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Strategic Export Subsidies and Reciprocal Trade Agreements: The Natural Monopoly Case

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Kyle Bagwell*

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Robert W. Staiger*

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* Bagwell: Northwestern University; Staiger, The University of Wisconsin-Madison and NBER. We thank Susan Athey for helpful comments.

STRATEGIC EXPORT SUBSIDIES AND RECIPROCAL TRADE AGREEMENTS: THE NATURAL MONOPOLY CASE

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Abstract: Why do governments seek restrictions on the use of export subsidies through reciprocal trade agreements such as GATT? With existing arguments, it is possible to understand GATT's restrictions on export subsidies as representing an inefficient victory of the interests of exporting governments over the interests of importing governments. However, to our knowledge, there does not exist a formal theoretical treatment that provides circumstances under which GATT's restrictions on export subsidies can be given a world-wide efficiency rationale. In this paper, we offer one such treatment in the context of a natural monopoly market. We emphasize that subsidy competition between governments can serve to *coordinate* the entry decisions of firms, finding that consumers in the importing countries may suffer if the coordination afforded exporters by government subsidy programs does more to *prevent* entry than to *promote* it. In such circumstances, we show that the existence of export subsidy programs can lead to inefficiencies, and importing countries and the world as a whole can be better off when such programs are banned.

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I. Introduction

Why do governments seek restrictions on the use of export subsidies through reciprocal trade agreements such as GATT? Standard arguments that view governments as using trade policy to maximize national income in a perfectly competitive environment fail to provide a satisfactory answer to this question for a simple reason: These arguments cannot explain why governments find export subsidies attractive in the first place, since such policies at best introduce costly domestic distortions into the economy and at worst cause a deterioration in the terms-of-trade as well.

One approach to answering this question is to abandon the view that governments are motivated solely by national income considerations in their trade policy choices, and to assume instead that trade policy choices are made with both national income and distributional goals in mind. In this setting, export subsidies can become attractive to governments as a way to redistribute surplus toward their export interests. Such government motivations will also alter the trade policy combinations that define the efficiency frontier of a trade agreement (as viewed from the governments' own objectives), introducing the possibility that reciprocal free trade is no longer on this frontier. An important issue is then whether governments with broader motivations might seek to restrain export subsidies as part of an efficiency-enhancing reciprocal trade agreement.

As we have shown elsewhere (Bagwell and Staiger, 1996a), whether or not governments have additional distributional motivations, the essential purpose of a reciprocal trade agreement remains the same: A reciprocal trade agreement is attractive to governments because it can promote efficiency by eliminating the terms-of-trade driven restrictions in trade volume that would arise in the absence of such an agreement. An implication of this observation is that reciprocal restrictions on export subsidies do not arise obviously in this setting, as they serve to reduce trade volumes. Rather, an efficient trade agreement will typically call for an *expansion* of export subsidies.

While the world as a whole benefits from greater export promotion, it is possible that restrictions on export subsidies would be attractive to a subset of governments. When two countries export similar products, for example, an export subsidy from one government drives down the world price, harming the export industry in the other country. As a consequence of this negative externality, *exporting* governments experience a Prisoners' Dilemma problem when export subsidies are allowed, as they subsidize more than is jointly optimal. This implies that exporting governments may benefit - at the expense of importers - from a reciprocal trade agreement to *restrain* export subsidies. Thus, when governments have distributional motivations, it is possible to understand GATT's restrictions on export subsidies as representing an inefficient victory of the interests of exporting governments over the interests of importing governments.

An alternative approach to answering this question is to abandon the assumption of perfect competition. This is the approach pursued in the the pioneering work of Brander and Spencer (1985), who posit that export markets are oligopolistic and establish that national income in an exporting country *can* be increased by an export subsidy. In their analysis, an exporting government acting in the national interest is attracted to a policy of export subsidization, since an export subsidy gives its exporters a strategic advantage in the ensuing oligopolistic competition. The subsidies offered by exporting governments again benefit consumers in importing countries, who enjoy a lower price. Moreover, with government subsidies driving oligopolistic output closer to the competitive level, the subsidies offered by exporting governments enhance world-wide efficiency as well.

While the Brander-Spencer (1985) analysis thus does not offer a world-efficiency rationale for export-subsidy restrictions, it does suggest that national-income-maximizing exporting governments may seek to restrain export subsidies. An export subsidy from one government again exerts a negative externality to exporters in other countries, who experience a consequent reduction in market share. The exporting governments thus face a Prisoners' Dilemma problem among themselves, as they select export subsidies that are higher than would be jointly optimal. As such, this approach also depicts GATT's restrictions on export subsidies as an inefficient victory of the interests of exporting governments over the interests of importing governments.

In fact, there does not appear to exist a formal theoretical treatment that can provide a set of circumstances under which GATT's restrictions on export subsidies could be given a world-efficiency rationale. The purpose of this paper is to offer one such treatment.

We follow the approach of Brander and Spencer (1985) and abandon the assumption of perfect competition while maintaining the assumption that governments set policies to maximize national income. Specifically, we assume that there are two firms, with each located in a different exporting country, that compete for sales in a third market in which all consumers reside. In contrast to Brander and Spencer (1985), however, who assume that the two firms engage in Cournot competition, we consider the role of strategic export subsidies when the two firms compete as pure Bertrand competitors and face positive fixed costs of production.[1] As only one firm can profitably produce in such a market, this market structure can be interpreted as a "natural monopoly market." For such markets, it becomes possible that export subsidies offered by governments may have important effects on the *entry* decisions of firms, with each government choosing its export subsidy so as to improve the odds that its firm enters and monopolizes the market.

In order to explore the consequences of a prohibition of export subsidies on the welfare of the various countries, we consider two games. In the "no-subsidy game," export subsidies are banned, and the two firms simultaneously decide whether or not to enter. In the unique symmetric equilibrium, the firms use random (mixed) entry strategies, with each balancing the prospect of monopoly profits against the fixed cost of entry.[2] In

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[1]Other forms of imperfect competition have also been considered. For example, Eaton and Grossman (1986) assume that the two firms sell differentiated products and compete via price, while Maggi (forthcoming) synthesizes the previous analyses with a model that includes a capacity-expansion cost. Finally, Bagwell and Staiger (1996a) demonstrate that a role for strategic export subsidies also exists in competitive markets, provided that governments have both national income and distributional motivations.

