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ABSTRACT

This paper analyzes the impact of differential tariffs on consumption and investment in a specific factors model of a small open economy in which capital is accumulated over time. Particular attention is devoted to the welfare aspects, highlighting the cost of the intertemporal distortions produced by protective trade policies. Several specific welfare propositions are obtained. First, tariff protection is shown to create short-run benefits but long-run costs in welfare. Secondly, the second-best policy for the two tariffs is characterized. Finally, several propositions summarizing the implications of our analysis for tariff reform are derived.

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I. INTRODUCTION

Theoretical work on capital accumulation under protective trade regimes has produced a substantial literature on the subject of "immiserizing growth." Much of the motivation for this literature derives from the experience of developing countries, since as Johnson (1967, p. 152) noted, the "possibility of income-reducing growth is relevant to the fact that countries industrializing by means of protectionist and import-substituting policies are frequently dissatisfied with the results." Most theoretical analyses of immiserizing growth, including Bhagwati (1973), Brecher and Diaz-Alejandro (1977), and Casas (1985), have stressed the ambiguous welfare consequences of an *exogenous* capital inflow (such as an unrequited transfer) in the presence of a tariff. In an important recent article, Neary and Ruane (1988) have analyzed the full equilibrium effects of an *endogenous* tariff-induced capital inflow. In so doing, they have provided an important clarification to the literature on immiserizing growth by showing that, unlike an exogenous capital inflow, a tariff-induced capital inflow will never be welfare improving in a standard convex economy.

Despite the use of the term "immiserizing growth," existing studies have conducted their analyses using a static framework, in which all capital accumulation is assumed to occur instantaneously. In this paper we extend the welfare analysis of immiserizing growth to a dynamic setting in which capital accumulates gradually over time. Like Neary and Ruane, we are concerned with the full equilibrium effects of tariff-induced capital inflows, and we discuss how the welfare consequences of tariff policy can be captured by a welfare integral over the time path of discounted instantaneous utility. We are unaware of any previous such dynamic welfare analysis of tariff protection.

The model we have chosen to analyze is the Jones (1971)—Samuelson (1971) specific factors model of trade in which the import-competing sector uses capital and the export sector uses land, both in conjunction with intersectorally mobile labor. This choice of production structure orients the analysis toward developing countries and, for a similar reason, was the structure chosen by Dixit and Grossman (1982) to model the effect of a uniform tariff in a model with multistage production, and by Brecher and Findlay (1983) to examine immiserizing growth in the presence of a tax on foreign investment.

The model includes three elements of the production technology that allow us to extend the welfare analysis of tariffs within a specific factors setting in several new directions. The first element is the specification of differential tariffs on the import–competing sector and on the imported investment good. Although previous welfare analyses of protection have focused on the case of uniform tariffs, differential tariffs on capital goods and consumer goods are the rule, rather than the exception, in developing countries.[1]

The second element of the model's technology is the specification of an endogenous labor supply. Although trade models typically assume an exogenously–given labor supply, we find that the elasticity of labor supply is an important determinant of the welfare cost of tariffs. We also find that the elasticity of labor supply is an important determinant of the initial employment effects of a tariff and that these initial effects may be reversed over time as the capital stock adjusts.

The third element of the model's technology is an adjustment cost function that is increasing in the rate of capital accumulation. The use of such a function has been made in the microeconomics literature beginning with the work of Lucas (1967), Treadway (1969) and others in the 1960s, and has been incorporated into trade models beginning with the work of Frenkel and Rodriguez (1975). We show that one determinant of the welfare cost of protection is the convexity of the adjustment cost function, since the speed (and, hence, the welfare cost) of the economy's adjustment to changes in tariffs depends in part on the marginal installation costs of new capital.

We provide a positive analysis of the dynamic adjustment of an economy to tariff changes and derive several welfare results. Our first result is that, starting from free trade, a uniform tariff increase distorts the time path of instantaneous utility, so that instantaneous utility is initially raised above the free–trade level before declining to a long–run level that is lower than the initial free–trade level. That is to say, tariff protection creates short–run benefits and long-run costs in welfare terms. Second, we show that a second-best optimal investment tariff will exceed the consumption tariff, both because investment goods in the model are general equilibrium substitutes for the exportable good and because the tariff on the investment good helps to correct factor price distortions caused by the consumption tariff.

The next two results extend the literature on the welfare gains associated with the concertina and radial tariff reduction methods of piecemeal tariff reform. The welfare calculations carried out for these methods include, in addition to the usual static gains, an intertemporal welfare term. Our fifth result concerns the welfare-improving effects of a reduction in the consumption tariff in conjunction with an increase in the tariff on the investment good, a method of piecemeal tariff reform that we label the "two-handed concertina" method. We view this last result as an important one, since several well-known trade liberalizations began by raising tariff rates on investment goods at the same time that tariff rates on consumption goods were lowered.[2]

The paper proceeds as follows. Sections II and III lay out the analytical framework. This framework is the infinitely-lived utility-maximizing representative agent model that has been recently employed to analyze a variety of macroeconomic disturbances in open economies.[3] Section IV describes some of the macroeconomic adjustments to tariff changes, while Section V conducts the welfare analysis of tariff changes. Both the short-run and long-run welfare implications are discussed. Section VI discusses some welfare propositions relevant to issues pertaining to tariff reform. Section VII concludes, while much of the technical detail is relegated to the Appendix.

II. THE ANALYTICAL FRAMEWORK

The economy we consider is inhabited by a single, infinitely-lived representative agent who rents out an inelastic quantity of land (T) at its competitive rental rate, accumulates capital (K) for rental at its competitively determined rental rate, and supplies labor at the competitive wage.[4] The agent produces an import–competing good (taken to be the numeraire) using the stock of capital and quantity of labor L^m, by means of a standard neoclassical production function $F(K, L^m)$. The agent also produces an exportable good using the endowment of land and the quantity of labor L^x, by means of a second standard neoclassical production function $G(T, L^x)$. The price of the exportable good is normalized to equal the price of the import–competing good. Capital is therefore specific to the production of the import–competing good and land to the production of the export good.

The capital stock depreciates at the constant rate δ. Capital goods are imported and unlike the import–competing final good, are not produced domestically. Expenditure on a given increase in the capital stock involves adjustment costs which we incorporate in the function

$$\psi(I, K) = I + \phi(I, K) \qquad \phi \geq 0$$

where the gross investment of I units of capital requires the use of $\phi(I, K)$ units of output. The function $\phi(I, K)$ is specified to be a non–negative, linearly homogeneous, convex function of the rate of gross investment and capital stock.[5] The homogeneity property of the installation cost function ensures that the market value of the capital stock is invariant with respect to changes in the scale of the economy.[6] For analytical convenience we assume $\phi(\delta K, K) = 0, \phi_I(\delta K, K) = 0$, so that adjustment costs are minimized (zero) in the neighborhood of steady-state equilibrium (where $I = \delta K$).[7]

The importable consumption good is subject to a tariff (τ^c) levied by the government. Imports of the investment good are subject to a separate tariff (τ^i). Revenues from both tariffs are distributed as lump sum transfers (z) by the government back to the representative agent.

The agent also accumulates net foreign bonds (b) that pay an exogenously–given world interest rate (r). Equation (1) describes the agent's instantaneous budget constraint

$$\dot{b} = (1+\tau^c)F(K,L^m) + G(T,L^x) + rb - (1+\tau^c)C^m - C^x - (1+\tau^i)\psi(I,K) + z \quad (1)$$

where C^m and C^x are the agent's consumption of the importable and exportable goods. Because of the depreciating capital stock, the agent also faces the standard capital accumulation constraint

$$\dot{K} = I - \delta K. \quad (2)$$

Finally, the agent must allocate one unit of time between leisure (ℓ), labor in the import-competing sector, and work in the exportable sector, in accordance with

$$\ell + L^m + L^x = 1. \quad (3)$$

The agent's decisions are to choose consumption levels C^m, C^x, leisure and labor allocation decisions, ℓ, L^m, L^x, and rate of investment I to

$$\text{Maximize} \quad \int_0^\infty [U(C^m,C^x) + V(\ell)]e^{-\rho t}dt \quad (4)$$

subject to the constraints (1) - (3), the given initial conditions, $K(0) = K_0, b(0) = b_0$, and the fixed stock of land T. The instantaneous utility function is taken to be additively separable in consumptions and leisure, the functions $U(\cdot,\cdot), V(\cdot)$ are increasing concave functions of their respective arguments, and the two consumption goods are assumed to be normal goods. The agent's rate of time preference, ρ, is taken to be constant.

The current value Hamiltonian for this optimization problem is given by

$$\begin{aligned} H \equiv\ & U(C^m,C^x) + V(\ell) + \lambda[(1+\tau^c)F(K,L^m) + G(T,L^x) + rb - (1+\tau^c)C^m - C^x \\ & - (1+\tau^i)\psi(I,K) + z] + q^*(I - \delta K) + w^*(1 - \ell - L^m - L^x) \end{aligned} \quad (5)$$

where λ is the shadow value (marginal utility) of wealth in the form of internationally traded bonds, q^* is the shadow value of the agent's capital stock, and w^* is the shadow wage. Exposition of the model is simplified by using the shadow value of wealth as numeraire. Consequently, $q = q^*/\lambda$ and $w = w^*/\lambda$ are defined to be the market value of capital and the real wage in terms of the (unitary) price of foreign bonds.

The optimality conditions with respect to C^m, C^x, L^m, L^x, ℓ, and I are respectively

$$U_m(C^m, C^x) = \lambda(1 + \tau^c) \tag{6a}$$

$$U_x(C^m, C^x) = \lambda \tag{6b}$$

$$(1 + \tau^c)F_L(K, L^m) = G_L(T, L^x) = w \tag{6c}$$

$$V'(\ell) = \lambda w \tag{6d}$$

$$(1 + \tau^i)\psi_I(I, K) = q. \tag{6e}$$

Equations (6a) and (6b) are the usual intertemporal envelope conditions that relate the marginal utility of consumption of the two goods to the shadow value of wealth. Equations (6c) and (6d) similarly relate work effort and leisure to the shadow value of wealth and to the real wage. Taken jointly, equations (6a)–(6d) define the usual rate of substitution conditions in consumption and work effort for the representative agent. Equation (6e) links the marginal installation costs of new capital, and hence, the rate of capital accumulation, to the market price of capital.

