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EXCHANGE RATE DYNAMICS AND THE STOCK MARKET

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This paper integrates two separate strands of the literature on monetary policy. The closed economy models emphasize the impact of monetary policy on asset yields and asset prices and the resulting link to investment and aggregate demand. By contrast, the open economy literature shows that, under conditions of capital mobility and flexible exchange rates, changes in net exports, not in investment, are the chief result of monetary policy. This paper integrates the two approaches by introducing the real price of capital as an additional key variable in the open economy macroeconomic model.

In the Mundell-Fleming model, the standard open version of the IS/LM model, a monetary expansion leads to an increase in aggregate demand. The income expansion is entirely due to the exchange rate depreciation, induced by incipient capital outflows. As long as foreign interest rates remain fixed, the monetary expansion has no effects on investment spending. Dornbusch (1976) extended the Mundell-Fleming model, to exchange rate expectations and long run price flexibility. In his model, given the differential speeds of adjustment in goods and

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assets markets, a monetary expansion leads to an initial overshooting of exchange rates. But, just as in the Mundell-Fleming model, the effects of the monetary expansion come entirely from the change in the relative price of domestic goods, and investment spending is not emphasized as a channel of transmission of monetary policy.

Those results stand in contrast with models of the closed economy, where the main channel of transmission from monetary expansions to aggregate demand is the stock market and investment as for example, in Tobin's analysis. In closed economies IS/LM models, a monetary expansion increases aggregate demand because it reduces interest rates, increases the price of capital and thus induces more investment spending.

This paper reconciles the two views, showing that in the open economy, with flexible exchange rates, a monetary expansion affects exchange rates and the price of stocks, expanding both investment and net exports.

The special features of the model are the presence of a stock market, full long run flexibility of prices and short run goods price stickness. Stock prices and exchange rates can jump at any point in time. In focussing on the stock market as a channel of transmission for policies, the analysis follows Tobin and Blanchard (1981). In emphasizing differential speeds of adjustment in goods and assets markets as a basis of exchange rate dynamics, the analysis follows Dornbusch (1976).

The first section develops the model under the assumption of full employment and a price level that rises when demand for domestic output exceeds its full employment level. Section 2 discusses the closed form solution of the dynamic system and section 3 examines the effects of monetary policy. An extension of the model to cover the case of an economy with less than full employment is presented in section 4.

1. The Model

Consider a small open economy, with flexible exchange rates and four assets: money, stocks and short term domestic bonds and foreign bonds. Nonmoney assets are assumed to be perfect substitutes and arbitrage ensures that they have the same expected short run rate of return. Therefore, the expected real interest rate on domestic bonds, r^*, must equal the given real interest rate on foreign bonds, $\bar{r}$, plus the expected real depreciation rate, $\dot{e}^*/e - \dot{p}^*/p$:

$$r^* = \bar{r} + \dot{e}^*/e - \dot{p}^*/p \tag{1}$$

We assume in (1) that the foreign inflation rate is zero and thus the real interest rate on foreign bonds is equal to its nominal interest rate. A dot indicates a time derivative, and an asterisk indicates an expectation; e is the nominal exchange rate and p is the price level.

Arbitrage also ensures that the expected real interest on bonds equal the real profit rate, ρ/p, plus expected capital gains, $\dot{q}^*/q$:

$$r^* = \rho/q + \dot{q}^*/q \tag{2}$$

Here q is the real price of stocks in terms of domestic goods and ρ are profits per unit of physical capital. Under the assumption of full employment and a constant capital stock, ρ is constant. Section 4 extends the analysis for the case of an economy with less than full employment and considers the case of a cyclical relationship between output and expected profits per unit of physical capital.

The expected real interest rate on domestic bonds is defined as the difference between the nominal interest rate, i, and the expected inflation rate:

(3) $$r^* = i - \dot{p}^*/p$$

Equations (1), (2) and (3) describe arbitrage among stocks and bonds. Since money is held for transactions purposes, it is assumed to be an increasing function of income, y, and an inverse function of the common nominal return on nonmoney assets, i. Portfolio balance obtains when the demand for real cash balances equals the real money stock, m $m \equiv M/p$:

(4) $$m = y/vi$$

I assume in (4), following Mundell (1965), that velocity is a linear function of the opportunity cost of holding money. The nominal interest rate is assumed positive.