[2]Variants of the no-subsidy game have been considered in the Industrial Organization literature. See, for example, Dixit and Shapiro (1986).

the "subsidy game," the entry decisions of firms are preceded by the export subsidy choices of governments. Introducing a new role for export subsidies, we suppose that the subsidy competition serves to *coordinate* the entry decisions of firms. Specifically, we consider symmetric equilibria in which the firm that receives the highest export subsidy is the only firm to enter the market. In the unique symmetric equilibrium of this class, governments use random subsidy strategies, with each balancing the prospect of generating a (subsidized) export monopoly against the "administrative cost" associated with setting up the export subsidy program infrastructure.

We show that the expected surplus to each exporting country from serving the export market is dissipated in equilibrium, regardless of whether governments are or are not allowed to offer export subsidies. In the no-subsidy game, firms are indifferent to entry in equilibrium, and so it follows immediately that expected profit (and hence expected export-country welfare) is zero. Similarly, in the subsidy game, an exporting government is indifferent between choosing not to subsidize (thus ceding the market, but saving administrative costs) and choosing positive subsidy values (thus raising the odds of securing a monopoly position, but incurring administrative costs). The competition in subsidies therefore drives "true" expected profit to zero, and so the expected surplus to each exporting country is also driven to zero in equilibrium. Hence, in natural monopoly markets, the desire to prohibit export subsidies does not emanate from exporting countries: The efficiency consequences of a prohibition of export subsidies is determined entirely by the impact that such a prohibition would have on third-country consumers.

We show that third-country consumers will be supplied by a subsidized monopolist in the subsidy game, while in the no-subsidy game third-country consumers face the possibility of (i). supply from an unsubsidized monopoly, (ii). supply from unsubsidized Bertrand duopolists, or (iii). no supply, with the probability weights on these outcomes determined by the equilibrium entry strategies of firms. We find that consumers (and thus the world as a whole) will be best served by allowing export subsidies if fixed costs are sufficiently high. On the other hand, if fixed costs are sufficiently small, then consumers and the world are better served by a ban on export subsidies. Accordingly, and in contrast to the analysis of Brander and Spencer (1985), we have in this case that the desire of governments to restrain export subsidies can be given a world-efficiency rationale.

The intuition for our results is as follows. When fixed costs are small, the firms are almost certain to experience a coordination failure in the no-subsidy game, with each entering with probability close to one, and as a consequence consumers are almost certain to get the Bertrand price. By contrast, in the subsidy game, the firms are able to coordinate their entry decisions and the consumers face a subsidized monopoly. The equilibrium subsidies will lower the price charged by the monopolist, but they must still leave exporting governments with some "true" profit to offset the administrative cost of their subsidy program initiative. Thus, the subsidized monopoly price cannot drop to marginal cost, and so consumers are better off when fixed costs are small with a ban on export subsidies. When fixed costs are high, the no-subsidy game is almost certain to lead to a coordination failure of a different kind for firms, as it becomes almost certain that no firm will enter, and consumers therefore fare better under the subsidy game where the entry of a single firm is assured. Thus, the coordination advantage that subsidies offer eventually implies that consumers are better off when subsidies are possible than when they are prohibited.

The rest of the paper proceeds as follows. Our basic model is presented in section II. Section III characterizes the no-subsidy game, in which government export subsidies are not allowed. The subsidy game in which governments are free to subsidize their exports is analyzed in Section IV. We also offer here a comparison of the welfare properties of the equilibria in the no-subsidy and subsidy games. Section V considers a reinterpretation of our results as pure-strategy equilibria when governments have private information. Finally, Section VI concludes.

II. Model

We present in this section our basic modeling framework. Following Brander and Spencer (1985), we assume that there are two countries, Countries 1 and 2, that each have a single exporting firm, with all consumers located in a third country, referred to as Country 3. The corresponding exporting firms are referred to as Firm 1 and Firm 2, and we assume that they sell a homogeneous good. We differ from Brander and Spencer (1985), however, in assuming that the two firms compete as pure Bertrand competitors, with each firm producing subject to a production technology that allows for constant marginal costs at level $c > o$ as well as fixed costs at level $F > 0$. Thus, the firms interact in a natural monopoly market, since positive profits are possible only if one firm produces.

Our specific assumptions are as follows. The consumer side of the market is represented by an indirect utility function, $V(P)$, where P is the price at which the homogeneous good is purchased. Letting $D(P) \equiv -V'(P)$ denote the consumer demand function, we assume that $V'(P) < 0 < V''(P)$, so that $D(P) > 0 > D'(P)$. Ignoring export subsidies for the moment, if a firm enters and offers the lowest price to consumers, its profit (gross of the fixed entry cost, F) is then $\Pi(P,c) \equiv [P-c]D(P)$, and we assume that $\Pi(P,c)$ is strictly concave in P with unique maximizer $P_m(c)$. The monopoly price, $P_m(c)$, is easily shown to satisfy $P_m'(c) > 0$, where a prime indicates a derivative. We may then define the corresponding monopoly profit as $\Pi_m(c) \equiv [P_m(c)-c]D(P_m(c))$, and a key assumption is that $\Pi_m(c) > F > 0$. Under this assumption, in the absence of government export subsidization, monopoly is viable but a Bertrand duopoly is not.

Consider next the objectives of the (exporting) governments. Recognizing that only one firm can profitably sell in Country 3, each government has a possible incentive to subsidize the exports of its firm and perhaps thereby increase the odds that its firm will emerge as the eventual monopoly. Let s denote the export subsidy selected by a government. Following Brander and Spencer (1985), we assume that the objective of each government is to maximize the expected welfare of its country, which is represented as the difference between expected producer surplus and expected subsidy expenses. To this end, it is useful to define the welfare that the government enjoys if it subsidizes at level s and its firm obtains the monopoly position:

$$W(s) \equiv \Pi(P_m(c-s),c-s) - sD(P_m(c-s)) - F - K(s) = \Pi(P_m(c-s),c) - F - K(s).$$

Observe that a subsidized firm will charge the subsidized monopoly price, $P_m(c-s)$, but that welfare is determined by the "true" cost of production, c.

