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<b>Authors(s)</b>	Neary, J. Peter
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**TRADE LIBERALISATION AND SHADOW PRICES  
IN THE PRESENCE OF TARIFFS AND QUOTAS**

by

**Peter Neary**

**Working Paper No. WP89/4**

April 1989

This paper was begun while I was visiting Queen's University, Kingston. For helpful comments and suggestions, I am grateful to Tatsuo Hatta and to seminar participants at Queen's, and at the Universities of Oslo and Western Ontario.

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## TRADE LIBERALISATION AND SHADOW PRICES

### IN THE PRESENCE OF TARIFFS AND QUOTAS

#### ABSTRACT

This paper examines the welfare effects of partial trade liberalisation when trade is restricted by either tariffs, quotas, or some combination of both instruments. Rules for optimal first- and second-best intervention are derived and illustrated (using a new geometric technique) in both small and large open economies. A general expression for shadow prices of factors of production, which applies in both small and large economies and with or without quotas, is also derived. Welfare paradoxes are possible whenever exogenous changes raise (resp. lower) imports of goods subject to trade restrictions which are below (resp. above) optimal levels.

(98 words)

**TRADE LIBERALISATION AND SHADOW PRICES**  
**IN THE PRESENCE OF TARIFFS AND QUOTAS**

**1. Introduction**

In recent years, international trade theory has developed an impressive array of tools for examining the welfare cost of tariff protection.<sup>1</sup> Yet, ironically, over the same period tariffs have lost the importance they once had as barriers to international trade. Under the auspices of the General Agreement on Tariffs and Trade and of regional free trade groupings such as the European Community, tariffs on trade at least between developed countries have been progressively reduced to extremely low levels. However, this has not meant that protectionist instincts have been totally abandoned. On the contrary, the reduction in average tariff levels has been accompanied by an explosion in the use of non-tariff barriers, especially quantitative restrictions. Although a large body of analysis has emerged dealing with quotas, it seems fair to say that their effects are still not as well understood as those of tariffs.<sup>2</sup>

In this paper, I attempt to provide a general framework within which the effects of both tariffs and quotas, in both small and large open economies, can be examined. This amounts to a generalisation in two directions of the results on the welfare effects of tariff cuts in small open economies

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<sup>1</sup> For up-to-date expositions, see Dixit and Norman (1980), Woodland (1982) and Dixit (1986).

<sup>2</sup> There is, of course, an extensive literature dealing with the issue of whether and in what circumstances tariffs and quotas are "equivalent." I give detailed references to this literature in Neary (1988a), where I also argue that the issue of equivalence refers to the properties of a particular equilibrium and does not throw light directly on the comparative statics responses of an economy subject to either tariffs or quotas. Anderson (1988) argues that tariffs and quotas are unlikely to be equivalent in practice.

obtained by Hatta (1977) and others. In addition, it turns out that the approach I have adopted lends itself easily to studying the effects of exogenous shocks (such as endowment or technology changes) in the presence of both tariffs and quotas. In all cases, the implications of quotas in isolation are found to be surprisingly straightforward.<sup>3</sup> It is the simultaneous presence of both tariffs and quotas, by far the most realistic situation, which poses the trickiest problems for analysis.

The plan of the paper is as follows. In Section 2 I introduce the framework to be adopted and look at the effects of tariff changes in a small open economy. The results of this section are not new, although my approach permits a more transparent derivation than any hitherto available and I also give a new diagrammatic illustration of the relationship between welfare and tariff levels. In Section 3, I extend both the algebraic and geometric analysis to allow for the simultaneous presence of tariffs and quotas and derive rules for welfare-improving trade liberalisation in this context.<sup>4</sup> Section 4 then extends the analysis of both tariffs and quotas to the large open economy: free trade is no longer the first-best policy but it is still possible to derive formulae for welfare-improving changes in trade policy which parallel those for the small open economy. Finally, Section 5 examines the effects of endowment changes and derives general expressions for shadow prices of factors of production; as a by-product, a number of different known results on immiserising growth are shown to be special cases of a general phenomenon: growth can lower welfare if it raises the levels of imports subject to tariffs which are above their optimal levels. The paper

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<sup>3</sup> This has been noted by Corden and Falvey (1985) and by Neary (1988a). In the latter paper I examine the effects of tariffs and quotas separately in a small open economy.

<sup>4</sup> After I had derived the results of this section, Tatsuo Hatta brought to my attention a paper by Falvey (1988), where similar results are obtained.

concludes with a summary and a discussion of how the results may be applied to a diverse range of issues, including economies with non-traded goods, international capital flows and increasing returns to scale.

## 2. Tariff Reform in a Small Open Economy

Consider a competitive small open economy trading  $n+1$  goods. One good is taken as numeraire and its price is set at unity and left implicit throughout. Some or all of the remaining  $n$  goods are subject to domestic trade restrictions which drive a wedge between domestic prices  $p$  and the fixed world prices,  $p^*$ . In this section, I shall refer to the vector of such wedges as tariffs,  $t$ , so that  $p = p^* + t$ , but this is only for expositional convenience: if good  $j$  is exported, for example, the model also allows for export taxes ( $t_j < 0$ ) or subsidies ( $t_j > 0$ ); the case of quantitative restrictions will be considered in Section 3.

The behaviour of the domestic economy can be summarised in terms of a trade expenditure function,  $E$ , defined as the excess of expenditure over GNP, both at domestic prices. The latter in turn are represented by standard expenditure and GNP functions respectively:<sup>5</sup>

$$(2.1) \quad E(p, u, v) \equiv e(p, u) - g(p, v).$$

Here  $u$  denotes aggregate utility or welfare (distribution effects are not considered in the paper) and  $g$  depends on the economy's technology and factor endowments,  $v$ . From standard properties of these functions, the price derivatives of the trade expenditure function are the economy's Hicksian net import demand functions:<sup>6</sup>

$$(2.2) \quad E_p(p, u, v) = e_p(p, u) - g_p(p, v) = m(p, u, v).$$

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<sup>5</sup>See Dixit and Norman (1980) and Woodland (1982) for textbook expositions.

<sup>6</sup>Subscripts denote partial derivatives throughout, with terms such as  $E_p$  representing a vector of first derivatives and terms such as  $E_{pp}$  a matrix of second derivatives. All vectors are column vectors and a prime (') denotes a transpose.

Equilibrium is characterised by equation (2.2) and by the condition that, at domestic prices, domestic spending should equal GNP plus tariff revenue:

$$(2.3) \quad E(p, u, v) = t'm.$$

I now wish to examine the welfare effects of arbitrary tariff changes. Totally differentiating (2.3) with  $v$  held constant and using (2.2) to cancel redistributive effects on existing imports yields:

$$(2.4) \quad dy = t'dm.$$

For convenience, I measure changes in utility or welfare in expenditure units throughout, writing  $dy$  for  $E_u du$ . Equation (2.4) thus shows that any change which raises the imports of tariff-restricted goods will raise welfare. Intuitively, protection reduces imports below their first-best levels; welfare will be raised by any measure which helps to reverse this process.

