}{(\beta_A)^2}(-2+T-6\tau) + \frac{(10T-2)\beta'_A + (-2+T-6\tau)\pi'_1}{\pi_1\beta_A} - (10T-2)\frac{\pi'_1}{\pi_1^2}\right\} < 0. \tag{8.12}$$

Using (8.6), and pulling out a factor $\frac{2}{\pi_1\beta_A} > 0$, it suffices that

$$\frac{1}{1-\alpha}\pi'_1(-2+T-6\tau) + \frac{1}{\alpha}\beta'_A(10T-2) < 0, \tag{8.13}$$

or

$$A(1+T)(-2+T-6\tau) + (1-5T-6\tau)(5T-1) < 0, \tag{8.14}$$

(where we recall $A \equiv \frac{\alpha}{1-\alpha}$). Since the LHS of (8.14) is decreasing in A, it must hold for all $A \geq \frac{1}{2}$ (equivalently, $\alpha \geq \frac{1}{3}$) if (8.14) holds at $A = \frac{1}{2}$, i.e., if

$$(-4+19T-49T^2) + 6\tau(1-11T) < 0. \tag{8.15}$$

The first term (in parentheses) is necessarily negative because $T \leq \frac{1}{5}$ for the case under consideration. For the second term, we know $(1-11T) < 0$ by (4.3), and, since $t < \frac{1}{5}$ for the case under consideration, $\tau \geq 0$ by (4.2).

(iv) Lastly, we show $\frac{d\tau^*}{dt} > -1$, so that, in conjunction with (iii), tariffs replace transport costs, but not completely. The expression for $\frac{d\tau^*}{dt}$ is given by (8.15), so we wish to show that

$$\frac{\partial f}{\partial \tau_A} + \frac{\partial f}{\partial \tau_B} - \frac{\partial f}{\partial t} < 0, \tag{8.16}$$

where the first two terms on the LHS are given by (8.3) and the last one is given by (8.10). Putting these together allows us to write (8.16) as

$$-2U_\beta + (1-2T)[U_{\beta\beta}\beta'_A + U_{\beta\pi}\pi'_1] < 0. \tag{8.17}$$

Once again, we can use the Cobb-Douglas form and the first-order condition (8.6) to rewrite the desired condition as

$$-2 + (1-2T)\frac{\pi'_1}{\pi_1}\frac{\alpha}{1-\alpha} < 0. \tag{8.18}$$

The LHS is increasing in $A \equiv \frac{\alpha}{1-\alpha}$, so that if it holds at $A = 2$, corresponding to $\alpha = \frac{2}{3}$, it holds for all $\alpha \leq \frac{2}{3}$. The sufficient condition is then (substituting in for π_1 and π_1'):

$$-(1+T)^2 - (1-2T)^2 + 2(1-2T)(1+T) < 0. \tag{8.19}$$

It is easy to check that this expression reduces to $-(9T)^2$ which is necessarily negative as $T \geq \frac{1}{11}$. It can be shown that (8.18) also holds for $\frac{2}{3} \leq \alpha \leq \frac{1}{16}$ provided that T is greater than $\frac{1}{11}$. Using (5.8), $T^* > \frac{2}{5}$ in this range, a sufficient condition for (8.18) to hold. ■

Appendix 3: Feasible (π, β) Combinations for Cooperative Tariff Case

The value $t = \frac{1}{5}$ forms a boundary between the main cases, so we begin by describing the $(\pi,\ \beta)$ locus for that value. For $t = \frac{1}{5}$, if one graphs π and β as functions of τ, the former is minimized at $\tau = 0$ whereas the latter is maximized there, and both are symmetric. This means that in $(\pi,\ \beta)$ space, the feasible combinations comprise a linear segment (given by $\pi = \frac{4-10\beta}{11}$) with one end anchored where $\tau = 0$ (see Figure A.1). As τ rises, we move back up the locus to the point corresponding to $\tau = \frac{3}{10}$ ($T = \frac{1}{2}$) at which trade stops at domestic monopoly. Likewise, as τ falls from zero, we move back up the same locus, stopping where the subsidy is sufficiently great that the consumer benefits shrink to zero ($\tau = -\frac{27}{50}$). (The subsidy can go up to $\tau = -\frac{6}{5}$ or $T = -1$ at which point the domestic firm wipes out the foreign firm in the foreign firm's market.) Superimposing the indifference curve map will then lead to either a solution with $\tau^{**} = 0$ (for 'steep' indifference curves, or $\alpha \leq .55$ in the Cobb-Douglas example), or else a solution where the policymaker is indifferent between a strictly positive tariff and a strictly negative one. The highest value of τ^{**} (given $t = \frac{1}{5}$) is attained at $\alpha = \frac{11}{16}$, at which point $T = \frac{1}{2}$ and so the foreign firm is debarred. For $\alpha = \frac{11}{16}$ (the highest value we consider), the optimal negative tariff is $\tau^{**} = -\frac{3}{10}$.

