

**DUMPING AND DOUBLE CROSSING: THE (IN)EFFECTIVENESS  
OF COST-BASED TRADE POLICY UNDER INCOMPLETE  
INFORMATION\***

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We argue that the rise of antidumping protection and the proliferation of voluntary export restraints (VERs) are fundamentally interrelated. We show that both can be explained by a cost-based definition of dumping when the domestic government has incomplete information about the foreign firm's costs. Given that its costs are only imperfectly observed and knowing the government's incentives to protect, efficient foreign firms will voluntarily restrain their exports prior to the antidumping investigation. In turn, the VER distorts the government's perception of the foreign firm's efficiency and leads to undesirably high duties regardless of the foreign firm's efficiency.

1. INTRODUCTION

In this article, we show that the two most widely given explanations for the rise of protection over the past 20 years—antidumping (AD) protection and voluntary export restraints (VERs)—are fundamentally interrelated.<sup>2</sup> We argue that VERs are a natural consequence of cost-based AD legislation. Specifically, when governments implement cost-based AD under incomplete information about foreign costs, foreign firms undertake VERs in an attempt to convince domestic authorities that they are not competitive threats. In fact, we show that although cost-based AD raises welfare under complete information, the distortions inherent with implementing it under incomplete information make it an undesirable policy.

Three important institutional characteristics of AD law motivate our approach. First, cost-based AD petitions have become “the dominant feature of U.S. antidumping law” (Horlick, 1989, p. 136). Traditionally, dumping was defined as

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<sup>2</sup> Almost 10 percent of U.S. imports were covered by antidumping orders in 1990, almost triple the coverage in 1980. During the same period, the number of VERs doubled (Krueger, 1995; Low, 1993).

international price discrimination, but in 1974 the definition was broadened to include sales below cost. According to Clarida (1996), since 1980 between one-half and two-thirds of U.S. AD cases have been conducted using the cost-based definition of dumping.<sup>3</sup> Not coincidentally, Bhagwati (1988) and Krueger (1995) both date the rapid increase in high-track (VERs) and low-track (AD duties) restraints to the mid-1970s. From this perspective, if one seeks to understand the rise of AD protection and the proliferation of VERs, cost-based AD policy is a sensible place to start.

Second, governments implement cost-based dumping under incomplete information. Under cost-based dumping, the domestic government estimates the foreign firm's production costs and then constructs an AD duty designed to insure that the exporter's price is "fair." Not surprisingly, the ambiguous nature of estimating the foreign firm's costs is the source of numerous complaints. Foreign defendants often claim that estimated costs have nothing to do with their actual costs. Rules such as the use of "best information available," which bases the cost estimate on the *domestic* firm's estimate of foreign costs, and *ad hoc* methods such as basing cost estimates on third market surrogates make AD procedures quite capricious.

Third, foreign firms often undertake VERs prior to any AD investigation hoping to appease domestic cries for protection. For instance, the 1981 automobile VER, perhaps the best-known VER, was negotiated under the threat of an AD action. Similarly, many of the steel restraints undertaken in the mid-1980s were negotiated under the threat of imminent AD action. Krueger (1995, p. 35) states that "*threats* of administered protection have induced trading partners to accept other bilateral measures, such as VERs" (emphasis added). A senior negotiator in the semiconductor dispute stated that the U.S. industry used "the *threat* of the dumping case to stimulate broad negotiations on all aspects of the problem" (Prestowitz, 1988, p. 196, emphasis added). Recently it was noted that the "threat of U.S. antidumping duties" caused U.S. steel imports to sharply fall (Lawrence, 1999, p. 9). In all of these cases, the VER was conceived of as a "pressure-release valve," where foreign firms reduce exports until protectionist sentiments subside.<sup>4</sup>

The starting point for our analysis is the long understood insight that governments have an incentive to implement cost-contingent protection (Brander and Spencer, 1984). We interpret cost-based AD as a GATT/WTO-sanctioned vehicle for implementing a cost-contingent tariff policy. Although this interpretation of cost-based procedures differs from GATT guidelines, many Department of Commerce (DOC) decisions are so perplexing that our interpretation is a plausible view of how AD is implemented in practice (Boltuck and Litan, 1991).

<sup>3</sup> Note also that the European Community (EC), the other major user of AD, has similarly embraced cost-based methodology. Messerlin (1989) estimates that over 90 percent of EC cases against developing countries are based on constructed costs.

<sup>4</sup> The view that AD actions are often motivated to restrain imports rather than offset unfair trade is widely held. In describing the United States' reluctance to amend AD rules, it was reported that "antidumping is the most convenient way of controlling the influx of low-priced goods" (*Korea Times*, 11/26/1999). In fact, the U.S. Trade Representative conceded that "antidumping rules are not intended as a remedy for predatory pricing practices." (*New Republic*, 11/01/1999, p. 16). Another expert estimated that "95 percent of AD investigations initiated resulted from irregular trade volume and only 5 percent due to pricing irregularities" (*The Nation*, 09/07/1999).

We also suppose that the home government cannot observe the foreign firm's costs; we show that this induces the foreign firm to announce a VER in order to signal its (in)efficiency in an attempt to reduce the size of the potential duty. Interestingly, as is often the case in practice, we find that the VER fails to release the protectionist pressures, and domestic industries clamor for more protection. A review of AD cases suggests that preemptive export restraints have only had mixed success at averting AD investigations. As a noted AD expert stated, VERs "have certainly been instrumental in preventing a number of antidumping proceedings from arising, but (they are not) . . . a substitute for relief" (Bellis, 1989, p. 54).

Our approach differs from Harris (1985) and Krishna (1989), who emphasize the collusive and cartel-enhancing features of VERs.<sup>5</sup> Although the facilitating practice explanation is a powerful *ex post* justification for VERs, we have found no evidence that collusion was the original motivation for a VER at the outset of any trade dispute.

Our article complements the recent work by Yano (1989), Anderson (1992), and Rosendorff (1996). Yano's and Anderson's models show that the expectation of a VER can intensify competition. Rosendorff assumes that the domestic government has a political incentive to increase the profits of the domestic firm and hence, is willing to offer a lower AD duty in return for a VER.<sup>6</sup> Our article also complements a growing body of work incorporating incomplete information in strategic trade policy models (Qiu, 1994; Collie and Hviid, 1993, 1994; Brainard and Martimort, 1997).

Our analysis is also of interest from a technical viewpoint. We show that the standard "single crossing" property (also referred to as the Spence–Mirrlees sorting condition) does not hold globally in our model. In our context, a key issue is the extent to which producers are willing to restrain exports in order to avoid the AD duty. For a given duty, if at every quantity level inefficient producers were more willing to restrain output than more efficient producers, then the single crossing condition would be satisfied. We demonstrate that single crossing does not hold for all parameter values and that producers' preferences are characterized by a "double crossing" property.

If the model were characterized by single crossing, it is well known from the work of Cho and Sobel (1990) that the stable equilibrium involves separation, albeit with some distortion to trade. If this were the case, then cost-based AD could be justified, at least to the extent that duties were being levied optimally. We show that double crossing inhibits firms' ability to separate and leads to pooling. This in turn implies AD duties are levied suboptimally. Thus, distortions occur before and after the investigation, making cost-based AD a particularly futile policy.<sup>7</sup>

<sup>5</sup> Staiger and Wolak (1989, 1992) and Prusa (1992) also emphasize AD's role for maintaining cartels.

<sup>6</sup> In his model, not only does the informational structure of the game differ from ours, but the policy choices available to each player are different. In terms of policy choices, Rosendorff (1996) is similar to Qiu (1994).

<sup>7</sup> For models where single crossing fails, see Bernheim (1991, 1994). The properties of our model are closest to those of Cho (1994) who revisits the limit pricing argument of Milgrom and Roberts (1982).

The article proceeds as follows. In Section 2, we describe the extensive form of the game and in Section 3, we solve for the unique equilibrium behavior of the players once the dumping case is completed. In Section 4, we provide the solution to the model and in Section 5, we show that a pooling outcome emerges under most reasonable demand and cost parameter values. The welfare implications of cost-based AD are discussed in Section 6. Policy implications and the applicability of our findings to other economic issues are discussed in Section 7.

## 2. THE MODEL

We describe a scenario where a single foreign producer competes against a home firm under the scrutiny of the home government. Broadly speaking, the game can be thought of as occurring in two distinct phases: pre-AD and post-AD determination. During the first part of the game, the foreign firm is aware of the build-up of protectionist pressure. It also understands the home country's rent-extracting and profit-shifting incentives for implementing an AD policy where lower cost firms will be subject to higher AD duties. Thus, during the first part of the game, the foreign firm's export decision is strategic since it can influence the government's posterior beliefs about the foreign firm's efficiency. We will show that the export decision involves a choice of either myopic profit maximization or a VER that might conceal the firm's true type and alleviate protectionist sentiments.

