DM/86/55

INTERNATIONAL MONETARY FUND

Research Department

Tariffs, Quotas, Retaliation, and the Welfare Loss from Protectionism in a Framework with Intra-Industry Trade

by Daniel Gros*

Approved by Donald J. Mathieson

August 12, 1986

Summary

This paper uses Krugman's (1981) model of trade with product differentiation and monopolistic competition to examine the effects of a uniform ad valorem tariff with and without retaliation. The main results are:

1. Diversity, i.e., the number of products available to consumers, will not be affected by any ad valorem tariff.

2. An export tariff has the same effect on exports, imports, and the terms of trade as an import tariff with the same tariff rate.

3. A quota is equivalent to a (uniform ad valorem) tariff if firms cannot price discriminate between markets. However, if firms can price discriminate between markets, i.e., if the market for import licenses is not competitive, a quota is not equivalent to a tariff and has effects on the size and number of firms abroad. If the market for import licenses is competitive, it is possible to calculate the tariff rates that are equivalent to certain quotas. These equivalent tariff rates seem substantial; under reasonable parameter assumptions a quota that reduces the market share of imports by, e.g., 50 percent, would be equivalent to a tariff of 47 percent.

4. A tariff war in which each country retaliates by imposing its own optimal tariff, taking the tariff of the other country as given, leads to a stable equilibrium in which each country imposes a tariff that is smaller than the tariff it would impose without retaliation.

5. The welfare losses from a tariff war are likely to be substantial. Under reasonable parameter assumptions, a tariff war between two countries of equal size causes a welfare loss for consumers in both countries equivalent to a drop in national income of about 4 percent. Quotas that take the form of "voluntary" export restraints by the foreign

*I wish to thank M. Mussa and C. Adams for helpful comments and discussions. K. Hannah was very helpful in providing the simulations. The usual disclaimer applies.

country are also likely to involve substantial welfare losses; under reasonable parameter assumptions a voluntary export restraint agreement that limits imports into the home country by only 10 percent causes a welfare loss for consumers in the home country equivalent to a drop in national income of about 2 percent.

I. Introduction

This paper uses a model of international trade with product differentiation and monopolistic competition to analyze the welfare consequences of various forms of trade restrictions. It also shows that export taxes are equivalent to import tariffs and that under certain conditions quotas are equivalent to ad valorem tariffs. Equivalence means in this context that an export tax leads to the same terms of trade, exports and imports as an import tariff of the same rate. Similarly, equivalence of quotas and ad valorem tariffs means that the same equilibrium can be reached via a quota or an ad valorem tariff.

Models of trade with product differentiation and monopolistic competition have been developed mainly to explain the large amount of two-way trade in similar but slightly differentiated products, also called intra-industry trade, that can be observed between similar, industrialized economies. The analysis of commercial policy, however, has so far been conducted mostly in the traditional Hechscher-Ohlin framework that is more suited to explain trade between countries that have substantially different endowments, i.e., trade between industrialized countries and LDCs. The purpose of this paper is to close this gap by providing an analysis of the effects of commercial policy in a framework that can be applied to trade among industrialized countries.

Among industrialized countries, visible trade barriers in the form of ad valorem tariffs have been greatly reduced over the last three decades. However, during the last years there has been a resurgence of protectionism in less visible forms such as quotas or so-called voluntary export restraints. The paper shows that under certain conditions these forms of protectionism are equivalent to tariffs and shows what tariff rates might correspond to quotas that limit the market shares for imports. The specific nature of the model used also makes it possible to calculate the welfare consequences of certain trade restrictions, such as quotas or voluntary export restraints (henceforth VERs). It appears that especially VERs are very damaging to the importing economy.

It is widely recognized that one of the main dangers of protectionism is that it can lead to trade wars in which each country retaliates to the tariff the other country is imposing by increasing its own trade barriers. The paper therefore analyzes the consequences of tariff wars in which each country selects its own optimal tariff, taking into account the tariff of the other country. It concludes that, in this framework, such a tariff war would not lead to ever increasing tariff rates. However, the welfare

losses from such a tariff appear to be substantial. Under reasonable assumptions about the parameters of the model, a tariff war between two countries of equal size would lead to a loss of welfare in both countries equivalent to about 4 percent of GNP.

Section II reviews the basic features of Krugman's (1980) model. Section III discusses the international equilibrium with a tariff. Section IV shows the equivalence of export and import tariffs. Section V discusses the equivalence between tariffs and quotas. Quotas are equivalent to tariffs only if firms cannot price discriminate between markets or if the market for import licenses is competitive. Section VI calculates the tariff rates that are equivalent to quotas that limit the market share of imports. Section VII analyzes the equilibrium that is obtained under retaliation and shows that a tariff war can lead to an equilibrium in which each country imposes its own optimum tariff taking the other country's tariff as given. The tariff rates resulting from a tariff war are lower than the optimal tariff rates without relation. Section VIII calculates the welfare consequences of tariff wars' quotas and VERs. Section IX contains some concluding remarks.

II. The Model

To focus on the issue of the effects of tariffs in the situation of intra-industry trade, it is convenient to consider a generalized one sector version of Krugman's (1980) model where there is only one industry producing a differentiated good with increasing returns to scale. The utility functions of consumers is given by:

$$(1) \quad U = \left[\sum_{i=1}^{m} (c_i)^{\theta} \right]^{1/\theta} \qquad 0 < \theta < 1$$

where c_i is consumption of good i of this industry. m is the number of <u>potential</u> products, which will be assumed to be larger than the number of products actually produced. The production function for each good is given by:

$$(2) \quad x_i = f(\ell_i)$$

where ℓ_i represents labor used to produce good x_i, the function $f(\cdot)$ is assumed to be the same for all goods. This symmetry makes it possible to concentrate on the market for any one good since the markets for all the other goods will behave identically. In the following, the subscript i will therefore be suppressed. The function $f(\ell)$ is assumed to exhibit increasing returns to scale in the sense that the elasticity of output with respect to labor input exceed one, i.e., $f'\ell/f > 1$. This assumption

insures that each product is produced by only one firm; the number of firms is thus equal to the number of different varieties actually produced. 1/

Given equation (1), the demand curve (for any one good) will have a constant price elasticity, equal to $1/(1-\theta)$ if the number of products is large. The profit maximizing price will therefore involve a constant markup over marginal cost:

$$(3) \quad p = [f'(\ell)]^{-1} w/\theta$$

where p is the price of a product and w the wage rate. Free entry drives profits, π, to zero:

$$(4) \quad 0 = \pi = px - \ell w$$

Combining this with equation (3), implies that output of each firm is equal to a constant, $\bar{x} = f(\bar{\ell})$, determined by:

$$(5) \quad \frac{\bar{\ell} f'(\bar{\ell})}{f(\bar{\ell})} = \frac{1}{\theta}$$

i.e., in the monopolistically competitive equilibrium, the degree of economies of scale, $f'(\ell)\ell/f(\ell)$, is equal to the degree of monopoly power, which in this case is equal to $1/\theta$. To guarantee a stable equilibrium, it is assumed that the degree of economies of scale is a decreasing function of firm size. The equilibrium number of firms is determined by the condition:

$$(6) \quad n = L/\bar{\ell}$$

where L represents the given economy-wide labor supply. 1/

1/ By definition, each firm produces only one product.

2/ It is relevant to note that this equilibrium represents a social optimum. This can be shown by solving the problem of a social planner who seeks to maximize the utility of a representative consumer; subject to the constraints:

If this economy opens to trade with another economy of the same type, 1/ each economy will exchange its home produced varieties against the foreign produced varieties; this two way trade of differentiated products that belong to one industry is called intra-industry trade. In this model, all trade is intra-industry trade. The elasticity of demand facing each firm in this two-country world will still be equal to $1/(1-\theta)$, hence the equilibrium level of the number of varieties available to consumers (equal to the number of firms) with trade, n_w, will be equal to:

$$(7) \quad n_w = n + n^* = (L^* + L)/\bar{\ell}$$

where an * refers to a foreign variable.

