Anti-dumping measures as a tool of protectionism: a mechanism design approach

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Abstract. In this paper we explore the design of optimal incentive-compatible anti-dumping (AD) measures. When the weight given to the domestic firm's profit in the government's objective function is relatively small, it is shown that no AD duty should be imposed if the foreign firm reports its own costs, but a constant AD duty should be imposed if the domestic firm reports the foreign firm's cost. When this weight is large, in either case of reporting the AD duty is a prohibitive tariff. The optimal AD measures are modified in the presence of a GATT/WTO constraint. JEL Classification: F12, F13

Les mesures anti-dumping en tant qu'outil de protectionnisme: une approche en termes de construction de mécanismes. Ce mémoire examine la construction de mesures optimales anti-dumping (AD). Quand la valence des profits de la firme domestique est faible dans la fonction objective du gouvernement, on peut montrer qu'aucune mesure AD ne devrait être imposée si l'entreprise étrangère révèle ses propres coûts, mais qu'un droit AD constant devrait être imposé si c'est la firme domestique qui révèle les coûts de l'entreprise étrangère. Quand la valence des profits de la firme domestique est grande, quelle que soit la source de l'information, la mesure AD qui s'impose est un droit de douane prohibitif. Les mesures optimales doivent évidemment être modifiées pour prendre en compte la contrainte engendrée par l'existence des règles du GATT/OMC.

One of the hottest issues discussed during the Uruguay Round of multilateral trade negotiations was the provision of more transparent rules and methods to member economies with regard to the determination of dumping. Even though anti-

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dumping (AD for short) laws were originally intended to address predatory pricing by foreign firms, over time they became a tool of protectionism. Dating back to almost a century ago, Viner (1923, 47–51) cited a number of examples of alleged dumping that were used as an excuse for protectionism. More recently, Moore (1992) has documented that firms in the United States competing with exporters in less developed countries were able to receive favourable outcomes in the process of AD petitions. The explosive use of AD actions, especially those taken by the United States and European producers, to restrain foreign competitors since the 1980s has resulted in what some policy analysts call 'anti-dumping protectionism.'[1]

Like other trade policy tools, it would be reasonable to expect that the imposition of AD measures reflects national welfare. Indeed, according to Veugelers and Vandenbussche (1999, 8), 'European antidumping legislation requires policy makers to consider the "Community's Interest" as a whole when taking protectionist action. This Community Interest Clause corresponds quite well with economists' notion of national welfare, which is composed of three elements, local consumer surplus, domestic firms' profits . . . and any possible tariff revenue.' Even though there are disagreements about whether domestic firms' profits should be given greater weight than the other two components, it remains true that the greater the weight attached to the former the more protective the AD measures.[2]

Before a ruling is given, the government agencies in charge of AD cases must investigate each case so as to determine (a) whether dumping has occurred and, if so, what the 'dumping margin' is, and (b) whether there is 'material injury' to the domestic industry. Such investigation requires substantial resources and the case load may outstrip the agencies' investigative capacity. 'From time to time, an industry's strategy has been to overload the system, to file so many cases that the government does not have the capacity to investigate each one in the way the law requires and so have little choice but to intermediate a settlement between the industry seeking protection and the foreign exporters' (Finger, 1993, 5). Two related questions naturally suggest themselves: (1) Is it possible to design AD measures that will induce truthful information revelation, thereby reducing costly investigation of AD cases? (2) What are the characteristics of such measures, and how do they compare with the actual AD measures that do not depend on information revelation?

In this paper, we explore the design of optimal incentive-compatible AD measures in an international Cournot duopoly model wherein the foreign firm's marginal cost is known to the home and foreign firms but not to the home government. Consistent with the actual implementation of AD measures, we assume that the optimal AD measures are chosen so as to maximize some weighted average of consumer surplus, producer surplus, and net government revenue.

1 See Cumby and Moran (1997, 162). For the world's total AD proceedings between 1970 and 1986, see Anderson and Schmitt (1997, table 5).

2 Three commentators, Bronckers, Hoogakker, and Quick (1989, 21), concluded in their *Financial Times* article that 'if more weight is to be given to the consumer interest, the antidumping law should be changed.'

We shall show that when the home firm is relied upon to report the foreign firm's cost, the optimal incentive-compatible AD duty is either a prohibitive tariff (if the relative weight attached to the domestic firm's profits in the government's objective function is high) or one that is independent of the actual dumping margin (if the relative weight attached to the domestic firm's profits is low). When the foreign exporting firm is asked to report its own cost, the optimal incentive-compatible AD duty will be zero if the weight given to the home firm's profit is relatively small, it will be a prohibitive tariff if the weight is large, and it becomes an increasing function of the dumping margin if the weight is intermediate. In the presence of a GATT/WTO constraint in that the AD duty cannot exceed the dumping margin, the optimal incentive-compatible AD duty may be modified by setting the AD duty equal to the dumping margin at low or high dumping margins.

In the literature, much effort has been devoted to explaining the phenomenon of dumping.[3] By contrast, the analysis of AD policies has received relatively little attention (among the exceptions: Dixit 1988; Anderson, Schmitt, and Thisse 1995). Moreover, even though asymmetric information has been incorporated into some studies of strategic trade policies, our exploration of the design of optimal AD measures to induce truthful information revelation represents a relatively new attempt.[4] The only paper on AD measures under incomplete information is that by Kohler and Moore (1998), which analyses the design of AD rules when the government does not know the level of material injury to the domestic firms. In the present paper, however, we investigate the nature of optimal incentive-compatible AD measures when the government does not know whether dumping has occurred and what the dumping margin is. Clearly, our model is complementary to that of Kohler and Moore (1998).

The rest of the paper is organized as follows. In the next section we lay out the basic model. In section 2 we characterize the optimal incentive-compatible AD measures based on information provided by the home firm. In section 3 we examine the other polar case in which information is provided by the foreign firm. In section 4 we conclude the paper and suggest a direction for future research.

1. The basic framework

Consider two countries, home and foreign, each of which has one risk-neutral firm producing a single homogeneous good. Only the home government (henceforth 'the

3 See, for example, Ethier (1982), Brander and Krugman (1983), and Staiger and Wolak (1992). Blair and Cheng (1984) provided a survey of the earlier literature on dumping with special emphasis on dumping induced by demand uncertainty. A brief and more current survey of the dumping literature can be found in Hartigan (1996).

4 Collie and Hviid (1993), Qiu (1994), and Brainard and Martimort (1996) study optimal strategic export policies, not AD measures, in the presence of asymmetric information. Rosendorff's (1996) study of AD and voluntary export restraint features asymmetric information in the model. However, he focuses on a signalling issue wherein the government, having private information regarding the pressure of protection, uses AD duties to send out the information. There are also some very recent works related to AD and signalling, for example, Kolev and Prusa (1998).

government') is active in policy measures. The two firms are Cournot quantity-setters that compete repeatedly over time in the market of the home country. Market demand in each period, albeit uncertain, has the same expected value. For simplicity, we assume that the inverse demand function is linear: $p = a - b(q_H + q_F) + \epsilon$, where p is the output price, a and b are positive constants, q_H is the production at home, q_F is the amount of imports (subscript H stands for home and subscript F stands for foreign), and ϵ is the random shock which is identically, independently distributed with mean zero over support $[\underline{\epsilon}, \bar{\epsilon}]$, where $\underline{\epsilon} < 0 < \bar{\epsilon}$.

The home and foreign firms' marginal costs of production, denoted by c_H and c_F, respectively, are assumed to be constant. While these costs are known to both firms, the government can observe only c_H, not c_F. Since c_H plays no crucial role in the subsequent analysis, we define, for the purpose of notational simplification, all price and unit cost variables as net of c_H. Specifically, let $c = c_F - c_H$, which will take on negative values if the foreign firm has a lower cost. The government has a prior belief that c is drawn from the distribution $F(c)$, with density $f(c)$ defined over support $[\underline{c}, \bar{c}]$, which is common knowledge. Define $H(c) \equiv [1 - F(c)]/f(c)$. Following the mechanism design literature, we assume that $H'(c) \leq 0$ for all $c \in [\underline{c}, \bar{c}]$. This is satisfied by many commonly used distribution functions, including the uniform and normal distribution functions.