The extensive form of the game has the following structure. The foreign firm's constant marginal cost is drawn from the set  $\mathcal{T} = \{C_1, \dots, C_T\}$ , with  $C_i < C_j$  for  $i < j$ , according to a commonly known probability distribution,  $\mu$ . The realization of the cost is private information for the exporter and will be referred to as its type. For simplicity, we will use  $i$  to denote the type of exporter with true cost  $C_i$ .

In the first period, we assume that the foreign firm's exports are subject to a specific tariff of  $\tau_0 \geq 0$ . Given this information, the foreign firm chooses and announces its first period export quantity,  $Q$ . Following the decision of its rival, the home firm chooses its first period quantity,  $q$ .

At the conclusion of the first stage, the government observes the level of imports and home production and then forms beliefs about the efficiency of the foreign firm. If an AD petition is filed, the government selects a per unit AD duty,  $\tau_D \geq 0$ , which will remain in effect during the next  $N$  periods of trade. Given the level of the AD duty, the two firms compete simultaneously in quantities for the remainder of the game.

A couple of comments about the design of the game are in order. First, we are modeling a situation where the home government has an AD statute and the home firm has an opportunity to file an AD petition at the end of the first period. As discussed above, it is not the foreign firm's costs per se that are the impetus for the investigation, but rather the high level of trade associated with an efficient firm. Thus, the foreign firm has an incentive to voluntarily restrict its exports in order to reduce the potential duty. Moreover, it is common knowledge that the foreign firm is likely to announce a VER; therefore it is natural to assume that the home firm will wait to observe the foreign firm's actions before proceeding with first period

sales and its filing decision. Thus, we model the home firm as a Stackelberg follower.<sup>8</sup>

Second, as is common in the signaling literature, we assume that the home firm learns the true costs of the foreign firm after the AD investigation.<sup>9</sup>

Third, demand in the home country is assumed to be linear  $p = a - Q - q$ . This simple functional form will allow us to describe the behavior of the players without resorting to abstract arguments.

Fourth, our model is a signaling game with three players. The foreign firm (the sender) signals its type through its export choice; the home firm then chooses its output level and whether to file a petition; finally, the government (the receiver) levies an AD duty based on its beliefs about the type of the exporter. One can show that a strategy that is not a best reply for the government and the home firm to a given level of exports is strictly dominated, and also that the best reply function of the government is independent of the first period strategy of the home firm. As a result, our analysis essentially reduces to a two-player signaling game.

Finally, we will refine the set of sequential equilibria by eliminating those which assign unreasonable beliefs at null events (Cho and Kreps, 1987; Banks and Sobel, 1987). In particular, we will require the government to perceive each out-of-equilibrium quantity as a possible signal by the exporter and place probability zero on a type which is unlikely to send it. We thus use the  $D_1$  refinement, and throughout the remainder of the article, when we use terms like "equilibrium" and "outcome" we mean " $D_1$  equilibrium" and " $D_1$  outcome."<sup>10</sup>

### 3. ANALYSIS OF THE SUBGAME FOLLOWING THE AD PETITION

3.1. *Firm Decisions.* Since the subgame starting after the government chooses an AD duty has a finite number of periods,  $N$ , the linear structure of the model guarantees that it has a unique path which is part of a subgame perfect equilibrium.

In any stage  $n$  of this proper subgame, a type  $i$  foreign firm takes the total per unit levy,  $t = \tau_0 + \tau_D$ , as given and maximizes its (variable) profit function

$$\pi_i(Q, q, t) = Q(a - Q - q) - tQ - C_iQ$$

The per-period payoff for the domestic firm is

$$\phi(Q, q) = q(a - Q - q) - c_dq$$

where  $c_d$  denotes the domestic firm's marginal costs.

<sup>8</sup> Modeling the home firm as a Stackelberg follower is not uncommon (Rosendorff, 1996). Since there is no obvious reason to give any firm the advantage of a first mover in subsequent periods, we model the competition à la Cournot. Furthermore, the mode of competition is inessential for the analysis of the postduty subgame.

<sup>9</sup> If costs are not revealed after the determination is made, we would enter a typical limit-pricing game in which the efficient types would try to prove themselves. This would shift the analysis away from the issue at hand. Of course, such problems would not arise if competition continues to be sequential in future periods.

<sup>10</sup> Readers interested in a more extensive discussion of the equilibrium should consult the working paper version of this article, Kolev and Prusa (1999).

At each stage, the resulting optimum quantity for a type  $i$  exporter is

$$(1) \quad \tilde{Q}_i^n = (a + c_d - 2C_i - 2t)/3$$

and for the domestic firm is

$$(2) \quad \tilde{q}^n(i) = (a + C_i + t - 2c_d)/3$$

where we use the superscript  $n$  to denote that these are solutions to the subgame following the AD duty.

The total profit (over all  $N$  periods following the AD duty) for the foreign and domestic firms, respectively, is

$$(3) \quad N \cdot \tilde{\pi}_i^n = (N/9)(a + c_d - 2C_i - 2t)^2 \quad \text{and} \quad N \cdot \tilde{\phi}^n(i) = (N/9)(a + C_i + t - 2c_d)^2$$

**3.2. Optimal AD Duty.** As discussed earlier, we will assume that the government uses its cost-based policy to implement a duty that maximizes host country welfare. Although this assumption does not follow official AD procedures, it is consistent with the widespread opinion that the DOC levies AD duties in an arbitrary fashion (Boltuck and Litan, 1991), and is consistent with the desire for governments to devise efficient protection schemes.

Assuming for the moment that the host government could observe the true cost of the exporter, its payoff for the  $N$  period subgame would be the sum of consumer surplus, profit of the domestic producer and tariff revenue

$$(4) \quad w = N \left[ (Q + q)^2 / 2 + \phi(Q, q) + tQ \right]$$

Using the unique subgame outcomes, the welfare can be expressed as

$$(5) \quad w(i, t) = N \left[ (2a - C_i - c_d - t)^2 / 18 + (a + C_i + t - 2c_d)^2 / 9 + t(a + c_d - 2C_i - 2t) / 3 \right]$$

When an AD petition is filed, the government chooses  $\tau_D$  to maximize (5), yielding a total levy of

$$(6) \quad \tilde{t}_i = (a - C_i) / 3$$

The above expression makes it clear that higher duties are levied against more efficient exporters. If an efficient exporter does not voluntarily restrict first period exports and behave like a more inefficient exporter and if a petition is filed, the home government would levy an AD duty in the amount of  $\tau_D = \tilde{t}_i - \tau_0$ . From this point on, a total tariff  $t > \tau_0$  is to be understood as the initial tariff plus an AD surcharge equal to  $t - \tau_0$ . Hence we will use the terms tariff and duty interchangeably to describe the total level of protection. To keep the model as simple as possible, we will assume that  $\tau_0 \leq \tilde{t}_T$ , which implies that an AD petition will be filed against all types.<sup>11</sup>

<sup>11</sup> This is not a restrictive assumption since the most frequent users of cost-based AD, the United States and the EC, also have very low tariffs. In addition, a higher initial tariff would introduce another stage to the game without providing additional insight. At this stage, the domestic firm would make a decision whether to file a petition. Since the beliefs of the government are common knowledge in equilibrium, the firm would obviously file a petition if the beliefs entail a positive AD duty.

Finally, we note that the marginal benefit to the home country from lowering the AD duty is increasing in  $C_i$ . This implies that the government’s best response is monotonically decreasing in the posterior likelihood of a more inefficient exporter. This explains the desire of each type to be considered type  $T$ .

4. SOLUTION OF THE SUBGAME PRIOR TO THE AD PETITION

We will solve for the first stage equilibrium by breaking the problem into several steps. First, we will characterize the foreign firm’s isoprofit curves and show that the game falls into a subclass of signaling games with double crossing. Next, we will establish two conditions: a mimicking condition and a condition that in conjunction with the double crossing property implies that the most natural outcome is for all types to pool. Finally, we will describe the behavior of each type in the pooling outcome.

4.1. *Isoprofit Curves and the Double Crossing Property.* In the first period, a type  $i$  exporter knows that upon observing  $Q$ , the home firm will produce according to its best response function

$$(7) \quad \tilde{q} = (a - Q - c_d)/2$$

From this point on, we adopt the convention that if there is no time superscript, we are referring to first period variables.