In addition, the shadow value of wealth and the market value of capital evolve in accordance with

$$\dot{\lambda} = \lambda(\rho - r) \tag{6f}$$

$$\dot{q} = -(1 + \tau^c)F_K(K, L^m) + (1 + \tau^i)\psi_K(I, K) + (r + \delta)q. \tag{6g}$$

Since ρ and r are both taken to be fixed, the ultimate attainment of a steady state is possible if and only if $\rho = r$. Henceforth we assume this to be the case. This implies $\dot{\lambda} = 0$ everywhere, so that λ is always at its steady-state level $\overline{\lambda}$ (to be determined below).

Finally, in order to ensure that the intertemporal budget constraint is met we need to impose the transversality conditions

$$\lim_{t \to \infty} \lambda b e^{-rt} = \lim_{t \to \infty} qKe^{-rt} = 0. \tag{6h}$$

The description of the macroeconomic equilibrium is completed by introducing the government budget constraint. In our analysis the role of the government is a simple one. In accordance with standard practice in the theory of domestic distortions, we assume that lump-sum subsidies are available to redistribute tariff revenue:

$$\tau^c[C^m - F(K, L^m)] + \tau^i\psi(I, K) = z. \tag{6i}$$

This equation taken in conjunction with the agent's budget constraint (1) implies that the economy's current account, which determines the evolution of the stock of net foreign assets, may be expressed as

$$\dot{b} = F(K, L^m) + G(T, L^x) - C^m - C^x - \psi(I, K) + rb. \tag{1'}$$

Our treatment of the agent as a price taker, who therefore ignores the aggregate constraint (6i), is standard in the intertemporal representative agent framework. One justification is that being in fact just one of a large number of agents, he is unable to infer his share of the total tariff revenue. As discussed by Corden (1987, p. 87) this raises problems of income distribution and our approach requires that the government use lump-sum subsidies to bring about the appropriate after-tax distribution of income.[8]

The complete macroeconomic equilibrium is thus described by the static equations (6a) – (6e), with $\lambda = \overline{\lambda}$, (2), together with the dynamic equations (1′), (3) and (6g), and the transversality condition (6h). The static equations define the short-run equilibrium and may be solved for $C^m, C^x, \ell, L^m, L^x, I$ as the following functions of the stock of capital, the market value of capital, the shadow value of wealth, and the two tariffs:[9]

$$C^m = C^m(\overline{\lambda}, \tau^c) \qquad C^m_\lambda < 0, \;\; C^m_\tau < 0 \tag{7a}$$

$$C^x = C^x(\overline{\lambda}, \tau^c) \qquad C^x_\lambda < 0, \;\; C^x_\tau \gtrless 0 \;\text{ as }\; U_{mx} \lesseqgtr 0 \tag{7b}$$

$$\ell = \ell(\overline{\lambda}, K, \tau^c) \qquad \ell_\lambda < 0, \;\; \ell_K < 0, \;\; \ell_\tau < 0 \tag{7c}$$

$$L^m = L^m(\overline{\lambda}, K, \tau^c) \qquad L^m_\lambda > 0, \;\; L^m_K > 0, \;\; L^m_\tau > 0 \tag{7d}$$

$$L^x = L^x(\overline{\lambda}, K, \tau^c) \qquad L^x_\lambda > 0, \;\; L^x_K < 0, \;\; L^x_\tau < 0 \tag{7e}$$

$$I = i(q, \tau^i)K \qquad I_q > 0, \;\; I_\tau < 0. \tag{7f}$$

The partial derivatives appearing in (7) may be obtained by differentiating the optimality conditions (6a) – (6e) and are given in the Appendix. With C^m and C^x being independent of the dynamic variables, it follows that the consumption of both goods is constant through time, responding only to changes in $\overline{\lambda}$ or τ^c. This extreme form of consumption smoothing is a consequence of the separability of the utility function in consumption and employment decisions. Given the assumption that both goods are normal in consumption, an increase in the shadow value of wealth leads to a substitution of savings for consumption. The consumption of both goods falls, the work effort in both sectors rises, and leisure time is reduced. An increase in the stock of capital raises the marginal productivity of labor in the import-competing sector, thereby attracting labor to that sector away from the export sector and leisure. An increase in the market value of capital will stimulate investment. An increase in the tariff on the importable will reduce the consumption of that good, but may raise or lower consumption of the exportable good, depending upon how the reduced consumption of the former impacts on the marginal utility of the latter.[10] The protection yielded by the tariff to the import-competing industry will stimulate that sector, attracting labor away from the export sector and leisure. Finally, a higher tariff on the investment good will reduce the level of investment expenditure.[11]

The evolution of the system is determined by substituting the short-run equilibrium (7a) - (7f) into the dynamic equations (2), (6g) and (1′) and ensuring that the transversality conditions (6h) are met. It is readily apparent that in fact the dynamics can be determined sequentially. Specifically equations (2) and (6g) (after substitution) constitute a pair of autonomous differential equations in q and K and are the core of the dynamics. Note that since this pair of equations is determined in part by the steady-state shadow value of wealth, $\bar{\lambda}$, the steady state in part determines the entire dynamic path. But having determined K and q, equation (1′) then determines the accumulation of foreign assets b.

III. DYNAMICS

We begin by considering the dynamic adjustment paths of K and q. We first substitute the solutions for $L^m(\cdot)$ and $I(\cdot)$ into equations (6g) and (2) and linearize around the steady-state equilibrium. This enables the equilibrium dynamics to be expressed by the following pair of linearized differential equations

$$\begin{bmatrix} \dot{q} \\ \dot{K} \end{bmatrix} = \begin{bmatrix} r & -(1+\tau^c)[F_{KK} + F_{KL}L_K^m] \\ \frac{1}{(1+\tau^i)\psi_{II}} & 0 \end{bmatrix} \begin{bmatrix} q - \tilde{q} \\ K - \tilde{K} \end{bmatrix} \tag{8}$$

where the elements of the matrix in (8) are evaluated at steady state, and tildes denote steady-state equilibrium values.[12] The determinant of the terms appearing in (8) can be shown to be negative. so that the long-run equilibrium is a saddlepoint with eigenvalues $\mu_1 < 0$, $\mu_2 > 0$. It is clear that while the capital stock must always evolve gradually, the value of capital, q, may jump instantaneously in response to new information. The stable solutions for K and q (consistent with the transversality condition (6h)) are

$$K = \tilde{K} + (K_0 - \tilde{K})e^{\mu_1 t} \tag{9a}$$

$$q - \tilde{q} = \mu_1(1+\tau^i)\psi_{II}(K - \tilde{K}). \tag{9b}$$

The convexity of ϕ implies $\psi_{II} > 0$, so that the stable arm described by (9b) is negatively sloped.

To determine the dynamics of the current account, we substitute for $C^m(\cdot), C^z(\cdot)$, $L^m(\cdot), L^z(\cdot)$ and $I(\cdot)$ into (1′)

$$\begin{aligned} \dot{b} &= F[K, L^m(\overline{\lambda}, K, \tau^c)] + G[T, L^z(\overline{\lambda}, K, \tau^c)] - C^m(\overline{\lambda}, \tau^c) \\ &\quad - C^z(\overline{\lambda}, \tau^c) - \psi[i(q, \tau^i)K, K] + rb. \end{aligned}$$

Linearizing this equation around steady state yields

$$\dot{b} = (F_K + F_L L_K^m + G_L L_K^z - \delta)(K - \tilde{K}) - \frac{1}{(1+\tau^i)\psi_{II}}(q - \tilde{q}) + r(b - \tilde{b}). \tag{10}$$

Next, using (9a) and (9b), this equation may be written as

$$\dot{b} = \Omega(K_0 - \tilde{K})e^{\mu_1 t} + r(b - \tilde{b}) \tag{11}$$

where

$$\Omega \equiv F_K + F_L L_K^m + G_L L_K^x - \delta - \mu_1.$$

Assuming that the economy starts out with an initial stock of traded bonds $b(0) = b_0$, the solution to this equation is

$$b(t) = \tilde{b} + \frac{\Omega(K_0 - \tilde{K})}{\mu_1 - r} e^{\mu_1 t} + \left[b_0 - \tilde{b} - \frac{\Omega}{\mu_1 - r}(K_0 - \tilde{K}) \right] e^{rt}.$$

In order for the transversality condition (6h) to be satisfied, we require

$$b_0 - \tilde{b} = \frac{\Omega}{\mu_1 - r}(K_0 - \tilde{K}) \tag{12}$$

in which case, the dynamic adjustment path for traded bonds, consistent with long-run solvency is

$$b(t) = \tilde{b} + \frac{\Omega(K_0 - \tilde{K})}{\mu_1 - r} e^{\mu_1 t}. \tag{13}$$

Equation (13) describes the relationship between the accumulation of capital and that of bonds. The quantity $F_K + F_L L_K^m + G_L L_K^x$ equals dY/dK, the marginal effect of capital on the value of gross domestic output, so that $dY/dK - \delta$ is the effect on net national output. A sufficient condition for the relationship between b and K to be a negative one is that $dY/dK - \delta \geq 0$.

IV. ANALYSIS OF TARIFF CHANGES

With the forward-looking behavior in the model, the dynamic adjustment of the economy to tariff changes is determined primarily by changes in the steady-state capital stock and shadow value of foreign bonds. The characterization of the steady-state equilibrium conditions themselves is presented in the Appendix. Any configuration of the two tariffs can be decomposed analytically into a uniform tariff, in conjunction with an investment tax (or subsidy, if the tariff on the capital good is lower than the tariff on the consumption good). We will find it useful first to analyze a uniform change in the two tariffs before examining the investment tax component of differential tariffs.

A. A Uniform Tariff Increase

Evaluating the differentials in (A.8) one can establish that starting from zero initial tariffs (free trade), the imposition of a small uniform tariff ($d\tau^c = d\tau^i = d\tau > 0$) implies

$$\frac{d\tilde{K}}{d\tau} = \frac{a_{22}}{J}\left[F_{KL}L_\tau^m - \frac{F_L L_\tau^m + G_L L_\tau^x - C_\tau^m - C_\tau^x}{F_L L_\lambda^m + G_L L_\lambda^x - C_\lambda^m - C_\lambda^x} F_{KL} L_\lambda^m\right] > 0. \tag{14a}$$

$$\begin{aligned} \left.\frac{d\tilde{\lambda}}{d\tau}\right|_{\tau=0} &= \frac{a_{22}}{J}\{[F_L L_\tau^m + G_L L_\tau^x - C_\tau^m - C_\tau^x] \\ &\quad + \left(\frac{\mu_1}{\mu_1 - r}\right)\left(\frac{dY}{dK} - r - \delta\right)\left[\frac{-F_{KL}L_\tau^m}{F_{KK} + F_{KL}L_K^m}\right]\} < 0. \end{aligned} \tag{14b}$$

The expression (14a) for the change in the capital stock contains two terms within the brackets. The first term, the substitution effect of the tariff, indicates that imposition of a small uniform tariff increases the capital stock by shifting labor into the import-competing sector and thereby raising the marginal product of capital. The second term, the wealth effect of the tariff on labor supply, while generally of opposite sign to the first term, is nevertheless dominated by the latter, so that overall the long-run capital stock increases unambiguously.