In each period, the firms simultaneously choose their output levels, q_H and q_F, before the demand uncertainty is resolved so as to maximize their expected profits, $\pi_H = [a - b(q_H + q_F)]q_H$ and $\pi_F = [a - b(q_H + q_F) - c]q_F$. The ex post output price is determined by the market-clearing condition. It is easily verified that the Cournot-Nash equilibrium is given by $q_H = (a + c)/3b$, $q_F = (a - 2c)/3b$, and $p = (a + c)/3 + \epsilon$. Throughout the paper, we assume that the vertical intercept of the inverse demand curve, a, is sufficiently large that both firms always produce positive quantities in the free trade equilibrium. Due to the noise term, ϵ, the government is unable to infer c from the realized output price.[5]

In practice, especially in the United States, an AD procedure must be initiated by domestic firms that file a petition accusing the foreign exporting firms of dumping in the domestic market. Dumping by foreign exporting firms is said to have occurred if imports have been sold at less than fair value (LTFV). LTFV can be defined in three different ways. First, the imports are priced at less than their prices in the exporters' home market. Second, the imports are priced at less than their prices in a third market. Third, the imports are priced at less than their costs of production. Determination of the incidence of dumping and the dumping margin is based on the actual prices of the imports over a *historic* period, normally six months (Staiger and Wolak 1994). To arrive at an average dumping margin when an AD duty is to be

5 A referee suggests that observing the tariff revenue may allow the government to infer the amount of import and thereby indirectly infer c. This is true in our simple model, but such an ability is undermined if there is no tariff in the absence of AD, or if tariff is an ad valorem one. At any rate, we assume that the government has to rely on either the firms' reports or its own investigation in order to obtain information about c.

imposed, the government excludes all transactions where dumping did not occur (Morkre and Kelly 1994). Partly because in many cases the first two definitions of LTFV are considered to be unreliable, the third definition has been used more frequently. According to Horlick (1989), about 60 per cent of all AD investigations in the United States have been based, at least in part, on allegations that prices were below some constructed values, which include, mainly, various costs of production.

In line with the observed practices, we specify in our model that dumping has occurred if $c > p_0$, where p_0 is some average of past prices,[6] and the dumping margin is $c - p_0$.[7] Note that with demand uncertainty, the realized price may be below c when the demand shock is sufficiently negative (e.g., $\epsilon < -a/3$). Thus, market uncertainties lead to cyclical dumping. This type of dumping is prevalent among many trading nations. Cyclical dumping has also attracted much attention in the studies of dumping, including Ethier (1982), Blair and Cheng (1984), Das (1992), and Staiger and Wolak (1992).

Suppose that the two firms have been competing for many periods. At the beginning of the next period, the home firm can file an AD petition at zero cost if the home firm finds it desirable to do so. Since investigation is costly, the government might wish to design an incentive-compatible AD measure that can induce a truthful report of c. Throughout this paper, we confine the government's AD measure to two instruments: a single-period *specific* (as opposed to ad valorem) AD duty levied on imports and a single-period lump-sum transfer either to the home firm (as in section 2) or to the foreign firm (as in section 3). It is well known that to induce information revelation, we need at least two instruments. An AD duty is our core instrument, while a lump-sum transfer or payment would be the simplest candidate for the second instrument. AD duty could be imposed for more than one period, but for simplicity we assume that it lasts for a single period. This allows us to focus on a one-period mechanism-design problem faced by the government.

As a benchmark, we shall first derive the optimal AD duty under complete information (the first-best policy). Given t, the home and foreign firms' profits are, respectively, $\pi_H = [a - b(q_H + q_F)]q_H$ and $\pi_F = [a - b(q_H + q_F) - c - t]q_F$. It is easily shown that $q_H = (a + c + t)/3b$ and $q_F = (a - 2c - 2t)/3b$. Since both q_H and q_F are constrained to be non-negative, increases in t would have no effect on q_H and q_F once t reaches the prohibitive level, $t_p \equiv a/2 - c$. Note that the home country's consumer surplus under linear demand is equal to $\text{CS} = b(q_H + q_F)^2/2$. Thus, the resulting home firm's profit is $\pi_H = (a + c + t)^2/9b$ and the consumer surplus is $\text{CS} = (2a - c - t)^2/18b$, where the dependence on t is meaningful only when $t \leq t_p$.

Consistent with Veugelers and Vandenbussche's (1999) report on consideration upon which AD measures are determined and following Baldwin's (1987) approach

6 See Rycken (1991) for a discussion of various methods used by the E.C. Commission to determine the average prices in the calculation of dumping margins.

7 Thus, this dumping margin is smaller than margins calculated by the various governments. The upward bias of the calculated dumping margin has been observed by many commentators (Morkre and Kelly 1994).

to the objective of trade policy, we assume that the government's preference can be described by a weighted average of the consumer surplus, the home firm's profit, and the tariff revenue: $W^0 = \alpha\pi_H + (1 - \alpha)(CS + tq_F)$, where $\alpha \in (0, 1)$ is the weight attached to the home firm's profit, and $(1 - \alpha)$ is the weight attached to the sum of the consumer surplus and the tariff revenue.[8] If $\alpha > 1/2$, it means that the government favours the home firm more than the consumers, as is often the case when it comes to dumping. However, the following analysis is not subject to this constraint.

The government chooses t so as to maximize W^0 when dumping occurs, subject to a GATT/WTO constraint that $t \leq c - p_0$. Also it sets $t = 0$ in the absence of dumping. Let us first examine the optimal t^0 that maximizes W^0 without the GATT/WTO constraint. Since W^0 consists of three different components, it helps to understand the properties of t^0 by examining how the tariff affects W^0 component by component. Taking the derivative of W^0 with respect to t yields

$$\frac{\partial W^0}{\partial t} = \frac{1}{9b}[2\alpha(a + c + t) - (1 - \alpha)(2a - c - t) + 3(1 - \alpha)(a - 2c - 4t)].$$

The first term in the square brackets captures the positive effect of t on π_H. The second term captures the negative effect of t on CS. The final term captures the usual effect of t on the tariff revenue, that is, positive for t small but negative for t large (even before it reaches t_p). Setting $\partial W^0/\partial t = 0$ yields the optimal AD policy under complete information:

$$t^0 = \frac{1}{11 - 13\alpha}[(1 + \alpha)a + (7\alpha - 5)c], \qquad \text{for } c > p_0. \tag{1}$$

The second-order condition requires that $11 - 13\alpha > 0$. When this condition is violated, we have $\partial W^0/\partial t > 0$ and the optimal tariff is equal to the prohibitive tariff t_p. Even if this condition holds, the prohibitive tariff also imposes a constraint on α if α is to have a non-zero effect on t^0, as described above. Using the formulae for t_p and t^0, we can show that there exists $\hat{\alpha} \equiv (9a - 12c)/(15a - 12c)$, such that t^0 varies with α for $\alpha \leq \hat{\alpha}$, and $t^0 = t_p$ for $\alpha > \hat{\alpha}$.