Balanced trade requires that

$$(8) \quad nc_h^* = n(\bar{x} - c_h) = n^*c_f = n^*(\bar{x} - c_f^*)$$

1/ (Cont'd from p. 3)
$$(2') \quad c = f(\ell)$$
$$(6') \quad L = n\ell$$

where c is the amount of each commodity consumed by the representative consumer, ℓ is the amount of labor used to produce each good, and n is the number of goods produced and consumed. Using these constraints directly in the utility function, the social planner's problem reduces to the choice of ℓ such as to maximize:

$$(7') \quad U^{\theta} = [L/\ell][f(\ell)]^{\theta}$$

The first order condition for this problem is:

$$(8') \quad 0 = L\left(-\ell^{-2}[f(\ell)]^{\theta} + \ell^{-1}\theta f'(\ell)[f(\ell)]^{\theta-1}\right)$$

The second order condition is always satisfied (see Appendix equation (A.1) through (A.5)); equation (8) can be transformed to yield:

$$(9') \quad \frac{\bar{\ell}f'(\bar{\ell})}{f(\bar{\ell})} = \frac{1}{\theta}$$

This shows that the monopolistically competitive equilibrium is the social optimum. It implies that there is no effective domestic distortion that should be corrected by any tax.

1/ That is, the two economies have the same production and utility functions.

where the subscripts h and f refer to the origin of the good, e.g., c_h. (c_f) is the amount consumed at home of a typical good produced domestically (abroad) and c_h^* (c_f^*) is the amount of this good consumed in the foreign country equal to $x - c_h$ ($x - c_f$). Symmetry implies that $c_f = c_h$ and $c_f^* = c_h^*$; hence, using equation (8); it follows that

$$(9) \quad \frac{c_f}{x - c_f} = \frac{c_h}{x - c_h} = \frac{n}{n^*} = \frac{L}{L^*} \equiv N$$

Thus, the ratio of domestic to foreign consumption of each good depends only on the relative sizes of the two economies represented by N. As Krugman (1979, 1980) explains, trade increases welfare because it increases the available number of products.

III. The Effects of an Ad Valorem Tariff

This section discusses the effects of a tariff on the number of firms, exports, and imports. These results are then used in the remainder of the paper to calculate the consequences of various forms of commercial policy. When a uniform ad valorem tariff, of rate t, is imposed on all imports into the home country, the first order conditions for a utility maximizing consumer in the home country imply that:

$$(10) \quad p_f(1+t) = \lambda^{-1} (c_f)^{\theta-1} \left[\sum_{i=1}^{n_w} (c_i)^{\theta}\right]^{\frac{1-\theta}{\theta}}$$

where p_f is the net of tariff price of a typical specification of imports, λ the marginal utility of income and the summation in the denominator goes over all products actually consumed. The worldwide demand curve facing each foreign producer is given by the sum of the demand coming from domestic and foreign consumers, this sum can be written as:

$$(11) \quad x_f = p_f^{\frac{1}{\theta-1}} \left\{(\lambda)^{\frac{1}{\theta-1}} \left(\sum_{i=1}^{n_w}(c_i)^{\theta}\right)^{\frac{1}{\theta}} (1+t)^{\frac{1}{\theta-1}} + (\lambda^*)^{\frac{1}{\theta-1}} \left(\sum_{i=1}^{n_w}(c_i^*)^{\theta}\right)^{\frac{1}{\theta}}\right\}$$

The terms inside the curled brackets represent the marginal utility of income for consumers (λ for home country consumers and λ^* for consumers abroad) and the total level of utility that consumers in both countries can achieve. Since the number of firms is assumed to be large, any single firm can assume that its actions do not significantly affect the marginal

utility consumers derive from income, λ, nor the overall level of utility. Thus, from the perspective of a single firm, the terms inside the curled brackets of equation (11) can be treated as constant. Taking the natural logarithm of both sides of equation (11), then (from the point of view of a single firm) a 1 percent change in the price (p_f) leads to a $1/(1-\theta)$ percent change in sales (x_f) and, therefore, the (own, net of tariff price) elasticity of demand for each product is still $1/(1-\theta)$. Intuitively, this means that tariff represents a selling cost for the foreign firms, but does not change the elasticity of demand by consumers. Since a tariff does not affect the elasticity of demand, equilibrium output per firm and the equilibrium number of products/firms are not affected. (However, a tariff does shift the composition of consumption towards home goods.) Formally, this can be seen by noting that the introduction of an ad valorem tariff does not have any effect on equations (3) through (16), which determines the general equilibrium. This also implies that a tariff does not affect the product wage which is given by $w/p = f'(\bar{\ell})\theta$. Moreover, since the tariff affects all foreign produced goods the same way, relative prices inside the group of foreign produced goods are also not affected by the imposition of a uniform ad valorem tariff on all imports. By symmetry, the same argument also implies that a uniform ad valorem tariff, of rate s, imposed by the foreign country on all its imports does not affect the equilibrium output per firm abroad.

Since a tariff does not change the number of products available to consumers worldwide or relative prices inside the group of domestically and foreign produced goods, consumers can be thought of as consuming two composite goods and the utility function of a consumer in the home country can be written as:

$$(12)\quad U = [n(c_h)^{\theta} + n^*(c_f)^{\theta}]^{(1/\theta)} = [n^{(1-\theta)}(nc_h)^{\theta} + n^{*(1-\theta)}(n^*c_f)^{\theta}]^{(1/\theta)}$$

where c_h indicates the consumption level of a typical home good and c_f indicates the level of consumption of a typical imported good, thus (nc_h) indicates the composite home good and (n^*c_f) indicates the composite foreign good. Since home consumers equate the marginal rate of substitution to the relative price they face in the market, it follows that:

$$(13)\quad \left(\frac{c_h}{c_f}\right)^{\theta-1} = \frac{p_h}{p_f(1+t)} = \frac{1}{q(1+t)}$$

where p_h is the price of domestic goods and $q = p_f/p_h$ is the (inverse of) terms of trade. A similar requirement for foreign consumers implies:

$$(14)\quad \left(\frac{c_h^*}{c_f^*}\right)^{\theta-1} = \left(\frac{\bar{x}-c_h}{\bar{x}-c_f}\right)^{\theta-1} = \frac{(1+s)}{q}$$

where c_h^* is set equal to $\bar{x}-c_h$ and c_f^* is set equal to $\bar{x}-c_f$, on the assumption that the government (in both countries) rebates the tariff proceeds lump-sum to consumers. Equilibrium of the balance of trade then requires that:

$$(15)\quad qc_f n^* = nc_h^* = n(\bar{x}-c_h)$$

The system (13) through (15) describes the general equilibrium under the tariff. It can be simplified by substituting equation (15) into equations (14) and (13) to yield:

$$(16)\quad \left(\frac{c_h}{c_f}\right)^{\theta-1} = \frac{c_f}{(1+t)(\bar{x}-c_h)N}$$

$$(17)\quad \left(\frac{\bar{x}-c_h}{\bar{x}-c_f}\right)^{\theta-1} = \frac{(1+s)c_f}{N(\bar{x}-c_h)}$$

where $N = n/n^*$, indicates the relative size of the home economy. This system can then be solved for the offer curves of the two countries: 1/

$$(18)\quad n^*cf = (1+t)^{1/\theta}\,(nch)^{\frac{\theta-1}{\theta}}\,(n\bar{x} - nch)^{1/\theta}\,N^{\frac{1-\theta}{\theta}}$$

1/ Solving equations (16) and (17) for c_f and $c_h^*(= \bar{x}-c_h)$ respectively, we obtain the results which characterize the amounts of a typical product imported by residents of the home country and the amounts consumed by residents of the foreign country.

$$c_f = (1+t)^{1/\theta}N^{1/\theta}\,c_h^{(\theta-1)/\theta}\,(\bar{x}-c_h)^{1/\theta}$$

$$c_h^* = \bar{x}-c_h = (1+s)^{1/\theta}\,N^{-1/\theta}\,c_f^{1/\theta}\,(\bar{x}-c_f)^{(\theta-1)/\theta}$$

Multiplying the amount of a typical good by the number of goods imported or exported one obtains the results which characterize the offer curves of the home and foreign country.

$$(19) \quad nc_h^* = (1+s)^{1/\theta} (n^*c_f)^{1/\theta} (n^*\bar{x} - n^*c_f)^{\frac{\theta-1}{\theta}} N^{\frac{\theta-1}{\theta}}$$

As illustrated by the offer curve $O^h_{t=T}$ in Figure 1, equation (18) indicates the home country's imports of foreign goods, $n\overset{*}{c}_f$, as a function of the home country's exports of home goods, $n(x-c_h)$, when the ad valorem tariff rate is T. Similarly, as illustrated by the offer curve $O^f_{s=0}$ in Figure 1, equation (19) indicates the foreign offer curve, which gives the foreign country's imports, $nc^*_h = n(\bar{x}-\bar{c}_h)$, as a function of its exports, n^*c_f, when the foreign country does not impose an import tariff, i.e., when $s = 0$. As in the standard trade model, the position of the foreign offer curve is not affected by the tariff imposed by the home country.

