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ABSTRACT

This paper analyzes the effects of a tariff in an intertemporal optimizing model, emphasizing the role of capital accumulation. Three types of increases in the tariff rate are considered: (i) unanticipated permanent; (ii) unanticipated temporary; (iii) anticipated permanent. There are two main general conclusions to be drawn from the analysis.

The first is that the introduction (or increase) of a tariff is contractionary, both in the short run and in the long run. In particular, employment is reduced both in the short run and in the long run, so that there is no significant intertemporal tradeoff, as obtained by previous authors. The fall in the long-run capital stock causes an immediate reduction in the rate of investment, which in turn leads to a current account surplus. While this response of the current account is in accordance with much (but not all) of the existing literature, the mechanism by which it is achieved, namely the decummulation of capital, has not been previously considered. Also, the fact that the declining capital stock is accompanied by an accumulation of foreign bonds means that the savings effect of the tariff is unclear, depending upon which influence dominates. This ambiguity of savings is, however, very different from those occurring in other studies. The second major conclusions stems from the fact that the steady state depended upon the initial stocks of the assets. As a consequence, a temporary tariff, by altering these initial conditions for some later date when the tariff is removed, leads to a permanent effect on the economy.

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1. INTRODUCTION

Recently, there has been a revival of interest in the macroeconomic effects of commercial policies under flexible exchange rates. Discredited after the thirties, they have returned to playing a much more central role in policy discussions. Theoretical models have been slow to appear, but by now a substantial literature has developed. This literature has addressed the two issues which are at the forefront of the policy discussions; namely the effects of commercial policies on employment, on the one hand, and on the current account, on the other. Most of the attention has focused on tariffs, but unlike the analysis of tariffs in pure trade theory, no retaliatory action is assumed to occur.

The modern theoretical literature analyzing the macroeconomic effects of tariffs originated with Mundell (1961), who established the proposition that a tariff is contractionary. The essential steps of the argument were that a tariff will raise the terms of trade, thereby increasing savings, reducing aggregate demand, and necessitating a fall in aggregate supply in order for the goods market to clear. While the result was based on a very simple model, relying on the Laursen–Metzler effect, subsequent work by Chan (1978), and more recently Krugman (1982), suggests that the result is in fact quite robust with respect to various extensions of the basic $IS - LM$ model.[1] Krugman also demonstrated that by reducing income more than expenditure, the tariff will lead to a deterioration of the current account balance.

The basic Mundell model is static. The first analysis of tariffs in a macrodynamic setting was Eichengreen (1981) who, using a currency substitution model, emphasized the intertemporal tradeoffs involved in a tariff. Whereas the contractionary effects suggested by Mundell were found to hold in the long run, the short–run effects of a tariff are likely to be expansionary.[2] This however, is gradually reversed over time through savings and the current account surplus which occurs. Kimbrough (1982) introduced a nontraded good and showed how the effect of the tariff on the current account balance depends critically upon the complementarity or substitutability of the imported good and the nontraded good in consumption demand.

Optimizing models analyzing the effects of tariffs are fewer, unless one includes the contributions studying the Laursen– Metzler effect.[3] In van Wijnbergen (1987) a two country– two period model is laid out and the effects of a tariff are analyzed in both a full employment and real wage rigidity (in the tariff imposing country) setting. In the full employment case, a permanent tariff has no effect on the current account, because permanent income and permanent consumption both fall by the same amount. However, a temporary tariff leads to a current account surplus. With rigid real wages, on the other hand, these results are subject to substantial modification; for example, a permanent tariff may now plausibly lead to a current account deficit.[4] Engel and Kletzer (1987) analyze the effects of a tariff in a two sector model (with labor mobile between the sectors) and capital employed in the import competing sector. Two alternatives are postulated for the consumers, the first where they have a variable rate of time preference as in Uzawa (1968), and the second where they face a constant probability of death as in Yaari (1965). In the former case it is demonstrated that current account surpluses characterize the adjustment path; in the uncertain lifetime case, deficits are possible, but not inevitable. Brock (1986) discusses trade liberalization in a model which resembles ours in some respects. He, however, has the small open economy facing a given terms of trade importing all its capital from abroad and with employment fixed.

In this paper, we analyze the effects of an increase in the tariff rate within an infinite horizon utility maximizing framework. The key feature of the model is that it incorporates capital accumulation by means of a q–theoretic investment function as in Abel and Blanchard (1983) and Hayashi (1982). In introducing capital, for reasons which will become evident in due course, it is important to endogenize the employment of labor, and we do so by introducing the labor–leisure choice as an integral part of the intertemporal optimization. We also allow the terms of trade to be determined endogenously. Our analysis therefore focuses on the dynamics of employment, capital accumulation, the terms of trade, and output, all of which are important aspects of the macrodynamics of tariffs.

By contrast, most of the existing literature abstracts from investment, in which case the current account surplus is identical to savings. To the extent that capital accumulation is considered,it is introduced in restrictive ways. Engel and Kletzer (1987), for instance, do have capital, but in order to maintain equality between the return to capital and the given foreign interest rate, the stock of capital jumps at the moment the tariff is imposed. (This is brought about by a swap of foreign bonds with capital.) In Brock (1986) all the capital stock is imported but there are installation costs in the various domestic sectors (i.e., the allocation is not costless). In an extension to his basic model, van Wijnbergen (1987) discusses endogenous investment which depends upon the ratio of the value of future output relative to the cost of producing capital.[5]

Three types of tariff changes are analyzed; namely an unanticipated permanent, an unanticipated temporary, and a future anticipated permanent, increase. Using this framework we show how a tariff reduces output and employment both in the short run and in the long run. At the same time, we show that a tariff reduces the rate of investment, while generating a current account surplus along the adjustment path.

These findings represent something of a combination of the Mundell–Krugman and Eichengreen results. The contractionary effect of the tariff is as in Mundell, but contrary to the short–run expansionary effect discussed by Eichengreen. On the other hand, the current account surplus is consistent with Eichengreen, although the mechanism is entirely different. In our analysis it is the result of reduced investment, rather than additional savings, and the latter may or may not increase.

The paper is organized as follows. Section 2 sets out the model, while the following section considers the dynamics. The long–run and dynamics effects of the tariff are analyzed in Sections 4 and 5 respectively. Section 6 provides some concluding remarks.

2. THE MODEL

We consider an economy which is specialized in the production of a single commodity. Households in this economy, however, also consume another good which is imported from abroad. The economy is large enough to affect the terms of trade. It can borrow or lend as much as it wants at a given world interest rate, though subject to an intertemporal budget constraint. However, by being able to influence the terms of trade, the real interest rate relevant for the economy is endogenously determined.

