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Optimal Taxation of a Foreign Monopolist with Unknown Costs

Aditya Bhattacharjea

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Centre for Development Economics
Delhi School of Economics
Delhi 110 007 INDIA
Tel: 7257005, 7257533-35
Fax: 7257159
E-mail: office@cdedse.ernet.in

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ABSTRACT

Optimal taxes on imports from a foreign monopolist have been frequently analysed. However, they are sensitive to the monopolist's costs and any export subsidy it receives, both of which are likely to be unknown to the importing country's government. This paper adapts the regulatory mechanism of Baron and Myerson (1982) to this situation, where the firm cannot be subjected to the same kind of regulation as a domestic monopolist. It is shown that the optimal mechanism always involves a license fee and is revenue-neutral. These features have important implications for the practicability of the mechanism.

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1. INTRODUCTION

When goods are imported from a firm located abroad, the latter's profits are beyond the reach of the tax authorities of the importing country. However, Katrak (1977), Svedberg (1979) and Brander and Spencer (1981) showed that a tariff can augment national welfare by extracting some of the foreign rent. This insight spawned a multitude of models of trade policy in the presence of imperfect competition, and an equally prolific critical literature that questioned the "new" trade theory's theoretical robustness and practical applicability. In particular, Srinivasan (1989) argued that the policy prescription of an optimum tariff to shift the foreign monopoly rent was not first-best. An import subsidy that induced the monopolist to price at marginal cost would be superior to a tariff, with the government recovering the subsidy revenue by charging the monopolist a lump-sum fee for the right to supply the home market. Similarly, de Meza (1979) pointed out that a price ceiling on imports would be superior to a tariff. However, fixation of the subsidy or price ceiling requires information on the firm's costs, which is not likely to be available to any real-world government. Katrak (1979, p. 510) and Brander and Spencer (1981, p. 385) pointed this out in response to critics of their early papers, but accurate calculation of their optimal tariff, which came to dominate the literature, requires the same information. The limited empirical work in this area shows that the optimal tariff is very sensitive to costs, which are notoriously difficult to estimate accurately.[1]

Foreign profits may also be augmented by government subsidies, in response to which countervailing duties (CVDs) can be imposed by the importing country. Although these are usually designed to "level the playing field" and protect domestic firms from unfair foreign competition, they also serve to divert some of the subsidy to the importing country when foreign supply is imperfectly competitive. Collie (1991) shows that a CVD is the optimal response to foreign export subsidies even when there is no domestic production. This again assumes that the foreign firms' costs and the subsidy rate are known, but since subsidies to manufactured exports violate WTO rules, they are hardly likely to be given overtly. "Countries have disagreed over which domestic programs should be classified as subsidies, and there has been resistance to providing information on subsidies when other [GATT]

[1] See, for example, the sensitivity analysis in Dixit (1988).

signatories request it" (Stern and Hoekman, 1987, p. 61). Legal scholars as well as trade policy analysts have expressed concern about the arbitrariness and inconsistency of CVD enforcement, leading to its misuse for protectionist purposes (Marvel and Ray, 1995). American analysts point to the Commerce Department's failure to analyze the impact of export subsidies on foreign firm conduct. This would require an assessment of their impact on foreign costs, which these authors admit is hard to determine: see the papers in Boltuck and Litan (1991).

A third area where foreign profits can escape the tax net, even though there is a taxable foreign entity within the home country's jurisdiction, is where foreign-owned multinationals source inputs from their overseas affiliates. The true cost of these inputs is unknown to the government, and transfer pricing is used to shift profits abroad. This is a subject of growing concern in many countries.

The scheme proposed below optimally taxes all three kinds of foreign profit in the presence of private cost information, in the foreign monopoly case addressed in the early tariff literature.[2] It draws on a solution, originally proposed in the domestic regulation literature by Baron and Myerson (1982), to the problem of asymmetric cost information. This requires adapting the Baron-Myerson regulatory mechanism to a situation where the monopolist is located abroad, and cannot be subjected to the same degree of control as one located within the regulator's jurisdiction. Instead, the optimal regulatory mechanism is implemented by deploying the usual tools of trade policy--tariffs, subsidies and quotas, augmented by a lump-sum tax in the form of a license fee for the right to sell in the country. I derive a tariff/quota equivalence result, and show that the fee is always positive under mild restrictions on the demand curve, and that the optimal policy is revenue-neutral in expectations. The proposed policy is superior to what will henceforth be called the Katrak tariff, and subsumes Srinivasan's (1989) tax/subsidy scheme as a special case under full information. The model

[2] Although pure foreign monopoly might seem to be of very limited interest, it is empirically relevant in many instances of imports financed by tied aid, technology licensing agreements with tying clauses, technological complementarities, exclusive marketing rights guaranteed by patents, intra-firm trade, export cartels sanctioned by the competition law of most countries, and first-mover advantages reinforced by sunk costs of market development. Chapter 1 of Bhattacharjea (1993) provides a fuller discussion of these issues.

has interesting implications for the taxation of foreign profits, trade policy under imperfect competition, and dealing with transfer pricing by foreign multinationals. It also offers benchmark results on the fiscal implications of the regulation of domestic monopolies. Section 2 discusses the informational and institutional constraints that motivate the model; section 3 derives the fiscal implications of the optimal mechanism; and section 4 discusses its significance and practical viability.