Under free trade, when the home and the foreign tariff rates are $s = t = 0$, the position of the home offer curve in Figure 1 is indicated by $O^h_{t=0}$, and the equilibrium trading position is indicated by the point E_0. As demonstrated by the analysis in Section II (equations (8) and (9)), at this free trade equilibrium point the relative price of foreign and domestically produced varieties is unity (i.e., q=1) and consumers in both countries consume the same amounts of each good (i.e., $c_h = c_f$, and $c_h/(\bar{x} - c_h) = c_f/(\bar{x}-c_f) = N = n/n^*$). Imposition of a positive tariff rate, T, shifts the home country's offer curve in Figure 1 upward and to the right to $O^h_{t=T}$. Assuming the foreign country does not retaliate by imposing its own tariff, the resulting tariff distorted traded equilibrium is at point E_1, with a lower volume of trade and a lower relative price of foreign good.

IV. The Equivalence of Export Taxes and Import Tariffs

To show that (uniform ad valorem) export taxes and import tariffs are equivalent, observe that an export tax of rate r does not affect the elasticity of demand by the same argument used to establish that a uniform ad valorem import tariff does not affect the (own, net of tariff) price

elasticity of demand for importables. 1/ However, it will raise the price of the home countries exports relative to their domestic price. The resulting equilibrium conditions for consumers at home and abroad and the balance of trade condition are given by:

$$(20) \quad \left(\frac{c_h}{c_f}\right)^{\theta-1} = \frac{1}{q}$$

$$(21) \quad \left(\frac{\bar{x}-c_h}{\bar{x}-c_f}\right)^{\theta-1} = \frac{(1+r)(1+s)}{q}$$

$$(22) \quad qc_f = N(1+r)(\bar{x}-c_h)$$

where equations (20) and (21) are the equivalents to equations (13) and (14); they indicate that consumers equate the marginal rate of substitution to the relative price they face in the market. However, substituting equation (22) into equations (21) and (20) yields:

$$(23) \quad \left(\frac{c_h}{c_f}\right)^{\theta-1} = \frac{c_f}{N(1+r)(\bar{x}-c_h)}$$

$$(24) \quad \left(\frac{\bar{x}-c_h}{\bar{x}-c_f}\right)^{\theta-1} = \frac{(1+s)c_f}{N(\bar{x}-c_h)}$$

It is apparent that equations (23) and (24) are identical to equations (16) and (17) as long as $r = t$ (and s is the same). The international equilibrium supported by an export or an import tariff will therefore be the same if $r = t$. The only difference will be that with an import tariff (the inverse of) the terms of trade indicated by q_i, are below unity, i.e., $q_i < 1$, whereas with an export tariff the terms of trade are given by $q_e/(1+r)$. By the equivalence proposition $q_i = q_e/(1+r)$ and therefore $q_e > 1$. By equation (3), $q = p_f/p_h$ is equal to w^*/w, this implies that an import tariff will raise domestic wage rates relative to those abroad; whereas an export tariff will have the opposite effect. However, the export tariff still benefits the home country since the tariff revenue is collected from foreigners.

1/ This can be proved by substituting (1+t) by (1+r) in equation (11), this change does not affect the fact that the terms inside the curled brackets of equation (11) are viewed as a constant from the point of view of any single form.

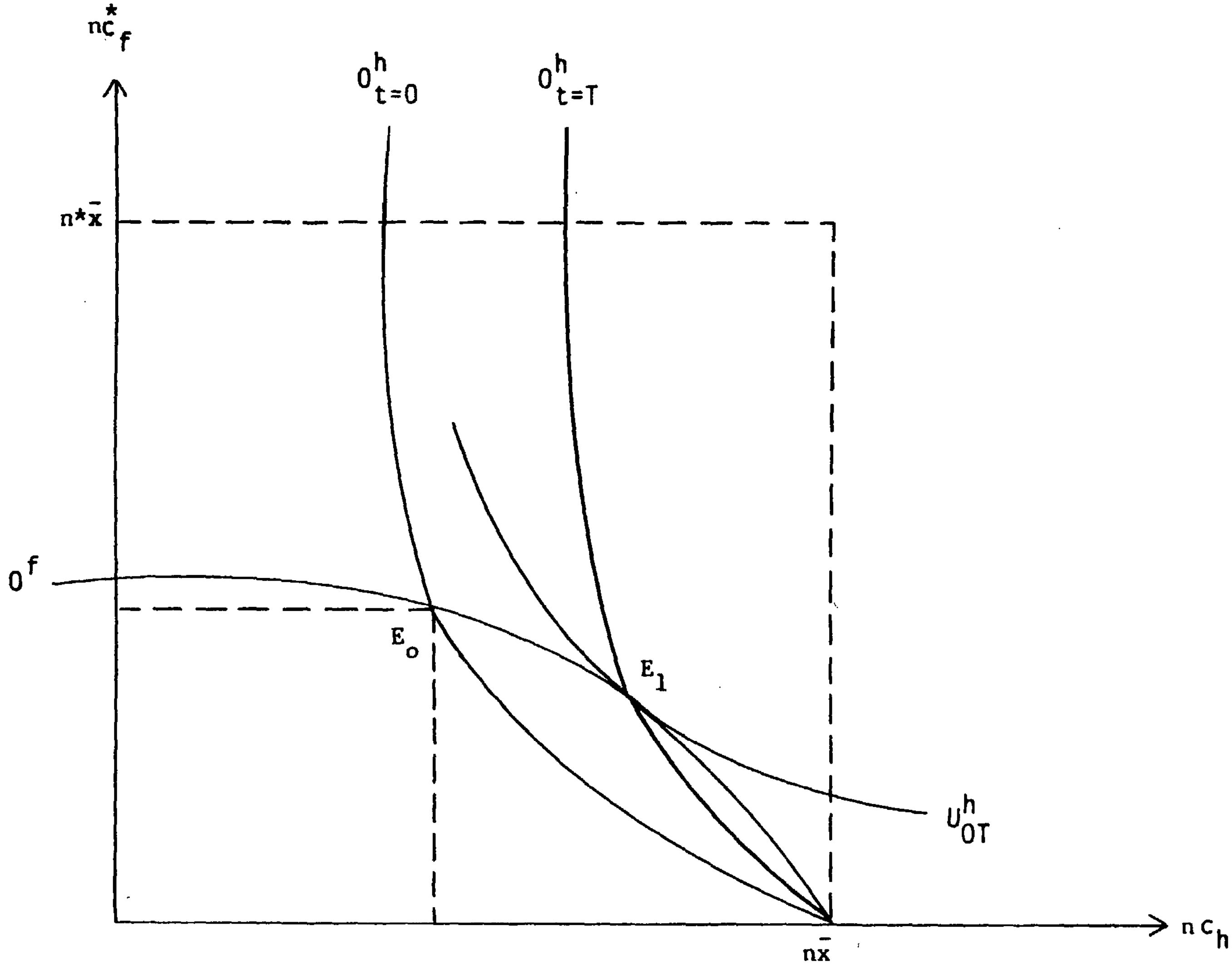

Fig. 1--A graphical illustration of the equilibrium with a tariff.

V. The Effects of Quotas and the Equivalence of Tariffs and Quotas

This section discusses the conditions under which a quota is equivalent to an ad valorem tariff. A quota, denoted by Q, that limits total imports implies that: 1/

$$(25) \quad Q = n^* c_f$$

since in this framework total imports are given by the quantity imported of each specification (c_f) times the number of foreign specifications (n^*). In this case, an import license allows the holder to import one unit of any (foreign) specification.

1. The case of equivalence between quotas and tariffs

A market for import licenses is crucial for the equivalence proposition. This becomes clear if one considers a world in which production is undertaken by monopolistically competitive firms, but the distribution of the output is an activity done by perfectly competitive middle-men. If the home-country government then distributes the import licenses by setting a market clearing fee, F, then a quota is identical to a specific tariff with the (absolute amount of the) tariff equal to F.