A. Structure of Economy

Consider first the representative consumer. His decisions are made by solving the following intertemporal optimization problem:

(1a) $$Max \int_0^\infty [U(x,y) + V(l)]e^{-\delta t}dt$$

subject to

(1b) $$\dot{b} = \frac{1}{\sigma}[\pi + wl - x] - \gamma y + i^* b + T$$

and initial condition

(1c) $$b(0) = b_0$$

where

x = consumption of the domestic good,

y = consumption of the imported good,

σ = relative price of the foreign good in terms of the domestic good (i.e., the real exchange rate),

l = labor supplied by the representative household,

b = stock of foreign bonds held by the household (in units of foreign output),

w = real wage rate, measured in terms of the domestic good,

π = real profits distributed to the household,

γ = one plus the tariff rate,

i^* = the world rate of interest, taken as given,

δ = consumer's discount rate, taken to be constant,

T = lump–sum transfers from the government.

The instantaneous utility function is assumed to be additively separable in goods and labor. We also assume that the utility function is increasing in the consumption of goods, but decreasing in labor, and that it is strictly concave. Finally, the two goods are taken to be Edgeworth complementary, so that $U_{xy} > 0$.[6]

In determining his optimal plans for $x, y, l,$ and b, the representative consumer is assumed to take σ, π, w, i^*, as given. These decisions are made subject to the budget constraint (1b), which is expressed for convenience in units of the foreign good. Note that the tariff rate, τ say, which is the focus of our analysis, is absorbed in the term $\gamma = 1 + \tau$.

The current value Hamiltonian for the household maximization problem is given by

$$(2) \qquad H_h \equiv U(x,y) + V(l) + \lambda\{\frac{1}{\sigma}[\pi + wl - x] - \gamma y + i^* b + T\}$$

where λ is the costate variable associated with (1b). The first order optimality conditions, with respect to the decision variables $x, y,$ and l are respectively.[7]

$$(3a) \qquad U_x(x,y) = \frac{\lambda}{\sigma}$$

$$(3b) \qquad U_y(x,y) = \lambda\gamma$$

$$V'(l) = -\frac{\lambda}{\sigma} w. \tag{3c}$$

In addition, the costate variable evolves according to

$$\dot{\lambda} = \lambda(\delta - i^*). \tag{3d}$$

Since δ and i^* are both fixed, the ultimate attainment of a steady state is possible if and only if $\delta = i^*$. Henceforth we assume this to be the case. This implies $\dot{\lambda} = 0$ everywhere, so that λ is always at its steady–state value $\bar{\lambda}$ (to be determined below).

To rule out Ponzi–type situations we need to impose the transversality condition

$$\lim_{t \to \infty} b(t) e^{-i^* t} = 0 \tag{3e}$$

The representative firm produces domestic output z by means of a production function with capital k and labor as inputs. This function is assumed to have the usual neoclassical properties of positive, but diminishing, marginal products and constant returns to scale, i.e.,

$$\begin{aligned} z &= F(k,l) \\ &F_k > 0, \quad F_l > 0 \\ &F_{kk} < 0, \quad F_{ll} < 0, \quad F_{kk}F_{ll} - F_{kl}^2 = 0. \end{aligned} \tag{4}$$

Profit net of investment expenditure at time t say, is defined to be

$$\pi(t) = F(k,l) - wl - C(I) \tag{5}$$

where

I = rate of investment.

The function $C(I)$ represents the installation costs associated with the purchase of I units of new capital. It is assumed to be an increasing, convex function of I; $C' > 0, C'' > 0$. In addition, we assume

$$C(0) = 0, \quad C'(0) = 1$$

so that the total cost of zero investment is zero, and the marginal cost of the initial installation is unity. This formulation of the installation function follows the original specification of adjustment costs introduced by Lucas (1967), Gould (1968) and Treadway (1969). More recent work by Hayashi (1982) and Abel and Blanchard (1983) postulates an installation function which depends upon k, as well as I. This modification makes little difference to our analysis and for simplicity we retain the simpler formulation. The specification implies that in the case that disinvestment occurs (for example as we shall show following a tariff increase), $C(I) < 0$ for low rates of disinvestment. This may be interpreted as reflecting the revenue as capital is sold off. The possibility that all changes in capital are costly can be incorporated by introducing sufficiently large fixed costs, so that $C(0) > 0$. This does not alter our analysis in any substantive way.[8]

Thus the firm's optimization problem is to

$$(6a) \qquad Max \int_0^\infty \pi(t)e^{-\int_0^t i(s)ds}dt = \int_0^\infty [F(k,l) - wl - C(I)]e^{-\int_0^t i(s)ds}dt$$

subject to

$$(6b) \qquad \dot{k} = I$$

and the initial condition

(6c) $$k(0) = k_0,$$

and where $i(t)$ denotes the domestic real interest rate. Given the assumption of interest rte parity, this is related to the world rate i^* by

$$i(t) = i^* + \frac{\dot{\sigma}}{\sigma}$$

where $\frac{\dot{\sigma}}{\sigma}$ is the (expected) percentage change in the terms of trade. Three further points should be noted about the formulation of the firm's problem. First, equation (6b) abstracts from depreciation. This simplifies the dynamics considerably, without much loss of generality. Second, for expositional simplicity, we assume that the firm finances investment through retained earnings. This assumption is unimportant, since as is well known, in a model such as this, which abstracts from taxation, all forms of financing yield the same optimality conditions. Third, the real interest rate appropriate to firms is $i = i^* + \frac{\dot{\sigma}}{\sigma}$, while that relevant to households is i^*. The difference arises from the fact that it is convenient to express the real accumulation equation for households, (1b), in terms of the unit of the traded bond, namely foreign output, while profit for domestic firms is expressed in terms of domestic output. If we were to transform (1b) to domestic good units, then i would become the relevant interest rate for households.[10]

The current–value Hamiltonian for the firm maximization problem is

$$H_f \equiv F(k,l) - wl - C(I) + qI$$

where q is the costate variable associated with (6b). The relevant optimality conditions for firms with respect to l and I are

(7a) $$F_l(k,l) = w$$

(7b) $$C'(I) = q$$

while q evolves according to

(7c) $$\dot{q} = i(t)q - F_k.$$

In addition there is the accumulation equation (6b), the initial condition (6c), as well as the transversality condition

(7d) $$\lim_{t \to \infty} qke^{-\int_0^t i(\tau)d\tau} = 0.$$

The government's role in this economy is a simple one. It just collects the tariff revenue from the public and redistributes it in a lump sum fashion, so that

(8) $$(\gamma - 1)y = T.$$

Finally, adding the household's budget constraint (1b), the government's budget constraint (8), and noting the definition of $\pi(t)$ in (5), we find that the current account surplus of the economy is given by

(9) $$\dot{b} = \frac{1}{\sigma}[F(k,l) - x - C(I)] - y + i^* b$$

i.e., income less absorption.

