NBER WORKING PAPER SERIES

TARIFF POLICY FOR A MONOPOLIST UNDER INCOMPLETE INFORMATION

Dobrin R. Kolev
Thomas J. Prusa

Working Paper 6090

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
July 1997

We would like to thank Reiko Aoki, Pradeep Dubey, John Hillas, Rich McLean, and Daijiro Okada for helpful suggestions. This paper has benefitted from the comments of seminar participants at SUNY-Stony Brook, New York University, Penn State University, Georgetown University, and University of Florida. This paper is part of NBER's research program in International Trade and Investment. Any opinions expressed are those of the authors and not those of the National Bureau of Economic Research.

Tariff Policy for a Monopolist Under Incomplete Information
Dobrin R. Kolev and Thomas J. Prusa
NBER Working Paper No. 6090
July 1997
JEL Nos. F13, D82, L12
International Trade and Investment

ABSTRACT

We examine the incentives for a government to levy an optimal tariff on a foreign monopolist. With complete information, the home government uses tariffs to extract rents and therefore implements a policy of discriminatory tariffs entailing higher tariffs on more efficient firms. By contrast if the government is incompletely informed about costs, we show that under reasonable conditions the unique self-enforcing outcome involves pooling where firms export the same quantity regardless of efficiency. Due to the distortions created by incomplete information we find that in general, home country welfare is higher under a policy of uniform tariffs than under one of discriminatory tariffs. Our results suggest that trade policies that are motivated by rent extraction are unlikely to be robust to the introduction of incomplete information.

Dobrin R. Kolev
Mitchell Madison Group
520 Madison Avenue
New York, NY 10022
kolev@mmgnet.com

Thomas J. Prusa
Department of Economics
Rutgers University
New Brunswick, NJ 08903-5055
and NBER
prusa@fas-econ.rutgers.edu

1. Introduction

The insight that a small positive tariff will cause a welfare-improving terms of trade effect is one of the fundamental explanations for the existence of trade restrictions.[1] Even though the standard analysis is conducted within a perfectly competitive framework (Johnson 1951), the incentive to use trade policy to manipulate the terms of trade emerges in a variety of market structures and technologies.[2]

The economics underlying the terms of trade effect is perhaps most clearly stated when the domestic market is serviced by a foreign monopolist (Katrak 1977, Brander and Spencer 1984). If demand is not too convex, a small positive tariff will cause the price of the product to rise by less than the full amount of the tariff. On net, the loss in consumer surplus is more than compensated by the gain in tariff revenue. Hwang and May (1991) further develop Katrak's (1977) insight and show that the size of the tariff is directly related to the efficiency of the foreign supplier: the more efficient is the monopolist, the larger is the optimal tariff.[3] Hwang and May's analysis suggests that the often observed deviations from MFN tariff levels are due at least in part to the government's desire to fine-tune their tariff structure to the exporter's efficiency. That is, exceptions will be sought against efficient suppliers (i.e., high tariffs such as antidumping and countervailing duties); on the other hand, custom unions or preferential trading arrangements (i.e., NAFTA and the Caribbean Basin Initiative) will be formed

[1]There are many other explanations for the widespread use of trade restrictions, including rent-seeking, political pressures (Grossman and Helpman 1994, 1995a, 1995b), increasing returns to scale (Krugman 1984), and profit-shifting motives (Brander and Spencer 1984).

[2]Feenstra (1996) offers an excellent summary of the terms of trade driven incentives for trade restrictions in both perfectly and imperfectly competitive models. Bagwell and Staiger (1996) argue that the terms of trade effect explains not only why tariffs are levied but also why unilateral liberalization (beyond the Nash tariff level) is rarely observed. They argue that the desire to escape from terms of trade driven prisoners' dilemma is the *primary* reason why countries enter into reciprocal trade agreements.

[3]While the idea of imposing duties as a function of the efficiency of a foreign exporter is implicit in the optimum tariff arguments of Katrak (1977), Hwang and May (1991) were the first to explicitly develop the result, albeit in a duopoly setting.

with countries whose firms are relatively inefficient.

A key assumption implicit in a model of discriminatory tariffs is that the government has complete information about, or is able to observe, the technology of the foreign supplier. If the government cannot observe costs, then the terms of trade incentive to deviate from MFN tariffs may disappear. The reason is that the foreign firm has an incentive to alter its exporting behavior in order to convince the government that it is an inefficient firm. And, if the foreign firm always acts as if it is inefficient, a discriminatory tariff policy leads to uniform low tariffs. However, an explicit commitment to GATT MFN tariffs would also lead to uniform tariffs, but without distorting the incentives for the monopolist to trade.

Thus, the main question we address in this paper is whether a policy of discriminatory tariffs makes sense for a government with incomplete information about the foreign firm. In order to answer this question, we develop a multi-period model where the foreign firm's efficiency is private information. In the first period foreign products are allowed to enter at a pre-existing tariff level. Upon observing the firm's first period exports, the government levies a tariff on future period trade. From a technical viewpoint, the model is essentially a signaling game where we seek to determine whether the outcome involves pooling or separation and whether in light of the signaling problem a discriminatory policy is superior to a commitment to uniform tariffs.

There are several key findings. First, we show that there is always a *unique* stable Nash equilibrium. In particular, we show that the type of equilibrium to emerge—separating or pooling—depends on the discount rate. If the discount rate is sufficiently large, pooling is the unique equilibrium; on the hand, if the discount rate is relatively small, separation is the unique equilibrium. Second, we show that a policy of discriminatory tariffs will typically lower welfare, suggesting that the welfare results of Katrak (1977), Brander and Spencer (1984), and Hwang and May (1991) depend crucially on the the assumption of full information. Specifically, we show that a policy of uniform tariffs is always preferred whenever the discount rate is sufficiently large to result in pooling and is usually preferred when separation is the unique equilibrium. Third, our model highlights the importance of the "single crossing" assumption which is typically made in signaling models. We show that our model falls into the category of signaling games with "double crossing" as defined by Kolev (1996). By double crossing we mean that the payoff function of the party with private information does not satisfy the usual monotonicity with respect to type. As a result the typically observed separating equilibria are rather fragile and the unique self-enforcing outcome is likely to involve pooling where exports are restricted regardless of the true type of the foreign firm.

Our paper complements a growing body of work incorporating incomplete information in strategic trade policy models, all of which in one from or another draw into question the robustness of benefits of rent extraction policies. The papers of Qiu (1994) and Collie and Hviid (1993, 1994) are the most closely related to the signaling approach developed in this paper. The first two papers use third market models in which a foreign firm is incompletely informed about the costs of a domestic producer. Qiu's (1994) model is a combination of screening and signaling, where he shows that a separation-inducing menu must involve subsidies proportional to efficiency. Collie and Hviid (1993) show that governments have an incentive to oversubsidize exports in order to signal the domestic firm's efficiency and soften foreign competition. In a model with a foreign monopolist who has incomplete information about domestic demand, Collie and Hviid (1994) show that the unique separating equilibrium involves excessive duties. All of these models are characterized by the usual single crossing property and thus all result in separating outcomes. Our analysis highlights the relevance of pooling outcomes. More recently, Brainard and Martimort (1997) have extended the basic Brander-Spencer duopoly game to allow both firms to have private information and to allow both governments to strategically use trade policy. They adopt a screening approach and find that the informational asymmetry reduces the optimal subsidy (and may even imply that an export tax is optimal).