2. MODELLING ISSUES

The problem created by costs being private information is well-known in the regulation literature. In their seminal paper on the subject, Baron and Myerson (1982, p. 911) quote Weitzman:

> An essential feature of the regulatory environment I am trying to describe is uncertainty about the exact specification of each firm's cost function. In most cases even the managers and engineers most closely associated with production will be unable to precisely specify beforehand the cheapest way to generate various hypothetical output levels. Because they are yet removed from the production process, the regulators are likely to be vaguer still about a firm's cost function.

When the firm is located abroad, regulators are yet more removed and presumably even vaguer about costs. However, the context of the tariff problem in the early debates reviewed above--a monopolist with private cost information confronting a government attempting to maximize social welfare--is formally very similar to the well-known regulatory mechanism design problem solved by Baron and Myerson. Can a similar scheme be implemented when the firm is located abroad? If so, the Revelation Principle embodied in such a scheme would guarantee that it would be at least as good for welfare as any "general mechanism" that maps the government's information about the firm's costs into a set of trade policies, such as the tariffs which have hitherto dominated the literature.

The Baron-Myerson mechanism consists of an elaborate set of incentives designed to induce truthful revelation of costs by the firm, which is invited to choose from a menu of

appropriately structured contracts by reporting a cost level. Contracts usually commit the firm to a price/output combination, with a lump-sum transfer from the government to the firm (which may be negative) ensuring participation and incentive-compatibility. For example, exaggeration of true costs, which would otherwise undermine regulatory efforts, is discouraged by pairing high cost reports with contracts forcing the firm to charge a price that is so high that it sells an unprofitably low amount. Truthful reporting is induced by ensuring that the firm earns as much by doing so as by misreporting its costs.

The Baron-Myerson mechanism has been adapted by Prusa (1990) to the regulation of intra-firm transfer pricing by multinational corporations. He treats as contractible an MNC affiliate's sales in the host-country market, treating the transfer price of its imports from its parent as the cost which the affiliate is induced to reveal. The contract consists of a price/quantity combination and a lump-sum transfer. In this application, the firm is located within the regulator's jurisdiction, where such contracts can be enforced on both parties.[3] However, in the case of "arm's-length" imports from a foreign monopolist to which the early Katrak tariff literature was confined, the "extra-territoriality" of the firm does present serious obstacles to implementing the Baron-Myerson mechanism. The regulatory package is evidently going to be an import quota (binding both upwards and downwards, unlike normal quotas) and a lump-sum transfer. This resembles proposals for two-part schemes involving such transfers, such as Srinivasan's (1989) suggested import subsidy financed by a lump-sum tax on the foreign firm, or Helpman and Krugman's (1989, pp. 56-57) suggestion of a minimum import requirement (MIR) combined with an access fee to sell to the domestic market. Both are infeasible when the foreign firm's true costs are unknown, and there also seems to be no institutional precedent for a MIR, or downward-binding quota.

The principal objection to recasting this as an optimal contract design problem is that there is no judicial machinery which can enforce such a contract between a sovereign regulator and a foreign firm. Absent minimum import requirements, the firm cannot be forced to supply the stipulated quantity. If the contract is for sales over a period of time, rather than a one-time delivery, the firm can opt out whenever it has delivered the quantity that is optimal

[3] Raff (1994) also uses mechanism design to tackle the obverse of this problem, an MNC affiliate with unknown costs that exports to its parent abroad.

for it, which may be less than the quota amount. (In a domestic setting, this is prevented by specifying both price and quantity, or by "common carrier" provisions that force the firm to cater to all demand at the regulated price). Moreover, the terms of the contract have to be enforced as much on the government as on the firm, for once the private information is revealed, the regulator has an incentive to apply the full information policy. Anticipating such opportunism, the firm will not truthfully reveal its costs (or subsidy), and typically full or partial pooling of types occurs.[4]

The problem of enforcing a sales level can be tackled by modifying the mechanism in the following manner. In the absence of institutional precedents for rigid bi-directional price or quantity controls on a foreign firm, presumably because of insurmountable enforcement problems, I consider a per-unit tax/subsidy to induce the correct choice of output, with the lump-sum transfer being adjusted appropriately. This would amount to the firm selecting from a menu of import restrictions, with each item consisting of a lump-sum transfer, a per-unit import tax or subsidy, and an import quota, one or more of which may be redundant. Commitments under GATT can then be invoked to rule out opportunistic behavior by the government. This could be supplemented by the usual reference to "reputational" considerations in a continuing relationship. Alternatively, one could visualize the government posting a "hostage" in the form of an escrow account in a third country which can be forfeited under specified circumstances. However, none of these commitment devices will be modelled here.