B. Macroeconomic Equilibrium

The macroeconomic equilibrium we consider is defined to be one where the planned demand and supply functions derived from the optimizations, consistent with the accumulation equations, clear all markets at all points of time. Combining the optimality conditions for households (3a) - (3e), and for firms (7a) - (7d), together with the accumulation equations (1b), (5) and (6b), the following equilibrium conditions are obtained

(10a) $$U_x(x,y) = \frac{\bar{\lambda}}{\sigma}$$

(10b) $$U_y(x,y) = \bar{\lambda}\gamma$$

(10c) $$V'(l) = -\frac{\bar{\lambda}}{\sigma}F_l(k,l)$$

(10d) $$C'(I) = q$$

(10e) $$F(k,l) = x + Z(\sigma) + C(I)$$

(10f) $$\dot{q} = (i^* + \dot{\sigma}/\sigma)q - F_k(k,l)$$

(10g) $$\dot{k} = I(q)$$

(10h) $$\dot{b} = \frac{1}{\sigma}[F(k,l) - C(I) - x] - y + i^* b$$

where $Z(\cdot)$ is the amount of domestic good exported, with $Z'(\sigma) > 0$. As noted, the costate variable λ remains constant over time at its steady state value $\bar{\lambda}$, determined below. In addition, the transversality conditions (3c) and (7d) must also hold.

Equations (10a) - (10c) define the short–run equilibrium. Pairwise, (10a) - (10c) define the usual rate of substitution conditions for consumers. Note that the distortionary effect of the tariff is included in γ. Equation (10d) equates the marginal cost of capital to the shadow price of investment, which is essentially a Tobin q theory of investment.[11] Finally, equation (10e) describes market clearing in the domestic goods market.

These five equations may be solved for x, y, l, I, and σ, in terms of $\bar{\lambda}, k, q$, and γ, namely

$$x = x(\bar{\lambda}, k, q, \gamma) \quad x_{\bar{\lambda}} < 0, \quad x_k > 0, \quad x_q < 0, \quad x_\gamma < 0 \tag{11a}$$

$$y = y(\bar{\lambda}, k, q, \gamma) \quad y_{\bar{\lambda}} < 0 \quad y_k > 0, \quad y_q < 0, \quad y_\gamma < 0 \tag{11b}$$

$$l = l(\bar{\lambda}, k, q, \gamma) \quad l_{\bar{\lambda}} \gtrless 0, \quad l_k \gtrless 0, \quad l_q > 0, \quad l_\gamma < 0 \tag{11c}$$

$$\sigma = \sigma(\bar{\lambda}, k, q, \gamma) \quad \sigma_{\bar{\lambda}} > 0, \quad \sigma_k > 0, \quad \sigma_q < 0, \quad \sigma_\gamma > 0 \tag{11d}$$

$$I = I(q) \quad I' > 0. \tag{11e}$$

An increase in the marginal utility of consumption $\bar{\lambda}$, leads to a reduction in the domestic consumption of both goods. The reduction in demand for the domestic good causes its relative price to fall, i.e., σ rises, thereby stimulating exports. The overall effect on the demand for domestic output depends upon whether or not this exceeds the reduction in x. If so, domestic output and employment rises; if not, employment falls. An increase in the stock of capital raises output and the real wage. The higher domestic income stimulates the consumption of x, though by a lesser amount, and the relative price σ rises, i.e., $\sigma_k > 0$. With the two goods being complementary in utility ($U_{xy} > 0$), the increase in the demand for the domestic good increases the demand for the import good. While the rise in the real wage rate tends to decrease V', thereby stimulating employment, the rise in σ has the opposite effect; the net effect on employment depends upon which influence dominates. An increase in q stimulates investment. This increase in the demand for domestic goods and the relative price σ falls, i.e., $\sigma_q < 0$. This raises the marginal utility of the domestic good, implying that the consumption of x must fall, and with $U_{xy} > 0, y$ falls as well. On balance, the increase in investment exceeds the fall in demand stemming from the reduction in x and lower exports, so that domestic output and employment rises. Finally, an increase in the tariff rate reduces the demand for the import good, and with $U_{xy} > 0$, the demand for x as well. This lowers the relative price of the domestic good, thereby reducing domestic output and employment. However, this describes only the partial effect of a short–run change in the tariff rate. In addition, it generates jumps in $\bar{\lambda}$ and q, thereby inducing further responses. The complete short–run responses consists of a combination of these two effects and will be discussed in Section 5 below.

One further observation regarding the short–run solutions is appropriate at this stage. Even though both the increase in $\bar{\lambda}$ and the partial effect of an increase in the tariff γ lead to an increase in the relative price σ, thereby stimulating exports, only in the case of the former is the effect sufficiently large to give rise to the possibility that employment may increase. To see the difference it is convenient to take the differential of (10e)

$$(V'' + \frac{\bar{\lambda}}{\sigma}F_{ll})dl = -F_l d(\frac{\bar{\lambda}}{\sigma}).$$

The increase in σ resulting from a tariff lowers the marginal utility of the domestic consumption good, there is substitution in favor of leisure and labor falls. On the other hand, although an increase in $\bar{\lambda}$ raises σ, the net effect on the marginal utility $\frac{\bar{\lambda}}{\sigma}$ is indeterminate, in which case employment may either rise or fall.

The three final equations describe the dynamics. The first two equations can be reduced to a pair of autonomous differential equations in q and k and these constitute the core of the dynamics. To see this, we first note that the path of the relative price σ must be consistent (from (11d)) with the dynamic paths of k and q, as well as the constant value of $\bar{\lambda}$, determined by the steady state equilibrium. As a consequence, differentiating (11d) with respect to t, yields

$$\dot{\sigma} = \sigma_k \dot{k} + \sigma_q \dot{q} \tag{11d'}$$

where as already shown $\sigma_k > 0, \sigma_q < 0$. Substituting this equation, together with (11c) and (11d) into (10f) and (10g), leads to a pair of dynamic equations in q and k. Note that since this pair of equations is determined in part by the constant steady state value of the marginal utility $\bar{\lambda}$, the steady state in part determines the entire dynamic adjustment path. Finally, (10h) equates the accumulation of foreign assets by the economy to its current account surplus. Using the domestic goods market clearing condition (10e), this may be expressed equivalently in terms of exports minus imports

$$\dot{b} = \frac{1}{\sigma}[Z(\sigma) - \sigma y + \sigma i^* b]. \tag{10h'}$$

This equation in turn may be reduced to an autonomous differential equation in b, after substituting the solutions for q and k.

3. EQUILIBRIUM DYNAMICS

Carrying out the procedure outlined above, (10f) and (10g) can be expressed as the following pair of linearized differential equations around the steady state:

$$(12) \qquad \begin{pmatrix} \dot{q} \\ \dot{k} \end{pmatrix} = \begin{pmatrix} \theta[i^* + \sigma_k I'q/\sigma - F_{kl}l_q] & -\theta[F_{kk} + F_{kl}l_k] \\ I/C'' & 0 \end{pmatrix} \begin{pmatrix} q - \tilde{q} \\ k - \tilde{k} \end{pmatrix}$$

where $\theta \equiv \frac{\sigma}{(\sigma - \sigma_q q)} > 0$, and $\tilde{}$ denotes steady–state values.