The remainder of the paper is organized as follows. In section 2 the basic model is developed and in section 3 we solve for the benchmark complete information discriminatory tariff. In section 4 we solve for the optimal tariff under incomplete information and show how the discount factor crucially influences the equilibrium outcome. In section 5 we analyze the welfare consequences of government's limited information. Concluding comments and extensions are discussed in section 6.

2. The basic model

We assume that there is a single multinational firm who serves the domestic market. The sequence of moves in the game we have in mind is as follows. At time zero the constant marginal cost of the foreign firm is drawn from the set $\mathcal{C} = \{c_l, c_h\}$, $c_l < c_h$, according to a commonly known probability distribution. Let μ be the probability that the monopolist is efficient (i.e., has cost c_l). The true realization of the draw is private information for the exporter. The assumption of constant marginal costs is convenient since it allows for an independent analysis of the export decision.

Exporting takes place over an infinite number of periods. In the first period the firm chooses a quantity from the positive orthant under conditions of free trade.[4] After observing the level of imports the government forms beliefs about the type of firm servicing its market and selects a per unit tariff, τ, which will be levied on trade during all other periods. Given the chosen tariff in each period the multinational makes its output decision and payoffs are realized.

We work with the standard model of Katrak (1977) where q_t, the demand for the imported product in period t in the home country, is derived from a quasi-linear utility function which yields an inverse aggregate demand function of the

[4]Assuming free trade in the first period is without loss of generality. Any exogenously given tariff at this time would leave the qualitative features of the model intact.

form[5]

$$p_t = a - q_t, \quad t = 1, \ldots, \infty.$$

3. The complete information tariff

In order to highlight the distortions caused by asymmetric information, we begin by examining the optimal tariff when the home government has full information about the firm's costs. In period t, $t \geq 2$, the multinational takes τ as given. Its variable profit function can be written as

$$\pi_{ti} = q_t(a - q_t) - \tau q_t - c_i q_t, \quad t = 2, \ldots, \infty,$$

where i denotes the firm's type (cost realization), $i = l, h$. For convenience, we will refer to a high cost firm as h and a low cost firm as l. The resulting optimum quantity and profit for a type i firm in each period are

$$q_i(\tau) = (a - c_i - \tau)/2 \quad \text{and} \quad \pi_i(\tau) = (a - c_i - \tau)^2/4. \tag{1}$$

The home government chooses τ in order to maximize discounted national welfare, $W = \sum_{t=2}^{\infty} \delta^{t-1} w_t$, where δ is the discount factor. Welfare is defined as is the sum of consumer surplus and tariff revenue. Given linear demand we can write period t welfare as

$$w_t = q_i(\tau)^2/2 + \tau q_i(\tau), \quad t = 2, \ldots, \infty. \tag{2}$$

Since maximizing total welfare (post-tariff) is equivalent to maximizing per period

[5]This functional form is chosen in order to make our claims explicit. Any other functional form satisfying the assumptions of Lemma 1 will lead to similar results.

welfare we can substitute the firm's unique best quantity response, $q_i(\tau)$, into (2)

$$w_t = (a - c_i - \tau)^2/8 + \tau(a - c_i - \tau)/2, \quad t = 2, \ldots, \infty. \tag{3}$$

Maximizing (3) with respect to τ yields an optimal tariff of

$$\tau_i^o = (a - c_i)/3. \tag{4}$$

The equilibrium tariff, which is the same as the one obtained by Katrak (1977), shows the clear incentive for the home country to exploit its information and levy a tariff proportionate to the efficiency of the exporter.

Given that the government observes realized costs, the firm's optimal first period decision is to simply sell the monopoly output, $q_{1i}^o = (a - c_i)/2$. This implies the firm's total profit (over all periods) is

$$\pi_i^o = \pi_i(0) + \sum_{t=2}^{\infty} \delta^{t-1} \pi_i(\tau_i^o) = \frac{(a - c_i)^2(9 - 5\delta)}{36(1 - \delta)}. \tag{5}$$

4. Tariff policy with incomplete information

We now return to the assumption that the government does not observe the firm's cost realization. By introducing private information on the part of the firm we explore the possibility that the producer can act strategically in the first period in order to influence the posterior beliefs and the subsequent choice of tariff by the government. A deviation from the monopoly level of output is costly and it can serve as a natural credible signal which the firm can employ to transmit information about its technology. From (3) note that $\partial W/\partial \tau$ is strictly decreasing in c_i. This means that the benefit of the home country from lowering the tariff rate is strictly increasing in cost which in turn implies that the government's best response function is strictly decreasing in the posterior likelihood of h. And, from the analysis of the prior section it is evident that the exporter would like the government to believe that it is inefficient so that it faces lower duties.

We restrict our attention to sequential equilibria in the sense of Kreps and Wilson (1982) as adapted to signaling games with continuum of strategies by Kreps and Sobel (1994). In short, sequential equilibria require that (i) both players maximize their respective payoff functions given the strategy of the other and the beliefs of the government (sequential rationality) and (ii) the set of posterior beliefs at each quantity level rationalizes the government's behavior in a manner compatible with Bayes' theorem at non-null events (consistency).

Incentives to distort first period trade

It is obvious that in any sequential equilibrium the firm will choose the monopoly level of exports and earn the corresponding profit in each period *following* the imposition of the tariff. If the state is able to correctly infer the technology and impose its optimal tariff, the best the monopolist can do is (substituting (4) into (1))

$$q_{ti}^o = \begin{cases} (a - c_i)/2 & t = 1, \\ (a - c_i)/3 & t = 2, \ldots, \infty \end{cases}$$

and

$$\pi_{ti}^o = \begin{cases} (a - c_i)^2/4 & t = 1, \\ (a - c_i)^2/9 & t = 2, \ldots, \infty. \end{cases}$$

It is also easy to show that, as usual in signaling games, there is a continuum of pooling, semi-pooling, and separating equilibria due to the wide range of permissible beliefs about the type of the monopolist which the government may entertain off a sequential equilibrium path. Most of these systems of beliefs are unreasonable, however, and we will further refine the set of sequential equilibria by employing the D_1 criterion of Cho and Kreps (1987) which is based on the notion of *divinity* of Banks and Sobel (1987). In essence, this requires the government to place probability one on the type more likely to produce a particular out of equilibrium quantity. To formalize the idea let us fix a sequential equilibrium outcome (a probability distribution over the end points of the game induced by a sequential equilibrium) in which an exporter of type i obtains total profit π_i^*. For an out of equilibrium quantity q_1 define the set

$$E_i^0(q_1) \equiv \{\tau \in BR(\eta, q_1) : \pi_i(q_1, \tau) = \pi_i^*\},$$

where $BR(\eta, q_1)$ is the set of best responses of the government at q_1 given that the induced beliefs about the types exporting this quantity are η. $E_i^0(q_1)$ is thus the set of best responses which would leave i indifferent between his equilibrium strategy and exporting q_1. Likewise, the set of sequentially rational tariffs which would make i strictly better off is denoted by

$$E_i(q_1) \equiv \{\tau \in BR(\eta, q_1) : \pi_i(q_1, \tau) > \pi_i^*\}.$$

We say that a sequential equilibrium is D_1 if and only if, at each off equilibrium quantity q_1, it can be supported with beliefs $\eta(i|q_1) = 0$ whenever

$$E_i^0(q_1) \cup E_i(q_1) \subseteq E_{i'}(q_1)$$

for $E_{i'}(q_1) \neq \{\emptyset\}$. An outcome arising from a D_1 equilibrium will be termed a D_1 outcome. The intuition behind the divinity refinement is that whenever i wants to deviate from a particular equilibrium, i' also does, which makes i' the more likely type to break the proposed play.