3. THE OPTIMAL MECHANISM

The main concern of this paper is the implementation and fiscal implications of the Baron-Myerson mechanism when the firm is located abroad. The regulatory pricing rule is simply their standard one in the special case with (a) constant marginal costs and no set-up

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[4] Regulatory relationships within a country hold out the possibility of legal guarantees in providing a substitute for commitment. The firm and the government can agree ex ante on a "fair" contract which limits opportunism on both sides, and this can be codified in law and enforced in the courts. In that case, separation can be ensured. (See Baron, 1989, pp.1405-1416, for a discussion of mechanism design in the absence of commitment). Again, no such judicial enforcement is conceivable when the firm is located abroad.

costs for the firm and (b) zero weight on the firm's profit in the regulator's objective function. It can thus be obtained by setting $\alpha = 0$ in section 5 of Baron and Myerson (1982). Adapting the mechanism to implement the pricing rule with subsidies and tariffs is straightforward. This is relegated to Appendix A; here I give only a compact description of the setting of the model.

Consider a situation where a single foreign firm is a country's only supplier of a particular good. Its constant unit cost c (net of any covert subsidy) is drawn from a commonly-known distribution with density $f(c) = F'(c)$ and support on $[\underline{c}, \bar{c}]$. This cost is known only to the firm. It sells to a home market characterized by demand $q = q(P)$ which is also common knowledge, with $q'(P) < 0$ for all P. It is usually assumed that demand is high enough so that it is always positive at the highest regulated price. The firm's objective is to maximize profits net of any payments to the regulator (here, the importing country's tariff authority). The regulator's objective is to maximize social welfare, defined as domestic consumers' surplus plus any net revenue realized from the firm.[5]

Following the revelation approach of Baron and Myerson, the interaction between the regulator and the monopolist is modelled as a Bayesian game. A strategy $\underline{\sigma}$ for the firm is to report a cost level c' to the regulator, that is, a mapping from the set of cost types into itself. The firm may also decline to participate in the regulator's mechanism. The regulator's strategy is a publicly-announced mechanism $\underline{\mu}$ that assigns to each reported level of costs a policy three-tuple $\{T,t,\bar{q}\}$ consisting of a lump-sum tax T, a per-unit tariff t (either or both of which may be negative), and an import quota $\bar{q}$ which binds only upwards. A (binding) quota and a (positive) tariff are alternative means of restricting imports, and will never be used together. A Bayesian equilibrium of this game is (a) a mechanism $\underline{\mu}^*$ which maximizes the regulator's objective function, given the strategy $\underline{\sigma}^*$ of the firm, and (b) a strategy $\underline{\sigma}^*$ of the firm that maximizes its profit given its (privately-known) cost level and the mechanism $\underline{\mu}^*$. The Revelation Principle establishes that a mechanism which induces the firm to report its cost truthfully is at least as good in terms of the regulator's objective as any other

[5] With a foreign monopoly subject to a binding quota, the implicit tariff (the wedge between the foreign and domestic prices) is zero (Shibata, 1968), so domestic quota holders earn no rents.

mechanism. Attention can therefore be restricted without loss of generality to the class of mechanisms in response to which the firm has no incentive to misrepresent its type.

Derivation of the optimal mechanism proceeds in two stages. First, the class of truth-revealing (incentive-compatible) mechanisms in which the firm will participate is derived. These are the feasible or implementable mechanisms. Second, the optimal mechanism is obtained by maximizing the regulator's objective function subject to the incentive-compatibility and participation (individual rationality) constraints. These constraints are:

$$\pi(c;c) \geq \pi(c';c) \qquad \text{(IC) and}$$

$$\pi(c;c) \geq 0 \qquad \text{(IR)}$$

for all c, $c' \varepsilon [\underline{c},\bar{c}]$, where the two arguments of the profit function $\pi(.\ ;\ .)$ represent the reported and actual cost levels respectively.[6] The optimal mechanism $\underline{\mu}^*$ that maximizes welfare subject to satisfying the IC and IR constraints can be obtained (see Appendix A) as

(a) the tariff t^* or quota $\bar{q}$ that enforces a price

$$P^*(c) = c + H(c), \qquad (1)$$

where $H(c) \equiv F(c)/f(c)$ is the hazard rate of the cost distribution, and

(b) a lump-sum tax of

$$T^*(c) = [P^*(c) - c - t^*(c)]\, q(p^*(c)) - \oint_{c}^{\bar{c}} q(s)\, ds \qquad (2)$$

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[6] Treating the firm's reservation profit as zero in IR is a consequence of the widely used assumption of segmented national markets, where the firm can charge prices independently of prices elsewhere. Alternatively, c could represent the opportunity cost of supplying this particular market, incorporating the (privately-known) marginal revenue the firm could earn by diverting its exports to the rest of the world, where it is a price-taker in the absence of the factors listed in footnote 2.

(1) and (2) define the optimal mechanism satisfying IC and IR. For illustrative purposes, Appendix B shows how the optimal policy package varies with the firm's revealed costs for a particular demand function and cost distribution. However, the following results pertain to the general case.