The determinant of the coefficient matrix in (12) is negative and therefore the long–run equilibrium is a saddlepoint with eigenvalues $\mu_1 < 0, \quad \mu_2 > 0$. It is clear that while the capital stock always evolves continuously, the shadow price of capital, q, may jump instantaneously in response to new information. Along the stable arm, therefore, k and q follow the paths

$$(13a) \qquad k = \tilde{k} + (k_0 - \tilde{k})e^{\mu_1 t}$$

$$(13b) \qquad q = \tilde{q} + [\frac{\mu_1}{I'}](k - \tilde{k})$$

To determine the dynamics of the current account, we consider (10h′) in the form

$$(14) \qquad \dot{b} = \frac{Z[\sigma(\bar{\lambda}, k, q)]}{\sigma(\bar{\lambda}, k, q)} - y(\bar{\lambda}, k, q) + i^* b$$

Linearizing this equation around steady state yields

$$\dot{b} = \frac{1}{\tilde{\sigma}}[(\beta\sigma_k - \sigma y_k)(k - \tilde{k}) + (\beta\sigma_q - \sigma y_q)(q - \tilde{q})] + i^*(b - \tilde{b})$$

where $\beta \equiv Z' + i^* b - y$. Using (13a), (13b), this equation may be written as

$$(15) \qquad \dot{b} = \Omega(k_0 - \tilde{k})e^{\mu_1 t} + i^*(b - \tilde{b})$$

where

$$\Omega \equiv \frac{1}{\tilde{\sigma}}[(\beta\sigma_k - \sigma y_k) + (\beta\sigma_q - \sigma q_q)\frac{\mu_1}{I'}].$$

Assuming that the economy starts out with an initial stock of traded bonds $b(0) = b_0$, the solution to (15) is

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

Invoking the intertemporal budget constraint for the economy, (3c), implies

$$b_0 = \tilde{b} + \frac{\Omega}{\mu_1 - i^*}(k_0 - \tilde{k}) \tag{16}$$

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

$$b(t) = \tilde{b} + \frac{\Omega}{\mu_1 - i^*}(k_0 - \tilde{k})e^{\mu_1 t}. \tag{17}$$

Equation (17) describes the relationship between the accumulation of capital and the accumulation of traded bonds. Of particular significance is the sign of this relationship. Writing Ω as

$$\Omega \equiv \frac{1}{\tilde{\sigma}}[\beta(\sigma_k + \sigma_q\frac{\mu_1}{I'}) - \sigma(y_k + y_q\frac{\mu_1}{I'})]$$

emphasizes that Ω measures the effects of two channels of influence of capital on the current account. First, an increase in k raises the relative price σ_k, both directly, but also through the accompanying fall in q, as seen in (13b). What this does to the trade balance depends upon β. Evaluating β at steady state, we may show[12]

$$\beta = Z' + i^*b - y = Z' - \frac{Z}{\sigma}$$

so that $\beta > 0$ if and only if the relative price elasticity of the foreign demand for exports exceeds unity. At the same time, the increase in k increases imports both directly and again through the fall in q, and this reduces the trade balance. While either case is possible, we shall assume that the relative price effect dominates, so that $\Omega > 0$.

The steady state of the economy is obtained when $\dot{k} = \dot{q} = \dot{b} = 0$ and is given by the following set of equations:

$$U_x(\tilde{x}, \tilde{y}) = \frac{\tilde{\lambda}}{\tilde{\sigma}} \tag{18a}$$

$$U_y(\tilde{x}, \tilde{y}) = \tilde{\lambda}\gamma \tag{18b}$$

$$V'(\tilde{l}) = -F_l(\tilde{k}, \tilde{l})\frac{\tilde{\lambda}}{\tilde{\sigma}} \tag{18c}$$

$$\tilde{q} = 1 \tag{18d}$$

$$F(\tilde{k}, \tilde{l}) = \tilde{x} + Z(\tilde{\sigma}) \tag{18e}$$

$$F_k(\tilde{k}, \tilde{l}) = i^* \tag{18f}$$

$$F(\tilde{k}, \tilde{l}) = \tilde{x} + \tilde{\sigma}\tilde{y} - \tilde{\sigma}i^*\tilde{b} \tag{18g}$$

(18h)
$$\tilde{b} - b_0 = -\frac{\Omega}{i^* - \mu_1}(\tilde{k} - k_0).$$

These equations jointly determine the steady–state equilibrium values of $\tilde{x}, \tilde{y}, \tilde{l}, \tilde{k}, \tilde{\lambda}, \tilde{\sigma}, \tilde{q}$ and $\tilde{b}$.

This long–run equilibrium is straightforward, although several aspects merit comment. Note that the steady–state value of q is unity, consistent with the Tobin q theory of investment. The steady–state marginal physical product of capital is equated to the foreign interest rate. Equations (18e) and (18g) together imply that in steady state equilibrium, the balance of payments on current account must be zero; the trade balance must offset net interest earnings on the traded bonds. Equation (18h) describes the equilibrium relationship between the change in the equilibrium stock of capital and the change in the equilibrium net credit of the economy. Note further, that the steady state depends upon the initial stocks k_0 and b_0. As we will show below, this has important consequences for the effects of temporary changes in the tariff rate.

4. LONG–RUN EFFECTS OF AN INCREASE IN THE TARIFF RATE

The long–run effects of an increase in the tariff rate, obtained by differentiating the steady–state relationships (18), are reported in Table 1.

Since the world interest rate i^* is assumed to remain fixed, the marginal product condition (18f) implies that the capital–labor ratio is a constant, independent of γ. Capital and labor therefore change in the same proportions, so that the marginal product of labor, and hence the real wage rate, also remain constant. From this table it is seen that the increase in the tariff leads to a long–run reduction in both employment and capital, and therefore in output. Intuitively, the imposition of a tax, in the form of a tariff, on the imported good leads to a substitution away from that good towards the two other goods favored by consumers, namely the domestic good and leisure. Consumers are willing to supply less labor so that equilibrium employment falls. This reduces the marginal physical product of capital, so that the equilibrium capital stock, and hence output, fall as well. The long–run effects of the tariff are therefore contractionary, consistent with long–run results of Eichengreen. The decline in output raises the relative price of the domestic good, i.e., σ falls. On the other hand, the relative price of good y facing the consumer, $\gamma\sigma$, is higher than before. The decline in the stock of capital leads to a long–run increase in the stock of traded bonds held by the economy. Also, the decline in employment, coupled with the fall in σ, means that the (constant) marginal utility of consumption $\bar{\lambda}$ must also decline.

Combining (18e) and (18g) in the form

$$Z(\tilde{\sigma}) - \tilde{\sigma}\tilde{y} = -i^{*}\tilde{\sigma}\tilde{b}$$

we see that the imposition of the tariff certainly causes the steady state trade balance, when measured in terms of the foreign currency $(-i^{*}\tilde{b})$ to fall. When measured in terms of domestic currency, however, it will also fall as long as the country is a debtor nation $(\tilde{b} < 0)$. For a creditor nation, it may either rise or fall, depending upon the size of the relative price effect.