[Insert Figures A.1 and A.2 about here]

For $t > \frac{1}{5}$, the graphs of β and π against τ show that β is maximized at a higher value ($\tau = \frac{1-5t}{11}$) than the value of τ that minimizes $\pi(\tau = \frac{1}{5} - t)$. The resulting feasible set of $(\pi,\ \beta)$ pairs is given in Figure A.2, from which it is clear that the optimum for $t > \frac{1}{5}$ must involve $\beta' < 0$ and $\pi' > 0$ along the locus LM (hence $\tau > \frac{1-5t}{11}$, although it is not necessarily positive). The diagram also shows the direction of increasing τ around the feasible locus. This implies that higher values of α yield higher values of τ.

For $t < \frac{1}{5}$, argmax $\beta(\tau) <$ argmin $\pi(\tau)$ so that the feasible locus has the same shape as in Figure 4 but counter-clockwise movements around it now correspond to decreasing τ. Note that the constraint locus is concave throughout in both cases. Hence, there is a unique point (the global maximum) that satisfies the first-order condition (5.1) together with $\beta' < 0$ and $\pi' > 0$ for $t > \frac{1}{5}$, and $\beta' > 0$ and $\pi' < 0$ for $t < \frac{1}{5}$. However the first-order condition may also pick up local maxima (on the dominated part of the locus) or local minima.

