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EFFECTS OF INFLATION ON THE PATTERN OF INTERNATIONAL TRADE

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ABSTRACT

This paper examines the relationship between inflation, exchange rates, and the pattern of international trade and payments in a small economy with utility-maximizing agents and a transactions demand for money. Fully anticipated inflation has real effects in the model through its role as a tax on money and thereby on monetary transactions.

An increase in the rate of monetary expansion generally reduces the value of domestic output and alters the composition of domestic production. The result is a change in the pattern of international comparative advantage and trade flows. The initial depreciation of the exchange rate following an increase in the rate of monetary expansion is accompanied by a trade surplus and capital outflow, while the subsequent depreciation is accompanied by a trade deficit.

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I. Introduction

The relationships between exchange rates, monetary policies, and real trade flows have received renewed attention recently as Dornbusch and Fischer (1980), Lucas (1980b), Rodriguez (1980), Weiss (1980), and Stockman (1980a, 1981a) have examined the effects of real shocks on the exchange rate, relative prices, and trade flows. Dornbusch and Fischer, and Helpman and Razin (1981) also examine the impact of systematic anticipated monetary policy on the exchange rate and real trade flows. Wilson (1979a) investigates similar issues in the context of Dornbusch's (1976) model. The current paper integrates this research with recent work by Lucas (1980a), Wilson (1979b), Jovanovic (1981), and Stockman (1981b), and examines the influence of fully anticipated inflation on the exchange rate, relative prices, and the pattern of international trade. Fully anticipated inflation has real effects in the model through its influence on the cost of holding money, which is used to facilitate transactions. These real effects have impacts on the exchange rate, relative prices, and the pattern of the international division of labor and trade flows.

The conclusions reached here contrast with those reached by Obstfeld (1980) in a related analysis. The essential difference between the analyses is that Obstfeld places money directly into the utility function, whereas money yields indirect utility in the analysis here, through its use in facilitating transactions. This latter formulation has been utilized by Lucas, Helpman (1981), Helpman and Razin, Wilson (1979b), and Stockman (1980a, 1981b) and a related formulation has been utilized by Jovanovic. The conclusions reached here also differ from those of Helpman and Razin, as this paper extends their analysis to incorporate elements of capital accumulation, the labor-leisure choice, and the markets for factors of production.[1]

The analysis is conducted for the case of a small country that takes its terms of trade as given by the outside world, although the last section of the paper discusses the implications of relaxing this assumption. The setup of the model is described in Section II. Sections III and IV investigate the effects of systematic, anticipated inflation on the relative price of nontraded goods, the production and consumption of importables, exportables, and nontraded goods, and the pattern of international trade. Section V discusses international trade in assets and extensions of the analysis to a full world equilibrium model.

II. A Small-Country Model

Consider a country in which there is a representative agent who consumes exportables, importables, and a nontraded good. Since trade patterns in this model will be determined endogenously, the two traded goods will be referred to simply as "good one" and "good two." Good one can be consumed directly, or turned into "capital," which is an input into the production of all three goods. The representative agent chooses a sequence of consumptions of the three goods, c_1, c_2, c_N, leisure, $1-\ell$, and the allocations of capital and labor across industries, to maximize utility,

$$\sum_{t=0}^{\infty} \beta^t U(c_{1t}, c_{2t}, c_{Nt}, 1-\ell_t). \tag{1}$$

It will be assumed that U is concave and strongly separable (i.e., $U_{ij} = 0$ for all $i \neq j$, where U_{ij} denotes the second derivative of U with respect to its i*th* and j*th* arguments).

Utility is maximized subject to the (period-by-period) budget constraint[2]

$$
\begin{aligned}
&M_t + p_{1t}f(K_{1t},\ell_{1t}) + p_{2t}g(K_{2t},\ell_{2t}) + p_{Nt}h(K_{Nt},\ell_{Nt}) \\
&= M^d_{t+1} + p_{1t}c_{1t} + p_{2t}c_{2t} + p_{Nt}c_{Nt} + p_{1t}(K_{t+1} - K_t(1-\delta)).
\end{aligned} \tag{2}
$$

where M_t is the nominal quantity of money held by the agent at the beginning of period t, which consists of the amount held at the end of period t-1, M^d_{t-1}, plus transfer payments of money received at the beginning of period t, τ_t, so

$$M_t = M^d_{t-1} + \tau_t. \tag{3}$$

The nominal prices of goods one, two, and N, are denoted p_{1t}, p_{2t}, and p_{Nt} in units of domestic currency. These goods are produced with capital, K, and labor, ℓ, inputs into the production functions f, g, and h. Capital and labor are both freely transportable across industries, so

$$K_{1t} + K_{2t} + K_{Nt} = K_t \tag{4a}$$

and

$$\ell_{1t} + \ell_{2t} + \ell_{Nt} = \ell_t. \tag{4b}$$

Capital depreciates at rate δ.