Since $\hat{\alpha} < 5/7$, from (1) we see that t^0 is a negative function of c for $\alpha \leq 5/7$. To gain a better understanding of the relationship between t^0 and c, let us use the Implicit Function Theorem to obtain $\mathrm{d}t^0/\mathrm{d}c = -(\partial^2 W^0/\partial c\partial t)/(\partial^2 W^0/\partial t^2)$. The denominator is negative by the second-order condition. Thus, the sign of $\mathrm{d}t^0/\mathrm{d}c$ is given by that of the numerator, which can be written as

$$\frac{\partial^2 W^0}{\partial c\partial t} = \frac{1}{9b}[2\alpha + (1 - \alpha) - 6(1 - \alpha)] = \frac{1}{9b}(7\alpha - 5).$$

8 If $\alpha = 1/2$, W^0 becomes the utilitarian social welfare function as considered by Dixit (1988). Rosendorff (1996) interprets α as an index gauging the lobbying pressure of the domestic firm.

The three terms in the square brackets capture the effects of increasing c on π_H (positive), CS (positive), and the tariff revenue (negative), respectively. Clearly, the first effect is smaller, but the second and third effects are larger, for a smaller α. Hence, for sufficiently small α (i.e., $\hat{\alpha} \leq 5/7$), t^0 should be set lower for a larger c. Intuitively, if the foreign firm is less efficient, raising tariffs is more effective in shifting profit, less harmful in reducing consumer surplus, but more dramatic in reducing the tariff revenue. When the home government does not care too much about producer profit (smaller α), however, the positive profit-shifting effect is small, calling for a lower tariff (responding to a higher c).

Under the GATT/WTO constraint, the optimal AD duty denoted t_G^0 can easily be obtained: $t_G^0 = \min\{t^0, c - p_0\}$. Note that $t^0 \leq c - p_0$ if and only if $(1 + \alpha)a + (11 - 13\alpha)p_0 \leq 4(4 - 5\alpha)c$. Thus, t_G^0 is equal to the dumping margin unless $\alpha < 4/5$ and c is sufficiently large.[9] The intuition is that an AD duty equal to a very large dumping margin is overkill.

We summarize the above results as follows.

PROPOSITION 1. *Suppose the home government has full information and dumping occurs (i.e., $c > p_0$).*

(i) Without the GATT/WTO constraint, the optimal AD duty is t_p for $\alpha > \hat{\alpha}$, and is t^0 as given by (1) for $\alpha \leq \hat{\alpha}$.
(ii) With the GATT/WTO constraint, the optimal AD duty is $t_G^0 = \min\{t^0, c - p_0\}$.

2. AD measures based on the home firm's report

2.1. Characterization of the AD program

In this section we examine the optimal incentive-compatible AD measures based on the home firm's report of the foreign firm's cost. The reported cost, denoted by $\hat{c}$, may or may not be equal to its true cost. Following the report, the government imposes a specific duty, $t(\hat{c}) \geq 0$, on imports, and a lump-sum tax, $\tau(\hat{c})$, on the home firm. If $\tau(\hat{c}) < 0$, it is a lump-sum subsidy to the home firm.

Let $\tilde{\pi}_H$ be the home firm's profit in this case. It is easy to check that Cournot competition yields $\tilde{\pi}_H(\hat{c}|c) = \pi_H(\hat{c}|c) - \tau(\hat{c})$, where (and hereafter) $x(\hat{c}|c)$ stands for the value of any function (variable) x given that c is the true cost while $\hat{c}$ is reported. If the home firm does not file any AD petition, it will receive its profit under free trade: $\pi_H^0(c) = (a + c)^2/9b$. The excess profit of the home firm given a truthful report is thus

$$U_H(c) \equiv \tilde{\pi}_H(c) - \pi_H^0(c) = \pi_H(c) - \tau(c) - \pi_H^0(c). \tag{2}$$

9 Even though the above inequality holds if $\alpha > 4/5$ and c is sufficiently negative, it can be ignored because it implies a negative dumping margin.

The government's objective function is

$$\widetilde{W}(\hat{c}|c) = \alpha\tilde{\pi}_H(\hat{c}|c) + (1-\alpha)[\mathrm{cs}(\hat{c}|c) + t(\hat{c})q_F(\hat{c}|c)] + \alpha\tau(\hat{c})$$
$$= \alpha\pi_H(\hat{c}|c) + (1-\alpha)[\mathrm{cs}(\hat{c}|c) + t(\hat{c})q_F(\hat{c}|c)],$$

where the weight attached to profit tax on the domestic firm is the same as that attached to the domestic firm's profit. Under this assumption a lump-sum transfer alone will not alter the welfare. For notational convenience, let $x(c)$ stand for $x(c|c)$. Thus, optimal AD measures can be described by the following program:

$$\max_{t(c)\geq 0,\,\tau(c)} \int_{\underline{c}}^{\bar{c}} \widetilde{W}(c)\,\mathrm{d}F(c), \qquad \text{subject to} \tag{**P1**}$$

$$\tilde{\pi}_H(c) \geq \tilde{\pi}_H(\hat{c}|c) \text{ for all } \hat{c},\, c \in [\underline{c}, \bar{c}] \tag{i}$$

$$\tilde{\pi}_H(c) \geq \pi_H^0(c) \text{ for all } c \in (p_0, \bar{c}] \tag{ii}$$

$$\tilde{\pi}_H(c) \leq \pi_H^0(c) \text{ for all } c \in [\underline{c}, p_0] \tag{iii}$$

$$t(c) = \tau(c) = 0 \text{ for all } c \in [\underline{c}, p_0] \tag{iv}$$

$$t(c) \leq c - p_0 \text{ for all } c \in (p_0, \bar{c}]. \tag{v}$$

(**P1**)(iii) is a non-participation constraint to ensure that the home firm does not report dumping in its absence. Condition (**P1**)(i), the incentive compatibility constraint, ensures that the home firm reports the true cost. Condition (**P1**)(iv) is an institutional constraint that says that AD duty should not be imposed if dumping does not occur. Condition (**P1**)(v) is the GATT/WTO constraint.

Lemma 1. *Given the institutional constraint (**P1**)(iv) and the GATT/WTO constraint (**P1**)(v), the AD measures* $[t(c), \tau(c)]$ *satisfy (**P1**)(i), (ii) and* (iii) *if, and only if, for all* $c \in [\underline{c}, \bar{c}]$*, the following two conditions hold:*

$$\text{(i)}\ \ U_H(c) = \int_{p_0}^{c} \frac{2}{9b}\, t(\hat{c})\,\mathrm{d}\hat{c}, \text{ and (ii)}\ \ t'(c) \geq 0.$$

Proof: See the appendix. ■

Condition (ii) of lemma 1 is a necessary condition for incentive compatibility. It says that an incentive-compatible AD duty schedule $t(c)$ should be non-decreasing in reported costs. To see the intuition, suppose the contrary, that is, that there exist c^1 and c^2 with $c^1 < c^2$ but $t(c^1) > t(c^2)$. First, note that the home firm's output is higher when the foreign firm's true cost is c^2 than when the true cost is c^1. This implies that the gain accrued to the home firm due to a duty increase is greater in the former case than in the latter case. Second, a change in the lump-sum tax has the same effect on the home firm's profit regardless of the foreign firm's true marginal cost. Therefore, if the foreign firm's true cost is c^1 and the home firm prefers

reporting c^1 to reporting c^2, then it has an even stronger incentive to report c^1 when the foreign firm's true cost is c^2. Thus, $t'(c) \geq 0$ is needed for incentive compatibility.