Equation (14b) indicates that, beginning from free trade, a uniform tariff on the consumption and investment goods will lower the shadow value of foreign bonds ($\bar{\lambda}$). Two effects are involved. The first term within the braces shows that, holding the capital stock constant, the effect of the tariff on labor supply and consumption is to improve the trade balance, thereby relaxing the foreign exchange constraint and lowering the shadow value of foreign bonds.

Secondly, the accumulation of capital following the imposition of the tariff further lowers the shadow value of foreign bonds by further relaxing the foreign exchange constraint. In equation (14b), the term $(-F_{KL}L^m_\tau)/(F_{KK} + F_{KL}L^m_K)$ measures the increase in the capital stock, holding labor supply constant, that will accompany the tariff. The term $dY/dK - r - \delta$ measures the excess of the economywide marginal product of capital relative to the opportunity cost of those funds. In general, this expression can be written in terms of underlying preferences and technology as follows:

$$\frac{dY}{dK} - r - \delta = F_K\left[\frac{\tau^i - \tau^c}{1+\tau^i}\right] + \frac{(1+\tau^c)F_L F_{KL}(V''\tau^c - \lambda G_{LL})}{\lambda(1+\tau^c)F_{LL}G_{LL} + V''[(1+\tau^c)F_{LL} + G_{LL}]}. \tag{15}$$

Under free trade ($\tau^c = \tau^i = 0$), equation (15) will be greater than or equal to zero, with equality holding only in the limit as labor supply becomes perfectly inelastic ($V'' \to -\infty$).[13] With a finitely elastic labor supply, the tariff raises the agent's supply of labor and causes the accompanying accumulation of capital to relax the foreign exchange constraint by the amount $dY/dK - r - \delta$ for each unit of capital that is purchased. In the presence of a pre-existing uniform tariff ($\tau > 0$), the marginal product of capital dY/dK will exceed the equilibrium cost of capital $r + \delta$ if and only if the labor supply is sufficiently elastic.[14] The last two terms in parentheses in the second term of equation (14b) therefore measure the total amount of foreign exchange generated by the accumulation of capital in response to the tariff. The term $\mu_1/(\mu_1 - r)$ converts the gain in foreign exchange from the accumulation of capital into present value terms by taking into account the adjustment speed of the capital stock.

Transitional Dynamics

The stable dynamic adjustment paths followed by q and K are described by (9a, 9b) and are a negatively-sloped saddlepath illustrated by XX in Figure 1. As long as no future shock is anticipated, the system must lie on the stable locus XX. An unanticipated increase in the uniform tariff τ causes the market price of capital q to increase instantaneously by an amount

$$\frac{dq(0)}{d\tau} = -\mu_1(1+\tau)\psi_{II}\frac{d\tilde{K}}{d\tau} > 0. \tag{16}$$

This is represented by an upward shift of XX to $X'X'$. If initially, the economy is in steady state at the point A lying on XX, the new steady state corresponding to the higher uniform tariff is at B on $X'X'$ with a higher capital stock and a higher market price of capital (although $F_K = r + \delta$ at both points A and B).

The instantaneous increase in q given by (16) is represented by the jump from A to C on the new stable locus $X'X'$. Since the rate of capital accumulation is proportional to q, capital begins to accumulate with the increase in the uniform tariff. Along the saddlepath, the rate of capital accumulation declines as the economy approaches the new steady state at point B. As capital accumulates, the economy's stock of net foreign assets declines, as established in (12), reflecting a deficit in the current account of the balance of payments.

Besides inducing the agent to alter investment expenditure, the higher tariff alters the agent's total supply of labor, as well as the allocation of labor supply between the two sectors of the economy. The initial response of labor supply ($L = 1 - \ell$) to the higher tariff can be decomposed into a direct substitution effect, $\partial L/\partial\tau$, and a wealth effect $(\partial L/\partial\overline{\lambda})(\partial\overline{\lambda}/\partial\tau)$. As capital accumulates, the rise in the real wage over time produces an additional substitution effect on labor supply, whose cumulative magnitude is $(\partial L/\partial\tilde{K})(\partial\tilde{K}/\partial\tau)$. Equations (17a) - (17c) divide the long-run responses of total labor supply and the sectoral allocations into the initial substitution and wealth effects and into the substitution effect that accompanies the accumulation of capital:

$$\frac{d\tilde{L}}{d\tau} = \overset{+}{\frac{\partial L}{\partial\tau}} + \overset{+}{\frac{\partial L}{\partial\lambda}}\overset{-}{\frac{\partial\overline{\lambda}}{\partial\tau}} + \overset{+}{\frac{\partial L}{\partial K}}\overset{+}{\frac{\partial\tilde{K}}{\partial\tau}} \tag{17a}$$

$$\frac{d\tilde{L}^m}{d\tau} = \overset{+}{\frac{\partial L^m}{\partial \tau}} + \overset{+}{\frac{\partial L^m}{\partial \lambda}} \overset{-}{\frac{\partial \bar{\lambda}}{\partial \tau}} + \overset{+}{\frac{\partial L^m}{\partial K}} \overset{+}{\frac{\partial \tilde{K}}{\partial \tau}} \tag{17b}$$

$$\frac{d\tilde{L}^x}{d\tau} = \overset{-}{\frac{\partial L^x}{\partial \tau}} + \overset{+}{\frac{\partial L^x}{\partial \lambda}} \overset{-}{\frac{\partial \bar{\lambda}}{\partial \tau}} + \overset{-}{\frac{\partial L^x}{\partial K}} \overset{+}{\frac{\partial \tilde{K}}{\partial \tau}}. \tag{17c}$$

As seen in (17a), while the substitution effect of the higher tariff increases labor supply, the wealth effect associated with the loosening of the foreign exchange constraint has the opposite effect, so that the initial employment effects of the tariff are ambiguous. Over time, as capital accumulates, employment will unambiguously increase relative to its initial response to the higher tariff.

In terms of the sectoral allocation of labor, labor supply to the import-competing sector follows the same pattern as overall labor supply; the initial wealth and substitution effects are offsetting, but the additional substitution effect created by the rising real wage (as capital accumulates) increases labor supply over time. In the export sector, both wealth and substitution effects initially lower labor supply. As the economy accumulates capital, labor supply continues to decline in that sector, so that the long-run decline in employment in the export sector is even greater.

B. *Increase in the Tariff on the Investment Good*

Given an initial uniform tariff, an increase in the tariff on the investment good represents a tax on the purchase price of investment goods that will lower the steady-state size of the capital stock, as shown in equation (18a):

$$\frac{d\tilde{K}}{d\tau^i} = \frac{-(r+\delta)a_{22}}{J} < 0. \tag{18a}$$

Note that equation (18a) is similar to the expression for the change in the capital stock from an increase in the uniform tariff, equation (14a), except that the wealth and substitution effects found in the former expression are replaced by $-(r+\delta)$, which represents the increased steady-state cost of a higher purchase price of capital.

Starting from an initial positive uniform tariff, an increase in the tariff on the investment good will have an ambiguous effect on the shadow value of foreign bonds, as shown by equation (18b):

$$\frac{d\bar{\lambda}}{d\tau^{i}} = \frac{a_{11}}{J}\left(\frac{\mu_1}{\mu_1 - r}\right)\left(\frac{dY}{dK} - r - \delta\right)\left(\frac{r+\delta}{F_{KK} + F_{KL}L_K^m}\right). \tag{18b}$$

Note that equation (18b) is similar to the expression for the change in the shadow value of foreign bonds following an increase in the uniform tariff, equation (14b), except that the direct substitution effect on labor supply and consumption is absent and the term that captures the change in the capital stock from the uniform tariff, $(-F_{KL}L_{\tau}^m)/(F_{KK} + F_{KL}L_K^m)$, is replaced by $(r+\delta)/(F_{KK} + F_{KL}L_K^m)$.

The ambiguity in sign of equation (18b) is due to the term $dY/dK - r - \delta$. Starting from a positive uniform tariff, equation (15) shows that the sign of $dY/dK - r - \delta$ depends on the elasticity of labor supply. If labor supply is very elastic, $dY/dK - r - \delta$ will be positive, so that an increase in the tariff on the investment good will tighten the foreign exchange constraint and raise the shadow value of foreign bonds. If labor supply is very inelastic, $dY/dK - r - \delta$ will be negative, and an increase in the tariff on the investment good will relax the foreign exchange constraint, thereby lowering the shadow value of foreign bonds.

Transitional Dynamics

The dynamic adjustment followed by q and K following an increase in the tariff on the investment good is illustrated in Figure 2. Starting from the initial market price of capital, $q = 1 + \tau^{i}$, the increase in the investment tariff shifts the $\dot{K} = 0$ locus upward by the amount of the tariff increase. The price of capital initially jumps from point A to point

C on the new stable locus $X'X'$. Since the initial increase in q is less than the increase in the tariff, $q/(1+\tau^i)$ declines and the capital stock begins to decrease. Eventually, the economy reaches the new steady state at B, having a lower capital stock and an increase in the market price of capital by the amount of the additional tariff. During the transition, the economy's stock of net foreign assets increases.