To proceed further, differentiate (2.2) (with  $v$  held constant) to get the change in the demand for imports:

$$(2.5) \quad dm = E_{pp} dp + x_I dy,$$

$$dp = dt \Rightarrow t' dt + t' E_{pp} dt + t' x_I dy = dy$$

where  $E_{pp}$  is the matrix of compensated price derivatives and  $x_I$  is the vector of income derivatives of demand ( $x_I = e_u^{-1} e_{pu} = E_u^{-1} E_{pu}$ ). Now substitute into

(2.4) (recalling that  $dp=dt$  for domestic policy changes in the small open economy) to obtain:

$$\text{so } dy - t' x_I dy = t' E_{pp} dt$$

$$(2.6) \quad (1 - t' x_I) dy = t' E_{pp} dt.$$

The coefficient of  $dy$  is the inverse of the "tariff multiplier" or "shadow price of foreign exchange," the former because it reflects the second- and subsequent round effects of a tariff increase in reducing import demand and tariff revenue; the latter because it measures the effect on welfare of a unit transfer of the numeraire good from abroad. (See Jones (1969) and Neary (1988a).)<sup>7</sup> This term equals unity under free trade and I will assume

<sup>7</sup> Fukushima (1981), following Hatta (1977), calls the coefficient of  $du$  the "aggregate income term evaluated at world prices": by homogeneity,  $x_{0I} + p \cdot x_I = 1$ , so the term can be written  $x_{0I} + p \cdot x_I$  (where  $x_{0I}$  is the income derivative

throughout that it is always positive.<sup>8</sup> Equation (2.6) therefore gives the well-known result that a radial tariff reduction ( $dt = t d\alpha$  where  $\alpha$  is a positive scalar and  $d\alpha$  is negative) must raise welfare.<sup>9</sup> It also demonstrates the well-known corollary that a non-uniform tariff reduction need not be welfare-improving (since the restrictions that  $E_{pp}$  is negative definite and  $dt$  non-positive do not allow us to sign the term  $t'E_{pp} dt$ ). In fact I will show below that, under weak conditions, it is always possible to find a welfare-reducing tariff reduction.

To investigate further the relationship between welfare and non-proportional tariff changes, consider next the classic second-best problem where not all tariff rates can be varied freely. For concreteness, disaggregate the import vector into two sub-vectors, labelled "1" and "2", and suppose for the present that tariffs on category 2 imports are positive and irremovable:  $t_2 = \bar{t}_2 > 0$  and  $dt_2 = 0$ . The right-hand side of (2.6) can therefore be expanded to give:

$$(2.7) \quad (1 - t'x_1)dy = (t_1'E_{11} + \bar{t}_2'E_{21}) dt_1,$$

where the  $E_{ij}$  terms are appropriate sub-matrices of the matrix of price responses  $E_{pp}$ . This illustrates the standard problem of the second-best: even a radial reduction in tariffs on the first category of imports ( $dt_1 = t_1 d\alpha_1$ ,  $d\alpha_1 < 0$ ) cannot be assured of a welfare improvement unless either  $t_2$  is zero (so all tariffs are reduced) or all the elements of the matrix  $E_{21}$

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of demand for the numeraire good and a dot denotes a vector inner product).

<sup>8</sup> From the previous footnote, a sufficient condition for this is that all goods be normal. Stability arguments can also be invoked to justify the assertion that the tariff multiplier be positive. See Foster and Sonnenschein (1970), Hatta (1977) and Fukushima (1981).

<sup>9</sup> Strictly speaking, welfare could be unaffected by such a change. To avoid tedious qualifications of this sort throughout the paper, I assume henceforward that there is some substitutability in either demand or supply between the numeraire and all other goods. This ensures that  $E_{pp}$  and its principal minors are non-singular and therefore negative definite, so that terms such as  $t'E_{pp}t$  and  $t_1'E_{11}t_1$  are negative scalars.



are zero (so the two categories of imports are separable in aggregate excess demand).<sup>10</sup> In order to proceed further, we can first set the coefficient of  $dt_1$  in (2.7) equal to zero and solve for the second-best optimal values of  $t_1$ :

$$(2.8) \quad t_1^0 = -E_{11}^{-1}E_{12}\bar{t}_2.$$

To see the implications of this, it is helpful to look at the special case where there is one good in each of the sub-categories of imports. Each term in (2.8) is therefore a scalar and (since  $E_{11}$  is negative) the sign of the relationship between  $t_1^0$  and  $\bar{t}_2$  hinges on the sign of the cross-price term  $E_{12}$ . Suppose for concreteness that the two goods are general equilibrium substitutes at all times, so that  $E_{12}$  is always positive. The determination of  $t_1^0$  is then as illustrated in Figure 1.<sup>11</sup> The upward-sloping line through OB represents the relationship between  $t_1^0$  and  $\bar{t}_2$  given by (2.8), while the constraint that  $\bar{t}_2$  cannot be reduced is represented by the vertical dashed line through A. Given this, the second-best optimal value of  $t_1$  is indicated by the point B. The intuition justifying a welfare improvement following an increase in  $t_1$  as we move from A to B can be seen by recalling equation (2.4). At A, protection imposes a welfare cost because imports of

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<sup>10</sup>The fact that separability avoids second-best problems was pointed out by Davis and Whinston (1965). Of course, it is very unlikely that restrictions of this sort could be met in practice. See Boadway and Harris (1977) and Jewitt (1981) for further discussion.

<sup>11</sup> Because (2.8) does not give a closed-form expression for  $t_1^0$ , the locus OB need not be a straight line. For the same reason, (2.7) does not guarantee that welfare must increase following an equiproportionate movement of the tariffs on the first category of goods towards their optimal second-best values (i.e., a policy change of the form  $dt_1 = (t_1 - t_1^0)d\alpha$ ). Instead, (2.7) should be interpreted as providing an algorithm for approaching the optimal second-best point. Writing the right-hand side of (2.8) as  $\psi(t_1, \bar{t}_2)$ , (2.7) may be written as follows:

$$(2.9) \quad (1-t'x_1)dy = \{[t_1 - \psi(t_1^0, \bar{t}_2)] + [\psi(t_1^0, \bar{t}_2) - \psi(t_1, \bar{t}_2)]\}'E_{11}dt_1.$$

If the trade expenditure function is quadratic in prices (so that Hicksian import demand functions are linear in prices),  $\psi$  is independent of  $t_1$  and all these problems disappear.

good 2 are "too low" relative to the free trade optimum. (Imports of good 1 are likely to be above their free trade level since the two goods are substitutes, but this imposes no welfare cost because  $t_1$  is zero at A.) The direct method of raising imports of good 2 would of course be to lower  $t_2$ , but this is precluded by assumption. There remains an indirect method: to raise the domestic price of its substitute, good 1, by imposing a tariff on it, so deflecting demand from good 1 to good 2. Naturally, this also serves to reduce imports of good 1 itself, but for a small tariff on good 1 the resulting welfare loss may be ignored. Only when point B is reached is the welfare gain from indirectly encouraging imports of good 2 exactly offset by the welfare loss from directly discouraging imports of good 1.

The relationship between  $t_1^0$  and  $\bar{t}_2$  is of interest less for itself than for the light it throws on the relationship between welfare and the values of both tariff rates. Note first that the choice of  $t_2$  as the fixed tariff rate was arbitrary and the role of the two tariff rates can be reversed. A series of steps identical to those which led to (2.8) then gives the optimal second-best tariff on good 2,  $t_2^0$ , when the tariff on good 1 is fixed at an arbitrary level  $\bar{t}_1$ :

$$(2.10) \quad t_2^0 = -E_{22}^{-1}E_{21}\bar{t}_1.$$

Bearing in mind that the direction of causation is now different, equation (2.10) can also be represented in Figure 1. Once again this locus must be upward-sloping provided the two goods are always substitutes; moreover it must be more steeply-sloped than the  $t_1^0$  locus implied by (2.8).<sup>12</sup> We can go further if we assume that for each value of  $\bar{t}_1$  and  $\bar{t}_2$  there is a unique second-best optimal value of the other tariff. For in that case there must be an iso-welfare contour tangential to the vertical line through B and

<sup>12</sup> When the two goods are substitutes, the  $t_2^0$  locus is more steeply-sloped than the  $t_1^0$  locus provided  $E_{11}E_{22} - E_{12}E_{21}$  is strictly positive. This must hold since I have assumed that  $E_{pp}$  is negative definite.

another tangential to the horizontal line through D. By appropriate choice of  $\bar{t}_1$  and  $\bar{t}_2$ , these can be linked to form a single iso-welfare contour which can also be extended into regions where either or both tariffs is zero.

