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TARIFFS AND SECTORAL ADJUSTMENTS IN AN OPEN ECONOMY

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ABSTRACT

This paper analyzes the impact of a tariff on sectoral adjustments in an economy which produces two traded consumption goods, one of which is exported, and a non-traded investment good. The importance of sectoral capital intensities is emphasized. In particular, the qualitative dynamic adjustment depends upon the relative capital intensities of the import-competing consumption good sector and the non-traded investment good sector. Sectoral labor allocation effects are analyzed and the long-run effect on aggregate capital accumulation is shown to depend upon the relative capital intensities of the import and export sectors. Temporary as well as permanent tariffs are discussed.

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1. INTRODUCTION

The use of tariffs as an instrument of macroeconomic policy has been the subject of increased investigation recently. Two issues have been at the forefront of the discussion. The first, is the effect on economic activity, such as the level of employment and rate of capital accumulation, the second is the impact on the current account deficit.

Various approaches to the analysis of the macroeconomic effects of tariffs can be identified. Early theoretical work, which originated with Mundell (1961), was based on an extension of the traditional $IS - LM$ model. Using this static framework, he established the proposition that, by raising the terms of trade and reducing aggregate demand, a tariff is contractionary. Subsequent work by Krugman (1982) suggested that this result was quite robust with respect to various aspects of this model. He also demonstrated that by reducing income more than expenditure, the tariff will lead to a deterioration in the current account balance.

The first macrodynamic analysis of tariffs was by Eichengreen (1981), who emphasized the intertemporal tradeoffs generated by a tariff. In contrast to the static model, his analysis suggested that the short-run effects of the tariff are likely to be expansionary. These gains, however, are only temporary since the associated savings and current account surplus is likely to lead to a contraction over time.

The Eichengreen study, while dynamic, is based on an arbitrarily specified macroeconomic model. Recent approaches to the dynamic analysis of tariffs and other macroeconomic disturbances have adopted the intertemporal optimizing representative agent framework; see e.g., Brock (1986), Edwards (1987), van Wijnbergen (1987), Sen and Turnovsky (1989b). These models differ from one another in various respects. Brock focuses primarily on trade liberalization issues in an economy which imports all its capital from abroad. The studies by Edwards and van Wijnbergen are both restricted to a two period analysis. The Sen–Turnovsky paper deals purely with aggregative issues, emphasizing the impact of the tariff on the rate of capital accumulation and the current account. It shows how in such a model a tariff is contractionary in both the short run and the long run, while generating a current account surplus during the transition.

Much of the motivation for the use of a tariff as a policy instrument is to achieve sectoral restructuring. A tariff is imposed to protect an industry from foreign competition and removed when this is no longer desired. The purpose of the present paper is to address this sectoral adjustment aspect of tariffs, while at the same time considering macroeconomic issues as well. Specifically, we consider an economy which produces two consumption goods, one of which it exports, the other of which is import–competing. In addition, it produces an investment good which is nontraded and serves as an input into the production of the two consumption goods. Aggregate capital in the economy is accumulated gradually, though it may be reallocated instantaneously across sectors at each point of time.

The basic production framework being adopted is essentially an open economy extension of the early two–sector growth model pioneered by Uzawa (1961), Inada (1964) and others. The relative sectoral factor intensities, characteristic of that literature, play a prominent role in the present analysis as well. In particular, the contrast between the capital–labor ratio in the import–competing industry on the one hand, and in the investment good industry, on the other, is fundamental. The dynamic adjustment of the economy in response to a tariff is dependent upon these relative quantities, in much the same way as it was in the original two–sector growth models. At the same time, our sectoral analysis closely resembles the Heckscher–Ohlin framework used to analyze tariffs and other disturbances in the real trade context, but in contrast to that literature the accumulation of capital and other aspects of the macrodynamic adjustments are emphasized.[1]

Both permanent and temporary tariffs are analyzed. Whereas Sen and Turnovsky showed how a temporary tariff will give rise to a permanent effect, which is qualitatively the same as, though quantitatively smaller than, that of a permanent tariff, whether this is true in the present context depends upon the relative capital intensities of the investment and the import-competing sectors. In one case, the hysteresis obtained by Sen and Turnovsky continues to hold; in the other case it does not.

Other papers address the sectoral effects of tariffs, although under somewhat different sets of assumptions. For example, both Brock (1986) and Gavin (1990) impose sectoral adjustment costs. In addition Brock assumes that all capital is imported, while Gavin assumes that it is fixed in the aggregate. The production framework employed in this analysis is similar to, but not identical to, that employed by van Wincoop (1988) in his sectoral analysis of the Dutch disease problem.[2]

The remainder of the paper is structured as follows. Section 2 sets out the framework, while Section 3 discusses the dynamic structure and its dependence upon the relative sectoral capital intensities. The next section discusses the long-run effects of a permanent tariff on the economy. Sections 5 and 6 analyze the transitional adjustments, under the alternative assumptions concerning sectoral intensities. Section 7 considers the case of a temporary tariff, while Section 8 reviews the main conclusions. Technical details are relegated to the Appendix.

2. THE ANALYTICAL FRAMEWORK

We consider an open economy which has the following characteristics. It produces a distinct export good, part of which is consumed domestically, and an import-competing consumption good. In addition, it produces an investment good, which is neither consumed nor traded, but serves only as an input into the production of the two consumption goods.[3] In order to focus on sectoral effects, we assume that the aggregate supply of labor remains fixed, though like capital, it may move instantaneously across sectors. The relative prices of both the import-competing good and the investment good, in terms of the domestic export good, treated as numeraire, are endogenously determined. On the financial side, the economy can borrow or lend as much as it wants at the given world interest rate, though subject to an intertemporal budget constraint.[4] However, by being able to influence the terms of trade, the real interest rate of the economy, measured in terms of the numeraire, is endogenously determined.

A. *Structure of the Economy*

The representative consumer is assumed to make decisions in accordance with the following intertemporal optimization problem

$$Max \int_0^\infty U(x,y)e^{-\beta t}dt \tag{1a}$$

subject to

$$\dot{b} = \frac{1}{\sigma}[w\bar{\ell} + \pi - x] - \gamma y + i^* b + T \tag{1b}$$

and initial condition

$$b(0) = b_0 \tag{1c}$$

where

x = consumption of the export good,

y = consumption of the import–competing good,

σ = relative price of import–competing good in terms of export good (net of the tariff),

$\bar{\ell}$ = fixed supply of labor,

b = stock of traded bonds, held by domestic consumers (in units of foreign output),

w = real wage rate, expressed in terms of domestic export good,

π = real profit distributed to households, expressed in terms of domestic export good,

γ = $1+\tau$, where τ = tariff rate,

i^* = world interest rate,

β = consumer rate of time discount, taken to be constant,

T = lump–sum transfers from the government.

The utility function is strictly concave and in addition, the two goods are taken to be Edgeworth complementary, so that $U_{xy} > 0$. In determining his optimal plans for x, y, and bond holdings b, the consumer treats σ, π, w, i^* as given. The optimization is standard and leads to the following first order conditions

$$U_x(x, y) = \frac{\lambda}{\sigma} \tag{2a}$$

$$U_y(x, y) = \lambda\gamma \tag{2b}$$

$$\dot{\lambda} = \lambda(\beta - i^*) \tag{2c}$$

where λ, the costate variable associated with the accumulation equation (1b), is the marginal utility of wealth, the latter measured in terms of units of the traded bond.[5] Since β and i^* are both assumed to be fixed, the ultimate attainment of a steady-state equilibrium is possible if and only if $\beta = i^*$. Henceforth, we assume this to be so in which case $\dot{\lambda} \equiv 0$, so that the marginal utility of wealth is always at its steady-state level $\overline{\lambda}$ (determined below). In addition, we impose the transversality condition

$$\lim_{t\to\infty} \overline{\lambda} b(t) e^{-i^* t} = 0 \tag{2d}$$

which rules out the possibility of consumers running up an infinite stock of debt.

The production sector is more involved and is a direct analogue of the Uzawa two-sector framework. The production functions are of the usual form

$$Y_X = F(K_X, L_X); \quad Y_M = G(K_M, L_M); \quad Y_I = H(K_I, L_I) \tag{3}$$

where

Y_i is the output of sector i,

K_i is the capital employed in sector i,

L_i is the labor employed in sector i

and the export, import-competing, and investment sectors are indexed by X, M, and I, respectively. All three production functions are assumed to have the usual neoclassical properties of positive, but diminishing, marginal physical products, and constant returns to scale.

For analytical convenience, and without essential loss of generality, we assume that the production decisions facing the three producers can be consolidated into the following optimization problem, namely

$$Max \int_0^\infty [F(K_X, L_X) + \sigma\gamma G(K_M, L_M) + pH(K_I, L_I) - p[\dot{K} + \delta K] - w\bar{\ell}]e^{-\int_0^t i(s)ds} dt \quad (4a)$$

subject to

$$K_X + K_M + K_I = K \quad (4b)$$

$$L_X + L_M + L_I = \bar{\ell} \quad (4c)$$

and initial condition

$$K(0) = K_0 \quad (4d)$$

where

K denotes the aggregate capital stock,

p denotes relative price of investment good in terms of export good as numeraire,

δ is the rate of depreciation of capital.

This problem is straightforward, but the following should be noted. First, the price of the import-competing good includes the tariff. Secondly, the capital stock is assumed to depreciate at the constant rate δ. Thirdly, net revenues, being measured in terms of the export good as numeraire, are discounted at the domestic real interest rate i, defined in terms of that good. Given interest parity, this is related to the world real interest rate, defined in terms of the world good, by

$$i = i^* + \frac{\dot{\sigma}}{\sigma}. \tag{5}$$

The two constraints (4b), (4c), respectively, incorporate the fact that the aggregate capital stock is fixed instantaneously, accumulating only gradually, while the total stock of labor is fixed at all times by assumption.