One distinctive feature of our approach is the subsidy-cost function K(s), which is assumed to satisfy $K(0) = 0 < K'(s)$. This function captures the costs incurred by the government when it proposes an export subsidization initiative at level s. Intuitively, a government that elects to erect a subsidization program must incur the costs of developing the administrative infrastructure associated with that program.[3] These costs are naturally positive and increasing in the planned rate of subsidization. Importantly, we do not require that these costs are large in any absolute sense; they may also increase quite slowly with the level of planned subsidization. We assume further that the costs of erecting a subsidy infrastructure apply whether or not the firm actually ends up entering, producing and receiving the subsidy. Thus, if a government announces a subsidy program at rate s, and its firm elects not to enter, then welfare is -K(s).[4]

We consider two different games. Our first game is referred to as the "no-subsidy game." It is described by two stages:

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[3]An possible alternative interpretation is that a subsidization program at level s is offered only if the exporting firm incurs dissipative lobbying expenses in the amount K(s), with larger programs naturally requiring greater lobbying expenses (i.e., $K'(s) > 0$).

[4]In defining the government welfare function, one remaining possibility is that both firms enter, a Bertrand price game is induced, and a government's welfare is given by Bertrand profits (which depend on the respective subsidy levels) less F and K(s). This case will not arise in the analysis that follows, so we refrain from describing it further here.

The No-Subsidy Game:

Entry Stage: With all subsidies fixed at zero, each firm simultaneously decides whether to enter at cost F.

Pricing Stage: Observing whether or not its rival has elected to enter, an entering firm sets its price.

Equilibrium behavior in the pricing stage entails Bertrand competition (P=c) if both firms enter and monopoly pricing ($P = P_m(c)$) if only one firm enters. Of course, no transactions occur if no firm enters. At each stage, each firm makes its selection with the objective of maximizing its expected profits.

We refer to our second game as the "subsidy game." This is a three-stage game that admits a possible role for strategic government behavior:

The Subsidy Game:

Subsidy Stage: Governments simultaneously choice subsidy levels.

Entry Stage: Observing the subsidy levels of each government, each firm simultaneously decides whether to enter at cost F.

Pricing Stage: Observing the subsidy levels of each government and whether or not its rival has elected to enter, an entering firm sets its price.

Equilibrium behavior in the pricing stage is described as before, with each firm now operating according to a subsidized profit function. Once again, in each of the last two stages, each firm makes its selection with the objective of maximizing its expected profits. In the initial subsidy stage, each government makes its selection with the goal of maximizing its expected welfare.[5]

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[5]The subsidy game is in some respects similar to the "battles for monopoly" game analyzed by Bagwell and Staiger (1992), although important differences exist. In the battles for monopoly game, firms invest in R&D that generates production costs in a stochastic fashion; also, the subsidy policy allowed for governments is an R&D subsidy. As we will see, the subsidy game considered here requires an analysis of mixed-strategy equilibria. An extension of our analysis that considers R&D subsidies is developed in footnote 8.

For each game, we will be interested in symmetric subgame perfect equilibria. As a consequence, the firms' equilibrium entry strategy in the no-subsidy game must be a mixed strategy. Similarly, in the symmetric equilibria upon which we focus, governments must adopt symmetric mixed strategies in the selection of their subsidy levels.

III. The No-Subsidy Game

The no-subsidy game serves as a convenient benchmark, as the symmetric equilibrium of this game indicates the expected welfare that the three countries would enjoy were export subsidies prohibited. In this section, we characterize the symmetric equilibrium of the no-subsidy game. We then turn in the following section to a characterization of a class of symmetric equilibria for the subsidy game, so that a comparison of the expected welfare properties arising in the two equilibrium classes can be made.

To characterize the symmetric equilibrium of the no-subsidy game, let ρ represent the probability that a firm enters. If a firm is to be indifferent to entry, then ρ must satisfy:

(1). $(1-\rho)\Pi_m(c) - F = 0$, or equivalently

(2). $$\rho = \frac{\Pi_m(c) - F}{\Pi_m(c)}.$$

Observe that $\rho < 1$ since $F > 0$, while $\rho > 0$ since $\Pi_m(c) > F$.

Consider next the payoffs received in the unique symmetric equilibrium. Expected profits are zero by construction. Expected welfare for Country's 1 and 2 is also zero, since by (1):

$$\rho[(1-\rho)W(0) - \rho F] = \rho[(1-\rho)(\Pi_m(c) - F) - \rho F] = \rho[(1-\rho)\Pi_m(c) - F] = 0.$$

Finally, expected welfare in Country 3 in the symmetric equilibrium of the no-subsidy game is given by its expected consumer welfare, which is:

$$E_nV = (1-\rho)^2V(\infty) + 2\rho(1-\rho)V(P_m(c)) + \rho^2V(c),$$

where $V(\infty)$ denotes the indirect utility received under no entry. We may re-write the expected indirect utility as:

$$(3). \quad E_nV = V(c) - (1-\rho)^2[V(c) - V(\infty)] - 2\rho(1-\rho)[V(c) - V(P_m(c)].$$

Intuitively, expected consumer welfare in the symmetric equilibrium of the no-subsidy game equals $V(c)$, the indirect utility enjoyed when both firms enter, less the expected indirect utility loss associated with the events that no firm enters or only one firm enters.

It follows that the only payoff that is sensitive to the model's parameters is the expected welfare experienced in Country 3. To explore this dependence, we consider how expected indirect utility varies with the parameter F. Using (2), we begin by noting that:

$$(4). \quad \frac{\partial\rho}{\partial F} = \frac{-1}{\Pi_m(c)} < 0.$$

Thus, as F increases, firms enter with lower probability. Further, (2) also gives that:

$$(5). \quad \lim_{F\to\Pi_m(c)} \rho = 0 \text{ and } \lim_{F\to 0} \rho = 1.$$

The probability that a given firm enters is thus approximately zero as the fixed entry cost approaches its upper bound, and the probability that a given firm enters is approximately unity as the fixed cost of entry approaches zero.

We may now evaluate the dependence of the consumers' expected indirect utility upon the parameter F. We have that:

$$\frac{dE_nV}{dF} = \frac{\partial E_nV}{\partial \rho}\frac{\partial \rho}{\partial F},$$

where calculations reveal that:

$$\frac{\partial E_nV}{\partial \rho} = 2\{(1-\rho)[V(P_m(c)) - V(\infty)] + \rho[V(c) - V(P_m(c))]\}.$$

We thus discover that:

$$(6). \quad \frac{dE_nV}{dF} = 2\{(1-\rho)[V(P_m(c)) - V(\infty)] + \rho[V(c) - V(P_m(c))]\}\left(\frac{-1}{\Pi_m(c)}\right) < 0,$$

from which we may conclude that expected indirect utility declines as F increases. Finally, using (3) and (5), we may also report limiting values for expected consumer welfare:

$$(7). \quad \lim_{F\to\Pi_m(c)} E_nV = V(\infty) \text{ and } \lim_{F\to 0} E_nV = V(c),$$

indicating that the no-entry utility is approached as fixed costs get large, while the Bertrand utility is approached as fixed costs go to zero.