This gives the cigar or potato shaped contour in Figure 1: the fact that it has an upward tilt follows from the assumption that the two goods are substitutes.<sup>13</sup> In this case, starting from any point in the positive quadrant which is either below the  $t_1^0$  locus (such as point H) or above the  $t_2^0$  locus (such as point G), it is possible to find a vector of tariff cuts which will reduce welfare. Of course, such perverse tariff cuts have to deviate significantly from equiproportionate cuts (movements towards O), which we know must raise welfare.

### 3. Tariff and Quota Reform in a Small Open Economy

In Section 2, I presented a simple framework within which all known results in the theory of tariff reform may be derived and illustrated.<sup>14</sup> I

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<sup>13</sup> When the  $E_{ij}$  coefficients of the import demand equations are constant, it can be shown that each iso-welfare contour encloses a convex set. Straightforward but tedious calculations show that:

$$\frac{d^2 t_1}{dt_2^2} = - \frac{A B}{C^2}$$

Here A equals  $E_{11}E_{22} - E_{12}E_{21}$ , which is positive as already noted; B equals  $t_1^2 E_{11} + 2t_1 t_2 E_{12} + t_2^2 E_{22}$ , which is negative, being a quadratic form in the negative definite matrix  $E_{pp}$ ; and C is proportional to  $\partial y / \partial t_1$ , and so is positive below the  $t_1^0$  locus. Hence along a given iso-welfare contour,  $dt_1/dt_2$  is increasing in  $t_2$  below the  $t_1^0$  locus and decreasing in  $t_2$  above it. This proves that the contour is concave to the origin and so encloses a convex set.

<sup>14</sup> The other result which I have not illustrated is that welfare must rise if the highest tariff rate is reduced, provided the good in question is a substitute for all other goods. This follows from (2.8), treating  $t_1$  as a scalar and making use of the homogeneity restriction:  $p_0 E_{01} + p_2 E_{21} = -p_1 E_{11} > 0$ , where the subscript "0" denotes the numeraire good. Substituting into (2.8) now gives:

$$(2.8') \quad \tau_1^0 = \sum \omega_j \tau_j$$

where the summation is over all goods (including the numeraire) except good 1 itself,  $\tau_j$  is the tariff rate on good  $j$  ( $\tau_j = t_j/p_j$ ) and  $\omega_j = -p_j E_{j1} / p_1 E_{11}$ . If

now wish to extend the analysis to allow for the coexistence of tariffs on some goods and quotas on others. (The case of quotas only is particularly simple, as we shall see.) Suppose therefore that category 1 goods are subject to tariffs while those in category 2 are subject to quotas. The domestic prices of the latter will therefore adjust to equate the economy's net import demands to the quota levels:

$$(3.1) \quad E_2(p_1, p_2, u, v) = \bar{m}_2.$$

Differentiating this, with  $v$  fixed, allows us to solve for changes in domestic prices:

$$(3.2) \quad dp_2 = E_{22}^{-1} (d\bar{m}_2 - E_{21} dp_1 - x_{2I} dy).$$

Now use this to derive a general equilibrium reduced form import demand function for category 1 goods:

$$(3.3) \quad dm_1 = E_{11} dp_1 + E_{12} dp_2 + x_{1I} dy$$

$$(3.4) \quad = \tilde{E}_{11} dp_1 + \tilde{x}_{1I} dy + E_{12} E_{22}^{-1} d\bar{m}_2.$$

Here I have introduced two new terms,  $\tilde{x}_{1I}$  and  $\tilde{E}_{11}$ , representing respectively the income and compensated price responsiveness of demand for imports of type 1, taking into account the induced changes in the home prices of type 2 imports:<sup>15</sup>

good 1 is a substitute for all other goods, then all the  $\omega_j$  are positive and so the optimal second-best tariff on good 1,  $t_1^0$ , is a true weighted average of the tariffs on all other goods. Equation (2.7) now becomes:

$$(2.7') \quad (1 - t^* x_I) dy = (\tau_1 - \sum \omega_j \tau_j) p_1 E_{11} dt_1,$$

implying that, if  $\tau_1$  is the highest tariff rate, welfare must rise if it is reduced. These results may also be illustrated in Figure 1 if the prices of both goods are normalised at unity so that the axes may be identified with  $\tau_2$  and  $\tau_1$ . It may be checked that, if good 1 is a substitute for all other goods, then the  $t_1^0$  locus must be less steeply sloped and the  $t_2^0$  locus must be more steeply sloped than a 45° line from the origin. It follows that a change in either tariff rate which induces a movement towards the 45° line must raise welfare.

<sup>15</sup> Identical expressions arise in the microeconomic analysis of consumer behaviour in the presence of rationing. See Neary and Roberts (1980). The only difference is that in the consumer case the actual prices of rationed goods are fixed and any exogenous shock changes only their virtual or demand

$$(3.5) \quad \tilde{x}_{1I} \equiv x_{1I} - E_{12} E_{22}^{-1} x_{2I}$$

$$(3.6) \quad \tilde{E}_{11} \equiv E_{11} - E_{12} E_{22}^{-1} E_{21}$$

Thus, an increase in income has the usual direct effect on the demand for type 1 goods, represented by  $x_{1I}$ ; in addition, it changes the demand for type 2 goods, to an extent determined by  $x_{2I}$ . In the model of the last section this induced changes in actual imports of type 2, but in the presence of binding quota constraints the adjustment must be borne by the domestic prices of those goods instead. Finally, these price changes spill over onto the demand for type 1 imports. With one good of each type, both of which are normal, the income responsiveness of demand for good 1 is greater in the presence of a quota constraint if and only if the two goods are substitutes in excess demand ( $E_{12} > 0$ ). An identical chain of reasoning applied to (3.6) shows that (with utility held constant) the price responsiveness of demand for good 1 is always algebraically greater (and so smaller in absolute value) irrespective of the sign of the cross-price term. This is, of course, a standard Le Chatelier type result.<sup>16</sup>

In other respects, the model is unchanged. In particular, equation (2.3) continues to hold, on the assumption that all the quota rents accrue to domestic residents. (As I have shown in Neary (1988a), the results are sensitive to this assumption. See also Anderson and Neary (1989).) Using (3.4) to eliminate  $dm_1$  from (2.4) therefore yields, after some manipulations:

$$(3.7) \quad (1 - t_1 \tilde{x}_{1I}) dy = t_1 \tilde{E}_{11} dt_1 + (t_2' + t_1' E_{12} E_{22}^{-1}) d\bar{m}_2.$$

Equation (3.7) can also be rewritten in an alternative way, making use of the

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prices; whereas here the domestic prices of the quota-constrained goods adjust.