The initial labor supply response of the agent to the tariff is driven entirely by wealth effects. If labor supply is elastic enough (so that $dY/dK - r - \delta > 0$), the higher tariff will raise total labor supply and employment in each of the two sectors. If labor supply is relatively inelastic (so that $dY/dK - r - \delta < 0$), the higher investment tariff will lower total labor supply and employment in each of the two sectors. Regardless of the initial response of labor supply, as capital decreases the total supply of labor and the supply of labor to the import–competing sector will decline as the real wage falls. On the other hand, employment in the export sector will increase as the capital stock declines. Equations (19a) - (19c) divide the overall response of total labor supply and labor supply in the two sectors into the wealth effect and the substitution effect that accompany the decumulation of capital:

$$\frac{d\tilde{L}}{d\tau^i} = \overset{+}{\frac{dL}{d\lambda}} \overset{\pm}{\frac{d\tilde{\lambda}}{d\tau^i}} + \overset{+}{\frac{dL}{dK}} \overset{-}{\frac{d\tilde{K}}{d\tau^i}} \tag{19a}$$

$$\frac{dL^m}{d\tau^i} = \overset{+}{\frac{dL^m}{d\lambda}} \overset{\pm}{\frac{d\tilde{\lambda}}{d\tau^i}} + \overset{+}{\frac{dL^m}{dK}} \overset{-}{\frac{d\tilde{K}}{d\tau^i}} \tag{19b}$$

$$\frac{dL^x}{d\tau^i} = \overset{+}{\frac{dL^x}{d\lambda}} \overset{\pm}{\frac{d\lambda}{d\tau^i}} + \overset{-}{\frac{dL^x}{dK}} \overset{-}{\frac{d\tilde{K}}{d\tau^i}}. \tag{19c}$$

V. WELFARE EFFECTS OF TARIFFS

Much of the focus of the immiserizing growth literature has been on the welfare effects of *exogenous* flows of investment in the presence of a tariff. As Neary and Ruane (1988) have demonstrated, an equally important analytical focus involves the computation of the welfare effects of *endogenous* flows of investment in response to the imposition of a tariff. With regard to these endogenous investment flows, Neary and Ruane considered two polar cases of complete mobility or immobility of capital, so that in either case the economy's response to a tariff change is instantaneous. By contrast, the slow adjustment of capital in our model requires an analysis of the welfare effects of tariff protection over the entire time path of instantaneous utility of a representative agent.

We define the agent's instantaneous utility at time $t, Z(t))$ as

$$Z(t) = U(C^m, C^x) + V(\ell) \tag{20a}$$

with the overall level of welfare being (with $\rho = r$):

$$W = \int_0^\infty [U(C^m, C^x) + V(\ell)]e^{-rt}dt \equiv \int_0^\infty Z(t)e^{-rt}dt. \tag{20b}$$

We shall discuss the effects of the tariffs on both the time path of $Z(t)$ and total welfare W, when C^m, C^x, and ℓ follow the optimal paths described by (7a) - (7c), with capital stock being accumulated in accordance with (9a). We do this by linearizing (20a) about its steady-state level and then substituting the linearized expression into (20b), and integrating, to yield an approximate measure of the welfare of the representative agent.

We have already remarked that the two consumption levels C^m, C^x always adjust instantaneously to their respective steady-state levels in response to an unanticipated permanent change in the tariff. Leisure, being a function of K, follows a transitional path, which may be linearly approximated by

$$\ell \cong \tilde{\ell} + \ell_K(K_0 - \tilde{K})e^{\mu_1 t}. \tag{21}$$

Accordingly, $Z(t)$ and W may be approximated linearly by the expressions

$$Z(t) \cong U(\tilde{C}^m, \tilde{C}^x) + V(\tilde{\ell}) + V'\ell_K(K_0 - \tilde{K})e^{\mu_1 t} \tag{22a}$$

$$W \cong \frac{1}{r}[U(\tilde{C}^m, \tilde{C}^x) + V(\tilde{\ell})] + \frac{V'\ell_K(K_0 - \tilde{K})}{r - \mu_1} \tag{22b}$$

where the steady–state values of consumption and leisure are respectively

$$\tilde{C}^m = C^m(\overline{\lambda}, \tau^c); \quad \tilde{C}^x = C^x(\overline{\lambda}, \tau^c); \quad \tilde{\ell} = \ell(\overline{\lambda}, \tilde{K}, \tau^c).$$

The first term in (22b) represents the agent's welfare if the steady state were attained instantaneously. The second term reflects the adjustment to this due to the fact that the steady state is reached only gradually along the transitional path.

A. Increase in the Uniform Tariff

The effect of a higher uniform tariff on the level of instantaneous welfare $Z(t)$ is given by

$$\frac{dZ(t)}{d\tau} = U_m\frac{d\tilde{C}^m}{d\tau} + U_x\frac{d\tilde{C}}{d\tau} + V'\frac{d\tilde{\ell}}{d\tau} - V'\ell_K e^{\mu_1 t}\frac{d\tilde{K}}{d\tau}. \tag{23}$$

Using the fact that

$$\frac{d\tilde{C}^j}{d\tau} = C^j_\lambda\frac{d\overline{\lambda}}{d\tau} + C^j_\tau \qquad j = m, x$$

$$\frac{d\tilde{\ell}}{d\tau} = \ell_\lambda\frac{d\overline{\lambda}}{d\tau} + \ell_K\frac{d\tilde{K}}{d\tau} + \ell_\tau$$

and that in equilibrium

$$U_m = \overline{\lambda}(1 + \tau^c), U_x = \overline{\lambda}, V' = \overline{\lambda}G_L$$

(23) becomes

$$\frac{dZ(t)}{d\tau} = \overline{\lambda}[(1+\tau^c)C^m_\lambda + C^x_\lambda + G_L\ell_\lambda]\frac{d\overline{\lambda}}{d\tau} + \overline{\lambda}G_L\ell_K(1-e^{\mu_1 t})\frac{d\tilde{K}}{d\tau} + \overline{\lambda}[(1+\tau^c)C^m_\tau + C^x_\tau + G_L\ell_\tau]. \tag{24}$$

Since $d\tilde{K}/d\tau > 0$, this implies

$$\frac{dZ(0)}{d\tau} \geq \frac{dZ(t)}{d\tau} \geq \frac{d\tilde{Z}}{d\tau}. \tag{24'}$$

As shown in the Appendix, starting from free trade (zero tariffs), the imposition of a uniform tariff has the following effects on the short-run and steady-state levels of instantaneous utility

$$\frac{dZ(0)}{d\tau} = \overline{\lambda}\left(\frac{\mu_1}{\mu_1 - r}\right)\left(\frac{dY}{dK} - r - \delta\right)\frac{d\tilde{K}}{d\tau} > 0 \tag{25a}$$

$$\frac{d\tilde{Z}}{d\tau} = \frac{\overline{\lambda}r\left(\frac{dY}{dK} - r - \delta\right)}{\mu_1 - r}\frac{d\tilde{K}}{d\tau} < 0. \tag{25b}$$

The total change in welfare from the introduction of the uniform tariff can then be calculated as follows

$$\begin{aligned}\frac{dW}{d\tau} &= \frac{1}{r}\frac{dZ(0)}{d\tau} + \frac{\overline{\lambda}}{r}\left(\frac{\mu_1}{\mu_1 - r}\right)G_L\ell_K\frac{d\tilde{K}}{d\tau} \\ &= \frac{\overline{\lambda}}{r}\left(\frac{\mu_1}{\mu_1 - r}\right)\left(\frac{dY}{dK} - r - \delta\right)\frac{d\tilde{K}}{d\tau} + \frac{\overline{\lambda}}{r}\left(\frac{\mu_1}{\mu_1 - r}\right)\left(r + \delta - \frac{dY}{dK}\right)\frac{d\tilde{K}}{d\tau} = 0.\end{aligned} \tag{26}$$

Equations (25a), (25b), and (26) allow us to establish the following proposition:

Proposition 1. Starting from free trade, the imposition of a uniform tariff raises instantaneous utility in the short run while lowering it in the long run.

In common with the usual static welfare analysis of tariff changes in the neighborhood of free trade, our analysis finds that a small uniform tariff leaves total welfare (as measured by the discounted value of instantaneous utility) unchanged, but it does so in a way that involves an intertemporal tradeoff in utility. Figure 3 illustrates the behavior of instantaneous utility over time, where the shaded areas are the same in discounted value terms.

The general expression for the change in welfare resulting from increasing a pre-existing uniform tariff is given by equation (27):

$$\begin{aligned}\frac{dW}{d\tau} &= \frac{\overline{\lambda}}{r}\tau\left[\frac{e_2}{a_{22}}(F_L L_\lambda^m - C_\lambda^m) - F_L L_\tau^m\right] \\ &\quad + \frac{\overline{\lambda}}{r}\tau\frac{F_L}{a_{22}}\left(\frac{\mu_1}{\mu_1 - r}\right)[G_L(L_\lambda^m L_K^x - L_K^m L_\lambda^x) + (L_K^m C_\lambda^x - (1+\tau)L_K^x C_\lambda^m)]\frac{d\tilde{K}}{d\tau} \le 0.\end{aligned} \tag{27}$$

The first term in this expression is the welfare cost of the change in the uniform tariff, holding the capital stock fixed. The second term is the welfare cost associated with the worsening of the initial distortion as capital accumulates. The latter welfare cost is influenced by the speed of adjustment of the capital stock, with a more rapid adjustment causing a greater deterioration in welfare.[15]

When adjustment costs are linear ($\psi_{II} = 0$), adjustment is instantaneous ($\mu_1 \to -\infty$) and the term $\mu_1/(\mu_1 - r)$ equals one. In the other limiting case, as adjustment costs become infinitely convex ($\psi_{II} \to \infty$), the term $\mu_1/(\mu_1 - r)$ approaches zero. In this latter case, adjustment of the economy to a higher tariff becomes infinitely slow, so that the discounted value of the increase in foreign exchange from the tariff becomes negligible. These two polar cases of adjustment costs correspond to the distinction made by Neary and Ruane (1988) between perfect capital mobility and perfect capital immobility. Like Neary and Ruane, we find that welfare is unambiguously lower for an economy with mobile capital relative to the economy with immobile capital, since the accumulation of capital worsens the initial distortion produced by the tariff. In addition, it can be shown that the adjustment speed of the economy to a higher tariff varies inversely with the elasticity of labor supply. In the polar cases, where the supply of labor becomes perfectly elastic ($V'' = 0$) or perfectly inelastic ($V'' \to -\infty$), the entire adjustment of the economy's factors of production to the higher tariff is borne either by the supply of labor, or by the stock of capital, respectively.[16]

B. Increase in the Tariff on the Investment Good

The welfare analysis of an increase in the tariff on the imported investment good is analogous to an increase in the uniform tariff, but is somewhat simpler because of the absence of the direct effect on the consumption–leisure choice. Parallel to (24) and (24') we have:

$$\frac{dZ(t)}{d\tau^i} = \overline{\lambda}[(1+\tau)C_\lambda^m + C_\lambda^x + G_L\ell_\lambda]\frac{d\overline{\lambda}}{d\tau^i} + \overline{\lambda}G_L\ell_K(1-e^{\mu_1 t})\frac{d\tilde{K}}{d\tau^i} \tag{28}$$

$$\frac{dZ(0)}{d\tau^i} \leq \frac{dZ(t)}{d\tau^i} \leq \frac{d\tilde{Z}}{d\tau^i}. \tag{28'}$$

Again, as shown in the Appendix, $dZ(0)/d\tau^i, d\tilde{Z}/d\tau^i$ can be expressed as follows

$$\frac{dZ(0)}{d\tau^i} = \overline{\lambda}\left[1 + \frac{(\tau F_L L_\lambda^m - C_\lambda^m)}{a_{22}}\right]\left(\frac{\mu_1}{\mu_1 - r}\right)\left[\frac{dY}{dK} - r - \delta\right]\frac{d\tilde{K}}{d\tau^i} \gtrless 0 \tag{29a}$$

$$\frac{d\tilde{Z}}{d\tau^i} = \frac{dZ(0)}{d\tau^i} + \overline{\lambda}[r - a_{21} - \tau F_L L_K^m]\frac{d\tilde{K}}{d\tau^i}. \tag{29b}$$

As equation (29a) indicates, the sign of the short-run change in instantaneous utility following an increase in the tariff on the investment good depends on the term $dY/dK - r - \delta$. As shown in (15), starting from an initial *positive* uniform tariff, $dY/dK - r - \delta$ will be positive if labor supply is sufficiently elastic and will be negative otherwise.[17] If labor supply is elastic, the increase in the tariff will cause a decrease in consumption (since $dY/dK - r - \delta > 0$ implies a tightening of the foreign exchange constraint as capital decumulates) and an initial increase in labor supply as the agent intertemporally substitutes work effort into the present to take advantage of the transitorily high capital stock. This intertemporal substitution of labor for leisure produces an initial drop in instantaneous utility. Over time, labor supply will decrease below its initial level, causing a rise over time in instantaneous utility.