If we assume that the maximum willingness to pay, a, is sufficiently large, the chosen actions by both players will be strictly positive. An isoprofit curve for a monopolist of type i, which represents the combinations of quantities q_1 and tariffs τ yielding the same payoff, $\bar{\pi}$, is implicitly given by

$$\bar{\pi} = \pi_i(q_1, \tau) = q_1(a - q_1 - c_i) + \frac{\delta(a - c_i - \tau)^2}{4(1-\delta)}. \tag{6}$$

Let us first look at the pure strategy separating equilibria of the game, i.e., those where each type exports a distinct quantity in the first period with probability one. In any such situation the true types are revealed and if this is to be a sequential equilibrium outcome, the efficient firm (type l) must produce its monopoly level, q^o_{1l}—knowing that the state would meet its exports with τ^o_l any other strategy would not be optimal. This yields a first period profit of $\pi^o_{1l} = (a - c_l)^2/4$. From (5) the separating equilibrium profit (over all periods) for l is

$$\pi^s_l \equiv \frac{(a - c_l)^2(9 - 5\delta)}{36(1-\delta)}.$$

In order to derive the equilibrium behavior of the inefficient firm (type h) we construct the separating (complete information) equilibrium isoprofit curve for l which is the locus of quantity-tariff pairs in (6) yielding π^s_l:

$$\frac{(a - c_l)^2(9 - 5\delta)}{36(1-\delta)} = q_1(a - q_1 - c_l) + \frac{\delta(a - c_l - \tau)^2}{4(1-\delta)}. \tag{7}$$

For there to exist an incentive to signal we must assume that the efficient type would rather export q^o_{1h} and receive τ^o_h (i.e., mimic h) than produce its complete information optimum and face high duties. Using (7) this amounts to requiring that

$$\left(\frac{a - c_h}{2}\right)\left(a - \frac{a - c_h}{2} - c_l\right) + \frac{\delta\left(a - c_l - (a - c_h)/3\right)^2}{4(1-\delta)} > \frac{(a - c_l)^2(9 - 5\delta)}{36(1-\delta)}.$$

Division by $(a - c_h)^2$ yields

$$\frac{2A-1}{4} + \frac{\delta(3A-1)^2}{36(1-\delta)} - \frac{A^2(9-5\delta)}{36(1-\delta)} > 0, \tag{8}$$

where we have used a measure of the relative cost differential between the two types

$$A \equiv \frac{a - c_l}{a - c_h} > 1. \tag{9}$$

Solving (8) for δ, it is straightforward to show that for all

$$\delta > \delta^m \equiv \frac{9A^2 - 18A + 9}{14A^2 - 24A + 10} \tag{10}$$

l will choose to mimic. One can show that (i) δ^m goes to zero as $A \to 1$, and (ii) δ^m increases monotonically to 9/14 as $A \to \infty$. From this point on we will assume that the mimicking condition is satisfied. In Figure 1 we graph δ^m. The mimicking condition would be violated if δ is sufficiently small in comparison with the difference in marginal costs. In this case, the reduction in the efficient type's (l) output in order to imitate the high cost producer is unacceptable given the low weight on future profits.

With this at hand, it is easy to check that the incentive constraint (7) implicitly defines a function which is strictly concave in q_1 and symmetric around q^o_{1l}. This isoprofit curve yields an open set of quantities around q^o_{1l}, $\mathcal{S} = (\underline{q}_1, \overline{q}_1)$, which l would prefer to its equilibrium strategy if the response was τ^o_h. The end points of this interval are[6]

$$\underline{q}_1 = (a - c_l)/2 - (1/6)\sqrt{(c_h - c_l)(4a - 5c_l + c_h)\delta/(1-\delta)},$$
$$\overline{q}_1 = (a - c_l)/2 + (1/6)\sqrt{(c_h - c_l)(4a - 5c_l + c_h)\delta/(1-\delta)}.$$

[6]In order to compactify the strategy spaces of the players we will assume that a type which is indifferent between its proposed equilibrium action and another quantity will follow the former.

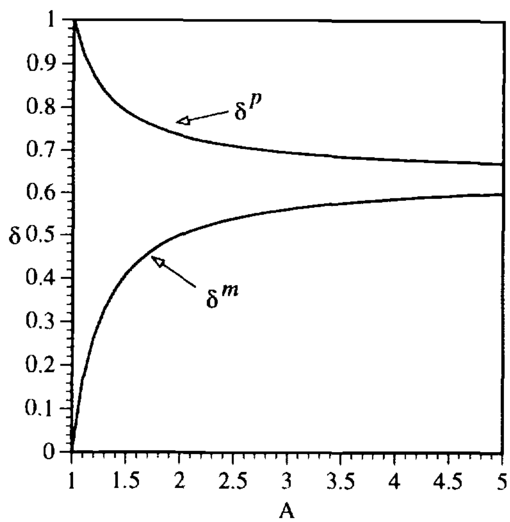

Figure 1: Graph of δ^m and δ^p.

For every export level $q_1 \in \mathcal{S}$ we have $\pi_l^s < \pi_l(q_1, \tau_h^o)$.

Note that as δ goes to one, $\mathcal{S}$ tends monotonically to $\mathbb{R}$. In other words, the set of quantities at which l is willing to mimic h if that would convince the home country to levy τ_h^o expands the more important are future profits. Note also that since (i) $\mathcal{S}$ is symmetric around q_{1l}^o, (ii) $\underline{q}_1 < q_{1h}^o < q_{1l}^o < \overline{q}_1$, and (iii) the profit function of h is symmetric about q_{1h}^o (given τ_h^o), it follows that the payoff for h at $\underline{q}_1$ is higher than at $\overline{q}_1$. In fact, because h's profit is monotonically increasing up to q_{1h}^o and decreasing thereafter, $\underline{q}_1$ is the unique maximizer among the set of separating equilibrium quantities. We can now show that

Proposition 1 *Among the set of separating export levels for h, $q_{1h}^s = \underline{q}_1$ is the unique candidate to emerge in a D_1 equilibrium.*

Proof: Fix a sequential separating equilibrium outcome obtained from h exporting $q_1^* \in \mathcal{S}^c$, $q_1^* \neq \underline{q}_1$ and l exporting q_{1l}^o, where $\mathcal{S}^c$ is the complement of $\mathcal{S}$. Take an out of equilibrium message $q_1' \in \mathcal{S}^c$ such that $|q_1^* - q_h^o| > |q_1' - q_h^o|$.

Let us construct the sets of sequentially rational responses of the government to

q_1' which would make each type break the equilibrium. By the definition (incentive compatibility) of $\mathcal{S}$ no tariff $\tau \in [\tau_h^o, \tau_l^o]$ would make l deviate from q_{1l}^o to q_1' regardless of the beliefs which this would generate. Continuity and monotonicity of h's profit function guarantee that exporting q_1' would be strictly preferred to q_1^* if that would make the country impose τ_h^o. Hence,

$$E_l^0(q_1') \cup E_l(q_1') \subseteq E_h(q_1'),$$

and because this condition holds the D_1 criterion of Cho and Kreps (1987) requires the beliefs of the receiver to place probability one on h at q_1'. This would clearly make h defect from the equilibrium we set out to check.