Equations (1)-(4) determine the price of capital, the nominal exchange rate, and domestic interest rates (q, e, i, r^*) as functions of the foreign interest rate, $\bar{r}$, of the policy variable, M, of the price level, p, and of expectations, $\dot{p}^*$, $\dot{q}^*$, $\dot{e}^*$.

I next specify the behavior of the price level. I assume that prices increase whenever aggregate demand for domestic goods exceeds the full employment level of output. The aggregate demand for domestic goods is made up of investment spending, of consumers' and government expenditures and of net exports. Following Tobin, investment is an increasing function of the real price of stocks. Consumption is assumed to depend on permanent and transitory income. Under the assumption of full employment and a constant tax structure, consumption is constant. Net exports depend on the real exchange rate, defined as $x \equiv e/p$. An increase in the real exchange rate raises competitiveness of our goods relative to foreign goods, increasing demand for our goods, and reducing our demand for foreign goods. We assume that an increase in the real exchange rate expands net exports.

From this argument it follows that the demand for domestic goods exceeds its full employment level whenever the real exchange rate or the real price of stocks exceed their steady state levels. The equation for the rate change of the price level can be written as:

$$\dot{p}/p = \theta(x - \bar{x}) + \phi(q - \bar{q}) \qquad (5)$$

Where, $\bar{x}$ and $\bar{q}$ are respectively the steady state values of the real exchange rate and price of stocks. Θ represents the product of the aggregate demand elasticity in relation to the real exchange rate times the speed of adjustment of prices and ϕ represents the product of the aggregate demand elasticity in relation to the real price of stocks times the speed of adjustment of prices.

The model is closed by assuming rational expectations. It reduces to three differential equations describing the behavior of the real price of stocks, of the real exchange rate and of the real money stock:

$$\dot{q}/q = y/vm - \rho/q - \theta\,(x - \bar{x}) - \phi\,(q - \bar{q}) \qquad (6)$$

(7) $$\dot{x}/x = y/vm - \theta(x - \bar{x}) - \phi(q - \bar{q})$$

(8) $$\dot{m}/m = - \theta(x - \bar{x}) - \phi(q - \bar{q})$$

We have assumed in (8), that the nominal money stock is constant. Thus the growth rate of the real money stock equals the rate of deflation.

In steady state, $\dot{q} = \dot{x} = \dot{m} = \dot{p} = o$ and the real price of stocks is equal to the ratio between the real profit rate and the real interest rate:

$$\bar{q} = \rho/\bar{r}$$

2. Dynamics

Linearization of the system formed by equations (6)-(8) around its steady state is presented in the appendix. The system has three characteristic roots:

$$\lambda_1 = \bar{r}$$

$$\lambda_{2,\ 3} = -A \pm (A^2 + \bar{r}\bar{x}\ \theta)^{\frac{1}{2}}$$

where: $A \equiv (\bar{x}\theta + \bar{q}\phi\ )/2$.

Two roots are positive and one is negative. We define the absolute value of the negative root as λ. The steady state is a saddle point equilibrium. Given the value of the real money stock, there is a unique combination of the price of stocks and the exchange rate, such that the economy converges to the steady state. The equations of motion along the stable arm are:

(9) $$m(t) = \{m(0) - \bar{m}\}e^{-\lambda t} + \bar{m}$$

(10) $$q(t) = (\bar{q}/\bar{m})\ \dot{m}(t)$$

(11) $$x(t) = (\bar{x}/\bar{m})\ B\ [m(t) - \bar{m}] + \bar{x}$$

Where: $B \equiv 1 + \bar{r}/\lambda$. Observe that $B > 1$. Equations (9), (10) and (11) are derived in the appendix.

In response to a shock, granted that the price of stocks and the exchange rate jump to place the economy on the stable path to equilibrium, the adjustment process is faster, the larger the elasticities of aggregate demand in relation to the real price of stocks and in relation to the exchange rate; the faster prices move in response to excess demand; and the larger the foreign interest rate.