<sup>16</sup> See Tobin and Houthakker (1950-51) and Neary and Roberts (1980) for further discussion.

formula for  $t_2^0$  from (2.10):

$$(3.8) \quad (1-t_1'x_{1I}-t_2^0x_{2I})dy = (t_1'E_{11}+t_2^0E_{21})dt_1 + (t_2-t_2^0)'d\bar{m}_2.$$

Consider first the shadow price of foreign exchange, the inverse of the coefficient of  $dy$  in either (3.7) or (3.8). It can evidently still be given a tariff multiplier interpretation and, as in Section 2, a sufficient condition for it to be positive is that all goods are normal in demand.<sup>17</sup>

Summarising:

*Proposition 1:* In the presence of tariffs and quotas, the shadow price of foreign exchange may be identified with the tariff multiplier evaluated either for goods subject to tariffs only (in which case the quota-constrained income derivative  $\tilde{x}_{1I}$  should be used) or for goods subject to trade restrictions (in which case the income derivatives for goods subject to quotas should be multiplied by the corresponding second-best optimal tariffs).

An immediate corollary is that, if quotas only are in place, the shadow price of foreign exchange simply takes on its free trade value of unity: an extra unit of foreign aid cannot have a secondary benefit by encouraging additional imports of protected goods.

Turning next to the effects of tariff reform in the presence of quotas, concavity of the trade expenditure function in prices ensures that the matrix expression  $E_{11}-E_{12}E_{22}^{-1}E_{21}$  is negative definite, so that a proportional reduction in all tariffs continues to be welfare-improving despite the presence of quotas. However, from the Le Chatelier principle, welfare rises less rapidly than if quotas are not in force (since the difference between

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<sup>17</sup> To show this, group all freely traded goods together as a composite numeraire good,  $x_0$ , the income responsiveness of demand for which is:  $\tilde{x}_{0I} = x_{0I}-E_{02}E_{22}^{-1}x_{2I}$ . The price-weighted sum of income responsivenesses of goods not subject to quotas is therefore:

$$(3.9) \quad p_0\tilde{x}_{0I} + p_1\tilde{x}_{1I} = p_0x_{0I} + p_1x_{1I} - (p_0E_{02}+p_1E_{12})E_{22}^{-1}x_{2I}$$

$$(3.10) \quad = p_0x_{0I} + p_1x_{1I} + p_2x_{2I} = 1.$$

Hence the coefficient of  $dy$  may be written as either  $p_0\tilde{x}_{0I}+p_1\tilde{x}_{1I}$  or  $p_0x_{0I}+p_1x_{1I}+p_2x_{2I}$ . Note that it is only the former expression which can be interpreted as the "aggregate income term evaluated at world prices."

$\bar{E}_{11}$  and  $E_{11}$  is itself negative definite). This is illustrated in Figure 2. The iso-welfare locus is the same as in Figure 1 and the locus MM represents equation (3.1) for a given value of  $\bar{m}_2$ ; thus, it shows how the implicit tariff on the quota-restricted good 2 depends on the actual tariff on good 1. The locus is upward sloping because the goods are substitutes (since a rise in  $t_1$  raises demand for good 2 and so forces its domestic price further above the world price); the locus has the same slope as an iso-welfare locus along the  $t_2$  axis (from (2.6) and (3.2) the slopes of both loci equal  $-E_{22}^{-1}E_{21}$  when  $t_1$  is zero); and at all other points it lies to the right of the iso-welfare locus. The latter property reflects the fact that, for a fixed quota, the optimal value of  $t_1$  is zero. Finally, the Le Chatelier property is reflected in the fact that, starting from the point E (where good 1 is subsidised), welfare rises faster with a cut in the absolute value of  $t_1$  if  $t_2$  is fixed (as in the move from E to F) than if  $t_2$  adjusts to keep imports of good 2 equal to the quota level (as in the move from E to J). Summarising:

*Proposition 2:* In the presence of fixed quotas on some imports, reduction of all tariffs is always welfare-improving but welfare rises more slowly than when quotas are not in force.

Another perspective on the difference between tariffs and quotas is highlighted by noting that, starting from point R, there are two alternative ways of reaching the iso-welfare locus drawn. If the tariff on good 2 is fixed then  $t_1$  should be raised to the second-best optimal level shown by B; whereas if a quota on good 2 is fixed then  $t_1$  should be reduced to zero (as shown by the point V).

Finally, what of quota reform when tariffs are in force? As (3.8) shows, the optimal second-best quota levels are not zero; rather, they equal those levels which will induce implicit tariffs equal to the optimal second-best levels,  $t_2^0$ . Nonetheless, quota reform is "easier" than tariff reform in the sense that a small change in a quota can be recommended solely

on the basis of a comparison between the current and the optimal second-best levels of the implicit tariff on that good; i.e., the presence of quotas on other goods can be ignored. Summarising:

*Proposition 3:* In the presence of irremovable tariffs, welfare is maximised by setting quotas not at zero but at levels which generate implicit tariffs equal to the optimal second-best tariffs. If many goods are subject to quotas, the direction of welfare-improving reform can be determined by applying the formula for the optimal second-best tariff on that good; i.e., other goods subject to quotas can be ignored.

#### 4. Tariff and Quota Reform in a Large Open Economy

The key feature of the analysis so far is that world prices have been treated as fixed. This greatly simplifies the analysis of piecemeal policy reform, and it is necessary to examine how much of the intuition for the small open economy case survives when world prices are allowed to vary. The first difference is that differentiation of (2.3) now yields not (2.4) but rather the following:

$$(4.1) \quad dy = t'dm - m'dp^*.$$

This is a familiar decomposition of welfare changes into a volume-of-trade and a terms-of-trade effect. Since the latter is now endogenous, the most natural way to proceed is to relate it to changes in the net import vector of the rest of the world.<sup>18</sup> This can be done in terms of the derivatives of the foreign inverse demand functions:

$$(4.2) \quad dp^* = p_m^* dm^*.$$

Since home and foreign net imports must sum to zero,  $m+m^* = 0$ , this yields:

$$(4.3) \quad dy = (t' + m'p_m^*) dm.$$

Setting the coefficient of  $dm$  equal to zero gives an expression for the

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<sup>18</sup> In fact, most textbook expositions proceed instead by relating  $dm^*$  to  $dp^*$  via the derivatives of the foreign direct import demand functions. This leads to explicit expressions for the optimal quota rather than the optimal tariff vector and obscures the similarity between the small and large economy cases. For a similar treatment to that here, see Dixit (1986) and Neary (1987).



optimal tariff vector, or, more precisely, for the vector of implicit tariffs implied by the optimal quota vector:<sup>19</sup>

$$(4.4) \quad (t^{00})' = -m'p_m^*$$

This states that, at the optimum, a unit increase in the permitted level of imports of any good should yield a change in quota rents which is exactly matched by the welfare cost of the induced changes in the terms of trade.

This might be thought to imply that all optimal tariffs must be positive, but this is not in fact the case.<sup>20</sup> Consider, for example, the optimum tariffs on the first group of commodities (given by the first row of the matrix equation (4.4):

$$(4.5) \quad (t_1^{00})' = -m_1'p_{11}^* - m_2'p_{21}^*$$

As with the formulae for optimal second-best tariffs in Section 2, this expression shows that a unit increase in the permitted level of imports of category 1 goods has a direct and an indirect effect on the terms of trade. The former effect, represented by  $-m_1'p_{11}^*$ , represents the impact of liberalising imports of type 1 on the terms of trade for that category itself. Assuming that the foreign inverse net demand functions for type 1 goods are downward-sloping, the terms of trade deteriorate, so encouraging a positive optimal tariff. However, the indirect effect could go the other way, if other import goods are "Antonelli complements" for type 1 goods: the elements of the matrix  $p_{21}^*$  are then positive (a reduced availability of type

<sup>19</sup> If foreign demands are inelastic, there may not be a one-to-one correspondence between tariffs and quotas. (See Melvin (1986) for a discussion of some of the problems to which this gives rise.) I ignore this problem in what follows.