In addition to the budget constraint, the agent faces a payments technology that requires that all purchases during a "period" be made with money holdings acquired by the beginning of the period. This is formalized by a "cash-in-advance" constraint that has been used in the papers cited above by Lucas, Wilson, Helpman, Helpman and Razin, and Stockman. The constraint takes the form,[3]

$$M_t \geq p_{1t}c_{1t} + p_{2t}c_{2t} + p_{Nt}c_{Nt} + p_{1t}(K_{t+1} - (1-\delta)K_t). \tag{5}$$

It is convenient to reformulate the maximization problem in terms of the functional equation

$$\begin{aligned} V(K_t, M_t, p_{1+t}, p_{2t}, p_{Nt}) = \max\{ & U(c_{1t}, c_{2t}, c_{Nt}, 1-\ell_{1t}-\ell_{2t}-\ell_{3t}) \\ & + \beta V(K_{t+1}, M_{t+1}, p_{1t+1}, p_{2t+1}, p_{3t+1})\} \end{aligned} \tag{6}$$

where the maximization is with respect to c_{1t}, c_{2t}, c_{Nt}, ℓ_{1t}, ℓ_{2t}, ℓ_{Nt}, K_{1t}, K_{2t}, K_{Nt}, M_{t+1}, and K_{t+1}, and is subject to (2), (4a), and (5). Letting λ_t, ϕ_t, and γ_t be Lagrange multipliers on these constraints, necessary conditions for a maximum are[4]

$$\lambda + \gamma = \frac{U_1}{p_1} = \frac{U_2}{p_2} = \frac{U_3}{p_N} \tag{7}$$

$$\frac{U_4}{\lambda} = p_1 f_2 = p_2 g_2 = p_N h_2 \tag{8}$$

$$\frac{\phi}{\lambda} = p_1 f_1 = p_2 g_1 = p_N h_1 \tag{9}$$

$$\beta v_1' = (\lambda+\gamma)p_1 \tag{10}$$

$$\beta V_2' = \lambda \tag{11}$$

where U_i, f_i, g_i, h_i indicate partial derivatives with respect to the *ith* element of the function, and a "prime" (') following a function means "evaluated at the values the variables take in period t+1."

(7) equates marginal rates of substitution and relative prices, and the marginal utility of each good per dollar spent to the marginal utility of money on hand at the beginning of the period, $\lambda + \gamma$. (8) equates the shadow price of leisure to the value of the marginal product of labor in each industry, and (9) equates the shadow price of capital to the value of the marginal product of capital in each industry. (10) equates the discounted marginal value of future capital with its marginal cost, and (11) does the same for money balances.

Note that the marginal value of current period capital is

$$V_1 = \phi + (1-\delta)(\lambda+\gamma)p_1 \tag{12}$$

and the marginal value of money at the beginning of the current period is

$$V_2 = \lambda + \gamma. \tag{13}$$

Thus (10) and (11) can be replaced by the Euler equations

$$\beta\phi' + \beta(1-\delta)(\lambda'+\gamma')p_1' = (\lambda+\gamma)p_1 \tag{14}$$

and

$$\beta(\lambda'+\gamma') = \lambda. \tag{15}$$

This completes the description of the optimization problem for a representative, price-taking, agent in the domestic economy.[5] The next section investigates the characteristics of the equilibrium for the case of a small economy (taking as given the terms of trade and foreign nominal prices).

III. Equilibrium of a Small Open Economy

The equilibrium conditions for the economy require that the money market and the market for the nontraded good clear, i.e.

$$M^d = M^s \quad \text{and} \quad h(K_N, \ell_N) = c_N. \tag{16}$$

Together, the equations (16) and the budget constraint (2) require a zero balance of trade.[6]

The domestic nominal prices of traded goods, p_1 and p_2, are equal to the exchange rate times the (fixed) foreign currency prices of goods one and two. The domestic price of nontraded goods and the exchange rate, are, however, determined endogenously by (16).

Denote the rate of monetary expansion (through transfer payments) μ, so

$$M_t = (1+\mu)M_{t-1}.$$

Then consider a steady state equilibrium. Since consumption is constant over time in the steady state, (7) implies that there is a unique, constant steady state value of $p_1(\lambda+\gamma)$. So (15) implies that there is a unique, constant steady state value of $\lambda p_1'$, while (14) implies that ϕ is constant in the steady state. (9) then implies that λp_1 takes a constant steady state value. So (15) implies that, in the steady state,

$$\gamma = \frac{\lambda}{\beta}[\frac{p_1'}{p_1} - \beta] \tag{17}$$

is positive except when there is deflation at the discount rate $\frac{1-\beta}{\beta}$, which is the rule for the optimal quantity of money. A positive value for γ, however, implies that (5) holds as a strict equality for all t, so that the velocity of money is fixed in the steady state (at unity),

$$M = p_1(c_1 + K' - (1-\delta)K) + p_2c_2 + p_Nc_N \tag{5'}$$

and so

$$\frac{p_1'}{p_1} = 1 + \mu. \tag{18}$$

Combining (9), (14), and (18), we have

$$f_1(K_1,\ell_1) = (1+\mu)\left[\frac{1-\beta(1-\delta)}{\beta^2}\right] \tag{19}$$

as an analog to the result in Stockman (1981b). Given employment of labor in industry one, a higher rate of monetary expansion reduces capital and production in that industry. Given fixed terms of trade, $\frac{p_1}{p_2}$, to the small economy, similar results hold in industry two:

$$g_1(K_2,\ell_2) = (1+\mu)\left[\frac{1-\beta(1-\delta)}{\beta^2}\right]. \tag{20}$$