The imposition of such an import quota (by the home country) will not affect the elasticity of demand each firm faces on the home or foreign market. 2/ This implies that foreign firms will sell their output for the same price, p_f^*, to consumers in the foreign country and to the middle-men in the home country. If the middle-men are perfectly competitive and the import license fee, F, is the only cost associated with distribution activities, then the price to home country consumers is equal to $p_f^* + F$. Moreover, since the elasticity of demand and the cost functions of firms are not affected, output per firm and hence the number of varieties produced at home and abroad will not change either.

The price of imports in terms of domestic goods is given by:

$$(26) \quad q = p_f/p_h = p_f^* + F = p_f^* (1 + F/p_f^*)$$

If the government rebates the proceeds from the sale of import licenses lump-sum to consumers, the balance of trade condition implies:

1/ Assuming the quota is binding.

2/ See the discussion in Section III, especially equation (11).

(27) $p_f^* c_f n^* = n c_h^* p_h$

Setting $F/p_f^* = t$ this implies that an import quota is equivalent to a uniform ad valorem tariff of rate t, since the above conditions equations (26) and (27) identical to the system of equations (13) through (15) that determines the equilibrium in the tariff case (with s=0). Equivalence in this context means that the two systems will involve the same prices, the same quantities produced and consumed and the same number of varieties produced at home and abroad. Equivalence also implies that an import quota should be equivalent to an export quota, since export and import tariffs are equivalent.

2. The case of nonequivalence between tariffs and quotas: market segmentation

The equivalence of tariffs and quotas does not hold if the market for import licenses is organized differently. Assume the government sells import licenses only to firms that produce the specific product to be imported. This would allow firms to control the distribution of their products abroad. 1/ The same effect would be obtained if each specification could be imported by only one middle-man who would become the exclusive importer-distributor.

The fact that the distribution of imports (in the home country) is no longer a competitive business will affect the price charged to home consumers. Foreign firms (or the exclusive importers) will consider the import fee, F, as a marginal selling cost. Since their price is a markup over total marginal cost, they will charge a price equal to: 2/

(28) $p_f = ([f'(\ell)^{-1} w^* + F)/\theta = p_f^* + F/\theta$

on the home country market. Since θ is smaller than unity, the difference between the domestic and foreign price is greater than the "transportation cost" given by F. This pricing policy is clearly possible only if the import licensing policy keeps the two markets separate.

Since the unit profits are different in the two markets the zero-profit condition will be affected too. Profits, π, of a typical foreign firm are given by:

1/ In the sense that consumers in the home country could not buy the product, ship it to a foreign country and resell it.

2/ The markup over marginal cost is still given by $1/\theta$ since the elasticity of demand is not affected by the quota, i.e., the import license fee. However, marginal cost is now given by the marginal cost of production $[f'(\ell)]^{-1} w^*$ plus the import license fee, F.

$$(29) \quad \pi = p_f^* c_f^* + c_f(p_f^* + (F/\theta) - F) - w^*(\ell)$$

$$= p_f^*[c_f^* + c_f + c_f(F/p_f^*)((1-\theta)\theta)) - \theta f'(\ell)\ell]$$

Setting $\pi = 0$ (i.e., assuming competition eliminates excess profits) and using the pricing condition (3) yields an implicit equation for the size of a typical foreign firm:

$$(30) \quad \frac{f'(\ell)}{f(\ell)\ell} = \frac{1}{\theta}[1 + \frac{c_f}{f(\ell)} (\frac{F}{p_f^*}) (\frac{1-\theta}{\theta})]$$

This equation shows that the degree of economics of scale, $f'(\ell)\ell/f(\ell)$ now exceeds $1/\theta$. This implies that the size of a typical firm abroad 1/ has to be smaller in this case. If the labor market continues to clear, then the number of varieties produced abroad has to increase.

Thus, there will be no equivalence between tariffs and quotas (or between ad valorem and specific tariffs) since the number of varieties produced, the quantities consumed, and the relative prices are different when the market for import licenses is not competitive. This result is again independent of the specific form of the quota, i.e., whether it limits total imports or imports per specification. For the individual foreign firm (or exclusive importing agent) it does not matter whether the quota limits total imports or imports of each specific variety as long as it has a monopoly for this specific product on the home market.

VI. The Correspondence Between Quota Limits and Tariff Rates

The preceding section has shown that quotas are equivalent to ad valorem tariffs if the market for import or export licenses is competitive. This section calculates the ad valorem tariff rate that has the same effect on a given quota assuming that the equivalence proposition holds. Since quotas are often stated in terms of the maximum share of the domestic market allocated to foreign suppliers, this section calculates the tariff rate that is necessary to achieve a given market share for imports. The market share of imports is determined by the distribution of consumption between imports and domestically produced goods. This distribution of

1/ Domestic firms face the same cost condition and the same elasticity of demand as without a quota; their output will not be affected by the imposition of the quota.

consumption in turn depends on the relative number of domestic and foreign varieties available, i.e., N, and the terms of trade, q. The market share of foreign suppliers, MS, is defined as: 1/

$$(31) \quad MS \equiv \frac{n^{*} c_f p_f}{n^{*} c_f p_f + n c_h p_h} = \frac{1}{1 + N(\frac{c_h}{c_f})q}$$

With free trade, $(c_f/c_n)=q=1$; and the market share of imports is equal to 1/(1+N), where N indicates the relative size of the home country. A more accurate measure of the impact of the trade restriction caused by a quota would thus be the ratio of the market share allowed by the quota to the free trade market share. Denoting this ratio by RMS, it is apparent that RMS=MS(1+N). A value of, e.g., 0.9 for RMS indicates that the quota lowers the share of imports in total domestic rates by 10 percent from its free trade value of 1/(1+N); at an unchanged level of domestic sales this would correspond to a fall of 10 percent in imports. For the case of two countries of equal size (i.e., N=1) RMS=0.9 implies that the market share of imports has to go from 50 percent to 45 percent.

Equation (31) can also be used to calculate the tariff rate that would lead to a certain import share RMS or:

$$(32) \quad (1+t)^{o} = q^{-\theta} N^{(\theta-1)} \left[\frac{(1+N)-RMS^{o}}{RMS^{o}}\right]^{(1-\theta)}$$

This implies that the tariff rate, t^{o}, that achieves a given target reduction in the market share of imports in the home country, RMS^{o}, is a function of the size of the home country, as expressed by N, and the degree of product differentiation, as expressed by θ.

Table 1 shows the values of t^{o} that achieve a reduction in the import share of 10 percent ($RMS^{o}=0.9$) and 50 percent ($RMS^{o}=0.5$) for various values of N and θ and under the assumption that the foreign country does not impose its own quota or tariff. The values of θ, which determines the producer's markup over marginal cost, were chosen such as to give a markup below 100 percent. A value of $\theta=0.8$ implies a markup of 25 percent, which is taken here as a close approximation of reality. Thus, for the case of two countries of equal size, i.e., N=1 and $\theta=0.8$, the table implies that a quota that limits the market share of imports

1/ Dividing numerator and denominator by $(n^{*} c_f p_f)$ yields the second line of equation (31).

Table 1. The Tariff Rates Implicit in Quotas 1/

RMS = 0.9: corresponds to a 10 percent reduction in the market share of imports

Markup over marginal cost 2/		Relative size of the home economy, N:				
(θ)	(1/θ)-1	2	1	0.5	0.1	0.01
(0.9)	11	3.9	3.7	4.3	9.4	29.7
(0.8)	25	6.8	7.0	8.3	19.5	67.8
(0.7)	45	9.1	9.8	12.2	30.1	116.7
(0.6)	62	10.9	12.3	15.8	41.3	179.2
Free trade import market share		0.33	0.50	0.67	0.91	0.99
Quota limit on import market share		0.30	0.45	0.60	0.82	0.89

RMS = 0.5: corresponds to a 5 percent reduction in the market share of imports

Markup over marginal cost 2/		Relative size of the home economy, N:				
(θ)	(1/θ)-1	2	1	0.5	0.1	0.01
(0.9)	11	23.3	22.8	21.5	32.0	69.1
(0.8)	25	46.4	46.7	51.8	84.9	181.9
(0.7)	43	67.7	70.7	81.4	145.7	363.6
(0.6)	67	86.7	94.2	112.2	221.6	651.7
Free trade import market share		0.33	0.50	0.67	0.91	0.99
Quota limit on import market share		0.17	0.25	0.33	0.45	0.49

1/ In percentage terms; for example, a quota that lowers imports by 10 percent, i.e., RMS=0.9, is equivalent to a tariff of 3.9 percent for θ=0.9 and N=2.