Using (2) and (i) of lemma 1, we have

$$\tau(c) = \pi_H(c) - \pi_H^0(c) - \int_{p_0}^{c} \frac{2}{9b}\, t(\hat{c})\, \mathrm{d}\hat{c}. \tag{3}$$

Thus, with lemma 1 we can rewrite program (**P1**) equivalently as

$$\max_{t(c)\geq 0} \int_{p_0}^{\bar{c}} \widetilde{W}(c)\mathrm{d}F(c) \text{ subject to } t'(c) \geq 0 \text{ and } t(c) \leq c - p_0. \tag{**P1′**}$$

2.2. Equivalent AD program without the GATT/WTO constraint

In solving (**P1′**), we first ignore constraint (ii) of lemma 1 and the GATT/WTO constraint. The corresponding (unconstrained) optimal duty is given by t^0 in (1) when $(11 - 13\alpha) > 0$ and by t_p when $(11 - 13\alpha) \leq 0$. We then examine the optimal duty in the light of $t'(c) \geq 0$. First, similar to the method applied to $\hat{\alpha}$, which was defined and discussed in section 1, we define $\alpha_p \equiv (9a - 12p_0)/(15a - 12p_0)$. Then, the optimal duty is t_p for $\alpha \geq \alpha_p$ and for all $c > p_0$. However, $t_p = a/2 - c$ is a decreasing function of c, violating $t'(c) \geq 0$. We choose $\bar{t}_p \equiv a/2 - p_0$, which is the lowest tariff prohibitive for all $\alpha \geq \alpha_p$ and $c > p_0$ and satisfying $t'(c) \geq 0$.

Second, since $\alpha_p < 5/7$, $t^0(\alpha, c)$ is a decreasing function of c for $\alpha < 5/7$, violating non-decreasing condition. According to a well-known result in the principal-agent literature (Guesnerie and Laffont 1984, Theorem 4), the combination of condition (ii) of lemma 1 and (1) results in a simple optimal incentive compatible policy, namely, a constant duty that is independent of c.[10]

Imposing the restriction that $t(\alpha, c) = t(\alpha)$ for all $c \in (p_0, \bar{c}]$ on (**P1′**) and using (1), the optimal constant AD duty is given by

$$t^*(\alpha) = \frac{1}{11 - 13\alpha}\left[(1 + \alpha)a + (7\alpha - 5)\mathrm{E}(c|c > p_0)\right],$$

$$\text{for } \alpha < \frac{5}{7},\ c \in (p_0, \bar{c}]. \tag{4}$$

Note that a constant duty (with respect to c) also implies a constant lump-sum tax, which can easily be obtained using (4) in (3). We summarize the above results in the following proposition.

10 Our model provides an example of countervailing incentives. The home firm wants to understate c in order to receive more protection should the optimal policy be governed by (1). However, there exists another incentive for the home firm to overstate c so that its reservation profit becomes larger and thereby a lower lump-sum tax is used. Because $U_H(c)$ is monotonic, the optimal AD duty is a constant.

PROPOSITION 2. *Suppose the optimal incentive compatible AD measure is based on the home firm's report of the foreign firm's cost and the GATT/WTO constraint is not imposed.*

(i) If $\alpha \geq \alpha_p$, *then the optimal AD duty is a prohibitive one,* $\bar{t}_p = a/2 - p_0$, *for all* $c > p_0$.

(ii) If $\alpha < \alpha_p$, *then the optimal AD duty is given by* $t^*(\alpha) = [(1+\alpha)a + (7\alpha - 5)E(c|c > p_0)]/(11 - 13\alpha)$, *which is independent of c.*

(iii) $t^* < t^0(c)$, *for all* $c \in (p_0, \bar{c}]$.

Let us discuss the implications of proposition 2. First, if the home government attaches a large weight to the home firm's profits (i.e., α is large), then the optimal AD duty is a prohibitive one for all c. Second, if the weight attached to the home firm's profit is small, then the government needs to know (through policy design, not investigation) only whether dumping has occurred. If it has occurred, the home firm will file an AD petition, and the government simply applies an optimal constant specific duty, as given by (4), and a corresponding constant lump-sum tax. Even though the government is free to design measures that depend on the reported cost, it is not optimal to do so, owing to the incentive compatibility constraint. The intuition is as follows. If the government has information about the foreign firm's marginal cost and attaches a relatively small weight to π_H, then, according to (1), it should set a lower duty when the foreign firm's cost is higher. On the other hand, for the home firm to report truthfully the foreign firm's marginal cost, the duty cannot be lower if c is larger according to condition (ii) of lemma 1, as explained above. Thus, the first-best AD duty goes against the incentive-compatibility condition. As a result, a constant duty is a compromise between these two conflicting requirements. Moreover, this constant duty is lower than the first-best AD duty regardless of the dumping margin.[11]

2.3. Equivalent AD program with GATT/WTO constraint

We now impose the GATT/WTO constraint. Let t_G^* denote the optimal AD duty for (**P1′**), that is, under the GATT/WTO constraint. It is noteworthy that when the

11 In the above analysis we have omitted the uninteresting case where the optimal AD duty, t^0 or $t^*(\alpha)$, may exceed the prohibitive tariff t_p. It can be shown that there exists a critical value of c such that the AD duty exceeds the prohibitive tariff if and only if c is greater than the critical value. If such a critical value is greater than $\bar{c}$, then the corresponding part in proposition 2 will remain unchanged. If, however, the critical value is less than $\bar{c}$, then proposition 2 is only slightly modified by setting the corresponding optimal AD duty equal to the prohibitive tariff t_p for c greater than the critical value.

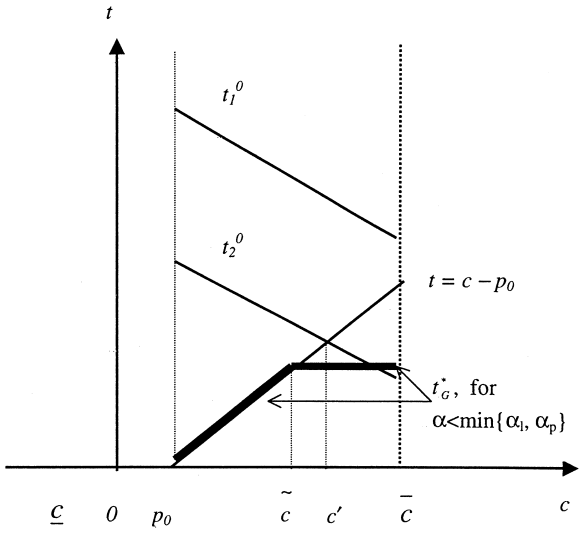

FIGURE 1 The optimal GATT/WTO-constrained AD duty when home firm reports

GATT/WTO constraint is binding, that is, $t(c) = c - p_0$, the monotonicity condition (ii) of lemma 1 is automatically satisfied.

The optimal AD duty derived in the previous subsection may or may not exceed the dumping margin, depending on the value of α. Let us look first at the case when $\alpha \geq \alpha_p$. It is easily seen that $\bar{t}_p$ violates the GATT/WTO constraint. Hence, the optimal AD subject to the GATT/WTO constraint is simply $t_G^* = c - p_0$, the dumping margin.

In the case of $\alpha < \alpha_p$ we know from (1) that in the absence of the GATT/WTO constraint and monotonicity constraint $t'(c) \geq 0$, the optimal duty schedule is a decreasing function of c. Figure 1 depicts two of these schedules. The higher schedule of t^0 (i.e., t_1^0) is everywhere above the GATT/WTO constraint line, which holds if and only if $\alpha \geq \alpha_l$, where $\alpha_l \equiv -(a - 16\bar{c} + 11p_0)/(a + 20\bar{c} - 13p_0)$. In this case, the GATT/WTO-constrained optimal AD duty is simply the dumping margin, that is, $t_G^* = c - p_0$, which automatically satisfies the incentive-compatibility constraint $t'(c) \geq 0$.