Figure 1

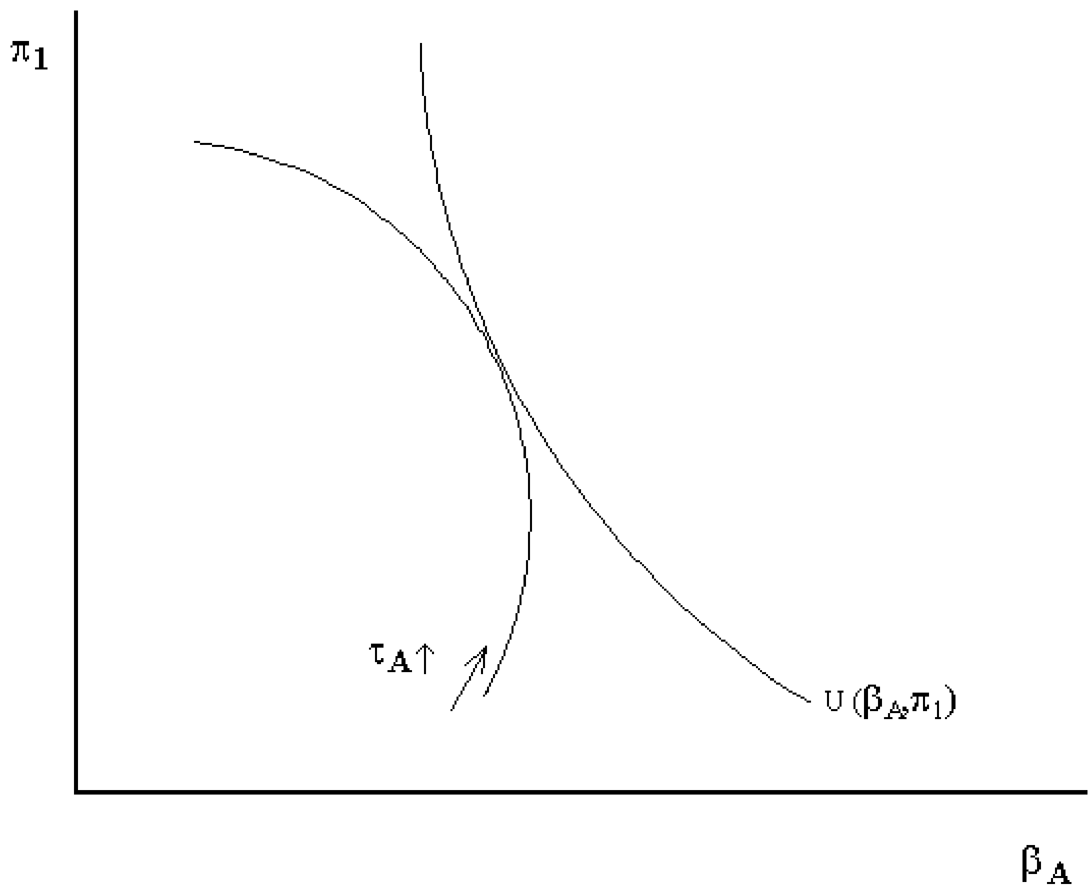
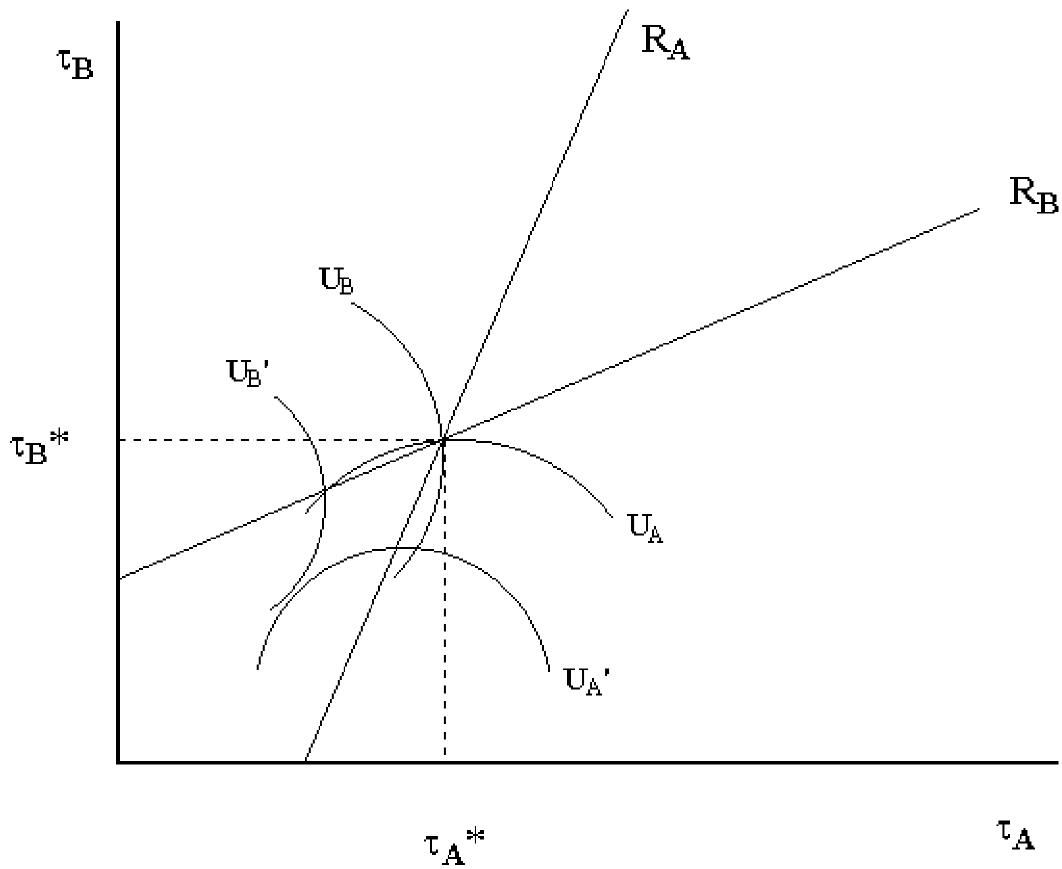