3. Comparative Dynamics

Consider an unanticipated monetary expansion. Steady state real price of capital, interest and real exchange rates are invariant to nominal money, which only affects prices proportionately in the long run. To understand the short run effects of a monetary expansion, we assume that the economy is initially in steady state when the unanticipated expansion in nominal money occurs. When it does take place, real balances increase as the price level does not adjust instantaneously. The nominal interest rate falls to maintain portfolio equilibrium, and the expected inflation rate further decreases the expected real interest rate on domestic bonds. Arbitrage makes for an immediate depreciation of the exchange rate and an immediate jump of the price of stocks. As the price level increases, real balances fall. Consequently, interest rates start to increase, the exchange rate slowly appreciates, q falls and the economy

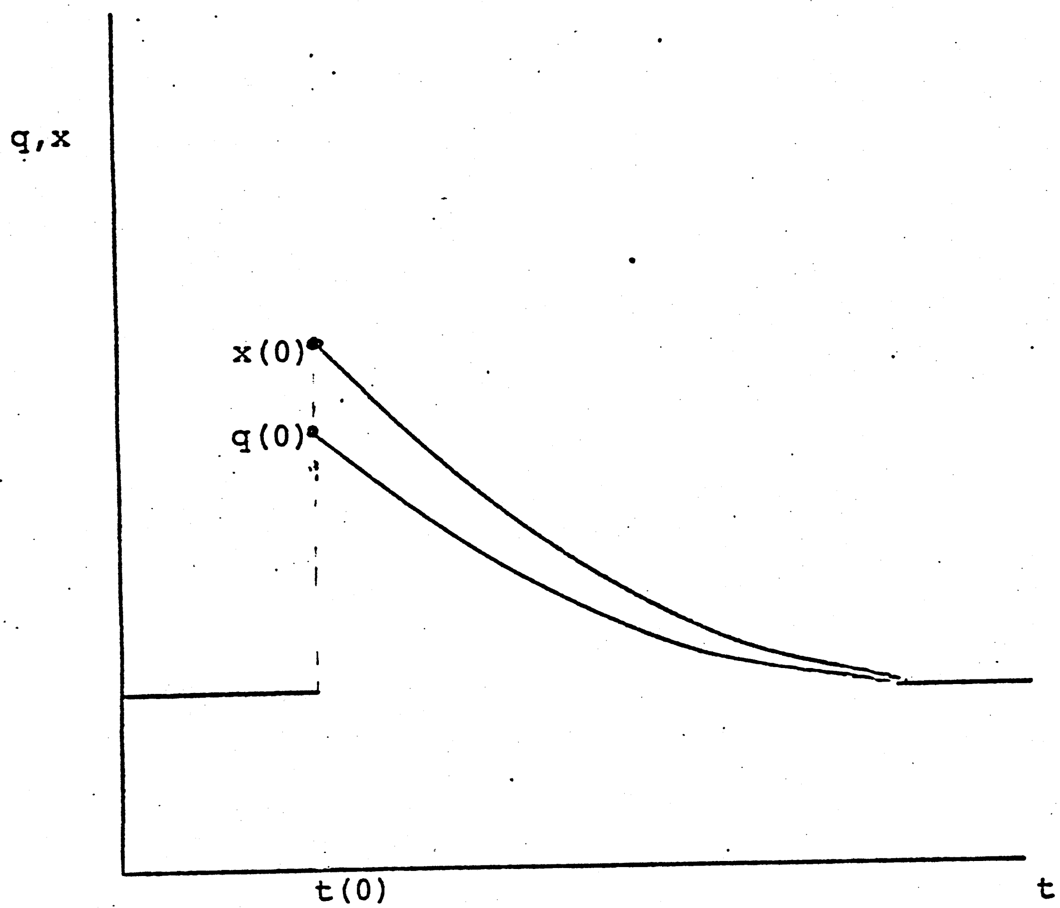

Figure 1. An unanticipated monetary expansion

returns to steady state equilibrium. The process of adjustment is illustrated in Figure 1.

