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ABSTRACT

This paper resolves a long-standing obstacle in the development and use of the dependent economy model with investment. This obstacle derives from the fact that models of the dependent economy with investment have been criticized for arbitrarily assuming that capital is either tradable or nontradable, and for choosing either the traded or nontraded sector to be capital intensive. The model incorporates both types of capital and shows that it is the relative sectoral intensity of nontraded capital that matters for the dynamic adjustment of the relative price of nontradables. When the traded sector is relatively intensive in nontraded capital, the saddlepath is flat (at the long-run value of the relative price of nontradables). When the nontraded sector is relatively intensive in nontraded capital, the saddlepath is negatively sloped. The relative sectoral intensity of traded capital primarily affects the adjustment of the current account. In particular, we consider the role of the complementarity or substitutability of traded and nontraded capital in the production structure on the behavior of the current account. The dynamic behavior of the model is illustrated by considering a permanent increase in foreign transfers.

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1. INTRODUCTION

The study of nontraded goods in the adjustment of the balance of payments has a long history. The earliest analysis of nontraded goods in a macroeconomic setting appears to be that of Cairnes (1859), while Taussig (1917, 1920), Graham (1922), and Ohlin (1929) provided other early treatments.[1] Modern analytical treatments of nontraded goods in a macroeconomic setting can be traced to the Australian school of Salter (1959), Swan (1960), Corden (1960), Pearce (1961), and McDougall (1965), to which should be added the important work of Diaz Alejandro (1965) in a Latin American context.[2] The first published use of the term "dependent economy", to which the title of this paper refers, was made by Salter (1959) to describe an economy that was a price-taker on world markets but that also produced nontraded goods for domestic use.[3]

During the 1960s, static versions of the dependent economy model were developed to analyze the issues of balance of payments adjustment and adjustment of the relative price of nontraded goods to an exogenous shock to expenditure. The first published intertemporal models with nontraded goods were those of Fischer and Frenkel (1972, 1974), and Bruno (1976). The models that have followed these first papers, such as Dornbusch (1983), have generally included consumption of both the traded and nontraded good, although a number of analyses have restricted consumption to include only the traded good.

The treatment of investment expenditure in intertemporal optimizing models of the dependent economy has been more problematical than the treatment of consumption. Whereas investment in a closed economy model requires the production of capital goods, investment in the dependent economy model requires either internationally-traded capital (such as equipment) or domestically-produced nontraded capital (such as structures). Models that specify *investment goods* to be *traded* -- such as Bruno (1982), Razin (1984), Engel and Kletzer (1989) and Ostry (1991) -- have been criticized for the narrowness of that assumption.[4] Similarly, models specifying *investment goods* to be *nontraded* -- such as Fischer and Frenkel (1974), Marion (1984), van Wijnbergen (1985), Murphy (1986), Turnovsky (1991), and van Wincoop (1993) -- have also been criticized for the lack of realism of that assumption.[5] For any particular specification of investment goods, a further assumption that the *traded sector* is relatively *capital intensive* -- such as that made in Fischer and Frenkel (1974), Dornbusch (1980), Obstfeld and Stockman (1985), Brock (1988), and Murphy (1989) -- can be (and has been) criticized as much as the opposite assumption made by Bruno (1982) that the *nontraded sector* is *capital intensive.*[6]

In this paper we introduce investment expenditure into the dependent economy model in a way that we believe can satisfactorily answer many of the long-standing questions regarding the dependence of the model's results on the specificity of its investment and capital intensity assumptions. Our model includes both traded and nontraded investment expenditure, so that the production structure uses three factors (nontraded capital, traded capital, and labor) in two sectors (traded and nontraded). The model is, we believe, an attractive one and is identical to the model presented, but not solved, in the Appendix to Bruno (1976).[7] In addition to providing answers to questions concerning the dependence of the model's results on the choice of capital good and sectoral capital intensities, we are also able to examine a previously unasked question regarding the dependence of the model's results on the complementarity or substitutability of traded and nontraded capital in the production structure.

The paper proceeds as follows. Section 2 presents the structure of the dependent economy model with two types of capital. Section 3 develops the macroeconomic equilibrium of the model, including the derivation of the equilibrium dynamics of the capital stock, the relative price of nontraded goods, and the adjustment of the current account under alternative factor intensity and factor substitutability assumptions. Section 4 illustrates the behavior of the model by characterizing the adjustment of the economy to a permanent increase in foreign transfers. Section 5 calculates the time path of instantaneous utility to compute the welfare integral associated with an increase in foreign transfers. Section 6 discusses briefly the role of long-run price adjustment in response to different kinds of shocks. Section 7 concludes, while technical details are relegated to the Appendix.

2. THE ECONOMIC STRUCTURE

The economy under consideration is inhabited by a single, infinitely-lived representative agent who is endowed with a fixed supply of labor (normalized to be one unit) which he sells at the competitive wage. The agent accumulates two kinds of capital for rental at the competitively-determined rental rate. One type of capital good is nontraded and we shall identify this good as *structures (S)*. The other capital good is tradable and we shall refer to this good as *equipment (E)*. We assume that structures depreciate at the rate δ_S while equipment depreciates at the rate δ_E. Thus investment expenditure on structures (I_S) and investment expenditure on equipment (I_E) are related to their respective stocks, S and E, by the accumulation equations

$$\dot{S} = I_S - \delta_S S \tag{1a}$$

$$\dot{E} = I_E - \delta_E E \tag{1b}$$

The agent produces a tradable good (Y_T, taken to be the numeraire) using structures (S_T), equipment (E_T), and labor (L_T) by means of a linearly homogeneous neoclassical production function, which we write in intensive form as:

$$Y_T = F(S_T, E_T, L_T) \equiv f(s_T, e_T)L_T, \qquad \text{where } s_T \equiv \frac{S_T}{L_T}, e_T \equiv \frac{E_T}{L_T}.$$

The agent also produces a nontraded good (Y_N) using structures (S_N), equipment (E_N), and labor (L_N) by means of a second linearly homogeneous production function:

$$Y_N = H(S_N, E_N, L_N) \equiv h(s_N, e_N)L_N, \quad \text{where } s_N \equiv \frac{S_N}{L_N}, e_N \equiv \frac{E_N}{L_N}$$

The relative price of nontraded goods (p) is taken as exogenously given by the agent and is determined by market-clearing conditions in the economy. All three factors of production are mobile across the traded and nontraded sectors, with the sectoral allocations being constrained by:

$$L_T + L_N = 1 \tag{2a}$$

$$S_T + S_N = S \tag{2b}$$

$$E_T + E_N = E \tag{2c}$$

In addition to accumulating the two types of capital, the agent receives an exogenously given flow of transfer income (τ) from the rest of the world and also accumulates net foreign bonds (b) that pay an exogenously given world interest rate (r). Thus the agent's instantaneous budget constraint is described by:

$$\dot{b} = \tau + f(s_T, e_T)L_T + ph(s_N, e_N)L_N + rb - C_T - pC_N - I_E - pI_S \tag{3}$$

where C_T, and C_N are consumption of the traded and nontraded goods. The price of the traded investment good (equipment) is normalized to equal the unitary price of the tradable consumption good.

The agent's decisions are to choose consumption levels (C_T,C_N), labor allocation decisions (L_T, L_N), capital allocation decisions (S_T, S_N, E_T, E_N), and rates of investment (I_S,I_E) to maximize the intertemporal utility function:

$$\int_o^\infty U(C_T, C_N)e^{-\beta t}dt \tag{4}$$

subject to the constraints (1) - (3), the initial stocks of assets S_0, E_0, b_0 and the fixed stock of labor. The instantaneous utility function is assumed to be concave and the two consumption goods are assumed to be normal. The agent's rate of time preference (β) is a constant which, given a perfect world capital market, must be assumed to equal the world real interest rate (r) in order for a steady-state equilibrium ultimately to prevail.

This is a standard intertemporal optimization problem, for which the following optimality conditions obtain:

$$U_T(C_T, C_N) = \lambda \tag{5a}$$

$$U_N(C_T, C_N) = \lambda p \tag{5b}$$

$$f_s(s_T, e_T) = ph_s(s_N, e_N) \equiv r_s \tag{5c}$$

$$f_e(s_T, e_T) = ph_e(s_N, e_N) \equiv r_e \tag{5d}$$

$$f(s_T, e_T) - s_T f_s(s_T, e_T) - e_T f_e(s_T, e_T) = p\left[h(s_N, e_N) - s_N h_s(s_N, e_N) - e_N h_e(s_N, e_N)\right] = w \tag{5e}$$

$$\frac{\dot{\lambda}}{\lambda} + \beta = r \tag{5f}$$

$$r_s = p(r + \delta_S) - \dot{p} \tag{5g}$$

$$r_e = r + \delta_E \tag{5h}$$

where λ, the Lagrange multiplier associated with the accumulation equation (3) is the shadow value (marginal utility) of wealth held in the form of internationally traded bonds, r_s is the rental rate on structures, r_e is the rental rate on equipment, and w is the real wage rate, all measured in terms of the numeraire. In addition, the transversality conditions

$$\lim_{t \to \infty} \lambda b e^{-\beta t} = \lim_{t \to \infty} \lambda p S e^{-\beta t} = \lim_{t \to \infty} \lambda E^{-\beta t} = 0 \tag{5i}$$

ensure that the agent's intertemporal budget constraint is met.