Features of the optimal mechanism: It is possible to deduce a number of characteristics of the mechanism. H(c) is necessarily non-negative, and is increasing in c for most common statistical distributions. Getting the firm to reveal its costs truthfully thus involves impelling more efficient types to supply at lower prices (higher quantities), closer to their marginal costs. For the most efficient type with cost $\underline{c}$, $H(\underline{c})=F(\underline{c})=0$, so $P^*(\underline{c}) = \underline{c}$. Clearly, normal (upward-binding) import quotas will not be effective in inducing the correct level of deliveries from these types: they will want to charge prices above marginal cost, so the quota will be undersupplied. An import subsidy $(t^* < 0)$ now becomes necessary to induce the correct level of sales. For higher cost types, whose sales have to be restricted relative to what they would like to sell, the quota does bind, but the regulator might prefer to restrict imports with a tariff $(t^* > 0)$ instead. It is immediately obvious from (2) that for the same level of revealed costs, the lump-sum tax must be adjusted so that it offsets exactly any tariff or subsidy revenue so as to prevent the firm from retaining excessive rents, while maintaining incentive-compatibility. In particular, the tax that supports the tariff scheme is always lower than the one that supports the quota by exactly the amount of the tariff revenue. Call this Lemma 1. (See Prusa 1990 for a similar result involving pre-existing taxes on an MNC affiliate.) Since the tariff and quota schemes are equivalent in their implications for government revenue, and result in the same price and import levels, it immediately follows that

PROPOSITION 1: The tariff and quota schemes are welfare-equivalent.

This result is inherent in the construction of the mechanism. I now derive some further results that are not so obvious, and are vital for the practicability of the mechanism. First, differentiating (2) with respect to c, and suppressing the asterisks and unnecessary function operators gives:

$$\frac{dT}{dc} = \left[\frac{d(P-t)}{dc}\right] q(c) + \frac{dq}{dc}\,[P(c) - c - t(c)] - q(\bar{c}) \qquad (3)$$

Consider a scheme that implements the mechanism with tariffs. Recall the assumption that demand is positive at the highest regulated price, so q(c) > 0 for all c, and the tariff is never prohibitive (P > c+t). The first term in (3) is therefore negative if dP/dt < 1, that is, for all demand specifications that allow incomplete pass-through of the tariff.[7] The second term is also negative, since the bracketed expression is positive and dq/dc < 0 because dP/dc > 0 from (1). Thus, dT/dc < 0, which gives us

Lemma 2: When output is induced by tariffs and dP/dt < 0, the tax is decreasing in the firm's true costs.

Intuitively, more efficient types pay more tax, because their profits are augmented by import subsidies. The tax recovers some of the subsidy without impairing the firm's incentive to report its cost truthfully. Symmetrically, the tax declining in c compensates higher-cost types for the tariffs that induce the stipulated quantity for incentive-compatibility.

Further, the optimal mechanism satisfying the individual rationality constraint requires that the highest-cost firm not earn any profit: if it did, the regulator could improve welfare by increasing the lump-sum tax. This type should thus be charged an amount equal to its operating profit at the regulated price $P^*(\bar{c})$. By our earlier assumption on demand, this profit is strictly positive. Hence $T(\bar{c}) > 0$. In conjunction with Lemma 2, this implies that if dP/dt < 1, then T(c) > 0 for all c. If output is restricted (where necessary) by quotas rather than tariffs, then the first term in (3) becomes positive, and consequently the sign of dT/dc becomes indeterminate. But recall from Lemma 1 that a quota scheme involves a higher tax on the relevant types than one involving tariffs, so T(c) > 0 for quotas as well. For both the tariff and quota schemes, then, we have

[7] This implies that the demand curve should not be too convex, as Brander and Spencer (1984) showed in their extension of the Katrak tariff to general demand.

PROPOSITION 2: If dP/dc < 1, then T(c) > 0 for all c, that is, the tax is always positive.[8]

The tax can thus take the form of an import license fee. Since the firm is never paid a transfer, it cannot "take the money and run", which is a common problem in the regulation literature. (The government can renege, but we continue to assume that reputational or institutional constraints preclude such opportunism). Proposition 2 is a direct consequence of ruling out MIRs and eliciting the required output from lower cost types by subsidies. If output contracting were feasible for such types, the tax could be negative for some of them, as shown in expression (4) below.

Concerns have been expressed in the more recent strategic trade literature, as well as the regulation literature, about the government being under a fiscal constraint, and therefore being unable credibly to implement subsidies.[9] It is therefore worth investigating the expected fiscal implications of the optimal mechanism, which are also relevant in judging its legality under GATT, as shown in section 4 below. Since (2) shows that for every cost realization, net revenue is the same whether the optimum quantity is induced by a tariff/subsidy or by quantity contracts, it is simpler to work with the latter. Setting t=0 and $P^* = c + H(c)$ in (2) gives

$$T^*(c) = [H(c)]\, q(P^*) - \oint_c^{\bar{c}} q(P^*(s))\, ds \qquad (4)$$

The regulator's expected revenue from the optimal mechanism is

$$E(T) \equiv \oint_{\underline{c}}^{\bar{c}} T^*(c) f(c)\, dc,$$

[8] The convexity restriction on dP/dt is equivalent to a restriction on dP/dc for constant costs and specific tariffs. Note that this condition is sufficient, not necessary, and Proposition 2 may hold even if it is violated.