<sup>20</sup> As Feenstra (1986) and Bond (1987) have noted, a positive value even for total tariff revenue at the optimum can only be guaranteed if foreign income effects can be ignored: from (4.4),  $(t_1^{00})'m = -m'p_m^*$ , for which a positive value is assured only if the matrix  $p_m^*$  is negative definite. The latter in turn equals  $(E_{pp}^* + x_1^*m')^{-1}$  so that foreign income effects could in principle lead to a negative value for tariff revenue at the optimum. Bond (1987) discusses reasons why this outcome is unlikely.

1 goods abroad reduces the demand prices for type 2 goods there) so that liberalising imports of type 1 goods improves the terms of trade on type 2 goods. If this effect dominates (which is more likely the less important are imports of type 1 goods) then the optimal trade intervention on type 1 goods could be a subsidy rather than a tariff.

So far, I have characterised the first-best optimum, which is the same whether tariffs or quotas are the control instruments. The analysis also applies to quota reform if imports of all goods (other than the numeraire) are assumed to be directly controllable. But this is a highly implausible situation. To expand the analysis to other cases, consider first the problem of tariff reform. Equation (4.3) still applies, of course, but the import vector is now controlled indirectly only. To relate changes in imports to changes in tariff levels, first differentiate the import demand equation (2.2). This gives:

$$(4.6) \quad dm = E_{pp} dp^* + E_{pp} dt + x_I dy.$$

Now use (4.2) to eliminate  $dp^*$  and collect terms to give the general equilibrium import demand function:

$$(4.7) \quad dm = A(E_{pp} dt + x_I dy), \quad \text{where: } A \equiv (I_n + E_{pp} p_m^*)^{-1},$$

and  $I_n$  is the identity matrix of order  $n$ . Here  $A$  may be interpreted as a *matrix import demand multiplier*: it shows how a unit increase in domestic demand for imports for whatever reason is enhanced by the induced change in the terms of trade. For example, with only one import good, a rise in domestic import demand raises both world and home prices for imports (assuming  $p_m^*$  is negative, so a fall in  $m^*$  raises  $p^*$ ), which tends to reduce home demand; and this process continues as the multiplier chain works itself out. In the small open economy, with world prices fixed, the matrix  $p_m^*$  is zero and so  $A$  reduces to the identity matrix. In giving intuitive explanations for the derivations which follow, I shall assume that the



multiplier matrix is positive but there is no guarantee that this is the case.<sup>21</sup>

To find the welfare consequences of tariff changes, I first rewrite (4.3) in a form which emphasises that an increase in the permitted level of imports of a particular good raises welfare if and only if the current implicit tariff on that good exceeds the "optimal" tariff, calculated by evaluating the formula for the optimal tariffs, (4.4) at the initial point:

$$(4.8) \quad dy = \hat{t}' dm, \quad \text{where:} \quad \hat{t} \equiv t - t^{00}.$$

Substituting from (4.7) and collecting terms now yields a general expression for the welfare effects of tariff changes in a large open economy:

$$(4.9) \quad (1 - \hat{t}' Ax_I) dy = \hat{t}' AE_{pp} dt.$$

Considering first the coefficient of  $dy$ , this is clearly the inverse of the shadow price of foreign exchange in a large open economy. An exogenous unit transfer of the numeraire good<sup>22</sup> has an impact effect on home demand for importables of  $x_I$  which leads to a total effect of  $Ax_I$ . This in turn gives rise to a welfare gain (over and above the direct welfare gain from the transfer itself) if and only if the tariffs on these goods are above their optimal levels. As in Section 2, this term could be negative if tariffs are very high or if demand is highly inferior (in the sense that the total demand responses, the elements of the vector  $Ax_I$ , are negative). Since such a state would be unstable under plausible adjustment assumptions, I will assume henceforward that it does not occur.

Turning to the right-hand side of (4.7), it shows that the expression

<sup>21</sup> If foreign income effects can be ignored and home and foreign tastes are identical,  $p_m^*$  equals  $(E_{pp})^{-1}$  and so the multiplier equals  $I_n/2$ . In this case, all the results of the small open economy carry over directly to the large open economy case.

<sup>22</sup> For this interpretation to be valid, the transfer should come from "nature" rather than from the foreign country. The effects of the latter kind of transfer depend inter alia on the foreign income derivatives of demand,  $x_I^*$ .

for the cost of tariff protection in a small open economy (the right-hand side of (2.6) in Section 2) must be modified in the large open economy in two respects. First, the matrix  $E_{pp}$  measures only the impact effect of tariff changes on import demand; with world prices variable this must be multiplied by the A matrix to get the full impact on home demand for importables. Secondly, as with the shadow price of foreign exchange, the social valuation of changes in import demand hinges on whether tariff levels are above or below the optimal. (Of course, the small open economy is just a special case, in which the optimal tariff levels are zero.) While this intuition is clear, it is unfortunately not possible to derive detailed results on tariff reform analogous to those derived in Section 2, since the matrix product  $AE_{pp}$  has no convenient properties except in very special cases.<sup>23</sup> Summarising:

*Proposition 4:* Raising a tariff in a large open economy increases welfare if it increases imports of goods subject to tariffs which are above their optimal levels (or if it reduces imports of goods subject to tariffs which are below their optimal levels).

The last case to consider is where some goods are subject to tariffs and some to quotas. With quotas on category 2 imports, the general equilibrium import demand functions for category 1 goods given by (3.4) continue to apply. The key difference is that the change in world prices for category 1 goods must be eliminated using the first row of equation (4.2). (Note that, as long as the quotas on imports of category 2 goods continue to bind, changes in their foreign prices  $p_2^*$  have no impact on the domestic economy.) Collecting terms now yields:

$$(4.10) \quad dm_1 = A_1[\tilde{E}_{11}dt_1 + \tilde{x}_{11}dy + (E_{12}E_{22}^{-1} - \tilde{E}_{11}p_{12}^*)d\bar{m}_2],$$

where  $\tilde{x}_{11}$  and  $\tilde{E}_{11}$  were defined in (3.4) and (3.5) and:

$$(4.11) \quad A_1 \equiv (I_1 + E_{11}p_{11}^*)^{-1}$$

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<sup>23</sup> Thus it is not necessarily true that a proportional movement of all tariffs towards their first-best levels must raise welfare.

is the matrix import demand multiplier for category 1 imports. From (4.10), changes in tariffs and in real income have effects on home demand for imports of category 1 goods which are exactly analogous to those already discussed in equation (4.7). The new feature in equation (4.10) is the effect of changes in the permitted levels of imports of category 2. As in the small open economy (see (3.4)), a rise in  $\bar{m}_2$  drives down the domestic prices of quota-constrained goods and tends to lower demand for type 1 goods if and only if they are substitutes (so the elements of  $E_{12}$  are positive). In addition, the effects of an increase in  $\bar{m}_2$  on the foreign country must be taken into account. By reducing the availability of type 2 goods abroad, the demand prices of type 1 goods there are increased if and only if the two types of goods are Antonelli substitutes (i.e., the elements of the matrix  $p_{12}^*$  are negative). This in turn raises their prices at home, so tending to reduce home import demand. Note that these two effects reinforce each other if the two categories of goods are *net Hicksian* substitutes at home and *gross Antonelli* substitutes abroad; although even if tastes are identical at home and abroad the two senses of substitutability need not coincide.<sup>24</sup> Finally, these impact effects on home demand for imports of type 1 goods must be grossed up by the appropriate matrix multiplier,  $A_1$ , to obtain the full effect of a change in  $\bar{m}_2$  on demand for  $m_1$ .