The equilibrium first period profit of the foreign firm when producing  $Q$  is

$$(8) \quad \pi_i(Q) = Q(a - Q - 2C_i - 2\tau_0 + c_d)/2$$

The incentive compatible constraint for type  $i$  can be constructed by defining an isoprofit curve consisting of combinations of quantities  $Q$  and duties  $t$  which yield the same total profit,  $\bar{\Pi}_i$ , given that the home firm produces according to its best response, (7). From (8) and (3), the isoprofit curve is implicitly given by

$$(9) \quad \bar{\Pi}_i = \Pi_i(Q, t) \equiv \pi_i(Q) + (N/9)(a + c_d - 2C_i - 2t)^2$$

Consider the case when the government has full information. In this case, each type  $i$  knows that a petition will lead to an AD duty,  $\tilde{t}_i - \tau_0$ . Hence, each type will myopically maximize its first period profit yielding

$$(10) \quad \tilde{Q}_i = (a - 2C_i - 2\tau_0 + c_d)/2 \quad \text{and} \quad \tilde{\pi}_i = (a - 2C_i - 2\tau_0 + c_d)^2/8$$

and an equilibrium profit over all periods

$$\Pi_i^s \equiv (a + c_d - 2C_i - 2\tau_0)^2/8 + (N/81)(a + 3c_d - 4C_i)^2$$

In Figure 1 we depict the isoprofit curves for three types under the full information outcome. Note that as graphed, each firm’s preferred set lies to the south of its respective isoprofit curve—for a given quantity, profit increases as the tariff falls.

In standard signaling games, it is assumed that one type always has a greater incentive to deviate from a given outcome than another type. This is referred to as

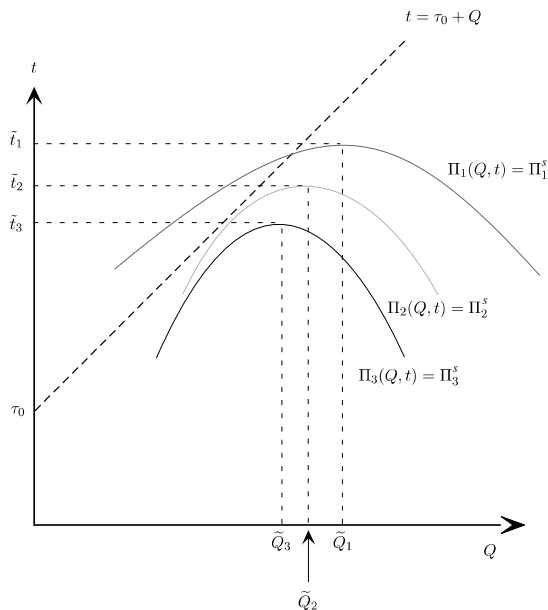


FIGURE 1

ISOPROFIT CURVES UNDER FULL INFORMATION

the single crossing property since it implies that the isoprofit curves cross only once. We will now show that the isoprofit function of the exporter does not exhibit the single crossing property. As will become apparent, this fact will play a key role in solving for the equilibrium of the model.

LEMMA 1. *For any two isoprofit curves  $\{\bar{\Pi}_i, \bar{\Pi}_j\}$ ,  $i < j$ , the graph of the function  $t = \tau_0 + Q$  divides  $(Q, t)$ -space in such a way that at any  $(Q, t)$  the slope of  $\bar{\Pi}_j$  is bigger (smaller) (the same as) the slope of  $\bar{\Pi}_i$  whenever  $t > (<)(=) \tau_0 + Q$ .*

All proofs are in the Appendix.

Lemma 1 implies that the isoprofit curves can cross at most once in either of the two half-spaces defined by  $t = \tau_0 + Q$ . If they cross in the half-space  $t < \tau_0 + Q$ , then  $j$ 's curve crosses  $i$ 's from below; if they cross in the half-space  $t > \tau_0 + Q$ , then  $j$ 's curve crosses  $i$ 's from above. This implies that the incentives for any two types to deviate from a given outcome differ depending on the relative sizes of  $t$  and  $Q$ . Furthermore, if the isoprofit curves have a point in common along  $t = \tau_0 + Q$ , then they are tangent at that point. We will refer to this property as “double” crossing.

Intuitively, the double crossing property reflects the varying incentives to lower current quantity in order to receive a lower duty in the future. On the one hand, high-cost firms already produce less than low-cost firms, and, hence, do not have to distort their sales as much as low-cost firms. Thus, in this respect, high-cost firms find it easier to deviate from a given outcome (by lowering quantities). On the other

hand, low-cost firms have more to gain if future duties are lower, and, hence, they benefit more when today's lower exports result in lower duties tomorrow. Thus, in this respect, low-cost firms find it easier to deviate from a given outcome. Which incentive dominates depends on the relative sizes of  $t$  and  $Q$ . If  $t$  is relatively small, the former effect dominates, while if  $t$  is relatively large, the latter effect dominates.

The double crossing property is graphically depicted in Figure 2. Consider first the case when  $Q > t - \tau_0$  (i.e., relatively high quantity levels). This case is depicted graphically by point  $X$  in Figure 2. At the point of intersection ( $X$ ), the slope of isoprofit curve for the more efficient type (type 1) is bigger than the slope of inefficient type's isoprofit curve. This relationship can simply be interpreted as implying that at  $X$ , a decrease in exports by 1 is *less* profitable than a decrease by 2.

Consider the other case, when  $Q < t - \tau_0$ . This case is depicted by the point  $Y$  in Figure 2. At the point of intersection, the slope of the isoprofit curve for the efficient type is smaller than the inefficient type's, implying that at  $Y$ , a decrease in exports by 1 is *more* profitable than a decrease by 2.

Finally, if the two isoprofit curves have a point in common along the locus  $Q = t - \tau_0$ , they must be tangent at that point. This case is depicted by the point  $Z$  in Figure 4 and will be discussed at greater length in Section 4.3. Hereafter, we will refer to the line  $t = \tau_0 + Q$  as the tangency locus.

Another property of the isoprofit curve is:

**COROLLARY 1.** *Any isoprofit curve can cross the tangency locus at most once.*

Corollary 1 implies that an isoprofit curve either never crosses the tangency locus or only crosses the tangency locus once. As will become clear, whether an isoprofit curve crosses the tangency locus depends primarily on the duration of the AD duty.

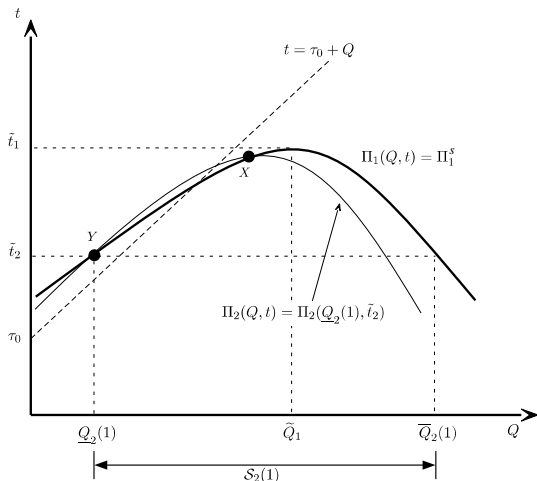


FIGURE 2

INCENTIVE COMPATIBILITY CONSTRAINT FOR 2 DEFINED BY 1

4.2. *The Unique Candidate for a Pure Strategy Separating Equilibrium Outcome.* We begin by deriving the unique candidate for a pure strategy separating equilibrium outcome. In order to support such a solution, we must provide each type with a quantity,  $Q_i^s$ , which is exported with probability one.

If the outcome is a pure strategy separating equilibrium, then the government is able to infer each type's true cost and will in turn levy the optimal duty,  $\tilde{t}_i$ . This implies that type 1's unique separating sequential equilibrium strategy is to maximize its first period profit myopically, yielding exports of  $Q_1^s = \tilde{Q}_1$  and profit over all periods of  $\Pi_1^s$ .

The extent to which types  $j > 1$  distort exports depends on whether others have a desire to mimic them. If the game is not to be trivial, we must assume that some  $i$  is willing to mimic some type  $j, i < j$ . In general, this means  $\Pi_i^s < \Pi_i(\tilde{Q}_j, \tilde{t}_j)$ . Since we are interested in explaining why the most efficient firms restrain their exports, we require that type 1 be willing to mimic 2,

$$(11) \quad \Pi_1^s < \Pi_1(\tilde{Q}_2, \tilde{t}_2)$$

In Figure 1 we depict a game where (11) is satisfied. As depicted, 2's full information outcome,  $(\tilde{Q}_2, \tilde{t}_2)$  lies in 1's strictly preferred region. In other words, as depicted, 1 has an incentive to mimic 2, if doing so could induce an AD duty of only  $\tilde{t}_2$ .

Since  $\Pi_1^s$  is the minimum profit type 1 will earn in any sequential equilibrium, the incentive-compatible constraint for type 1 can be defined by the locus of quantity-duty pairs in (9), yielding at least  $\Pi_1^s$

$$(12) \quad \Pi_1^s \leq \Pi_1(Q, t)$$

In Figure 1, (12) is satisfied for all  $(Q, t)$  lying below  $\Pi_1^s = \Pi_1(Q, t)$ .