Intuitively, as F rises, the probability that a given firm enters drops, and so monopoly outcomes are increasingly replaced with no-entry outcomes while Bertrand outcomes are increasingly replaced by monopoly outcomes. Expected consumer welfare drops as a consequence, ranging from Bertrand utility (when $F = 0$) to no-entry utility (when $F = \Pi_m(c)$). Figure 1 illustrates.

We now summarize our findings for the no-subsidy game:

Proposition 1: In the no-subsidy game, there exists a unique symmetric equilibrium, in which:

(i). Countries 1 and 2 receive zero expected welfare.

(ii). Country 3 receives positive expected welfare.

(iii). The expected welfare in Country 3 declines with F, ranging from $V(c)$ when $F = 0$ to $V(\infty)$ when $F = \Pi_m(c)$.

IV. The Subsidy Game

We turn now to the subsidy game. Keeping with our emphasis on symmetric equilibria, we assume now that the exporting governments employ symmetric subsidy strategies. The entry strategies for the firms are now functions, mapping from observed subsidy levels to entry decisions, and we now add a further equilibrium selection requirement and specify that the firm that receives the largest subsidy is the firm that enters. If the governments choose the same subsidy level, then the firms enter with a symmetric probability. While this is only one particular symmetric strategy that firms might employ, it seems a reasonable selection criterion. We refer to equilibria that satisfy these selection criteria as *symmetric equilibria*.

Symmetric equilibria of the subsidy game admit some appealing features. Governments are attracted to export subsidies, because by raising its subsidy level, a government improves the odds that its firm will become a monopolist. This strategic incentive will be neutralized across exporting governments in a symmetric equilibrium, with each government's unconditional probability of sponsoring a monopolist being 1/2. Still, the unconditional probability of sponsoring a monopolist is higher in the subsidy game than in the no-subsidy game, in which the probability of having a monopolist is $\rho(1-\rho) \leq 1/4$. The difference arises because of the coordination gains allowed when subsidies are possible. In the no-subsidy game, it is possible that neither firm enters and that both firms enter. These coordination losses to the exporting governments are averted in the subsidy game, in which a monopoly structure always emerges. As we will see, however, the exporting governments do not benefit from the improvement in coordination, as the coordination gains are dissipated through government rivalry and the associated expenditure of resources on the subsidy infrastructure, as captured via the subsidy-cost function K(s).

As for consumers, the introduction of subsidies and the corresponding coordination gains generates competing effects. First, when subsidies are possible, consumers lose the event in which firms fail to coordinate with both entering and Bertrand pricing resulting. Second, when governments are able to subsidize, consumers gain in that they avoid the coordination failure between firms that is associated with no entry. Thus, the coordination of entry decisions that subsidies make possible may hurt or benefit consumers. Third, when subsidies are possible, consumers gain in the event of monopolization, since the monopoly that serves them has subsidized costs and therefore charges a lower monopoly price. The net resolution of these three effects for expected consumer welfare may be parameter dependent, suggesting that consumers may win or lose when export subsidization is allowed.

We now proceed to a formal development of these points. We begin with the observation that the symmetric equilibrium (as defined above) for the subsidy game is unique. We offer here a sketch of the proof, referring the interested reader to related arguments in the price-dispersion literature (Varian, 1980; Bagwell and Ramey, 1994). The first step is to note that the governments' strategy cannot involve mass points (i.e., subsidy levels that are played with positive probability). Otherwise, there would be a positive probability that the governments would tie, in which case a government could do better by shifting probability weight to a slightly higher subsidy level, thus converting "ties" into "wins." An implication is that pure-strategy symmetric equilibria do not exist.

The second step is to argue that there cannot be gaps in the support of the symmetric mixed strategy with which the governments choose subsidy levels. Intuitively, if there were such a gap, a government could play a subsidy level in the gap instead of the subsidy level at the top of the gap.[6] Since there are no atoms at the top of the gap (or anywhere else), the government wins with the same probability under the deviant strategy, but it saves subsidy expenses (recall K(s) is increasing).

A third necessary characteristic of a symmetric equilibrium concerns the lowest subsidy in the support of the mixed strategy. Given that there are no atoms, a government that chooses the minimal subsidy level, referred to as $\underline{s}$, is certain not to have the highest subsidy level. Under such a policy, a government thus induces entry by its firm with probability zero, and so the government does even better with a lower subsidy level (since K(s) is increasing). It follows that the lowest subsidy in the support of the mixed strategy is zero, i.e., $\underline{s} = 0$. At this subsidy choice, the government earns zero expected welfare. Since a government must be indifferent throughout the support of its mixed strategy, we therefore have that each government receives zero expected welfare in a symmetric equilibrium of the subsidy game. As suggested above, the coordination gains associated with the employment of subsidies are dissipated through government rivalry and the associated costs of export subsidy initiatives.

A final and fourth necessary feature of a symmetric equilibrium concerns the maximal subsidy level in the support of the mixed strategy. Let this subsidy level be denoted as $\bar{s}$. Given that there are no mass points, if a government selects this subsidy level, then it is sure to sponsor a monopolist. Since the government's expected welfare

[6]Formally, the government could replace a small probability measure of subsidy levels at the top of the gap with an equal probability measure of subsidies in the interior of the gap.

must be zero throughout the support of its mixed strategy, we therefore have that $\bar{s}$ must be defined by $W(\bar{s}) = 0$.

Having derived the necessary properties that a symmetric equilibrium subsidy strategy must obey, we now construct the unique strategy that satisfies all of these properties. This mixed strategy is defined by a distribution function, H(s), with lower support $\underline{s} = 0$ and upper support $\bar{s}$ defined by $W(\bar{s}) = 0$, that makes the government indifferent over all subsidy levels in the described support:

$$(8).\quad H(s)W(s) - [1 - H(s)]K(s) = 0.$$

To interpret this condition, note that a government that subsidizes at level s has the highest subsidy level with probability H(s), which is the probability that the rival government (which uses the same strategy) selects a lower subsidy. The second term arises since the government incurs the cost K(s) whether or not it wins the subsidy contest.