The overall impact of the higher tariff on the domestic consumptions of the two good $\tilde{x}$ and $\tilde{y}$ is unclear. While the substitution effect is away from y in favor of x, the income effect is ambiguous. One effect of the reduction in domestic output resulting from the higher tariff is to reduce domestic income. But at the same time, the reduction in the relative price serves to raise income as measured in terms of domestic goods. The net effect depends upon which dominates.

5. TRANSITIONAL DYNAMICS AS TO INCREASE IN TARIFF

We consider now the dynamic adjustment path of the economy following an increase in the tariff rate. As noted previously, the dynamics of q and k are described by a saddlepoint in $k-q$ space. The stable arm XX is given by

$$q = 1 + \frac{\mu_1}{I'}(k - \tilde{k})$$

and is negatively sloped; the unstable arm YY is described by

$$q = 1 + \frac{\mu_2}{I'}(k - \tilde{k})$$

and is positively sloped. The phase diagram is illustrated in Fig. 1.

As long as no future shock is anticipated, the system must lie on the stable locus XX. The initial jump in $q(0)$, following an unanticipated permanent increase in γ is

$$\frac{dq(0)}{d\gamma} = -\frac{\mu_1}{I'}\frac{d\tilde{k}}{d\gamma} < 0. \tag{20}$$

The long–run fall in the capital stock is seen to give rise to a short–run drop in the shadow price $q(0)$.

The dynamics following an unanticipated permanent increase in the tariff rate is illustrated in Figs. 2A and 2B. Part A describes the dynamics of q and k, while Part B describes the accumulation of traded bonds. Suppose that the economy is initially in steady state equilibrium at the point P on the stable arm XX and that there is a permanent increase in γ. The new steady state is at the point Q, having a reduced equilibrium capital stock $\tilde{k}$, with an unchanged shadow price of capital. In the short run q drops from P to A on the new stable locus X′ X′. From (10g) it is seen that the decrease in q has an immediate contractionary effect on investment and capital begins to decumulate. Likewise upon reaching point A, q immediately begins to rise.

The initial responses of other key variables are

$$\frac{dl(0)}{d\gamma} = \frac{\partial l}{\partial \gamma} + \frac{\partial l}{\partial \bar{\lambda}}\frac{d\bar{\lambda}}{d\gamma} + \frac{\partial l}{\partial q}\frac{dq(0)}{d\gamma} < 0 \tag{21a}$$

$$\frac{d\sigma(0)}{d\gamma} = \frac{\partial\sigma}{\partial\gamma} + \frac{\partial\sigma}{\partial\bar{\lambda}}\frac{d\bar{\lambda}}{d\gamma} + \frac{\partial\sigma}{\partial q}\frac{dq(0)}{d\gamma} \tag{21b}$$

$$\frac{dx(0)}{d\gamma} = \frac{\partial x}{\partial\gamma} + \frac{\partial x}{\partial\bar{\lambda}}\frac{d\bar{\lambda}}{d\gamma} + \frac{\partial x}{\partial q}\frac{dq(0)}{d\gamma} \tag{21c}$$

$$\frac{dy(0)}{d\gamma} = \frac{\partial y}{\partial\gamma} + \frac{\partial y}{\partial\bar{\lambda}}\frac{d\bar{\lambda}}{d\gamma} + \frac{\partial y}{\partial q}\frac{dq(0)}{d\gamma} \tag{21d}$$

which consist of two kinds of effects. First, there are the direct effects, given by the partial derivatives such as $\frac{\partial l}{\partial\gamma}$, discussed in Section 2. Secondly, there are indirect effects, which operate through induced jumps in $\bar{\lambda}$, and q. These may, or may not, work in the same direction as one another or as the direct effect.

In the case of employment, for example, the direct effect of the higher tariff is contractionary. This is accentuated by the fact that it also generates a short–run reduction in the shadow price of investment. At the same time, the fall in the marginal utility $\bar{\lambda}$ has a further impact on employment, though for reasons noted in Section 2 the direction is not entirely clear. However, one can establish that on balance, the contractionary effects dominate, so that the imposition of the tariff reduces employment and output in the short run. There are various ways to see why this must be so. One way is to consider what happens to (10f) on impact. We have already seen that the immediate effect of the tariff is to cause q to drop instantaneously to the point A on the new stable locus X$'$X$'$, where q immediately begins to start rising, while k starts to fall; i.e., $dq(0) < 0$, $d\dot{q}(0) > 0$, $d\dot{k}(0) < 0$. It then follows from (11d$'$) that $d\dot{\sigma}(0) < 0$, so that interest rate parity implies an instantaneous fall in the domestic interest rate; i.e., $di(0) < 0$. Given these responses, the only way for (10f) to hold is for the marginal physical product of capital to fall instantaneously and with the stock of capital being predetermined, this occurs through a fall in employment.

The resulting increase in the capital–labor ratio means of course a higher short–run real wage. Over time, however, as capital is decumulated, the capital–labor ratio falls and the real wage returns to its original long–run level.

The initial response of the relative price (real exchange rate) σ is in general unclear. The direct effect of a higher tariff, together with the induced reduction in the shadow price q, causes σ to rise; the fall in $\bar{\lambda}$ causes it to fall. The fact that $\dot{q} > 0, \dot{k} < 0$, at all points on the new stable locus, implies from (11d′) that σ falls steadily over time, so that there is continuous real exchange rate appreciation, leading ultimately to a lower relative price σ. The fact that $\dot{\sigma} < 0$ also means that the initial reduction in the domestic real interest rate persists along the transitional path, until equilibrium is restored, when it returns to the given world rate.

The initial reductions in q and $\bar{\lambda}$ both serve to stimulate consumption. In the case of the import good, this is offset by the negative effect of the higher tariff. This is also true in the case of the domestic good, as long as $U_{xy} > 0$. If the utility function is additively separable in the two consumption goods, then in this latter case only the indirect effects occur; the tariff on the import good stimulates the consumption of the domestic good in the short run.

These dynamic responses to the tariff depend critically upon two aspects of the model; (i) the endogeneity of employment and (ii) the endogeneity of the relative price σ. Of these, the former is the more important. To see its role consider the steady–state relationships (18) and assume now that employment is fixed, so that the optimality condition (18c) is no longer applicable. The marginal productivity condition now implies that the steady–state capital stock k (rather than the capital–labor ratio) is determined by i^* and is independent of the tariff. It therefore follows from the dynamic equations (13a), (13b) that the capital stock and the shadow price q remain constant at all points of time. The tariff therefore leaves output unchanged! There are no dynamics. The only effect of the tariff is to generate a once–and–for–all adjustment in the relative price and in the consumptions, x

and y. Turning to the role of the relative price, suppose that the economy is sufficiently small for this to be fixed exogenously. It is clear from (10a), (10b) that consumptions x, y are determined by the constant values of $\bar{\lambda}, \gamma$, and σ and are therefore constant over time. On the other hand, employment being a function of the capital stock via (11c), does evolve over time, as capital is decumulated. In order to restore dynamics to the consumption levels x and y, the assumption of additive separability of utility in goods and labor being made in this analysis must be dropped. In that case, x and y will depend upon the dynamics of k in the same way as does employment.