The change in production in each of the traded goods industries, when μ changes, is independent of demand for those goods, given employment of labor in the traded good industries. However, that is not true in the nontraded goods industry. There, the equilibrium conditions impose domestic market-clearing, so the response of demand for the nontraded good is central, as discussed below.[7]

Equations (19) and (20) utilized the first equation in (9) in their derivation, so that they hold whenever the total capital stock is endogenously determined. It is useful, however, to first investigate the properties of the model with a fixed capital stock. This will be discussed in two stages. First, both the aggregate domestic capital stock and its allocation across industries will be taken as fixed. The model then is similar to Jones' (1971) specific-factor model. Second, the aggregate capital stock will be assumed to be exogenously determined, but the allocation of capital services across industries will be chosen endogenously. Finally, Section V will return to the case of an endogenously determined aggregate capital stock.

Exogenous Capital in Each Industry

When capital in each industry is exogenously fixed, equations (9) and (14) are not part of the model. As noted above, (7) and (15) imply that $(\lambda+\gamma)p_1$ and $\lambda p_1'$ are constant in the steady state. Now, since (8) implies a constant steady state value of λp_1, (15) implies that

$$\beta(\lambda'+\gamma')p_1' = \lambda p_1 \frac{p_1'}{p_1}$$

which, in the steady state, implies (17). So, unless there is deflation at the rate $\frac{1-\beta}{\beta}$, (5') and (18) continue to hold.

The effects of an increase in μ can then be determined from the following, which follow directly from (7), (8), (5') and (17),[8]

$$\lambda p_1 \frac{1+\mu}{\beta} = U_1(c_1,\ldots) = \frac{p_1}{p_2} U_2(\ldots,c_2,\ldots) = \frac{p_1}{p_N} U_3(\ldots,h(\ell_N),\ldots) \tag{21}$$

$$\frac{U_4(\ldots,1-\ell,-\ell_2-\ell_N)}{\lambda p_1} = f_2(K_1,\ell_1) = \frac{p_2}{p_1} g_2(K_2,\ell_2) = \frac{p_N}{p_1} h_2(K_N,\ell_N) \tag{22}$$

$$M = p_1(c_1+\delta K) + p_2c_2 + p_Nh(K_N,\ell_N) \tag{23}$$

$$f(K_1,\ell_1) - c_1 - \delta K + \frac{p_2}{p_1}(g(K_2,\ell_2) - c_2) = 0. \tag{24}$$

Without loss of generality, units can be chosen so that $\frac{p_2}{p_1}$ is unity.

The system of equations (21) - (24) is discussed in the Appendix. Differentiation of the system leads to the result that a rise in μ reduces λp_1, and through (22), reduces ℓ_1, ℓ_2, and ℓ_N. This reflects a substitution effect on the part of agents away from goods and toward leisure as μ rises, as discussed in Wilson (1979b), Stockman (1980b), and Aschauer (1981). The allocation of labor across traded good industries changes to maintain equality of (the value of) the marginal products of labor in these industries.

The change in the pattern of international trade as μ rises depends on the relative magnitudes of f_{22} and g_{22}, and on U_{11} and U_{22}. Suppose, for example, that both the exportable and importable goods industries have Cobb-Douglas production functions with the same constant-returns-to-scale technology (same parameters), but that industry one, the exportable-goods industry, has a greater (fixed) capital stock than the importable-goods industry. Then $g_{22} < f_{22} < 0$ and an increase in μ reduces production of the exportable by more than it reduces production of the importable. If $U_{11} = U_{22}$ then the reductions in c_1 and c_2 are identical, so that both exports and imports fall. An increase in μ, in this case, reduces the total volume of international trade.

Production of the nontraded good falls with an increase in μ, but the effect of a higher μ or the relative price of the nontraded good, $\frac{p_N}{p_1}$, is ambiguous, reflecting both a decrease in supply and a decrease in demand. The effect of a higher μ on the exchange rate can be determined from (5'), (16), (2), and the condition

$$p_i = ep_i^*, \qquad i = 1,2,$$

where e is the exchange rate and p_1^* and p_2^* are the foreign currency prices of the two traded goods. The exchange rate is consequently

$$e = \frac{\frac{M_s}{p_1^*}}{f + \frac{p_2}{p_1}g + \frac{p_N}{p_1}h} \quad . \tag{25}$$

An increase in μ, by reducing f, g, and h, raises e except in the case where $\frac{p_N}{p_1}$ (which may rise or fall with a higher μ) rises sufficiently to offset the falls in f, g, and h. This exceptional case would correspond to a kind of immiserizing (negative) growth, where the reduction in the supply of the non-traded good raises its price sufficiently to increase the value of total output in all industries.