The optimality conditions for firms include the following:

$$\sigma\gamma \frac{\partial G}{\partial K_M} = p\frac{\partial H}{\partial K_I} = \frac{\partial F}{\partial K_X} \tag{6a}$$

$$\sigma\gamma \frac{\partial G}{\partial L_M} = p\frac{\partial H}{\partial L_I} = \frac{\partial F}{\partial L_X} \tag{6b}$$

together with

$$p\frac{\partial H}{\partial K_I} = p[i + \delta] - \dot{p} \tag{6c}$$

the constraints (4b), (4c), and the transversality condition

$$\lim_{t\to\infty} K(t)e^{-\int_0^t i(s)ds}dt = 0. \tag{4d}$$

Equations (6a) and (6b) describe the instantaneous allocation conditions, whereby the marginal physical product are equated across sectors. Equation (6c) is an intertemporal arbitrage condition equating the marginal return on investment to the rate of return on a bond. This can be seen more clearly, when this equation is rewritten in the form

$$\frac{\partial H}{\partial K_I} - \delta + \frac{\dot{p}}{p} = i. \tag{6c'}$$

Using the linear homogeneity of the production functions and defining the sectoral capital–labor ratios by

$$k_i = \frac{K_i}{L_i} \qquad i = X, M, I$$

the intratemporal allocation conditions may be expressed as

$$\sigma\gamma g'(k_M) = ph'(k_I) = f'(k_X) \tag{7a}$$

$$\sigma\gamma[g(k_M) - k_M g'(k_M)] = p[h(k_I) - k_I h'(k_I)] = f(k_X) - k_X f'(k_X) \tag{7b}$$

where

$$f(k_X) = F\left(\frac{K_X}{L_X}, 1\right)$$

and

$$f' > 0, \quad f'' < 0 \quad \text{etc.}$$

These equations may be solved as follows:

$$k_i = k_i(p) \qquad i = X, M, I \tag{8}$$

$$\sigma = \sigma(p, \gamma) \tag{9}$$

and have the following properties

$$\frac{dk_X}{dp} = \frac{h}{f''(k_I - k_X)} \tag{10a}$$

$$\frac{dk_M}{dp} = \left[\frac{ff''}{(f')^2}\frac{(g')^2}{gg''}\right]\frac{dk_X}{dp} \tag{10b}$$

$$\frac{dk_I}{dp} = \left[\frac{ff''}{(f')^2}\frac{(h')^2}{hh''}\right]\frac{dk_X}{dp}. \tag{10c}$$

The responses of the sectoral capital-labor ratios to changes in the relative price of the investment good all depend upon the relative capital intensities k_X, k_I. If $k_X > k_I$, a rise in the relative price of the investment good p, will raise the capital–labor ratios in all three sectors. Intuitively, the higher relative price p will cause resources to move from Sector X to Sector I. If $k_X > k_I$, labor increases in relative scarcity, causing the wage–rental ratio to rise and inducing producers in all sectors to substitute capital for labor.

In addition, the relative domestic price of the import good, inclusive of the tariff, $\sigma\gamma$, is independent of the tariff, so that

$$\frac{d\sigma/\sigma}{d\gamma/\gamma} = -1. \tag{11a}$$

The elasticity of the net relative price with respect to the tariff is -1. Further, we may show

$$\frac{d\sigma}{dp} = \frac{(k_M - k_X)}{k_I - k_X}\frac{h}{\gamma g} \tag{11b}$$

which depends upon the relative capital intensities of all three sectors. Again, taking $k_X > k_I$, the rise in the wage–rental ratio resulting from a higher relative price p will raise the relative price of the import good to the export good, σ, if and only if Sector M is more intensive than Sector X in the relatively more expensive factor of production (labor).

Finally, the government in this economy plays a simple role, collecting tariff revenues from the public and redistributing them in lump sum fashion, namely

$$(\gamma - 1)[y - \rho_M g]\sigma = T. \tag{12}$$

B. *Macroeconomic Equilibrium*

The macroeconomic equilibrium is obtained where the planned demand and supply functions derived from the respective optimizations, consistent with the accumulation equations, clear all markets. This reduces to the following set of relationships:

$$U_x(x,y) = \frac{\overline{\lambda}}{\sigma(p,\gamma)} \tag{13a}$$

$$U_y(x,y) = \overline{\lambda}\gamma \tag{13b}$$

$$\rho_X k_X(p) + \rho_M k_M(p) + \rho_I k_I(p) = k \tag{13c}$$

$$\rho_X + \rho_M + \rho_I = 1 \tag{13d}$$

$$\rho_X f(k_X(p)) - x - Z[\sigma(p,\gamma)] = 0 \tag{13e}$$

$$\dot{p} = p\left[i^* + \frac{\dot{\sigma}}{\sigma} + \delta - h'(k_I(p))\right] \tag{14a}$$

$$\dot{k} = \rho_I h(k_I(p)) - \delta k \tag{14b}$$

$$\sigma\dot{b} = \rho_X f(k_X(p)) + \sigma\rho_M g(k_M(p)) - x - \sigma y + i^*\sigma b. \tag{14c}$$

In writing the equilibrium in this form, we have utilized the solutions for k_i, σ, derived in (8) and (9). Equations (13a), (13b) simply repeat the marginal utility conditions (2a), (2b), noting now that the marginal utility of wealth is constant. Equations (13c), (13d) are the sectoral allocation constraints, expressed in fractional form, where

$k = \frac{K}{\ell}$ is the aggregate capital–labor ratio;

$\rho_i = \frac{L_i}{\ell}$ is the fraction of labor employed in industry i.

Equation (13e) describes the clearance of the domestic export good market, where Z, the export demand is assumed to be an increasing function of the relative price σ.

These five equations define the short–run equilibrium. They may be solved in the following sequential way. Given σ, the marginal utility conditions (13a), (13b) may first be solved for domestic consumptions x, y in terms of $p, \overline{\lambda}$, and γ. Having determined x, and thus the demand for the domestic export good, the market clearing condition (13e) determines the output of Good X, which given the sectoral capital–labor ratio, determines the fraction of the labor force employed in that sector. Given ρ_X, the sectoral allocation constraints (13c), (13d) then determine the fractions of the domestic labor force, ρ_M, ρ_I, employed in the other two sectors.

The short–run solutions may be written in the form

$$x = x(p, \overline{\lambda}, \gamma) \qquad x_{\overline{\lambda}} < 0 \quad x_\gamma < 0 \tag{15a}$$

$$y = y(p, \overline{\lambda}, \gamma) \qquad y_{\overline{\lambda}} < 0 \quad y_\gamma < 0 \tag{15b}$$

$$\rho_X = \rho_X(p, \overline{\lambda}, \gamma) \qquad \rho_{X,\overline{\lambda}} < 0, \quad \rho_{X,\gamma} < 0 \tag{15c}$$

$$\rho_M = \rho_M(p, k, \overline{\lambda}, \gamma) \tag{15d}$$

$$\rho_I = \rho_I(p, k, \overline{\lambda}, \gamma). \tag{15e}$$

The formal expressions for the partial derivatives of these functions are given in the Appendix and except for those noted above, the signs are dependent upon relative sectoral capital intensities. Here we simply offer some informal intuitive interpretations. A higher marginal utility of wealth encourages savings, leading to a decline in the consumption of both goods. With the relative price p, and therefore the sectoral capital intensities fixed, the decline in the output of the domestic export good leads to a reduction in employment in that industry. To which sector labor moves depends upon the capital intensity of Sector X, relative to that of Sectors I and M. If, for example, $k_I > k_X > k_M$, the labor released from Sector X (along with the corresponding capital), can, given the fixed sectoral capital–labor ratios, be absorbed in both of the other industries, so that employment in both of them rises. By contrast, if $k_X > k_I > k_M$, the decline in the output of X releases too much capital to be absorbed in both the other industries, at the given sectoral intensities. Instead, employment in the investment industry rises, while that in the import–competing industry declines.

The partial effects of the higher tariff, as given by the corresponding partial derivatives, are essentially analogous. The complete short–run effects involve in addition to these effects, the responses resulting from the jumps in $\overline{\lambda}$, and possibly p, induced by this change. The only partial effect of a higher stock of capital is to cause labor to move between sectors M and I, in the direction of the more capital intensive of the two, in response to the higher wage–rental ratio. Finally, the effects of a higher relative price p operate through two channels. The first is through the induced change in the relative price σ; the second is through the adjustments in the sectoral capital intensities. Both of these sources of impact depend upon the pre–existing capital intensities.

The remaining three equations describe the dynamics and have the following recursive structure. First, equation (14a), which is the arbitrage pricing relationship, can be reduced to an equation in the relative price p alone. To see this, note that the path of the relative price σ is determined by that of p, in accordance with (9). Differentiating this equation, yields

$$\dot{\sigma} = \sigma_p \dot{p}$$

which upon substitution yields the required equation. The second equation describes the accumulation of capital as equal to the output of the investment sector less depreciation. Given the relative price p, as determined by (14a), this equation determines the stock of capital. Note that since (14a), (14b) are determined in part by the constant steady-state value of the marginal utility $\overline{\lambda}$, the steady state in part determines the entire adjustment path.

Finally, equation (14c) describes the accumulation of foreign bonds by the economy, this being equal to the current account surplus. The latter comprises the trade balance, equal to the value of output of tradeables less domestic consumption, plus interest payments on outstanding assets. Using (13e), this may be expressed in equivalent form as

$$\dot{b} = \frac{1}{\sigma} Z(\sigma(p, \gamma)) + \rho_M g(k_M(p)) - y + i^* b. \tag{14c$'$}$$

3. DYNAMICS

We begin by considering the dynamics of k and p. Linearizing the pair of equations (14a), (14b) about steady state, these may be approximated by [6]

$$\begin{bmatrix} \dot{p} \\ \dot{k} \end{bmatrix} = \begin{bmatrix} a_{11} & 0 \\ a_{21} & a_{22} \end{bmatrix} \begin{bmatrix} p - \tilde{p} \\ k - \tilde{k} \end{bmatrix} \tag{16}$$

where

$$a_{11} = \frac{-p\sigma}{\sigma - \partial\sigma/\partial p} h'' k_I'$$

$$a_{21} = h \frac{\partial \rho_I}{\partial p} + \rho_I h' k_I'$$

$$a_{22} = h \frac{\partial \rho_I}{\partial k} - \delta$$

and the terms a_{ij} are to be evaluated at steady state.

Performing these calculations, we may establish the following:

$$(i)\ \ sgn\ \ a_{11} = sgn\ \ (k_M - k_I)$$

$$(ii)\ \ sgn\ \ a_{22} = sgn\ \ (k_I - k_M)$$

$$(iii)\ \ sgn\ \ a_{21} = sgn\ \ (k_X - k_I)(k_M - k_I)$$

Details of these calculations are tedious and are relegated to the Appendix. For example, to understand a_{11}, an increase in p will attract resources from Sector X to Sector I, lowering the wage–rental ratio if $k_I > k_X$, thereby lowering the sectoral capital–labor ratio and raising the marginal physical product of capital. In order to maintain the real rate of return on capital equal to the world interest rate i^*, the relative rate of price change $(\dot{p}/\sigma)$ must fall and this will occur if and only if $k_I > k_X, k_I > k_M$.