2/ In percent.

to 90 percent of its free trade level is equivalent to a tariff rate of 7 percent. The table also shows that smaller countries need relatively large tariff rates to achieve a given proportional reduction in the market share of imports than larger countries. Thus, a country that is only one tenth the size of its trading partner, i.e., N=0.1, needs a tariff rate of almost 20 percent to achieve a 10 percent reduction in the market share of imports.

The table also shows that larger reductions in the market share of imports imply much larger implicit tariffs. Thus, if the aim of the quota is to limit the market share of imports to one half its free trade level, the implicit tariff is equal to 46.7 percent for the case of two countries of equal size (N=1) and it is equal to almost 85 percent for the case of a small country (N=0.1) (both for θ=0.8).

VII. Retaliation and Tariff Wars

This section considers the consequences of tariff wars in which each country takes the tariff of the other country into account when choosing its own tariff rate. It is assumed that each country always chooses the optimum tariff rate, which is the tariff rate that maximizes the ability of a representative consumer, given the offer curve of the foreign country and the foreign country's tariff rate. The principle of the optimum tariff can be illustrated with the aid of Figure 1.

At the free trade equilibrium, E_0, the home indifference curve (not drawn) would clearly intersect the foreign offer curve. In the absence of retaliation, this implies that the imposition of a small tariff will generally benefit the home country, since it will move it to a trading position on a higher indifference curve. The optimal tariff is given, as usual, by the point, where the home indifference curve, derived from equation (12) is tangent to the foreign offer curve. This indifference curve is graphed as $U^h{}_{OT}$ and the corresponding tariff distorted offer curve is shown as $O^h_{t=T}$.

In general, the optimal tariff rate, T, in terms of the parameters of the model can be calculated by setting:

$$(33) \quad \frac{d(U^\theta)}{dt} = \theta n^*(N(c_h)^{\theta-1} \frac{dc_h}{dt} + (c_f)^{\theta-1} \frac{dc_f}{dt})$$

equal to zero. The values of dc_h/dt and dc_f/dt are obtained by differentiating equations (18) and (19) and assuming that the foreign country does not retaliate, i.e., ds $\equiv$ 0. The resulting expression for the optimal tariff

rate can be simplified to: 1/

$$(34) \quad 1 + T = \frac{1}{\theta} + \frac{1-\theta}{\theta} N(1+s)^{\frac{1}{\theta-1}} q^{\frac{-\theta}{\theta-1}}$$

where, as before, $N = n/n^*$, indicates the relative size of the home economy and $q = p_f/p_h$, the terms of trade. The result, equation (39), implies that even a small country, $N = 0$, will have a finite optimal tariff given by $T = (1/\theta) - 1 = (1-\theta)/\theta$.

The expression for the optimal tariff equation (34) indicates that the home country will take any foreign tariff into account when choosing its own optimal tariff rate. Since it can be assumed that the foreign country does likewise, commercial policy in this context becomes a two player game. This section considers a particular solution to this game. It is assumed that each country takes the tariff of the other country as given when choosing its own optimal tariff rate. A Nash equilibrium obtains when no country has an incentive to further adjust its own tariff rate.

The process by which such a Nash equilibrium is reached is assumed to be the following: starting from a free-trade equilibrium, the home country imposes its own optimal tariff, the foreign country retaliates by imposing the tariff that is optimal given the initial tariff imposed by the home country. The home country in turn retaliates by adjusting the tariff it imposed in the first place and so on. In the present model, such a tariff war leads to an equilibrium since equation (34) implies that the optimal tariff for the home country is a declining function of the tariff rate imposed by the foreign country:

$$(35) \quad \frac{dT}{ds} = -\frac{N}{\theta}(1+s)^{\frac{1}{\theta-1}} q^{\frac{-\theta}{\theta-1}} [(1+s)^{-1} - \theta q^{-1}(\frac{dq}{ds})] < 0$$

which is negative since the direct effect of a higher foreign tariff, s, outweighs the indirect effect which leads to a deterioration of the home country's terms of trade (i.e., $dq/ds > 0$). 2/

Denoting the tariff rates that represent the outcome of a tariff war by $\bar{s}$ and $\bar{t}$ the home country has no incentive to further adjust its tariff rate when equation (34) holds with $\bar{s}$ and $\bar{t}$ in place of s and T. The

1/ See Appendix (A.6) through (A.12).
2/ See Appendix (A.22).

expression that gives the optimal tariff for the foreign country is symmetric to equation (34), consequently, the foreign country has no incentive to further adjust its own tariff rate if:

$$(36) \quad (1+\bar{s}) = \frac{1}{\theta} + \frac{1-\theta}{\theta} N^{-1} q^{\frac{\theta}{\theta-1}} (1+\bar{t})^{\frac{1}{\theta-1}}$$

This equation can be used in equation (34) to derive an expression for the "equilibrium" tariff rate for the home country:

$$(37) \quad (1+\bar{t}) = \frac{1}{\theta} + \frac{1-\theta}{\theta} N q^{\frac{-\theta}{\theta-1}} \left[\frac{1}{\theta} + \frac{1-\theta}{\theta} N^{-1} q^{\frac{\theta}{\theta-1}} (1+\bar{t})^{\frac{1}{\theta-1}}\right]^{\frac{1}{\theta-1}}$$

An equivalent expression determines the equilibrium tariff rate for the foreign country, $\bar{s}$. Since $dT/ds < 0$, this tariff rate is lower than the rate the home country would impose in the absence of retaliation, i.e., if $s \equiv 0$. It can be shown from equation (37) that the "equilibrium" tariff rate for the home country, $\bar{t}$, is an increasing function of the size of the home country, N, and t is also an increasing function of the degree of product differentiation, as measured by the degree of monopoly power, $1/\theta$. Equation (37) also implies that the "equilibrium" tariff rate for the small country is given by $(1+\bar{t}) = 1/\theta$, i.e., the same tariff the small country would impose in the absence of retaliation. 1/ In a world with many small countries a generalized tariff war would thus lead to the same tariff rate, equal to $\bar{t} = (1-\theta)/\theta$, in all countries.

VIII. The Welfare Consequences of Quotas, Voluntary Export Restraints and Tariff Wars

This section calculates the gains or losses in welfare of a representative consumer in the home country by various commercial policy measures. The gains or losses in welfare are calculated by comparing the utility level a representative consumer can achieve with free trade with the utility level this consumer can achieve with the various commercial policy measures considered here.

1/ See the Appendix for a derivation of these results.

The free trade utility level of a representative consumer can be calculated from equation (12); since with free trade $q = (c_f/c_h)^{1/(\theta-1)} = 1$ this implies: 1/

$$(38) \quad U_{\substack{s=0\\t=0}} = N\bar{x}[N + 1]^{(1-\theta)/\theta}$$

where the number of firms abroad, n*, has been set equal to one. 2/ This shows that utility is proportional to the value of the output of the economy, $N\bar{X}$, and utility is also an increasing function of the number of varieties available, and the degree of product differentiation, $1/\theta$. If the home country imposes a tariff, of rate t, or equivalently a quota that has the same effect as an ad valorem tariff of rate t, the utility level of a representative consumer is given by: 3/

$$(39) \quad U_{\substack{s=0\\t\neq0}} = N\bar{x}\left(N + [q(1+t)]^{\frac{\theta}{\theta-1}}\right)^{\frac{1}{\theta}} \left(N + q[q(1+t)]^{\frac{1}{\theta-1}}\right)^{-1}$$

The gain or loss in welfare from imposing a tariff in this case without retaliation can be expressed as the proportional gain in utility over the free trade utility level that can be achieved with the tariff: gain in welfare $\equiv G \equiv U_{\substack{s=0\\t\neq0}}/U_{\substack{s=0\\t=0}} - 1$:

$$(40) \quad G = \left\{\frac{\left(N + [q(1+t)]^{\frac{\theta}{\theta-1}}\right)\left(N + q[q(1+t)]^{\frac{1}{\theta-1}}\right)^{-\theta}}{(1+N)^{1-\theta}}\right\}^{\frac{1}{\theta}} - 1$$

1/ The welfare calculations in this section depends on the cardinal nature of the utility function. They are invariant only up to a linear transformation of equation (1).