These results have been obtained for the case of fixed capital stocks in each industry. If the aggregate capital stock is fixed but capital is free to move across industries, then the last two equations in (9) are relevant for determining the equilibrium distribution of capital across industries. If there were no nontraded good, then the change in the pattern of production in the economy when μ rises would be given by the Rybczynski theorem, with the pattern of trade affected also by wealth elasticities of demand. With nontraded goods in the model, the resulting reallocation of production depends partly on consumer preferences, through the effect of preferences on the relative price of the nontraded good and consequently on the amounts of labor and capital employed in the nontraded goods industry. The derivation of these results is straightforward; the next section turns to the case in which investment, and hence the aggregate capital stock, is endogenous.

IV. Endogenous Determination of Investment and Capital

If the amount of investment, and hence the aggregate capital stock, is viewed as endogenously determined, then (14), and consequently (19) and (20), are again relevant to the model. Given total employment of labor in each industry, (19) and (20) show a negative relationship between μ and production in each of the traded goods industries. Similarly, given the employment of labor in each industry, (2), (7), and (16) imply

$$\frac{dK_n}{d\mu} = \left(\frac{f_1}{\delta} - 1\right)\frac{dK_1}{d\mu} + \left(\frac{p_2}{p_1}\frac{g_1}{\delta} - 1\right)\frac{dK_2}{d\mu} - \left[\frac{1}{U_{11}} + \left(\frac{p_2}{p_1}\right)^2 \frac{1}{U_{22}}\right]\frac{1}{\delta}\frac{d[(\lambda+\gamma)p_1]}{d\mu} \tag{26}$$

$$\frac{dK_N}{d\mu} = \frac{1}{U_{33}h_1}\frac{p_N}{p_1}\frac{d[(\lambda+\gamma)p_1]}{d\mu} + \frac{(\lambda+\gamma)p_1}{U_{33}h_1}\frac{d\left(\frac{p_N}{p_1}\right)}{d\mu} . \tag{27}$$

But (9) implies

$$\frac{d\left(\frac{p_N}{p_1}\right)}{d\mu} = \frac{f_{11}}{h_1}\frac{dk_1}{d\mu} - \frac{f_1 h_{11}}{h_1^2}\frac{dK_N}{d\mu} . \tag{28}$$

so, using (26), (27), (19), and (20), and defining

$$A \equiv \frac{1}{U_{11}} + \left(\frac{p_2}{p_1}\right)^2 \frac{1}{U_{22}} ,$$

we obtain

$$\frac{dK_N}{d\mu} = \left\{\frac{[f_1 - \delta + A(\lambda+\gamma)\frac{p_1^2}{p_N}\frac{f_1 h_{11}}{h_1^2}]\frac{1}{f_{11}} + [\frac{p_2}{p_1}g_1 - \delta]\frac{1}{g_{11}}}{A[\frac{p_1}{p_N}\frac{h_1}{U_{33}} + \frac{p_1^2}{p_N}(\lambda+\gamma)\frac{f_1 h_{11}}{h_1^2} + \delta}\right\}\frac{1-\beta(1-\delta)}{\beta^2} , \tag{29}$$

which is seen to be negative. However, unlike the effects of a higher rate of monetary expansion on K_1 and K_2 (from (19) and (20)), (29) involves parameters of demand as well as supply, and involves supply parameters from all three industries.

Given these results, (28) can be used to obtain the change in the relative price of nontraded goods when the rate of monetary expansion changes, assuming that ℓ_1, ℓ_2, and ℓ_N are fixed. This is seen to involve two opposing effects. First, the increase in $(\lambda+\gamma)p_1$ as μ rises, which can be obtained from (26), (27), and (28), represents a wealth effect reducing the demand for nontraded goods. On the other hand, the shift in the capital stock involves a reduction in supply. So although production of the nontraded good is reduced, the relative price may either rise or fall as μ rises.

The effect of an increase in μ on the exchange rate is again obtained from (25), this time using (19), (20), (29), and (28). Again, as in the previous section, an increase in μ raises e except in an "immiserizing-growth" type situation.

These results hold fixed the employment of labor in each industry. Given these employments, capital in each industry falls when μ rises, and the pattern of international trade is changed. Similarly, it was shown in the previous section that, given the employment of capital in each industry, the employment of labor in each industry falls as μ rises. In both cases the relative price of the nontraded good may either rise or fall, and unless the relative price of the nontraded good rises substantially, the exchange rate rises (domestic currency depreciates).

When both total employment and the aggregate capital stock are free to adjust, and to move freely between industries, there are two additional effects on the patterns of production and trade. First, since with a fixed total capital stock (or employment of labor), an increase in μ reduces employment (or the capital stock), the marginal product of capital (or labor) is reduced. This tends to reduce production in each industry. Second, the negative wealth effect of an increase in μ raises the supply of labor, which tends to increase production.