The final step is to substitute from (4.10) into (4.8) to obtain:

$$(4.12) \quad (1 - \hat{t}_1' A_1 \tilde{x}_{11}) dy = \hat{t}_1' A_1 \tilde{E}_{11} dt_1 + \{ \hat{t}_1' A_1 (E_{12} E_{22}^{-1} - \tilde{E}_{11} p_{12}^*) + \hat{t}_2' \} d\bar{m}_2.$$

Comparing this with (4.9), it is clear that the presence of quotas on type 2 goods does not change the expressions for the shadow price of foreign

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<sup>24</sup> If the foreign country can be represented in the same aggregate way as I have characterised the domestic economy, then, by the Slutsky equation, the matrix  $p_{12}^*$  can be expressed as  $(E_{pp}^* + x_{12}^* m')$ .<sup>-1</sup> Clearly the relationship between off-diagonal elements of this matrix and the corresponding off-diagonal elements of the matrix  $E_{pp}^*$  is not a simple one. See Deaton (1979) for a discussion of Antonelli substitutes and complements and for further references.

exchange or for the welfare effects of changes in tariffs on type 1 goods. Of course, the price and income derivatives  $E_{pp}$  and  $x_I$  must be replaced by their general equilibrium counterparts,  $\tilde{E}_{11}$  and  $\tilde{x}_{1I}$ , which reflect the induced changes in home prices of quota-constrained goods. With this qualification, the intuition developed for the tariffs-only case carries over completely. By contrast, the welfare effects of quota changes are greatly complicated by the presence of tariffs. (Compare the coefficient of  $d\bar{m}_2$  in (4.12) with (4.8).) It is still true that a relaxation of quotas is desirable to the extent that the domestic prices of quota-constrained goods are above the levels implied by the optimal tariffs (i.e., to the extent that the elements of  $\hat{t}_2$  are positive). But, in addition, the effect of quota changes on imports of goods subject to tariffs must be taken into account, as the first term in the coefficient of  $d\bar{m}_2$  in (4.12) shows. In particular, if the two categories of goods are substitutes (in both senses - Hicksian at home and Antonelli abroad) then a relaxation of quotas on type 2 goods tends to reduce imports of type 1, which tends to lower welfare if the tariffs on those goods are above their optimal levels. While the principles which should govern quota liberalisation are relatively straightforward, therefore, it is clear that the informational requirements for a welfare-improving quota reform are almost as demanding as those for a desirable change in tariffs.<sup>25</sup>

Summarising:

*Proposition 5: The criteria for tariff reform are essentially unaffected by the presence of quotas. By contrast, in the presence of tariffs, quota reform must take account of the induced effects on demand for tariff-constrained imports and on whether the tariffs on those goods are above or below their optimal levels.*

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<sup>25</sup> I say "almost" as demanding, because there is still one sense in which quota reform requires less information than tariff reform: the decision to relax or tighten a quota on a particular good can be taken without knowledge of whether the quotas on other goods are above or below their optimal levels.

## 5. Shadow Prices of Factors of Production: A Unified Treatment

The techniques developed in previous sections for the evaluation of changes in trade policy instruments can easily be extended to the analysis of the welfare effects of factor accumulation.<sup>26</sup> Moreover, it is convenient to consider this issue in a general framework which allows for variable world prices. The results for a small open economy then emerge as special cases.

Returning to the aggregate budget constraint, (2.3), differentiate it again, allowing both  $p^*$  and  $v$  to be variable. This yields, instead of (4.1):

$$(5.1) \quad dy = w'dv + t'dm - m'dp^*.$$

Here  $w$  is the vector of competitive factor prices, which measure the marginal social valuation, or shadow prices, of factors of production in a small open economy with no distortions. Now, allowing for the endogeneity of world prices as in the last section leads to a generalisation of (4.8):

$$(5.2) \quad dy = w'dv + \hat{t}'dm.$$

This allows a general statement of the conditions under which market and shadow factor prices coincide:

*Proposition 6:* Shadow and market prices of factors of production coincide when either all goods (other than the numeraire) are subject to fixed quotas or when all trade restrictions are at their optimal levels.

Naturally, these conditions are extremely stringent. To consider the implications of factor accumulation when non-optimal trade policies are in force, it is necessary to endogenise changes in imports. Returning to the import demand functions, (2.2), differentiate them making allowance for changes in factor endowments:

$$(5.3) \quad dm = E_{pp} dp + x_I dy - g_{pv} dv.$$

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<sup>26</sup> The analysis of this section applies to technological progress as well as to factor accumulation, provided  $w$  is reinterpreted as the marginal private valuation of the technological improvement.

Here  $g_{pv}$  is the matrix of Rybczynski derivatives, giving the output effects (at constant commodity prices) of increases in factor endowments: other things equal, an increase in domestic production of a good reduces import demand for it. Of course, prices in general are not fixed and it is necessary to substitute for  $dp^*$  from the foreign inverse import demand functions (4.2). A series of steps analogous to those which led to (4.7) now yields:

$$(5.4) \quad dm = A(E_{pp} dt + x_I dy - g_{pv} dv).$$

Finally, substitute from (5.4) into (5.2), with tariffs held fixed, and collect terms to obtain:

$$(5.5) \quad (1 - \hat{t}' A x_I) dy = (w' - \hat{t}' A g_{pv}) dv.$$

This gives an extremely general expression for shadow prices of factors of production which is also very easy to interpret. (Note that, following standard convention, I refer to the coefficients of  $dv$  as shadow factor prices; these must be grossed up by the shadow price of foreign exchange, the inverse of the coefficient of  $dy$ , to obtain the full effects of factor accumulation on welfare.) Essentially, shadow prices diverge from market prices to the extent that (a) factor accumulation (taking account of induced changes in world prices, as indicated by the  $A$  matrix) alters the domestic output of goods which are subject to tariffs; and (b) the tariffs differ from their optimal levels. The implications of (5.5) may be summarised as follows:

**Proposition 7:** Shadow factor prices are lower than domestic market prices if factor accumulation tends to raise the output of goods on which tariffs are above their optimal levels or to lower the output of goods on which tariffs are below their optimal levels.

The wide applicability of this result may be seen by noting that two well-known examples of "immiserising growth" or negative shadow factor prices are special cases of (5.5). First, the result of Edgeworth (1894, pp. 40-41)



(subsequently reworked by Johnson (1955) and Bhagwati (1958)), whereby a large country loses because growth leads to a worsening of its terms of trade, corresponds to the case where factor accumulation is export-biased (so that the output of importables falls) but tariffs are below their optimal levels. Secondly, the result of Johnson (1967), whereby growth lowers welfare in a small open economy where tariffs are in force, corresponds to the case where factor accumulation is import-biased (the output of importables rises) and tariffs are above their optimal levels.