Figure 1: Determination of the Non-Cooperative Tariff Rate

Figure 2



$U_A' > U_A$, $U_B' > U_B$

Figure 2: Tariff Equilibrium and Indifference Curves

Figure 3

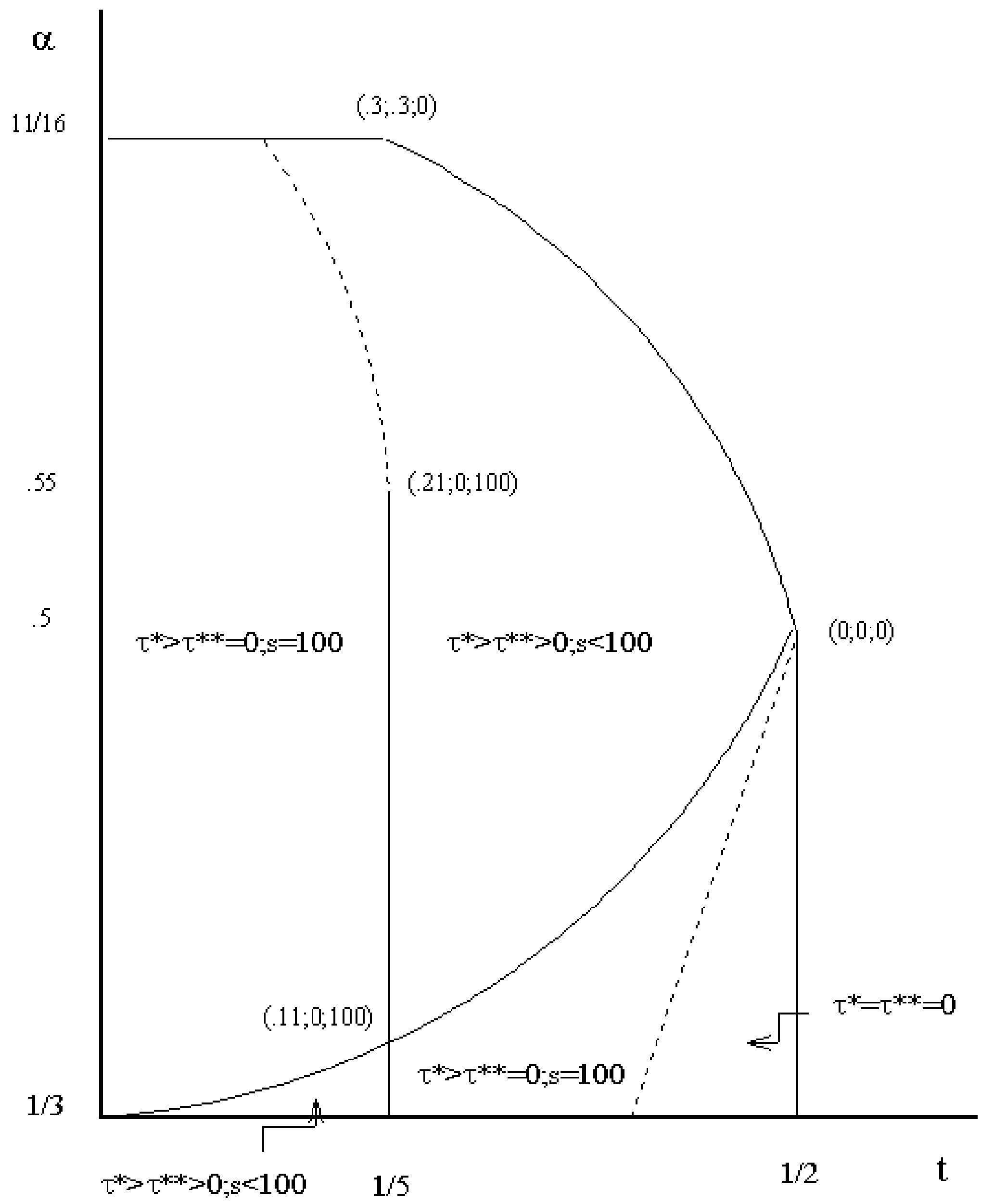


Figure 3: Cooperative and Non-Cooperative Tariff Rates

Figure 4

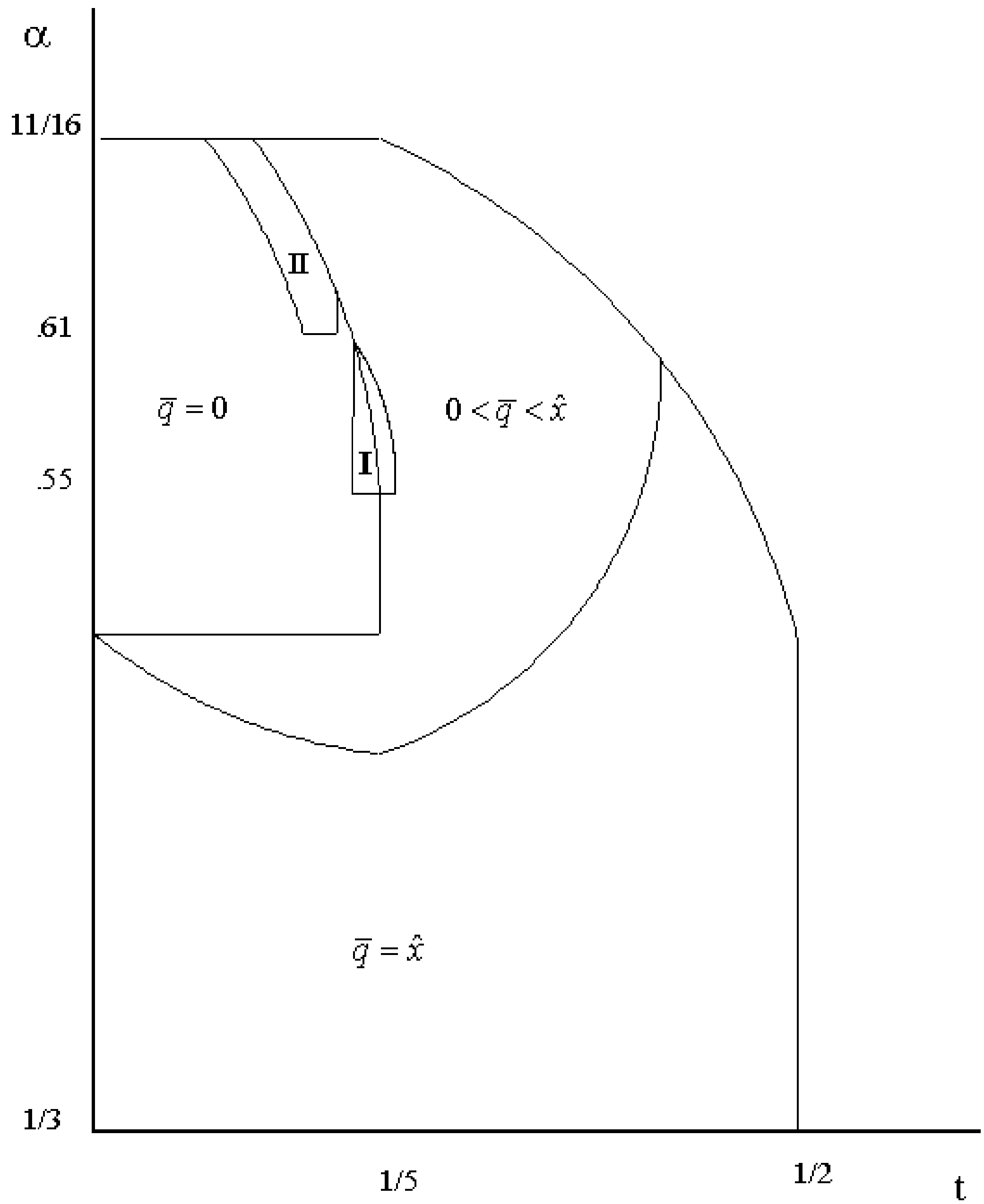


Figure 4: Quotas and Antidumping ($\tau^{**} \geq 0$)