The lower schedule of t^0 (i.e., t_2^0) intersects the GATT/WTO-constraint line from above, say, at c' ($< \bar{c}$) in figure 1. As before, combining the downward-sloping property of the first-best schedule with the upward-sloping incentive compatibility requirement leads to a constant duty. In the light of the GATT/WTO constraint, however, the optimal incentive compatible duty schedule is equal to the dumping margin when the margin is small and is equal to a constant if the margin is large, that is, there exists $\tilde{c}(< c')$ such that

$$t_G^*(c) = \begin{cases} c - p_0 & \text{for } c \in (p_0, \tilde{c}] \\ \tilde{c} - p_0 & \text{for } c \in (\tilde{c}, \bar{c}]. \end{cases} \tag{5}$$

Therefore, the government's decision is to choose $\tilde{c}$ to maximize the objective function of (**P1′**) subject to (5). Applying Leibniz's rule, the first-order condition yields the optimal solution,[12] $\tilde{c}^*$:

$$\int_{\tilde{c}^*}^{\bar{c}} [a(1+\alpha) + (7\alpha - 5)c - (11 - 13\alpha)(\tilde{c}^* - p_0)\mathrm{d}F(c) = 0. \tag{6}$$

The lump-sum tax for $c \in (\tilde{c}^*, \bar{c}]$ can be obtained by using this equation in (3).

Proposition 3. *Suppose the incentive-compatible AD measure is based on the home firm's report.*

(i) If $\alpha \geq \min\{\alpha_l, \alpha_p\}$*, then the optimal AD duty subject to the GATT/WTO constraint is simply the dumping margin, that is,* $t_G^*(c) = c - p_0$ *for* $c \in (p_0, \bar{c}]$.
(ii) If $\alpha < \min\{\alpha_l, \alpha_p\}$*, then the AD duty is given by*

$$t_G^*(c) = \begin{cases} c - p_0 & \text{for } c \in (p_0, \tilde{c}^*], \\ \tilde{c} - p_0 & \text{for } c \in (\tilde{c}^*, \bar{c}]. \end{cases}$$

According to proposition 3, if the home government attaches a large weight to the home firm's profits, then the optimal AD duty is equal to the dumping margin for all possible values of c. Otherwise the optimal AD duty becomes a constant after the dumping margin exceeds a certain critical level. This optimal incentive compatible AD duty corresponds to the actual policy observed in the real world.

The intuition behind proposition 3(ii) is as follows. On the one hand, the optimal tariff consideration calls for a negative relationship between the AD duty and c. On the other hand, the incentive-compatibility constraint calls for a positive relationship between the AD duty and c. As a compromise, the optimal AD duty ignoring the GATT/WTO constraint would be a constant independent of c. Apparently the GATT/WTO constraint is binding for c small (i.e., when the dumping margin is small) but not for c large. Consequently, the optimal AD duty is as illustrated in figure 1.

3. AD measures based on the foreign firm's report

3.1. Characterization of the AD program

In this section we examine the optimal incentive-compatible AD measures based on the foreign firm's report of its own cost. Based on the report, the foreign firm will be subject to a specific duty on its exports, $t(\hat{c}) \geq 0$, and a lump-sum transfer, $s(\hat{c})$,

12 The second-order condition automatically holds under $\alpha < 11/13$.

which could be positive (for a lump-sum subsidy) or negative (for a lump-sum tax).[13] Given policy (t,s) and the report $\hat{c}$, the firms' profits are, respectively, $\pi_H = [a - b(q_H + q_F)]q_H$ and $\pi_F = [a - b(q_H + q_F) - c - t(\hat{c})]q_F + s(\hat{c})$. Thus, provided that $t < t_p$, the Cournot-Nash equilibrium is given by

$$q_H(\hat{c}|c) = \frac{1}{3b}[a + c + t(\hat{c})],\ q_F(\hat{c}|c) = \frac{1}{3b}[a - 2c - 2t(\hat{c})].$$

The resulting home firm's profit and consumer surplus are

$$\pi_H(\hat{c}|c) = \frac{1}{9b}[a + c + t(\hat{c})]^2,\ \mathrm{cs}(\hat{c}|c) = \frac{1}{18b}[2a - c - t(\hat{c})]^2,$$

and the foreign firm's profit is

$$\pi_F(\hat{c}|c) = \frac{1}{9b}[a - 2c - 2t(\hat{c})]^2 + s(\hat{c}). \tag{7}$$

The expected market price is $p(\hat{c}|c) = [a + c + t(\hat{c})]/3$.

If the foreign firm refuses to report its cost, we assume that the government will impose a pre-specified duty, $t_N > 0$, upon the imports regardless of the foreign firm's cost. In this case, the foreign firm's profit is given by $\pi_F^N(c) = (a - 2c - 2t_N)^2/9b$, which is less than its profit under free trade, $\pi_F^0(c) = (a - 2c)^2/9b$.

When the foreign firm reports its own cost, the government's objective function is

$$W(\hat{c}|c) = \alpha\pi_H(\hat{c}|c) + (1 - \alpha)[\mathrm{cs}(\hat{c}|c) + t(\hat{c})q_F(\hat{c}|c) - s(\hat{c})].$$

Note that the weight attached to the subsidy to the foreign firm is the same as that attached to consumer surplus and tariff revenue, which is justifiable if we consider that the government uses only part of the tariff revenue to finance the subsidy payment. The government's optimal AD measures can be described by the following program:

$$\max_{t(c)\geq 0,\, s(c)} \int_{\underline{c}}^{\bar{c}} W(c)\,\mathrm{d}F(c) \text{ subject to} \tag{**P2**}$$

$$\pi_F(c) \geq \pi_F(\hat{c}|c) \text{ for all } \hat{c}, c \in [\underline{c}, \bar{c}]; \tag{i}$$

$$\pi_F(c) \geq \pi_F^N(c) \text{ for all } c \in [\underline{c}, \bar{c}]; \tag{ii}$$

$$t(c) = s(c) = 0 \text{ for all } c \in [\underline{c}, p_0]; \tag{iii}$$

$$t(c) \leq c - p_0 \text{ for all } c \in [\underline{c}, p_0]. \tag{iv}$$

13 Although we do not impose any restriction on the sign of $s(\hat{c})$, the analysis below shows that it is always non-negative. That is, a lump-sum subsidy is part of an AD measure. Thus, we do not have to face the question whether it is beyond the government's jurisdiction to impose lump-sum taxes on the foreign firm.

Condition (**P2**)(ii), the participation constraint, guarantees that the foreign firm always reports, while the rest of the conditions are similar to those discussed under (**P1**).

A combination of (**P2**)(i) and (**P2**)(iii) implies that the foreign firm must receive a profit no smaller than that under free trade ($\pi_F^0(c)$), since, without being investigated, the foreign firm can always declare its marginal cost to be below p_0; that is,

$$U_F(c) \equiv \pi_F(c) - \pi_F^0(c) \geq 0 \text{ for all } c \in [\underline{c}, \bar{c}]. \tag{8}$$

Since (8) satisfies the participation constraint as well as the institutional constraint, there is no loss of generality in replacing condition (**P1**)(ii) by (8).

Lemma 2. *Given the institutional constraint (**P2**)(iii) and the GATT/WTO constraint (**P2**)(iv), the AD measures,* $[t(c), s(c)]$, *satisfy constraints (**P2**)(i) and (8) if, and only if, for all* $c \in [p_0, \bar{c}]$, *the following conditions hold:*

$$\textit{(i) } U_F(c) = U_F(p_0) + \int_{p_0}^{c} \frac{8}{9b}\, t(\hat{c})\, \mathrm{d}\hat{c}\textit{; (ii) } U_F(p_0) \geq 0\textit{; and (iii) } t'(c) \geq 0.$$

Proof. See the appendix. ■

The intuition behind lemma 2 about the monotinicity of $t(c)$ is similar to that behind lemma 1. Another necessary condition for incentive compatibility is that the information rent, $U_F(c)$, is also an increasing function of c, as is clear from condition (i) of lemma 2. Thus, the foreign firm must be rewarded more to induce it to report its higher production cost.