As the same reasoning applies to all $q_1^* \neq \underline{q}_1$ it follows that the unique candidate separating D_1 equilibrium outcome is the one arising from h exporting $\underline{q}_1$.[7] □

Proposition 1 provides us with a unique candidate for a separating equilibrium strategy for h by assigning reasonable beliefs on $\mathcal{S}^c$. However, to support this candidate as part of a D_1 equilibrium we must first assign beliefs on $\mathcal{S}$. In addition, we must also check for the existence of pooling equilibria. In order to do this we first prove the next claim which puts the game into the subclass of signaling games with double crossing.

Lemma 1 *The graph of the function $\tau = 2q_1$ divides (q_1, τ)-space in such a way that the isoprofit curves of the two types through (q_1, τ), $\tau > (<)(=) 2q_1$, have slopes increasing (decreasing) (constant) in c.*

Proof: Implicit differentiation of (6) at any (q_1, τ) yields a slope of an isoprofit curve given by

$$s(q_1, \tau) = \frac{dt}{dq_1} = \frac{(2a - 4q_1 - 2c_i)(1-\delta)}{(a - \tau - c_i)\delta}.$$

[7] The readers familiar with equilibrium refinements in signaling games must have observed that the *Intuitive Criterion* of Cho and Kreps (1987) would suffice to make this argument: q_1' is equilibrium dominated for l and hence the beliefs of the government should concentrate on h which would in turn invoke deviation.

The claims follow directly from differentiating $s(\cdot)$ with respect to c_i at any (q_1, τ). □

Lemma 1 will be central to the application of the D_1 criterion to test the stability of $\underline{q}_1$. It shows that the incentives for the two types to deviate from a given outcome differ depends on the relative sizes of τ and q_1. At low quantity levels ($q_1 < \tau/2$) the inefficient producer stands to gain more than the efficient one by increasing its exports at any given tariff. The opposite is true for high quantity levels ($q_1 > \tau/2$). Lemma 1 combined with monotonicity (the payoff of the monopolist is strictly decreasing in τ) implies that any two isoprofit curves can cross at most once in any of the two half-spaces defined by the tangency locus.

4.1. Equilibrium when δ is small

From (6) it is obvious that the slope of the isoprofit curve depends critically on the size of δ. As we will show below, this fact combined with Lemma 1 will imply different equilibrium outcomes of the game for different values of δ.

For expositional clarity let us begin our analysis with δ relatively small.[8] In this case we can show that the relevant subspace for our purposes is (q_1, τ) with $\tau < 2q_1$ (Lemma 2). This will in effect render the analysis identical to that of games which satisfy the standard single crossing property.[9]

Lemma 2 *No point along the tangency locus $\tau = 2q_1$ is preferred to the complete information maximum by the low cost type if δ is sufficiently small.*

Proof: It suffices to prove that the separating equilibrium profit for l is higher than that obtained at $(q_1 = 0, \tau = 0)$. This is due to the fact that $\pi_i(q_1' = \tau'/2, \tau') \geq \pi_i(q_1, \tau)$ implies $\pi_i(q_1'' = \tau''/2, \tau'') > \pi_i(q_1, \tau)\ \forall \tau'' < \tau'$, where $\pi_i(q_1, \tau)$

[8]Keep in mind that δ is restricted to $\delta > \delta^m$. We will formally define what it meant by δ being "small" in section 4.2.

[9]If our model satisfied single crossing, the isoprofit lines of the two types at any (q_1, τ) would cross at most once with their slopes monotone in c_i. For an excellent exposition of such games see Cho and Sobel (1990).

denotes the payoff of the firm from producing q_1 and being taxed τ. In other words, any isoprofit curve can cross the tangency locus at most once.

If there was a point $(q_1 = \tau/2, \tau)$ preferred to l's complete information profit which in turn were higher than the payoff at $(q_1 = 0, \tau = 0)$, then the separating equilibrium isoprofit curve (7) would have to cross the tangency line twice (by its strict concavity). The continuity of the l-type exporter's payoff in (q_1, τ) would guarantee that there exists an isoprofit curve which is tangent to $\tau = 2q_1$, say at (q_1', τ'). Lemma 1 shows that an isoprofit line of h through the same point would be tangent also and both curves lie in the same half space defined by $\tau = 2q_1$ at least in a ϵ-neighborhood of the common point. Since profit is continuous we can always find a sufficiently small perturbation of the payoff of one type so that the isoprofit curves cross twice within ϵ of (q_1', τ'). This would violate Lemma 1.

It is trivial now to see from (7) that for δ sufficiently small

$$\pi_l^s \equiv \frac{(a-c_l)^2(9-5\delta)}{36(1-\delta)} > \frac{\delta(a-c_l)^2}{4(1-\delta)} = \pi_l(0,0).$$

□

Combined with the fact that profit is decreasing in τ Lemma 2 establishes that the graph of the function defined by (7) lies entirely in the half-space below the tangency locus $\tau = 2q_1$. We are now in a position to claim that no pooling equilibrium outcome can survive the D_1 criterion.

Proposition 2 *There do not exist any D_1 pooling equilibria when δ is sufficiently small.*

Proof: Note first that the incentive compatible constraint (7) for l implies that the only possible levels of exports which can arise in a sequential pooling equilibrium must be in $\mathcal{S}$. Moreover, Lemma 2 ensures that $\tau_h^o/2 < q_1, \forall q_1 \in \mathcal{S}$.

Suppose that both types export with positive probability quantity q_1^* in the first period, the sequentially rational response of the government is $\tau^* \in (\tau_h^o, \tau_l^o)$, and the profit is π_i^*. Lemmas 1 and 2 prove that the slope of the equilibrium isoprofit curve of h at (q_1^*, τ^*) is strictly smaller than the corresponding isoprofit curve for l. This implies that at a q_1', which is ϵ-smaller than q_1^*, the set of best responses which make q_1' weakly preferred by l to q_1^* is a subset of the set of best responses which h strictly prefers to q_1^*. Hence in a D_1 equilibrium the beliefs of the government should place probability one on q_1' being exported by h, and the corresponding tariff would be τ_h^o. Since in a pooling sequential equilibrium $\exists\, \Delta > 0$ such that $\tau^* - \tau_h^o > \Delta$, by continuity and strict monotonicity of the profit function in τ, $\exists\, \epsilon$ such that $|q_1' - q_1^*| < \epsilon$ and $\pi_h^* < \pi_h(q_1', \tau_h^o)$. This would induce h to break the proposed pool and export q_1'. □

Proposition 1 states that $\underline{q}_1$ is the unique candidate for a D_1 equilibrium strategy for h among the pure separating export levels, and Proposition 2 rules out any pooling in stable outcomes. Indeed, as the next claim shows, $\underline{q}_1$ turns out to be a self-enforcing norm of behavior. The graphical representation of the equilibrium is provided in Figure 2.

Proposition 3 *The equilibrium outcome in which h exports $\underline{q}_1$, l exports q_{1l}^o, and the response of the government is τ_h^o and τ_l^o, respectively, is the unique D_1 outcome of the tariff game for δ sufficiently small.*

Proof: All we need to do is construct off equilibrium beliefs consistent with the D_1 criterion and check that h would not deviate from the prescribed equilibrium.