Observe that initially, the exchange rate movement exceeds that of the capital price. At t(0), when the monetary expansion takes place, the exchange rate relative to the value of stocks is:

$$e(0)/p(0)q(0) = B\bar{x}/\bar{q}$$

where $\bar{x}$ and $\bar{q}$ are the values of x and q in the initial steady state and $B > 1$.

The reason why the exchange rate depreciation has to exceed the initial increase in the price of stocks rests on the fact that expected movements in q affects both the real profit rate and the expected capital gains, while movements in the exchange rate only affects expected capital gains, as can be seen in the arbitrage equation below:

$$i - \dot{p}^*/p = \rho/q + \dot{q}^*/q = \bar{r} + \dot{e}^*/e - \dot{p}^*/p$$

The initial jump in the price of stocks increases investment spending. The initial jump of the exchange rate makes domestic goods more competitive. Both effects contribute to an increase in aggregate demand and create inflation. As the price level increases the economy returns to the steady state.

4. An Extension for Economies with less than full Employment.

This section extends the analysis to the case of economies described by IS/LM type models, where output is assumed to be determined by aggregate demand, yd:

(12) $$y = yd$$

We re-write the equation for the slow adjustment of prices:

(5') $$\dot{p}/p = -h(1 - yd/\bar{y}) = \theta(x - \bar{x}) + \phi(q - \bar{q})$$

where $\bar{y}$ is the steady state level of output and h is the speed of adjustment of prices. It follows that:

(13) $$yd/\bar{y} - 1 = (\theta/h)\ (x - \bar{x}) + (\phi/h)\ q - \bar{q})$$

We next consider the cyclical behaviour of profits. IS/LM models assume mark-up pricing and a constant capital stock. Those assumptions imply that profits per unit of physical capital are an increasing function of output:

(14) $$\rho = ay$$

We substitute (12) and (14) in the system of differential equations formed by (6)-(8). Linearization of this system around its steady state gives:

$$\begin{bmatrix} \dot{q} \\ \dot{x} \\ \dot{m} \end{bmatrix} + \begin{bmatrix} \bar{q}\phi - \bar{r} & \bar{q}\theta & \bar{r}\bar{q}/\bar{m} \\ \bar{x}\phi\gamma & \bar{x}\theta\gamma & \bar{r}\bar{x}/\bar{m} \\ \bar{m}\phi & \bar{m}\theta & 0 \end{bmatrix} \begin{bmatrix} q - \bar{q} \\ x - \bar{x} \\ m - \bar{m} \end{bmatrix} = 0$$

where: $\gamma \equiv 1 - \bar{r}/h$.

This system has three characteristic roots: $z_1 = \bar{r}$ and $z_{2,\ 3} = -\ F \pm (F^2 + \bar{r}\bar{x}\theta)^{\frac{1}{2}}$, where $F \equiv (\bar{q}\phi + \bar{x}\theta\gamma)/2$. As before, two roots are prositive and one is negative. The steady state is a saddle point equilibrium.

We can distinguish two cases. If prices move fast, $h > \bar{r}$ and $1 > \gamma > 0$. We call the absolute value of the negative root in this case $\bar{z}$.

If prices move very slowly, $h < \bar{r}$, $\gamma < 0$ and $\bar{q}\phi < \bar{x}\theta|\gamma|$. We call the absolute value of the negative root under those last assumptions $\bar{\bar{z}}$.

We can immediately verify that $\bar{\bar{z}} < \bar{z} < \lambda$, where λ is the absolute value of the negative root in the model with full employment. We conclude that the speed of adjustment in response to monetary shocks in an economy with less than full employment is slower than in the case of fully employed economies. During the adjustment process to the steady state, in addition to inflation (or deflation) we also observe levels of activity above (or below) the activity level in steady state.

For economies with less than full employment where prices move relatively fast, the equations of motion along the stable arm are:

(15) $$m(t) = [m(0) - \bar{m}]\, e^{-\bar{z}t} + \bar{m}$$

(16) $$q(t) = (\bar{q}/\bar{m})\, m(t)$$

(17) $$x(t) = (\bar{x}/\bar{m})\, H\, [m(t) - \bar{m}] + \bar{x}$$

where: $H \equiv 1 + \bar{r}[(1/\bar{z})-(1/h)]$.