These optimality conditions are standard and require only brief discussion. Equations (5a) and (5b) are the usual intertemporal envelope conditions that relate the marginal utility of consumption of the two goods to the shadow value of wealth. Equations (5c), (5d), and (5e) equate the marginal returns to structures, equipment, and labor, respectively, across the two sectors. Equations (5f)-(5h) are arbitrage conditions. The assumed equality of the rate of time preference β and the world interest rate r implies that the shadow value of wealth λ remains constant through time at $\lambda = \bar{\lambda}$. Equation (5g) indicates that the equilibrium rental rate on structures, expressed in terms of the numeraire commodity, equals the world interest rate plus the depreciation rate on structures less its relative price change. Similarly, (5h) shows that the equilibrium rental rate on equipment, also measured in terms of the numeraire is fixed by the world interest rate and the rate of depreciation on equipment.

3. MACROECONOMIC EQUILIBRIUM

3.1 Short-Run Equilibrium

Setting $\lambda = \bar{\lambda}$ permits us to summarize the macroeconomic equilibrium by the following set of relationships:

$$U_T(C_T, C_N) = \bar{\lambda} \tag{6a}$$

$$U_N(C_T, C_N) = \bar{\lambda} p \tag{6b}$$

$$f_s(s_T, e_T) = p h_s(s_N, e_N) \tag{6c}$$

$$f_e(s_T, e_T) = p h_e(s_N, e_N) = r + \delta_E \tag{6d}$$

$$f(s_T, e_T) - s_T f_s(s_T, e_T) - e_T f_e(s_T, e_T) = p\left[h(s_N, e_N) - s_N h_s(s_N, e_N) - e_N h_e(s_N, e_N)\right] \tag{6e}$$

$$S = L_T s_T + (1 - L_T) s_N \tag{6f}$$

$$E = L_T e_T + (1 - L_T) e_N \tag{6g}$$

$$\dot{p} = p\left[(r + \delta_S) - h_S(s_N, e_N)\right] \tag{7a}$$

$$\dot{S} = (1 - L_T)h(s_N, e_N) - C_N - \delta_S S \tag{7b}$$

$$\dot{b} = L_T f(s_T, e_T) - C_T - I_E + rb + \tau \tag{7c}$$

Equations (6a) - (6e) correspond to (5a) - (5e), together with (5h). Equations (6f) and (6g) describe the sectoral allocation relationships (2a) - (2c), normalized per unit of labor. Equation (7a) just rewrites the arbitrage condition (5g), combining it with (5c). Equation (7b) specifies equilibrium in the nontraded goods market. Any output in excess of consumption and depreciation of structures is accumulated as capital to be used as structures. The final equation describes the economy's current account. The rate of accumulation of traded bonds equals the excess of the domestic output of the traded good over domestic consumption and investment expenditure, plus the interest earned on net foreign assets and the amount of the exogenous transfers from abroad.

The static equations (6a) - (6g) define a short-run equilibrium which may be solved recursively as follows. First, the two marginal utility conditions (6a), (6b) may be solved for C_T, C_N, in the form

$$C_T = C_T(\bar{\lambda}, p) \qquad \frac{\partial C_T}{\partial \bar{\lambda}} < 0; \frac{\partial C_T}{\partial p} \gtrless 0 \tag{8a}$$

$$C_N = C_N(\bar{\lambda}, p) \qquad \frac{\partial C_N}{\partial \bar{\lambda}} < 0; \frac{\partial C_N}{\partial p} < 0 \tag{8b}$$

Secondly, from the production block, (6c) - (6e), we may solve

$$s_T = s_T(p); \quad e_T = e_T(p); \quad s_N = s_N(p); \quad e_N = e_N(p) \tag{9a}$$

Expressions for the partial derivatives appearing in (8) and (9a) are reported in the Appendix. The effects in (8) are standard; those in (9a) are more complicated. In general the latter depend upon two sets of factors. As in the standard two-sector trade model, they depend upon the relative sectoral intensities of production in the nontraded capital good, structures. But, in addition, they depend upon the complementarity or substitutability of structures with equipment in production.

From the equations in (9a), we can immediately derive the short-run solutions for the rental rate on structures, r_s and the wage rate w, as follows:

$$r_s = r_s(p) \qquad\qquad w = w(p) \tag{9b}$$

Also, the equation for the sectoral allocation of structures (6f) allows us to express the sectoral allocation of labor (L_T) in the form:

$$L_T = \frac{S - s_N(p)}{s_T(p) - s_N(p)} \equiv L_T(p,S) \tag{9c}$$

It follows immediately from (9c) that an increase in S, with p held constant, will shift employment to the tradable from the nontraded sector if and only if that sector is relatively intensive in structures. Having obtained the sectoral allocation of labor it is straightforward to solve for both the domestic output of the two goods (Y_T, Y_N) and the stock of equipment (E) as follows:

$$Y_T = L_T(p,S) f(s_T(p), e_T(p)) \equiv Y_T(p,S) \tag{9d}$$

$$Y_N = (1 - L_T(p,S)) h(s_N(p), e_N(p)) \equiv Y_N(p,S) \tag{9e}$$

$$E = L_T(p,S) e_T(p) + (1 - L_T(p,S)) e_N(p) \equiv E(p,S) \tag{9f}$$

The partial derivatives of the functions appearing in (9b) - (9f) are provided in the Appendix.

Equations (7a) - (7c) describe the dynamics and can be solved as follows. First, substituting the solutions for $C_T, C_N, s_T, s_N, e_T, e_N, L_T$ into (7a) and (7b) leads to two equations describing the evolution of the relative price of nontraded goods (p) and the stock of structures (S). Next, substituting the solutions obtained for S and p into (7c) one can derive the evolution of the economy's current account.

3.2 Equilibrium Dynamics: Structures and Relative Prices

Performing the substitution into (7a) and (7b) and linearizing around steady-state values (denoted by tildes), the dynamics of p and S can be approximated by:

$$\begin{pmatrix} \dot{p} \\ \dot{S} \end{pmatrix} = \begin{pmatrix} a_{11} & 0 \\ a_{21} & a_{22} \end{pmatrix} \begin{pmatrix} p-\tilde{p} \\ S-\tilde{S} \end{pmatrix} \tag{10}$$

where we can establish:

$$a_{11} \equiv -\frac{dr_s(p)}{dp} + r + \delta_S = \frac{h}{s_T - s_N} + r + \delta_S$$

$$a_{21} \equiv \frac{\partial Y_N}{\partial p} - \frac{\partial C_N}{\partial p} > 0 \qquad a_{22} \equiv \frac{\partial Y_N}{\partial S} - \delta_S = \frac{dr_s}{dp} - \delta_S = \frac{h}{s_N - s_T} - \delta_S$$

From these expressions one can verify that $a_{11}a_{22} < 0$, implying that the dynamics are always a saddlepoint, having eigenvalues we shall denote by $\mu_1 < 0, \mu_2 > 0$. While the stock of structures always evolves gradually, the relative price p may jump in response to new information. In general, the stable solution is of the form

$$S = \tilde{S} + (S_0 - \tilde{S})e^{\mu_1 t} \tag{11a}$$

$$p = \tilde{p} - \left(\frac{a_{22} - \mu_1}{a_{21}}\right)(S - \tilde{S}) \tag{11b}$$

The stable eigenvalue, and therefore the nature of the dynamic evolution of the economy, depends critically upon the relative intensities of the two sectors in the nontraded investment good, structures. The two cases, $s_T > s_N$, $s_N > s_T$ will be considered in turn.