The simplicity of (5.5) contrasts noticeably with most textbook expositions of immiserising growth. (See, for example, Dixit and Norman (1980), pp. 133-142 and Woodland (1982), pp. 401-409.) To relate the two, consider how (5.5) may be simplified when actual tariffs are zero. Since the two countries are now adopting symmetric trade policies, it makes sense to specify their behaviour symmetrically. This can be done by replacing  $p_m^*$  from the Slutsky equation for the foreign country:

$$(5.6) \quad p_m^* = (E_{pp}^* + x_I^* m')^{-1}$$

This allows a rewriting of the key term  $\hat{t}'A$  as follows:<sup>27</sup>

$$(5.7) \quad \hat{t}'A = (1 - m'S^{-1}x_I^*)^{-1} m'S^{-1},$$

where  $S$  is shorthand for  $-(E_{pp} + E_{pp}^*)$ , the substitution matrix for the world as a whole. Substituting this into (5.5) yields eventually:

$$(5.11) \quad [1 + m'S^{-1}(x_I - x_I^*)]dy = [(1 - m'S^{-1}x_I^*)w' + m'S^{-1}g_{pv}]dv.$$

Finally, in the scalar case, this may be written in a familiar form by

<sup>27</sup> The steps leading to (5.7) are as follows:

$$(5.8) \quad \hat{t}'A = -(t^{00})'(I + E_{pp} p_m^*)^{-1}$$

$$(5.9) \quad = -m' p_m^* (p_m^*)^{-1} (p_m^* + E_{pp})^{-1}$$

$$(5.10) \quad = m'(S - x_I^* m')^{-1}.$$

This leads to (5.11) using a standard property of partitioned inverse matrices.

multiplying by  $S$  and grouping terms differently:<sup>28</sup>

$$(5.12) \quad [S+m(x_I-x_I^*)]dy = [S + m \frac{w}{p} (\epsilon-\mu^*)]dv.$$

The coefficient of  $dy$  is now the Marshall-Lerner term (see Jones (1961)); while the coefficient of  $dv$  illustrates a result of Johnson (1955) and Bhagwati (1958): in the absence of tariffs, the foreign marginal propensity to consume home imports  $\mu^*$  ( $\equiv px_I^*$ ) must exceed the elasticity of domestic supply of importables  $\epsilon$  ( $\equiv pg_{pV}/w$ ) if growth is to be immiserising.

The final result to consider is the effect of factor accumulation in the presence of both tariffs and quotas. As in Section 3, we first disaggregate the import demand functions (5.3):

$$(5.13) \quad dm_1 = E_{11}dp_1 + E_{12}dp_2 + x_{1I}dy - g_{1V}dv,$$

$$(5.14) \quad dm_2 = E_{21}dp_1 + E_{22}dp_2 + x_{2I}dy - g_{2V}dv.$$

As before, quotas on type 2 goods make their domestic prices a function of domestic variables only. Inverting (5.14) and eliminating  $dp_2$  from (5.13), with  $m_2$  held fixed, therefore yields:

$$(5.15) \quad dm_1 = \tilde{E}_{11}dp_1 + \tilde{x}_{1I}dy - \tilde{g}_{1V}dv,$$

where:

$$(5.16) \quad \tilde{g}_{1V} \equiv g_{1V} - E_{12}E_{22}^{-1}g_{2V},$$

which gives the total effect of endowment growth on domestic supply of type 1 goods, taking account of the cross-price effects arising from induced changes in the supply of the quota-constrained type 2 goods. Finally, the endogeneity of world prices of type 1 goods must be taken into account, and a series of steps identical to those which led to (4.10), except that tariff and quota levels are assumed fixed, gives:

$$(5.17) \quad dm_1 = A_1[\tilde{x}_{1I}dy + \tilde{g}_{1V}dv].$$

Substituting into (5.2) and collecting terms now gives the welfare effects of

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<sup>28</sup> Allowing for differences in notation, equation (5.11) is the same as equation (19) on p. 134 of Dixit and Norman and equation (5.12) is the same as equation (8) on p. 404 of Woodland.

endowment growth in the presence of fixed tariffs and quotas:

$$(5.18) \quad (1 - \hat{t}'_1 A_1 \tilde{x}_{1I}) dy = (w' - \hat{t}'_1 A_1 \tilde{g}_{1V}) dv.$$

The resemblance between shadow factor prices in this case and in the case of tariffs only (as given by (5.5)) is striking. In particular, with quotas on type 2 goods fixed, the impact of endowment growth on the markets for those goods and the gap between actual and optimal implicit tariffs on them (measured by the  $\hat{t}_2$  vector) can be ignored. All that matters is the impact of factor accumulation on the domestic supply of tariff-constrained goods, taking account of the import demand multiplier  $A_1$ , and whether or not tariffs on type 1 goods are above or below their optimal levels. Summarising:

*Proposition 8:* The conditions stated in Proposition 7 apply without any qualification whatsoever to factor accumulation in the presence of both tariffs and quotas; the impact on the markets for quota-constrained goods can be ignored, except insofar as they influence  $\tilde{g}_{1V}$ , the supply effect on goods subject to tariffs.

This proposition represents a considerable generalisation of the theory of immiserising growth and shadow prices of factors of production.

## 6. Summary and Conclusion

All the results of this paper are implications of a single general equation which combines equations (4.12) and (5.18) above: the relationship between aggregate welfare and changes in tariffs, quotas or factor endowments. These results therefore extend existing work in two distinct directions: they apply to both small and large open economies and they allow for the simultaneous presence of tariffs and quotas. Yet this increased generality has not been achieved at the cost of a significant increase in complexity. As well as developing a new and convenient diagrammatic technique for the small open economy case, I have shown that the mathematical expressions can be given a clear and intuitive interpretation in all cases. The key question throughout, as equation (4.8) shows, is how any exogenous

change affects the levels of imports which are not subject to optimal tariffs. If, for example, imports whose tariffs are above their optimal levels are reduced, then welfare tends to fall. Intuitively, tariffs which are "too high" lead to imports which are "too low"; any reduction in imports reduces welfare still further. This indirect effect must be balanced against the direct effect of the change, which is typically beneficial in those cases where common sense would lead us to expect it to be so: a movement of tariffs or quotas towards their optimal levels or an increase in factor endowments. Hence apparent paradoxes, such as a welfare-reducing partial tariff cut or quota relaxation in a small open economy or an immiserising increase in factor endowments, can be understood in terms of their by-product effects on imports which are not subject to optimal trade restrictions. This perspective permits a major synthesis and extension of existing results within a common framework.

The results obtained also have implications for a number of other issues in the welfare analysis of open economies. The first of these is the welfare analysis of economies in which some goods are non-traded. In the past it has been thought necessary to extend any given set of results in trade theory to allow for non-traded goods. However, this is not necessary in the present context, once it is recognised that non-traded goods can be viewed as goods subject to quotas at a zero level. (This is the converse of the fact that goods subject to quotas are, from an analytic point of view, *non-traded at the margin*.) Thus, all the results of this paper which take account of the presence of quotas continue to apply when some goods are non-traded. Of course, the derivatives of demand and supply functions for traded goods must be treated as general equilibrium derivatives which take account of the induced changes in non-traded goods prices (see, for example, the discussion of equations (3.5) and (3.6)). This is likely to pose

additional computational problems in practical applications of the results but it does not affect the ease with which the general principles can be interpreted.

A second application of the results is to the analysis of economies in which some factors as well as goods are internationally mobile. Provided factors move endogenously in response to international differences in factor rewards, they are formally identical to internationally traded goods. Thus the present paper's focus on tariffs and quotas on goods trade can be reinterpreted as applying to tariffs (or quotas) on goods in combination with investment taxes (or quantitative controls) on factor flows. The details of this reinterpretation must be approached with care but in many cases the interpretation of the results is made even easier.<sup>29</sup>

Yet a third application of the results is to the case where some goods are produced domestically subject to increasing returns to scale. It would be very desirable to extend the results obtained to non-competitive economies but, despite considerable progress in this direction in recent years, no satisfactory general equilibrium model in which firms earn positive profits in equilibrium has yet been devised. However, for models in which free entry of firms drives profits to zero, it is possible to construct an aggregate GNP function<sup>30</sup> and so the results of this paper can be applied. First steps in this direction (confining attention to the small open economy and without considering quotas) have been taken by Helpman and Razin (1983) for the case of monopolistic competition and by Neary (1988b) for the case of

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<sup>29</sup> For example, the condition for two goods to be general equilibrium substitutes (i.e., for the term  $E_{12}$  to be positive) implies (with good 2 reinterpreted as an internationally mobile factor) that good 1 uses factor 2 intensively. Details of this and other applications to the case of tariffs and investment taxes are set out in Neary (1977), where I first explored the properties of diagrams like Figures 1 and 2.