If labor supply is inelastic, the increase in the tariff on the investment good will produce an increase in consumption (since $dY/dK - r - \delta < 0$ implies a relaxing of the foreign exchange constraint as capital decumulates) and a decline in the work effort. Instantaneous utility will initially jump upward and will continue to rise in response to increasing leisure as the capital stock decreases. Figure 4 shows the response of instantaneous utility for the cases of elastic and inelastic labor supply.

Starting from an initial non-negative uniform tariff, the total change in welfare from the change in the tariff on the investment good can be shown to be the following

$$\frac{dW}{d\tau^i} = \frac{\tilde{\lambda}}{r}\frac{\tau F_L}{a_{22}}\left[\frac{\mu_1}{\mu_1 - r}\right][G_L(L_\lambda^m L_K^x - L_K^m L_\lambda^x) + (L_K^m C_\lambda^x - (1+\tau)L_K^x C_\lambda^m)]\frac{d\tilde{K}}{d\tau^i} \geq 0. \quad (30)$$

Equation (30) is sufficient to demonstrate the following:

> **Proposition 2.** (Second Best Tariff Policy). Starting from an initial positive level of a uniform tariff, an increase in the tariff on the investment good will always be welfare improving. Therefore, if the tariff on the consumption good cannot be lowered, the second best optimal tariff policy will set the tariff on the investment good higher than the tariff on the consumption good.

Proposition 2 embodies two general principles. First, if all three goods (importable consumption, exportable, and investment) were general equilibrium substitutes, the tariff on the investment good would be set lower than the tariff on the consumption good; see e.g., Lipsey and Lancaster (1956). In our model, the imported capital good and the exportable good are general equilibrium complements in the long-run equilibrium of the model: an increase in the tariff on the investment good reduces imports of the investment good and induces a reallocation of labor towards the exportable sector, thus increasing output of the exportable good. Consequently, standard theory of second best trade policies (see e.g., Bertrand and Vanek (1971), Lloyd (1974)) implies that the direct welfare loss from raising the tariff on the investment good (and thus reducing its imports) is more than offset by the indirect welfare gains as demand spills over from both the exportable good and the investment good onto the importable consumption good, causing a large welfare–raising increase in consumption good imports.

The second general principle embodied in Proposition 2 is a result of Findlay and Wellisz (1976) that factor taxes may raise welfare by correcting the factor market distortions created by the consumption tariff. In our model, the investment tariff offsets the distorted rental rate on capital produced by a consumption tariff, by acting like a factor tax on capital that raises the cost of capital goods and the steady–state required rate of return on capital.

VI. TARIFF REFORM

Many economies are characterized by tariff structures in which the tariffs on consumption goods exceed those on investment goods. Discussions of trade policy in such economies often focus on issues pertaining to tariff reform. An extensive theoretical literature has shown that in a static context, two simple methods exist to ensure that piecemeal (incomplete) tariff reforms will be welfare improving. The *concertina method* proposes lowering the highest tariff; see Bertrand and Vanek (1971), Corden (1974); the method of *radial reduction* advocates reducing tariffs by the same proportion; see Foster and Sonnenschein (1970), Bruno (1972).

Propositions 3 and 4 (proofs of whch are provided in the Appendix) yield results which integrate the piecemeal tariff reform literature's concern regarding the welfare consequences of tariff–induced relative price changes with the immiserizing growth literature's concerns regarding the welfare consequences of tariff-induced changes in the capital stock.

Proposition 3. (Concertina Method). Starting from initial tariff levels τ^i, τ^c, with $\tau^i < \tau^c$, a reduction in the tariff on the consumption good is welfare improving.

As shown by equation (A.23), there are two components to the welfare gains in Proposition 3. The first is the static gain, holding the capital stock constant. The second is the intertemporal gain created by the welfare-improving decline in the capital stock.

Proposition 4. (Method of Radial Reductions). Starting from initial tariff levels τ^i, τ^c, with $\tau^i < \tau^c$, a radial reduction in the two tariffs, related by $d\tau^i/\tau^i = \mu d\tau^c/\tau^c, (\mu > 0)$, will be welfare improving, as long as $\mu < \tau^c(1+\tau^i)/\tau^i(1+\tau^c)$. In particular, the case $\mu = 1$ corresponds to a proportionate reduction in the two tariffs and clearly satisfies the criterion for the tariff reduction to be welfare improving.

As shown in the Appendix, a radial tariff reduction will result in a static and intertemporal welfare gain from lowering the consumption tariff that will be partially offset by the intertemporal welfare loss caused by the reduction in the investment tariff. As long as the tariff reduction is proportionate, however, the welfare gain from the former will outweigh the loss from the latter.

The concertina method and method of radial reductions provide good theoretical guidance for piecemeal tariff reforms, especially if such reforms are part of a longer-run move towards free trade. However, whether for revenue or for other domestic policy reasons, there are few, if any, developing countries that adopt free trade as a goal of tariff reform. Rather, tariff reform generally attempts to lower the average tariff rate and to establish greater uniformity of tariff levels, without eliminating them. The twin goals of a lower average rate and greater uniformity of tariffs frequently imply that the lowest tariffs are raised, at the same time that the highest tariffs are lowered, thereby sandwiching the other tariffs in between. For example, in Korea between 1966 and 1968 the average tariff on nondurable consumer goods was lowered from 74.2 percent to 43.2 percent, while at the same time the average tariffs on transport equipment and on machinery were raised from 12.8 percent to 19.8 percent and from 25.5 percent to 47.0 percent respectively (Frank, Kim, and Westphal (1975, p. 61)). As another example, Chile's tariff reform of January 16, 1975 lowered most tariff rates but raised tariff rates on capital good imports that had previously been subject to low tariff rates (de la Cuadra and Hachette (1991)).

Because the existing piecemeal tariff reform literature takes factor supplies as given, that literature cannot offer much guidance with respect to the intertemporal welfare effects associated with tariff reforms that resemble the Korean or Chilean programs. Under our assumption that investment goods are general equilibrium complements with exportable goods (as discussed in connection with Proposition 2), we are able to establish the following result:

Proposition 5. (The Two-Handed Concertina Method). Starting from initial tariff levels τ^i, τ^c, with $\tau^i < \tau^c$, an increase in the tariff on the investment good, in conjunction with a reduction in the tariff on the consumption good, is welfare improving.

VII. CONCLUSION

The preceding sections have laid out a model that describes the reaction of a competitive economy to tariff protection. As in standard analyses of tariff protection, our representative agent alters consumption decisions and the allocation of labor among productive activities in response to a tariff on the consumption good. As in the literature on immiserizing growth, the agent accumulates capital in response to a tariff on the consumption good.

Our model contributes to the welfare analysis of protection by adding an endogenous labor supply choice, incorporating costs of adjustment to the installation of capital, and specifying a tariff on the imported investment good. These additions all move the welfare analysis of protection in a direction that highlights the cost of the intertemporal distortions produced by protective trade policies.

The analysis has led, in the context of a specific factors model of production, to an integration of the immiserizing growth literature's concern for the welfare consequences of factor adjustment to tariffs at fixed relative prices with the piecemeal tariff reform literature's concern for the welfare consequences of tariff–induced relative price changes at fixed factor endowments. Among our welfare propositions on piecemeal tariff reform, we believe that Proposition 5, regarding the "two–handed concertina" method of tariff reform, is of practical importance for the evaluation of tariff reforms which raise tariffs on capital goods as part of a move toward a relatively uniform, but non–zero, tariff level.

Implicit throughout the paper's welfare analysis is the importance of the time path of instantaneous utility in response to the imposition of tariffs or to various types of tariff reform. Increases in the consumption tariff and decreases in the investment tariff cause instantaneous utility to be higher in the short run than in the long run. Consequently, our results suggest that empirical evaluation of any given protectionist policy or piecemeal tariff reform effort should not rely solely on short–run welfare results, since the sign of the welfare integral measuring the discounted change in the entire time path of instantaneous utility for any given change in tariff policy may be opposite to the sign of the change in short–run utility.

Future work on the intertemporal welfare consequences of tariff policy could usefully employ a more general specification of the production technology in order to generalize this paper's results. However, the essential welfare results of this paper will probably remain unchanged as long as investment goods are general equilibrium substitutes for exportable goods, a condition that appears to characterize most import–substituting trade regimes in developing countries.