Case (i): $s_T > s_N$: Under this assumption the traded sector is intensive in structures relative to the nontraded sector. We see from the definition of the elements of the matrix in (10) that the assumption of a structure-intensive traded sector implies $\mu_1 = a_{22} < 0$ and $\mu_2 = a_{11} > 0$ so that the stable path (11a), (11b) is

$$S = \tilde{S} + (S_0 - \tilde{S})e^{a_{22}t} \tag{11a'}$$

$$p = \tilde{p} \tag{11b'}$$

In this case, the relative price of the nontraded good remains constant over time at its steady-state level.[8]

Case (ii): $s_N > s_T$: The contrary case where the nontraded sector is more intensive in structures implies a reversal of the eigenvalues, namely $\mu_1 = a_{11} < 0$ and $\mu_2 = a_{22} > 0$, so that the stable adjustment path is now given by the negatively-sloped locus

$$S(t) = \tilde{S} + (S_0 - \tilde{S})e^{a_{11}t} \tag{11a''}$$

$$p(t) = \tilde{p} - \left(\frac{a_{22} - a_{11}}{a_{21}}\right)(S(t) - \tilde{S}) \tag{11b''}$$

In this case (as we will discuss in more detail below), a shock which leaves the steady-state relative price ($\tilde{p}$) unchanged will nevertheless cause a change in the short-run relative price (p), leading to transitional change in sectoral capital intensities.

There are three key features of the dynamics of the model we wish to highlight at this juncture. The first is that the simultaneous introduction of both traded and nontraded investment goods into the dependent economy model is relatively simple. The qualitative characteristics of the dynamic paths are essentially the same as those obtained where all investment is assumed to be nontraded; see e.g. Brock (1992) and Turnovsky and Sen (1992). The second key observation is that the dynamic response of the relative price of nontraded goods depends critically upon the relative sectoral intensities of the nontraded investment good, structures. This is because p is playing the role of an asset price as well as the relative price of nontraded consumption. Finally, the speed of adjustment of the economy (μ_1) is driven by variables that dictate the rate at which the economy can produce structures. The speed of adjustment varies positively with average labor productivity in the nontraded sector, $h = H(S_N, E_N, L_N) / L_N$, since the nontraded sector produces structures. The speed of adjustment varies negatively with the absolute difference in sectoral structure intensities, $|s_T - s_N|$, since since the opportunity cost of shifting structures to the production of nontraded investment rises with the size of the gap in sectoral structure intensities.

3.3 Dynamics of Equipment

The solution (9f) for E in conjunction with (11a, 11b) enables us to determine the adjustment path followed by the stock of equipment, as structures are accumulated. This path can be expressed in linearized form about its steady-state, $\tilde{E}$, as follows:

$$E(t) = \tilde{E} + \left[\frac{\partial E}{\partial S} + \frac{\partial E}{\partial p}\left(\frac{dp}{dS}\right)_{xx}\right]\left[S(t) - \tilde{S}\right] \qquad (12)$$

where $\left(\frac{dp}{dS}\right)_{xx} = \frac{\mu_1 - a_{22}}{a_{21}}$ is the slope of the stable saddlepath. This slope is equal to zero in case (i) in Section 3.2 and is negative in case (ii). From equation (9f) we can establish that $\frac{\partial E}{\partial S} = \frac{e_T - e_N}{s_T - s_N}$.[9] In addition, we will define equipment and structures to be substitutes in production if $\frac{\partial E}{\partial S} = \frac{e_T - e_N}{s_T - s_N} < 0$ and to be complements in production if $\frac{\partial E}{\partial S} = \frac{e_T - e_N}{s_T - s_N} > 0$. Thus, in the case of the flat saddlepath, we see that an accumulating stock of structures will be accompanied by an acccumulating stock of equipment if and only if the two capital goods are complements in production. With $s_T > s_N$ this will be so if and only if $e_T > e_N$.

In case (ii), where the saddlepath is negatively sloped, the adjustment in the stock of equipment responds in addition to the decline in the relative price of nontraded goods, which now occurs along the saddlepath and is reflected in the term $\frac{\partial E}{\partial p}\left(\frac{dp}{dS}\right)_{xx}$.[10] This latter term is in general ambiguous and depends upon the sectoral intensities of the two sectors in the two types of capital. For any given set of equipment intensities, this relative price effect can be shown to be opposite in sign to the direct effect associated with the accumulation of structures, $\frac{\partial E}{\partial S}$.[11] Thus in the case where the nontraded sector is structures intensive, any pattern of comovements in the two types of capital is plausible.

3.4 The Current Account

To determine the accumulation of foreign bonds, we consider (7c) expressed in terms of p and S as follows:

$$\dot{b} = Y_T(p,S) - C_T(\lambda,p) - I_E(p,S) + rb + \tau \tag{13}$$

where $Y_T = L_T(p,S)f[s_T(p),e_T(p)]$. By linearizing (13), substituting (11a) and (11b), and invoking the transversality condition (5i), the stable adjustment of the stock of foreign assets consistent with intertemporal solvency is shown in the Appendix to be:

$$b(t) - \tilde{b} = \frac{\Omega}{\mu_1 - r}[S(t) - \tilde{S}] = \frac{\Omega}{\mu_1 - r}(S_0 - \tilde{S})e^{\mu_1 t} \tag{14}$$

with

$$b_0 - \tilde{b} = \frac{\Omega}{\mu_1 - r}(S_0 - \tilde{S})$$

where

$$\Omega \equiv \left(\frac{\partial Y_T}{\partial S} - \frac{\partial I_E}{\partial S}\right) + \left[\frac{\partial Y_T}{\partial p} - \frac{\partial C_T}{\partial p} - \frac{\partial I_E}{\partial p}\right]\left(\frac{dp}{dS}\right)_{xx}.$$

The expression Ω describes the instantaneous effect of an increase in the stock of structures on the current account. This may operate through two channels: directly, and indirectly through the relative price of nontradables.

If the tradables sector is relatively intensive in its use of structures ($s_T > s_N$), so that the relative price of nontraded goods remains fixed over time at $\tilde{p}$, only the direct effect on the current account is operative. In this case, one can show that[12]

$$\frac{\Omega}{\mu_1 - r} = -\left[\tilde{p} + \frac{\partial E}{\partial S}\right]$$

so that recalling the above expression for $\frac{\partial E}{\partial S}$ the current account is:

$$\dot{b} = -\left[\tilde{p} + \frac{e_T - e_N}{s_T - s_N}\right]\dot{S}. \tag{15}$$

Thus it is evident that the sign of the current account will depend on the complementarity of equipment and structures in production. Equation (15) indicates that if the relative intensities of equipment usage are the same across the two sectors, then the current account will solely reflect the cost of acquiring new structures, i.e., $\dot{b} = -\tilde{p}\dot{S}$. When equipment intensities differ across the two sectors, the current account response to an increase in structures will be magnified if equipment and structures are complements. The current account response will be dampened (and may be reversed in sign) if equipment and structures are substitutes in production, since the economy will sell excess equipment in exchange for bonds.

If the nontradables sector is relatively structure intensive ($s_N > s_T$), the relative price of nontraded goods will change along the saddlepath. In this case, one can derive the following expression for the current account:[13]

$$\dot{b} = -\left[p + \frac{e_T - e_N}{s_T - s_N} + \frac{\dot{p}}{\mu_1 - r} + \frac{\partial E}{\partial p}\left(\frac{dp}{dS}\right)_{xx} + \frac{1}{\mu_1 - r}\frac{\partial C}{\partial p}\left(\frac{dp}{dS}\right)_{xx}\right]\dot{S} \tag{15'}$$

In comparison with (15), equation (15') contains three additional terms, reflecting the adjustment in prices which now occurs along the transitional path. The first term, $-\frac{\dot{p}}{\mu_1 - r}$, is the capitalized value of capital losses on structures that accrue during the transition as the decline in p lowers the rental rate on structures. These capital losses must be added to the direct cost of investment in new structures when calculating the effect of the accumulation of structures on the current account. The second new term, $-\frac{\partial E}{\partial p}\left(\frac{dp}{dS}\right)_{ss}$, captures the change in the stock of equipment that accompanies the decline in the relative price of nontraded goods along the saddlepath. For any given values of equipment intensities (e_T, e_N), this term will be negative if the traded sector is equipment intensive. thereby amplifying the deterioration of the current account arising from the investment in structures. The third new term in (15') is the capitalized value of savings along the transition path toward the steady state, $-\left(\frac{1}{\mu_1 - r}\right)\left(\frac{\partial C}{\partial p}\right)\left(\frac{dp}{dS}\right)_{ss} > 0$, where $\frac{\partial C}{\partial p} \equiv \frac{\partial C_T}{\partial p} + p\frac{\partial C_N}{\partial p} < 0$. The decline in the relative price of nontradables along the saddlepath lowers consumption unambiguously and improves the current account by raising the consumption real interest rate.[14]

Equation (15') demonstrates that the current account bears no simple relationship to the rate of accumulation of structures in the economy when the nontraded sector is structures intensive. The direct effect of purchases of structures will tend to deteriorate the current account. That effect will be amplified by the accrual of capital losses on structures during the transition and will be dampened by the reduction in consumption. Further ambiguity is introduced by the fact noted above that the accumulating structures may be accompanied by an increasing or decreasing stock of equipment, depending upon the relative magnitudes of the direct effect and the relative price effect, which tend to be offsetting.