The interindustry allocation of capital and labor is now affected by consumer preferences as well as technology and prices. This is true even in the absence of a nontraded good. In order to see this, ignore the nontraded good. Using (21) - (24) (except the last equations in (21) and (22), which refer to the nontraded goods industry), one obtains

$$c_1 = J(p_1\lambda\frac{1+\mu}{\beta}), \qquad J_1 < 0 \tag{30}$$

from the first equation in (21), and

$$p_1\lambda\frac{1+\mu}{\beta} = L(f+g-\delta K), \qquad L_1 < 0 \tag{31}$$

from the second equation in (21), (24), and (30). Note that

$$J_1 = U_{11}^{-1} \tag{32}$$

and

$$L_1 = \frac{U_{11}U_{22}}{U_{11}+U_{22}} \tag{33}$$

Using (30) and (31) in (22) and (9), and differentiating, one obtains

$$- U_{44} \frac{1+\mu}{\beta L}(d\ell_1 + d\ell_2) + \frac{U_4}{\beta L} d\mu$$

$$- \frac{U_4(1+\mu)}{\beta L^2} L_1[f_1 dK_1 + f_2 d\ell_1 + g_1 dK_2 + g_2 d\ell_2 - \delta(dK_1 + dK_2)] \tag{34}$$

$$= f_{12} dK_1 + f_{22} d\ell_1 = g_{12} dK_2 + g_{22} d\ell_2$$

and

$$d\ell_1 = \frac{1-\beta(1-\delta)}{\beta^2 f_{12}} d\mu - \frac{f_{11}}{f_{12}} dK_1$$

$$d\ell_2 = \frac{1-\beta(1-\delta)}{\beta^2 g_{12}} d\mu - \frac{g_{11}}{g_{12}} dK_2 . \tag{35}$$

As a result,

$$\frac{dK_1}{d\mu} = N^{-1} g_{12}\left(b - \frac{1-\beta(1-\delta)}{\beta^2} \frac{f_{22}}{f_{12}}\right) + A \frac{1-\beta(1-\delta)}{\beta^2} \left(\frac{g_{22}}{g_{12}} - \frac{f_{22}}{f_{12}}\right)$$

and (36)

$$\frac{dK_2}{d\mu} = N^{-1} f_{12}\left(b - \frac{1-\beta(1-\delta)}{\beta^2} \frac{g_{22}}{g_{12}}\right) - B \frac{1-\beta(1-\delta)}{\beta^2} \left(\frac{g_{22}}{g_{12}} - \frac{f_{22}}{f_{12}}\right)$$

where

$$N = f_{12} g_{12} + B g_{12} + A f_{12} < 0$$

$$A = \frac{U_4(1+\mu)}{\beta L^2} L_1\left(g_1 - g_2 \frac{g_{11}}{g_{12}} - \delta\right) - U_{44} \frac{1+\mu}{\beta L} \frac{g_{11}}{g_{12}} < 0$$

$$B = \frac{U_4(1+\mu)}{\beta L^2} L_1\left(f_1 - f_2 \frac{f_{11}}{f_{12}} - \delta\right) - U_{44} \frac{1+\mu}{\beta L} \frac{f_{11}}{f_{12}} < 0$$

$$b = \frac{U_4}{\beta L} - U_{44} \frac{1-\beta(1-\delta)}{\beta^2} \frac{1+\mu}{\beta L} \left(\frac{f_{12}+g_{12}}{f_{12} g_{12}}\right) - \frac{1-\beta(1-\delta)}{\beta^2} U_4 \frac{1+\mu}{\beta L^2} L_1\left(\frac{f_2}{f_{12}} + \frac{g_2}{g_{12}}\right) > 0 .$$

The first term on the right-hand side of each equation in (36) is negative, as expected from the earlier results when the employment of labor in each industry (ant total employment) was fixed. Now, however, there is a second effect in (36) on capital employed in each traded goods industry, associated with the change in the pattern of production when μ rises. As a result, it is possible that capital employed in one of the two industries (though not both) rises when μ rises.

Suppose production in each traded goods industry is Cobb-Douglas, and that the exportable goods industry (industry one) is more capital intensive than the importable goods industry. Then

$$\frac{K_1}{\ell_1} > \frac{K_2}{\ell_2}$$

so

$$\frac{g_{22}}{g_{12}} - \frac{f_{22}}{f_{12}} > 0.$$

Consequently, the second terms on the right-hand side of equations (36) work to further reduce K_1 but to increase K_2. Equations (35) then can be solved for the change in ℓ_1 and ℓ_2 as μ rises. It is straightforward to show that aggregate production falls when μ rises. In the example being considered, production of exportables falls, while production of importables may either rise or fall (with a rise more likely the greater the divergence in capital intensities across industries). With a homothetic utility function, the volume of trade falls (as long as good one remains an exported good). If the capital intensities are sufficiently diverse, then an increase in μ may cause good one to become the imported good and good two the exported good, that is, there may be a complete reversal in the pattern of trade.