Part B of Fig. 2 illustrates the relationship between b and k, which combining (13a) and (17) is given by

$$b - \tilde{b} = -\frac{\Omega}{i^* - \mu_1}(k - \tilde{k}).$$

This is a negatively sloped locus, denoted by ZZ. Since neither k nor b are jump variables, this line remains fixed over time. The movement along A to Q in Part A is translated to a movement along LM in Part B. From this figure it is seen that an increase in the tariff rate causes an immediate accumulation of foreign bonds. This stems from the fact that our assumption $\Omega > 0$ implies that the net effect of the decumulation of capital is to create a current account surplus. With b being predetermined, the trade balance, as measured in terms of the foreign good, also rises. In terms of the domestic good, it will rise if the relative price σ increases; but it may fall if σ falls sufficiently. Over time, the initial accumulation of foreign bonds is reversed. This occurs through the fall in σ and k, which causes the trade balance to decline over time.

Consider now a temporary increase in the tariff. Specifically, suppose that at time $0, \gamma$ increases, but is expected to be restored to its original level at time T. The transitional adjustment is now as follows.[13] As soon as the increase in γ occurs, the stable arm XX will drop instantaneously (and temporarily) to X′X′, while the shadow price q falls to the point B, which lies above X′X′. At the same time, the marginal utility of consumption

$\bar{\lambda}$ will fall by precisely the same (constant) amount as if the shock were permanent. On the other hand, since the fall in the shadow price $q(0)$ is only to the point B, the fall in initial investment is moderated. The same is true of employment. As a result of the initial fall in q, capital begins to decumulate and q begins to rise, for analogous reasons to those noted in connection with the permanent shock. Moreover, the decumulation of capital is accompanied by an accumulation of traded bonds. Immediately following the initial jump, q and k follow the path BC in Fig. 2.A, while k and b follow the corresponding path LH in Fig. 2.B. At time T, when the tariff is restored to its original level, the stock of capital and traded bonds will have reached a point such as H in Fig. 2.B. The accumulated stocks of these assets, denoted by k_T and b_T respectively, will now serve as initial conditions for the dynamics beyond time T when γ reverts permanently to its original level. As noted in Section 3, 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 shock was announced at the outset), and no further jumps, the stable locus relevant for subsequent adjustments in q and k beyond time 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, q and k follow the stable locus CR in Fig. 2.A to the new steady state equilibrium at R, while correspondingly k and b follow the locus HN in Fig. 2.B to the new equilibrium point N. One can establish formally that X″X″ lies below the original stable locus XX, while Z′Z′ lies above ZZ, as these curves have been drawn. In the new steady state, the shadow price q reverts to 1, but with a lower stock of capital and a higher stock of traded bonds than originally. The striking feature of the adjustment is that the temporary tariff leads to a permanent reduction in the stock of capital, accompanied by a higher stock of traded bonds. This is because during the transitional adjustment period, during which the higher tariff is in effect, the accumulation of capital and bonds will influence subsequent initial conditions, which in turn will affect the subsequent steady state.

As the figures are drawn, C lies below R and H lies below N, respectively. The complete adjustment paths BCR and LHN are therefore monotonic. We are unable to rule out the possibility of C lying above R and H lying above N, in which case, the accumulation of capital and accumulation of bonds would be reversed at some point during the transition. In any event, the temporary increase in the terms of trade generates an initial current account surplus, which continues as long as capital is being decumulated.

As a third disturbance, we briefly consider a future permanent increase in the tariff which is announced at time 0, to take effect at time T. This is not illustrated in the figure. At the time of the announcement, q drops instantaneously to a point such as B, which lies above A on X′X′. This reduction in q implies a smaller initial decumulation in the capital stock, than when the permanent deterioration occurs instantaneously.

Since neither γ nor $\bar{\lambda}$ change until time T, when the announced increase in the tariff rate actually occurs, the initial responses of l, σ, x, and y are determined solely by the initial downward jump in $q(0)$. Hence the announcement causes employment and output to fall, while the relative price and the two consumptions both rise. However, the reduction in employment is smaller than for an unanticipated increase. Consequently, the fall in the marginal physical product of capital is moderated and q continues to fall; see (10f). Thus following the announcement both q and k decline, while foreign bonds are accumulated. At time T, when the announced increase in the tariff rate occurs, the stocks of capital and bonds at that time, k_T, b_T, will determine the stable paths X″X″ and Z′Z′ relevant for subsequent adjustments, beyond T. Because of the changed initial conditions at time T, from time 0, these paths will not coincide with X′X′, ZZ the corresponding paths for unannounced changes. In particular, X″X″ can be shown to lie above X′X′ in Fig. 2.A. This implies that the long–run contraction in the capital stock following an increase in the tariff rate is reduced by announcing this change in advance.

6. CONCLUSIONS

This paper has analyzed the effects of a tariff in an intertemporal optimizing model, emphasizing the role of capital accumulation. Three types of increases in the tariff rate have been considered: (i) unanticipated permanent; (ii) unanticipated temporary; (iii) anticipated permanent. There are two main general conclusions to be drawn from the analysis.

The first is that the introduction (or increase) of a tariff is contractionary, both in the short run and in the long run. In particular, employment is reduced both in the short run and in the long run, so that there is no significant intertemporal tradeoff, as obtained by Eichengreen. The fall in the long-run capital stock causes an immediate reduction in the rate of investment, which in turn leads to a current account surplus. While this response of the current account is in accordance with much (but not all) of the existing literature, the mechanism by which it is achieved, namely the decumulation of capital, has not been previously considered. Also, the fact that the declining capital stock is accompanied by an accumulation of foreign bonds means that the savings effect of the tariff are unclear, depending upon which influence dominates.[14] This ambiguity of savings is, however, very different from those occurring in other studies. For example, the absence of capital accumulation in the Edwards (1987) model means that the ambiguity of the current account to a tariff translates directly to an ambiguity in savings. In the Engel–Kletzer (1987) model, the response of savings is shown to depend upon the formulation of consumer behavior. The second major conclusion stems from the fact that the steady state depends upon the initial stocks of the assets. As a consequence, a temporary tariff, by altering these initial conditions for some later date when the tariff is removed, leads to a permanent effect on the economy.