Since the determinant in (16) $= a_{11}a_{22} < 0$, the dynamics are a saddlepoint, irrespective of the capital intensities k_I, k_M. We shall denote the eigenvalues by $\mu_1 < 0, \mu_2 > 0$. While the capital stock always evolves continuously, the relative price p may jump instantaneously to new information. The stable solution is of the form

$$k = \tilde{k} + (k_0 - \tilde{k})e^{\mu_1 t} \tag{17a}$$

$$p = \tilde{p} - (\frac{a_{22} - \mu_1}{a_{21}})(k - \tilde{k}) \tag{17b}$$

where the two cases $k_I < k_M, k_I > k_M$ need to be considered separately.[7]

Case (i): $k_M > k_I$**:** This assumption asserts that the capital intensity of the import–competing consumption good sector exceeds that of the investment good sector and is analogous to that originally made by Uzawa. It implies

$$\mu_1 = a_{22} < 0; \quad \mu_2 = a_{11} > 0$$

so that the stable path (17a), (17b) is

$$k = \tilde{k} + (k_0 - \tilde{k})e^{a_{22}t} \tag{17a'}$$

$$p = \tilde{p}. \tag{17b'}$$

In this case, along the stable path, the relative price p remains constant at its steady-state level.

Case (ii): $k_I > k_M$**:** The contrary case where the investment sector is more capital intensive than is the import-competing sector yields

$$\mu_1 = a_{11} < 0; \qquad \mu_2 = a_{22} > 0$$

and the stable adjustment path now becomes

$$k = \tilde{k} + (k_0 - \tilde{k})e^{a_{11}t} \tag{17a''}$$

$$p - \tilde{p} = (\frac{a_{11} - a_{22}}{a_{21}})(k - \tilde{k}). \tag{17b''}$$

The slope of the stable path, given by (17b″) now depends upon sgn (a_{21}); i.e., it will be positively or negatively sloped according to whether the capital intensities satisfy $k_X \gtrless k_I$.[8]

The striking feature of the stable transitional adjustment paths described by (17a′), (17b′) and (17a″), (17b″) to be discussed in more detail in Sections 5 and 6 below, is the qualitative dependence of the behavior of the relative price p on the relative capital intensities of Sectors M and I. In the case where $k_M > k_I$, the fact that p remains unchanged can be seen by considering the arbitrage relationship (6c′). Writing this as

$$h'(k_I) - \delta = i^* + \left(\frac{\sigma_p p}{\sigma} - 1\right)\frac{\dot{p}}{p} \tag{6c''}$$

the comovement of the rental rate on capital and the (expected) rate of change of the relative price p depends upon whether the elasticity of σ_p with respect to $p, \sigma_p p/\sigma \gtrless 1$. The latter in turn can be shown to depend upon the sectoral capital intensities, in accordance with

$$\text{sgn } \left[\frac{\sigma_p p}{\sigma} - 1\right] = \text{sgn } \left(\frac{k_M - k_I}{k_I - k_X}\right).$$

Consider, for example, the case where $k_M > k_X > k_I$ and suppose that instead of remaining fixed in response to an increase in γ, p were in fact to rise in the short run. Given these relative capital intensities, k_X, k_M and k_I would all rise, while σ would fall; see (10), (11b). The rental on capital would fall and in order to maintain the equality between the rates of return to capital and bonds, p must be expected to rise further. As this occurs, the rental rate on capital falls more and as σ also continues to fall, p must continue rising still further. This is clearly an unstable path. The same applies if on impact p were to fall, leaving us with an unchanging p as being the only outcome consistent with stability.

By contrast, consider the alternative case where say $k_X > k_I > k_M$, when as we shall show below, an increase in γ gives rise to a short–run rise in p. For these capital intensities k_X, k_I and k_M will rise, causing the rental rate on capital to fall. But now $\sigma_p p/\sigma > 1$, so that σ rises more than p, implying that following the initial rise, p must be expected to fall in order for the arbitrage condition to hold. But this is a perfectly stable adjustment path.

To determine the dynamics of the current account, we consider (14c′), rewritten as

$$\dot{b} = \frac{Z[\sigma(p,\gamma)]}{\sigma(p,\gamma)} + \rho_M[\overline{\lambda}, p, \gamma, k]g[k_M(p)] - y(\overline{\lambda}, p, \gamma) + i^* b. \tag{18}$$

Linearizing this equation about steady state, yields

$$\dot{b} = \left[\frac{1}{\sigma}\beta\frac{\partial\sigma}{\partial p} - \frac{\partial y}{\partial p} + \frac{\partial\rho_M}{\partial p}g + \rho_M g' k_M'\right](p - \tilde{p}) + g\frac{\partial\rho_M}{\partial k}(k - \tilde{k}) + i^*(b - \tilde{b})$$

where $\beta \equiv Z' - Z/\sigma$. Using (17a), (17b), this equation may be written as

$$\dot{b} = \Omega(k_0 - \tilde{k})e^{\mu_1 t} + i^*(b - \tilde{b}) \tag{19}$$

where

$$\Omega \equiv - \left[\frac{1}{\sigma}\beta\frac{\partial\sigma}{\partial p} - \frac{\partial y}{\partial p} + \frac{\partial\rho_M}{\partial p}g + \rho_M g' k'_M\right]\left(\frac{a_{22} - \mu_1}{a_{21}}\right) + g\frac{\partial\rho_M}{\partial k}. \tag{20}$$

Assuming that the economy starts out from an initial stock of traded bonds $b(0) = b_0$, the solution to (19) is

$$b(t) = \tilde{b} + \Omega\frac{(k_0 - \tilde{k})}{\mu_1 - i^*}e^{\mu_1 t} + \left[b_0 - \tilde{b} - \frac{\Omega}{\mu_1 - i^*}(k_0 - \tilde{k})\right]e^{i^* t}.$$

Invoking the intertemporal budget constraint for the economy (2d) implies

$$b_0 - \tilde{b} = \frac{\Omega}{\mu_1 - i^*}(k_0 - \tilde{k}) \tag{21}$$

so that the solution for $b(t)$ consistent with long-run solvency is

$$b(t) - \tilde{b} = \frac{\Omega}{\mu_1 - i^*}(k_0 - \tilde{k})e^{\mu_1 t}. \tag{22}$$

Equation (22) describes the relationship between the accumulation of traded bonds and the accumulation of physical capital. Of particular significance is the sign of this relationship as reflected by Ω. This depends critically upon the relative capital intensities k_I and k_M.

Case (i): $k_M > k_I$: In this case $\mu_1 = a_{22}$ and the relative price p remains fixed; see (17b'). This reduces Ω to $g\frac{\partial\rho_M}{\partial k} = \frac{g}{(k_M - k_I)} > 0$. An increase in the capital stock lowers the rate of capital accumulation, $\dot{k}$, while raising employment in the import-competing industry, thereby reducing imports and increasing the current account balance. A decumulating capital stock is therefore accompanied by an accumulating stock of traded bonds.

Case (ii): $k_I > k_M$: In this case $\mu_1 = a_{11}$ and the changing capital stock now has two general effects on the current account. First, there is a direct effect, $\rho\frac{\partial \rho_M}{\partial k}$ which with $k_I > k_M$ is now negative.[9] Secondly, an increase in k will now generate an adjustment in the relative price p, in accordance with (17b″), the direction of which depends upon a_{21}, i.e., upon the relative capital intensities of the export industry and the investment sector. The impact of the resulting change in the relative price level, whatever its direction, in turn has additional effects, which may, or may not, be reinforcing.

To take a concrete example, let us assume $k_I > k_X$, so that $a_{21} > 0$. A rising capital stock ($\dot{k} > 0$) is associated with a falling relative price ($\dot{p} < 0$); see (17b″). Intuitively, an increasing capital stock implies an increasing wage-rental ratio, inducing a substitution towards more capital. Given the capital intensities $k_I > k_X$, the relative price p must fall in order to release relatively sufficient capital to accommodate the substitution stemming from the rising wage-rental ratio.

Now a declining p has an effect on the relative price of the import-competing to the export good (σ) which depends upon both relative capital intensities ($k_M - k_X$) and ($k_I - k_X$). Again, to be concrete, taking the former to be positive as well, the falling p will lead to a falling relative price σ and therefore a declining trade balance, as measured in terms of the foreign good, as long as β is assumed to be positive. This will be so provided the price elasticity of export demand exceeds unity. At the same time, the declining relative price σ will raise the marginal utility of wealth measured in terms of the export good, leading to a decrease in the consumption of that good. With $U_{xy} > 0$, the consumption of the import-competing good also declines, leading to an improvement in the current account. Furthermore, with $k_I > k_X$, the declining relative price p raises the sectoral capital-labor ratio k_M. In addition, the falling p attracts labor to the import-competing industry and away from the export industry, so that ρ_M will tend to rise.[10] Both these effects will tend to increase the output of the import- competing industry, improving the trade balance. The overall effect on the current account deficit is unclear and depends upon which effect dominates. The same is also true in other cases regarding the sectoral capital intensity, which can be analyzed similarly.

4. STEADY-STATE EQUILIBRIUM

The steady-state equilibrium of the economy, reached when $\dot{k} = \dot{\sigma} = \dot{p} = \dot{b} = 0$, implies

$$\tilde{\rho}_I h(\tilde{k}_I) = \delta \tilde{k} \tag{23a}$$

$$h'(\tilde{k}_I) = i^* + \delta \tag{23b}$$

$$\frac{1}{\tilde{\sigma}} Z(\tilde{\sigma}) + \tilde{\rho}_M g(\tilde{k}_M) - \tilde{y} + i^* \tilde{b} = 0 \tag{23c}$$

where tildes denote steady-state values. Equation (23a) asserts that in steady-state equilibrium, the output of the investment sector just equals the depreciation of the capital stock. The second equation implies that the marginal physical product of the investment sector, net of depreciation, must equal the given world interest rate, while the last equation requires that in the long run, the current account balance must be zero.