We may re-write (8) in terms of the underlying profit function as follows:

$$(9).\quad H(s)[\Pi(P_m(c-s),c) - F] - K(s) = 0.$$

Observe that $H(0) = 0$ since $K(0) = 0$ and $H(\bar{s}) = 1$, where $\bar{s}$ satisfies:

$$(10).\quad W(\bar{s}) = \Pi(P_m(c-\bar{s}),c) - F - K(\bar{s}) = 0.$$

Finally, we may solve for H(s) as:

$$(11).\quad H(s) = \frac{K(s)}{W(s) + K(s)} = \frac{K(s)}{\Pi(P_m(c-s),c) - F}.$$

It is now a simple matter to establish that $H'(s) > 0$, confirming that $H(s)$ is uniquely defined and also a well-defined distribution function.[7]

Having constructed the unique symmetric equilibrium for the subsidy game, we next consider the expected payoffs received in this equilibrium. By construction, the expected welfare of exporting governments is zero. It is interesting to observe that expected profits are positive. To see this, observe that for any positive subsidy that a firm might receive, expected profits are given by:

$$H(s)[\Pi(P_m(c-s),c-s) - F] > H(s)[\Pi(P_m(c-s),c) - F] = K(s) > 0.$$

The remaining calculation is the expected welfare enjoyed by Country 3, where all consumers reside.

Expected consumer indirect utility is determined by the distribution of *maximal* subsidy levels, since it is the maximal subsidy level that determines the price that consumers pay. The distribution of maximal subsidy levels is defined by:

$$(12).\quad G(s) = H(s)^2.$$

Expected indirect utility is thus positive and given by:

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[7]Calculations reveal that

$$H'(s) = \frac{[\Pi(P_m(c-s),c) - F]K'(s) + \Pi_p(P_m(c-s),c)P_m'(c-s)K(s)}{(\Pi(P_m(c-s),c) - F)^2} > 0,$$

since for $s > 0$ we have that $\Pi_p(P_m(c-s),c)P_m'(c-s)K(s) > 0$, $K'(s) > 0$, and $\Pi(P_m(c-s),c) - F > 0$. The last inequality follows because

$$\frac{d[\Pi(P_m(c-s),c) - F]}{ds} = \Pi_p(P_m(c-s),c)P_m'(c)(-1) < 0$$

and (10) gives that $\Pi(P_m(c-\bar{s}),c) - F = K(\bar{s}) > 0$.

(13). $E_s V = \int_0^{\bar{s}} V(P_m(c-s))dG(s) > 0.$

Integrating by parts and using $V'(P) = - D(P)$, we can re-write this as:

(14). $E_s V = V(P_m(c-\bar{s})) - \int_0^{\bar{s}} G(s)D(P_m(c-s))P_m'(c-s)ds.$

The equation provides a convenient measure of expected consumer welfare with which to investigate the consequences of changes in the fixed cost F.

To explore the dependence of expected consumer welfare on F, we use (10) and (11) and find that, for s > 0, we have:

(15). $H_F(s) = \dfrac{K(s)}{[\Pi(P_m(c-s),c) - F]^2} > 0$

(16). $\dfrac{\partial \bar{s}}{\partial F} = \dfrac{1}{\Pi_p(P_m(c-\bar{s}),c)P_m'(c-\bar{s})(-1) - K'(\bar{s})} < 0.$

Thus, as F increases, each government shifts (in the sense of first-order stochastic dominance) probability weight toward lower subsidies, and in fact the support shrinks toward lower subsidies as well. It then follows that, for s > 0, we have that:

(17). $G_F(s) = 2H(s)H_F(s) > 0,$

so that the maximal subsidy distribution also shifts (in the sense of first-order stochastic dominance) toward lower subsidies, with the support again shrinking in this direction as well.

We also have the following limiting results:

(18). $\lim_{F \to \Pi_m(c)} \bar{s} = 0,$

which follows from (10) since $\Pi(P_m(c),c) \equiv \Pi_m(c)$ and $K(0) = 0$, and:

(19). $\lim_{F \to 0} P_m(c-\bar{s}) > c,$

which follows from (10) since then $\Pi(P_m(c-\bar{s}),c) = K(\bar{s}) > 0$.

With these results at hand, we note now from (14) that:

$$\frac{dE_sV}{dF} = -V'(P_m(c-\bar{s}))P_m'(c-\bar{s})\frac{\partial \bar{s}}{\partial F}$$

$$- G(\bar{s})D(P_m(c-\bar{s}))P_m'(c-\bar{s})\frac{\partial \bar{s}}{\partial F} - \int_0^{\bar{s}} G_F(s)D(P_m(c-s))P_m'(c-s)ds,$$

so that using $G(\bar{s}) = 1$ and $V'(P) = -D(P)$, we have that:

(20). $$\frac{dE_sV}{dF} = -\int_0^{\bar{s}} G_F(s)D(P_m(c-s))P_m'(c-s)ds < 0,$$

where the inequality follows from (17).

We have thus demonstrated that the expected consumer welfare declines as the fixed entry cost rises. Intuitively, as F rises, the distribution of maximal subsidies shifts toward lower levels, and so consumers pay higher prices on average. It is interesting to compare (20) with (6). In the no-subsidy game, a higher value for F also lowers expected consumer welfare; however, in this case, a higher value for F harms consumers since the probability of entry is reduced. By contrast, in the subsidy game, consumers face a monopolist with probability one. The cost to consumers of a higher value for F is that governments subsidize less aggressively, and so the expected price that consumers pay is higher.

Using (14), (18) and (19), we also have some limiting results for expected consumer welfare. First, we have that:

(21). $$\lim_{F \to \Pi_m(c)} E_s V = V(P_m(c)).$$

Next, we also have that:

(22). $$\lim_{F \to 0} E_s V < V(c),$$

where the inequality follows since (13) and (19) imply that:

$$\lim_{F \to 0} E_s V = \lim_{F \to 0} \int_0^{\bar{s}} V(P_m(c-s))dG(s)$$

$$< \lim_{F \to 0} \int_0^{\bar{s}} V(P_m(c-\bar{s}))dG(s) = \lim_{F \to 0} V(P_m(c-\bar{s})) < V(c).$$

Intuitively, as the fixed cost rises, the expected maximal subsidy declines, leading to a higher expected price and lower expected consumer welfare. As the fixed cost rises toward its upper bound, the maximal expected subsidy tends toward zero, and so consumers expect to pay the unsubsidized monopoly price. At the other extreme, as F shrinks to zero, the subsidy distribution converges toward the largest possible subsidy, and consumers buy at the monopoly price associated with the lowest conceivable cost. This price still exceeds the true production cost, c, however, since governments must earn some positive producer surplus to counter the expense of erecting an export subsidization infrastructure. Figure 1 illustrates.