3.5 Steady-State Equilibrium

The steady-state equilibrium, reached when $\dot{p} = \dot{S} = \dot{E} = \dot{b} = 0$, implies the relationships

$$\frac{f_s(\tilde{s}_T, \tilde{e}_T)}{\tilde{p}} = h_s(\tilde{s}_N, \tilde{e}_N) = r + \delta_S \tag{16a}$$

$$(1 - \tilde{L}_T)h(\tilde{s}_N, \tilde{e}_N) - \tilde{C}_N - \delta_S \tilde{S} = 0 \tag{16b}$$

$$\tilde{L}_T f(\tilde{s}_T,\tilde{e}_T) - \tilde{C}_T - \delta_E \tilde{E} + r\tilde{b} + \tau = 0 \qquad (16c)$$

where tildes denote steady-state values. Equation (16a) asserts that the long-run values of the marginal product of structures in the two sectors must equal the long-run rental rate, which expressed in terms of the traded good is fixed at $r + \delta_S$. The second equation requires that the output of the nontraded sector equal private consumption demand plus depreciation of existing structures, while the third equation states that the long-run current account balance must be zero.

The steady-state equilibrium can be determined as follows. First, equations (6a) and (6b) determine long-run consumption levels, $\tilde{C}_T$ and $\tilde{C}_N$, as functions of the shadow value of wealth ($\overline{\lambda}$) and the relative price of nontraded goods ($\tilde{p}$). Second, equations (6d), (6e), and (16a) jointly determine the steady-state sectoral intensities of structures, $\tilde{s}_T, \tilde{s}_N$, equipment, $\tilde{e}_T, \tilde{e}_N$, and the relative price of nontraded goods, $\tilde{p}$. These equilibrium quantities are determined by production conditions alone, including foreign financial shocks insofar as they impact on r. They are independent of any disturbance impinging elsewhere in the economy, including the exogenous income flow from abroad (τ). Third, having determined the sectoral capital intensities and the relative price of nontraded goods equations (6f), (6g), (16b), and (16c), together with the intertemporal solvency condition (5i), jointly determine the equilibrium stock of structures ($\tilde{S}$), the equilibrium stock of equipment ($\tilde{E}$), the steady state labor allocation ($\tilde{L}_T$), and the constant marginal utility of wealth ($\overline{\lambda}$):

$$\tilde{S} = \tilde{L}_T \tilde{s}_T + (1 - \tilde{L}_T)\tilde{s}_N \qquad (17a)$$

$$\tilde{E} = \tilde{L}_T \tilde{e}_T + (1 - \tilde{L}_T)\tilde{e}_N \qquad (17b)$$

$$(1 - \tilde{L}_T)h(s_N(\tilde{p}), e_N(\tilde{p})) - C_N(\overline{\lambda}, \tilde{p}) - \delta_s \tilde{S} = 0 \qquad (17c)$$

$$\tilde{L}_T f(s_T(\tilde{p}), e_T(\tilde{p})) - C_T(\overline{\lambda}, \tilde{p}) - \delta_E \tilde{E} + r\left[b_0 - \frac{\Omega}{\mu_1 - r}(S_0 - \tilde{S})\right] + \tau = 0 \qquad (17d)$$

From the equilibrium quantities determined by (17a) - (17d), the equilibrium stock of bonds, consumption, and sectoral outputs can be derived.

Two further points should be noted. First, from (17d) it is clear that the steady state-equilibrium depends upon the initial stocks of structures, S_0, and traded bonds, b_0. This dependence upon initial conditions is a consequence of the assumption $\beta = r$ and raises the potential for temporary shocks to have permanent effects; see Sen and Turnovsky (1990). Second, the expression Ω, which describes the relationship between the accumulation of structures and the stock of traded bonds, depends upon the relative sectoral intensities of the two types of capital.

4. PERMANENT INCREASE IN FOREIGN TRANSFERS

To illustrate the behavior of the model, we shall consider one of the oldest and most important problems in the literature on the balance of payments, *viz.*, the adjustment of an economy to a foreign transfer.[15] Specifically, we shall analyze the adjustment of the dependent economy to a permanent increase in the flow of transfer income (τ).

The long-run effects of an increase in transfers are reported in the Appendix and can be summarized as follows. As already noted, the long-run sectoral intensities of structures ($\tilde{s}_T$, $\tilde{s}_N$,) and equipment ($\tilde{e}_T, \tilde{e}_N$), and the relative price of nontraded goods ($\tilde{p}$) all remain unchanged. An increase in transfers (τ) raises the long-run wealth of the economy, lowering its shadow value ($\bar{\lambda}$). With the relative price remaining constant, and both goods being normal, the long-run consumption of both traded and nontraded goods must rise. In particular, the increase in demand for nontraded consumption requires the output of the nontraded good to rise; this rise is accomplished by attracting labor from the traded sector, whose output therefore declines. With the sectoral intensities of the two types of capital remaining unchanged, the effect of the increase in the flow of transfer income on the two types of capital depends upon whether labor is moving from a relatively less to a relatively more intensive sector in that type of capital. Specifically, an increase in τ will raise the long-run stock of structures ($\tilde{S}$) if and only if the nontraded sector is relatively intensive in its use of structures

$(s_N > s_T)$. Likewise, an increase in transfer income will raise the long-run stock of equipment $\tilde{E}$ (imported from abroad) if and only if the nontraded sector is relatively equipment intensive $(e_N > e_T)$. What happens to the long-run stock of foreign bonds depends upon the response of the long-run stock of structures and how this response translates into the accumulation of assets, as described by Ω.

The dynamic adjustment paths are illustrated in Figs. 1 and 2 and depend critically upon the relative intensities of the two sectors in the non-traded investment good, structures. Consider first the case where the traded sector is relatively structures intensive ($s_T > s_N$). An increase in τ will lead to a gradual decline in the stock of structures. With the long-run relative price remaining unchanged, and with no transitional adjustment, p remains fixed throughout the transition. The adjustment path for S and p is therefore depicted by the horizontal locus AP in the middle panel of Fig. 1. Moreover, the constancy of p along this path implies that sectoral structures and equipment intensities must also remain fixed throughout the transition. The corresponding adjustment in the stock of equipment is illustrated in the upper panel. In the absence of any instantaneous jump in the relative price p, the adjustment of labor occurs gradually, as resources are attracted to the nontraded sector. Whether or not this gradual adjustment in labor towards the nontraded sector leads to an increasing or decreasing stock of equipment depends upon the long-run response of $\tilde{E}$, as determined by the relative sectoral intensities $e_T - e_N$. Alternative adjustment paths for the stock of equipment are illustrated in the upper panel corresponding to the two cases where equipment and structures are substitutes and complements, respectively, in production. In the former case, $(e_T < e_N)$, equipment accumulates along the negatively sloped path RS; in the latter case $(e_T > e_N)$, the stock of equipment declines with structures along the positively sloped line RS'. Alternative time paths for the corresponding accumulation of bonds are presented in the lower panel. From (15) we see that -- provided equipment and structures are complements or at most weak substitutes, so that $\Omega > 0$ — the decline in structures will be accompanied by a current account surplus and bonds will accumulate along the negatively sloped locus LM. While we view this as the more likely scenario, the alternative case of an accompanying current account deficit is also illustrated by the positively sloped locus LM'.

Suppose now that the relative structural intensities of the two sectors are reversed ($s_N > s_T$.). In this case, the decline in $\bar{\lambda}$, resulting from the increase in τ, generates an instantaneous increase in the demand for both consumption goods. In particular, with the stock of nontraded goods being fixed instantaneously, this will tend to raise their relative price, so that $p(0)$ will immediately rise. The increase in $p(0)$ causes an immediate shifting of resources away from the traded to the nontraded sector. With $s_N > s_T$, structures increase in relative scarcity, the ratio of the wage rate to the rental rate on structures tends to fall, and firms substitute labor for structures. While the structures-labor ratio falls in the traded sector, its net response in the nontraded sector depends to some degree upon whether equipment is a complement or a substitute for structures in the production of nontradables. Under plausible conditions, one would expect s_N to decline as well, but the opposite cannot be ruled out. The rise in the relative price of nontradables tends to cause an immediate shift of labor to the nontraded sector. Output of that sector immediately increases and then the rate of nontraded investment begins to rise. Along the adjustment path, the stock of structures increases steadily, while the relative price of nontradables gradually returns to its initial equilibrium level. This type of adjustment takes place because the shift of resources to the nontradable sector resulting from the higher price raises the marginal physical product of structures in that sector, requiring a continuous decline in $\dot{p}$ in order for the rates of return on the assets to be equalized. The adjustment in p and S is illustrated in Fig. 2 by the initial jump in AE followed by the continuous adjustment along the saddlepath EQ. Because of the wider range of potential adjustments in E and b which are now possible, time paths for these variables are not illustrated. We should note, however, that the initial jump in $p(0)$ which now occurs will lead to an initial jump in the stock of equipment, with the direction of this jump depending upon the sectoral intensities of the two sectors in the two types of capital.

