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LDCs, International Capital Mobility and the Shadow Price of Foreign Exchange under Tariffs and Quantitative Restrictions

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For a very general, small open less-developed country with a convex production set, the shadow price of foreign exchange is lower with tariffs on one subset of imports and VERs on another than with tariffs and quotas. This is true with and without international capital mobility. Furthermore, the introduction of international capital mobility reduces the shadow price of foreign exchange in the presence of tariffs and quotas and raises the shadow price of foreign exchange in the presence of tariffs and VERs when tariff- and quantity-constrained goods are both capital intensive or both not capital intensive and are substitutes in import demand.

I. Introduction

For years now, several less developed countries (LDCs), such as Chile, have imposed foreign exchange constraints while others, such as Malaysia, in the wake of the Asian Financial Crisis have or are considering imposing capital controls. Furthermore, LDCs face a foreign exchange constraint deriving from limited export earnings. With the large flows of capital into and out of these economies, LDCs are sometimes unable to import critical inputs and the production supplies of some goods are interrupted. For many LDCs the scope of their production is limited and consequently, a greater need arises than in developed countries for calculating a correct valuation of this scarce resource called foreign exchange. This correct valuation is significantly complicated by the imposition of price and quantity constraints on commodity trade. As a result, adjustments to formulas should be made in the empirical calculation of shadow prices so as not to obtain biased estimates. However, the role of rapid international capital movements to and from these LDCs has not been adequately addressed in the shadow price literature. The purpose of this paper is to fill this gap. In particular, we find that the phenomenon of international capital movements leads to *Le Chatlier* results.

Another contribution of this paper is the consideration of multiple trade restrictions. While there has been an overall fall in tariffs in the world, such price controls continue to be in place in spite of the continued efforts of the WTO and its predecessor GATT. Quantitative trade restrictions, however, have grown both in variety and scale. Typically, LDCs employ many forms of both price constraints, including import tariffs, *and* quantity controls that take the form of import quotas or voluntary export restraints (VERs). Chandra and Naqvi (1997, p.959) have asked "If the existing resource allocation is determined by a trade-policy-

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induced distortion, does the receipt of a unit transfer of the numeraire good increase or decrease welfare when it changes the existing allocation?"[1] This paper uses the shadow price of foreign exchange as a social valuation criterion to ascertain the welfare effects of the receipt of a transfer under multiple trade restrictions and international capital mobility.

The shadow price of foreign exchange is defined as the welfare effect of the receipt of a unit of a numeraire good transferred from abroad. Considerable attention has been paid to evaluating these shadow prices by, for example, Dasgupta, Marglin, and Sen (1972), Batra and Guisinger (1974), Neary (1988), and Chao and Yu (1995) because the total effect of any policy shock on social welfare is the *impact effect* combined with the corresponding shadow price of foreign exchange.

The principal contribution of this paper is to advance this literature by explicitly considering VERs and international capital mobility. The results reported here may be seen as extending two strands of the literature. First, in the absence of international capital mobility, Neary (1995, p.539), calculates the shadow price of foreign exchange in the presence of tariffs and quotas. We also consider the case of tariffs and VERs, and compare our results with his. Second, Neary (1988) considers only tariffs or only quotas or only VERs in the presence of international capital mobility; we consider tariff-quota and tariff-VER pairs when capital is internationally mobile. In particular, in the presence of quotas or VERs on the one hand, and tariffs on the other, we determine the value of the shadow price of foreign exchange, both when capital is internationally mobile and when it is not. We also compare the magnitudes of these shadow prices.

For a very general Arrow-Debreu, but *open*, economy, containing an arbitrary number of goods and factors, intermediate- and joint-goods production, a linearly homogenous and convex production set for the economy, and perfect competition: international capital mobility reduces the shadow price of foreign exchange in the presence of tariffs and quotas when tariff- and quota-constrained goods are substitutes in import demand and are both capital intensive or both not capital intensive. In the presence of a tariff on one class of goods, the introduction of a VER on another dass of goods reduces the shadow price of foreign exchange. In addition, international capital mobility raises the shadow price of foreign exchange in the presence of tariffs and VERs when tariff- and VER-constrained goods are both capital intensive or both not capital intensive and are substitutes in import demand. Furthermore, the shadow price of foreign exchange is lower under tariffs and VERs than under tariffs and quotas. This is true both with and without international capital mobility, and regardless of the factor-intensity ranking of the two types of goods.