These three equations, together with (7a) - (7b), (13a) - (13e), which hold at each point of time, and the intertemporal solvency condition (21), jointly determine the long-run equilibrium values of $\tilde{k}, \tilde{k}_X, \tilde{k}_M, \tilde{k}_I, \tilde{\rho}_X, \tilde{\rho}_M, \tilde{\rho}_I, \tilde{x}, \tilde{y}, \tilde{\sigma}, \tilde{p}, \tilde{b}, \overline{\lambda}$.

The long-run effects of a permanent increase in the tariff γ are readily obtained and are summarized in Table I. They may be understood as follows. First, (23b) immediately implies that the long-run capital intensity of the investment goods sector is determined by the given rental rate $i^* + \delta$ and is therefore independent of the tariff. It then follows from the sectoral allocation equations (7a), (7b) that the same is true for the capital intensities $\tilde{k}_X, \tilde{k}_M$, as well as for the relative price of the investment good $\tilde{p}$, and the domestic price of the import- competing good, $\sigma\gamma$, facing domestic consumers. Hence the net relative price, $\tilde{\sigma}$, will appreciate at the same rate as the tariff

$$\frac{d\tilde{\sigma}}{\tilde{\sigma}} = \frac{-d\gamma}{\gamma}.$$

With sectoral capital intensities fixed, the long-run effect on the aggregate capital stock $\tilde{k}$ depends solely upon the relative employment effects.[11] While the higher tariff will protect the import-competing industry, leading to additional labor being employed in that industry, it will at the same time by lowering $\tilde{\sigma}$, lead to a reduction in the demand for the export good, causing a decline in employment in that industry. The effect of this shift on the aggregate capital stock then depends upon whether labor is moving from a relatively less, to a relatively more, capital intensive industry. If it is, i.e., if $k_M > k_X$, then given that the sectoral capital intensity remains fixed, the aggregate capital stock will be raised; otherwise, if $k_M < k_X$, the aggregate stock will decline.[12] Since output in the investment sector is proportional to the aggregate capital stock (by the depreciation factor), employment in the investment sector (with k_I fixed) will in turn mirror the response of the aggregate capital stock.

The long-run stock of foreign bonds $\tilde{b}$ is closely linked to the long-run stock of capital through the intertemporal solvency relationship (21) and in particular depends upon the relative capital intensities k_I, k_M. If $k_I < k_M$, then as we have seen $\Omega > 0$, so that the long-run stock of foreign bonds is inversely related to that of capital. In this case it rises if $k_X > k_M$, and falls otherwise. If $k_M < k_I$ the relationship between $\tilde{b}$ and $\tilde{k}$ is more involved and no unambiguous response can be obtained.

Finally, the response of the marginal utility of wealth $\bar{\lambda}$ is also noted in Table I, since this plays some role in determining the short-run response to the tariff. While we cannot establish a definite effect, it seems likely that it will decline following an increase in the tariff. Basically this is because a higher tariff rate will cause consumers to substitute away from consumption towards wealth accumulation, thereby reducing the marginal utility of wealth.

5. TRANSITIONAL DYNAMICS: $k_M > k_I$

We turn now to the transitional dynamics following a permanent increase in the tariff γ, dealing first with the case where the Uzawa factor intensity hypothesis holds ($k_M > k_I$). In this case, the relative price p is given by (17b′) and is always equal to its steady-state level $\tilde{p}$. With the latter being independent of the tariff, it follows that p is independent of the tariff at all points of time, so that the sectoral factor intensities also remain fixed, independent of the tariff. The relative price σ, on the other hand, drops instantaneously in response to the tariff to its new steady-state level.

The time paths for the aggregate capital stock and the stock of foreign bonds are illustrated in Figs. 1A, 1B, which correspond to the cases where $k_X > k_M, k_X < k_M$, respectively. In the former case, the long-run decline in the capital stock from A to B leads to a short-run decumulation of capital, accompanied by a current account surplus, leading to an eventual accumulation of bonds from P to Q. In the latter case, there is an accumulation of capital, accompanied by a current account deficit. Thus whether a tariff leads to a short-run current account deficit or surplus depends upon the relative capital intensities of the import-competing and investment sectors.

The initial impact of the tariff on sectoral employment can now be easily derived. First, differentiating (15c), the initial effect on employment in the export sector is

$$\frac{d\rho_X(0)}{d\gamma} = \frac{\partial\rho_X}{\partial\gamma} + \frac{\partial\rho_X}{\partial\lambda}\frac{\partial\overline{\lambda}}{\partial\gamma}. \tag{24a}$$

Since (i) p remains unchanged over time, (ii) employment in the export sector is independent of the capital stock, and (iii) the marginal utility adjusts instantaneously to its new steady-state level, it is also true that employment in the export sector declines instantaneously to its new (lower) steady-state level. Thereafter it remains unchanged.

Initial employment effects in the other two sectors are related to that in the export sector as follows (see (A.4b), (A.4c), (A.5b), (A.5c) of the Appendix)

$$\frac{d\rho_I(0)}{d\gamma} = \frac{\partial \rho_I}{\partial \gamma} + \frac{\partial \rho_I}{\partial \overline{\lambda}} \frac{\partial \overline{\lambda}}{\partial \gamma} = \left(\frac{k_X - k_M}{k_M - k_I} \right) \frac{d\rho_X(0)}{d\gamma}$$

$$\frac{d\rho_M(0)}{d\gamma} = \frac{\partial \rho_M}{\partial \gamma} + \frac{\partial \rho_M}{\partial \overline{\lambda}} \frac{\partial \overline{\lambda}}{\partial \gamma} = \left(\frac{k_I - k_X}{k_M - k_I} \right) \frac{d\rho_X(0)}{d\gamma}$$

which under the present assumption $k_M > k_I$ implies

$$sgn \left(\frac{d\rho_I(0)}{d\gamma} \right) = sgn\ (k_M - k_X) \tag{24b}$$

$$sgn \left(\frac{d\rho_M(0)}{d\gamma} \right) = sgn\ (k_X - k_I). \tag{24b}$$

The initial response of employment in the investment sector follows that of investment itself, being qualitatively the same as its long–run response, though overshooting in the short run. This is because of the subsequent adjustment in the capital stock which provides a partially offsetting influence. More specifically, suppose $k_M > k_X$, when the higher tariff leads to a higher long–run capital stock. The rising capital stock during the transition raises the wage–rental ratio, causing labor to shift over time from the less capital intensive industry I to the more capital intensive industry M. By contrast, the initial response of employment in the import–competing industry depends upon the relative capital intensities $k_X - k_I$. It may therefore decline on impact, before ultimately increasing to its new, higher long–run level, in part, as it shifts away from the investment sector.

6. TRANSITIONAL DYNAMICS: $k_I > k_M$

The case where the investment sector is more capital intensive than the import–competing sector is more complex due to the presence of short– run adjustments in the relative price p, which now occur. The relevant dynamic adjustment equations for k and p are now (17a″) and (17b″) and in particular, it will be recalled that the stable saddle path

(17b″) is positively or negatively sloped, depending upon the relative capital intensities k_X and k_I.

As before, the long-run response of the capital stock $\tilde{k}$ determines the short-run rate of investment. The new element, the initial response of the relative price $p(0)$ is

$$\frac{dp(0)}{d\gamma} = -\left(\frac{a_{11} - a_{22}}{a_{21}}\right)\frac{d\tilde{k}}{d\gamma}$$

i.e.,

$$sgn\ \left(\frac{dp(0)}{d\gamma}\right) = sgn\ \left(a_{21}\frac{d\tilde{k}}{d\gamma}\right) = sgn\ [(k_I - k_X)(k_M - k_X)] \tag{25}$$

the direction of which depends upon both the slope of the stable locus and the response of the long-run capital stock. But whatever the direction of the initial response, the subsequent adjustment returns the relative price to its fixed long-run equilibrium level.

The initial response in the relative price p leads to the following short-run adjustments in the sectoral capital-labor ratios

$$sgn\ \left[\frac{dk_i(0)}{d\gamma}\right] = sgn\ \left[k_i'\frac{dp(0)}{d\gamma}\right] = sgn\ (k_X - k_M) \tag{26a}$$

$$sgn\ \left[\frac{dk_i(0)}{d\gamma}\right] = sgn\ (k_M - k_X). \tag{26b}$$

An interesting, and somewhat anomolous, feature of these responses is that the introduction of the tariff leads to an immediate response in the sector capital-labor ratios which is opposite to that of the aggregate capital stock. Thus, for example, if $k_M > k_X$, so that the aggregate capital stock begins to rise, the sectoral capital-labor ratios will *fall* instantaneously, after which they will continuously increase back towards their respective equilibrium levels, which are independent of the level of the tariff.

To see more intuitively what is going on consider the following example, where $k_I > k_M > k_X$. In this case, the tariff will lead to an instantaneous increase in the relative price of the investment good $p(0)$, as well as an increase in the short-run rate of investment $\dot{k}(0)$. The stimulus to the investment sector will attract both capital and labor away from the export sector. If the investment sector is more capital intensive than the export sector, capital is released at an insufficient relative rate. As a consequence, the wage-rental ratio will fall, thereby inducing a substitution of labor for capital in that, and indeed in all sectors, generating a decline in the sectoral capital-labor ratios. As the relative price p starts to decline following its initial rise, this process begins to reverse itself. Other cases can be reasoned similarly.

The domestic relative price of the import-competing good to the export good, inclusive of the tariff, $\sigma\gamma$, will always rise with the tariff. This follows by combining (11b) with (25). The short-run response of the net relative price σ, may either rise or fall, depending upon the relative magnitudes of the negative direct effect (11a) and the positive induced price effect, which operates through p.

What happens to sectoral employment is less clear. The general responses are given by the expressions

$$\frac{d\rho_i(0)}{d\gamma} = \frac{\partial \rho_i}{\partial \gamma} + \frac{\partial \rho_i}{\partial \overline{\lambda}}\frac{\partial \overline{\lambda}}{\partial \gamma} + \frac{\partial \rho_i}{\partial p}\frac{\partial p(0)}{\partial \gamma} \qquad i = X, M, I. \tag{27}$$

The first two terms are analogous to those appearing in Section 5, although with the reversal of the capital intensities k_M and k_I, these effects on ρ_M and ρ_I will be reversed from before.[13] The last term reflects the additional effect arising from the initial jump in the relative price $p(0)$ which now occurs. These two sets of effects are likely to be in conflict. To see this, consider again the example $k_I > k_M > k_X$. Now, the effects of the higher tariff which operates through the first two terms is to shift employment from the export and investment sectors to the import-competing sector. But on the other hand, the higher $p(0)$ has precisely the opposite effects, stimulating employment in the export and investment sectors, at the expense of the import-competing sector. The overall responses cannot be determined a priori.