Lemma 2 guarantees that at $\underline{q}_1$ the slope of the h's isoprofit curve is smaller than that of l. Lemma 1 and the monotonicity of the profit functions in τ ensure that in each half space any two isoprofit curves intersect at most once. Hence the isoprofit curve of h through $(\underline{q}_1, \tau_h^o)$ is below that of l for all $q > \underline{q}_1$, and above that of l otherwise. In a D_1 equilibrium the government should place probability one on l for output levels higher than $\underline{q}_1$, and zero at $q < \underline{q}_1$. Since (as shown in Proposition 1) $\underline{q}_1$ is the best for h among the choices met with τ_h^o, and any other quantity in combination with τ_l^o is strictly inferior to the given equilibrium strategy (the separating equilibrium curve for l is everywhere below the line $\tau = \tau_l^o$ and so is that of h), h has no incentive to deviate from $\underline{q}_1$. □

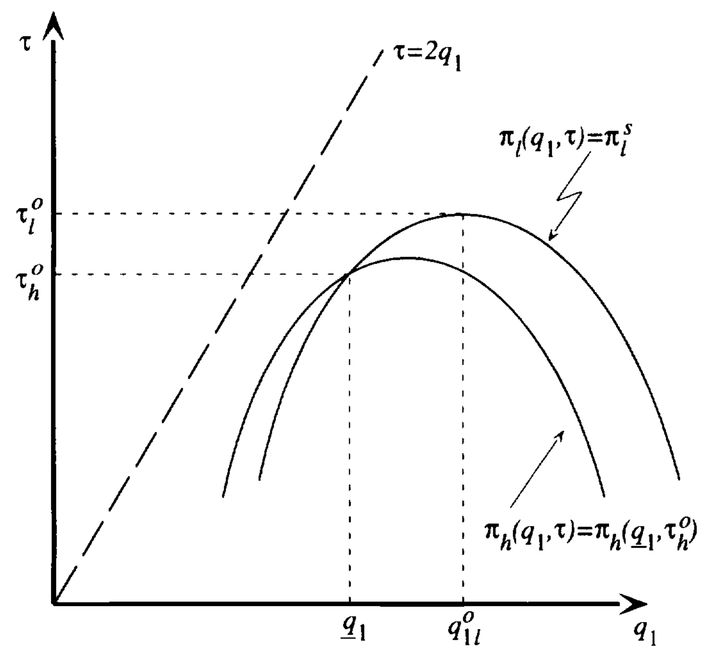

Figure 2: The D_1 separating equilibrium

Besides completing the description of the unique stable equilibrium of the game, Proposition 3 illustrates another interesting phenomenon: the robustness of separation in monotonic signaling games where single crossing holds in the relevant range of the parameter space. It is well-known from the work of Cho and Sobel (1990) that if single crossing is a global property of a model, the unique D_1 outcome under standard regularity assumptions must be separating.

One of the points we are trying to make, however, is that if the payoff function of the firm satisfies the double crossing condition (as defined in Lemma 1) the outcome of the model is easily reversed. This will be shown in the next section.

4.2. Equilibrium when δ is large

Note that as δ becomes larger, the set of quantities such that l prefers $(q_1 = \tau_h^o/2, \tau_h^o)$ to its separating equilibrium profit increases. This implies that eventually some point along the tangency locus $\tau = 2q_1$ will be preferred to the complete information maximum by the low cost type (i.e., Lemma 2 will eventually be violated).

It is easy to show the arguments made in Propositions 1 and 2 are valid as long as $\pi_l^s \geq \pi_l(q_1 = \tau_h^o/2, \tau_h^o)$. We will show that $\pi_l^s < \pi_l(q_1 = \tau_h^o/2, \tau_h^o)$ is a necessary and sufficient condition for pooling to emerge as the unique D_1 equilibrium outcome of the game. See Figure 3 for a graphical representation of the condition. Let us first characterize this condition.

From (6) the point $(q_1 = \tau_h^o/2, \tau_h^o)$ is preferred by l to the myopic payoff whenever

$$\frac{(a-c_l)^2(9-5\delta)}{36(1-\delta)} < \left(\frac{a-c_h}{6}\right)\left(a-\frac{a-c_h}{6}-c_l\right)+\frac{\delta}{4(1-\delta)}\left(a-c_l-\frac{a-c_h}{3}\right)^2.$$

Using our measure of the relative cost differential, A, this condition can be rewritten as

$$\frac{6A-1}{36}+\frac{\delta(3A-1)^2}{36(1-\delta)}-\frac{A^2(9-5\delta)}{36(1-\delta)}>0. \tag{11}$$

Solving (11) for δ, it is straightforward to show that for all

$$\delta>\delta^p\equiv\frac{9A^2-6A+1}{14A^2-12A+2} \tag{12}$$

the point $(q=\tau_h^o/2,\tau_h^o)$ is preferred by l to the myopic payoff.

One can show that $\delta^p\geq\delta^m$ for all A (see Figure 1). Keep in mind that in order for signaling to cause any distortion relative to the complete information case, $\delta>\delta^m$. Hence, for a large fraction of the relevant parameter space (11) will hold.

Following the steps in Proposition 1 we can show that the unique candidate for a D_1 separating equilibrium must involve h exporting $\underline{q}_1$, if the latter exists.[10] As Proposition 4 shows, however, assigning reasonable beliefs at out of equilibrium export levels leads to this solution being discarded.

Proposition 4 *When $\delta>\delta^p$ [i.e., when $\pi_l^s<\pi_l(q_1=\tau_h^o/2,\tau_h^o)$] there does not exist a pure strategy D_1 separating equilibrium.*

Proof: The claim, as we noted, is equivalent to proving that $\underline{q}_1$ is not a D_1 strategy for h.

Let us fix the outcome arising from h exporting $\underline{q}_1$. By assumption $\delta>\delta^p$ which implies $\underline{q}_1<\tau_h^o/2$; i.e., the isoprofit curve of h through $(\underline{q}_1,\tau_h^o)$ has a bigger slope than l's (by Lemma 1). This implies that for q_1' ϵ-bigger than $\underline{q}_1$ the set of sequentially rational tariffs weakly preferred to $(\underline{q}_1,\tau_h^o)$ by l in combination with q_1' is a subset of the best responses which h strictly prefers to its equilibrium action. If the given equilibrium produces a D_1 outcome we should be able to support it with beliefs placing probability one on h at q_1'. Since, with τ_h^o fixed, the profit of

[10]If $\underline{q}_1$ is not defined on the positive orthant than the claim that no sequential equilibrium is separating is trivial.

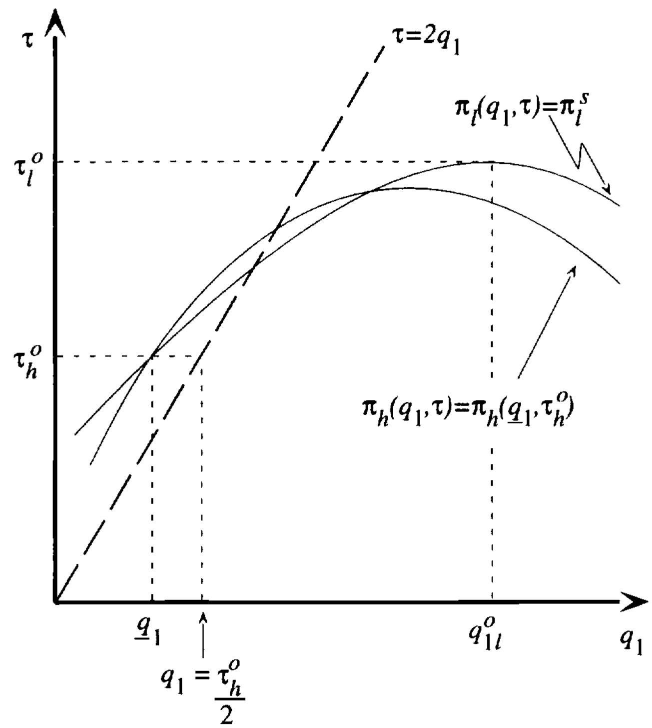

Figure 3: The unique candidate for a D_1 separating equilibrium

h is monotonically increasing at $\underline{q}_1$, the inefficient exporter would deviate to q_1', thus upsetting the unique candidate for a D_1 pure strategy separating equilibrium outcome. □