2/ Equation (38) seems to suggest that the utility of home consumers is an increasing function of the size of the home country, this is true only because n* = 1. Consumers' utility depends on the number of firms worldwide, with n* = 1. N is also a measure of the number of firms in the world which is given by n*+n = 1+N in this case.

3/ In this case (c_f/c_h) is given by equation (15) and c_f is determined by equation (A.13).

This gain or loss is a function of the size of the home country, N, and the degree of product differentiation and the tariff rate t. It does not seem possible to derive a closed form solution for the gain G, in terms of these parameters, however, Tables 2, 3, and 4 contain some numbers for G for selected values of Θ and N and various commercial policy measures. 1/

The first commercial policy measure considered here is the unilateral imposition by the home country of a quota that limits the market share of imports. Assuming that the market for import licenses is competitive, this is equivalent to the unilateral imposition of a tariff by the home country. The tariff rates that correspond to given values of the market share of imports were calculated in the previous section. Table 2 thus shows the welfare gain or loss of quotas that reduce the market share of imports by 10 percent and 50 percent respectively. 2/

The data in the table shows that while a large country might gain from the imposition of such a quota (or its equivalent tariff), a small country is likely to lose from such a policy. The gain of a large country might reap from the unilateral imposition of a quota or a tariff derives largely from the fact that a large country has "market power" on the world market and can thus turn the term of trade in its favor. This effect can outweigh the loss due to the distortions created by the quota or tariff. The small country does not have this market power; it may therefore lose even from the imposition of a unilateral quota or tariff. Indeed, Table 2 shows that a very small country (N=0.01) would lose even from the imposition of a quota that reduces imports only 10 percent below their free trade level.

Retaliation by the foreign country has to diminish the gains or increase the losses the home country could expect from imposing its own unilateral tariff. The question therefore arises whether it would be in the interest of the home country to start a tariff war. To answer this question, it is necessary to compare the utility level the home country could achieve under free trade to the utility level the home country could achieve when a tariff war has led to the equilibrium tariff rate, $\bar{t}$.

After a tariff war, the home country imposes the tariff, t, the utility level of a representative consumer is given by equation (39) with $\bar{t}$ instead of t:

1/ The values for G were obtained by inserting values for Θ, N, and t into equations (40), (32), and (A.14) to obtain values for the endogenous variables q and G.

2/ Tariffs and quotas are often used to protect jobs in certain industries, this motivation for protectionism cannot be dealt with in the framework used here.

Table 2. The Welfare Consequences of Quotas 1/ 2/

RMS = 0.9: corresponds to a 10 percent reduction in the market share of imports

Markup over marginal cost 2/ (θ)	(1/θ)-1	Relative size of the home economy, N: 2	1	0.5	0.1	0.01
(0.9)	11	0.7	0.8	0.8	0.6	-0.6
(0.8)	25	1.3	1.5	1.6	1.1	-0.9
(0.7)	45	1.8	2.1	2.3	1.8	-0.9
(0.6)	62	2.1	2.7	3.0	2.4	-0.8
Free trade import market share		0.33	0.50	0.67	0.91	0.98
Quota limit on import market share		0.30	0.45	0.60	0.82	0.89

RMS = 0.5: corresponds to a 5 percent reduction in the market share of imports

Markup over marginal cost 2/ (θ)	(1/θ)-1	Relative size of the home economy, N: 2	1	0.5	0.1	0.01
(0.9)	11	1.8	1.7	1.0	-2.6	-10.4
(0.8)	25	3.8	3.7	2.6	-3.9	-16.5
(0.7)	43	5.9	6.1	4.7	-4.1	-19.3
(0.6)	67	7.9	8.6	7.2	-3.3	-19.7
Free trade import market share		0.33	0.50	0.67	0.91	0.98
Quota limit on import market share		0.17	0.25	0.33	0.45	0.49

1/ Indicates the percentage differences between the utility level (of a typical consumer in the home country) under free trade and with a unilateral quota imposed by the home country. A positive value, indicates that the home country is better off with the quota than with free trade.

$$(41) \quad U_{\substack{s=\bar{s} \\ t=\bar{t}}} = N\bar{x}\left(N + [1(1+\bar{t})]^{\frac{\Theta}{\Theta-1}}\right)^{\frac{1}{\Theta}} \left(N + q[q(1+\bar{t})]^{\frac{1}{\Theta-1}}\right)^{-1}$$

The home country gains from starting a tariff war if $G > 0$, i.e., if $U_{\substack{s=\bar{s} \\ t=\bar{t}}} > U_{\substack{s=0 \\ t=0}}$ or if:

$$(42) \quad \left(N + [1(1+\bar{t})]^{\frac{\Theta}{\Theta-1}}\right)\left(N + q[q(1+\bar{t})^{\frac{1}{\Theta-1}}\right)^{-\Theta} \geq (1+N)^{1-\Theta}$$

If equation (40) holds with equality, it can be interpreted as giving the critical value of N, i.e., the size of the home country, for which the home country is just indifferent between the free trade equilibrium critical value of N depends on θ and is an increasing function of the degree of monopoly power, 1/θ. Panel A in Table 3 lists the critical values of N as a function of 1/Θ. 1/ It is apparent that this critical value of N is an increasing function of 1/Θ, the minimum is equal to 2.6, when 1/θ goes towards one. This implies that only a country that is almost three times as big as the rest of the world can gain from a tariff war.

Panel B in Table 3 also shows the welfare loss from a tariff war for countries that are smaller than the critical size of N calculated above (a negative value of G signifies a welfare loss). Since (1/Θ)-1 is equal to the proportional markup of producers, the values of Θ used in Table 3 were chosen such as to give reasonable values for this markup. For Θ =0.8, the markup is 25 percent, taking this as reasonable approximation of reality, Panel C then suggests that in a trade war between two countries of equal size (N=1), the welfare of consumers in each country would drop by about 3.8 percent compared to the welfare level they could achieve under free trade. 2/

1/ To calculate the critical value of N for which $U_{\substack{s=\bar{s} \\ t=\bar{t}}} = U_{\substack{s=0 \\ t=0}}$ it is necessary to use a system of equations consisting of (25), (29), and (35) (with equality sign) and (A.14).

2/ The analysis of tariff wars has so far relied on the Nash assumption that each country takes the tariff of the other country as given when deciding on its own (optimal) tariff. However, it might also be useful to consider a different situation in which retaliation consists simply of imposing a tariff of the same rate as the other country. In this case the home country is assumed to be the leader in the sense that it selects a certain tariff rate and the foreign country is the follower in the sense that it retaliates simply by imposing a tariff of the same rate. If the

Table 3

Panel A: The Critical Value of N 1/ for which the Home Country is Indifferent Between a Tariff War and Free Trade

Relative size of the home country, N:	2.68	2.77	2.90	3.06
Markup over marginal cost (1/Θ)-1 2/	11	25	43	67

Panel B: The Welfare Loss from a Tariff War 3/

Markup over marginal cost 2/		Relative size of the home economy, N:				
(Θ)	1/Θ	2	1	0.5	0.1	0.01
(0.9)	1.11	-0.4	-1.8	-4.1	-12.0	-25.1
(0.8)	1.25	-0.8	-3.8	-8.5	-23.6	-45.4
(0.7)	1.43	-1.5	-6.2	-13.4	-34.7	-61.4
(0.6)	1.67	-2.3	-9.0	-18.8	-45.4	-73.6

1/ The value 2.77 (for 1/Θ = 1.25) means that only a country that is at least 2.77 times as large as the rest of the world can gain from a tariff war.

2/ In percent.

3/ Indicates the percentage differences between the utility level (of a typical consumer in the home country) under free trade and after a tariff war. The negative values indicate that the home country is worse off with after the tariff war than with free trade.