<sup>30</sup> This approach was initiated by Helpman (1984). See also Markusen and Svensson (1986) and Markusen and Wigle (1989).

increasing returns to scale which are external to firms.<sup>31</sup> This seems likely to prove the most fruitful direction in which further extensions of the theory of trade policy should be attempted.

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<sup>31</sup> This approach to modelling increasing returns to scale follows a long tradition in international trade theory. See for example Jones (1967) and Ethier (1982).

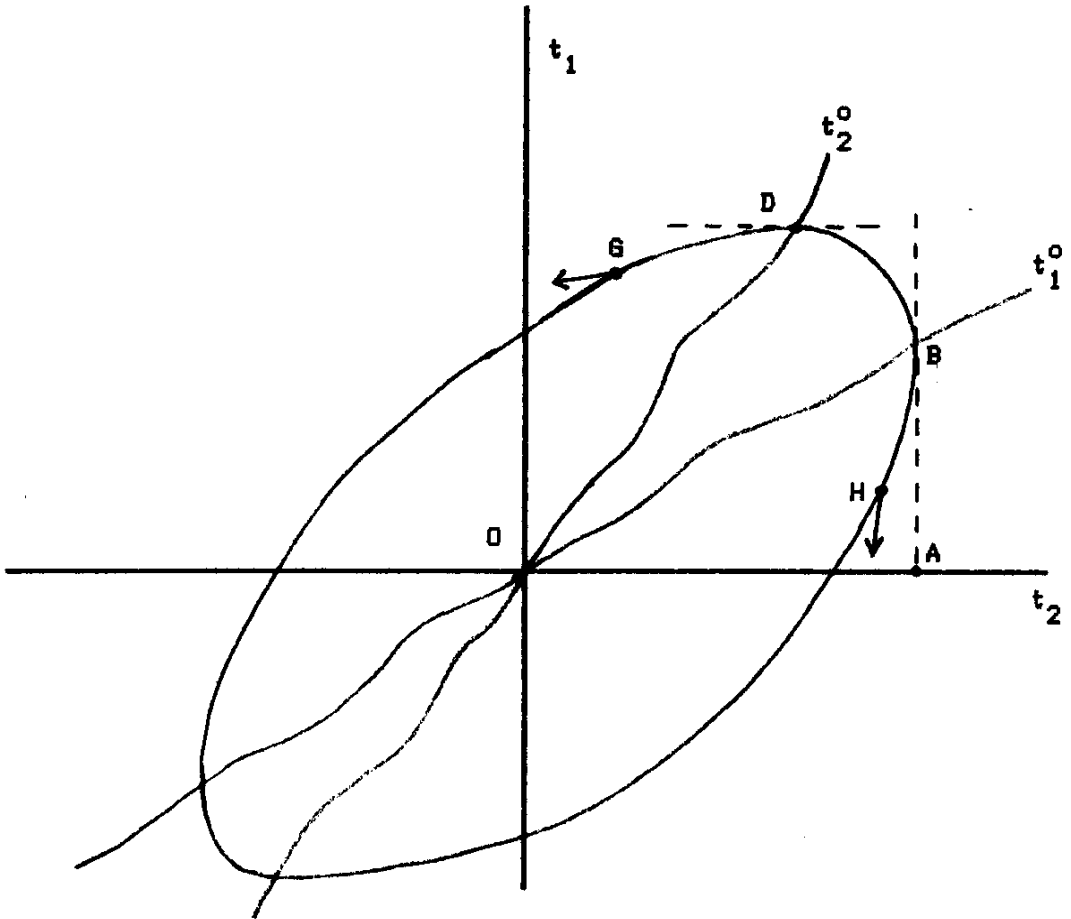


Figure 1: Iso-welfare locus in tariff space when goods 1 and 2 are substitutes. The arrows from points G and H illustrate tariff cuts which lower welfare

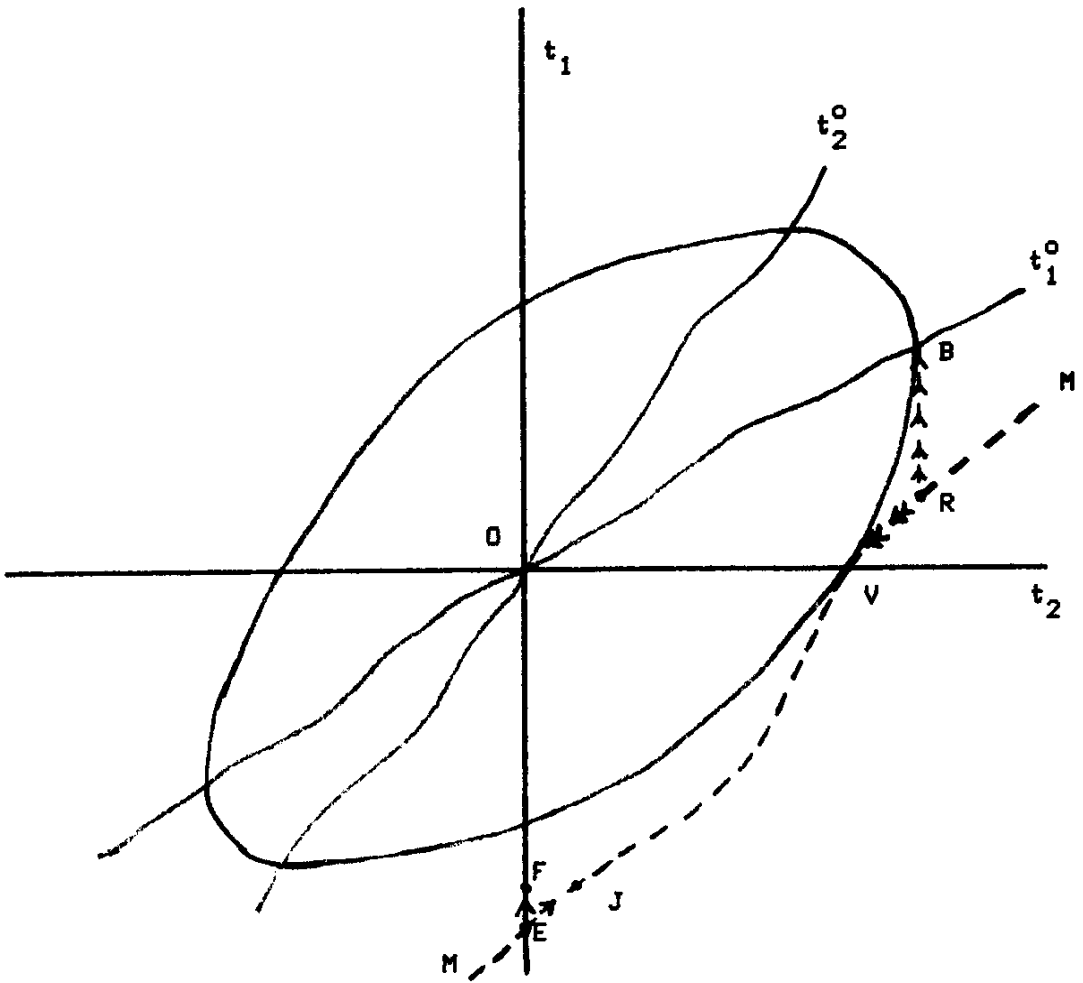


Figure 2: Iso-welfare and iso-import-volume loci in tariff space when goods 1 and 2 are substitutes



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