It is easy to verify that the equation in (12) implicitly defines a function which is strictly concave in  $Q$  and symmetric around  $\tilde{Q}_1$ . For each  $i > 1$ , (12) defines an open set of quantities around  $\tilde{Q}_1, S_i(1) = (\underline{Q}_i(1), \bar{Q}_i(1))$ , which type 1 would strictly prefer to its equilibrium strategy if the response was  $\tilde{t}_i$ . The end points of these intervals are

$$\begin{aligned} \underline{Q}_i(1) &= \tilde{Q}_1 - (2/9)\sqrt{2N(C_i - C_1)(C_i + 3c_d + a - 5C_1)} \\ \bar{Q}_i(1) &= \tilde{Q}_1 + (2/9)\sqrt{2N(C_i - C_1)(C_i + 3c_d + a - 5C_1)} \end{aligned}$$

Since  $C_1 < C_i$ , the above quantities are real. In addition,  $S_i(1)$  is strictly increasing in  $N$ , implying that the longer the period the AD duty stays in effect, the more type 1 is willing to sacrifice if doing so could insure a lower duty. In Figure 2, we depict an incentive compatible quantity set,  $S_2(1)$ .

Incentive compatibility has several important implications for the behavior of each type  $i > 1$  in a separating equilibrium. For instance, in any pure strategy sequential separating equilibrium, each  $i > 1$  would be at least restricted to  $Q \in S_i^c(1)$ , where  $S_i^c(1)$  is defined as the complement of  $S_i(1)$ .<sup>12</sup> Type 2's possible quantity choices can be further restricted by noting that:  $S_2(1)$  is symmetric around  $\tilde{Q}_1$ ;

<sup>12</sup> The strategy set of type  $i, S_i(h)$ , may be further restricted by the incentive compatibility constraint of other types  $h, h < i$ .

$\underline{Q}_2(1) < \tilde{Q}_2 < \tilde{Q}_1 < \bar{Q}_2(1)$ ; and, given  $\tilde{t}_2$ , the profit function of type 2 is symmetric about  $\tilde{Q}_2$ . These observations imply that the payoff for 2 at  $\underline{Q}_2(1)$  is higher than at  $\bar{Q}_2(1)$ . Moreover, the fact that 2's profit is monotonically increasing up to  $\tilde{Q}_2$  and decreasing thereafter implies that  $\underline{Q}_2(1)$  is the unique maximizer among the set of quantities available to 2 in a separating equilibrium. Not surprisingly, then, it is the unique candidate to be a part of a self-enforcing separating equilibrium outcome.

PROPOSITION 1. *If there exists separating equilibria, then their outcome is unique and must contain type 2 exports of  $Q_2^s = \underline{Q}_2(1)$ .*

Denote by  $\underline{Q}_j(i)$  and  $\bar{Q}_j(i)$  the end points of the interval  $S_j(i)$ ,  $1 \leq i < j$ .  $S_j(i)$  is the set of quantities in combination with  $\tilde{t}_j$  that type  $i$  would prefer to  $\Pi_i^s$ . We can also show:

COROLLARY 2. *There exists a unique candidate for a separating equilibrium outcome. The export quantity for type  $j$  in this outcome is  $Q_j^s = \min \{ \underline{Q}_j(i) \}$ ,  $1 \leq i < j$ .*

We depict this outcome in Figure 3. The outcome has several nice properties. First, the most efficient exporter does not restrain its exports. Rather, the potential AD duty distorts trade from the less efficient types who voluntarily restrain their exports in order to separate themselves. Second, this outcome involves the least amount of trade restraint, and, as such, is the best outcome in the sense of Riley

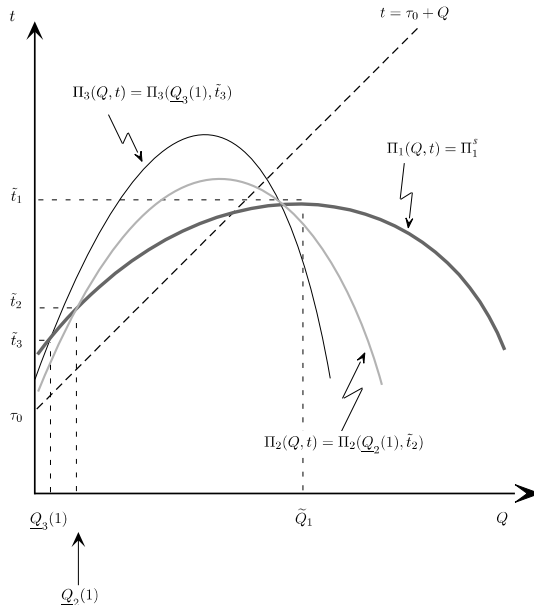


FIGURE 3

THE UNIQUE CANDIDATE FOR A SEPARATING EQUILIBRIUM

(1979). Finally, the outcome has the desirable characteristic that the optimal duties are levied.

4.3. *The Unique Pooling Equilibrium.* Now we explore the possibilities for pooling.<sup>13</sup> The next two lemmas will provide a candidate for an equilibrium in which more than one type exports the same quantity and characterize the foreign firm's isoprofit function in the equilibrium.

LEMMA 2. *Fix a pooling outcome in which more than one type exports  $Q^p$  with positive probability in the first period, and the response of the government is  $t^p$ . Then it must be that  $Q^p = t^p - \tau_0$ .*

Lemma 2 states that any export-duty pair that does not lie on the tangency locus cannot be a part of a pooling outcome.

We now show that if the indifference curves of two types have a point in common along the tangency line, then everywhere else the isoprofit line of the lower type lies above that of the higher type.

LEMMA 3. *Let  $i < j$  and let  $\hat{Q} = \hat{t} - \tau_0$ . Then  $\Pi_i(\hat{Q}, \hat{t}) = \Pi_i(Q', t_i)$  and  $\Pi_j(\hat{Q}, \hat{t}) = \Pi_j(Q', t_j)$  imply  $t_j < t_i$ .*

Figure 4 is useful for clarifying Lemma 3. Consider a point, say  $Z$ , on the tangency locus. By Lemma 1 we know that any two isoprofit curves through  $Z$  must be tangent. For example, in Figure 4 we have drawn three isoprofit curves containing  $Z$ . Lemma 3 implies that the isoprofit curves of the higher types are nested within the isoprofit curve of the lower types. For instance, 3's isoprofit curve lies within 2's which, in turn, lies within 1's isoprofit curve. Lemma 3 is important since it implies that the government can clearly rank each type's incentive to deviate from a candidate on the tangency locus. In particular, at  $Z$ , type 1 has the strongest incentives to make a small deviation.

Using Lemma 3 we can also show:

COROLLARY 3. *If type  $i$  pools with positive probability in a sequential equilibrium then every type  $j > i$  exports the pooled quantity with probability one.*

We are now ready to prove our main proposition. In particular, we now show that if

$$(13) \quad \Pi_1^s \leq \Pi_1(\tilde{t}_2 - \tau_0, \tilde{t}_2)$$

then there is a unique equilibrium in which the AD threat induces all types to sell the same quantity. In this equilibrium, the most efficient types voluntarily restrain their exports in order to receive a lower AD duty.

<sup>13</sup> We use the term pooling to refer to any outcome wherein a quantity is exported with positive probability by more than one type. In our discussion, we are explicit when the pooling is partial or full, and which types participate in the pool.

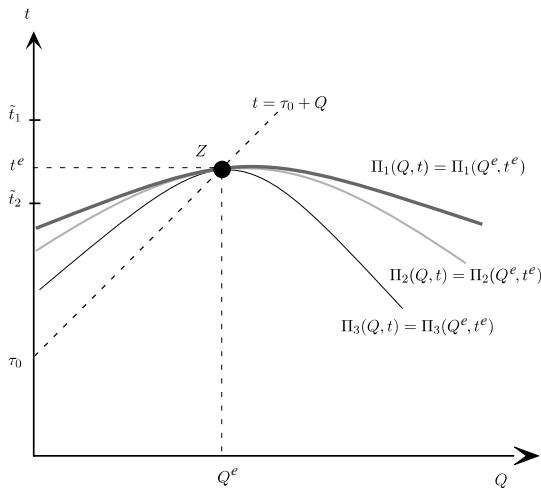


FIGURE 4

THE UNIQUE POOLING EQUILIBRIUM

PROPOSITION 2. *If (13) is satisfied, then there exists a unique equilibrium. In it, type 1 produces the pooled quantity with positive probability and all other types pool with probability one.*

Figure 4 depicts the unique pure pooling equilibrium. Several comments are warranted. First, unlike the separating candidate, in the pure pooling equilibrium, the most efficient firm voluntarily restricts its output prior to the AD investigation. In fact, it is generally the case that exports are restrained not just by 1 but by many of the more efficient types. Thus, the pooling equilibrium is consistent with the empirical evidence that the threat of an AD duty induces VERs by most efficient foreign competitors.