5. WELFARE EFFECTS

Thus far we have described the economy's adjustment to an increase in the flow of transfer income from abroad. What is of ultimate concern is the impact on economic welfare. In considering this aspect, the criterion will be taken to be the welfare of the representative agent and we will consider both the time path of the level of instantaneous utility and the overall accumulated welfare over the agent's infinite planning horizon.

The instantaneous level of utility of the representative agent at time t, $Z(t)$, is specified to be

$$Z(t) = U(C_T(t), C_N(t)) \tag{18}$$

with the overall level of utility over the agent's infinite planning horizon being the discounted value of (18):

$$W = \int_o^\infty U(C_T, C_N) e^{-rt} dt = \int_o^\infty Z(t) e^{-rt} dt \tag{19}$$

where, as before, the agent's discount rate β is assumed to equal the world interest rate r. The effects of τ on $Z(t)$ and W will be analyzed when C_T and C_N follow the paths described by (8a), (8b) and S and p evolve in accordance with (11a) and (11b). The cases where $s_T > s_N$ and $s_N > s_T$ will be treated separately.

A. Traded Sector Relatively Intensive in Structures

This case is very straightforward. As noted previously, consumption of both goods is always at its steady-state level, and therefore constant over time. Thus

$$Z(t) = \tilde{Z} = U(\tilde{C}_T, \tilde{C}_N) \qquad \text{for all } t$$

implying that

$$W = \frac{U(\tilde{C}_T, \tilde{C}_N)}{r}. \tag{20}$$

Since an increase in the transfer of income from abroad raises steady-state consumption of both goods, it follows immediately that welfare improves uniformly at all points of time.

B. Nontraded Sector Relatively Intensive in Structures

Writing

$$Z(t) = U(C_T(\bar{\lambda}, p(t)), C_N(\bar{\lambda}, p(t))) \tag{21}$$

we see that $Z(t)$ changes over time, as p evolves along its transitional path. Differentiating (21), the following impacts on instantaneous welfare can be derived:

$$\frac{dZ(0)}{d\tau} = \bar{\lambda}\left[\frac{\partial C_T}{\partial \bar{\lambda}} + p\frac{\partial C_N}{\partial \bar{\lambda}}\right]\frac{\partial \bar{\lambda}}{\partial \tau} + \bar{\lambda}\left[\frac{\partial C_T}{\partial p} + p\frac{\partial C_N}{\partial p}\right]\frac{\partial p(0)}{\partial \tau} \tag{22a}$$

$$\dot{Z}(t) = \bar{\lambda}\left[\frac{\partial C_T}{\partial p} + p\frac{\partial C_N}{\partial p}\right]\dot{p}(t) > 0 \tag{22b}$$

$$\frac{d\tilde{Z}}{d\tau} = \bar{\lambda}\left[\frac{\partial C_T}{\partial \bar{\lambda}} + p\frac{\partial C_N}{\partial \bar{\lambda}}\right]\frac{\partial \bar{\lambda}}{\partial \tau} > 0 \tag{22c}$$

where $\frac{\partial C_T}{\partial p} + p\frac{\partial C_N}{\partial p} = \bar{\lambda}\frac{\partial C_N}{\partial \bar{\lambda}} < 0.$

In the short run, an increase in the rate of income flow from abroad has two effects on the level of instantaneous welfare, $Z(0)$. The first is a positive wealth effect, which is permanent and raises the level of consumption of both goods, and is therefore welfare improving. However, the positive wealth effect is offset by an expenditure reduction effect, given by the second term in (22a). The initial increase in the relative price $p(0)$ induces more saving and less total consumption, thereby deteriorating welfare. On balance, without imposing further restrictions, one cannot say unambiguously which effect will dominate.[16] With the wealth effect constant over time, instantaneous welfare $Z(t)$ rises over time as the price of nontraded good declines to its initial level, and the expenditure reduction effect is mitigated. In steady state, only the positive wealth effect prevails, and steady-state utility increases unambiguously.

A linear approximation to the overall level of welfare, represented by equation (19) can be obtained by observing that along the equilibrium path $Z(t)$ can be approximated by

$$Z(t) \approx \tilde{Z} + (Z(0) - \tilde{Z})e^{\mu_1 t} \tag{23}$$

Substitution of (23) into (21), and integrating, yields

$$W \approx \frac{\tilde{Z}}{r} + \frac{Z(0) - \tilde{Z}}{r - \mu_1} \tag{24}$$

The first term of (24) is the capitalized value of instantaneous welfare, $Z(t)$, evaluated at the steady state. It is the level of welfare which would obtain if the steady state were attained instantaneously. The remaining term reflects the adjustment to this, due to fact that the steady state is reached only gradually along the transitional path. Differentiating (24) with respect to τ yields:

$$\frac{dW}{d\tau} = \frac{1}{r - \mu_1}\left(\frac{dZ(0)}{d\tau} - \frac{\mu_1}{r}\frac{d\tilde{Z}}{d\tau}\right) \tag{25}$$

Substituting from (22a), (22c), and with some manipulation, one can establish that $dW/d\tau > 0$, unambiguously. Thus, we conclude that even though an increase in transfer income from abroad may have a temporarily adverse effect on domestic utility, overall it will be welfare improving, as one would expect.

6. LONG-RUN RELATIVE PRICE ADJUSTMENT

Our objective in this paper has been primarily to integrate both nontraded and traded investment goods into the dynamic dependent economy model, and to show how the resulting system is both tractable and intuitive. To illustrate the behavior of this system, we have chosen a relatively simple shock to analyze -- namely the impact of a foreign transfer -- though we hasten to add that this is an important shock, having a long history in balance of payments analysis. From an analytical viewpoint, the significant feature of this disturbance is that it generates no long-run adjustment in the relative price of nontraded to traded goods, though there may be some short-run transitional price adjustment, depending upon the relative intensities of the nontraded and traded sectors in nontraded capital (structures). Furthermore, the relative traded capital (equipment) intensity of the two sectors plays no role in any transitional price adjustment which may occur; the relative intensity is, however, important in determining the evolution of the current account.

This limited role played by relative price adjustment applies with respect to any disturbance which does not impact directly on production decisions. The dynamics that we have been discussing would therefore characterize other disturbances, such as a change in tastes, or in government expenditure policy. This is a consequence of the recursive structure of the steady-state equilibrium, outlined in Section 3.4. As noted in that discussion, the long-run relative price, $\tilde{p}$, and sectoral capital intensities, $\tilde{s}_T, \tilde{s}_N, \tilde{e}_T, \tilde{e}_N$, are all determined by production conditions alone. They will therefore respond to any shocks which impinge on production decisions, such as: (i) differential tax and incentive treatments associated with different types of investment; (ii) productivity shocks; (iii) foreign financial shocks; (iv) a change in the relative price of equipment to traded consumption. In particular, there is growing interest in studying the differential impact of taxes and subsidies on investment in equipment and structures; see e.g. Auerbach and Hines (1987). Most of the work in this area is being carried out in the context of a closed economy and the framework developed in this paper is a natural one for addressing the international ramifications of this important policy issue.

Space limitations preclude a detailed analysis of these types of shocks, since any long-run change in the relative price of nontraded capital increases the possible range of outcomes for both the accumulation of structures and the behavior of the current account, relative to the corresponding outcomes associated with a transfer. But to illustrate the important role played by the long-run relative price adjustment to such shocks, we briefly discuss the case of an increase in the relative price of equipment to traded consumption, a relative price that De Long and Summers (1991) find to be empirically important in explaining economic growth. Denoting this price (which previously was normalized at unity) by p_E, one can establish that[17]

$$\frac{\partial \tilde{p}}{\partial p_E} = \frac{\dfrac{\partial E}{\partial S}}{\dfrac{\partial r_s}{\partial p} - r - \delta_S} = \frac{\dfrac{e_T - e_N}{s_T - s_N}}{\dfrac{\partial r_s}{\partial p} - r - \delta_S} \tag{26}$$

where from (10) $\dfrac{\partial r_s}{\partial p} - r - \delta_S = \mu_1 - r < 0$ if the traded sector is structures intensive $(s_T > s_N)$, and $\dfrac{\partial r_s}{\partial p} - r - \delta_S = -\mu_1 > 0$ if the sectoral intensities in structures are reversed. Table 1 summarizes the possible configuration of the long-run responses of the relative price of nontraded capital to traded consumption in terms of: (i) the intensities of the two sectors in structures; and (ii) the complementarity and substitutability of the two types of capital in production.