Using (7), (8), and lemma 2(i), we have

$$s(c) = \frac{4}{3}\, t(c) q_F(c) + \frac{4}{9b}\, t(c)^2 + U_F(p_0) + \int_{p_0}^{c} \frac{8}{9b}\, t(\hat{c})\, \mathrm{d}\hat{c}. \tag{9}$$

Since $U_F(p_0) \geq 0$, $s(c) > 0$ whenever $t(c) > 0$. That is, because AD duty is a positive tariff, the lump-sum transfer is always a subsidy to the foreign firm. It is evident from the government's objective function that it is optimal to pay as little subsidy as possible. As a result, $U_F(p_0) = 0$ at the optimum. Substituting $s(c)$ into $W(c)$ with $U_F(p_0) = 0$, and then integrating by parts, we can rewrite program (**P2**) equivalently as

$$\max_{t(c)\geq 0} \int_{p_0}^{\bar{c}} W^*(c)\mathrm{d}F(c), \text{ subject to } t'(c) \geq 0 \text{ and } t(c) \leq c - p_0, \tag{**P2′**}$$

where

$$W^*(c) \equiv \alpha \pi_H(c) + (1-\alpha)\left[\mathrm{cs}(c) - \frac{1}{3}\, t(c) q_F(c) - \frac{4}{9b}\, t(c)^2 - \frac{8}{9b}\, t(c) H(c)\right].$$

3.2. Equivalent AD program without the GATT/WTO constraint

For the moment let us ignore the GATT/WTO constraint in the equivalent AD program (**P2′**). Suppose that condition (iii) of lemma 2 and the non-negativity of $t(c)$ are also ignored for the time being. Then for every given c, differentiating the objective function of (**P2′**) with respect to $t(c)$ gives the first-order condition

$$\frac{\partial W^*(c)}{\partial t(c)} = \frac{1}{9b}\{2\alpha(a + c + t) - (1 - \alpha)[3(a - c + t) + 8H(c)]\} = 0. \tag{10}$$

The second-order condition for optimality is $\partial^2 W^*(c)/\partial t(c)^2 = [2\alpha - 3(1 - \alpha)]/9 < 0$, which implies an upper bound for α: $\alpha < 3/5$. If this condition fails, we have $\partial W^*(c)/\partial t(c) > 0$ and so the optimal duty is the prohibitive tariff t_p. We solve the first-order condition (10) to obtain the optimal unconstrained duty as a function of α as well as c.

$$t^*(\alpha, c) = -a + \frac{3 - \alpha}{3 - 5\alpha}c - \frac{8(1 - \alpha)}{3 - 5\alpha}H(c). \tag{11}$$

Define $\alpha^* \equiv 3(a - \bar{c})/(5a - \bar{c})$, which is smaller than 3/5. Let us establish the properties of $t^*(\alpha, c)$ by temporarily ignoring the constraint $t \geq 0$ and the institutional constraint ($t = 0$ for $c \leq p_0$).

LEMMA 3. *Suppose* $\alpha < 3/5$.

(i) $\partial t^*(\alpha, c)/\partial c > 0$ *for all* α *and* c.

(ii) $t^*(\alpha, c) < 0$ *for all* $\alpha < \alpha^*$ *and* $c \in [\underline{c}, \bar{c}]$;

(iii) For any given $\alpha > \alpha^*$, *there exists a unique* $c^*(\alpha) \in (\underline{c}, \bar{c})$ *such that* $t^*(\alpha, c) < 0$ *for all* $c < c^*(\alpha)$, $t^*(\alpha, c^*(\alpha)) = 0$, *and* $t^*(\alpha, c) > 0$ *for all* $c > c^*(\alpha)$;

(iv) At $\alpha = \alpha^*$, *we have* $t^*(\alpha^*, \bar{c}) = 0$ *and* $t^*(\alpha^*, c) < 0$ *for all* $c < \bar{c}$.

Proof. See the appendix. ■

It is worth pointing out that, owing to constraint (8), the optimal duty $t^*(\alpha, c)$ given in (11) is an increasing function of c (lemma 3(i)). This is in contradiction to the decreasing function of the optimal duty t^0 with respect to c in the complete information case.

We now restore all constraints (except the GATT/WTO constraint), one at a time, to obtain the optimal AD duty. First, because of part (i) of lemma 3, the solution obtained in (11) automatically satisfies the constraint in (**P2′**) that $t'(c) \geq 0$. Second, the definition of an AD duty implies that t^* must be non-negative, which, in turn, implies that $t^* = 0$ whenever the unconstrained t^* is negative. Lastly, the institutional constraint requires the AD duty to be zero for $c \leq p_0$. There are two possible cases: $c^*(\alpha) \geq p_0$ or $c^*(\alpha) < p_0$. In the former case, the institutional constraint is automatically satisfied. In the latter case, we must set $t^* = 0$ for $c \in (c^*(\alpha), p_0]$.

When the optimal duty is a prohibitive tariff, the corresponding analysis used in section 2 applies here. The optimal lump-sum subsidy corresponding to (11) can be calculated by simply substituting (11) into (9).

We summarize the results of the above analysis in the following proposition.

PROPOSITION 4. *Suppose the optimal incentive-compatible AD measure is based on the foreign firm's report of its cost and the GATT/WTO constraint is not imposed.*

(i) If $\alpha \leq \alpha^*$*, then optimal incentive-compatible policy is free trade, that is,* $t^* = 0$ *and* $s^* = 0$.

(ii) If $\alpha \in (\alpha^*, 3/5)$*, then the optimal incentive-compatible policy is free trade for* $c \leq \max\{c^*(\alpha), p_0\}$*. However, for* $c \in (\max\{c^*(\alpha), p_0\}, \bar{c}]$*, the optimal AD duty is given by (11) for small c and then becomes constant after the tariff rate begin to hit the prohibitive* t_p.

(iii) If $\alpha \geq 3/5$*, the optimal AD duty is* $\bar{t}_p = a/2 - p_0$.

The proposition can be summed up as follows. First, the home government does not levy any AD duty on dumping either if it does not care about the home firm's profits very much or if the foreign firm enjoys a large competitive advantage. Second, when a positive AD duty is levied on dumped import, the optimal AD duty is higher if the dumping margin is larger, but not exceeding the prohibitive tariff t_p.

3.3. Equivalent AD program with GATT/WTO constraint

In the previous subsection, the optimal AD duty t^* may exceed the dumping margin, $c - p_0$, thus violating the GATT/WTO constraint. It is noteworthy that when the GATT/WTO constraint is binding, the monotonicity condition (iii) of lemma 2 is automatically satisfied. Note that whenever the optimal AD in proposition 4 is a prohibitive tariff, the GATT/WTO constraint is violated. Therefore, the corresponding AD duty must be equal to the dumping margin, $c - p_0$. We now focus on the case where the optimal AD duties derived in the previous two sections are below the prohibitive tariff t_p, and consider the two cases, $c^*(\alpha) \geq p_0$ and $c^*(\alpha) < p_0$, in turn.

First, $c^*(\alpha) \geq p_0$. According to proposition 4, when $\alpha > \alpha^*$ and $c > c^*(\alpha)$, the optimal duty in the absence of the GATT/WTO constraint is given by (11). This AD duty may or may not violate the GATT/WTO constraint. Figure 2 depicts these two possibilities: one upward-sloping curve (which represents AD duty schedule under some $\alpha^* < \alpha < \alpha^{**}$, where α^{**} is defined below) is entirely below the GATT/WTO-constraint line, and another upward-sloping curve (which represents AD duty schedule under some $\alpha \geq \alpha^{**}$) intersects the GATT/WTO-constraint line from below at $c = c^{**}(\alpha)$. In the former curve, the unconstrained AD duty (11) does not violate the GATT/WTO constraint and so remains as the optimal AD duty under the

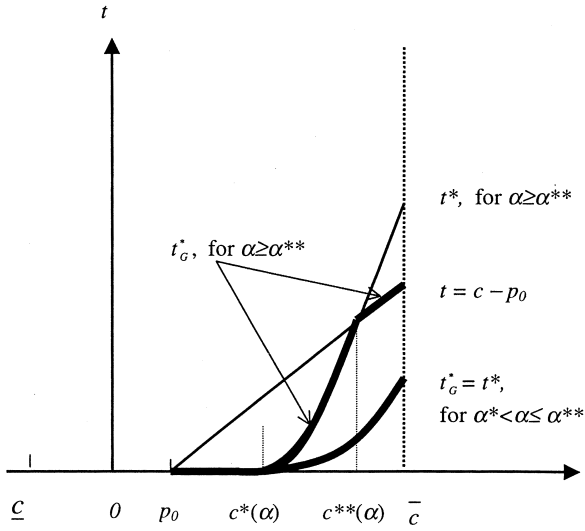

FIGURE 2 The optimal GATT-constrained AD duty when foreign firm reports

GATT/WTO constraint, that is, $t_G^* = t^*$ as given by (11). In the latter curve, (11) violates the GATT/WTO constraint for $c > c^{**}$. As a result, $t_G^* = t^*$ as given by (11) for $c \leq c^{**}$, but $t_G^* = c - p_0$ for $c > c^{**}$. We prove the existence of these two cases in the appendix.