V. Asset Trade and World Equilibrium

The previous sections have examined the effect of an increase in the rate of monetary expansion on international trade by comparing steady states for an economy that faces a relative price of traded goods determined in the outside world. This section discusses changes in portfolio and asset positions during the transition from one rate of monetary expansion to another, and the impacts of an increase in μ on the rest of the world and feedbacks on the domestic economy.

The steady state is associated with a constant net credit (debt) position for the domestic economy with respect to the rest of the world. Initially, retain the small country assumption that $\frac{p_1}{p_2}$ is given by the rest of the world, and assume that there is a foreign asset, that may be held by domestic residents, that earns a real rate of return of β.[9] Consider an increase in μ. The resulting decline in K in the steady state can be accomplished immediately if capital can be exported. Since consumption behavior (see (7)) is of a permanent-income type, the domestic country does not trade away capital in return for consumption goods, but, rather, for foreign assets. The interest on these assets then finances a steady stream of future consumption, with the principal intact. Thus an increase in μ leads to an immediate current account surplus and capital account deficit. Recall that this is associated with a depreciation of domestic currency. Following this immediate current account surplus is a trade deficit (associated with an equal service account surplus) in the new steady state, and a continuing depreciation of domestic currency. So, while the initial increase in the exchange rate following an increase in μ is associated with a trade surplus and capital outflow, the subsequent rise in the exchange rate over time is associated with a trade deficit.

The changing relationship between the balance of trade and exchange rate movements is similar to a conclusion reached by Dornbusch and Fischer as a response to an anticipated one-time change in the money supply. In their model the initial surplus and subsequent deficit are part of the transition back to the initial real equilibrium. Here, the initial surplus and subsequent trade deficit occur in response to an increase in the rate of monetary expansion, and are associated with the economy's movement to a new real equilibrium.

Although the model presented in this paper considers a single (small, open) economy, the results can shed some light on the new world equilibrium. In the Cobb-Douglas case considered in Section IV, the decline in exports of good one and imports of good two due to an increase in the rate of monetary expansion would tend to raise $\frac{p_1}{p_2}$ on world markets. This would induce the rest of the world to shift resources away from industry two and into industry one. As a result, world factor prices would change. If industry one is relatively capital intensive in the rest of the world, as it is in the domestic country, the Stolper-Samuelson theorem implies an increase in the real return to capital and a decrease in the real return to labor. This would induce additional investment and capital accumulation in the rest of the world until the foreign analogs of (19) and (20) are satisfied. Consequently, in the new steady state equilibrium, the reduction in the domestic capital stock would be partly offset by an increase in the foreign capital stock.

The extent to which a change in $\frac{p_1}{p_2}$, determined on world markets, feeds back on the domestic economy obviously depends on the size of the country, the magnitude of the initial shift in trade patterns following a change in μ, and the elasticity of substitution in production along the transformation curve in the rest of the world. It also depends upon the behavior of labor supply in the rest of the world, since, through the foreign analogs of (19) and (20), the behavior of labor supply affects the magnitude of capital accumulation in the rest of the world. Foreign capital accumulation thus provides an additional margin of substitution when a single country experiences an increase in inflation. This additional margin of substitution would be absent, however, if the increase in inflation were worldwide.

VI. Concluding Remarks

Recent models of exchange rates and real trade flows have focused on the effects of real disturbances in relative prices, exchange rates, and asset accumulation. The effects of monetary changes in these models have typically emphasized real-balance effects or Mundell-Tobin non-neutralities. This paper has examined the effect on exchange rates and the pattern of international trade of an increase in the rate of monetary expansion. The framework for the introduction of money was borrowed from recent research on monetary economies with transactions technologies that motivate a demand for fiat money. Although the paper has focused on the effects of monetary expansion, the framework of the analysis maintains the features that have been emphasized in the recent work on the effects of real disturbances.

An increase in the rate of monetary expansion has real effects in the model presented here because it raises the cost of transacting, since, with a transactions demand for money, money is more costly to hold. Given an exogenous stock of capital and its allocation across industries, an increase in the rate of monetary expansion reduces the employment of labor in the exportables, importables, and nontraded goods industries, and alters the nation's comparative advantage. When capital can freely move between industries, the total employment of labor falls but some industries may expand production. With capital accumulation or decumulation permitted, an increase in the rate of monetary expansion reduces the aggregate capital stock as well, further affecting the nation's comparative advantage. The movement of capital between industries can result in an increase in production in some, but not all, industries. If capital intensities across industries are sufficiently diverse, the pattern of trade may undergo a complete reversal, with previously imported (exported) goods becoming exports (imports). If financial assets are traded, then an increase in the rate of monetary expansion results in a depreciation of domestic currency associated initially with a trade surplus and subsequently with a trade deficit.