The time paths for the aggregate capital stock and the stock of traded bonds are illustrated in Figs. 2.A - 2.C which correspond to the various assumptions regarding factor intensities. As noted previously, we are unable to determine the qualitative relationship between the rate of capital accumulation and the accumulation of foreign bonds. To be concrete, we have illustrated the case where $\Omega > 0$. This corresponds to the more likely relationship in the aggregate model (see Sen and Turnovsky (1989b)), as well as being the case in Section 5. However, we recognize that the opposite relationship $\Omega < 0$, certainly cannot be ruled out.[14]

Fig. 2.A illustrates the dynamic adjustment in response to a higher permanent tariff rate, for the case where the sectoral capital intensities satisfy $k_X > k_I > k_M$. Turning to the upper part of the figure, suppose that the economy starts in steady-state equilibrium at the point A on the stable arm XX. In response to the higher tariff, the stable arm XX moves up to $X'X'$, with the new steady state being at B with a lower capital stock and unchanged relative price p. In the short run, the relative price p increases from A to C, causing a short-run increase in the sectoral capital-labor ratios, followed by subsequent gradual reversals. In the lower part of the figure, the stock of foreign bonds increases from its equilibrium at P to the final equilibrium at Q. During the transition, the higher tariff leads to a *decumulation* of capital accompanied by a current account *surplus*.

Figures 2.B and 2.C are analogous and correspond to different assumptions regarding relative sectoral capital intensities. In the latter case, the implementation of the tariff is associated with an *accumulation* of capital, accompanied by a current account *deficit*.

7. TEMPORARY TARIFFS

The tariffs discussed thus far have been permanent. We now consider the case where the tariff introduced at time 0 is known at the outset to be only temporary, to be permanently removed at time T say. The analysis of this temporary tariff is potentially of interest because of the fact that with the marginal utility of wealth λ being constant, the underlying dynamics has a zero root, the effect of which frequently is for a temporary policy to have a permanent effect; see e.g., Brock (1988), Sen and Turnovsky (1989a, 1989b). Whether this turns out to be so in the present instance depends critically upon the relative capital intensities of the import-competing sector, on the one hand, and the investment goods sector, on the other.

In principle, to determine the dynamic path in response to a temporary tariff, we need to solve the dynamics over the period during which the policy is temporarily in effect (when the economy may follow an unstable path) and the subsequent period, after which the tariff is permanently removed (and when the economy follows a stable path). Technical details of these solutions are available, but are omitted. Our discussion will therefore be somewhat more heuristic.

The critical element giving rise to the potential hysteresis is that the steady state depends upon the initial stocks of assets

$$V_0 \equiv b_0 + \frac{\Omega}{i^* - \mu_1} k_0$$

which is in existence at the time any permanent policy change is implemented. This arises through the intertemporal solvency condition (21). In the present case, the relevant permanent change is the permanent restoration of the tariff to its original level at time T. The quantity V_0 represents the initial present value of total resources available to the economy, measured in terms of the import-competing good, and can be termed national wealth measured in terms of that good. National wealth in terms of the numeraire export good is then $V_0' = \sigma\gamma V_0$. A temporary tariff will have a permanent effect if and only if $V_T' \neq V_0'$.

In the case where the Uzawa capital intensity hypothesis holds, $k_M > k_I$, we can show that $V_T = V_0, \sigma\gamma$ remains fixed, so that $V_T' = V_0'$; that is national wealth (however measured) does not change over the period $(0, T)$ while the temporary tariff is in effect. In terms of Figs. 1.A and 1.B, the locus ZZ, the equation of which may be written as,

$$b + \frac{\Omega}{i^* - \mu_1} k = b_0 + \frac{\Omega}{i^* - \mu_1} k_0$$

remains fixed over time. The response to a temporary increase in the tariff rate is thus as follows. Starting from the initial steady-state equilibrium A, the capital stock decreases in Fig. 1.A (increases in Fig. 1.B) until the point G, which is reached at time T, when the tariff is permanently removed. At that time, the path followed is imply reversed and the economy retraces its steps back to its initial equilibrium at A. The corresponding adjustment in bonds is described by the path PRP. The economy runs an initial current account surplus in Fig. 1.A (deficit in Fig. 1.B), which is eventually reversed. In both cases, a temporary tariff has only a temporary effect.

The case where $k_I > k_M$ is illustrated in Figs. 2.A - 2.C under the three alternative assumptions regarding the relative sectoral capital intensities. In these cases hysteresis does obtain. Focusing on Fig. 2.A, where $k_X > k_I > k_M$, the dynamics is as follows. As soon as the tariff is imposed, the stable arm XX will shift up instantaneously (and temporarily) to $X'X'$, while the relative price p increases to C', which lies below C. Sectoral capital-labor ratios therefore increase in the short run, though by less than if the tariff were permanent. Immediately following this initial jump, p will begin to fall, as does total capital, following the unstable path $C'D'$. During this period k and b will follow the corresponding path PP' in the lower part of the figure. Whether this latter locus is positively sloped (as it is drawn) or negatively sloped depends upon the relative adjustments of p and k along the upper unstable path $C'D'$. While the falling capital stock is likely to lead to a current account surplus, the declining relative price, given the sector intensity assumptions, will have the opposite effect, and indeed will dominate, if it is in fact accelerating as drawn along $C'D'$. At time T, when the temporary tariff is removed, the aggregate stock of capital and bonds will have reached a point such as P' in the figure. The accumulated stock of capital and traded bonds, denoted by k_T and b_T respectively, will now serve as initial conditions for the dynamics beyond time T, when the tariff is permanently removed.

As noted, they will therefore in part determine the new steady-state equilibrium. With no new information being received at time T (since the temporary nature of the tariff was known at the outset) and no further jumps, the stable locus relevant for subsequent adjustments in p and k beyond T is the locus $X''X''$ parallel to XX which passes through the point $k = k_T$. Likewise, the relevant locus linking the accumulation of capital and traded bonds is now $Z'Z'$.

After time T, p and k follow the stable locus $D'B'$ to the new steady-state equilibrium at B', while correspondingly, k and b follow the locus $P'Q'$ to the new equilibrium Q'. One can formally establish that $X''X''$ lies between XX and $X'X'$, while $Z'Z'$ lies below ZZ, as these curves have been drawn. In the new steady state, the relative price p reverts to its original level, but with a lower stock of capital and a higher stock of traded bonds than originally. In other words, the temporary tariff leads to a permanent decrease in the stock of capital, accompanied by a higher permanent stock of traded bonds.

The following explanation for this result may be given. On the one hand, one can establish that the effect of the temporary tariff is to reduce national wealth, measured in terms of the import competing good; that is, $V_T < V_0$, which is illustrated by the downward shift in the ZZ curve to $Z'Z'$. On the other hand, the temporary tariff will raise the relative price $\sigma\gamma$ over the same period $(0, T)$. Under the sectoral capital intensity assumption underlying Fig. 2.A, the latter effect dominates, so that overall there is an increase in national wealth, measured in terms of the export good (numeraire) during the period that the tariff is temporarily in effect; thus $V'_T > V'_0$. The higher level of national wealth so measured at time T, when the tariff is removed (the new initial condition for the subsequent adjustment) results in a permanent decline in the marginal utility of wealth as measured in terms of the numeraire good, encouraging a shift away from work towards more leisure and consumption. This results in a permanent reduction in the supply of labor and hence employment. Since in the long run the capital-labor ratio must be restored to its initial level, the reduction in employment implies a lower equilibrium capital stock.

Figs. 2.B and 2.C can be explained analogously. In all cases the permanent effect of the temporary policy is a dampening down of the permanent effect of the corresponding permanent policy.

8. CONCLUSIONS

This paper has analyzed the impact of a tariff on sectoral adjustments in an economy which produces two traded consumption goods, one of which is exported, and a nontraded investment good, which serves as an input in the production of the two consumption goods. The analysis emphasizes the importance of the factor intensities in the various sectors. More importantly, the dynamic adjustment depends fundamentally upon the relative capital intensities of the import–competing consumption good and the nontraded investment good sectors.

In the case where the former is more capital intensive—the Uzawa capital intensity hypothesis—the dynamic adjustment following a permanent increase in the tariff is relatively simple. The relative price of the investment good to the domestic traded consumption good remains unchanged, as do the sectoral capital intensities. Aggregate capital is accumulated or decumulated, depending upon whether the import–competing sector is more or less capital intensive than the export sector and this adjustment is reflected (inversely) in the behavior of the current account. In particular, a tariff increase will generate a long–run accumulation or decumulation of foreign bonds, depending upon these same relative capital intensities. Also, under the Uzawa capital intensity hypothesis, a temporary tariff will have only a temporary effect.

In the converse situation where the investment good is more capital intensive than the import–competing consumption sector, the long–run response of aggregate capital continues to depend upon the relative capital intensities k_M and k_X, in precisely the same way as before. However, the relationship between the accumulation of capital and foreign bonds is now less clear cut. Furthermore, the dynamics change in significant ways.

First, and most importantly, the relative price of the investment to the domestic exported consumption good responses to the tariff in the short run, thereby generating transitory adjustments in the sectoral capital intensities, which in the long run remain unchanged. Also, in this case a temporary tariff will have a permanent effect, which is qualitatively in the same direction, though smaller in magnitude, than that of the corresponding permanent increase.

Irrespective of the relative sectoral intensities k_M and k_I, an increase in the tariff will, in the long run, shift labor from the export sector to the import–competing sector, with the effect on the investment sector depending upon the relative capital intensities of this latter sector and the export sector. In the short run, the dynamics broadly follows this pattern, as long as $k_M > k_I$, so that the relative price p remains fixed. When $k_M < k_I$, so that p adjusts in the short run, the transitory responses of employment become less clear cut.