A consequence of the long-run adjustment in $\tilde{p}$ and in the corresponding sectoral intensities $\tilde{s}_T, \tilde{s}_N, \tilde{e}_T, \tilde{e}_N$ is that a change in the relative price p_E impacts on the remainder of the steady state in three ways. First there is a wealth effect, analogous to the effect of the change in τ. In addition, there will be two other effects; a relative price effect resulting from the change in the long-run relative price $\tilde{p}$, and a further effect stemming from the accompanying changes in the sectoral capital intensities. These all impact on the long-run stock of structures in ways which are not straightforward and will themselves depend upon existing sectoral capital intensities. Given the various potential responses in $\tilde{p}$ noted in Table 1, it is evident that in the long run, $\tilde{S}$ and $\tilde{p}$ may both rise together, fall together, or move in opposite directions.

But despite the potential ambiguities in these long-run responses, the transitional dynamics remain essentially as discussed previously and as illustrated in Figs. 1 and 2. Specifically, whether or not the relative price adjusts instantaneously to its new long-run equilibrium -- irrespective of whether this adjustment involves a rise or a fall -- depends solely upon the relative intensities of the two sectors in structures, just as it did before. If the traded sector is structures intensive, the adjustment is instantaneous; if the relative intensities are reversed there will be an initial jump in the relative price, followed by a transitional adjustment to its new equilibrium.

7. CONCLUSION

Dependent economy models since Salter (1959) have developed a parsimonious theory of current account determination and relative price adjustment for economies that are price takers in world goods and asset markets. Our model resolves a long-standing obstacle in the development and use of the dependent economy model with investment. This obstacle dates back at least to Bruno's (1976) formulation, but not solution, of the model that we have analyzed in this paper. Since Bruno's paper, models of the dependent economy with investment have been criticized for arbitrarily assuming that capital is either tradable or nontradable, and for choosing either the traded or nontraded sector to be capital intensive.

In this paper, we have shown that it is the relative sectoral intensity of structures (i.e., nontraded capital) that matters for the dynamic adjustment of the relative price of nontradables. When the traded sector is structure intensive, the saddlepath is flat (at the long-run value of the relative price of nontradables). When the nontraded sector is structure intensive, the saddlepath is negatively sloped. The relative sectoral intensity of equipment (i.e., traded capital) primarily affects the adjustment of the current account. In particular, when equipment is a complement to structures in production, equipment investment magnifies the current account response generated by investment in structures.

The presence of investment creates an allocative role for the relative price of nontraded goods in addition to that found in the standard dependent economy model without capital, where the relative price of nontraded goods is simply the relative price of nontraded consumption to traded consumption. In our model the relative price of structures is the same as the relative price of the nontraded consumption good. The price of structures is a forward-looking asset price satisfying an intertemporal arbitrage condition (equation 7a), implying that the relative price of nontradables can be interpreted as a consumption-based asset price. The forward-looking behavior of the relative price of nontradables reflects the interaction between the consumption-smoothing desires of a utility-maximizing representative agent and the economy's technological constraints governing capital accumulation.

The dependent economy model, in its progression from verbal to static algebraic to dynamic algebraic form, has evolved as the result of successive attempts to analyze the structural adjustment of small open economies to aggregate disturbances.[18] Earlier analytical work on the dependent economy model has generated an interest in the collection and creation of data for empirical studies. The widespread use of real exchange rates as empirical proxies for the relative price of nontraded goods (see, e.g., Edwards 1989), and the concern for internal and external balance in macroeconomic adjustment programs by international lending agencies substantiate Krueger's (1969, p. 10) assessment that, "the home goods-traded goods relationship is...considered by some to be the most promising approach to payments analysis." We think that the dependent economy model with investment in equipment and structures extends existing models in a way that should aid policy analysis and spur new empirical work.

Table 1. The Long-Run Response of the Relative Price of Nontradables to an Increase in the Relative Price of Equipment

	Traded Sector is Structure Intensive $[(s_T - s_N) > 0]$	Nontraded Sector is Structure Intensive $[(s_T - s_N) < 0]$
Equipment and Structures are Complements $(\frac{\partial E}{\partial S} > 0)$	$\frac{\partial \tilde{p}}{\partial p_E} < 0$	$\frac{\partial \tilde{p}}{\partial p_E} > 0$
Equipment and Structures are Substitutes $(\frac{\partial E}{\partial S} < 0)$	$\frac{\partial \tilde{p}}{\partial p_E} > 0$	$\frac{\partial \tilde{p}}{\partial p_E} < 0$

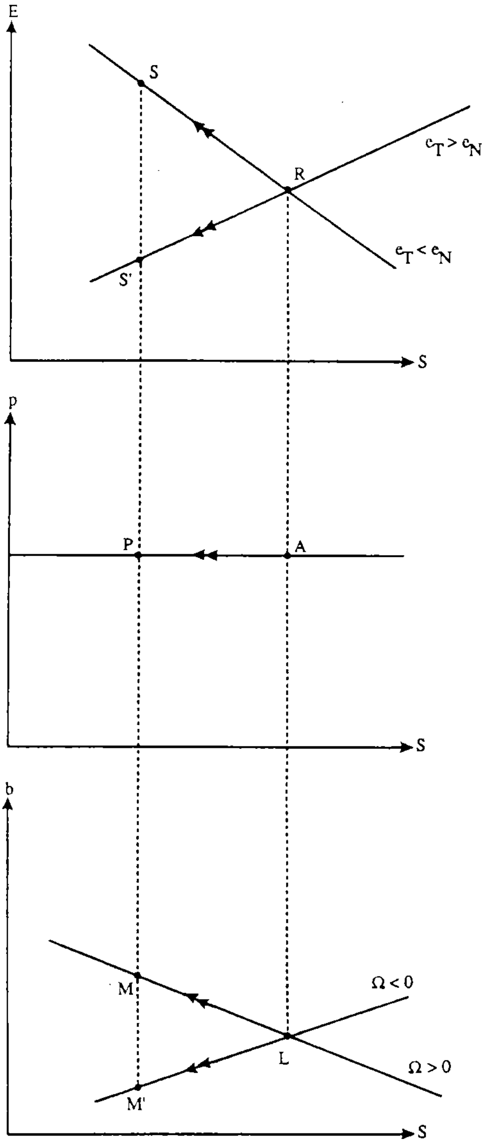

FIGURE 1

Adjustment of Economy to an Increase in τ:

$s_T > s_N$

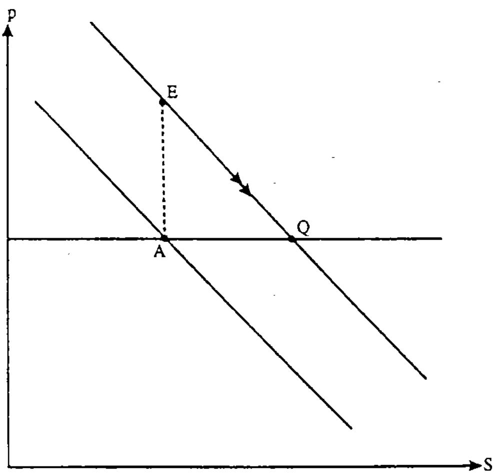

FIGURE 2

Adjustment of Relative Price and Structures to an Increase in τ:

$s_N > s_T$

FOOTNOTES

1. Cairnes (1859) analyzed the changes in the structure of Australian production, volume of trade, and the relative price of home goods following the discovery of gold in 1852. Graham (1922) employed data from the U.S. greenback period to test empirically Taussig's (1917) theory of relative price changes under a floating exchange rate regime. Taussig (1920) and Ohlin (1929) independently analyzed the role of nontraded goods in the macroeconomic adjustment process put into motion by the payment of war reparations by Germany after World War I.

2. Although not Australian, Pearce and McDougall published their research while at the Australian National University. Oppenheimer (1974) has drawn attention to Meade's analysis of home goods (1951, Chapter 26), while at the same time pointing out that Meade did not consider the case of a price-taking economy on world markets and did not incorporate the income-expenditure link utilized by Salter (1959). Meade's (1956) verbal analysis, which credited its ideas "to many conversations with many economists in Australia," advocated expenditure reduction in combination with adjustment to the relative price of home goods as one way of correcting Australia's balance of payments problem. See Dornbusch (1980) for references to three analyses of nontraded goods published in the 1930s.

3. Salter (1959, p. 226) wrote, "[w]hatever may be the case in economies playing a major role in world trade, in a dependent economy such as Australia no great damage is done if secondary terms of trade effects are neglected." Following Salter, Swan (1960) used "dependent economy" in the title of his paper. Dornbusch (1974, 1980), in his extensions to the Salter-Swan model, also used the term "dependent economy." The "Scandinavian" version of the dependent economy model is one in which labor is the only factor of production and fixed coefficients production functions are used (see Dornbusch 1980). In this paper, we will refer to any model that includes a nontraded sector and exogenously-given world prices as a variant of the "dependent economy model."