[9] See, e.g., Dixit (1988), Levy and Nolan (1992) and Neary (1994) for the trade literature, virtually any work by Laffont and Tirole on regulation, and Brainard and Martimort (1996) for a recent coming together of the two streams.

Substituting from (4) gives

$$E(T) = \int_{\underline{c}}^{\bar{c}} q(c + H(c))\, F(c)\, dc - \int_{\underline{c}}^{\bar{c}} R(c)\, f(c)\, dc \qquad (5)$$

where F(c) = H(c) f(c) from the definition of H(c), and

$$R(c) \equiv \int_{c}^{\bar{c}} q(s + H(s))\, ds$$

Integrating the second integral in (5) by parts gives

$$E(T) = [R(c)\, F(c)]_{\underline{c}}^{\bar{c}} - \int_{\underline{c}}^{\bar{c}} R'(c)\, F(c)\, dc$$

$$= [R(c)\, F(c)]_{\underline{c}}^{\bar{c}} + \int_{\underline{c}}^{\bar{c}} q(c + H(c))\, F(c)\, dc \qquad (6)$$

Substituting this back into (5), the expression for expected revenue reduces to

$$E(T) = -[R(c)\, F(c)]_{\underline{c}}^{\bar{c}} = R(\underline{c}).F(\underline{c}) \qquad (7)$$

since $R(\bar{c}) = 0$ and $F(\bar{c}) = 1$.

Now $F(\underline{c}) = 0$, so expression (7) for expected revenue is identically zero if and only if $R(\underline{c})$ is bounded. Referring back to the transfer schedule (2), we see that this restriction is implied in any case, to preclude infinitely large transfers. A sufficient condition for $R(\underline{c})$ to be bounded is that the area under the demand curve be bounded. A weaker restriction is to interpret $R(\underline{c})$ directly as the area enclosed by the demand curve and the lowest and highest regulated prices, where we know from (1) that $P^*(\underline{c}) = \underline{c}$. It is this area which has to be bounded for (7) to be zero.

At first sight the result that E(T) = 0 may seem inconsistent with Proposition 2, which established that T(c) > 0 for all c. Recall however that subsidies were explicitly involved in that derivation, requiring higher taxes to offset them. Putting the subsidies (tariffs) back into (4) will result in T being raised (lowered) by exactly the same amount, as required by (2).

The proof that E(T) = 0 therefore applies equally to E(T+tq). This leads, under very general conditions, to the following:

PROPOSITION 3: The optimal mechanism is revenue-neutral in expectations, irrespective of the policy package used to implement it.

This is a novel result, which has not been demonstrated before in the regulation literature. It is independent of the probability distribution of costs and the form of the demand function, except for the weak restriction that R(c) is bounded. Note that this proof does not require the additional assumptions on demand required for Proposition 2. From the definition of social welfare, we also get:

COROLLARY: The optimal mechanism maximizes expected consumer surplus.

In other words, whatever foreign profit the mechanism succeeds in shifting to the home country does not on average accrue to the government as revenue. It goes directly to augment consumer surplus, as it would indirectly in standard welfare analysis in which any tax revenue is assumed to be rebated to consumers as lump-sum transfers.

Finally, with full information, the probability distribution collapses to a single point, at which H(c) = 0 in (1) and the second term in (2) vanishes. This gives $P^* = c$, and consequently $T^* = -tq$ in (2). The monopolist is subsidized to price at marginal cost, and charged a fee that takes away its entire profit, which is now identically equal to the subsidy amount. Revenue neutrality is preserved. This is what Srinivasan (1989) prescribed as a superior alternative to the Katrak tariff; his scheme can now be seen as the limiting special case of a general model with asymmetric information.

4. ASSESSMENT AND CONCLUSIONS

The optimal policy for a foreign monopolist with unknown cost was shown to be a menu consisting of various combinations of license fees, import subsidies, and tariffs or quotas, with the particular combination implemented depending on the cost level reported by the firm. It

is worth re-emphasizing that by the Revelation Principle, this package is at least as good as any other mechanism that maps the regulator's information into a set of policies, such as a (Katrak) tariff. Unusually from the perspective of the imperfect competition trade policy literature, it makes a qualified case for having import quotas in the policy-maker's armoury. These were shown to be equivalent in terms of welfare to the corresponding tariffs. The revenue-neutrality result circumvents a common criticism of both the strategic trade policy and domestic regulation literatures, based on the social costs of raising the revenues to finance net subsidies. Although probably of limited relevance to the regulation of domestic monopolies where profits and fixed costs cannot be ignored,[10] Propositions 2 and 3 do provide benchmarks for the fiscal implications of such regulation. Proposition 3 also contains an element of self-fulfillment in that if the government designs its policy by disregarding the firm's profits, the resulting mechanism involves no net transfer to the firm. This can also be seen as a useful property of Prusa's (1990) application of mechanism design to the regulation of transfer pricing by foreign multinationals, provided fixed costs can be ignored. This would be true if for example such costs were already sunk, and almost true if the local subsidiary is only a distributor of the imported product (as in the original Katrak model) and operates with low overheads.