In Section II we set up a very simple model, in Section III obtain the shadow-price values from which we deduce the conclusions stated above, and in Section IV summarize our results.

1. Chandra and Naqvi (1997) deal with the instance of one set of trade restrictions. In the present analysis we deal with the reality of multiple trade restrictions.

II. The Model

Consider a small, open economy with an arbitrary number of goods and factors, intermediate- and joint-goods production, a linearly homogenous and convex production set for the economy, and perfect competition. Assume that this country imports two categories of goods, Category 1 subject to tariff restrictions, and Category 2 subject to binding quotas or VERs. In addition, Category 1 goods contain an untaxed numeraire good. Domestic and world price vectors of the importable goods are represented by $p' = (p_1' \; p_2')$, $p^{*\prime} = (p_1^{*\prime} \; p_2^{*\prime})$, respectively. Let $t' = (t_1' \; t_2')$, and $p_i = p_i^* + t_i$, so that t_i is the difference between domestic and world prices, and $m' = (m_1' \; \overline{m}_2')$ is the import-demand vector, where $i = 1, 2$ and t_1 is the vector of tariffs on class 1 goods.[2] The world prices, p_1^* and p_2^*, are parameters insofar as the country is small.

Whereas the quantity of tariff-restricted goods imported, m_1, is endogenously determined, the amount of quota- or VER-constrained goods, $\overline{m}_2$, is exogenously fixed by government policy. Since these quantity constraints are binding for Category 2 goods, the domestic relative prices are strictly greater than the corresponding world prices, so that $t_2 = (p_2 - p_2^*) > 0$ is determined endogenously in the economy. The tariff-revenue and quota/VER-rents are $t_1' m_1$ and $t_2' \overline{m}_2$, respectively. The tariff revenue accrues to the home government, and is assumed to be rebated lump-sum to the household sector. Similarly, the quota rents accrue to domestic importers, or to the home government in the case of quota-license auctioning, and are entirely retained within the country. In a regime of voluntary export restraints, however, foreign exporters voluntarily cut back their supply of exports to the home country, so foreigners receive the higher price p_2, above the free trade level p_2^*. In this instance, the VER rents, $t_2' \overline{m}_2$, accrue to foreigners, and are lost by the home country. For the small, open home country, we examine both the case with and without international capital mobility.

1. Structure

The national expenditure function, denoted $e(p, u)$, is defined over domestic prices and the utility of the home-country representative agent. The GDP function summarizes production in the economy and is described by $g(p, k)$, where k is the total amount of capital employed in the home country. The gross domestic product depends on domestic relative prices, factor endowments, and technology, which is assumed to be convex and characterized by constant returns to scale. From standard properties of the expenditure and GDP functions, we know that the Hicksian demand functions are $e_p(p, u)$, and the vector of import-competing production is $x = g_p(p, k)$.[3]

2. All vectors are column vectors and a prime (') indicates a transpose.

3. See Neary (1985). The derivatives of the expenditure function with respect to prices are Hicksian (compensated)

The Rybczynski Theorem implies that in the scalar case, $dx/dk > 0$ if the commodity in question is capital intensive. In a multi-commodity and multi-factor setting, $x_k = g_{pk}(p,k)$ is called the Rybczynski matrix, and if the elements of this matrix are positive, we say that the commodities under consideration are capital intensive. In our formulation, as also in Neary (1995), the factors of production, k, called capital are those factors which are at least potentially mobile internationally.