The analysis has shown how the pre–existing sectoral capital intensities are crucial in determining the dynamic adjustments in response to a changing tariff (or other shock for that matter). The responses we have described are all based on the assumption that the relative capital intensities remain unchanged, so that strictly speaking the changes must be infinitesimally small. For larger changes in tariffs, as sectoral intensities respond, the economy will move from one configuration of sectoral intensities to another. The fact that this will occur must be taken into account at the outset. The analysis of this aspect is extremely difficult, but promises to be an interesting extension of this analysis.

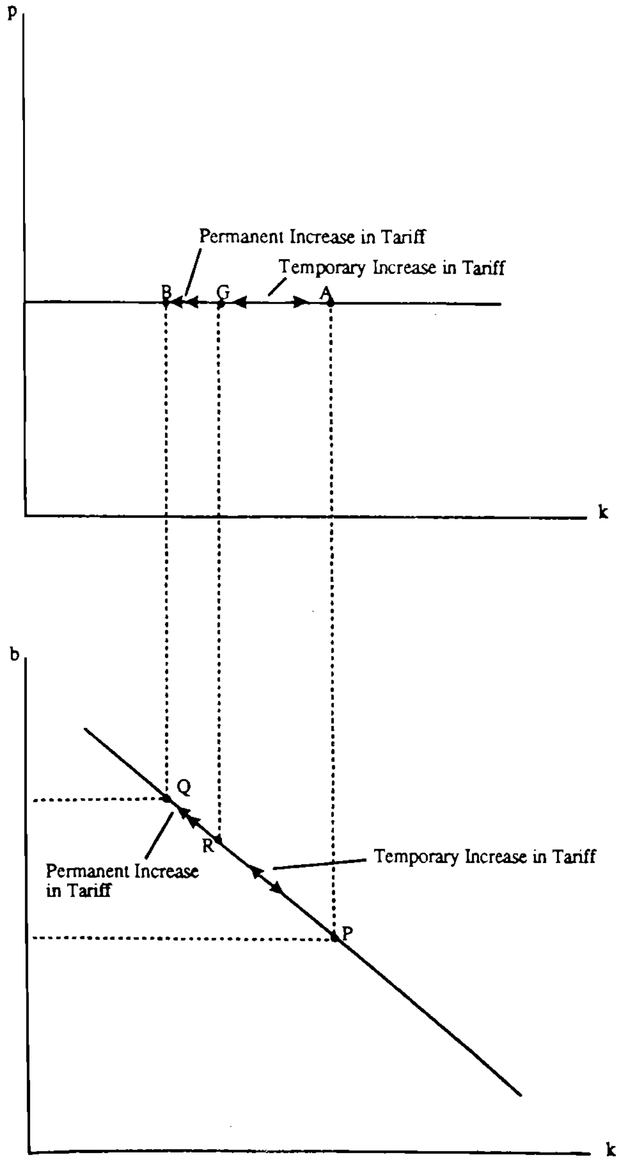

FIGURE 1.A

$k_X > k_M > k_I$

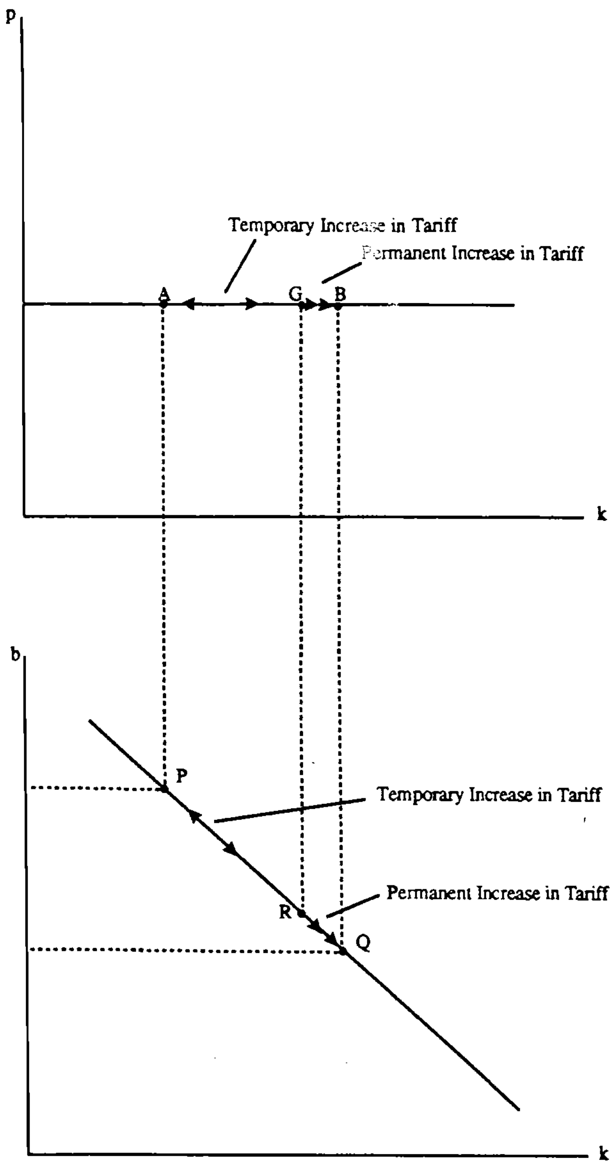

FIGURE 1.B

$k_M > k_X > k_I$

$k_M > k_I > k_X$

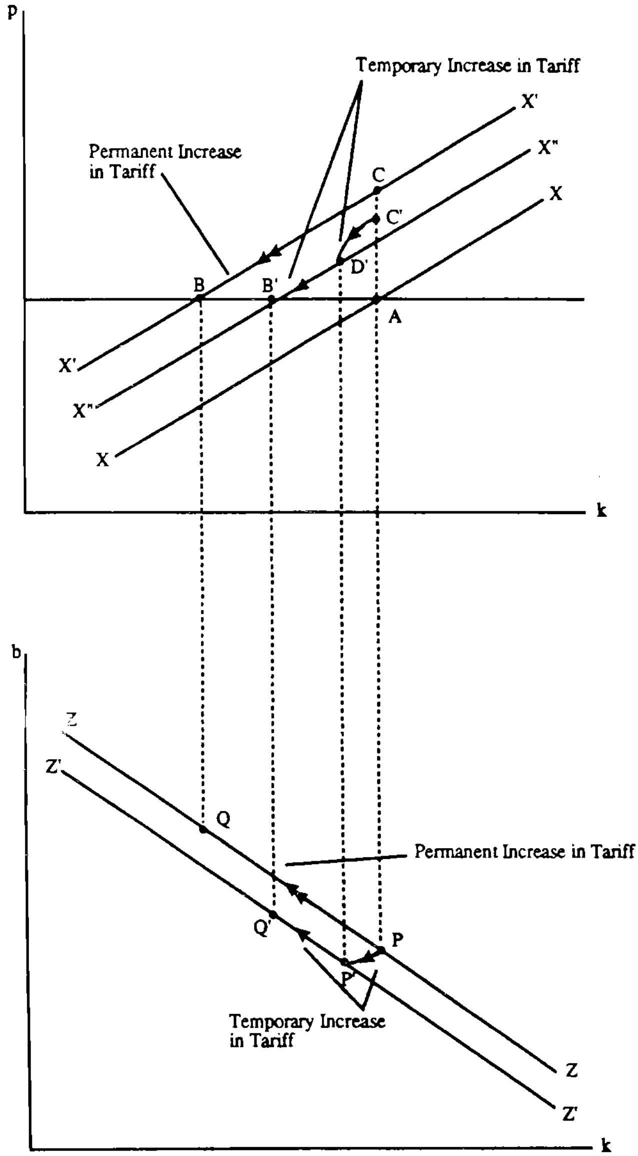

FIGURE 2.A

$k_X > k_I > k_M$

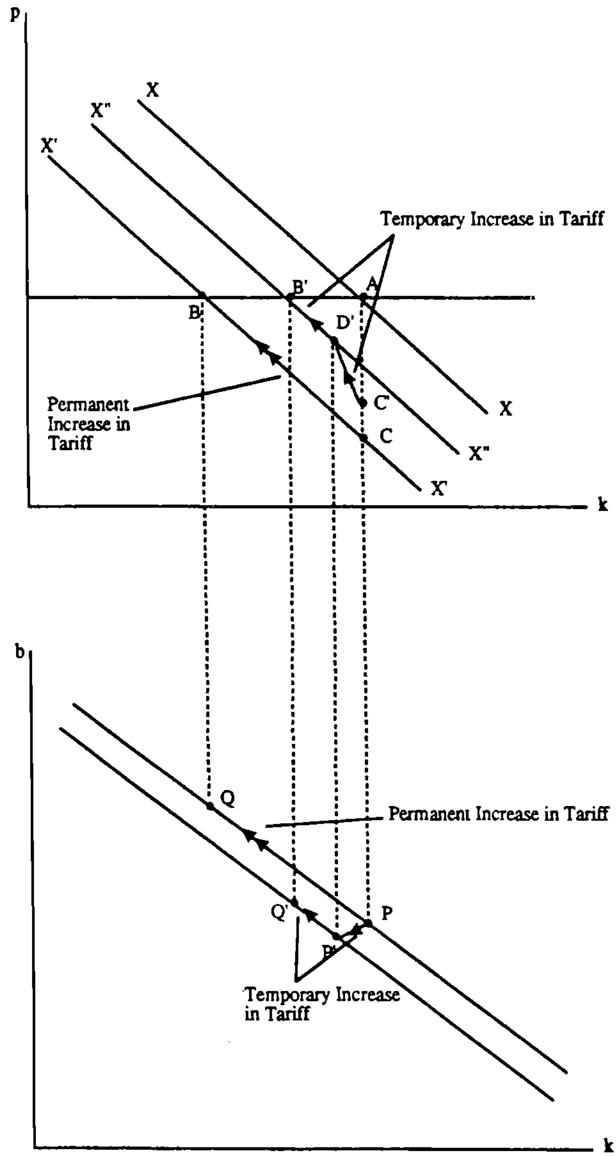

FIGURE 2.B

$k_I > k_X > k_M$

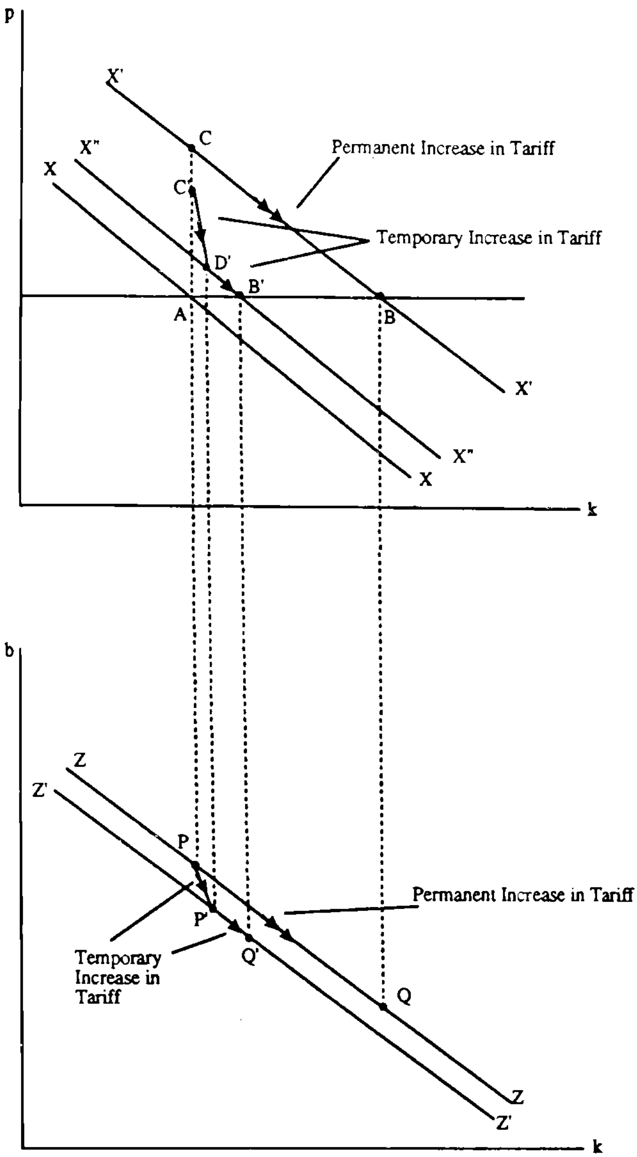

FIGURE 2.C

$k_I > k_M > k_X$

TABLE 1

LONG RUN EFFECTS OF PERMANENT INCREASE IN TARIFF

I. *Sectoral Capital Intensities*

$$\frac{d\tilde{k}_X}{d\gamma} = \frac{d\tilde{k}_M}{d\gamma} = \frac{d\tilde{k}_I}{d\gamma} = 0.$$

II. *Relative Prices*

$$\frac{d\tilde{p}}{d\gamma} = 0$$

$$\frac{d\tilde{\sigma}}{d\gamma} < 0.$$

III. *Aggregate Capital Stock*

$$sgn\left(\frac{d\tilde{k}}{d\gamma}\right) = sgn\,(k_M - k_X).$$

IV. *Stock of Foreign Bonds*

(i)	$k_X > k_M > k_I$	$\frac{d\tilde{b}}{d\gamma} > 0$
(ii)	$k_M > k_X > k_I$	
	$k_M > k_I > k_X$	$\frac{d\tilde{b}}{d\gamma} < 0$
(iii)	$k_M < k_I$	$\frac{d\tilde{b}}{d\gamma}$ is indeterminate

V. *Sectoral Employment Effects*

$$\frac{d\tilde{\rho}_X}{d\gamma} < 0$$

$$\frac{d\tilde{\rho}_M}{d\gamma} > 0$$

$$sgn\,\frac{d\tilde{\rho}_I}{d\gamma} = sgn\,(k_M - k_X)$$

TABLE 2

SHORT-RUN EFFECTS OF PERMANENT INCREASE IN TARIFFS

A. $k_M > k_I$

I. *Sectoral Capital Intensities*

$$\frac{dk_X(0)}{d\gamma} = \frac{dk_M(0)}{d\gamma} = \frac{dk_I(0)}{d\gamma} = 0.$$

II. *Relative Prices*

$$\frac{dp(0)}{d\gamma} = 0$$

$$\frac{d\sigma(0)}{d\gamma} < 0$$

III. *Rate of Investment*

$$\frac{d\dot{k}(0)}{d\gamma} = sgn\ [k_M - k_X].$$

IV. *Current Account*

(i) $k_X > k_M > k_I$ $\qquad \frac{d\dot{b}}{d\gamma} > 0$

(ii) $k_M > k_X > k_I$

$\qquad \frac{d\dot{b}}{d\gamma} < 0$

$k_M > k_I > k_X$

V. *Sectoral Employment Effects*

$$\frac{d\rho_X(0)}{d\gamma} < 0$$

$$\frac{d\rho_M(0)}{d\gamma} = \left(\frac{k_I - k_X}{k_M - k_i}\right) \frac{d\rho_X(0)}{d\gamma}$$

$$\frac{\partial \rho_I(0)}{\partial \gamma} = \left(\frac{k_X - k_M}{k_M - k_I}\right) \frac{d\rho_X(0)}{d\gamma}$$

B. $k_I > k_M$

I. *Sectoral Capital Intensities*

$$sgn\left(\frac{dk_X(0)}{d\gamma}\right) = sgn\left(\frac{dk_M(0)}{d\gamma}\right) = sgn\left(\frac{dk_I(0)}{d\gamma}\right) = sgn\,(k_X - k_M).$$

II. *Relative Prices*

$$sgn\left(\frac{dp(0)}{d\gamma}\right) = sgn\,[(k_X - k_I)(k_X - k_M)]$$