Figure 3 illustrates the arguments behind Proposition 4. If $\pi_l^s > \pi_l(q_1 = \tau_h^o/2, \tau_h^o)$ we would know from Proposition 3 that the unique stable outcome of the game would involve pure strategy separation with h exporting $\underline{q}_1$. In the present setting, however, the model will have a unique equilibrium which may involve partial or pure pooling in first period quantities depending on the prior probability over C. Before constructing this outcome we need the following preliminary result which shows (i) that if the isoprofit curves of the two types have a point in common along the tangency locus, then the isoprofit curve for l is everywhere above the isoprofit curve for h and (ii) that pooling can only occur along the tangency locus.

Lemma 3 *Fix a D_1 outcome in which either type of monopolist exports q_1^p with positive probability in the first period, and the response of the government is τ^p. Then it must be that $q_1^p = \tau^p/2$, and $\forall\, q_1 \neq q_1^p$, $\pi_l(q_1^p, \tau^p) = \pi_l(q_1, \tau)$ and $\pi_h(q_1^p, \tau^p) = \pi_h(q_1, \tau')$ imply $\tau' < \tau$.*

Proof: First we want to show that at a point (q_1, τ) along $\tau = 2q_1$ the isoprofit curve of h is below that of l. As a corollary of Lemma 2 we established that any point along the $\tau = 2q_1$ locus is the unique intersection of the tangency locus with the isoprofit functions $\pi_i(q_1 = \tau/2, \tau) = \pi_i(q_1, \tau)$ so that any $q_1' < q_1$ and τ' such that $\pi_i(q_1 = \tau/2, \tau) = \pi_i(q_1', \tau')$ implies $\tau' > 2q_1'$.

Assume that at $q_1' < q_1 = \tau/2$, $\pi_l(q_1, \tau) = \pi_l(q_1', \tau')$ and $\pi_h(q_1, \tau) = \pi_h(q_1', \tau'')$ with $\tau'' > \tau'$, so that the isoprofit curve of h through (q_1, τ) is above that of l. We will show that this assumption is inconsistent with the model. By monotonicity of the profit in τ we have

$$\pi_l(q_1, \tau) = \pi_l(q_1', \tau') > \pi_l(q_1', \tau''). \tag{13}$$

Since $\tau'' > 2q_1'$, Lemma 1 shows that the slope of h's isoprofit curve through (q_1', τ'') is bigger than the corresponding slope for l. This translates into

$$\pi_l(q_1, \tau) \geq \pi_l(q_1', \tau'') \Rightarrow \pi_h(q_1, \tau) > \pi_h(q_1', \tau'').$$

The last statement contradicts (13) and our construction of τ'' as $\pi_h(q_1, \tau) = \pi_h(q_1', \tau'')$. Similar arguments hold for $q_1' > q_1$.

Next, note that in any pooling D_1 equilibrium it must be that the beliefs of the home country place probability one on l for all disequilibrium messages at least in the neighborhood of the quantity. Otherwise, continuity and monotonicity of the firm's payoff function would break the proposed play (the proof would be similar to that of Proposition 3). This implies that the equilibrium isoprofit curve for

l must be above that of h in this neighborhood, and tangent at the equilibrium message. According to the double crossing property of the firm's payoff given in Lemma 1 and the arguments in the first part of the proof these conditions are satisfied only along the tangency locus, $\tau = 2q_1$. □

Proposition 4 proves that if $\delta > \delta^p$ then a D_1 outcome (if it exists) must involve pooling. Lemma 3 establishes that the pooled quantity and the corresponding equilibrium tariff must lie along the tangency locus. Next we explicitly construct the unique D_1 outcome of the game thus showing that the necessary condition for pooling is also sufficient.

Proposition 5 *If $\delta > \delta^p$ then there exists a unique D_1 equilibrium outcome which must involve pooling.*

Proof: As a preliminary step observe that in a D_1 pooling equilibrium h must export the pooled quantity q_1^* with probability one. The reason is as follows: if π_l^* is the equilibrium payoff for l, it must be that $\pi_l^* \geq \pi_l^s$. Monotonicity in τ implies that for all q_1 the isoprofit curve yielding profit π_l^* is below the complete information isoprofit curve for l. By Lemma 3 the response of the government to q_1^* must be $\tau^* = 2q_1^*$ and the equilibrium isoprofit curve for h giving payoff π_h^* must be everywhere below the equilibrium curve for l. Since the locus defined by π_l^s is under $\tau = \tau_l^o$, $\forall q_1$, the equilibrium payoff for h must be strictly higher than producing any q_1 in combination with τ_l^o.

The above description of the equilibrium isoprofit curves implies that $\forall q_1 \neq q_1^*$:

$$E_h^0(q_1) \cup E_h(q_1) \subseteq E_l(q_1).$$

Hence in a D_1 equilibrium the beliefs of the government at $q_1 \neq q_1^*$ must place probability one on l and the corresponding tariff should be τ_l^o. This would make h export q_1^* with probability one.

Suppose now that the prior probability of an l-type exporter, μ, is such that $\pi_l^s \geq \pi_l(q^e = \tau^e/2, \tau^e)$, where $\tau^e = \mu\tau_l^o + (1-\mu)\tau_h^o$ is the ex-ante optimal tariff.

We claim that in this case l can not pool with probability one in any sequential equilibrium. This follows from the fact that if l pools with probability one, then the unique best response of the government would be τ^e to the quantity $q^e = \tau^e/2$. The point (q^e, τ^e) is strictly inferior for l compared to full separation at q^o_{1l}. This implies that l can not pool with probability one at q^e. Therefore, the only possibility for a solution must involve partial pooling.

As argued above, in any D_1 pooling equilibrium all disequilibrium tariffs will be τ^o_l. The strict concavity of l's profit function will then guarantee that the only quantity produced with positive probability and met with τ^o_l is the unique maximizer, q^o_{1l}. Moreover, the payoff from such an action must be equal to the payoff at the pooled message if l is to randomize. This implies that the pool must occur at the point of intersection of l's complete information isoprofit curve (6) and the tangency locus. Call this quantity q^p_1. In order to make the corresponding tariff $\tau^p = 2q^p_1$ a sequentially rational response l must randomize in such a way that the unique government's posterior about l at q^p_1, η, should satisfy

$$\tau^p = \eta\tau^o_l + (1-\eta)\tau^o_h.$$

In other words, the probability ρ with which l plays q^p_1 should determine its conditional probability given q^p_1 through

$$\eta = \frac{\mu\rho}{\mu\rho + (1-\mu)}.$$

Thus we have shown the existence of a unique partial pooling D_1 equilibrium outcome for the case when $\pi^s_l \geq \pi_l(q_1 = \tau^e/2, \tau^e)$.

On the other hand, if $\pi^s_l < \pi_l(q_1 = \tau^e/2, \tau^e)$, then l would rather pool at $q^e = \tau^e/2$ than separate. The partial pooling equilibrium described in the preceding paragraph is not even sequential in this case since the posterior η would require l to export q^p_1 with probability larger than one.[11] This shows that the

[11]Keep in mind that in any pooling D_1 equilibrium h must pool with probability one.