If prices move fast, h is large and $H > 0$. In this case, the effects of a monetary expansion are qualitatively the same as in the case of the fully employed economy. It leads to an overshooting of the exchange rate, a jump of the price of stocks and an increase in aggregate demand. To the inflationary effects obtained in the fully employed economy we must now add an output expansion. The increase in output increases demand for real balances leading to an initial reduction of the interest rate that is smaller than in the case of the fully employed economy. It follows that the overshooting of the exchange rate in the present case is smaller than in the case of the fully employed economy.[1]

Note that in (10) and (16), q(0) is the same. This puzzling result can be readily understood. The expected cyclical profits that did not exist in the full employment case, are now discounted at higher interest rates, arising from the cyclical increase in the demand for real cash balances.

5. Conclusions

The model developed in this paper is also useful in the analysis of fiscal policies and of external shocks. Consider, for instance, an increase in the steady state foreign interest rate. It raises expected domestic interest rates by the same amount, reducing demand for real cash balances: the exchange rate immediately depreciates and the price of stocks immediately falls. As a consequence the composition of aggregate demand changes, as net exports substitute for investment spending.

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[1] Observe that $H < B$. In economies where prices move very slowly, the possibility of undershooting arises. For this perverse case to obtain, the elasticity of aggregate demand in relation to the real price of capital has to be large enough to generate an income expansion and thus an increase in the demand for money that would exceed the initial expansion in real balances.

The main argument of the paper is that the channels of transmission in the open economy with flexible exchange rates include both the exchange rate and the price of stocks.

The results derived in this paper are important for policy. We have shown that, even under the assumption of a small open economy, of perfect capital mobility and perfect substitution among assets, monetary policy still affects the price of capital and investment spending if prices are not fully flexible in the short run.

Appendix

Linearization of the system formed by (6)-(8) gives:

$$\begin{bmatrix} \dot{q} \\ \dot{x} \\ \dot{m} \end{bmatrix} + \begin{bmatrix} -\bar{r}+\bar{q}\phi & \bar{q}\theta & \bar{r}\bar{q}/\bar{m} \\ \bar{x}\phi & \bar{x}\theta & \bar{r}\bar{x}/\bar{m} \\ \bar{m}\phi & \bar{m}\theta & 0 \end{bmatrix} \begin{bmatrix} q-\bar{q} \\ x-\bar{x} \\ m-\bar{m} \end{bmatrix} = 0$$

The system has three roots. λ_1 and λ_2 are positive. λ_3 is negative.

To obtain equations (9), (10) and (11) we solve the system:

$$\begin{matrix} \text{(i)} \\ \text{(ii)} \\ \text{(iii)} \end{matrix} \begin{bmatrix} \bar{q}\phi - \bar{r} + \lambda_3 & \bar{q}\theta & \bar{r}\bar{q}/\bar{m} \\ \bar{x}\phi & \bar{x}\theta + \lambda_3 & \bar{r}\bar{x}/\bar{m} \\ \bar{m}\phi & \bar{m}\theta & \lambda_3 \end{bmatrix} \begin{bmatrix} N_1 \\ N_2 \\ N_3 \end{bmatrix} = 0$$

Substitution of (iii) in (ii) gives:

(iv) $$N_2 = B(\bar{x}/\bar{m})\, N_3 \qquad ; \text{ where } B \equiv 1 + r/\lambda,$$

and $\lambda \equiv |\lambda_3|$.

Substitution of (iv) in (i) gives:

$$N_1 = -\,(\bar{q}/\bar{m})\ [(B\bar{x}\,\theta + \bar{r})/(\bar{q}\phi + \lambda_3 - \bar{r})]\ N_3$$

Observe that $[(B\bar{x}\,\theta + \bar{r})/(q\,\phi + \lambda_3 - \bar{r})] = -1$, since:

$\lambda_3^2 + (\bar{q}\,\phi + \bar{x}\,\theta)\,\lambda_3 - \bar{x}\bar{r}\,\theta = 0.$

The choice of the initial money stock establishes the value of N_3 and equations (9), (10) and (11) immediately follow.

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