Second, depending on the probability distribution  $\mu$ , cost-based AD can easily result in the perception that inefficient exporters are more threatening than they actually are. For instance, as depicted, all types  $i > 1$  will receive a higher duty than is optimal. This prediction is again consistent with the empirical evidence. In the steel industry, for instance, a large number of cases have been filed against relatively inefficient producers. This perception was most forcefully asserted during the Uruguay Round negotiations as representatives from developing countries (i.e., relatively inefficient firms) vigorously negotiated for changes in the rules governing cost-based AD.

Third, these distortions imply that domestic consumers get the worst of both worlds. Prior to the AD investigation, consumers suffer as the efficient firms restrict output. Following the investigation, consumers bear the burden of having overly large AD duties being levied on inefficient firms.

4.4. *A Necessary and Sufficient Condition.* Before concluding this section, we would like to relax condition (13) and give a necessary and sufficient condition for the unique equilibrium to involve pooling in exports (not necessarily by all types) and characterize the outcome. The condition requires type  $T - 1$  to prefer the point  $(Q = \tilde{t}_T - \tau_0, \tilde{t}_T)$  to its unique candidate separating equilibrium strategy.

Intuitively, this is the case because Lemma 1 guarantees that if  $T - 1$  prefers to separate rather than mimic  $T$  at  $(Q = \tilde{t}_T - \tau_0, \tilde{t}_T)$ , then so will every lower type. Consequently, the separating equilibrium isoprofit curves of each lower type lie in the right half space defined by the tangency locus. In the proposition below, we establish that if this necessary and sufficient condition does not hold, then the candidate for a separating equilibrium outcome defined in Corollary 2 arises from a unique equilibrium.

**PROPOSITION 3.** *There exists a pooling equilibrium if and only if  $\Pi_{T-1}^s \leq \Pi_{T-1}(\tilde{t}_T - \tau_0, \tilde{t}_T)$ . Moreover, this equilibrium is unique and involves all but (possibly) the lowest types exporting the same quantity with positive probability.*

Proposition 2 gives a sufficient condition for type 1 to voluntarily restrict exports in equilibrium. Proposition 3 provides a necessary condition for a type  $i$  to participate in a pool. By replacing  $i$  with 1 in the construction of the unique pooling equilibrium, we see that the most efficient type will restrict exports only if  $\Pi_1^s > \Pi_1(\tilde{t}_T - \tau_0, \tilde{t}_T)$ .

5. CHARACTERIZATION OF THE POOLING CONDITION

We have argued above that if (13) holds, then pooling is the unique equilibrium. In this section we will relate this condition to the underlying primitives of the model. For analytical convenience we will now assume that the foreign firm is one of two possible types, 1 and 2. We will also assume that  $c_d = C_2$  and that  $\tau_0 = \tilde{t}_2$ .

First, we want to establish that the mimicking condition (11) holds. Substituting, we can show that 1 would like to mimic 2 if

$$N > N^m \equiv \frac{81(A - 1)}{8(5A - 4)}$$

where we have defined relative costs as

$$(14) \quad A \equiv \frac{a - C_1}{a - C_2} > 1$$

In Figure 5, we graph the mimicking condition in  $A - N$  space. The mimicking condition is satisfied for all points lying above the  $N^m$  contour. As the graph makes clear, for all  $N > 1$  the mimicking condition holds for all reasonable values of  $A$ . For  $N = 1$  the condition only holds for  $A \in (1, 49/41)$ . Recall that when a firm restrains exports to  $\tilde{Q}_2$ , some first period profit is sacrificed. If the game is sufficiently short, the gain from the lower duty is insufficient to induce mimicking. In current U.S. practice, duties are rarely removed sooner than 2 years after being imposed. Given

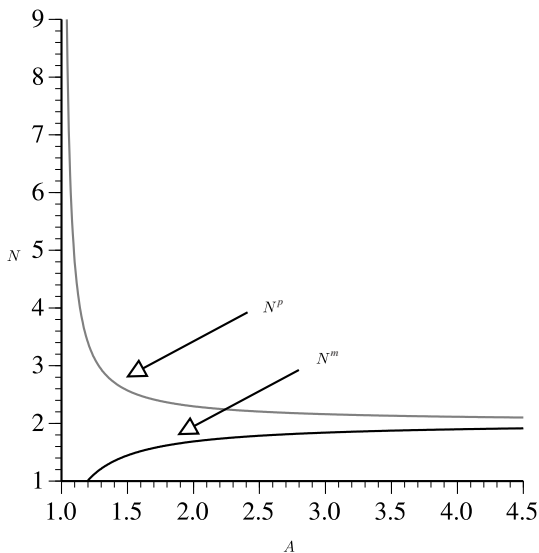


FIGURE 5

$N^m$  AND  $N^p$  CONTOURS

this practice, we believe that the relevant scenario is when the AD duty stays in effect for longer than one period, and thus that the mimicking condition holds for all values of  $A$ .

Conditional on (11), the question now is whether (13) is satisfied. Substituting, we can show that the pooling condition holds if

$$N > N^p \equiv \frac{9(6A - 5)^2}{32(5A - 4)(A - 1)}$$

This sufficient condition is also graphed in Figure 5 and is satisfied for all points lying above the  $N^p$  contour. The graph shows that the pooling condition is likely to hold for most reasonable parameter values. In particular, if the duty is levied for at least several periods, the condition is satisfied for almost all  $A$ . For instance, if  $N = 3$ , the condition holds for all  $A > 1.284$ , if  $N = 5$ , the condition holds for all  $A > 1.093$ , and if  $N = 10$ , the condition holds for all  $A > 1.035$ .

Although the precise values are clearly specific to this example, this exercise does illustrate the two general insights. First, pooling is most likely to occur the larger the cost differential among types. Second, the longer is the duration of the postduty game, the more likely will the pooling outcome emerge. Note that the postduty game does not have to be particularly lengthy for pooling to emerge. A review of the United States' experience reveals that AD duties are often quite long-lived. For instance, in the United States, the duties have been in place for at least 10 years in more than 20 percent of (affirmative) AD cases; in fact, according to International Trade Commission (1995), more than half of the AD duties levied between 1955 and

1991 were still in effect in 1991. Thus, the model's prediction that foreign firms restrain exports in order to reduce potential AD duties seems plausible.

## 6. WELFARE IMPLICATIONS

We would like to conclude our discussion by conducting a simple welfare analysis. As we did in the previous section, we will assume that the foreign firm is one of two possible types, 1 and 2. The prior probability of type 1 is  $\mu$ . We will continue to assume that  $c_d = C_2$  and that  $\tau_0 = \tilde{t}_2$ .

We compare the expected welfare in the pure strategy pooling equilibrium with a situation in which the government does not have a cost-based AD mechanism. In keeping with GATT rules, we thus consider an alternative where exporters are subject to a uniform tariff.<sup>14</sup>

In a pure strategy pooling equilibrium, the government levies a duty equal to  $t^e - \tau_0$  where  $t^e = \mu\tilde{t}_1 + (1 - \mu)\tilde{t}_2$ . Regardless of the firm's type, first period exports are  $Q^e = t^e - \tau_0$  and the domestic firm maximizes its profit taking  $Q^e$  as given. In subsequent periods, the welfare results from the unique Cournot equilibrium with the AD duty imposed.

If the government does not have AD law and commits to  $\tau_0$ , the welfare would be calculated from the unique Stackelberg and Cournot equilibria in first and later periods, respectively. Using our expression for relative costs ( $A$ ), the difference between the expected equilibrium welfare and the ex ante expected welfare from precommitment can be shown from (4) and (5) to be

$$\Delta(N, A, \mu) = (1/72)(4N + 11)(A - 1)^2\mu^2 - (1/72)(27A - 14)(A - 1)\mu - 7/288$$

$\Delta(\cdot)$  is increasing with  $N$ , implying that the longer the duration of the duty the larger are the losses due to a commitment to a suboptimal duty.

In Figure 6, we depict the zero contours of  $\Delta(\cdot)$  for  $N = 5$  and  $N = 10$ . Cost-based AD raises welfare in the region lying above the contour. The intuition is quite clear: Cost-based AD raises welfare the more likely the firm is type 1 (higher  $\mu$ ) and the longer the duration of the duty (larger  $N$ ). However, note that if the duty stays on for five periods, the cost difference between the firms must get quite large before the AD policy raises welfare.  $\Delta(\cdot)$  is positive for a substantial region of the parameter space only for  $N = 10$ .