The Hicksian *import demand* functions are the difference between domestic demand and output, given by m_1 in the case of imports subject to tariffs, and $\overline{m}_2$ for imports subject to quantity restrictions such as quotas or VERs. These are, respectively,

$$m_1 = e_1(p,u) - g_1(p,k), \tag{1a}$$

and

$$\overline{m}_2 = e_2(p,u) - g_2(p,k). \tag{1b}$$

With k denoting total capital employed in the home economy, and $\overline{k}$ representing the quantity of domestically owned capital, the foreign owned capital employed in the home country is $(k-\overline{k})$. Let r represent the domestic rental rate of capital, and r^* the fixed world rate. Then, net factor payments to foreigners are $(k-\overline{k})'r$. The economy we consider is small not only in world commodity markets, but also in world capital markets.

The budget constraint of the economy in the presence of tariffs and *quotas* is

$$e(p,u) = g(p,k) + t_1'm_1 + t_2'\overline{m}_2 - (k-\overline{k})'r + T, \tag{2}$$

where T is the transfer received by the home country in terms of the numeraire good. However, if tariffs and *VERs* are in force, the budget constraint becomes

$$e(p,u) = g(p,k) + t_1'm_1 - (k-\overline{k})'r + T, \tag{3}$$

since VER rents, $t_2'\overline{m}_2$, accrue to foreign exporters, and are lost by the home country. A transfer, T, is included in each budget constraint so as to obtain the shadow price of foreign exchange. In both (2) and (3), national expenditure must equal GDP *plus* any revenue

demand functions are $e_p(p,u)$, and the second derivative, $e_{pp}(p,u)$ is negative definite. The derivative of the Hicksian demand functions with respect to utility is the income effect vector, $e_{pu}(p,u)$.

The price derivatives of the GDP function are the output supply vectors, $g_p(p,k) = x(p,k)$. The prices of the mobile factors are $g_k(p,k) = r(p,k)$. The effect of factor price changes on factor demand is given by $g_{kk}(p,k) = r_k(p,k)$, which is negative definite. Also, $dx = x_1dp_1 + x_2dp_2 + x_kdk$, where $x_1 = g_{p1}$; $x_2 = g_{p2}$ *and* $x_k = g_{pk}$.

generated from trade restrictions, *less* net factor payments to foreigners *plus* any receipt of transfers. Further, the domestic rental rate of capital is given by

$$r = g_k(p,k). \tag{4}$$

Clearly, m_1 and $\overline{m}_1$ are imports of final goods. Also, the international transfer, *T*, amounts to receiving *T* units of the rest-of-the-world's GDP in terms of the numeraire commodity, which itself is a final good. International capital mobility, on the other hand, refers to cross-country movements of factors of production. As for the relationship between the monetary foreign exchange rate and the social value of the receipt of a unit of the numeraire commodity, they are the same in a long-run full-stock equilibrium under a mild separability condition.[4]

The five Equations, (1a), (1b), (2), (3), and (4), constitute the complete model. By utilizing these relationships, we obtain expressions (5) and (6) below for the relevant shadow prices. Given that our sole interest here is in the determination of the shadow prices of foreign exchange, all exogenous variables other than the transfer, *T*, are deliberately not made explicit, because these other variables are not permitted to change in the analysis presented here.[5]

2. General Welfare Effects

In this subsection, we provide a sketch of the derivation of (5) and (6), which are the fundamental expressions required for determining the shadow prices of foreign exchange. In the presence of both tariffs and quotas, the relevant budget constraint is (2). Totally differentiating this constraint, and noting that the change in welfare measured in numeraire-good units is $dy = e_u du$, we obtain[6]

$$dy = t_1' dm_1 - (k - \overline{k})' dr + dT, \tag{5}$$

where dy is the change in real income. Equation (5) continues to hold with or without international capital mobility when tariffs and quotas are in force. When capital is internationally immobile, domestic rental rates of capital are endogenously determined, $dr \neq 0$, and total capital in use is fixed, so that, $dk = 0$. In this case, we make the simplifying assumption that $k = \overline{k}$, so that $(k - \overline{k})' dr$ is zero despite $dr \neq 0$.

4. For more on the monetary versus real shadow price of foreign exchange, see Dusansky, Franck and Naqvi (2000).

5. Anderson and Neary (1992) examine partial rent retention in a model of coexisting policy regimes, but without international capital mobility.