The paper has not analyzed a full world equilibrium along the lines of the paper by Helpman and Razin, and it would be important to do so for an empirical application, since the effects of a change in foreign inflation on a country's pattern of trade would have to be distinguished from the effects of a change in its own inflation rate. Furthermore, the transactions technology postulated to motivate a demand for money is quite crude. Alternative transactions technologies might consider the role of other assets and perhaps a system of financial intermediation. If the financial industry uses capital and labor inputs and if the volume of financial services expands with inflation, then there will be additional factors affecting comparative advantage and the pattern of trade.

Appendix

Equations (21) - (24) determine ℓ_1, ℓ_2, ℓ_N, c_1, c_2, $\frac{p_N}{p_1}$, λp_1, and p_1. Only (23) involves p_1 (given $\frac{p_2}{p_1}$ and the other seven variables), so (21), (22), and (24) can be solved for the other variables. Using (24) to eliminate c_1 from (21), and differentiating, one obtains (where $\frac{p_2}{p_1}$ is normalized to unity)

$$U_3\left(\frac{p_1}{p_N}\right)^2 d\left(\frac{p_N}{p_1}\right) = U_{33}\frac{p_1}{p_N}h_2 d\ell_N - \frac{1+\mu}{\beta}d(\lambda p_1) - \frac{\lambda p_1}{\beta}d\mu \tag{A1}$$

$$d(\lambda p_1) = Qf_2 d\ell_1 + Qg_2 d\ell_2 - \frac{\lambda p_1}{1+\mu}d\mu \tag{A2}$$

$$\frac{1+\mu}{\beta}d(\lambda p_1) = U_{22}dc_2 - \frac{\lambda p_1}{\beta}d\mu \tag{A3}$$

where

$$Q = \frac{\beta}{1+\mu}\left(\frac{U_{11}U_{22}}{U_{11}+U_{22}}\right)$$

and (noting that $f_2 = g_2$)

$$\begin{bmatrix} \lambda p_1 f_{22} + U_{44} + f_2^2 Q & U_{44} + f_2^2 Q & U_{44} \\ \cdot & \lambda p_1 g_{22} + U_{44} + f_2^2 Q & U_{44} \\ \cdot & \cdot & \lambda p_1 h_{22} + U_{44} + \lambda p_1 h_2^2 \frac{U_{33}}{U_3} \end{bmatrix}$$

$$\begin{pmatrix} d\ell_1 \\ d\ell_2 \\ d\ell_N \end{pmatrix} = \begin{pmatrix} f_2 \\ f_2 \\ h^2 \frac{p_N}{p_1} \end{pmatrix} \frac{\lambda p_1}{1+\mu} d\mu \tag{A4}$$

where the matrix is symmetric.

The matrix equation leads to

$$\frac{d\begin{bmatrix}\ell_1\\ \ell_2\\ \ell_N\end{bmatrix}}{d\mu} = \frac{\lambda p_1 f_2}{(1+\mu)H}\begin{pmatrix}\lambda p_1 g_{22}(h_{22} + f_2 h_2 \frac{U_{33}}{U_3})\\ \lambda p_1 f_{22}(h_{22} + f_2 h_2 \frac{U_{33}}{U_3})\\ \lambda p_1 f_{22} g_{22} + \dfrac{f_2^2 \beta U_{11}(f_{22}+g_{22})}{(1+\mu)(1 + \frac{U_{11}}{U_{22}})}\end{pmatrix} \tag{A5}$$

where

$$H = \lambda p_1(h_{22} + f_2 h_2 \frac{U_{33}}{U_3})[(f_{22} + g_{22})(U_{44} + f_2^2 Q) + \lambda p_1 f_{22} g_{22}]$$
$$+ f_2^2 Q U_{44}(f_{22} + g_{22}) + \lambda p_1 U_{44} f_{22} g_{22} < 0.$$

Since f_2, g_2, h_2, λ, U_3 are positive and f_{22}, g_{22}, h_{22}, U_{11}, U_{22}, U_{33}, U_{44} are negative, it is seen that $\frac{d\ell_i}{d\mu} < 0$ for $i = 1,2,N$.

Now substitute (A4) into (A2) to obtain

$$\frac{d(\lambda p_1)}{d\mu} = \frac{-\lambda p_1}{(1+\mu)H}[\lambda p_1(h_{22}+f_2 h_2 \frac{U_{33}}{U_3})(U_{44}(f_{22}+g_{22}) + \lambda p_1 f_{22} g_{22})$$
$$+ f_2^2 Q U_{44}(f_{22}+g_{22}) + \lambda p_1 U_{44} f_{22} g_{22}] < 0. \tag{A6}$$

(A3) then implies

$$\frac{dc_2}{d\mu} = \frac{1}{\beta U_{22}}[\lambda p_1 + (1+\mu)\frac{d(\lambda p_1)}{d\mu}] < 0$$

and

$$\frac{dc_1}{d\mu} = \frac{1}{\beta U_{11}} [\lambda p_1 + (1+\mu)\frac{d\lambda p_1}{d\mu}] < 0.$$

And (A1) implies

$$\frac{d(\frac{p_N}{p_1})}{d\mu} = - \frac{(\lambda p_N)^2}{\beta H U_3} (h_{22} + f_2 h_2 \frac{U_{33}}{U_3})(f_{22} + g_{22}) f_2^2 Q$$

$$+ \frac{\lambda p_N h_2 f_2}{(1+\mu)H} \frac{U_{33}}{U_3} \left[\lambda p_1 f_{22} g_{22} + \frac{f_2^2 \beta U_{11}(f_{22}+g_{22})}{(1+\mu)(1 + \frac{U_{11}}{U_{22}})} \right].$$

Footnotes

[1]Helpman and Razin, however, examine a full 2 country world equilibrium model, while the current paper is mainly restricted to a small open economy.