The case for $c^*(\alpha) < p_0$ is much simpler. It is proved in the appendix that the unconstrained t^* is everywhere above the GATT/WTO-constraint line.

PROPOSITION 5. *Suppose the optimal incentive-compatible AD measure is based on the foreign firm's report and subject to the GATT/WTO constraint.*

(i) The optimal AD duty is free trade if $\alpha \leq \alpha^*$ *and is equal to the dumping margin,* $c - p_0$*, for all* $c > p_0$*, if* $\alpha \geq 3/5$ *or if* $\alpha \in (\alpha^*, 3/5)$ *and* $c^*(\alpha) \leq p_0$.

(ii) Suppose $c^*(\alpha) > p_0$*. Then, for all* $\alpha \in (\alpha^*, \alpha^{**})$*, where* $\alpha^{**} \equiv 3(a - p_0)/[5a + 4\bar{c} - 5p_0] < 3/5$*, the optimal AD duty is*

$$t_G^* = \begin{cases} 0 & \text{for } c \leq c^*(\alpha) \\ -a + \dfrac{3-\alpha}{3-5\alpha}\, c - \dfrac{8(1-\alpha)}{3-5\alpha}\, H(c) & \text{for } c > c^*(\alpha). \end{cases}$$

For any given $\alpha > \alpha^{**}$*, there exists a unique* $c^{**}(\alpha)$*, where* $c^*(\alpha) < c^{**}(\alpha) < \bar{c}$*, and the optimal AD duty is*

$$t_G^* = \begin{cases} 0 & \text{for } c \leq c^*(\alpha), \\ -a + \dfrac{3-\alpha}{3-5\alpha}\, c - \dfrac{8(1-\alpha)}{3-5\alpha}\, H(c) & \text{for } c \in (c^*(\alpha), c^{**}(\alpha)], \\ c - p_0 & \text{for } c > c^{**}(\alpha). \end{cases}$$

Proof. See the appendix. ■

The results contained in proposition 5 are illustrated by figure 2. If the dumping margin is small, the optimal policy is free trade. If the dumping margin is in the intermediate range, then it is given by an optimal tariff that rises with the margin, but nevertheless falling short of the full margin. If the dumping margin is very large or if the home government attaches a large weight to the home firm's profits, then the optimal tariff is equal to the full margin.

The intuition behind the above results is as follows. Without the incentive-compatibility constraint, the optimal AD duty would be given by the first-best optimal tariff as modified by the GATT/WTO constraint. The incorporation of the incentive-compatibility constraint serves to weaken, but not completely offset the optimal tariff considerations. Thus, when the optimal tariffs are small, the incorporation of the incentive-compatibility constraint makes the optimal AD duty zero. When the optimal tariffs are very large, however, they are constrained directly by the GATT/WTO constraint, while the incentive-compatibility constraint loses its bite. As a result, the optimal AD duty is equal to the full dumping margin.

Given the optimal AD duty, the corresponding lump-sum subsidy can be easily obtained, but is omitted to save space.

4. Concluding Remarks

Recognizing that AD investigations are time consuming and costly, we have explored the design of optimal incentive-compatible AD measures that can induce the firms involved to report their truthful information and thus save both time and costs. When the home firm is relied upon to report the foreign firm's cost, we have found that the optimal AD duty is either a prohibitive tariff (if the relative weight attached to the domestic firm's profits is high) or one that is independent of the actual dumping margin (if the relative weight attached to the domestic firm's profits is low). If the foreign firm is asked to report its own cost, we have found that the optimal AD duty is zero if the weight attached to the domestic firm's profit is not large enough. If the weight is sufficiently large, the optimal AD duty is a prohibitive tariff. If the weight is intermediate, then the optimal AD duty is an increasing function of the dumping margin.

Under the GATT/WTO rule, the optimal incentive-compatible AD duty is modified by setting the optimal AD duty equal to the dumping margin. Only if α is very small can we have a constant AD at high dumping margins.

Although it is well known that private information extracted from firms may help to design better government policies, we have shown in this paper that in some cases the scope of designing optimal incentive-compatible AD measures may be limited by the conflicting twin roles assumed by the AD measure, namely, welfare maximization (or efficiency) vis-à-vis incentive compatibility. These cases arise when the weight attached to the domestic firms's weight is not sufficiently larger than that attached to consumer surplus. From the point of view of the home country's national welfare, incentive-compatible AD measures save the costs of investigation but themselves are costly because the incentive-compatibility requirement imposes a constraint on the choice of AD duties. If the latter cost is high relative to the costs of investigation, then incentive-compatible AD measures are inferior despite savings in the costs of investigation. Thus, an extension of the present study is to introduce an additional mechanism to discourage lying. A feasible mechanism to consider would be random investigation plus penalty for mis-reporting. We leave this task for future research.

Appendix

Proof of lemmas 1 and 2

Since the proofs of lemmas 1 and 2 are essentially the same, to save space we will prove only lemma 1.

In order for the home firm to report the foreign firm's true marginal cost, a necessary condition for (**P1**)(i) is that, for all $c \in [\underline{c}, \bar{c}]$,

$$\left.\frac{\partial \tilde{\pi}_H(\hat{c}|c)}{\partial \hat{c}}\right|_{\hat{c}=c} = \frac{2}{9b}[a + c + t(c)]t'(c) - \tau'(c) = 0. \tag{A1}$$

The second-order condition for (**P1**)(i) is $\left.\partial^2 \tilde{\pi}_H(\hat{c}|c)/\partial \hat{c}^2\right|_{\hat{c}=c} \leq 0$. The latter condition can be rewritten using (A1) as

$$\left.\frac{\partial^2 \tilde{\pi}_H(\hat{c}|c)}{\partial \hat{c}^2}\right|_{\hat{c}=c} = -\left.\frac{\partial^2 \tilde{\pi}_H(\hat{c}|c)}{\partial \hat{c}\partial c}\right|_{\hat{c}=c} \leq 0.$$

Or, equivalently,

$$\left.\frac{\partial^2 \tilde{\pi}_H(\hat{c}|c)}{\partial \hat{c}\partial c}\right|_{\hat{c}=c} = \frac{2}{9b}t'(c) \geq 0. \tag{A2}$$

Thus, (A2) implies that $t'(c) \geq 0$. By the envelope theorem, we must have

$$U_H'(c) = \left.\frac{\partial \tilde{\pi}_H(\hat{c}|c)}{\partial c}\right|_{\hat{c}=c} - \frac{\mathrm{d}\pi_H^0(c)}{\mathrm{d}c} = \frac{2}{9b}t(c). \tag{A3}$$

Thus, we know that $U_H(c)$ is non-decreasing in c, so that constraints (**P1**)(ii) and (**P1**)(iii) collapse to $U_H(p_0) = 0$. Integrating (A3) and using the fact that $U_H(p_0) = 0$ yields lemma 1 (i).