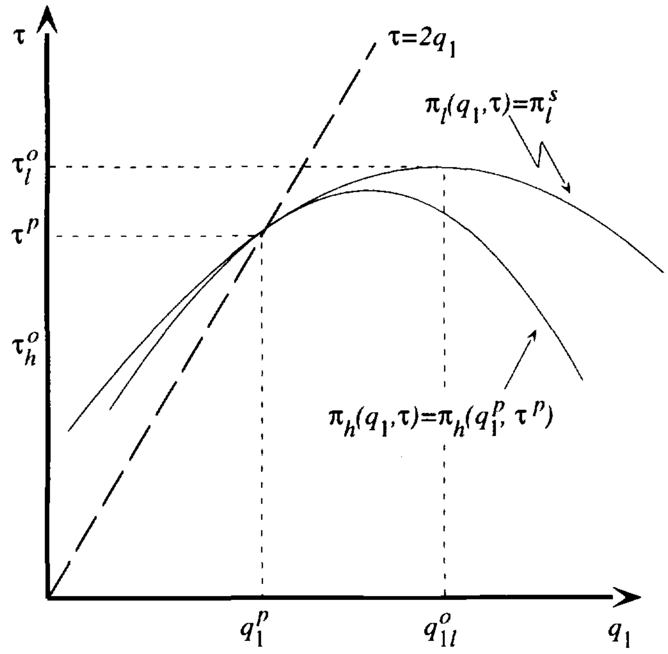

Figure 4: The mixed pooling equilibrium of the game

only D_1 equilibrium is in pure strategies at exports q^e and tariff level τ^e. The off equilibrium response is τ_l^o, $\forall q_1 \neq q^e$. □

The unique D_1 equilibrium outcome when the prior guarantees the existence of a mixed pool is depicted in Figure 4.

Remark: It is clear that in the pooling equilibrium outcome l restricts its exports with positive probability, and would never increase exports above the complete information quantity. However, it is conceivable that h might export more than its complete information optimum, q_{1h}^o, in the pool. For this to happen three conditions must be met simultaneously:

1. q_{1h}^o must be smaller than $q_1 = (a - c_l)/6$, the intersection of the tangency line with $\tau = \tau_l^o$. This is the case if $A > 3$.

2. The profit of l at $(q^o_{1h}, \tau = 2q^o_{1h})$ must be higher than π^s_l. One can show that this condition holds only if $A > 3$, and if

$$\delta > \frac{9A^2 - 18A + 9}{14A^2 - 36A + 4} > \delta^p.$$

Both of these conditions are significantly more difficult to achieve than the thresholds sufficient for pooling to emerge as a D_1 equilibrium.

3. The prior probability of l should be sufficiently large so that $\tau^e > 2q^o_{1h}$. In particular, it must be that $\mu > 2/(A-1)$.

It is unlikely for this unusual result (an increase in h's exports) to hold. Moreover, independent of h's output relative to its complete information monopoly level, the welfare analysis below shows that in general discriminatory tariff protection lowers welfare relative to uniform tariff.

5. Welfare implications of incomplete information

We would now like to determine whether a policy of discriminatory tariffs raises expected welfare. As shown in sections 4.1 and 4.2 the equilibrium under the discriminatory tariff policy depends on the discount rate: if $\delta^m \leq \delta < \delta^p$ the unique equilibrium is separating while if $\delta \geq \delta^p$ the unique equilibrium is pooling.

In order to construct a suitable benchmark, we consider an alternative scenario where the home country can *precommit* itself to the GATT MFN standard which we interpret as uniform tariffs. This plausible alternative scenario might arise if there were bilateral or multilateral trade arrangements involving the exporting country which bind the trade barriers to mutually acceptable levels. This would credibly remove the possibility for differential tariff treatment and hence eliminate the incentives of the exporting firm to signal its technology through quantity restraints.

Assuming the GATT uniform tariff is designed in order to maximize expected welfare, using (3) we can show the optimal MFN tariff is

$$\tau^{\mathrm{MFN}} = \mu(a - c_l)/3 + (1 - \mu)(a - c_h)/3.$$

Note that $\tau^{\mathrm{MFN}} = \tau^e$.

Let's first consider the case when the primitives of the model give rise to the pooling equilibrium, i.e., for any A such that $\delta > \delta^p$.[12] Since the welfare in a mixed strategy equilibrium is rather tedious to compare we restrict ourselves to the case where the prior over the types induces pure pooling.[13] In the pure pooling equilibrium both types export q^e in the first period under conditions of free trade, and produce their profit maximizing levels given τ^e in the subsequent periods. By contrast, in the GATT MFN scenario the monopolist produces its complete information optimum quantity, q^o_{1i}, and faces τ^{MFN} in the subsequent periods. Using our measure of the relative cost differential and substituting into equation (3), the difference in welfare (Ω) is easily derived as

$$\Omega^{\mathrm{pool}}(\mu, A) \equiv w^{\mathrm{pool}} - w^{\mathrm{MFN}} = (1/72)\left(\mu^2(A-1)^2 - 9\mu A^2 + 2\mu A + 7\mu - 8\right).$$

One can show that $\Omega^{\mathrm{pool}}(\mu, A) < 0$ for all (μ, A), implying

Proposition 6 *If the primitives of the model induce pure pooling in equilibrium, then relative to a GATT MFN optimal tariff a discriminatory tariff policy always lowers welfare.*

Let's now consider the case when the primitives of the model induce separation in equilibrium, i.e., for any A such that $\delta^m \leq \delta \leq \delta^p$. In this scenario the type l (h) firm exports q^o_{1l} ($\underline{q}_1$) in the first period and q^o_{tl} (q^o_{th}) in subsequent periods.

[12] While not written explicitly, it is important to recall that δ^m and δ^p are functions of A.

[13] This scenario would become exceedingly likely the larger is the discount rate.

Using our measure of the relative cost differential, the difference in welfare is

$$\begin{aligned}\Omega^{\text{sep}}(\delta, \mu, A) &\equiv w^{\text{sep}} - w^{\text{MFN}} \\ &= \beta_1 \left[\beta_2 - 6A\sqrt{\beta_2} + 3\mu(A-1)^2\delta/(1-\delta) + 9(A-1)(A+1)\right],\end{aligned}$$

where $\beta_1 = (1-\mu)/72 > 0$ and $\beta_2 = (A-1)(5A-1)\delta/(1-\delta) > 0$.