$$\frac{d\sigma(0)\gamma}{d\gamma} > 0$$

$$\frac{d\sigma(0)}{d\gamma} \text{ indeterminate}$$

III. *Rate of Investment*

$$sgn\left(\frac{d\dot{k}(0)}{d\gamma}\right) = sgn\,(k_M - k_X).$$

IV. *Current Account*

$$sgn\left(\frac{d\dot{b}(0)}{d\gamma}\right) \text{ in general indeterminate.}$$

V. *Sectoral Employment Effects*

$$\frac{d\rho_X(0)}{d\gamma};\ \frac{d\rho_M(0)}{d\gamma};\ \frac{d\rho_I(0)}{d\gamma} \text{ are indeterminate.}$$

APPENDIX

1. *Properties of Short – –Run Solutions* (15)

Taking differential of equations (13a), (13b) yields

$$\begin{bmatrix} U_{xx} & U_{xy} \\ U_{xy} & U_{yy} \end{bmatrix} \begin{bmatrix} dx \\ dy \end{bmatrix} = \begin{bmatrix} \frac{d\overline{\lambda}}{\sigma} - \frac{\overline{\lambda}}{\sigma^2}\sigma_p dp - \frac{\overline{\lambda}}{\sigma^2}\sigma_\gamma d\gamma \\ \gamma d\overline{\lambda} + \overline{\lambda} d\gamma \end{bmatrix}$$

leading to the following partial derivatives

$$\frac{\partial x}{\partial p} = \frac{-\overline{\lambda}}{\sigma^2 \Delta} U_{yy}\sigma_p = \frac{-\overline{\lambda} U_{yy}}{\sigma^2 \Delta}\left(\frac{k_M - k_X}{k_I - k_X}\right)\frac{h}{\gamma g} \tag{A.1a}$$

$$\frac{\partial x}{\partial \overline{\lambda}} = \frac{1}{\Delta}\left[\frac{1}{\sigma}U_{yy} - \gamma U_{xy}\right] < 0 \tag{A.1b}$$

$$\frac{\partial x}{\partial \gamma} = \frac{-\overline{\lambda}}{\Delta}\left[\frac{\sigma_\gamma}{\sigma^2}U_{yy} + U_{xy}\right] = \frac{\overline{\lambda}}{\gamma \Delta}\left[\frac{1}{\sigma}U_{yy} - \gamma U_{xy}\right] < 0 \tag{A.1c}$$

$$\frac{\partial y}{\partial p} = \frac{\overline{\lambda}}{\sigma^2 \Delta} U_{xy}\sigma_p = \frac{\overline{\lambda}}{\sigma^2 \Delta} U_{xy}\left(\frac{k_M - k_X}{k_I - k_X}\right)\frac{h}{\gamma g} \tag{A.2a}$$

$$\frac{\partial y}{\partial \overline{\lambda}} = \frac{1}{\Delta}\left[\gamma U_{xx} - \frac{1}{\sigma}U_{xy}\right] < 0 \tag{A.2b}$$

$$\frac{\partial y}{\partial \gamma} = \frac{\overline{\lambda}}{\Delta}\left[U_{xx} + \frac{\sigma_\gamma}{\sigma^2}U_{xy}\right] = \frac{\overline{\lambda}}{\gamma \Delta}\left[\gamma U_{xx} - \frac{1}{\sigma}U_{xy}\right] < 0 \tag{A.2c}$$

where $\Delta \equiv U_{xx}U_{yy} - U_{xy}^2 > 0$. Next, taking the differential of (13e)

$$f d\rho_X + \rho_X f' k'_X dp - z_{\overline{\lambda}} d\overline{\lambda} - z_p dp - z_\gamma d\gamma - Z'[\sigma_p dp + \sigma_\gamma d\gamma] = 0$$

which implies

$$\begin{aligned} \frac{\partial \rho_X}{\partial p} &= \frac{1}{f}[z_p + Z'\sigma_p - \rho_X f' k'_X] \\ &= \frac{h}{f(k_I - k_X)}\left[\left(Z' - \frac{\overline{\lambda}}{\sigma^2}U_{yy}\right)\frac{(k_M - k_X)}{\gamma g \Delta} - \frac{\rho_X f'}{f''}\right] \end{aligned} \tag{A.3a}$$

$$\frac{\partial \rho_X}{\partial \overline{\lambda}} = \frac{1}{f}\frac{\partial x}{\partial \overline{\lambda}} < 0 \tag{A.3b}$$

$$\frac{\partial \rho_X}{\partial \gamma} = \frac{1}{f}\left[\frac{\partial x}{\partial \gamma} + Z'\sigma_\gamma\right] < 0 \qquad (A.3c)$$