Conditions (A1) and (A2) give the local conditions for incentive compatibility. It remains to show that these two conditions also imply global incentive compatibility, which can be written as

$$[\tilde{\pi}_H(c|c) - \tilde{\pi}_H(\hat{c}|\hat{c})] - [\tilde{\pi}_H(\hat{c}|c) - \tilde{\pi}_H(\hat{c}|\hat{c})] \geq 0 \qquad \forall c, \hat{c} \in [\underline{c}, \bar{c}].$$

The first term is equivalent to

$$\int_{\hat{c}}^{c} \frac{\mathrm{d}\tilde{\pi}_H(x|x)}{\mathrm{d}x}\,\mathrm{d}x = \int_{\hat{c}}^{c} \left\{ \frac{\partial \tilde{\pi}_H(\hat{x}|x)}{\partial \hat{x}}\bigg|_{\hat{x}=x} + \frac{2}{9b}[a + x + t(x)] \right\} \mathrm{d}x$$

$$= \int_{\hat{c}}^{c} \frac{2}{9b}[a + x + t(x)]\,\mathrm{d}x, \tag{A4}$$

where the second equality follows from (A1). The second term can be written as

$$\frac{2}{9b}(c - \hat{c})\left[a + \frac{c + \hat{c}}{2} + t(\hat{c})\right] = \int_{\hat{c}}^{c} \frac{2}{9b}\left[a + \frac{c + \hat{c}}{2} + t(\hat{c})\right] \mathrm{d}x. \tag{A5}$$

Using (A4) and (A5), we have

$$\tilde{\pi}_H(c|c) - \tilde{\pi}_H(\hat{c}|c) = \int_{\hat{c}}^{c} \frac{2}{9b}\left[x - \frac{c + \hat{c}}{2} + t(x) - t(\hat{c})\right] \mathrm{d}x$$

$$= \int_{\hat{c}}^{c} [t(x) - t(\hat{c})]\,\mathrm{d}x. \tag{A6}$$

When $c \geq \hat{c}$, the integrand is positive, since $t'(c) \geq 0$. When $c \leq \hat{c}$, the integral is negative and so is the integrand since $t'(c) \geq 0$. Thus, (A6) is always non-negative. ■

Proof of lemma 3

Recalling $H'(c) < 0$, it is then straightforward to verify the first result, that is, part (i) of the lemma, that $\partial t^*/\partial c > 0$, by directly differentiating $t^*(\alpha, c)$ as given in (11) with respect to c.

Now turn to parts (ii)–(iv) of the lemma. Directly differentiating $t^*(\alpha, c)$ as given in (11) with respect to α gives

$$\frac{\partial t^*}{\partial \alpha} = \frac{4(3c - 4H(c))}{(3 - 5\alpha)^2}.$$

By definition of $H(c)$, we have $3\bar{c} - 4H(\bar{c}) = 3\bar{c} > 0$, but $3\underline{c} - 4H(\underline{c}) = 3\underline{c} - 4/f(\underline{c}) < 0$ for small $\underline{c}$. Then, since $\mathrm{d}(3c - 4H(c))/\mathrm{d}c > 0$, there exists a unique $c^* \in (\underline{c}, \bar{c})$ such that $\partial t^*/\partial \alpha$ is positive (negative, or zero) if and only if c is greater

than (less than, or equal to) c^*. To avoid considering other cases, let us focus on the case where $c^* > p_0$.

Note from $t^*(\alpha, c)$ as given in (11), at $\alpha = 0$ and $c = \bar{c}$, $t^*(0, \bar{c}) = -a + \bar{c} < 0$, but at $c = \bar{c}$ and α close to 3/5, $t^*(\alpha, \bar{c})$ is positive, since $3\bar{c} - 8H(\bar{c}) = 3\bar{c} > 0$. Since at $c = \bar{c}$, t^* strictly increases in α, there exists a unique α^* such that $t^*(\alpha, \bar{c}) < 0$ for all $\alpha < \alpha^*$, $t^*(\alpha, \bar{c}) > 0$ for all $\alpha > \alpha^*$ and $t^*(\alpha^*, \bar{c}) = 0$. This critical point α^* is therefore determined by the equality $t^*(\alpha^*, \bar{c}) = 0$, which gives $\alpha^* = 3(a - \bar{c})/(5a - \bar{c})$, as defined in the text. Using all the properties derived above about the function $t^*(\alpha, c)$, we are able to draw a figure characterizing $t^*(\alpha, c)$ for various values of α. The results (ii), (iii) and (iv) of the lemma then become obvious from the figure. ■

Proof of Proposition 5

Let us look at (ii) first. Suppose $c^*(\alpha) > p_0$. Define $T(\alpha, c) \equiv t^*(\alpha, c) - (c - p_0)$ where $t^*(\alpha, c)$ is given in (11). First, fix $c = \bar{c}$ and note that $H(\bar{c}) = 0$. Then, we have $T(0, \bar{c}) = -a + p_0 < 0$, and $T(\alpha, \bar{c}) = -(a + p_0) + 4\alpha\bar{c}/(3 - 5\alpha) > 0$ for α sufficiently close to 3/5. Moreover, $\partial T(\alpha, \bar{c})/\partial\alpha = 12\bar{c}/(3 - 5\alpha)^2 > 0$. Thus, there exists $\alpha^{**} \in (0,3/5)$ such that $T(\alpha, \bar{c}) > (<, =)\ 0$ if and only if $\alpha > (<, =)\ \alpha^{**}$. In addition, $\alpha^{**} > \alpha^*$ because α^* is determined by the equation $t^*(\alpha^*, \bar{c}) = 0$ (see the proof of lemma 3), α^{**} is determined by the equation $T(\alpha^{**}, \bar{c}) = 0$, but $T(\alpha, \bar{c}) < t^*(\alpha, \bar{c})$. In fact, from $T(\alpha^{**}, \bar{c}) = 0$, we obtain $\alpha^{**} = 3(a - p_0)/(5a + 4\bar{c} - 5p_0)$.

Next, we have $\partial T(\alpha, c)/\partial c = 4[\alpha - 2(1 - \alpha)H'(c)]/(3 - 5\alpha) > 0$ for all α and c, since $H'(c) < 0$ and $(3 - 5\alpha) > 0$. This property, combined with those derived above, implies that $T(\alpha^{**}, c) < 0$ for all $c < \bar{c}$ and $T(\alpha, c) < 0$ for all $c \leq \bar{c}$ and $\alpha < \alpha^{**}$. This proves the first part of proposition 5(ii).

Given $\alpha > \alpha^{**}$, we have $T(\alpha, \bar{c}) > 0$. Note $T(\alpha, c^*(\alpha)) = -(c^*(\alpha) - p_0) < 0$, since $t^*(\alpha, c^*(\alpha)) = 0$, and $T(\alpha, c)$ strictly increases in c. It becomes obvious that there exits a unique $c^{**}(\alpha) \in (c^*(\alpha), \bar{c})$ such that $T(\alpha, c) > (<, =)\ 0$ if and only if $c > (<, =)\ c^{**}(\alpha)$. The second part of proposition 5(ii) is proved.

Now look at (i) of the proposition. The cases for $\alpha \leq \alpha^*$ and $\alpha \geq 3/5$ are straightforward. As for $\alpha \in (\alpha^*, 3/5)$ and $c^*(\alpha) \leq p_0$, we have figure 2. In particular, at point p_0, we have $T(\alpha, p_0) > 0$. Recall that $\partial T(\alpha, c)/\partial c > 0$. Hence, the unconstrained AD schedule $t^*(\alpha, c)$ is every where above the GATT/WTO-constraint line. Thus, with the GATT/WTO constraint, the optimal AD must be identical to the GATT/WTO-constraint line, that is, the dumping margin. ■

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