4. With regard to Bruno (1982), Svensson (1982, p. 225) pointed out that, "Another necessary assumption for the simple investment theory and the given long-run price of nontraded

goods [in Bruno's model] is that investment consists of traded goods only." Models with traded investment and traded installation costs, such as Bruno and Sachs (1982), are a variant of the class of models with traded investment.

5. Fischer and Frenkel (1972, p. 213) wrote, "...it is usually assumed that there is no trade in capital goods and that additions to the capital stock consist only of domestic output of investment goods. This assumption has little but convenience to recommend it...."

6. Referring to a paper by Neary and Purvis (1982) that assumed a labor-intensive nontraded sector, Flemming (1982, p. 256) wrote, "The least acceptable restriction [of the model] is the exclusion of capital from any role in the production of nontradeable services. These include extremely capital-intensive public utilities (electricity generation and transport) as well as housing, so that empirically it is quite probable that the tradeable goods sector is *less* capital intensive [italics in the original]." In a comment on Bruno's (1982) model, Svensson (1982, p. 225) emphasized "the two crucial assumptions that traded goods production is oil dependent and that nontraded goods are relatively capital intensive. It is obvious that some of the effects mentioned above [in the paper] may change signs if either of these assumptions is changed."

7. Bruno (1976, p. 575) appeared to have considered the model unsolvable algebraically, stating that "[f]ull analytical characterizations for general models are hard to obtain." Our own specification of the model grew out of recent work on the dependent economy model in which we examined various assumptions regarding investment, factor intensities, and factor complementarities without providing a single framework for the analysis. See Turnovsky and Sen (1992) and Brock (1992).

8. The fact that in the case where $s_T > s_N$, p remains unchanged during the transition can be seen by considering the arbitrage relationship (7a) in the form

$$\frac{\dot{p}}{p} + h_s(s_N, e_N) = r + \delta_s$$

Suppose that instead of remaining fixed over time, p were increasing. One can show that the net effect of this is to reduce the marginal physical product of structures in the nontraded sector. In order to ensure that the rate of return on structures in that sector equals the exogenously given return on traded bonds, this requires $\dot{p} > 0$, that is, a further increase in p, and this is clearly an unstable path. The same applies if p is decreasing over time. An unchanging relative price is the only stable possibility. By contrast, if $s_N > s_T$, an increasing p is associated with $\dot{p} < 0$, and this is clearly a stable adjustment process.

9. More specifically, the expression for $\partial E / \partial S$ is obtained by combining (A.4a) and (A.7a) of the Appendix.

10. Following (9f), the stock of equipment can be written as $E = L_T e_T(p) + (1 - L_T)e_N(p)$, so that $\frac{\partial E}{\partial p} = (e_T - e_N)\frac{\partial L_T}{\partial p} + L_T\frac{de_T}{dp} + (1 - L_T)\frac{de_N}{dp}$. The expression for $\partial E / \partial p$ is obtained by utilizing expressions (A.2a), (A.2b), (A.4b) of the Appendix. For any given equipment intensities, the sign of $\frac{\partial E}{\partial p}$ will depend on the relative equipment intensities.

11. To see this, for given equipment intensities, footnote 10 implies $\frac{\partial E}{\partial p} = (e_T - e_N)\frac{\partial L_T}{\partial p}$, which combined with (A.4) of the Appendix can be seen to be of opposite sign to $\frac{\partial E}{\partial S}$.

12. In this case, $\frac{\Omega}{\mu_1 - r} = \frac{\frac{\partial Y_T}{\partial S} - \frac{\partial I_E}{\partial S}}{\mu_1 - r}$. By noting that:

(i) $\frac{\partial Y_T}{\partial S} = -p\frac{\partial Y_N}{\partial S} + r_s + (r + \delta_E)\frac{\partial S}{\partial E}$, see equations (5c)-(5e), (5g), (5h), (A.4a)-(A.7a);

(ii) $r_s = (r + \delta_S)p$ along the flat saddlepath, see (5g); (iii) $\frac{\partial I_E}{\partial S} = \frac{\partial E}{\partial S}\left(\frac{\partial Y_N}{\partial S} - \delta_S + \delta_E\right)$, see (1b), (7b), (9f); and (iv) $\mu_1 = \frac{\partial Y_N}{\partial S} - \delta_S$, it is straightforward to derive the expression in the text.

13. By noting that $\frac{\partial Y_N}{\partial S} = \frac{\partial I_S}{\partial S}$ and that $\frac{\partial Y_N}{\partial p} = \frac{\partial C_N}{\partial p} + \frac{\partial I_S}{\partial p}$ -- see (1a) and (7b) -- one can write the current account as follows:

$$\dot{b} = \frac{1}{\mu_1 - r}\left[\frac{\partial Y_T}{\partial S} + p\frac{\partial Y_N}{\partial S} - \frac{\partial I_E}{\partial S} - p\frac{\partial I_S}{\partial S} + \left(\frac{\partial Y_T}{\partial p} + p\frac{\partial Y_N}{\partial p} - \frac{\partial C_T}{\partial p} - p\frac{\partial C_N}{\partial p} - \frac{\partial I_E}{\partial p} - p\frac{\partial I_S}{\partial p}\right)\left(\frac{dp}{dS}\right)_{xx}\right]\dot{S}$$

It is straightforward to derive the current account expression given in equation (15') by inserting and slightly rearranging the following relationships (obtained from the short-run solutions provided in the Appendix) into the above expression for the current account and using (5c -(5e):

$$\frac{\partial Y_T}{\partial S}+p\frac{\partial Y_N}{\partial S}=r_s+(r+\delta_E)\frac{\partial E}{\partial S};\qquad \left(\frac{\partial Y_T}{\partial p}+p\frac{\partial Y_N}{\partial p}\right)=(r+\delta_E)\frac{\partial E}{\partial p};$$

$$\frac{\partial I_E}{\partial S}+\frac{\partial I_E}{\partial p}\left(\frac{dp}{dS}\right)_{xx}=(\mu_1+\delta_E)\left(\frac{\partial E}{\partial S}+\frac{\partial E}{\partial p}\left(\frac{dp}{dS}\right)_{xx}\right);\quad \frac{\partial I_S}{\partial S}+\frac{\partial I_S}{\partial p}\left(\frac{dp}{dS}\right)_{xx}=\mu_1+\delta_S.$$

14. See Dornbusch (1983) for a more detailed discussion of this effect in a model without capital.

15. Regarding the paradigmatic nature of the transfer problem for balance of payments analysis, Harry Johnson (1958) wrote, "any actual balance-of-payments disequilibrium involves a transfer in some form from the surplus to the deficit country (or countries), and the problem of rectifying the disequilibrium can be framed as the problem of creating a transfer of equal amount in the opposite direction." (cited by Oppenheimer 1974, p. 883).

16. This will depend upon the relative magnitudes of the adjustments in $\overline{\lambda}$ and $p(0)$. A sufficient condition for the former to prevail, and for the increase in τ to be unambiguously welfare-improving in the short run is that

$$\frac{\partial Y_N}{\partial p}\frac{p}{Y_N}+\frac{\partial C_N}{\partial \overline{\lambda}}\frac{\overline{\lambda}}{C_N}>0$$

This condition suffices to ensure that the price elasticity of supply of the nontraded good is sufficiently large to moderate the price rise in that good, thereby ensuring that the positive wealth effect dominates.

17. To establish (25), we must first introduce p_E into the basic equilibrium conditions (5), in which case $r_s=r_s(p,p_E)$. Having amended the model in this way, (25) is obtained by using essentially the same procedures as followed in the text in analyzing τ.

18. The most recent demonstration of the link between research on the dependent economy model and observable rapid structural change is the important set of models published in the 1980s on the macroeconomic adjustment of an economy to a resource discovery. See Neary and van

Wijnbergen (1986) and Corden (1985) for surveys of this literature. Bevan, Collier and Gunning (1990) and van Wincoop (1992) are more recent models that examine the role of nontraded goods in the macroeconomic adjustment to a resource boom.