6. From (2) we have $e_u du + e_p dp = g_p dp + g_k dk + t_1' dm_1 + m_1' dt_1 + \overline{m}_2' dt_2 - (k - \overline{k})' dr - r' dk + dT$. Noting that $dp_1 = dt_1$, since p_1^* is fixed on world markets for a small country, $d\overline{m}_2 = 0$, since quota levels are held constant throughout the analysis, using (1a) and (1b), and $g_k dk = r dk$ we obtain (5).

In the presence of tariffs and VERs the relevant budget constraint is (3) and VER rents are now lost by the home country. The analogous expression to (5) is

$$dy = -\overline{m}_2' dp_2 + t_1' dm_1 - (k - \bar{k})' dr + dT, \tag{6}$$

which continues to hold with or without international capital mobility.[7] In the appendix we obtain expressions (A4), (A5), (A6), and (A7) for dp_2 and dm_1 with and without international capital mobility, and by substituting these expressions into (5) and (6), we obtain the relevant shadow prices (7), (8), and (9) below.

III. The Shadow Price of Foreign Exchange

We now employ (5), (6), (A4), (A5), (A6) and (A7) to derive the welfare implications of the receipt of a unit transfer, namely the effect of a change in T. First consider the case of coexisting tariffs and quotas. In the presence of international capital mobility, $dr = dr^* = 0$, and k is variable. Utilizing this, substituting the expression for dm_1 from (A7) into (5), and rearranging, we obtain the shadow price of foreign exchange in the presence of tariffs *and* quotas,

$$\frac{dy}{dT} = [1 - t_1' \tilde{\tilde{x}}_{1I}]^{-1}, \tag{7}$$

where, under international capital mobility, $\tilde{\tilde{x}}_{1I} = x_{1I} - (e_{12} - \tilde{g}_{12})(e_{22} - \tilde{g}_{22})^{-1} x_{2I}$ is the vector of income effects capturing the presence of both international capital mobility and a second trade policy in place, where $x_{iI} = e_u^{-1} e_{iu}$, for $i = 1, 2$ is the vector of income effects for importable goods, which is in keeping with the notation in Neary (1995).We assume that importables are normal goods.[8] In (7) $\tilde{g}_{ij} = [g_{ij} - g_{ik} g_{kk}^{-1} g_{kj}]$ for $i, j = 1, 2,$ is the additional output-supply response, over and above g_{ij} in the presence of international capital mobility.

For $i = j$, $g_{ik} g_{kk}^{-1} g_{kj}$ is a matrix quadratic form in a negative definite matrix g_{kk}^{-1}, and is, therefore, unambiguously negative definite. And for $i \neq j$, this is a bilinear form in the same negative definite matrix. Consider $i \neq j$ when category i goods are capital intensive and category j goods are not capital intensive. Then the generalized Rybczynski derivatives, g_{ik}, and the Stopler-Samuelson derivatives, g_{kj}, are of different signs and $\tilde{g}_{ij} < g_{ij}$ algebraically, since $g_{ik} g_{kk}^{-1} g_{kj}$ is unambiguously positive.[9] In summary, international

7. Since VER rents accrue to foreign residents, the manipulations used above yield (6). The total differential of (3) with tariffs and VERs is $e_u du + e_p dp = g_p dp + g_k dk + t_1' dm_1 + m_1' dt_1 - (k - \bar{k})' dr - r' dk + dT.$

8. Neary (1988, p.720 footnote 13).

9. Recall the Stopler Samuelson Theorem states: An increase in the relative price of a good, raises the real reward to the factor used intensively in the production of that good, and reduces the reward to the other factor used

capital mobility induces an enhanced output-supply response that increases the total output-supply response of category i goods to a change in the price of category j goods if category $i = j$, *or* if $i \neq j$ *and* i, j are both not capital intensive or both capital intensive. The presence of these effects shows that, unlike the case of pure tariffs or pure quotas, international capital mobility *does* affect the shadow price of foreign exchange when both tariffs *and* quotas are in force.[10]