Depending on the parameters $\Omega^{\text{sep}}(\cdot) \lesseqgtr 0$. Nevertheless, we are able to characterize the welfare effect by making the following observations. First, at $\delta = \delta^m$, $\Omega^{\text{sep}}(\cdot) > 0$ for all (μ, A); this implies that a discriminatory tariff raises welfare for small δ. Second, we can show that $d\Omega^{\text{sep}}(\cdot)/d\delta < 0$ for all (μ, A). In other words, a discriminatory tariff policy becomes less desirable as δ increases. Third, we can also show that at $\delta = \delta^p$, $\Omega^{\text{sep}}(\cdot) \lesseqgtr 0$ and that the sign depends on μ and A. In Figure 5 we depict the zero contour for $\Omega^{\text{sep}}(\cdot)$ at $\delta = \delta^p$. Clearly, the smaller is A, the greater is the range of μ in which $\Omega^{\text{sep}}(\cdot) < 0$.[14] Taken together we know that if $\Omega^{\text{sep}}(\delta = \delta^p, \mu, A) < 0$, then by continuity and monotonicity of $\Omega^{\text{sep}}(\cdot)$ in δ there exists a function $\hat{\delta}(\mu, A) < \delta^p$ such that $\Omega^{\text{sep}}(\hat{\delta}(\mu, A), \mu, A) = 0$. Formally, define

$$\overline{\delta}(\mu, A) = \begin{cases} \hat{\delta}(\mu, A) & \text{if } \Omega^{\text{sep}}(\cdot) < 0 \text{ at } \delta = \delta^p, \\ \delta^p & \text{otherwise.} \end{cases}$$

We can now summarize our discussion as follows,

Proposition 7 *If the primitives of the model are such that $\delta > \overline{\delta}(\mu, A)$ then a discriminatory tariff policy lowers welfare regardless of whether the outcome of the game is separation or pooling.*

[14]Note that since typically one would expect $A < 2$ the relevant region for all $\mu < 1$ is $\Omega^{\text{sep}}(\cdot) < 0$ at $\delta = \delta^p$.

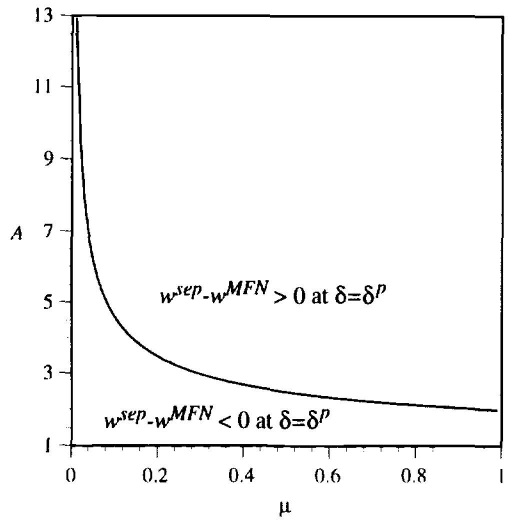

Figure 5: Zero contour of $w^{\text{sep}} - w^{\text{MFN}}$.

6. Conclusion

The model developed here highlights an issue often ignored in the literature on optimal tariff regimes: the desire of importing countries to discriminate on the basis of foreign monopolist's technology is likely to provoke an undesirable strategic reaction by the monopolist in the form of reduced trade. Typically, the equilibria in signaling games involve separation and hence only the player with attractive information alters its behavior. In our model this would mean that only the firm with high costs would reduce exports relative to their profit maximizing level. This is the case when the discount rate is relatively small. However, when the discount rate is relatively large the unique outcome involves pooling where exports are restricted regardless of the true type of the foreign firm.

Our analysis shows that incomplete information makes it very difficult, if not impossible, to implement a policy of discriminatory tariffs and highlights the difficulties in making clear-cut policy recommendations when faced with the unavoidable ambiguity associated with pooling equilibrium. Given this, we show that a policy of optimal MFN tariffs is generally superior to one of discriminatory tariffs. The results from this paper complement other recent work on trade policy with incomplete information in two important ways. First, we adopt a signalling approach to model the government's informational asymmetry while most of the other literature uses a screening approach. Second, we emphasize the relevance of pooling outcomes while the other research in this area emphasizes separation. Taken together this body of work severely draws into question the welfare benefits of trade policies aimed at rent extraction.

Also, we believe an important methodological contribution of the paper is the description of double crossing property of the payoff function. We show that this phenomenon gives rise to a pooling outcome. We hope that our analysis will lead other researchers to question the plausibility of separating equilibria when single crossing is not satisfied.

Finally, we note a few extensions. First, the unique stable pooling equilibrium outcome can be arrived at in other reasonable ways, not just through our assumption that the tariff is in place for many periods. Any factor that increases the marginal impact of tariffs on the exporter's payoff decreases the likelihood of pure strategy separating equilibria. For instance, consider a model where there are only two periods, one before the tariff is levied and one after. If demand grows over time then one can show that the unique equilibrium is the same as that derived in section 4.2. Second, one can alternatively view the government's objective as maximizing tariff revenue only. It is straightforward to show that this again makes pooling more likely and hence exacerbates the welfare consequences. Third, the qualitative features of the model remain similar if we consider a foreign duopoly or if we allow for domestic production. The latter model is of significant practical interest since the attempt to tariff discriminate among exporters is not feasible under the MFN clause of the WTO. The presence of domestic production serves as an excuse for the proliferation of contingent measures of protection such as antidumping duties. The introduction of additional strategic players adds some new aspects to the interactions without altering the results significantly.

References

Bagwell, K.W. and R.W. Staiger, 1996, Reciprocal trade liberalization, NBER working paper, No. 5488.

Banks, J.S. and J. Sobel, 1987, Equilibrium selection in signaling games, Econometrica 55, 647–661.

Brainard, S.L. and D. Martimort, 1997, Strategic trade policy with incompletely informed policymakers, Journal of International Economics 42, 33–66.

Brander, J.A. and B.J. Spencer, 1984, Tariff protection and imperfect competition, in: H. Kierzkowsky, ed., Monopolistic competition and international trade, (Clarendon, Oxford) 194–206.

Cho, I.K. and D.M. Kreps, 1987, Signaling games and stable equilibria, Quarterly Journal of Economics 42, 179–221.

Cho, I.K. and J. Sobel, 1990, Strategic stability and uniqueness in signaling games, Journal of Economic Theory 50, 381–413.

Collie, D. and M. Hviid, 1993, Export subsidies as signals of competitiveness, Scandinavian Journal of Economics 95(3), 327–339.

Collie, D and M. Hviid, 1994, Tariffs for a foreign monopolist under incomplete information, Journal of International Economics 37, 249–264.

Feenstra, R.C., 1996, Estimating the effects of trade policy, NBER working paper, No. 5051.

Grossman, G.M. and E. Helpman, 1994, Protection for sale, American Economic Review, 84, 833–50.

Grossman, G.M. and E. Helpman, 1995a, Trade wars and trade talks, Journal of Political Economy, 103, 675–708.

Grossman, G.M. and E. Helpman, 1995b, The politics of free-trade agreements, American Economic Review, 85, 667–690.

Hwang, H. and C. May, 1991, Optimum discriminatory tariffs under oligopolistic competition, Canadian Journal of Economics 24(3), 693–702.

Johnson, H., 1951-1952, Optimum welfare and maximum revenue tariffs, Review of Economic Studies 19, 28–35.

Katrak, H., 1977, Multi-national monopolies and commercial policy, Oxford Economic Papers 29, 283–291.

Kolev, D., 1995, Monotonic signaling games with double crossing, mimeo, SUNY at Stony Brook.

Kreps, D.M. and J. Sobel, 1994, Signaling, in: R.J. Aumann and S. Hart, eds., Handbook of game theory, Vol. 2 (North-Holland, Amsterdam) 849–867.

Kreps, D.M. and R. Wilson, 1982, Sequential equilibria, Econometrica 50, 863–894.

Krugman, P., 1984, Import protection as export promotion: international competition in the presence of oligopoly and economies of scale, in: H.Kierzkowsky, ed., Monopolistic competition and international trade, (Clarendon, Oxford) 180–193.

Qiu, L., 1994, Optimal strategic trade policy under asymmetric information, Journal of International Economics 36, 333–354.

Svedberg, P., 1979, Optimal tariff policy on imports from multinationals, Economic Record 55, 64–67.