Profits and fixed costs can be legitimately disregarded if the firm is located abroad, as in the early rent-shifting trade policy literature. Most writers in this tradition continue to prescribe tariffs, disregarding the explicit injunctions of GATT. In contrast, my results help to establish the legality of the optimal mechanism. The variable tariff component would of course run into problems with GATT, which encourages bound tariffs. As an unorthodox means of countervailing foreign export subsidies, the mechanism also has the disconcerting property that the unsubsidized (high-cost) types must pay the highest duties. Also, CVD action legally requires establishing both the fact of subsidization and injury to a domestic industry, which is absent in this model. These problems can be circumvented if the firm is simply required to report its cost level without going into the extent to which it has been subsidized, and a quota is used instead of a tariff. This can be regarded as a voluntary export restraint (VER) selected by the exporter, to which there can be no objection under current law. Import

[10] Both require increased net subsidization of every type of firm that is allowed to operate, and it can be verified that both result in additional negative terms on the right side of (7).

subsidies, although unusual, are also unexceptionable. What about the license fee? Although Article VIII of GATT does discourage charging fees, it specifically prohibits levies that "represent an indirect protection to domestic production or a taxation of imports or exports for fiscal purposes". The former is not relevant here, and Proposition 3 shows that the latter is not a characteristic of the scheme devised in this paper. The proposed mechanism thus follows the time-honoured practice of using "grey areas" in GATT, in this case not to protect domestic industry but to tax foreign profits--with the government truthfully denying that its policy is designed to earn revenue.

APPENDIX A

The profit of a firm with cost c which reports c' can be written as

$$(A1) \quad \pi(c';c) \equiv [P(q(c'))-c-t(c')]\, q(c') - T(c')$$

where q(c') is the export level the regulatory mechanism elicits from the firm, either through an appropriate tariff/subsidy or through a quota. The derivative of the profit function with respect to c is

$$\frac{d\pi(c';c)}{dc} = \frac{\partial\pi(c';c)}{\partial c'}\frac{dc'}{dc} + \frac{\partial\pi(c';c)}{\partial c}$$

Applying the envelope theorem, the first term is zero from the firm's first-order profit-maximization condition. The second term, $\partial\pi(c';c)/\partial c = -q(c')$ from (A1). Condition IC requires that c'=c be a solution to the firm's problem, so we get

$$d\pi^*(c;c)/dc = -q(c) < 0 \quad ,$$

where π^* represents profit levels satisfying IC. Integrating both sides,

$$(A2) \quad \pi^*(c) = \pi^*(\underline{c}) - \oint_{\underline{c}}^{\bar{c}} q(s)ds$$

Under IC, the firm's profits are decreasing in its true cost level. Therefore, if condition IR is satisfied for the type with the highest cost ($\bar{c}$), it is satisfied for all lower cost types. The continuum of IR constraints can then be replaced with the single constraint

$$(A3) \quad \pi^*(\bar{c}) \equiv [P(q(\bar{c})) - \bar{c} - t(\bar{c})]\, q(\bar{c}) - T(\bar{c}) \geq 0$$

The type with the highest cost will participate and reveal its true costs as long as it receives any non-negative profit. Obviously the regulator should adjust the transfer $T(\bar{c})$ so as to leave this type with no profit, so that (A3) holds as an equality. For $c=\bar{c}$, therefore, (A2) gives

$$\pi^*(\bar{c}) = \pi(\underline{c}) - \int_{\underline{c}}^{\bar{c}} q(s)\,ds = 0$$

so that

$$\pi^*(\underline{c}) = \int_{\underline{c}}^{\bar{c}} q(s)\,ds.$$

Substituting this back into (A2) and subtracting the two integrals:

$$\text{(A4)} \quad \pi^*(c) = \int_{\underline{c}}^{\bar{c}} q(s)\,ds.$$

This represents both IC and IR as a restriction on the profit function, and completes the first stage of the design of the mechanism, defining the class of feasible mechanisms. The second stage is to incorporate this into the regulator's optimization problem. The objective function comprises consumers' surplus (S) from consumption of q, plus any (net) revenue realized from the firm as license fee or tariff revenue. Welfare is thus:

$$W \equiv S(q(c)) + T(c) + tq(c)$$

Substituting from the firm's profit expression (A1), for the class of truth-revealing mechanisms, this can be written:

$$W = S(q(c)) + P(q(c))q(c) - cq(c) - \pi^*(c)$$

Substituting the representation of IC and IR (A4), the regulator's problem is to maximize expected welfare conditional on the known cost distribution or:

$$\max_q \; E\left[S(q(c)) + P(q(c))q(c) - cq(c) - \int_{c}^{\bar{c}} q(s)\,ds\right] | f(c)$$