The qualitative conclusions we have obtained are based on the assumption that the two goods are complementary in the sense $U_{xy} > 0$. As noted previously (footnote 6), we view this as being plausible, particularly when dealing with aggregate commodities. Since the main driving force of the results are the long-run response of the capital stock, it is evident from Table 1 that the key qualitative aspects of the results will continue even if U_{xy} is mildly negative. However, if U_{xy} is strongly negative, so that the effect of the tariff is to raise the long–run capital stock, then both the short–run and long–run effects of the tariff on employment are expansionary. The detailed analysis of this case can be carried out following the procedures of this paper. However, we should caution that this case raises the possibility that the dynamics may no longer be a saddlepoint. In this case with capital being assumed to evolve smoothly, the perfect foresight equilibrium, which now coincides with the steady state, cannot be sustained without some active form of government intervention.[15]

The model is obviously simple and could be extended in several ways. For instance, monetary considerations could be introduced and the exchange rate regime would determine how much of a change in the terms of trade would pass into domestic prices and how much into a change in the nominal exchange rate. The issue of real wage rigidity could also be discussed. Finally, one could extend the framework into a two country setting and introduce game–theoretic considerations.

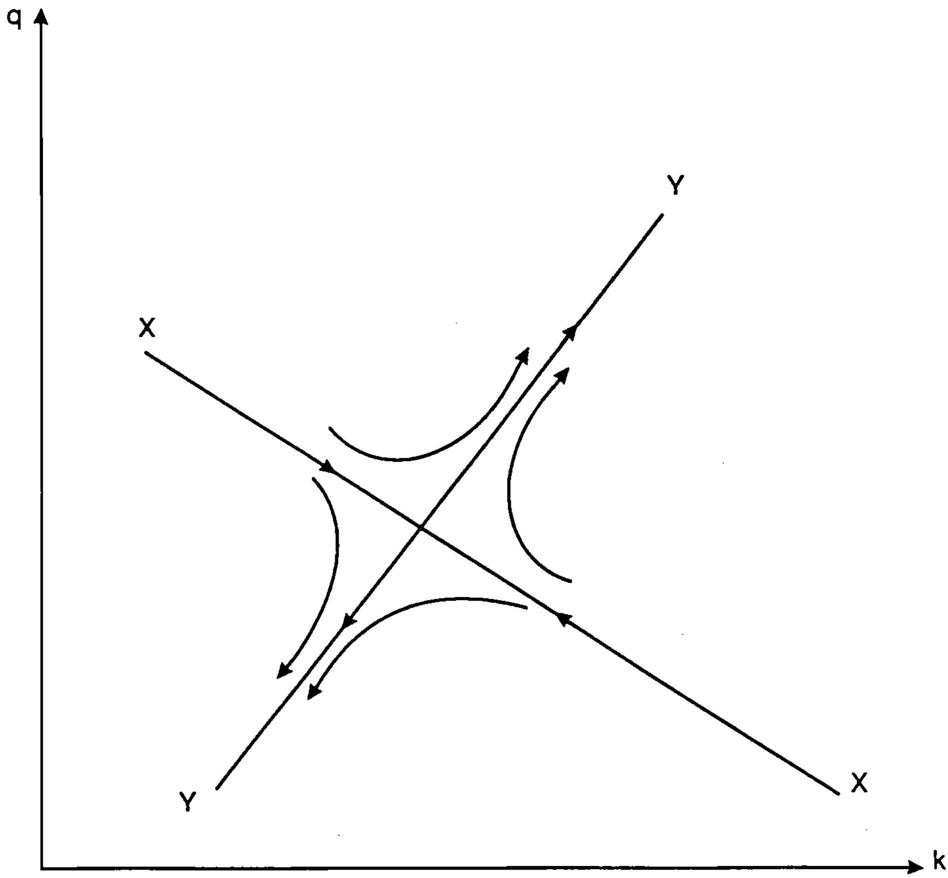

Figure 1

Phase Diagram

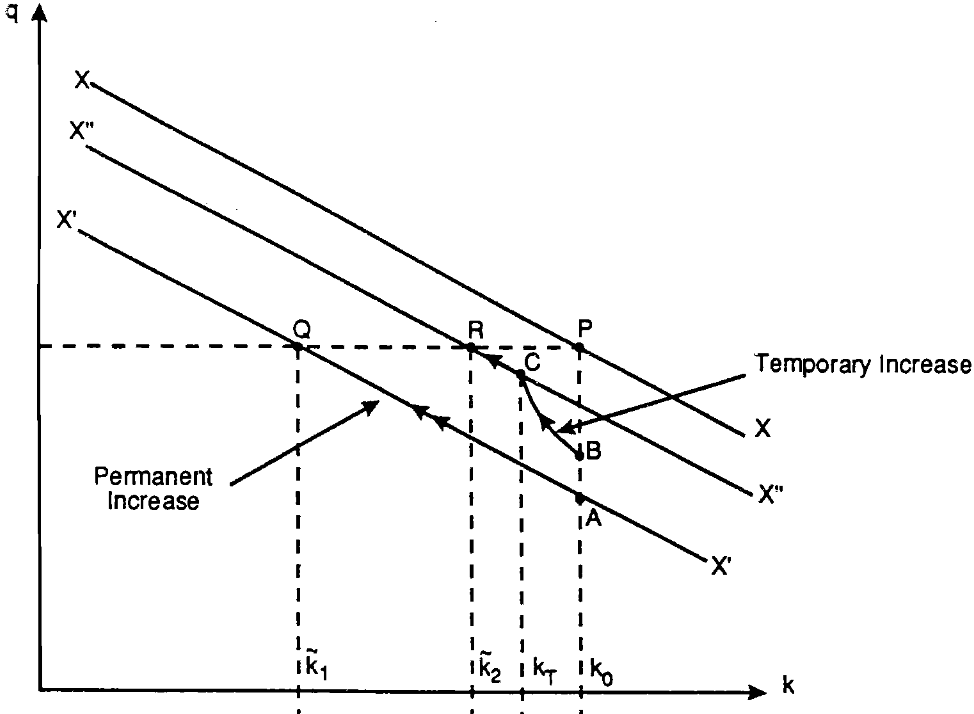

Figure 2.A

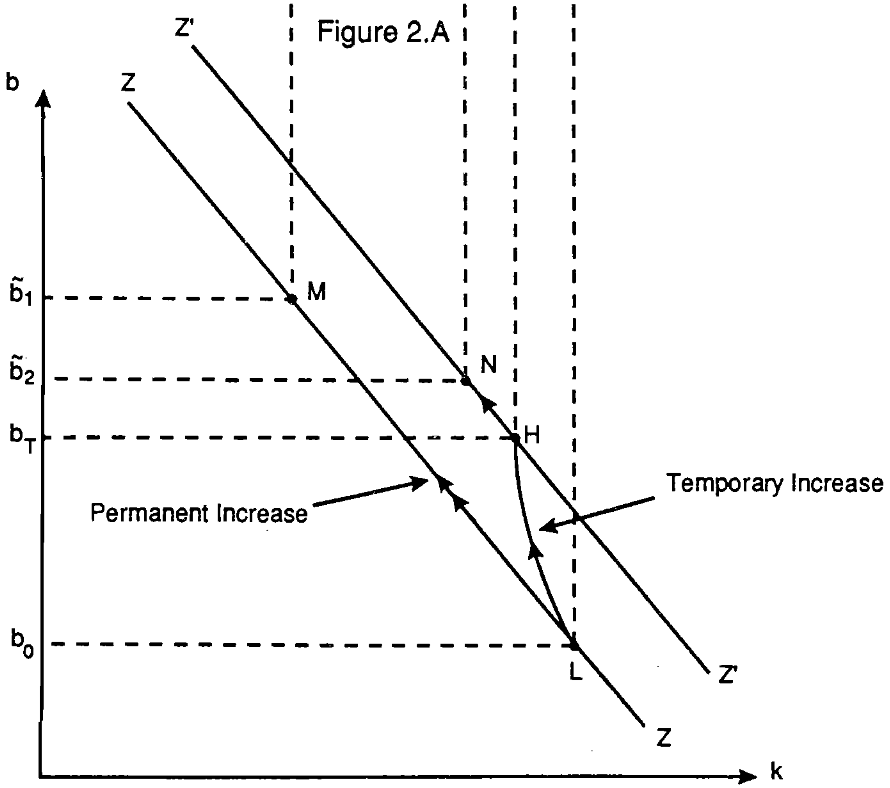

Figure 2.B

Increase in Tariff

TABLE 1

LONG RUN EFFECTS OF INCREASE IN TARIFFS

Capital–labor ratio:

$$\frac{d(\tilde{k/l})}{d\gamma} = 0.$$

2. Capital, employment and output:

$$\frac{d\tilde{k}/d\gamma}{k} = \frac{d\tilde{l}/d\gamma}{l} = \frac{d\tilde{z}/d\gamma}{z} = -\frac{\lambda}{D}\frac{F_l}{l\sigma}[-U_{xx}\sigma Z' + \beta U_{xy}] < 0.$$

3. Relative Price:

$$\frac{d\tilde{\sigma}}{d\gamma} = \frac{\bar{\lambda}}{\sigma D}[V''\sigma + \frac{\sigma}{l}FF_l U_{xx} + \psi U_{xy}F_l] < 0.$$

4. Domestic Good:

$$\frac{d\tilde{x}}{d\gamma} = -\frac{\bar{\lambda}}{D}[U_{xy}\frac{F_l}{\sigma}(F\beta/l + Z'\psi) + V''Z'] \gtrless 0.$$

5. Import Good:

$$\frac{d\tilde{y}}{d\gamma} = \frac{\bar{\lambda}}{D}[U_{xx}\frac{F_l}{\sigma}(F\beta/l + Z'\psi) + V''\frac{\beta}{\sigma}] \gtrless 0.$$

6. Marginal Utility:

$$\frac{d\bar{\lambda}}{d\gamma} = \frac{\bar{\lambda}}{D}[V''(-\sigma Z'U_{xx} + \frac{\bar{\lambda}}{\sigma} + \beta U_{xy}) + \frac{\bar{\lambda}F_l}{\sigma^2}[\sigma FU_{xx}/l + \psi U_{xy}]] < 0.$$

where

$$\psi \equiv -\frac{\sigma i^* \Omega}{i^* - \mu_1}(k/l) < 0; \quad \beta \equiv Z' - y + i^* b > 0$$

$$D \equiv -V''[U_{xy}Z' + \gamma\frac{\bar{\lambda}}{\sigma} - Z'\gamma U_{xx}\sigma] - V''\beta[U_{xy}\gamma - \frac{1}{\sigma}U_{yy}]$$

$$-F_l\psi U_{xy}\gamma\frac{\bar{\lambda}}{\sigma^2} - F_l F U_{xx}\gamma\frac{\bar{\lambda}}{\sigma l} > 0.$$

FOOTNOTES

*The paper has benefited from seminar presentations at the University of Washington and the University of Toronto, as well as from the constructive comments of two referees.

[1]Krugman (1982) presents a comprehensive survey of this model. His analysis includes the cases of nominal and real wage rigidity; fixed and flexible prices; immobile and mobile capital.

[2]Eichengreen (1981) considers two forms of expectations, static and rational. In the former case, the short–run effect of the tariff is definitely expansionary. In the latter case, it may or may not be, depending upon the extent to which the domestic currency appreciates in the short run.