The explanation is intuitive. An increase in income directly raises the demand for tariff-ridden goods. In addition, there is an indirect effect from the induced change in the domestic prices of quota-constrained goods. Binding quotas prevent the rise in imports, so that domestic prices of quota-constrained goods change. This change in domestic prices leads to a change in the demand for goods subject to tariffs. Equation (7) relates the exogenous shock of the transfer to a change in welfare in the presence of tariffs and quotas under international capital mobility. This result can be compared with Neary's (1995, p.538 Equation 2.16) when endowments and trade policy are held fixed in a small economy, that is, $dy/dT = [1 - t_1' \tilde{\tilde{x}}_{1I}]^{-1}$, where $\tilde{\tilde{x}}_{1I} = x_{1I} - (e_{12} - g_{12})(e_{22} - g_{22})^{-1} x_{2I}$. Neary's (1995) result for the shadow price of foreign exchange when capital is immobile in the presence of tariffs *and* quotas is contained as a special case of (7) and can be derived by substituting (A6) into (5) with $dk = 0$ and $k = \bar{k}$, so that $(k - \bar{k})' dr$ is zero despite $dr \neq 0$. The key difference is that (7) contains the additional output-supply response from the introduction of international capital mobility. Comparison of (7) with Neary's (2.16) reveals that:

Proposition 1*: International capital mobility reduces the shadow price of foreign exchange in the presence of tariffs and quotas when tariff- and quota-constrained goods are substitutes in import demand and are both capital intensive or both not capital intensive.*

The greater output supply response when capital is internationally mobile requires a smaller price rise for the quota restricted goods in response to the receipt of a transfer and therefore less substitution of tariff-ridden imports for quota-restricted imports.[11]

Relating changes in welfare to an exogenous receipt of a transfer from abroad in the presence of tariffs and VERs is similarly straightforward. In the absence of any distortions, the shadow price of foreign exchange equals unity. The shadow price of foreign exchange when capital is immobile in the presence of VERs *and* tariffs is derived by substituting (A4) and (A6) into (6) with $dk = 0$, $k = \bar{k}$, and rearranging to obtain

$$dy/dT = [1 - \overline{m}_2' (e_{22} - g_{22})^{-1} x_{2I} - t_1' \tilde{\tilde{x}}_{1I}]^{-1}. \qquad (8)$$

unintensively in the production of that good.

10. Here g_{ij} refers to the economy that does not experience international capital mobility, and $\tilde{g}_{ij}$ to the economy that does. Similarly, x_{1I} is employed when one trade policy is in place, $\tilde{x}_{1I}$ when more than one. If there is international capital mobility and more than one trade policy is in place, we use $\tilde{\tilde{x}}_{1I}$.

11. Propositions 1, 4 and 5 compare two otherwise identical economies with the same initial general equilibrium configuration. That is, these results are local in character.

Three interesting results are revealed by (8). If tariffs are the only trade restriction in force, the value of a unit transfer is $dy/dT = [1 - t'x_1]^{-1} > 1$, as in Neary (1988, p.720 Equation 11), and is the tariff multiplier as in Jones (1969). When VERs are the only trade restriction in force, the shadow price of foreign exchange is $dy/dT = [1 + \overline{m}\, S^{-1} x_1]^{-1} < 1$ where $\overline{m}$ for Neary (1988, p.720 Equation 12), would be $\overline{m}_2$ in our case, and S equals $(g_{pp} - e_{pp})$. In a VER regime, the VER rents are not returned to domestic residents and therefore do not constitute part of domestic income. A transfer from abroad raises welfare by less than the amount of the transfer, so that we have

Proposition 2*: If capital is internationally immobile, in the presence of a tariff on one class of goods, the introduction of a VER on another class of goods reduces the shadow price of foreign exchange.*

The immediate corollary is

Corollary 1*: If capital cannot move internationally, in the presence of a VER on one class of goods, the introduction of a tariff on another class of goods raises the shadow price of foreign exchange.*

The shadow price of foreign exchange when capital is immobile in the presence of VERs *and* tariffs, (8), is unambiguously lower than with tariffs *and* quotas. This is due to the loss of VER rents by domestic residents and leads to