Finally, taking the differentials of (13c) and (13d)

$$\begin{bmatrix} k_M & k_I \\ 1 & 1 \end{bmatrix}\begin{bmatrix} d\rho_M \\ d\rho_I \end{bmatrix} = \begin{bmatrix} dk - [\rho_X k'_X + \rho_M k'_M + \rho_I k'_I]dp \\ -k_X\left[\frac{\partial \rho_X}{\partial \bar{\lambda}}d\bar{\lambda} + \frac{\partial \rho_X}{\partial p}dp + \frac{\partial \rho_X}{\partial \gamma}d\gamma\right] \\ -\left[\frac{\partial \rho_X}{\partial \bar{\lambda}}d\bar{\lambda} + \frac{\partial \rho_X}{\partial p}dp + \frac{\partial \rho_X}{\partial \gamma}d\gamma\right] \end{bmatrix}$$

which yields

$$\frac{\partial \rho_M}{\partial p} = -\frac{1}{(k_M - k_I)}\left[\left[\rho_X + \rho_M\left(\frac{ff''}{f'^2}\frac{g'^2}{gg''}\right) + \rho_I\left(\frac{ff''}{f'^2}\frac{h'^2}{hh''}\right)\right]\frac{dk_X}{dp} + (k_X - k_I)\frac{\partial \rho_X}{\partial p}\right] \qquad (A.4a)$$

$$\frac{\partial \rho_M}{\partial \bar{\lambda}} = \left(\frac{k_I - k_X}{k_M - k_I}\right)\frac{\partial \rho_X}{\partial \bar{\lambda}} \quad \text{i.e.} \quad sgn\left(\frac{\partial \rho_M}{\partial \bar{\lambda}}\right) = sgn\left[(k_X - k_I)(k_M - k_I)\right] \qquad (A.4b)$$

$$\frac{\partial \rho_M}{\partial \gamma} = \left(\frac{k_I - k_X}{k_M - k_I}\right)\frac{\partial \rho_X}{\partial \gamma} \quad \text{i.e.} \quad sgn\left(\frac{\partial \rho_M}{\partial \gamma}\right) = sgn\left[(k_X - k_I)(k_M - k_I)\right] \qquad (A.4c)$$

$$\frac{\partial \rho_M}{\partial k} = \frac{1}{k_M - k_I} \qquad (A.4d)$$

$$\frac{\partial \rho_I}{\partial p} = \frac{1}{(k_M - k_I)}\left[\left[\rho_X + \rho_M\left(\frac{ff''}{f'^2}\frac{g'^2}{gg''}\right) + \rho_I\left(\frac{ff''}{f'^2}\frac{h'^2}{hh''}\right)\right]\frac{dk_X}{dp} + (k_X - k_M)\frac{\partial \rho_X}{\partial p}\right] \qquad (A.5a)$$

$$\frac{\partial \rho_I}{\partial \bar{\lambda}} = \left(\frac{k_X - k_M}{k_M - k_I}\right)\frac{\partial \rho_X}{\partial \bar{\lambda}} \quad \text{i.e.} \quad sgn\left(\frac{\partial \rho_I}{\partial \bar{\lambda}}\right) = sgn\left[(k_M - k_X)(k_M - k_I)\right] \qquad (A.5b)$$

$$\frac{\partial \rho_I}{\partial \gamma} = \left(\frac{k_X - k_M}{k_M - k_I}\right)\frac{\partial \rho_X}{\partial \gamma} \quad \text{i.e.} \quad sgn\left(\frac{\partial \rho_I}{\partial \gamma}\right) = sgn\left[(k_M - k_X)(k_M - k_I)\right] \qquad (A.5c)$$

$$\frac{\partial \rho_I}{\partial k} = \frac{-1}{k_M - k_I}. \qquad (A.5d)$$

2. *Evaluation of Elements of the Matrix in* (16) *at Steady State*

I. $a_{11} = \frac{-p\sigma}{\sigma - p\sigma_p}h''k'_I$

Substituting for k_I' from (10a), (10c), and for σ_p from (11b) and simplifying yields

$$a_{11} = \frac{-\sigma\gamma g f}{p[\sigma\gamma g(k_I - k_X) - ph(k_M - k_X)]} \tag{A.6}$$

Next, we may note that (7a), (7b) together imply

$$\sigma\gamma g = f - (k_X - k_M)f'$$

$$ph = f - (k_X - k_I)f'$$

and substituting the latter into (A.6), we obtain

$$a_{11} = \frac{\sigma\gamma g}{p(k_M - k_I)} \tag{A.7}$$

that is

$$sgn\ (a_{11}) = sgn\ (k_M - k_I). \tag{A.8}$$

II. $\quad a_{22} = h\frac{\partial\rho_I}{\partial k} - \delta$

which using (A.5d) above implies

$$a_{22} = \frac{-[h + \delta(k_M - k_I)]}{k_M - k_I}.$$

Substituting the steady-state equilibrium condition (23a) leads to

$$a_{22} = \frac{-\delta[k + \rho_I(k_M - k_I)]m}{\rho_I(k_M - k_I)} \tag{A.9}$$

and recalling the instantaneous sectoral capital allocation constraint (13c) we obtain

$$a_{22} = \frac{-\delta[\rho_I k_M + \rho_M k_M + \rho_X k_M]}{\rho_I(k_M - k_I)} \tag{A.10}$$

that is,

$$sgn\ (a_{22}) = sgn\ (k_I - k_M). \tag{A.11}$$

III. $\quad a_{21} = h\frac{\partial\rho_I}{\partial p} + \rho_I h' k_I'.$

Substituting for $\frac{\partial\rho_I}{\partial p}$ from (A.5a) and for k_I' from (10c) leads immediately to

$$a_{21} = \frac{h}{k_M - k_I}\left[\rho_X + \rho_M\left(\frac{ff''}{f'^2}\frac{g'^2}{gg''}\right) + \rho_I\left(\frac{ff''}{f'^2}\frac{h'^2}{hh''}\right)\right]\frac{dk_X}{dp}$$
$$+ h\frac{(k_X - k_M)}{k_M - k_I}\frac{\partial \rho_X}{\partial p} + \rho_I h'\left(\frac{ff''}{f'^2}\frac{h'^2}{hh''}\right)\frac{dk_X}{dp} \tag{A.12}$$

Next, substituting for $\frac{\partial \rho_X}{\partial p}$ from (A.3a), for $\frac{dk_X}{dp}$ from (10a), and regrouping terms

$$a_{21} = \frac{h}{f''(k_M - k_I)(k_I - k_X)}\left[\rho_X h\left(1 - \frac{f'(k_X - k_M)}{f}\right) + \rho_M h\left(\frac{ff''}{f'^2}\frac{g'^2}{gg''}\right)\right.$$
$$\left. + \rho_I\left(\frac{ff''}{f'^2}\frac{h'^2}{hh''}\right)[h - h'(k_I - k_M)]\right] - \frac{h^2(k_X - k_M)^2}{f\gamma g(k_M - k_I)(k_I - k_X)}\frac{(Z' - \frac{\bar{\lambda}}{\sigma^2}U_{yy})}{\Delta} \tag{A.13}$$

Since

$$f - f'k_X + f'k_M > 0, \quad h - h'k_I + h'k_M > 0$$

one can verify that the sign of each term appearing in (A.13) depends upon that of $(k_X - k_I)(k_M - k_I)$ and hence

$$sgn\ (a_{12}) = sgn\ (k_X - k_I)(k_M - k_I). \tag{A.14}$$

FOOTNOTES

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[1]For example, Mussa (1974) analyzes the effects of a relative price change in a two sector production model where capital is specific to each industry. In a later paper, Mussa (1978), allows for costly intersectoral movements of capital, while capital gradually accumulates in response to the price of the capital intensive commodity.

[2]Van Wincoop (1988) breaks down consumption goods into tradeable and nontradeable, with investment goods also being assumed to be nontradeable.

[3]The assumption that the investment good is nontraded is stronger than necessary. What is important is that its relative price be endogenously determined. This is consistent with the good being tradeable and with the domestic economy being sufficiently important in the market so as to be able to influence its relative price.

[4]This type of economy can best be characterized as being semi–small. It is sufficiently small in the market for the import good and the world capital market to have negligible effects on prices in those markets. But it is important enough in the market for the export good to be able to influence its terms of trade.

[5]The choice of numeraire is, of course, arbitrary. The measurement of the marginal utility of wealth in terms of the traded bond, seems natural, and is quite convenient. Expressed in terms of units of the domestic export consumption good, it would become $\lambda' = \lambda\sigma\gamma$.

[6]Writing (14a) as

$$\frac{\dot{p}}{p} - \frac{\dot{\sigma}}{\sigma} = i^* + \delta - h'(k_I(p))$$

and using the relationship $\dot{\sigma} = \sigma_p \dot{p}$, we have

$$\dot{p} = \frac{p\sigma}{\sigma - p\sigma_p}[i^* + \delta - h'(k_I(p))].$$

Using (23b) to evaluate $\frac{\partial \dot{p}}{\partial p}$ at steady state yields a_{11} as defined in (16).

[7]We can contrast the dynamics in this model with much of the recent aggregate literature which often assumes (usually only implicitly) that physical capital is tradeable. In this case, the sluggish dynamics is obtained by imposing convex cost of adjustment on the aggregate capital stock; see e.g., Brock (1988), Sen and Turnovsky (1989a, 1989b), Matsuyama (1987). The nontradeability of capital, being assumed here, plays precisely the same role as the convex adjustment costs in limiting the rate of adjustment of capital.

[8]We may note that if instead of X, M were chosen to be numeraire, then the corresponding value of a_{21}, with this choice of units would be positive. While this has the advantage of ensuring that the slope of the stable path XX in the space of capital and the new relative price is negative, this is offset by the fact that the steady–state shifts are now no longer unambiguous. In short, there is no great advantage to any particular choice of numeraire, and in any event, our qualitative results are obviously independent of this arbitrary choice.

[9]See equation (A.4d) in the Appendix.

[10]These proportions can be easily established by imposing the conditions $k_I > k_M > k_X$ on equations (A.3a) and (A.4a) of the Appendix.

[11]This can be seen from the sectoral capital allocation equation (13c).

[12]Analogous responses of the aggregate capital stock to other types of shocks have been obtained by Bruno (1982) and Van Wincoop (1988).

[13]This can be seen from an inspection of (A.4b), (A.4c), (A.5b), (A.5c) of the Appendix.

[14]Intuitively, the presumption that $\Omega > 0$ follows from the fact that positive investment means that consumable income is low in the short run relative to what it will be in the long run, both because the capital stock will be higher in the long run and because the investment required to increase the capital stock reduces consumption in the short run. Consumption smoothing considerations therefore make borrowing optimal in the short run implying a positive relationship between the accumulation of capital and foreign borrowing.

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