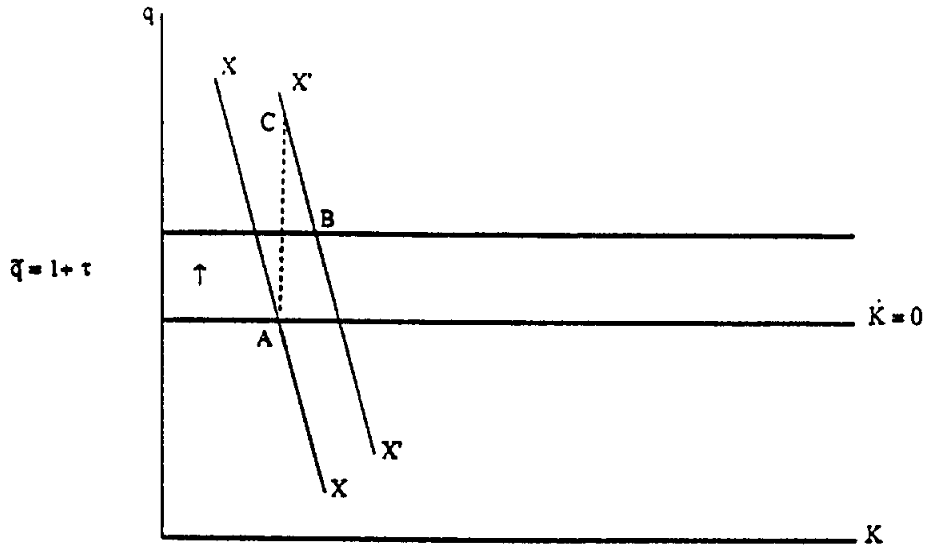

FIGURE 1

INCREASE IN UNIFORM TARIFF

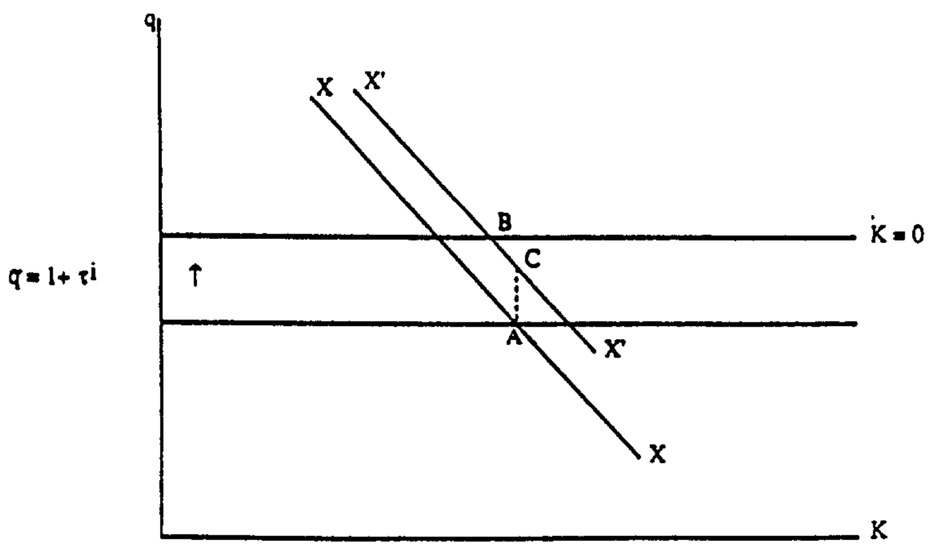

FIGURE 2

INCREASE IN TARIFF ON INVESTMENT GOOD

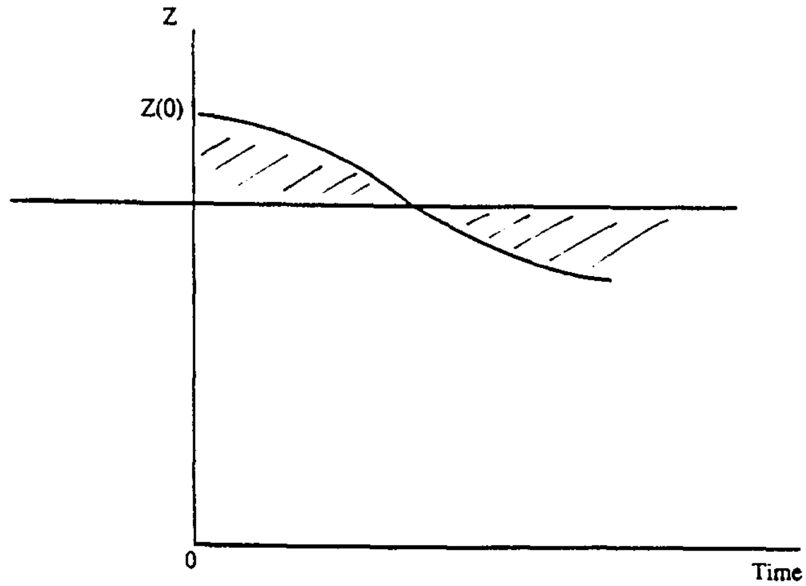

FIGURE 3

WELFARE EFFECTS OF INCREASE IN UNIFORM TARIFF

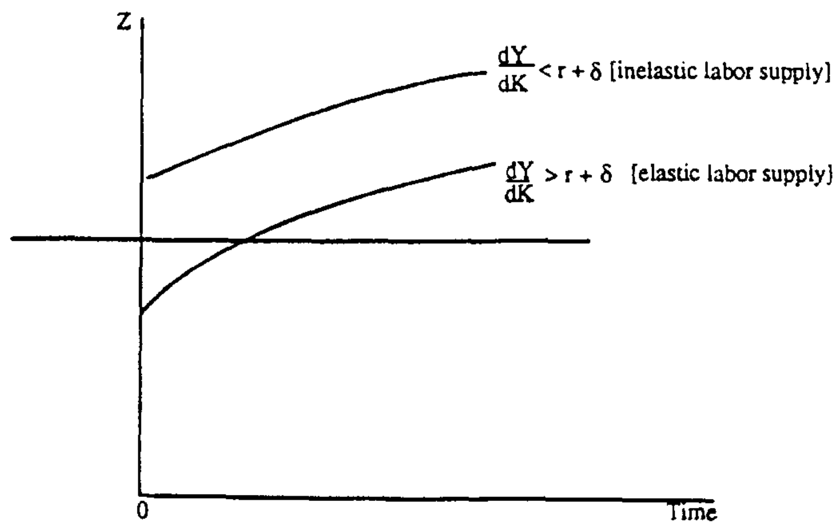

FIGURE 4

WELFARE EFFECTS OF INCREASE IN TARIFF
ON INVESTMENT GOOD

APPENDIX

1. *Properties of Short-Run Solutions (7)*

Taking the differential of equations (6a), (6b) yields

$$\begin{bmatrix} U_{mm} & U_{mx} \\ U_{xm} & U_{xx} \end{bmatrix} \begin{bmatrix} dC^m \\ dC^x \end{bmatrix} = \begin{bmatrix} (1+\tau^c)d\overline{\lambda} + \overline{\lambda}d\tau^c \\ d\overline{\lambda} \end{bmatrix}$$

leading to the following partial derivatives, where the assumption of normality for C^m and C^x is used in signing $\frac{\partial C^m}{\partial \lambda}$ and $\frac{\partial C^x}{\partial \lambda}$.

$$\frac{\partial C^m}{\partial \overline{\lambda}} = \frac{1}{D}((1+\tau^c)U_{xx} - U_{mx}) < 0; \quad \frac{\partial C^m}{\partial \tau^c} = \overline{\lambda}\frac{U_{xx}}{D} < 0 \tag{A.1}$$

$$\frac{\partial C^x}{\partial \overline{\lambda}} = \frac{1}{D}(U_{mm} - (1+\tau^c)U_{mx}) < 0; \quad \frac{\partial C^x}{\partial \tau^c} = -\overline{\lambda}\frac{U_{mx}}{D} \tag{A.2}$$

where $D \equiv U_{mm}U_{xx} - U_{mx}^2 > 0$. Next, taking differentials of (6c), (6d), together with (3),

$$\begin{bmatrix} \overline{\lambda}(1+\tau^c)F_{LL} & 0 & -V'' \\ 0 & \overline{\lambda}G_{LL} & -V'' \\ 1 & 1 & 1 \end{bmatrix} \begin{bmatrix} dL^m \\ dL^x \\ d\ell \end{bmatrix} = \begin{bmatrix} -(1+\tau^c)F_L d\overline{\lambda} - \overline{\lambda}(1+\tau^c)F_{LK}dK - \overline{\lambda}F_\ell d\tau^c \\ -G_L d\overline{\lambda} \\ 0 \end{bmatrix}$$

we obtain

$$\frac{\partial L^m}{\partial \overline{\lambda}} = \frac{-\overline{\lambda}}{D'}(1+\tau^c)G_{LL}F_L > 0; \quad \frac{\partial L^m}{\partial K} = \frac{-\overline{\lambda}(1+\tau^c)F_{LK}}{D'}[\overline{\lambda}G_{LL} + V''] > 0; \quad \frac{\partial L^m}{\partial \tau^c} = \frac{-\overline{\lambda}F_L}{D'}[\overline{\lambda}G_{LL} + V''] > 0 \tag{A.3}$$

$$\frac{\partial L^x}{\partial \overline{\lambda}} = \frac{-\overline{\lambda}}{D'}(1+\tau^c)F_{LL}G_L > 0; \quad \frac{\partial L^x}{\partial K} = \frac{\overline{\lambda}(1+\tau^c)F_{LK}V''}{D'} < 0; \quad \frac{\partial L^x}{\partial \tau^c} = \frac{\overline{\lambda}F_L V''}{D'} < 0 \tag{A.4}$$

$$\frac{\partial \ell}{\partial \overline{\lambda}} = \frac{\overline{\lambda}}{D'}(1+\tau^c)[G_{LL}F_L + G_L F_{LL}] < 0; \quad \frac{\partial \ell}{\partial K} = \frac{\overline{\lambda}^2(1+\tau^c)}{D'}G_{LL}F_{LK} < 0; \quad \frac{\partial \ell}{\partial \tau^c} = \frac{\overline{\lambda}^2}{D'}F_L G_{LL} < 0 \tag{A.5}$$

where $D' \equiv \overline{\lambda}^2(1+\tau^c)F_{LL}G_{LL} + V''\overline{\lambda}[(1+\tau^c)F_{LL} + G_{LL}] > 0$. Finally, (7f) follows directly from (6e) and the linear homogeneity of ψ.

2. Steady-State Equilibrium

Steady-state equilibrium is reached when $\dot{K} = \dot{q} = \dot{b} = 0$, so that (2) implies a gross rate of investment equal to the rate of depreciation

$$\tilde{I} = \delta \tilde{K}. \tag{A.6a}$$

Given that $\psi_I(\delta K, K) = 1$, (6e) implies a steady-state shadow value of capital

$$\tilde{q} = 1 + \tau^i. \tag{A.6b}$$

Furthermore, using (A.6a), (A.6b) and noting from footnote 7 that $\psi_K(\delta K, K) = 0$, (6g) implies

$$F_K(\tilde{K}, \tilde{L}^m) = \left(\frac{1+\tau^i}{1+\tau^c}\right)(r+\delta). \tag{A.6c}$$

The relevant steady-state cost of capital, to which the marginal physical product of capital is the rental rate $r+\delta$, adjusted by tariffs.