We now summarize our findings for the subsidy game:

Proposition 2: In the subsidy game, there exists a unique symmetric equilibrium, in which:

(i). Countries 1 and 2 receive zero expected welfare.

(ii). Country 3 receives positive expected welfare.

(iii). The expected welfare in Country 3 declines with F, ranging from a level below V(c) when $F = 0$ to $V(P_m(c))$ when $F = \Pi_m(c)$.

At this point, we are prepared to evaluate the winners and losers from the strategic export subsidization programs that governments might employ. A first observation is that exporting governments earn zero expected welfare, whether subsidies are used or not. When subsidies are not allowed, firms randomize with respect to their entry choices, and the exporting governments receive zero expected welfare. On the other hand, when export subsidies are allowed, a monopoly structure is assured, but exporting governments dissipate the coordination gains that export subsidization enables, via their expenses on the infrastructure associated with an export subsidization initiative.

If there is to be a winner or loser associated with the subsidization of exports in Bertrand markets, therefore, it must be the country in which consumers reside. Appealing to Figure 1, it is apparent that consumers gain from a restriction on export subsidies when fixed costs are low. When fixed costs are high, however, consumers prefer that export subsidies are allowed. We summarize our findings as follows:

Proposition 3:

(i). Exporting countries receive zero expected welfare whether or not subsidies are allowed.

(ii). For F sufficiently close to zero, $E_sV < E_nV$. Expected consumer welfare is higher when export subsidies are not allowed.

(iii). For F sufficiently close to $\Pi_m(c)$, $E_sV > E_nV$. Expected consumer welfare is higher when export subsidies are allowed.

These results are illustrated in Figure 1. While we assume in this illustration that a single crossing exists for the two expected consumer welfare functions, we have not established this property. We do, however, have rankings at the respective limits, which suffices for a proof of Proposition 3.

The intuition underlying our findings is quite simple. When F is small, consumers almost certainly get the Bertrand price in the no-subsidy game, since both firms enter. By contrast, in the subsidy game, the firms are able to coordinate their entry decisions, and the consumers face a monopoly. As exporting governments compete aggressively in their subsidization programs, the monopoly is highly subsidized; nevertheless, since exporting governments must earn some "true" profit to offset the cost of their subsidy program initiatives, the subsidized monopoly price does not drop to c, and so consumers are better off when subsidies are banned.

As F rises, expected consumer welfare drops in both the no-subsidy and the subsidy games. In the no-subsidy game, the Bertrand outcome associated with two actual entrants becomes less likely while the no-entry outcome associated with no entry becomes more likely. The consequences of an increase in F for the coordination failures associated with entry thus act to diminish expected consumer welfare in the no-subsidy game. While there is no coordination failure in firms' entry decisions in the subsidy game, as F rises, governments subsidize less vigorously, and so the eventual monopoly has higher expected costs and thus a higher expected price, implying that expected consumer welfare falls with F in the subsidy game as well.

Finally, as F approaches its upper limit of $\Pi_m(c)$, the situation for consumers becomes quite dire in the no-subsidy game, and the consumers are almost certain to face a coordination failure with no entry. Consumers also fare poorly in this case in the subsidy game. As governments see no profits to pursue via subsidization, the maximal subsidy trends toward zero. Nevertheless, there will not be a coordination failure when subsidies are allowed, and so consumers will at least be served by an unsubsidized monopolist, which is better than no entry. Thus, the coordination advantage that subsidies offer eventually implies that consumers are better off when subsidies are possible than when they are prohibited.

The results found here contrast interestingly with those developed for Cournot markets by Brander and Spencer (1985). In their model, exporting governments are always better off when export subsidies are prohibited. By contrast, expected consumer welfare is always higher when export subsidies are allowed. We may thus conclude that traditional conclusions regarding the winners and losers from strategic export subsidy policies are highly sensitive to the industry structure at hand. In particular, in natural monopoly markets, exporting governments may have little to gain or lose from the mutual employment of export subsidies, while it is possible (if fixed costs are small) that consumers actually gain from a prohibition on export subsidies.

We conclude this section with some remarks concerning the policy of GATT (and now the WTO) with regard to export subsidies. The official policy of GATT is that export subsidies are prohibited. As discussed in the Introduction, if the purpose of GATT is to promote more efficient policies between governments, then the prohibition of export subsidies is somewhat puzzling. In competitive markets, when a government subsidizes its exports, some of the benefits of the subsidy are received by foreign consumers, who pay a lower price for the good. As a consequence of this positive externality, export subsidies tend to be undersupplied, in comparison to the levels that would maximize the joint welfare of governments. It would therefore seem that GATT should encourage export subsidization.

One possible resolution to this puzzle lies in the literature on strategic export subsidization. As Brander and Spencer (1985) argue, in Cournot markets, export subsidies from one exporting country promote greater competition and exert a negative externality on the producers in other exporting countries. Even though export subsidies raise consumer and world welfare, it is then possible to understand the prohibition of export subsidies as reflecting the desire of exporting countries to avoid a ruinous export subsidy contest. The model developed here adds a new dimension to this argument. In natural monopoly markets, exporting governments have no particular desire to allow or prohibit export subsidies. Instead, if fixed costs are low, consumer and world welfare are lower when export subsidies are allowed, and it becomes possible to understand the official prohibition of export subsidies as corresponding to a policy that promotes consumer and world welfare.[8]

V. Purification

One possible limitation with the results presented above is the reliance on randomized strategies. Do firms and governments really make random decisions out of indifference? As Harsanyi (1973) has shown, one interpretation of a mixed-strategy equilibrium is that it really represents the equilibrium of a "nearby" game of incomplete information, in which players use pure strategies. For this "purification" argument to be