A couple of comments about the effect of the duration of the game are in order. First, our model does not endogenously derive the duration of AD duties. The long-standing nature of AD duties could be explained by factors such as political influence, bureaucratic inertia, and so on. Be that as it may, given that in practice antidumping duties remain in place for a long time and also that they are in most cases cost based, our analysis shows that pooling is likely to emerge, and hence that AD policy is inefficient. Second, we assume that  $N$  is known. Adding uncertainty

<sup>14</sup> The unique ex ante optimum duty is easily seen to be  $\mu\tilde{t}_1 + (1 - \mu)\tilde{t}_2$ . We can perform the welfare analysis with this tariff imposed in all periods, but we want to emphasize that even with suboptimal tariffs (and maybe even the worst ex ante tariff), the country is still better off without an AD law.

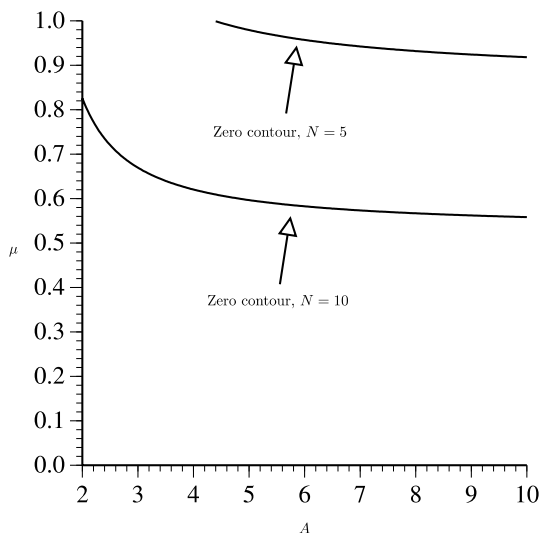


FIGURE 6

ZERO CONTOUR OF  $\Delta(N, \mu, A)$ 

about the duration of the game will not yield significant insights; the firms will simply maximize their expected profits given the distribution of  $N$ .

The example suggests that pooling is likely for almost all  $N$ . Nevertheless, expected welfare and realized welfare may differ. Our findings make the Uruguay Round's sunset amendment particularly relevant. This provision mandates that AD duties must be reviewed after 5 years and the duty should be removed unless there is evidence that doing so will result in injury. The sunset amendment was designed to limit the attractiveness of AD actions (to domestic industries), and, as such, this provision should raise welfare. Surprisingly, we find that it may well exacerbate the costs of cost-based AD policy.

## 7. CONCLUDING COMMENTS

By most accounts, the downward trend in trade restrictions was halted (or at least slowed) in the mid-1970s (Bhagwati, 1988; Krueger, 1995). Blame is usually pointed to the combination of high-track (VERs) and low-track (AD duties) restraints. In this article, we have demonstrated that both phenomena can be explained by the fact that AD laws were broadened to allow for cost-based allegations in the mid-1970s. We have shown that VERs are undertaken to discourage cost-based AD complaints. However, we find that in general, the VER does not completely release the protectionist pressures but rather causes the duties to be clumsily levied.

Our results also help explain why all concerned parties—domestic firms, foreign firms, and consumers—are unhappy with AD protection. Domestic industries complain that AD does not sufficiently protect them against their most feared foreign competitors (Stewart, 1991). At the same time, foreign firms often gripe that

the duties are excessive. Our model shows that both charges have validity. The VER distorts the government’s perception of the foreign firm’s efficiency and leads to undesirably low (high) duties on efficient (inefficient) competitors. Cost-based duties would be more efficiently levied if the VERs did not interfere with the government’s ability to perceive costs. Finally, consumers suffer due to both the anticipatory VER and to the ineptly determined duty. Our results provide additional evidence that AD law creates a heavy burden on consumers. All in all, even though cost-based AD raises welfare under complete information, the distortions inherent with implementing it under incomplete information make it an undesirable policy—especially if the duties are levied for relatively short durations. Thus, GATT/WTO parties would be well served to couple the recent sunset provision with additional restrictions on cost-based allegations.

From a technical perspective, our results highlight the importance of the single crossing assumption in economic models. Although this assumption is usually imposed, our model suggests that those interested in accurately depicting the outcomes in signaling games should formally model agents’ payoffs, that is, derive payoffs from more basic economic primitives. As we have shown, the equilibrium depends crucially on whether the payoffs satisfy single crossing or double crossing.

APPENDIX

PROOF OF LEMMA 1. Implicit differentiation of (9) at any  $(Q, t)$  yields a slope of an isoprofit curve given by

$$\sigma(Q, t) = \frac{dt}{dQ} = \left(\frac{9}{8n}\right) \left(\frac{a - 2Q - 2C_i - 2\tau_0 + c_d}{a - 2t - 2C_i + c_d}\right)$$

The first part of the claim follows directly from the definition of  $\sigma(Q, t)$  and monotonicity of the profit function. The second part of the claim follows from differentiating  $\sigma(Q, t)$  with respect to  $C_i$  at any  $(Q, t)$ . □

PROOF OF COROLLARY 1. If the isoprofit curve of type  $i$  crossed the tangency locus twice, then continuity would imply that  $i$  must have another isoprofit curve tangent to  $t = \tau_0 + Q$  at a point  $(\hat{Q} = \hat{t} - \tau_0, \hat{t})$ . Lemma 1 shows that an isoprofit curve of any  $i'$  through  $(\hat{Q} = \hat{t} - \tau_0, \hat{t})$  would be tangent also and both curves would lie in the same half space defined by  $t = \tau_0 + Q$  at least in an  $\epsilon$ -neighborhood of  $(\hat{Q} = \hat{t} - \tau_0, \hat{t})$ . Since profit is continuous, we can always find a sufficiently small  $\delta$ -perturbation of the payoff of one type so that the isoprofit curves cross twice within  $\epsilon$  of  $(\hat{Q} = \hat{t} - \tau_0, \hat{t})$ . This would violate Lemma 1. □

PROOF OF PROPOSITION 1. Before we proceed with the proof of the proposition, we introduce some notation and concepts relevant to applying the  $D_1$  refinement in this proof and others that follow.

Fix a probability distribution over the end points of the signaling subgame induced by a sequential equilibrium in which an exporter of type  $i$  obtains a profit (over all periods) of  $\Pi_i^*$ . Call this probability the outcome of the game associated with the given equilibrium. Fix also an out-of-equilibrium export level,  $Q'$ . Let  $BR(\eta, Q')$

denote the set of best responses of the government at  $Q'$  given that: (a) the induced beliefs about the types exporting this quantity are  $\eta$ , and (b) the home firm produces its unique maximizer when it observes  $Q'$ . Write element  $i$  of  $\eta$  as  $\eta(i|Q')$ . Then

$$BR(\eta, Q') \equiv \arg \max_{t \in [\tau_0, \tilde{t}_1]} \sum_{i=1}^T w(i, t) \eta(i|Q')$$

Let  $\Pi_i(Q, t)$  denote the foreign firm's profit over all periods when it exports  $Q$  in period 1 and is thereafter subject to a total duty,  $t$ . Define

$$E_i^0(Q') \equiv \{t \in BR(\eta, Q') : \Pi_i(Q, t) = \Pi_i^*\}$$

to be the set of best responses of the government that would leave  $i$  indifferent between his/her equilibrium strategy and exporting  $Q'$ . Similarly, the set of sequentially rational AD duties that would make  $i$  strictly better off is denoted by

$$E_i(Q') \equiv \{t \in BR(\eta, Q') : \Pi_i(Q, t) > \Pi_i^*\}$$

We say that a sequential equilibrium outcome is  $D_1$  if and only if there exists an equilibrium giving rise to this outcome which can be supported with beliefs  $\eta(i|Q')=0$  at each off equilibrium quantity  $Q'$  whenever

$$(A.1) \quad E_i^0(Q') \cup E_i(Q') \subseteq E_{i'}(Q')$$

for  $E_{i'}(Q') \neq \{\emptyset\}$ . Thus,  $D_1$  requires the beliefs of the government to place probability zero on type  $i$  if whenever  $i$  wants to deviate from a particular equilibrium so does  $i'$ . Intuitively, this makes  $i'$  the more likely type to break the equilibrium.

Fix a sequential separating equilibrium outcome obtained from 2 exporting  $Q^* \in \mathcal{S}_2^c(1)$ ,  $Q^* \neq \underline{Q}_2(1)$ , and 1 exporting  $\tilde{Q}_1$ . Take an out of equilibrium message  $Q' \in \mathcal{S}_2^c(1)$  such that  $|Q^* - \tilde{Q}_1| > |Q' - \tilde{Q}_1|$ .