The third steady-state condition, that the flow of bonds cease, yields

$$F(\tilde{K}, \tilde{L}^m) + G(T, \tilde{L}^x) - \tilde{C}^m - \tilde{C}^x - \delta\tilde{K} + r\tilde{b} = 0 \tag{A.6d}$$

requiring that the current account balance must eventually be zero.

In principle, equations (7a) - (7e), (12), (A.6a) - (A.6d) jointly determine the steady-state solutions for the entire economy. For our purposes, it is more convenient to focus on the steady-state relationships in the form

$$(1+\tau^c)F_K[\tilde{K}, L^m(\overline{\lambda}, \tilde{K}, \tau^c)] = (1+\tau^i)(r+\delta) \tag{A.7a}$$

$$\begin{aligned}(F[\tilde{K}, L^m(\overline{\lambda}, \tilde{K}, \tau^c)] &+ G[T, L^x(\overline{\lambda}, \tilde{K}, \tau^c)] \\ &- C^m(\overline{\lambda}, \tau^c) - C^x(\overline{\lambda}, \tau^c) - \delta\tilde{K} + r\tilde{b} = 0\end{aligned} \tag{A.7b}$$

$$\tilde{b} - b_0 = \frac{\Omega}{\mu_1 - r}(\tilde{K} - K_0) \tag{A.7c}$$

which jointly determine the equilibrium stock of capital, $\tilde{K}$, the shadow value of wealth, $\overline{\lambda}$, and the stock of traded bonds, $\tilde{b}$. From these relationships, the remaining aspects of the steady state can be derived.

Taking differentials of equations (A.7a) - (A.7c), we obtain

$$\begin{bmatrix} a_{11} & a_{12} & 0 \\ a_{21} & a_{22} & r \\ \frac{\Omega}{\mu_1 - r} & 0 & -1 \end{bmatrix} \begin{bmatrix} d\bar{K} \\ d\bar{\lambda} \\ d\bar{b} \end{bmatrix} = \begin{bmatrix} -e_1 d\tau^c + (r+\delta)d\tau^i \\ -e_2 d\tau^c \\ 0 \end{bmatrix} \tag{A.8}$$

where

$$a_{11} \equiv (1+\tau^c)[F_{KK} + F_{KL}L_K^m] = \frac{F_{KK}G_{LL}V''\bar{\lambda}(1+\tau^c)}{D'} < 0$$

$$a_{12} \equiv (1+\tau^c)F_{KL}L_\lambda^m = \frac{-(1+\tau^c)^2\bar{\lambda}F_{KL}G_{LL}F_L}{D'} > 0$$

$$a_{21} \equiv \frac{dY}{dK} - \delta = F_K - \delta + F_L L_K^m + G_L L_K^x = F_K - \delta + \frac{\bar{\lambda}(1+\tau^c)F_L F_{LK}(V''\tau^c - \bar{\lambda}G_{LL})}{D'}$$

$$\begin{aligned} a_{22} &\equiv F_L L_\lambda^m + G_L L_\lambda^x - C_\lambda^m - C_\lambda^x \\ &= -\frac{\bar{\lambda}(1-\tau^c)}{D'}[F_L^2 G_{LL} + G_L^2 F_{LL}] - \frac{[(1+\tau^c)U_{xx} + U_{mm} - (2+\tau^c)U_{mx}]}{D} > 0 \end{aligned}$$

$$e_1 \equiv F_K + (1+\tau^c)F_{KL}L_\tau^m > 0$$

$$e_2 \equiv F_L L_\tau^m + G_l L_\tau^x - C_\tau^m - C_\tau^x \equiv \frac{-\bar{\lambda}F_L^2[\bar{\lambda}G_{LL} - \tau^c V'']}{D'} - \frac{\bar{\lambda}(U_{xx} - U_{mx})}{D} > 0$$

$$D \equiv U_{mm}U_{xx} - U_{mx}^2 > 0$$

$$D' \equiv \bar{\lambda}^2(1+\tau^c)F_{LL}G_{LL} + V''\bar{\lambda}[(1+\tau^c)F_{LL} + G_{LL}] < 0.$$

Stability requires that the determinant in (A.8) be positive.

3. Derivation of Welfare Properties

a. Increase in Uniform Tariff

Setting $t = 0$ in (24),

$$\frac{dZ(0)}{d\tau} = \overline{\lambda}[(1+\tau)C_{\lambda}^{m} + C_{\lambda}^{x} + G_L\ell_{\lambda}]\frac{d\overline{\lambda}}{d\tau} + \overline{\lambda}[(1+\tau)C_{\tau}^{m} + C_{\tau}^{x} + G_L\ell_{\tau}]. \tag{A.9}$$

Starting from an initial zero tariff, $G_L = F_L$ and (A.9) can be expressed in terms of the notation of equation (A.8) as

$$\frac{dZ(0)}{d\tau} = -\overline{\lambda}\left[a_{22}\frac{d\overline{\lambda}}{d\tau} + e_2\right]. \tag{A.10}$$

Consider the second and third rows of equation (A.8), namely

$$\begin{aligned} a_{21}d\tilde{K} + a_{22}d\overline{\lambda} + rd\tilde{b} &= -e_2 d\tau \\ \frac{\Omega}{\mu_1 - r}d\tilde{K} \qquad\qquad - d\tilde{b} &= 0. \end{aligned}$$

Recalling $\Omega = a_{21} - \mu_1$, and eliminating $d\tilde{b}$, yields

$$a_{22}\frac{d\overline{\lambda}}{d\tau} + e_2 = -\left(\frac{\mu_1}{\mu_1 - r}\right)(a_{21} - r)\frac{d\tilde{K}}{d\tau} \tag{A.11}$$

and hence, we obtain

$$\frac{dZ(0)}{d\tau} = \lambda\left(\frac{\mu_1}{\mu_1 - r}\right)(a_{21} - r)\frac{d\tilde{K}}{d\tau} = \overline{\lambda}\left(\frac{\mu_1}{\mu_1 - r}\right)\left(\frac{dY}{dK} - r - \delta\right)\frac{d\tilde{K}}{d\tau} > 0. \tag{A.12}$$

Next, letting $t \to \infty$, in (24)

$$\frac{d\tilde{Z}}{d\tau} = \frac{dZ(0)}{d\tau} + \overline{\lambda}G_L\ell_K\frac{d\tilde{K}}{d\tau}. \tag{A.13}$$

Noting the expression for ℓ_K (see (A.5)), we see that when tariffs are initially zero, that $G_L\ell_K = F_L\ell_K = r - a_{21}$, and hence

$$\frac{d\tilde{Z}}{d\tau} = \frac{\overline{\lambda}r}{\mu_1 - r}(a_{21} - r)\frac{d\tilde{K}}{d\tau} = \frac{\overline{\lambda}r}{\mu_1 - r}\left(\frac{dY}{dK} - r - \delta\right)\frac{d\tilde{K}}{d\tau} < 0. \tag{A.14}$$

The impact on total welfare, W, obtained by differentiating (22b), is

$$\frac{dW}{d\tau} = \frac{1}{r}\frac{d\tilde{Z}}{d\tau} - \frac{\overline{\lambda}G_L\ell_K}{r - \mu_1}\frac{d\tilde{K}}{d\tau}$$

which using (A.13) may be written as

$$\frac{dW}{d\tau} = \frac{1}{r}\frac{dZ(0)}{d\tau} + \frac{\bar{\lambda}}{r}\left(\frac{\mu_1}{\mu_1 - r}\right) G_L \ell_K \frac{d\tilde{K}}{d\tau} \tag{A.15}$$

which is equation (26) of the text.

The overall welfare loss described by (27) in the general case arises because of the distortions caused by the pre-existing tariff. This reduces to 0, when $\tau = 0$.

b. Increase in Investment Tariff

Setting $t = 0$ in (28)

$$\frac{dZ(0)}{d\tau^i} = \bar{\lambda}[(1+\tau)C_\lambda^m + C_\lambda^s + G_L \ell_\lambda]\frac{d\bar{\lambda}}{d\tau^i} \tag{A.16}$$

which analogous to (A.10) may be expressed as

$$\frac{dZ(0)}{d\tau^i} = -\bar{\lambda}[a_{22} + \tau(F_L L_\lambda^m - C_\lambda^m)]\frac{d\bar{\lambda}}{d\tau^i}. \tag{A.17}$$

From the second and third rows of (A.8) we obtain

$$\frac{d\bar{\lambda}}{d\tau^i} = \frac{-1}{a_{22}}\left(\frac{\mu_1}{\mu_1 - r}\right)(a_{21} - r)\frac{d\tilde{K}}{d\tau^i} \tag{A.18}$$

enabling (A.17) to be rewritten as

$$\frac{dZ(0)}{d\tau^i} = \bar{\lambda}\left[1 + \frac{\tau(F_L L_\lambda^m - C_\lambda^m)}{a_{22}}\right]\left(\frac{\mu_1}{\mu_1 - r}\right)\left[\frac{dY}{dK} - r - \delta\right]\frac{d\tilde{K}}{d\tau^i} \gtrless 0 \tag{A.19}$$

Letting $t \to \infty$ in (28) and noting that with a pre-existing uniform tariff $G_L \ell_K = r - a_{21} - \tau F_L L_K^m$,

$$\frac{d\tilde{Z}}{d\tau^i} = \frac{dZ(0)}{d\tau^i} + \bar{\lambda}[r - a_{21} - \tau F_L L_K^m]\frac{d\tilde{K}}{d\tau^i}. \tag{A.20}$$

The impact on total welfare W is

$$\frac{dW}{d\tau^i} = \frac{1}{r}\frac{dZ(0)}{d\tau^i} + \frac{\bar{\lambda}}{r}\left(\frac{\mu_1}{\mu_1 - r}\right) G_L \ell_K \frac{d\tilde{K}}{d\tau^i} \tag{A.21}$$

which can be reduced to (30) by substitution.

4. Outline of Proofs of Propositions 3, 4, 5

These propositions are based on the assumption that $\tau^i < \tau^c$.