Proposition 3*: In the absence of international capital mobility, the shadow price of foreign exchange is lower under tariffs and VERs than under tariffs and quotas.*

While (8) holds in the case when capital is not internationally mobile, we now turn to the determination of the shadow price of foreign exchange in the presence of tariffs *and* VERs under international capital mobility. When capital is internationally mobile, $dr = 0$ and $dk \neq 0$. Noting that $dt_1 = dp_1$, and substituting (A5) and (A7) in (6), we have,

$$\frac{dy}{dT} = [1 - \overline{m}_2'(e_{22} - \tilde{g}_{22})^{-1} x_{2I} - t_1' \tilde{\tilde{x}}_{1I}]^{-1}. \qquad (9)$$

Equation (9) gives us the shadow price of foreign exchange in the presence of tariffs and VERs in the presence of international capital mobility, and thereby extends the results presented by Anderson and Neary (1992) and by Neary (1995). From comparing (8) and (9) we have

Proposition 4: *International capital mobility raises the shadow price of foreign exchange in the presence of tariffs and VERs when tariff- and VER-constrained goods are both capital intensive or both not capital intensive and are substitutes in import demand.*

The greater output supply response under international capital mobility results in a smaller price rise for the VER constrained goods and less substitution toward the tariff constrained goods, as in the tariff and quota case this reduces the shadow price of foreign exchange. In addition, prices of VER-constrained goods rise less due to the greater output supply response so that less VER rents are lost and the welfare loss is reduced. This raises the shadow price of foreign exchange and outweighs the reduction from tariff revenues gained by substitution. Comparing (7) and (9) leads to

Proposition 5*: In the presence of international capital mobility, the shadow price of foreign exchange is lower under tariffs and VERs than under tariffs and quotas regardless of the factor-intensity ranking of the two types of goods.*

In any case, the shadow price of foreign exchange under VERs *and* tariffs will be less than under quotas *and* tariffs due to the loss of VER rents.

IV. Conclusion

In the 1970's, and 1980's a substantial flow of international lending went to less-developed countries (LDCs). Again in the early 1990's some Latin American and Asian countries received large infusions of foreign capital. Especially because of their abundant labor, these LDCs experienced faster rates of growth than the major industrial countries of the world. Additionally, unsustainable expectations and periods of economic uncertainty have produced significant outflows of foreign capital from many of these same LDCs. Given the importance of foreign direct investment to the sustained growth of LDCs, the accurate valuation of this foreign exchange granting the reality of multiple trade restrictions is essential to avoid bias of shadow price estimates. However, the role VERs and particularly that of international capital mobility has not been adequately addressed in the previous shadow price literature. This paper fills a portion of this gap. In particular, we have found that the phenomenon of international capital movements leads to *Le Chatlier* results. Second, the presence of so called voluntary export restraints reduces the shadow price value of foreign exchange.

Appendix

In this appendix, we utilize Equations (1)-(4) to obtain the shadow price of foreign exchange. Since our sole concern is the shadow price of foreign exchange, changes in tariffs-, quotas- or VER-levels are not permitted, so that $dt_1 = d\overline{m}_2 = 0$. Equations (5) and (6) contain several endogenous variables. We will first address a change in the general equilibrium import-demand function for tariff-constrained imports, dm_1.

First, totally differentiate the vector of import-demand functions, (1a). This results in

$$dm_1 = (e_{12} - g_{12})dp_2 + x_{1I}dy - g_{1k}dk, \qquad \text{(A1)}$$

where $x_{iI} = e_u^{-1} e_{iu}$, *for* $i = 1, 2$ is the vector of income effects for importable goods, g_{pk} is a matrix of Rybczynski derivatives that give the output effects of increases in factor supplies, and e_{ij} and g_{ij} represent how the demand and output respectively, of importables of good i responds to changes in the domestic price of good j. In the absence of international capital mobility, $dk = 0$. When capital is internationally mobile, so that the domestic rental, r, equals the fixed world rental, r^*, $dr = dr^* = 0$, then from (4) we obtain