Let us construct the sets of sequentially rational responses of the government to  $Q'$  which would make each type break the equilibrium. By the definition (incentive compatibility) of  $\mathcal{S}_2(1)$ , no duty  $t \in [\tilde{t}_2, \tilde{t}_1]$  would make 1 deviate from  $\tilde{Q}_1$  to  $Q'$ . Continuity and monotonicity of 2's profit function guarantee that exporting  $Q'$  would be strictly preferred to  $Q^*$  if that would make the country impose  $\tilde{t}_2$  (or any lower duty). Hence,

$$E_1^0(Q') \cup E_1(Q') \subseteq E_2(Q')$$

and the  $D_1$  criterion requires the beliefs of the government to place probability zero on 1 at  $Q'$ . Hence, at  $Q'$ , we must have the posterior restricted to  $\eta|_{i \geq 2}$ , where

$$\eta|_{i \geq j}(i'|Q) = \begin{cases} \frac{\eta(i'|Q)}{\sum_{i \geq j} \eta(i|Q)}, & \text{if } i' \geq j \\ 0, & \text{otherwise} \end{cases}$$

Since the best reply of the government is decreasing in its beliefs, this would make 2 defect from the equilibrium.

We could make the same argument for all  $Q^* \neq \underline{Q}_2(1)$ . Hence, the unique candidate separating  $D_1$  equilibrium outcome is the one arising from type 2 exporting  $\underline{Q}_2(1)$ .  $\square$

**PROOF OF COROLLARY 2.** Note that the strict concavity of the separating equilibrium isoprofit curve for type 1 implies that  $\bar{Q}_j(1) > \bar{Q}_i(1)$  for  $j > i > 1$ . On the other hand, Lemma 1 implies that  $\Pi_i(\bar{Q}_i(1), \tilde{t}_i) > \Pi_i(\bar{Q}_j(1), \tilde{t}_j)$ . Hence,  $\bar{Q}_j(1) > \bar{Q}_j(i)$ ,  $\forall j > i > 1$  and each type  $j$  is constrained only by type 1 at high quantity levels.

Starting with type 3, for each type  $j \geq 3$ , apply the arguments used in Proposition 1 to show that any quantity  $Q' > \bar{Q}_j(1)$  in combination with  $\tilde{t}_j$  is inferior to  $\bar{Q}_j(1)$ . This is the case because the  $D_1$  criterion concentrates the beliefs of the government on  $k \geq j$  and the corresponding best response would make  $j$  deviate from  $Q'$ .

Fix a candidate equilibrium in which each type  $j$  exports  $\bar{Q}_j(1)$ . To see that  $\bar{Q}_j(1)$  is not a stable equilibrium, we use Lemma 1 once again to claim that

$$E_1^0(\bar{Q}_j(1) - \epsilon) \cup E_1(\bar{Q}_j(1) - \epsilon) \subseteq E_j(\bar{Q}_j(1) - \epsilon)$$

Since  $\Pi_j(\bar{Q}_j(1), \tilde{t}_j) > \Pi_j(\bar{Q}_{j-1}(1), \tilde{t}_{j-1})$ ,  $D_1$  requires that the response of the government at  $\bar{Q}_{j-1}(1) - \epsilon$  be at most  $\tilde{t}_{j-1}$ , which is sufficient to discard  $\bar{Q}_{j-1}(1)$  as a candidate equilibrium.

Proposition 1 showed that the unique candidate for a  $D_1$  strategy for 2 is  $\underline{Q}_2^S = \underline{Q}_2(1)$ . Let  $\hat{Q} = \min\{\underline{Q}_3(1), \underline{Q}_3(2)\}$ . Then both type 1 and type 2 are content with separation rather than mimic type 3 at  $Q' < \hat{Q}$  and get  $\tilde{t}_3$ . Hence,  $D_1$  would restrict the beliefs of the government to  $i \geq 3$  at  $Q' + \epsilon < \hat{Q}$  and the sequentially rational tariff would make 3 deviate from  $Q'$ . The arguments for all other types are identical.  $\square$

**PROOF OF LEMMA 2.** Without loss of generality, assume that  $Q^p < t^p - \tau_0$ . Let  $i$  be the highest type in the pool. Then  $t^p > \tilde{t}_i$ . Lemma 1 guarantees that in a  $D_1$  equilibrium, the beliefs of the government at  $Q'$ ,  $\epsilon$ -smaller than  $Q^p$  should place  $\eta(i' | Q') = 0$  for all  $i' < i$ . Hence, the response of the government at  $Q'$  should be less than or equal to  $\tilde{t}_i$ . Continuity of the exporter's payoff in  $Q'$  would make  $i$  strictly better off deviating from the pool for sufficiently small  $\epsilon$ .  $\square$

**PROOF OF LEMMA 3.** In Corollary 2, we established that any point  $(\hat{Q} = \hat{t} - \tau_0, \hat{t})$  is the unique intersection of the tangency locus with the isoprofit function  $\Pi_j(\hat{Q}, \hat{t}) = \Pi_j(Q, t)$  so that any  $Q' < \hat{Q}$  and  $t'$  such that  $\Pi_j(\hat{Q}, \hat{t}) = \Pi_j(Q', t')$  implies  $t' > Q' + \tau_0$ .

Assume that at  $Q' < \hat{Q}$ ,  $\Pi_i(\hat{Q}, \hat{t}) = \Pi_i(Q', t_i)$  and  $\Pi_j(\hat{Q}, \hat{t}) = \Pi_j(Q', t_j)$  with  $t_j > t_i$ , so that the isoprofit curve of  $j$  through  $(\hat{Q}, \hat{t})$  is above that of  $i$ . We will show that this assumption leads to a contradiction. By monotonicity of the profit in  $t$  we have

$$(A.2) \quad \Pi_i(\hat{Q}, \hat{t}) = \Pi_i(Q', t_i) > \Pi_i(Q', t_j)$$

On the other hand, since  $t_j > \tau_0 + Q'$ , Lemma 1 shows that the slope of  $j$ 's isoprofit curve through  $(Q', t_j)$  is bigger than the corresponding slope for  $i$ . This implies that

$$\Pi_i(\hat{Q}, \hat{t}) \geq \Pi_i(Q', t_j) \Rightarrow \Pi_j(\hat{Q}, \hat{t}) > \Pi_j(Q', t_j)$$

The last statement contradicts (2) and the construction of  $t_j$  as  $\Pi_j(\hat{Q}, \hat{t}) = \Pi_j(Q', t_j)$ . Similar arguments hold for  $Q' > \hat{Q}$ . □

PROOF OF COROLLARY 3. Suppose that  $i$  is the lowest type in the pool and  $j > i$  randomizes in equilibrium between some  $Q^*$  and the pooled quantity  $Q^p$ . Then  $j$  must be indifferent between  $Q^*$  and  $Q^p$ . Since the equilibrium isoprofit curve of  $i$  is everywhere above that of  $j$  according to Lemma 3, it must be that  $\forall Q \neq Q^*$  and  $j > i$

$$E_j^0(Q) \cup E_j(Q) \subseteq E_i(Q)$$

Hence, in a  $D_1$  equilibrium, the beliefs of the government at  $Q \neq Q^*$  must place probability one on  $i$  and the corresponding duty should be  $\tilde{t}_i$ . As shown above, every type  $j, j > i$ , is strictly better off with  $Q^p$  than producing  $Q$  in combination with  $\tilde{t}_i$ ; hence, every  $j > i$  exports  $Q^p$  with probability one. □

PROOF OF PROPOSITION 2. Note first that  $\underline{Q}_2(1)$  is not a  $D_1$  strategy for 2. Let us fix the outcome arising from 2 exporting  $\underline{Q}_2(1)$ . By construction,  $\underline{Q}_2(1) < \tilde{t}_2 - \tau_0$ , which guarantees that the isoprofit curve of 2 through  $(\underline{Q}_2(1), \tilde{t}_2)$  has a slope that is bigger than the corresponding slope for type 1 (by Lemma 1). This implies that for  $Q'$   $\epsilon$ -bigger than  $\underline{Q}_2(1)$ , the set of sequentially rational duties weakly preferred to  $(\underline{Q}_2(1), \tilde{t}_2)$  by 1 in combination with  $Q'$  is a subset of the best responses, which 2 strictly prefers to its equilibrium action. If the given equilibrium produces a  $D_1$  outcome, we should be able to support it with beliefs  $\eta|_{i \geq 2}$  at  $Q'$ . Hence, the best response of the government is at most  $\tilde{t}_2$ . Since, with any  $t \leq \tilde{t}_2$  fixed along with the fact that the profit of 2 is monotonically increasing in  $Q$  at  $\underline{Q}_2(1)$ , type 2 would deviate to  $Q'$ . Hence, if (13) holds, there are no pure strategy separating equilibria.

Let us fix a pooling equilibrium in which all types produce the pooling quantity with positive probability. By Corollary 3, all  $i \geq 2$  export the pooled quantity with probability one. We now consider the government's and type 1's equilibrium strategies. Let  $t^e \equiv \arg \max_t w(\mu, t) \geq \tau_0$  denote the ex ante optimal duty and let  $Q^e = t^e - \tau_0$ .