[8]In a separate paper, Spencer and Brander (1983) also consider the role of strategic R&D subsidies. It is straightforward to extend the model developed above to consider this case as well. In particular, if an R&D subsidy is understood to apply to a firm's fixed cost of entry, and if the firm with the highest R&D subsidy gets to enter in the corresponding subsidy game, then in the symmetric equilibrium of the subsidy game consumers always face a monopolist and receive the consumer welfare $V(P_m(c))$, regardless of the value that the parameter F assumes. In terms of Figure 1, E_sV assumes a constant value, being below (above) E_nV when fixed costs are low (high). In equilibrium, export-country welfare is again zero in both the subsidy and the no-subsidy games. Thus, it remains true that consumers and the world as a whole benefit from subsidies when fixed costs are high.

compelling in a given policy application, however, it is important to demonstrate that the "nearby" game is actually plausible, given the application of interest. In this section, we propose a plausible game of incomplete information that serves to purify the mixed-strategy equilibrium of the subsidy game.[9]

To this end, let B(t) denote the distribution function that determines a government's type. The support of B is given by $[0, \bar{t}]$, and we assume that $B'(t) > 0$ for all $t \in [0, \bar{t}]$. When a government of type t subsidizes at level s, and gets a monopoly, its welfare is now given by:

$$\Pi(P_m(c-s),c) - F - I(t)K(s) \equiv f(s) - I(t)K(s) ,$$

where $I(t) > 0 \geq I'(t)$. We will interpret I(t) as a function that indicates a government's "inclination" to subsidize. Notice that higher types are (at least weakly) more inclined to subsidize. Observe also that $f'(s) = \Pi_p(P_m(c-s),c)P_m'(c-s)(-1) < 0$ for $s > 0$.

The incomplete-information subsidy game is defined by the following four stages:

The Incomplete-Information Subsidy Game:

Nature Stage: Nature picks each government's type independently using the distribution function B(t).

Subsidy Stage: With each government privately informed of its own type, the governments simultaneously choice subsidy levels.

Entry Stage: Observing the subsidy levels of each government, each firm simultaneously decides whether to enter at cost F.

Pricing Stage: Observing the subsidy levels of each government and whether or not its rival has elected to enter, an entering firm sets its price.

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[9] The arguments presented in this section build and extend on those developed by Bagwell and Ramey (1992), who purify the mixed-strategy equilibria of an advertising game.

A symmetric subsidy strategy for governments will now be a non-random function, s(t). The incomplete-information subsidy game has the plausible feature that a given government is not certain as to the cost that the other government would incur in erecting the infrastructure necessary for a program of export subsidization.

We will construct equilibria in which s(t) is (strictly) increasing, so that a government of type t that picks $\tilde{s} = s(\tilde{t})$ receives expected welfare:

(23). $U(t,\tilde{t}) \equiv B(\tilde{t})f(s(\tilde{t})) - I(t)K(s(\tilde{t}))$.

The function s(t) then gives a symmetric equilibrium for the incomplete-information subsidy game if the incentive-compatibility condition holds:

(24). $U(t,t) \geq U(t,\tilde{t})$ for all $t \neq \tilde{t}$.

The equilibrium entails strict best responses if the inequalities in (24) are strict.

We proceed by considering two cases in turn. In the first case, types are payoff irrelevant: $I(t) \equiv 1$. In this case, we construct a (strictly) increasing function s(t) with the definition:

(25). $B(t) \equiv H(s(t))$, for all $t \in [0, \bar{t}]$.

Observe that, if s(t) gives an equilibrium, then the probability that $s \leq s^*$ equals the probability that $t \leq t^*$, where $s^* = s(t^*)$, which is in turn $B(t^*) \equiv H(s^*)$. Thus, such an equilibrium would give the same distribution over subsidy levels as in the mixed-strategy equilibrium of the subsidy game.

To prove that s(t) as defined in (25) gives an equilibrium for the incomplete-information subsidy game, note that (9) gives:

$$U(t,\tilde{t}) \equiv H(s(\tilde{t}))f(s(\tilde{t})) - K(s(\tilde{t})) = H(s(t))f(s(t)) - K(s(t)) = U(t,t) = 0.$$

Thus, (24) holds (weakly), and we have a pure-strategy equilibrium for the incomplete-information subsidy game with payoff-irrelevant types that induces the same distribution over subsidies as in the mixed-strategy equilibrium of the subsidy game. One limitation of this purification is that the governments' strategy is not a strict best response: since types are payoff irrelevant, the governments follow s(t) out of indifference.

To address this limitation, we now allow that types are payoff relevant: $I'(t) < 0$ for all $t \in [0, \bar{t}]$. If any (strictly) increasing function s(t) is to be an equilibrium of the incomplete-information subsidy game with payoff-relevant types, then it must satisfy the first-order condition:

(26). $$U_2(t,t) = B'(t)f(s(t)) + B(t)f'(s(t))s'(t) - I(t)K'(s(t))s'(t) = 0,$$

whence

(27). $$s'(t) = \frac{B'(t)f(s(t))}{I(t)K'(s(t)) - B(t)f'(s(t))} > 0.$$

An additional necessary condition is:

(28). $$s(0) = 0,$$

since s(0) is sure not to win the subsidy contest and $K(s) > 0$ for $s > 0$.

Equations (27) and (28) define a (strictly) increasing function s(t). This function satisfies local optimality conditions, but does it also satisfy the global optimality condition (24)? To see that it does, observe that:

$$(29).\quad U_{12}(t,\tilde{t}) = -I'(t)K'(s(t))s'(t) > 0,$$

which is a single-crossing property of the model. Now suppose that a government's true type is t. Then, using the Fundamental Theorem of Calculus:

$$(30).\quad U(t,t) - U(t,\tilde{t}) = \int_{\tilde{t}}^{t} U_2(t,x)dx.$$

Further, (26) implies that:

$$(31).\quad \int_{\tilde{t}}^{t} U_2(t,x)dx = \int_{\tilde{t}}^{t} [U_2(t,x) - U_2(x,x)]dx.$$

Using the Fundamental Theorem of Calculus once more, we have that:

$$(32).\quad \int_{\tilde{t}}^{t} [U_2(t,x) - U_2(x,x)]dx = \int_{\tilde{t}}^{t}\int_{x}^{t} U_{12}(s,x)dsdx > 0,$$

by the single-crossing property (29). Thus, s(t) is globally optimal for the government of type t, which establishes that the (strictly) increasing pure-strategy s(t) defined in (27) and (28) gives an equilibrium for the incomplete-information subsidy game with payoff-relevant types, in which s(t) is a strict best response to itself.