The expectation of the integral expression is

$$\text{(A5)} \quad \int_{\underline{c}}^{\bar{c}} \int_{c}^{\bar{c}} q(s) f(c)\,ds\,dc = \int_{\underline{c}}^{\bar{c}} q(c)\,F(c)\,dc$$

where F(c) is the cumulative density function corresponding to f(c), and the constant of integration $\pi^*(\bar{c}) = 0$, as shown above. Substituting the expression for expected profits in (A5) into the regulator's problem, the regulator solves

$$\text{(A6)} \quad \max_{q} \int_{\underline{c}}^{\bar{c}} [\, S(q(c)) + P(q(c))\, q(c) - c\, q(c) - \frac{F(c)}{f(c)}\, q(c)]\, f(c)\, dc$$

The first-order condition for the maximization of expected welfare is obtained by differentiating (A6) pointwise with respect to q for all c ε $[\underline{c}, \bar{c}]$ and equating to zero:

$$\partial W / \partial q = -qP'(q) + qP'(q) + P(q) - c - H(c) = 0$$

where H ≡ F(c)/f(c) is the hazard rate of the cost distribution, and the dependence of q on the cost report c has been suppressed for simplicity. (Since the objective function is concave in q, this necessary condition is also sufficient for a maximum.) From this, we get the price the regulator would like to enforce:

$$P^*(c) = c + H(c) \qquad \text{(Eq. 1 of the text)}$$

The size of the lump-sum transfer is obtained by equating expression (A1) for the firm's profit (after incorporating any tariff or subsidy) to the restriction (A4) which embodies IC and IR, and solving for T(c). The general form for this, with c'=c and t=t*, is:

$$\text{(A7)} \quad T(c) = [P(q(t(c))) - c - t^*(c)]\; q(P(c)) - \int_{c}^{\bar{c}} q(s)\, ds \qquad \text{(Eq. 2 of the text)}$$

APPENDIX B

A more precise idea of how the policy package varies with the firm's revealed costs can be obtained for a particular demand specification and cost distribution. Let inverse demand take the form P = a-q, and let f(c) be uniformly distributed on $[0,\bar{c}]$, so that H(c) = c. This case is often used to illustrate more clearly the features of the optimal mechanism.[11] From (1), the regulator would like to enforce $P^* = 2c$ or $\bar{q} = a-2c$. This is less than what the firm would like to supply, (a-c)/2, only if $c > a/3$. Therefore, if $\bar{c} > a/3$ (which will be assumed henceforth), there are some firm types in the upper part of the cost distribution who can be forced to supply the correct level of exports by either a tariff or a quota. Firms with lower costs $c \in [0,a/3)$ have to be induced to supply q = a-2c by means of an import subsidy. Further, our assumption on demand requires that $q(\bar{c}) > 0$, so $\bar{c} < a/2$.

The optimal subsidy/tariff mechanism: Recalling that subsidies figured in the profit and welfare expressions as negative tariffs, the required tariff or subsidy is easily calculated by equating the regulator's desired level of imports $q^* = a-2c$ to the firm's desired level (a-c-t)/2 and solving for

$$t^* = -(a-3c) \underset{<}{\geq} 0 \text{ as } c \underset{<}{\geq} a/3$$

Hence $P(t^*) = 2c$, $q(t^*) = a-2c$, and so from (2), T(c) is:

$$[2c - c + (a - 3c)](a - 2c) - \int_{c}^{\bar{c}} (a - 2c)\, ds$$

This gives a family of tax schedules parametrized by $\bar{c}$:

$$T(c) = a^2 - 3ac + 3c^2 - a\bar{c} + \bar{c}^2$$

We can see that T(c) > 0 and T'(c) = -3(a-2c) < 0 for all $c \in (0, a/2)$

[11] For example, see section 5 of Baron and Myerson (1982). The reader can easily verify that the optimal tariff formula is unaffected by suppressing the slope parameter of a linear demand function.

The optimal subsidy/quota mechanism: If the quantity is to be enforced by a quota for types which reveal c ε (a/3,$\bar{c}$], for such types (2) becomes

$$(2c - c)(a - 2c) - \int_{c}^{\bar{c}} (a - 2c)\, ds, \text{ which gives}$$

$$T(c) = \bar{c}^2 - a\bar{c} + 2ac - 3c^2$$

Again, T(c) > 0 and T'(c) = 2(a-3c) < 0 for c > a/3.

Finally, noting that for this uniform distribution, f(c) = $1/\bar{c}$, the expression for expected net revenue E(T+tq) can be written