Proposition 3 can be established as follows. Starting from $\tau^c > 0$, (A.10) can be expressed as

$$\frac{dZ(0)}{d\tau^c} = -\bar{\lambda}[a_{22} + \tau^c[F_L L_\lambda^m - C_\lambda^m]]\frac{d\bar{\lambda}}{d\tau^c} - \bar{\lambda}[e_2 + \tau^c[F_L L_\tau^m - C_\tau^m]]. \tag{A.10'}$$

Combining this equation with (A.11) and (A.15), which hold for arbitrary τ^i, τ^c, and using the definition of a_{21} to show,

$$G_L \ell_K = \left(\frac{\tau^i - \tau^c}{1+\tau^c}\right)(r+\delta) + r - a_{21} - \tau^c F_L L_K^m \tag{A.22}$$

we obtain

$$\begin{aligned}\frac{dW}{d\tau^c} = \frac{\bar{\lambda}}{r}\left(\frac{\mu_1}{\mu_1 - r}\right)&\left\{\tau^c[F_L L_\lambda^m - C_\lambda^m]\frac{(a_{21}-r)}{a_{22}} - \tau^c F_L L_K^m + \frac{\tau^i - \tau^c}{1+\tau^c}(r+\delta)\right\}\frac{d\tilde{K}}{d\tau^c}\\ &+ \frac{\bar{\lambda}}{r}\tau^c\left[(F_L L_\lambda^m - C_\lambda^m)\frac{e_2}{a_{22}} - (F_L L_\tau^m - C_\tau^m)\right].\end{aligned} \tag{A.23}$$

From (A.8) we can show $d\tilde{K}/d\tau^c > 0$, while a sufficient condition for the coefficient of this term in (A.23) to be negative is that $\tau^i < \tau^c$. The remaining term in (A.23) can also be shown to be negative, implying that $dW/d\tau^c < 0$, as stated in Proposition 3.

To obtain Propositions 4 and 5, we first derive the analogous welfare effects for τ^i. Equations (A.17), (A.18), and (A.21) all hold for arbitrary predetermined values of the tariff rates τ^i, τ^c. Combining these relationships, one can establish

$$\frac{dW}{d\tau^i} = \frac{\bar{\lambda}}{r}\left(\frac{\mu_1}{\mu_1 - r}\right)\left\{\left[1 + \frac{\tau^c[F_L L_\lambda^m - C_\lambda^m]}{a_{22}}\right](a_{21} - r) + G_L \ell_K\right\}\frac{d\tilde{K}}{d\tau^i}. \tag{A.24}$$

and noting (A.22), enables (A.24) to be written as

$$\frac{dW}{d\tau^i} = \frac{\bar{\lambda}}{r}\left(\frac{\mu_1}{\mu_1 - r}\right)\left\{\tau^c[F_L L_\lambda^m - C_\lambda^m]\frac{(a_{21}-r)}{a_{22}} - \tau^c F_L L_K^m + \frac{(\tau^i - \tau^c)}{1+\tau^c}(r+\delta)\right\}\frac{d\tilde{K}}{d\tau^i}. \tag{A.25}$$

From (A.8) we can readily show $d\tilde{K}/d\tau^i < 0$, while as before a sufficient condition for the term in parentheses in (A.25) to be negative is that $\tau^i < \tau^c$. These results together imply $dW/d\tau^i > 0$.

To establish Proposition 4, first write

$$W = W(\tau^c, \tau^i)$$

the differential of which is

$$dW = \frac{dW}{d\tau^c} d\tau^c + \frac{dW}{d\tau^i} d\tau^i.$$

Observe that (A.23) and (A.25) are of the form

$$\frac{dW}{d\tau^i} = \theta \frac{d\tilde{K}}{d\tau^i}$$
$$\frac{dW}{d\tau^c} = \theta \frac{d\tilde{K}}{d\tau^c} + \gamma$$

where $\gamma < 0$, and for $\tau^i < \tau^c, \theta < 0$. Thus

$$dW = \theta \left[\frac{d\tilde{K}}{d\tau^c} d\tau^c + \frac{d\tilde{K}}{d\tau^i} d\tau^i \right] + \gamma d\tau^c.$$

Consider now a radial reduction in τ^c and τ^i specified by $d\tau^i/\tau^i = \mu d\tau^c/\tau^c$. The net effect on wealth is

$$dW = \theta \left[\frac{d\tilde{K}}{d\tau^c} + \frac{\mu\tau^i}{\tau^c} \frac{d\tilde{K}}{d\tau^i} \right] d\tau^c + \gamma d\tau^c. \qquad (A.26)$$

The reduction in the capital stock from the lower tax on consumption goods is welfare improving, while the higher capital stock resulting from the higher tax on investment is welfare deteriorating. Using (A.8), equation (A.26) becomes

$$dW = \frac{\theta}{J} \left[[e_1 - \frac{\mu\tau^i}{\tau^c}(r + \delta)]a_{22} - e_2 a_{12} \right] d\tau^c + \gamma d\tau^c. \qquad (A.27)$$

It is easy to show that a sufficient condition for the term in parentheses to be positive is that $\mu < \tau^c(1 + \tau^i)/\tau^i(1 + \tau^c)$. If this condition is met, a radial reduction in tariffs is welfare improving, thereby establishing Proposition 4.

Proposition 5 follows immediately by combining the results of (A.23) and (A.25), namely $dW/d\tau^c < 0, dW/d\tau^i > 0$.

FOOTNOTES

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[1]Neary and Ruane present their analysis in terms of a vector of tariffs, but for expository reasons do not emphasize differential tariffs (see their footnote 4). Our specification of differential tariffs on consumer and investment goods was motivated, in part, by Krueger's (1983) survey of protective trade policies. In that survey, Krueger (p. 8) noted that the "emphasis on import substitution led to...implicit subsidization of capital goods imports. Although one might think that import substitution policies would be across the board in their application, almost all countries with overvalued exchange rates were reluctant to impose surcharges and high duties on machinery and equipment imports for fear of discouraging investment."

[2]Two of these reforms (Korea and Chile) are discussed in Section VI.

[3]See, e.g., Matsuyama (1987), Brock (1988), Obstfeld (1989), Sen and Turnovsky (1989).

[4]We could have considered the three agent problem of the consumer, firm, and landlord. However, the analytical results are the same. Compactness of presentation of the model convinced us to adopt the single agent formulation.

[5]Throughout we adopt the following conventional notation. Partial derivatives are denoted by corresponding letters, while total derivatives of a function of a single argument are denoted by primes. Time derivatives are denoted by dots.

[6]Results are robust with respect to the specification of the adjustment cost function $\phi(I, K)$ and many variants can be found in the literature. For further discussion of the specification of adjustment costs in the investment process see Hayashi (1982).

[7]These properties imply: $\psi(\delta K, K) = \delta K, \quad \psi_I(\delta K, K) = 1$. Using Euler's theorem, the following additional properties of ψ, evaluated at steady-state equilibrium are used below:

$$(i)\ \ \psi_K(\delta K, K) = 0; \ \ (ii)\ \ \psi_{II}(\delta K, K)\delta + \psi_{IK}(\delta K, K) = 0; \ \ (iii)\ \ \psi_{KI}(\delta K, K)\delta + \psi_{KK}(\delta K, K) = 0.$$

[8]The Corden discussion is carried out in terms of a static framework. The assumption of appropriate lump-sum transfers in conjunction with distortionary taxes is also widely employed in intertemporal public finance models, such as Judd (1987) and King and Rebelo (1990).

[9]Since C^m, C^x, ℓ, L^m, and L^x are functions of τ^c, but not τ^i, for convenience the notation C^m_τ refers to $\partial C^m/\partial\tau^c$ etc. Likewise, since I depends upon τ^i but not τ^c, I_τ refers to $\partial I/\partial\tau^i$. This choice of notation should be clear.

[10] With the CES utility function U_{mx} depends upon the intertemporal elasticity of substitution relative to the intratemporal elasticity of substitution; see e.g., Dornbusch (1983).

[11] The behavioral responses described in (7a) - (7f) are only the compensated responses of the agent to changes in either of the two tariff rates, since changes in either rate will alter the shadow value of wealth, the market price of capital, and cause the capital stock to change over time. These overall effects are discussed in the Appendix.

[12] The fact that the elements appearing in the matrix of coefficients are to be evaluated at steady state permits substantial simplification. (i) In general, $\partial \dot{q}/\partial q = (1+\tau^i)\psi_{KI}I_q + (r+\delta)$. Differentiating (6e) implies $I_q = 1/(1+\tau^i)\psi_{II}$. Then using the steady state condition (ii) in footnote 7, $\partial \dot{q}/\partial q$ reduces to r. (ii) In general $\partial \dot{q}/\partial K = -(1+\tau^e)[F_{KK} + F_{KL}L_K^m] + (1+\tau^i)[\psi_{KK} + \psi_{KI}I_K]$. Using the fact that in steady state $I_K = \delta$, and condition (iii) of footnote 7 implies $[\psi_{KK} + \psi_{KI}I_K] = 0$. (iii) the remaining terms $\partial \dot{K}/\partial q, \partial \dot{K}/\partial K$ follow directly from (6e) and (2).

[13] From the optimality condition with respect to labor supply for the representative agent, the elasticity of labor supply, can be shown to be related to V'' by

$$\eta = -\frac{\overline{\lambda}}{V''}\frac{W}{L}.$$

[14] There is no general agreement on the magnitude of the compensated supply elasticity of labor in developing countries. Many early models, such as Lewis (1954) and Ranis and Fei (1961) emphasized the existence of surplus labor in a non utility-maximizing framework. Sen (1966) first showed that the existence of surplus labor in a utility-maximizing model implies that the compensated (i.e., λ constant) labor supply elasticity be infinite. Consequently, our model treats labor supply elasticities that are bounded below by the standard trade model assumption of a zero supply elasticity and above by the infinitely-elastic supply assumption of a surplus labor economy.

[15] When τ is sufficiently large, it is possible for a further increase to lead to an immediate reduction in instantaneous welfare (and continuous losses thereafter). This may occur if $d\overline{\lambda}/d\tau > 0$.

[16] These results follow from consideration of the terms ψ_{II} and V'' on the size of the system's negative eigenvalue:

$$\mu_1 = \frac{1}{2}r - \frac{1}{2}\sqrt{r^2 - 4\frac{1+\tau^e}{(1+\tau^i)\psi_{II}}(F_{KK} + F_{KL}L_K^m)}$$

where

$$F_{KK} + F_{KL}L_K^m = \frac{\{F_{KK}G_{LL}V''\overline{\lambda}^2\}}{\{\overline{\lambda}(1+\tau)F_{LL}G_{LL} + V''[(1+\tau)F_{LL} + G_{LL}]\}} < 0.$$

Equivently one can show that in the limiting case $V'' = 0, d\tilde{K}/d\tau = 0$.

[17] $dY/dK > r + \delta$ if and only if $\tau < -\left(\frac{G_{LL}L^*}{G_L}\right)\frac{\eta}{\rho}$, where $\eta \equiv dL/dW \frac{W}{L}$ is the elasticity of the supply of labor.

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