APPENDIX

1. Properties of Short-Run Solutions (8), (9)

(i) Consumption: Taking the differentials of (6a), (6b), yields:

$$\begin{pmatrix} U_{TT} & U_{TN} \\ U_{NT} & U_{NN} \end{pmatrix}\begin{pmatrix} dC_T \\ dC_N \end{pmatrix} = \begin{pmatrix} d\bar{\lambda} \\ pd\bar{\lambda} + \bar{\lambda}dp \end{pmatrix}$$

leading to the following partial derivatives:

$$\frac{\partial C_T}{\partial \bar{\lambda}} = \frac{1}{D}\left[U_{NN} - pU_{TN}\right] < 0; \qquad \frac{\partial C_T}{\partial p} = -\frac{\bar{\lambda}}{D}U_{TN} > 0 \tag{A.1a}$$

$$\frac{\partial C_N}{\partial \bar{\lambda}} = \frac{1}{D}\left[pU_{TT} - U_{NT}\right] < 0; \qquad \frac{\partial C_N}{\partial p} = \frac{\bar{\lambda}}{D}U_{TT} < 0 \tag{A.1b}$$

where $D \equiv U_{TT}U_{NN} - U_{TN}^2 > 0.$

(ii) Production: Next, differentiating the production block (6c) - (6e), we obtain

$$\begin{pmatrix} f_{ss} & f_{se} & -ph_{ss} & -ph_{se} \\ f_{es} & f_{ee} & 0 & 0 \\ 0 & 0 & ph_{es} & ph_{ee} \\ \begin{bmatrix} -s_T f_{ss} \\ -e_T f_{es} \end{bmatrix} & \begin{bmatrix} -s_T f_{se} \\ -e_T f_{ee} \end{bmatrix} & \begin{bmatrix} ps_N h_{ss} \\ +pe_N h_{es} \end{bmatrix} & \begin{bmatrix} ps_N h_{se} \\ +pe_N h_{ee} \end{bmatrix} \end{pmatrix}\begin{pmatrix} ds_T \\ de_T \\ ds_N \\ de_N \end{pmatrix} = \begin{pmatrix} h_s dp \\ 0 \\ h_e dp \\ \left[h - s_N h_s - e_N h_e\right]dp \end{pmatrix}$$

from which the following derivatives are derived:

$$\frac{ds_T}{dp} = -\frac{hf_{ee}}{F(s_T - s_N)}; \qquad \frac{de_T}{dp} = \frac{hf_{es}}{F(s_T - s_N)} \tag{A.2a}$$

$$\frac{ds_N}{dp} = \frac{1}{pH(s_T - s_N)}\left(-\left[h - (s_N - s_T)h_s\right]h_{ee} - (s_N - s_T)h_{se}h_e\right)$$

$$\frac{de_N}{dp} = \frac{1}{pH(s_T - s_N)}\left(\left[h - (s_N - s_T)h_s\right]h_{es} + (s_N - s_T)h_{ss}h_e\right) \tag{A.2b}$$

where: $F \equiv f_{ss}f_{ee} - f_{es}^2 > 0$, and $H \equiv h_{ss}h_{ee} - h_{es}^2 > 0$.

(iii) Rentals and Wages: The short-run effects of p on r_t and w are:

$$\frac{dr_t}{dp} = f_{ss}\frac{ds_T}{dp} + f_{se}\frac{de_T}{sp} = \frac{h}{s_N - s_T} \tag{A.3a}$$

$$\frac{dw}{dp} = \frac{s_T}{s_T - s_N} \tag{A.3b}$$

(iv) Sectoral Labor Allocations: The short-run effects on sectoral labor allocations are:

$$\frac{\partial L_T}{\partial S} = \frac{1}{s_T - s_N} \tag{A.4a}$$

$$\frac{\partial L_T}{\partial p} = -\frac{1}{s_T - s_N}\left(L_T\frac{ds_T}{dp} + (1 - L_T)\frac{ds_N}{dp}\right) \tag{A.4b}$$

where $\frac{ds_T}{dp}, \frac{ds_N}{dp}$ are obtained from (2a), (2b), respectively.

(v) Output and Equipment: The short-run effects on output and equipment are:

$$\frac{\partial Y_T}{\partial S} = f\frac{\partial L_T}{\partial S} = \frac{f}{s_T - s_N} \tag{A.5a}$$

$$\frac{\partial Y_T}{\partial p} = f\frac{\partial L_T}{\partial p} + L_T\left(f_s\frac{ds_T}{dp} + f_e\frac{de_T}{dp}\right) \tag{A.5b}$$

$$\frac{\partial Y_N}{\partial S} = -h\frac{\partial L_T}{\partial S} = -\frac{h}{s_T - s_N} \tag{A.6a}$$

$$\frac{\partial Y_N}{\partial p} = -h\frac{\partial L_T}{\partial p} + (1-L_T)\left(h_s\frac{ds_N}{dp} + h_e\frac{de_N}{dp}\right) \tag{A.6b}$$

$$\frac{\partial E}{\partial S} = (e_T - e_N)\frac{\partial L_T}{\partial S} \tag{A.7a}$$

$$\frac{\partial E}{\partial p} = (e_T - e_N)\frac{\partial L_T}{\partial p} + L_T\frac{de_T}{dp} + (1-L_T)\frac{de_N}{dp} \tag{A.7b}$$

2. Derivation of Current Account

Writing equation (12) as:

$$\dot{b} = Y_T(p,S) - C_T(\overline{\lambda},p) - I_E(p,S) - rb + \tau$$

and linearizing around the steady state, denoted by tildes, we obtain:

$$\dot{b} = \left(\frac{\partial Y_T}{\partial p} - \frac{\partial C_T}{\partial p} - \frac{\partial I_E}{\partial p}\right)(p-\tilde{p}) + \left(\frac{\partial Y_T}{\partial S} - \frac{\partial I_E}{\partial S}\right)(S-\tilde{S}) + r(b-\tilde{b}) \tag{A.8}$$

Substituting for (11a), and (11b) yields

$$\dot{b} = \left[\left(\frac{\partial Y_T}{\partial p} - \frac{\partial C_T}{\partial p} - \frac{\partial I_E}{\partial p}\right)\left(\frac{\mu_1 - a_{22}}{a_{21}}\right) + \left(\frac{\partial Y_T}{\partial S} - \frac{\partial I_E}{\partial S}\right)\right](S_o - \tilde{S})e^{\mu_1 t} + r(b-\tilde{b}) \tag{A.9}$$

which we write in the more compact form as:

$$\dot{b} = \Omega(S_o - \tilde{S})e^{\mu_1 t} + r(b-\tilde{b}) \tag{A.10}$$

The solution to (A.10), starting from an initial stock of bonds $b(o) = b_o$ is

$$b = \tilde{b} + \frac{\Omega}{\mu_1 - r}(S_o - \tilde{S})e^{\mu_1 t} + \left[b_o - \tilde{b} - \frac{\Omega}{\mu_1 - r}(S_o - \tilde{S})\right]e^{rt} \tag{A.11}$$

In order for the economy to satisfy the intertemporal solvency condition

$$\lim_{t \to \infty} be^{-rt} = 0$$

(A.11) implies that the following relationships must hold:

$$b(t) = \tilde{b} + \frac{\Omega}{\mu_1 - r}(S(t) - \tilde{S}) = \frac{\Omega}{\mu_1 - r}(S_o - \tilde{S})e^{\mu_1 t} \tag{A.12a}$$

$$b_o - \tilde{b} = \frac{\Omega}{\mu_1 - r}(S_o - \tilde{S}) \tag{A.12b}$$

3. Long-run Effects of Permanent Increse in Flow of Transfers

As noted in the text, the steady-state equilibrium values $\tilde{s}_T, \tilde{s}_N, \tilde{e}_T, \tilde{e}_N$ and $\tilde{p}$ are all independent of τ. Taking the differential of (17a) - (17d) yields:

$$\begin{pmatrix} 1 & 0 & 0 & (s_N - s_T) \\ 0 & 1 & 0 & (e_N - e_T) \\ -\delta_S & 0 & -\frac{\partial C_N}{\partial \bar{\lambda}} & -h \\ \frac{r}{\mu_1 - r}\Omega & -\delta_E & -\frac{\partial C_T}{\partial \bar{\lambda}} & f \end{pmatrix} \begin{pmatrix} d\tilde{S} \\ d\tilde{E} \\ d\bar{\lambda} \\ d\tilde{L}_T \end{pmatrix} = \begin{pmatrix} 0 \\ 0 \\ 0 \\ -d\tau \end{pmatrix} \tag{A.13}$$

from which the following partial derivatives are obtained:

$$\frac{\partial \tilde{S}}{\partial \tau} = (s_T - s_N)\frac{\partial C_N / \partial \bar{\lambda}}{\Delta} \tag{A.14a}$$

$$\frac{\partial \tilde{E}}{\partial \tau} = (e_T - e_N)\frac{\partial C_N / \partial \bar{\lambda}}{\Delta} \tag{A.14b}$$

$$\frac{\partial \bar{\lambda}}{\partial \tau} = -\frac{h}{\Delta} < 0 \quad \text{(A.14c)}$$

$$\frac{\partial \bar{L}_T}{\partial \tau} = \frac{\partial C_N / \partial \bar{\lambda}}{\Delta} < 0 \quad \text{(A.14d)}$$

where the determinant of (A.13), $\Delta > 0$, for stability to obtain.

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