$$dk = -(g_{kk})^{-1}(g_{k2})dp_2 \tag{A2}$$

as the change in capital used in the home country. Substituting this into Equation (A1) and rearranging yields:

$$dm_1 = (e_{12} - \tilde{g}_{12})dp_2 + x_{1I}dy. \tag{A3}$$

Equations (A1) and (A3) are used extensively in the derivations for the tariff/quota case *and* the tariff/VER case. In (A3), $\tilde{g}_{ij} = [g_{ij} - (g_{ik})(g_{kk})^{-1}(g_{kj})]$ *for* $i, j = 1, 2$. The first term g_{ij} represents how the output of importables of good i responds to changes in the domestic price of good j. The other terms in the matrix represent an additional supply response in the economy due to an endogenous capital flow. This matrix is a bilinear form in a negative-definite matrix for $i \neq j$ and a quadratic form in a negative-definite matrix for $i = j$. Consider $i \neq j$ when category i goods are capital intensive and category j goods are not capital intensive. Then the generalized Rybczynski derivatives, g_{ik}, and the Stopler-Samuelson derivatives, g_{kj}, are of different signs and $\tilde{g}_{ij} < g_{ij}$ algebraically, since $g_{ik} g_{kk}^{-1} g_{kj}$ is unambiguously positive. In summary, international capital mobility induces an enhanced output-supply response that increases the total output-supply response of category i goods to a change in the price of category j goods if category $i = j$, *or* if $i \neq j$ *and* i, j are both not capital intensive or both capital intensive.

The next step is to eliminate endogenous changes in unit-quota/VER rents, dp_2, from Equations (A1) and (A3). Totally differentiate Equation (1b) for $i = 2$ and invert the import-demand function for $\overline{m}_2$. This results in

$$dp_2 = -(e_{22} - g_{22})^{-1} x_{2I} dy, \tag{A4}$$

when capital is internationally immobile and

$$dp_2 = -(e_{22} - \tilde{g}_{22})^{-1} x_{2I} dy, \tag{A5}$$

in the presence of international capital mobility. Substituting (A4) into (A1) and rearranging gives the quota/VER-constrained import-demand function for m_1,

$$dm_1 = \tilde{x}_{1I}\, dy, \tag{A6}$$

where $\tilde{x}_{1I} = x_{1I} - (e_{12} - g_{12})(e_{22} - g_{22})^{-1} x_{2I}$. The coefficient of dy represents the direct and indirect income responsiveness for category-one goods. An increase in income raises the demand directly for category-one goods plus there is an indirect effect from the induced change in domestic prices of category-two goods. Binding quotas (VERs) prevent the rise in imports of category-two goods. Therefore, domestic prices adjust for the quota (VER) constrained goods. This change in domestic prices leads to a change in demand for type-one goods. This result is identified in Neary (1995, p.536 Equation 2.11).

The matrix $(e_{12} - g_{12})(e_{22} - g_{22})^{-1}$ shows how relaxing the quota (VER) on category-two goods changes the demand (in a general equilibrium sense) for category-one imports. Relaxing the quota (VER) leads to a fall in the domestic price of the quota (VER) constrained goods. This tends to lower the import demand for the tariff-restricted category of goods provided the two categories of goods are substitutes in import demand.

International capital mobility reduces this effect if the two categories of goods are both capital intensive or both not capital intensive. Substituting (A5) into (A3), and collecting terms, we obtain

$$dm_1 = \tilde{\tilde{x}}_{1I}\, dy, \tag{A7}$$

where $\tilde{\tilde{x}}_{1I} = x_{1I} - (e_{12} - \tilde{g}_{12})(e_{22} - \tilde{g}_{22})^{-1} x_{2I}$. If category-one goods and category-two goods are substitutes in import demand and are both capital intensive or both not capital intensive, then $(e_{12} - \tilde{g}_{12})(e_{22} - \tilde{g}_{22})^{-1}$ is smaller than $(e_{12} - g_{12})(e_{22} - g_{22})^{-1}$, in absolute value, and the elements of the vector $\tilde{\tilde{x}}_{1I}$ are smaller than $\tilde{x}_{1I}$.

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