First suppose that the prior probability,  $\mu$ , is such that  $\Pi_1^s \geq \Pi_1(Q^e, t^e)$ . We claim that in this case, type 1 cannot pool with probability one in any sequential equilibrium. This follows from the fact that if 1 pools with probability one, then the unique best response of the government would be  $t^e$  to the quantity  $Q^e$ . The point  $(Q^e, t^e)$  is strictly inferior for 1 compared to full separation at  $\underline{Q}_1$ . This implies that the only possible solution must involve partial pooling.

As argued above, in any  $D_1$  pooling equilibrium, all disequilibrium beliefs will induce the government to impose  $\tilde{t}_1$ . The strict concavity of 1's profit function will then guarantee that the only quantity produced with positive probability and met with  $\tilde{t}_1$  is the unique maximizer,  $\underline{Q}_1$ . Moreover, the payoff from such an action must be equal to the payoff at the pooled message if 1 is to randomize. This implies that the pool must occur at the point of intersection of 1's complete information

isoprofit curve (9) and the tangency locus. Denote this quantity  $Q^p$ . Since  $\Pi_1(Q, BR(Q^p, \rho\mu|_{i \geq 2} + (1 - \rho)\mu))$  is a continuous strictly increasing function of  $\rho$ , there exists a unique solution to

$$\Pi_1^s = \Pi_1(Q^p, BR(Q^p, \rho\mu|_{i \geq 2} + (1 - \rho)\mu))$$

such that if 1 puts weight  $\rho$  on  $Q^p$  and  $1 - \rho$  on  $\tilde{Q}_1$ ,  $t^p$  would be the unique best response to  $Q^p$ .

Second, suppose now that the prior probability,  $\mu$ , is such that  $\Pi_1^s < \Pi_1(Q^e, t^e)$ . In this case, type 1 would rather pool at  $Q^e$  than separate. The partial pooling equilibrium described in the preceding paragraph is not even sequential in this case, since the posterior making  $t^e$  a sequential best response would require 1 to export  $Q^p$  with probability larger than one. (Keep in mind that in any  $D_1$  pooling equilibrium  $i \geq 2$  must pool with probability one.) This shows that the only  $D_1$  equilibrium is in pure strategies at exports  $Q^e$  and duty level  $t^e$ . The beliefs of the government for any off-equilibrium quantity are uniquely defined as concentrated on type 1 regardless of the prior. The off-equilibrium response is  $\tilde{t}_1, \forall Q \neq Q^e$ . The domestic firm produces according to (7) in response to  $Q^e$ .

Finally, note that if  $t^e < \tau_0$ , then no AD petition will be filed in equilibrium and the firms simply maximize profits myopically and the tariff remains at  $\tau_0$ .  $\square$

**PROOF OF PROPOSITION 3.** Let  $Q_i^s$ , as defined in Corollary 2, be the unique candidate for a  $D_1$  separating equilibrium strategy for  $i$ . Then  $\Pi_i^s = \Pi(Q_i^s, \tilde{t}_i - \tau_0)$ .

To show necessity observe that  $\Pi_{T-1}^s > \Pi_{T-1}(\tilde{t}_T - \tau_0, \tilde{t}_T)$  implies  $\Pi_i^s > \Pi_i(\tilde{t}_T - \tau_0, \tilde{t}_T)$  by Lemma 1. It follows that  $Q_i^s > \tilde{t}_i - \tau_0$  for all  $i$ , and  $Q_i^s < Q_{i-1}^s$ . Hence, by Lemma 1 the isoprofit curve for  $i$  through  $(Q_i^s, \tilde{t}_i)$  has a slope smaller than the isoprofit curve of type  $i - 1$  through the same point. In fact, the isoprofit curve for type  $i$  is below the curve for type  $i - 1$  for export levels higher than  $Q_i^s$  and above the curve for  $i - 1$  at quantities smaller than  $Q_i^s$ . Hence,  $D_1$  requires that the beliefs of the government be placed on type  $i - 1$  at off-equilibrium exports  $Q \in (Q_i^s, Q_{i-1}^s)$  for all  $i$ . Above  $\tilde{Q}_1$ , the government levies a duty of  $\tilde{t}_1 - \tau_0$ , and below  $Q_T^s$ , the response is  $\tilde{t}_T - \tau_0$ . These are the unique  $D_1$  beliefs, and they support the outcome in which every type  $i$  exports a distinct quantity  $Q_i^s$  with probability one as the unique outcome of the game. By Lemma 2 no pooling equilibria exist.

We now show that if the condition of the proposition holds, there exists a unique  $D_1$  equilibrium, and that in its outcome, all but possibly the lowest types export the same quantity with positive probability.

Assume that  $\Pi_{T-1}^s > \Pi_{T-1}(\tilde{t}_T - \tau_0, \tilde{t}_T)$  and let type  $i$  be the smallest type such that  $\Pi_i^s > \Pi_i(Q = \tilde{t}_T - \tau_0, \tilde{t}_T)$ . According to Corollary 1, for each  $j \geq i$  there exists a unique point  $(\hat{Q}_j = \hat{t}_j - \tau_0, \hat{t}_j)$  such that  $\Pi_j^s = \Pi_j(\hat{Q}_j, \hat{t}_j)$ . Recall that if a type prefers a point along the tangency locus to its separating strategy, so does every higher type. Hence, if a type pools, every higher type produces the pooled quantity with probability one by Corollary 3. Every type lower than  $i$  separates with a pure strategy. We now construct the unique equilibrium by induction on  $j$ .

1. Suppose that  $t(\mu|_{j \geq i}) \leq \hat{t}_i$ . In this case all  $j \geq i$  pool with probability one at  $Q = t(\mu|_{j \geq i}) - \tau_0$ . The unique sequentially rational response to the pooled quantity is  $t(\mu|_{j \geq i})$ .
2. If  $t(\mu|_{j \geq i}) > \hat{t}_i$ , we have two possibilities.
  - (a) Assume that  $t(\mu|_{j \geq i+1}) < \hat{t}_i$ . In this case, there exists a unique mixed strategy for type  $i$  in which it randomizes between  $Q_i^s$  and  $\hat{Q}_i$  in a way that makes  $\hat{t}_i$  a sequential response for the government. (The construction of the mixed strategy for  $i$  is the same as the one for type 1 in Proposition 2.) All  $j \geq i$  export  $\hat{Q}_i$  with probability one.
  - (b) Let  $t(\mu|_{j \geq i+1}) \geq \hat{t}_i$ . If type  $i$  pools, we know that all  $j \geq i$  would pool with probability one. Hence, the equilibrium response of the government must be bigger than  $t(\mu|_{j \geq i+1})$ . This implies that  $i$  would separate at  $Q_i^s$ .

Suppose now that all types smaller than a type  $r > i$  separate. From the preceding analysis, it must be that  $t(\mu|_{j \geq r}) \geq \hat{t}_{r-1}$ .

1. If  $t(\mu|_{j \geq r}) \leq \hat{t}_r$ , then all  $j \geq r$  produce  $Q = t(\mu|_{j \geq r}) - \tau_0$  with probability one.
2. If  $t(\mu|_{j \geq r}) > \hat{t}_r$ , we are facing two scenarios.
  - (a) Let  $t(\mu|_{j \geq r+1}) < \hat{t}_r$ . In this case,  $r$  mixes between  $Q_r^s$  and  $\hat{Q}_r$ , all  $j \geq r$  export  $\hat{Q}_r$  with probability one, and the equilibrium duty is  $\hat{t}_r - \tau_0$ .
  - (b) If  $t(\mu|_{j \geq r+1}) \geq \hat{t}_r$ , type  $r$  separates at  $Q_r^s$  with probability one.

This completes the induction.

Since by assumption  $\hat{t}_{T-1} > \tilde{t}_T$ , separation is not feasible for  $T - 1$  by the above construction. Hence, in any  $D_1$  equilibrium, at least types  $T$  and  $T - 1$  export the same quantity with positive probability.

It is easy to see that if  $i$  is the lowest type in a pool,  $D_1$  restricts the off-equilibrium response of the government to  $\tilde{t}_i$  in the neighborhood of the pool where the equilibrium isoprofit curve for  $i$  is above that of  $i - 1$ . For lower quantity levels, the beliefs are concentrated on the type willing to break the equilibrium at the highest duty. By Lemma 1, this is necessarily a type smaller than  $i$ . For export levels where the equilibrium isoprofit curve of  $i$  is below the isoprofit curve for  $i - 1$  but (necessarily) lower than  $Q_{i-1}^s$ , the beliefs are concentrated on  $i - 1$ . For any  $j \leq i - 1$ , the beliefs of the government are placed on  $j - 1$  between  $Q_j^s$  and  $Q_{j-1}^s$ . For export levels higher than the equilibrium quantity of type 1, the response is  $\tilde{t}_1$ . This is the unique system of beliefs that satisfy  $D_1$  and they trivially support the pooling outcome of the game.  $\square$

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