Another type of commercial policy measure that is often used in practice is the so-called voluntary export restraint (VER). This amounts to the imposition of an export quota by the foreign country, usually done at the request of the home country. It is apparent that such a measure can never benefit the consumer in the home country, although it may benefit foreign and domestic producers in the short-run. Assuming that the foreign country allocates the export licences competitively an export quota is equivalent to an export tariff. Since it was shown that export and import tariffs are equivalent (in the sense that they lead to the same terms of trade, exports, and imports) this implies that the effects of a voluntary export restraint by the foreign country should be equivalent to the imposition of an import tariff by the foreign country.

2/ (Cont'd from p. 21) leader (the home country) takes this policy reaction of the follower (the foreign country) into account when choosing its own tariff rate, the tariff that would maximize the utility of a representative consumer in the home country is no longer given by equation (34), since equation (34) represents the optimal tariff under the assumption that the foreign country does not retaliate. If the foreign country follows the retaliation policy of setting s equal to t, the optimal tariff for the home country, T_r, is given by:

$$1 + T_r = 1 + \frac{1-\theta}{1+\theta}[q(1+s)]^{\frac{1}{\theta-1}}q \qquad 1 + \frac{1-\theta}{1+\theta}[q(1+s)]^{\frac{1}{\theta-1}}q(\frac{1}{N})$$

This equation implies that only a country that is larger than its "follower" (i.e., $N > 1$) has an interest to impose a positive tariff if it knows that the other country always retaliates with a tariff of the same rate. (With $N > 1$, the denominator of the RHS of this equation is smaller than the nominator and thus $T_r > 0$). This equation also implies that a country that is smaller than its follower (i.e., $N < 1$) would find it optimal to impose a negative tariff (i.e., a subsidy) if it can count on the follower to impose the same negative tariff or subsidy. It may not seem very plausible to assume that any country would retaliate to an import subsidy of its trading partner by imposing its own import subsidy. However, in Section V, it is shown that import and export tariffs (and therefore also subsidies) are equivalent. Thus, the leading country would achieve the same effect by imposing an export subsidy to which it is not unreasonable to assume that the follower would react by using the same export subsidy.

It is apparent from this equation that there can be no equilibrium at which both leaders and followers achieve an equilibrium because the tariff that is optimal for the leader is never optimal for the follower (except for the case $N = 1$, but in this case T_r is zero.

ntary export restraint agreements are also sometimes negotiated aim of limiting the market share of imports. Table 4 thus es the welfare losses for consumers in the home country of y export restraint agreements that lower the market share of by 10 and 50 percent, respectively. It is apparent from this data welfare losses from such an agreement can be considerable even umers in a large country. Thus, a voluntary export restraint by n country that is as big as the home country, N=1, leads to a loss of over 2 percent if the restraint reduces the import market y 10 percent and the welfare loss rises to almost 10 percent if the nts halve the import market share.

t another measure of commercial policy that can be analyzed within del are export subsidies. Export subsidies are not used as often rt tariffs and quotas but they are employed in some form by many ial countries in the form of interest rate subsidies used to exports of major investment goods. Given the equivalence between and import tariffs, it is clear that an export subsidy has the same s as an import subsidy. Furthermore, the analysis of the effects ort tariffs showed that, in the absence of retaliation, a negative rate, i.e., a subsidy always leads to a welfare loss for the home y. The magnitude of this welfare loss can be computed by applying me method that was used so far to compute the welfare implications tas and tariffs. The results are presented in Table 5. Since export ies are usually small in magnitude, Table 5 reports only the welfare for a typical consumer in the home country) caused by a 10 percent subsidy. For θ=0.8 and N=1, this loss is equal to about 3 percent free trade utility level. The table also indicates that larger ries stand to lose more from export subsidies than smaller ones, the n for this is that an export subsidy by a large country leads to a r deterioration of the terms of trade.

These welfare losses and gains can also be expressed in terms of the fer the home country would need to make in order to attain the same ty level under free trade prices as with the tariff war. 1/ This es that, e.g., for N=1, Θ=0.8, consumers in the home country would ndifferent between sustaining the welfare loss resulting from a f war or maintaining free trade and making a transfer to the rest of world equal to 3.8 percent of the home country's GNP. The numbers in l C of Table 3 can thus also be interpreted as the compensating per- age income loss caused by a tariff war.

This derives from the feature of the model that utility is propor- al to national income; see equation (38).

Another type of commercial policy ...

Table 4. Welfare Loss from Voluntary Export Restraints 1/ 2/

RMS = 0.9: corresponds to a 10 percent reduction in the market share of imports

Mark-up over marginal cost 2/ (θ)	(1/θ)-1	Relative size of the home economy, N: 2	1	0.5	0.1	0.01
(0.9)	11	-0.5	-1.1	-2.0	-7.4	-23.4
(0.8)	25	-1.2	-2.4	-4.5	-15.9	-45.1
(0.7)	43	-2.1	-4.0	-7.5	-25.7	-64.2
(0.6)	67	-3.2	-6.2	- 11.4	-37.0	-79.8
Free trade import market share		0.33	0.50	0.67	0.91	0.98
Quota limit on import market share 3/		0.30	0.45	0.60	0.82	0.89

RMS = 0.5: corresponds to a 5 percent reduction in the market share of imports

Markup over marginal cost 2/ (θ)	(1/θ)-1	Relative size of the home economy, N: 2	1	0.5	0.1	0.01
(0.9)	11	-2.4	-4.4	-7.4	-18.1	-35.4
(0.8)	25	-5.4	-9.6	-15.9	-36.1	-62.6
(0.7)	43	-9.1	-16.0	-25.7	-53.6	-81.6
(0.6)	67	-13.8	-23.7	-37.0	-69.7	-92.7
Free trade import market share		0.33	0.50	0.67	0.91	0.98
Quota limit on import market share 3/		0.17	0.25	0.33	0.45	0.49

1/ Indicates the percentage differences between the utility level (of a typical consumer in the home country) under free trade and with the VER indicated. Negative values indicate that the home country is better off with free trade than with the VER indicated.
2/ See Table 1 for the corresponding tariff rates.
3/ This limit is set by the "voluntary" export restraint agree-

Table 5. Welfare Loss from an Export Subsidy 1/

Subsidy on Exports = 10 percent

Markup over marginal cost 2/		Relative size of the home economy, N:				
(θ)	(1/θ)-1	2	1	0.5	0.1	0.01
(0.9)	11	-3.1	-3.5	-2.9	-0.9	-0.1
(0.8)	25	-2.7	-3.1	-2.6	-0.9	-0.1
(0.7)	43	-2.6	-2.9	-2.5	-0.9	-0.1
(0.6)	67	-2.5	-2.8	-2.5	-0.9	-0.1

1/ Indicates the percentage differences between the utility level (of a typical consumer in the home country) under free trade with the export subsidy. Negative values indicate that the home country is better off than with free trade, than with the export subsidy.
2/ In percent.

IX. Concluding Remarks

This paper has analyzed the effects of various measures of commercial policy in the context of a model that was developed to analyze trade among industrialized economies. Since tariffs among industrialized countries have been greatly reduced during the last decades, the paper has concentrated on the analysis of such nontariff barriers as quotas and so-called voluntary export restraints.

It is shown that quotas are equivalent to tariffs if the market for import licenses is competitive. Since it is also shown that export and import tariffs are equivalent, this implies that voluntary export restraints (VERs) are equivalent to tariffs imposed by the exporting country.

Given this equivalence between quotas and tariffs, the paper then calculates the tariff rates that would have the same effect as a quota that limits the market share of imports to a certain level. Even for relatively liberal quotas, the equivalent tariff rates are much higher than the actual tariff rates usually used by industrialized countries. This might explain the preference for quotas as the equivalent tariff rates would make the protectionist impact much more evident.

The model is also used to calculate the welfare consequences of quotas, VERs, and trade wars. It appears that especially VERs have a substantial negative impact on the welfare of consumers in the importing country. Trade wars are also shown to lead to substantial welfare losses, even if it is assumed that each country retaliates only by imposing its own optimal tariff (or equivalent quota) taking the other country's tariff as given.