[3]See, e.g., Obstfeld (1982) and Svensson and Razin (1983).

[4]A recent paper by Edwards (1987) develops a two period optimizing model to analyze the effects of changes in tariffs and shocks in the terms of trade on both the real exchange rate and the current account. In general he shows how in his model a tariff may lead to either an appreciation or depreciation of the real exchange rate, in which case the response of the current account is also ambiguous. By imposing additional restrictions, a tariff is shown to lead to a real depreciation in both periods.

[5]Other papers which examine the current account with capital accumulation include Buiter (1987), Ghosh (1987) and Matsuyama (1987). However, these authors do not analyze issues related to tariffs, which are the focus of this paper.

[6]While this assumption is restrictive, at the aggregate it is reasonably plausible and is met by a variety of widely used utility functions. For example, it holds if $U(x,y)$ is any utility function, homogeneous of degree one. It also holds for more specific utility functions, such as the CES, when these are homogeneous of any arbitrary degree less than one. It is also clear, that our results hold if $U(x,y)$ is additively separable in the two goods.

[7]Throughout the paper we shall adopt the following notational convention. Where

appropriate, primes shall denote derivatives, subscripts shall denote partial derivatives, and a dot shall denote a derivative with respect to time.

[8]For an alternative interpretation of $C(I) < 0$, see Hayashi (1982).

[9]More specifically, letting gross profits $\pi'(t) = F(k,l) - wl$, the assumption that investment $C(I)$ is financed from retained earnings (RE), implies that Dividends $= \pi'(t) - RE = \pi(t)$, as defined in (6a).

[10]Suppose $b' = \sigma b$ is the stock of bonds expressed in terms of domestic output. Then $\dot{b}' = \dot{\sigma} b + \sigma \dot{b}$. Combining this with (1b), and using the interest arbitrage relationship, the household accumulation equation becomes

$$\dot{b}' = \pi + wl - x - \sigma y + ib' + T.$$

Alternatively (but less conveniently), if the real stock of bonds were expressed in terms of a representative consumption basket, then the relevant real interest rate would be the rate defined in terms of that basket. Since any change in unit leads to a corresponding adjustment in the shadow price λ and its evolution, the choice is arbitrary and can be dictated by convenience, as we have done.

[11]In the case where the installation costs are specified by $C(I/k)$, the investment function (11e) is modified to $I/k = I(q)$.

[12]This can be immediately established by considering equations (18e) and (18g), below.

[13]The formal derivations of these adjustment paths are omitted, but are available from the authors on request.

[14]Savings S along the transition path is given by

$$S = \dot{k} + \sigma \dot{b} + \dot{\sigma} b = I + Z - \sigma y + i\sigma b$$

and this may be either positive or negative during the adjustment.

[15] It is well known that in order for a unique equilibrium solution to exist, the number of unstable roots must equal the number of jump variables, a condition that is met by a saddlepoint. The case $U_{xy} < 0$ raises the possibility of there being more unstable roots (two) than jump variables (one) and it is this insufficiency of the latter that requires active intervention by the government, if the system is not to diverge.

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