[2]The representative agent is a demander and supplier of all three goods. While any individual may actually supply labor to only one industry, financial markets within the economy permit each agent to act as if he were a hypothetical representative agent supplying all three goods.

[3]In the papers by Lucas (1980b), Helpman (1981), Helpman and Razin (1981), and Stockman (1980a), there are <u>two</u> equations of the form (5), one for domestic money and domestic purchases, and the other for foreign money held by domestic residents associated with their purchases of foreign goods. Here it is assumed that domestic importers are able to exchange domestic money for foreign money just prior to their purchase of foreign goods, so there need not be a transactions demand for foreign money. Alternatively, the analysis in the paper may be interpreted as assuming that the domestic currency is used in all international trade transactions.

[4]An interior solution is assumed, so non-negativity constraints are not explicitly considered.

[5]Although the current analysis does not explicitly include trade in financial assets, their introduction into the analysis is straightforward, following, for example, Helpman (1981). Section V discusses the transition between alternative steady states in the presence of tradeable financial assets.

[6]More generally, the equations imply a zero balance of payments. See footnote 5.

[7]See equation (29).

[8]Equation (24) comes from (2) and (16).

[9]The real return may be in terms of either traded good, since $\frac{p_2}{p_1}$ is fixed. If the real return differed from β, then there would be no steady state, since individuals would choose a rising or falling consumption path over time in order to equate the marginal rate of substitution of consumption in adjacent periods to the relative price.

References

Aschauer, David, 1981, "On a Positively Sloped Long Run Phillips Curve," University of Rochester.

Dornbusch, Rudiger, 1976, "Expectations and Exchange Rate Dynamics," Journal of Political Economy, 1161-76.

_______ and Stanley Fischer, 1980, "Exchange Rates and the Current Account," American Economic Review, 960-71.

Helpman, Elhanan, 1981, "An Exploration in the Theory of Exchange Rate Regimes," forthcoming, Journal of Political Economy.

_______ and Assaf Razin, 1981, "Comparative Dynamics of Monetary Policy in a Floating Exchange Rate Regime," Working Paper, Tel-Aviv University.

Jones, Ronald, 1971, "A Three-Factor Model in Theory, Trade, and History," in J. Bhagwati, R. Jones, R. Mundell, and J. Vanek (eds.), Trade, Balance of Payments and Growth: Papers in International Economics in Honor of Charles P. Kindleberger, Amsterdam: North-Holland.

Jovanovic, Boyan, 1981, "Inflation and Welfare in the Steady State," Working Paper, Bell Laboratories.

Lucas, Robert E. Jr., 1980, "Equilibrium in a Pure Currency Economy," in J. Kareken and N. Wallace (eds.) Models of Monetary Economies, Federal Reserve Bank of Minneapolis (a).

_______, 1980, "Interest Rates and Currency Prices in a Two-Country World," Working Paper, University of Chicago (b).

Obstfeld, Maurice, 1980, "Macroeconomic Policy, Exchange-Rate Dynamics, and Optimal Asset Accumulation;" NBER Working Paper No. 599.

Rodriguez, Carlos, 1980, "The Role of Trade Flows in Exchange Rate Determination: A Rational Expectations Approach," Journal of Political Economy.

Stockman, Alan, 1980, "A Theory of Exchange Rate Determination," Journal of Political Economy, 673-98 (a).

_______, 1980, "Inflation, Capital, and Real Output," University of Rochester Working Paper (b).

_______, 1981, "Exchange Rates, Relative Prices, and Resource Allocation," forthcoming, J. Bhandari and B. Putnam (eds.), The International Transmission of Inflation under Flexible Exchange Rates (a).

_______, 1981, "Anticipated Inflation and the Capital Stock in a Cash-in-Advance Economy," Journal of Monetary Economics, forthcoming (b).

Weiss, Laurence, 1980, "A Model of International Trade and Finance," Quarterly Journal of Economics.

Wilson, Charles, 1979, "Anticipated Disturbances and Exchange Rate Dynamics," Journal of Political Economy, 639-47 (a).

_______, 1979, "An Infinite Horizon Model with Money," in J. R. Green and J. A. Scheinkman (eds.), General Equilibrium, Growth, and Trade: Essays in Honor of Lionel McKenzie, New York: Academic Press (b).