SOC for a Social Optimum

To find the S.O.C. for a social optimum, it is convenient to rewrite the F.O.C. (8) as:

$$\text{(A.1)} \quad 0 = L\ell^{-1} f^{\Theta}[-\ell + \Theta f' f^{-1}]$$

The S.O.C. is then

$$\text{(A.2)} \quad \ell^{-2} + \Theta f'' f^{-1} - \Theta f' f^{-2} f' < 0$$

Using the equilibrium condition (5'), this implies:

$$\text{(A.3)} \quad \ell^{-2}[1 - \frac{1}{\Theta} + \Theta f'' f^{-1} \ell^{2}] < 0$$

However, the condition that the degree of economies of scale is decreasing with firm size implies:

$$\text{(A.4)} \quad \frac{f'}{f} + \frac{f''\ell}{f} - \frac{f'\ell f'}{ff} < 0$$

Using (5) twice this can be rewritten as:

$$\text{(A.5)} \quad \frac{f'}{f}[1 - \frac{1}{\theta} + \frac{\theta f''\ell^{2}}{f}] < 0$$

It is apparent that equations (A.5) and (A.3) express the same condition; hence, the S.O.C. for the social planner are given whenever the monopolistically competitive equilibrium is stable.

Calculations for the Optimum Tariff

The system of equations (15) through (17) can be reduced to the following two-equation system in two variables, c_h and c_f:

$$\text{(A.6)} \quad (c_f/c_h)^{\theta-1} - (1+t)N(\bar{x}-c_h)/c_f = 0$$

(A.7) $(1+s)c_f[(\bar{x}-c_f)/(\bar{x}-c_h)]^{\theta-1} - N(x-c_h) = 0$

Multiplying (A.1) by c_f and (A.2) by $(\bar{x}-c_h)^{-1}$, the total differential of the system can be written as:

$$\text{(A.8)} \quad \begin{vmatrix} (1+t)N + (1-\theta)[q(1+t)]^{\theta/\theta-1} & \theta q(1+t) \\ N\theta & q(1 - \frac{(\theta-1)c_f}{(\bar{x}-c_f)}) \end{vmatrix} \begin{vmatrix} dc_h \\ dc_f \end{vmatrix} = \begin{vmatrix} c_f q \; dt \\ - \frac{c_f q}{1+s} ds \end{vmatrix}$$

where the q comes from using equation (15) again after the differentiation.

The optimal tariff requires setting equation (33) in the text equal to zero, dividing this expression through by $n^*(c_h)^{\theta-1}$ yields a simplified condition for the optimal tariff:

(A.9) $dU^\theta/dt = 0 = N\,dc_h/dt + q(1+t)dc_f/dt$

Where dc_h/dt and dc_f/dt can be calculated from (A.8) using Cramers rule (det. denotes the determinant of (A.8)):

(A.10) $0 = \det^{-1} \{q(1+t)\ [(Nq(1 - \frac{(\theta-1)c_f}{(\bar{x}-c_f)}) - N\theta q(1+t)]\}$

Denoting the optimal tariff with T, this can be simplified to:

(A.11) $1 + T = \frac{1}{\theta} - \frac{(\theta-1)}{\theta} \frac{c_f}{(\bar{x}-c_f)}$

This can be transformed into equation (34) in the text by using the balance of trade equilibrium condition which implies $q = N(x-c_h)/c_f$. Multiplying and dividing this expression by $(\bar{x}-c_f)$ and using equation (16) to solve out for q and $(\bar{x}-c_h)/(\bar{x}-c_f)$ yields:

$$\text{(A.12)}\quad \frac{\bar{x}-c_f}{c_f} = q^{1+\frac{1}{\theta-1}} (1+s)^{\frac{-1}{\theta-1}} N^{-1}$$

Substituting (A.12) into (A.11) yields equation (34).

<u>The optimum tariff rate as a function of θ and N</u>

To derive an implicit expression for q in terms of t, s, and N, it is convenient to start again with the trade balance equation (17) and to use equation (15), substitute out c_h; this yields:

$$\text{(A.13)}\quad q = N\frac{\bar{x}}{c_f} - [q(1+t)]^{\frac{-1}{\theta-1}} N$$

Using (A.12) to substitute out $\bar{x}/c_f$, an implicit function $G(q, t, s, N) = 0$ is obtained:

$$\text{(A.14)}\quad G \equiv q^{\frac{\theta}{\theta-1}} (1+s)^{\frac{-1}{\theta-1}} - q + N - N[q(1+t)]^{\frac{-1}{\theta-1}} = 0$$

The partial derivatives of (A.14) are calculated below for further reference:

$$\text{(A.15)}\quad \frac{\partial G}{\partial \theta} = \frac{-1}{(\theta-1)^2} \Big\{ q^{\frac{\theta}{\theta-1}} (1+s)^{\frac{-1}{\theta-1}} [\ln(q) - \ln(1+s)] - N[q(1+t)^{\frac{-1}{\theta-1}} \ln(q(1+t)) \Big\}$$

$$\text{(A.16)}\quad \frac{\partial G}{\partial q} = \frac{\theta}{\theta-1} q^{\frac{1}{\theta-1}} (1+s)^{\frac{-1}{\theta-1}} - 1 - \left(\frac{-1}{\theta-1}\right) N(1+t)^{\frac{-1}{\theta-1}} q^{\frac{-\theta}{\theta-1}} < 0.$$

$$\text{(A.17)}\quad \frac{\partial G}{\partial N} = 1 - [q(1+t)]^{\frac{-1}{\theta-1}}$$

$$(A.18)\quad \frac{\partial G}{\partial t} = \frac{-1}{\Theta-1}N[q(1+t)^{\frac{-\Theta}{\Theta-1}}(1+t) \quad < \quad 0$$

$$(A.19)\quad \frac{\partial G}{\partial s} = \frac{-1}{\Theta-1}\, q^{\frac{\Theta}{\Theta-1}}\, (1+s)^{\frac{-\Theta}{\Theta-1}} \quad > \quad 0$$

From (A.16) and (A.19), dq/ds is positive since $dq/ds = -(\partial G/\partial s)/(\partial G/\partial q) > 0$;

and dq/dt is negative since by (A.16) and (A.18) $dq/dt = -(\partial G/\partial t)/(\partial G/\partial s) < 0$. To find the signs of $dT/d\Theta$ and dT/dN, it is first necessary to differentiate equation (25) which yields:

$$(A.20)\quad \frac{\partial T}{\partial \Theta} = \frac{1}{\Theta}\,[\frac{1}{-\Theta} + Nq^{\frac{-\Theta}{\Theta-1}}\,[\frac{1}{\Theta} + \frac{1}{1-\Theta}\ln q - \ln(1+s)] + \frac{\Theta dq}{q d\Theta}]]$$

$$(A.21)\quad \frac{\partial T}{\partial N} = \frac{1-\Theta}{\Theta}(1+s)^{\frac{1}{\Theta-1}}\,[q^{\frac{-\Theta}{\Theta-1}}\,[1 - \frac{\Theta}{\Theta-1}q^{-1}\,\frac{dq}{dN}]$$

If the foreign country does not impose a tariff, i.e., if $s = 0$, it follows that $q < 1$ and $q(1+t) > 1$. In this case $\partial G/\partial \Theta < 0$ and thus $dq/d\Theta = -(\partial G/\partial \Theta)/(\partial G/\partial q) < 0$; but this implies that $dT/d\Theta < 0$, see (A.20). In this case it is also apparent from (A.17) that $\partial G/\partial N < 0$ and

thus $dq/dN = -(\partial G/\partial N)/(\partial G/\partial q) < 0$ and thus from (A.21) $\partial T/\partial N > 0$.

To calculate the sign of dT/ds, the value of dq/ds has to be substituted into (28) which yields:

$$(A.22)\quad \frac{dT}{ds} = \frac{-N}{\Theta}(1+s)^{\frac{1}{\Theta-1}}\, q^{\frac{-\Theta}{\Theta-1}}$$

$$\{\frac{(1+s)^{-1}[\frac{\Theta}{\Theta-1}\, q^{\frac{1}{\Theta-1}}\, (1+s)^{\frac{-1}{\Theta-1}} - 1 + \frac{N}{\Theta-1}(1+t)^{\frac{-1}{\Theta-1}}\, q^{\frac{-\Theta}{\Theta-1}}] - \frac{\Theta}{\Theta-1}\, q^{\frac{\Theta}{\Theta-1}-1}\, (1+s)^{\frac{-1}{\Theta-1}-1}}{(\partial G/\partial q)}\}$$

After multiplying out the square brackets of the numerator the first and the last term of the numerator cancels out. The expression in the curled brackets is thus negative and since $(\partial G/\partial q)$ is negative it follows that $dT/ds < 0$ Q.E.D.

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