Figure A.1

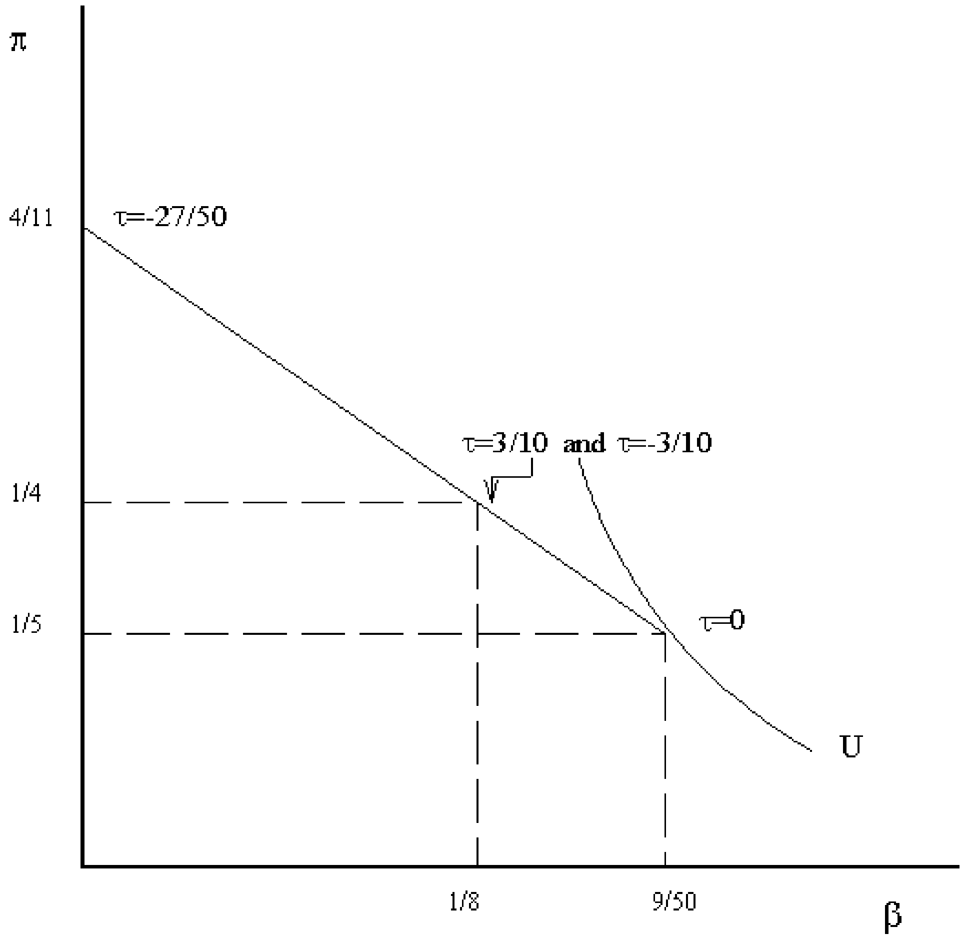


Figure A.1: Determination of the Cooperative Tariff Rate (t=1/5)

Figure A.2

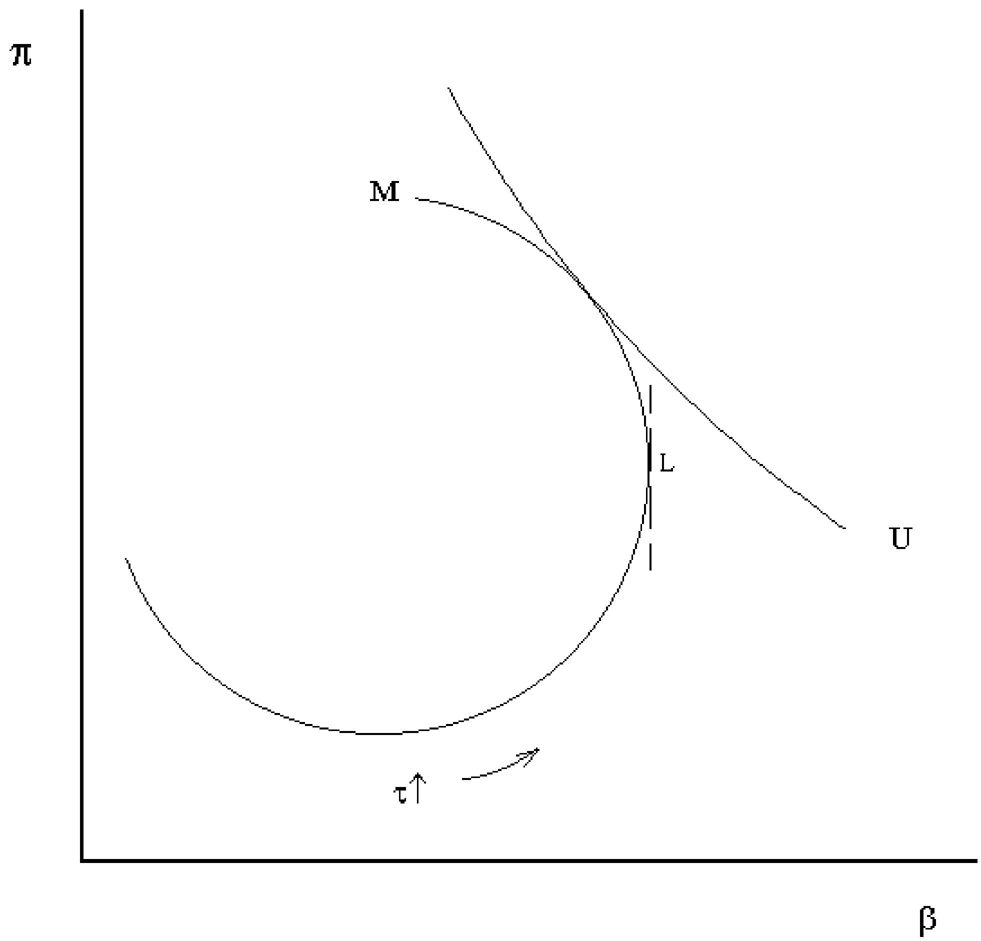


Figure A.2: Determination of the Cooperative Tariff Rate (t>1/5)