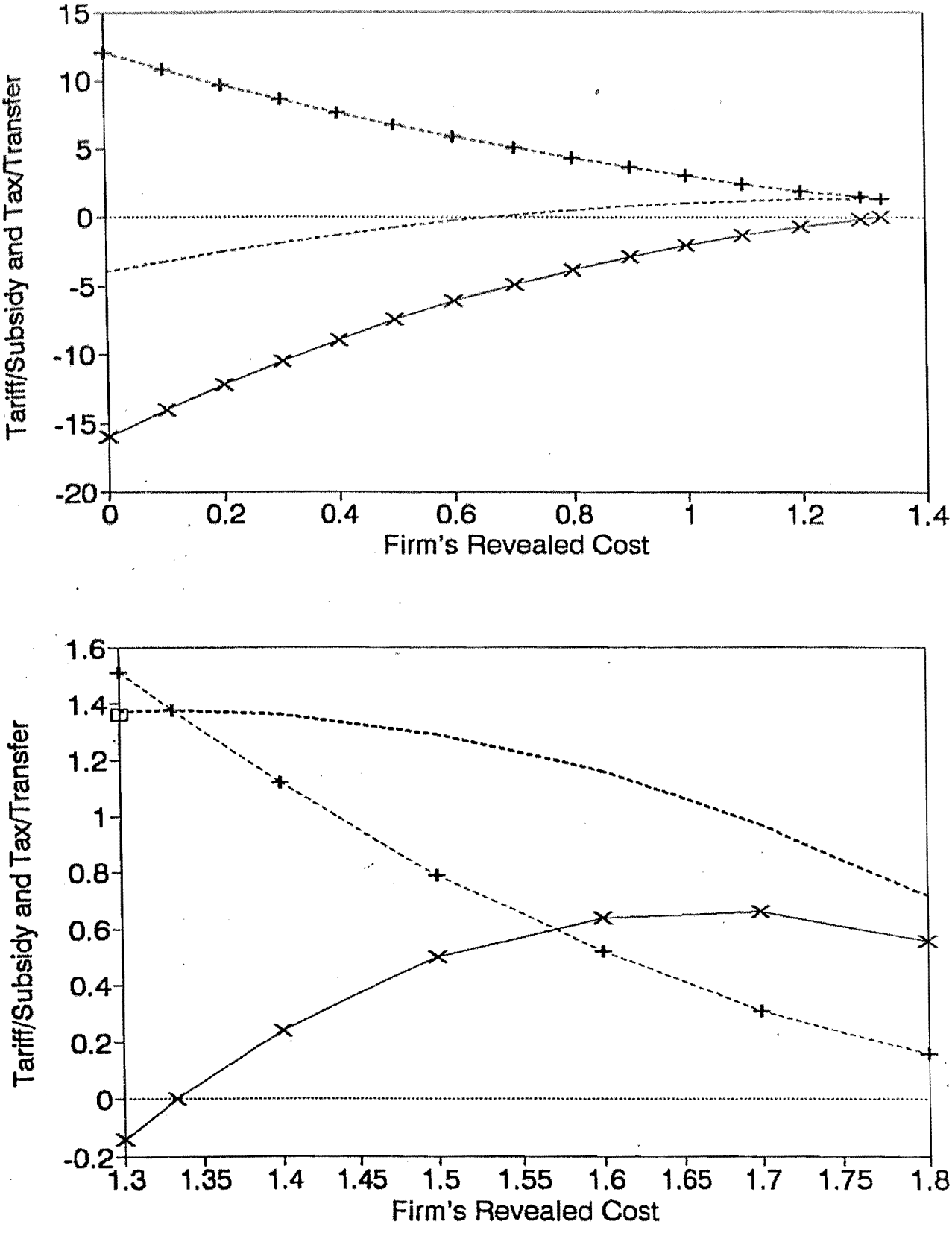
$$\int_{0}^{\bar{c}} [(a^2 - 3ac + 3c^2 - a\bar{c} + \bar{c}^2) - (a - 3c)(a - 2c)\, dc / \bar{c}$$

This is identically zero, confirming Proposition 3.

This version of the model, with linear demand and uniformly distributed costs, was simulated for a = 4 and $\bar{c}$ = 1.8. The resulting pattern of payments to and from firms revealing different levels of cost is illustrated in Figure 1. The dashed curve without markers in the upper panel shows how the transfer T would vary if quantity contracting were possible. It is negative for the lower cost types, becoming positive (a tax) at higher levels of revealed cost. However, as argued above, firm types in this part of the cost distribution (with c < 1.33 = a/3) would under supply the contracted amount. They must be induced to supply the correct amount by a subsidy, with the transfer being increased by exactly the same amount. This results in the curve marked with plus signs, which lies everywhere above zero. Since the various curves almost coincide for c > 1.33, the scale is expanded for higher cost levels in the lower panel of the figure. Here, t > 0 since the firm's sales have to be restricted relative to what it would like to sell, and upward-binding quotas are a possible alternative to tariffs, with the lump-sum transfer being adjusted appropriately. The transfer remains positive as shown above and by Proposition 2 of the text.

We see that payments to and from the firm largely offset each other. Net receipts are realized only from the higher cost types. It might appear that better cost information, in the form of a smaller support for the cost distribution (lower $\bar{c}$), might eliminate such types. But from the algebra above, this will increase T(c) on all types, preserving revenue-neutrality in terms of expectations.

FIGURE 1


Tariff/Subsidy and Tax/Transfer
15
10
5
0
-5
-10
-15
-20
0
0.2
0.4
0.6
0.8
1
1.2
1.4
Firm's Revealed Cost
Tariff/Subsidy and Tax/Transfer
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
-0.2
1.3
1.35
1.4
1.45
1.5
1.55
1.6
1.65
1.7
1.75
1.8
Firm's Revealed Cost
Subsidy/Tariff
T(c) with tariff
T(c) with quota

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