We come now to the final step in the argument. In the incomplete-information subsidy game with payoff-irrelevant types, we have (trivially) that

$$U_2(t,t) = 0,$$

and so s(t) as defined in (27) and (28) (with $I(t) \equiv 1$ imposed) defines the equilibrium subsidy function for this game as well. Thus, the incomplete-information game with payoff-relevant types generates a strict-best-response pure-strategy-equilibrium subsidy function s(t) that describes as well the pure-strategy equilibrium for the incomplete-information subsidy game with payoff-irrelevant types as $I(t) - 1 \rightarrow 0$ for all t. Recalling that the latter equilibrium generates the same distribution over subsidies as did the mixed-strategy equilibrium of the subsidy game, we conclude that the equilibrium distribution of subsidies in the mixed-strategy equilibrium of the subsidy game is approximated by that which arises in the pure-strategy, strict-best-response equilibrium of a nearby incomplete-information subsidy game with payoff-relevant types.

VI. Conclusion

We began this paper with a question: Why do governments seek restrictions on the use of export subsidies through reciprocal trade agreements such as GATT? Existing theoretical arguments can explain why *exporting* governments might wish to seek restrictions on the use of export subsidies, but they cannot explain why *importing* governments would go along. Moreover, these arguments imply that restrictions on export subsidies will be *inefficient* from the point of view of all governments, and thus GATT's restrictions on export subsidies must be interpreted as an inefficient victory of the interests of exporting governments over the interests of importing governments.

We have offered a simple model that can under certain circumstances provide an efficiency rationale for attempts to restrict export subsidies. The model is very special, but it does deliver a striking result: When subsidy programs are used by exporting governments to coordinate the entry decisions of their firms, consumers in importing countries may suffer if the coordination afforded exporters by government subsidy programs does more to *prevent* entry than to *promote* it. In such circumstances, the existence of export subsidy programs can lead to inefficiencies, and importing countries and the world as a whole can be better off when such programs are banned.

An intriguing question is whether there are broader circumstances under which efficiency is served by negotiating restrictions on export subsidies. In a separate paper (Bagwell and Staiger, 1996b), we consider the possibility that governments lack commitment with regard to private producers and are driven to excessive use of import tariffs and export subsidies, as they cannot fully account for the distortions that their interventions create. A trade agreement might then be useful to a government as a mechanism for committing *itself* to lower levels of intervention, and in particular to *lower export subsidies*. We show that this possibility arises, and thus that all governments can gain from negotiating restrictions on export subsidies, if governments place sufficient value on export interests.

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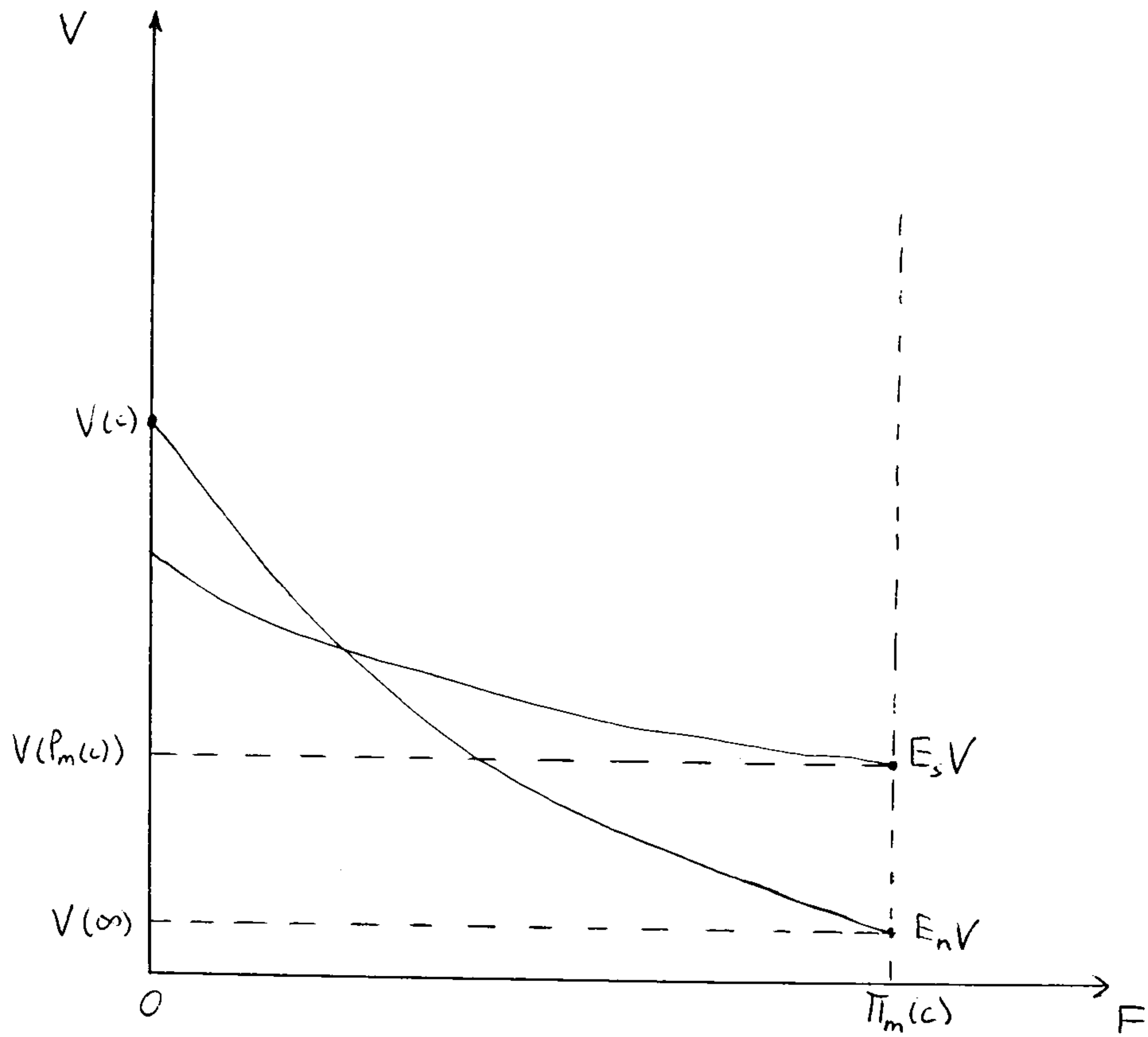

Figure 1