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Exchange Rate Regimes and the Real Exchange Rate

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Abstract

It is well established now that the (nominal) exchange rate regime has important implications for the behavior of real exchange rates. Two key stylized facts in this regard are that real exchange rate variability is greater under flexible exchange rates than under fixed exchange rates and that real and nominal exchange rate movements are positively related under flexible exchange rates. One class of models that are consistent with these observations are sticky price models. This paper constructs an equilibrium model of real and nominal exchange rate determination that is capable of explaining these observed facts without resorting to differences in other policies across regimes. The paper thus shows that there is an inherent tendency, due solely to the difference in monetary adjustment mechanisms across alternative exchange rate regimes, for real exchange rates to exhibit greater variability under flexible exchange rates and this tendency turns out to be compatible with the observed positive correlation between real and nominal exchange rates. The model relies on the inflation tax mechanism and the impact of temporary, country-specific shocks to generate these results.

I. Introduction

Choices among alternative exchange rate regimes are thought to be important because they influence the behavior of real variables and alter the

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real impact of other policies. For example, the exchange rate regime has been argued to be an important determinant of the efficacy of monetary and fiscal policies ⟨see Mundell [1963]⟩, the stability of real output ⟨see Kimbrough [1984]⟩, the volume of trade ⟨see Persson and Svensson [1989]⟩, and the behavior of relative prices such as the real exchange rate. In recent years this last issue, the implications of the exchange rate regime for the behavior of real exehange rates, has been the subject of extensive discussion.

Work by Stockman [1983] and Mussa [1986] has clearly established that the behavior of real exchange rates is significantly affected by the (nominal) exchange rate regime. In fact, Baxter and Stockman [1989] argue that, except for the behavior of real exchange rates, there is little evidence to suggest that the choice between fixed and flexible exchange rates matters for the behavior of macroeconomic aggregates and international trade flows. These results suggest that it is important for open economy macro models to explain the differences in the behavior of real exchange rates across exchange rate regimes. The attractiveness of broad classes of models will be considerably diminished if they are not able to explain the observed impact of the exchange rate regime on real exchange rates. Two key stylized facts emerging from the three papers cited above are that the variability of real exchange rates is greater under flexible exchange rates than it is under fixed exchange rates and real and nominal exchange rates are positively correlated under flexible exchange rates. Attractive approaches to open economy macroeconomic questions need to be able to be structured and parameterized to be consistent with these two empirical observations.

Mussa [1986] argues that one class of models that is consistent with these observations are those assuming that national price levels adjust sluggishly compared to the speed with which exchange rates adjust under flexible exchange rates. These "sticky price" models explain the difference in the behavior of real exchange rates under fixed and flexible exchange rate systems in the following manner. When exchange rates are fixed real exchange rate variability is low as a consequence of price level stickiness and the pegging of nominal exchange rates. However, when exchange rates are flexible real exchange rate variability increases substantially reflecting the variability of market determined exchange rates combined with the continued sluggishness of national price levels. Given the continued sluggishness of national price levels, movements in the real exchange rate under flexible exchange rates are dominated by nominal exchange rate movements. This accounts for the observed positive correlation between real and nominal exchange rates under flexible exchange rates.

Stockman [1987, 1988] considers the possibility that an entirely different class of models, other than those of the sticky price variety, may be able to explain the difference in the variability of real exchange rates across alternative exchange rate regimes. His argument is based on the notion that the fundamental difference in the monetary adjustment mechanism across alternative exchange rate regime leads countries to adopt different trade policies under different exchange rate regimes. It is the difference in trade policies across exchange rate regimes that accounts for the difference in the behavior of real exchange rates across exchange rate regimes.

Stockman's explanation is as follows. Fluctuations in real exchange rates are driven by shocks that shift the supply of and demand for goods. Under flexible exchange rates these shocks also affect the nominal exchange rate since it is the adjustment mechanism maintaining money market equilibrium. The simultaneous adjustment of real exchange rates to clear goods markets and of nominal exchange rates to clear money markets accounts for the correlation between real and nominal exchange rates under flexible exchange rates. Under fixed exchange rates international reserve flows through the balance of payments replace the exchange rate as the monetary adjustment mechanism. Shocks that would have depreciated a country's currency under flexible exchange rates cause a loss of international reserves under fixed exchange rates. When these losses are substantial countries are more likely to implement protective trade policies such as tariffs, quotas, or foreign exchange controls in order to prevent further international reserve losses. When reserve losses are substantial consumers thus expect future prices to be higher because of the increased likelihood that protective trade policies will be enacted. This causes consumers to substitute away from future goods and towards current goods. Current and future prices must adjust to clear current and future goods markets and these adjustments turn out to stabilize the real exchange rate. Stockman thus argues that the expectation that trade policies will be implemented to stop international reserve losses stabilizes real exchange rates when exchange rates are fixed and that this accounts for the observed greater variability of real exchange rates under flexible exchange rates.

The equilibrium explanation of the effects of the exchange rate regime on the behavior of real exchange rates Stockman offers is appealing to proponents of open economy macroeconomic models that do not incorporate sticky prices. It depends solely on the interaction of the differences in the monetary adjustment mechanism and prospective trade policies across alternative exchange rate regimes. However, given the universal tendency for differences in the exchange rate regime to be associated with differences in the behavior of real exchange rates, it is important to demonstrate that, differences in other policies aside, flexible exchange rate systems have an inherent tendency to be associated with greater real exchange rate variability. That is, it is important to demonstrate that by itself the difference in the monetary adjustment mechanism across alternative exchange rate regimes can account for the observed effects of the exchange rate regime on real exchange rate behavior. The aim of this paper is to demonstrate that this can be accomplished in a model that does not rely on sticky prices.

The paper outlines an equilibrium model of real and nominal exchange rate determination in which monetary shocks have real effects via an inflation tax channel. ⟨See Aschauer and Greenwood [1983] and Kimbrough [1990, 1993] for other open economy models emphasizing the importance of the inflation tax.⟩ The world economy is comprised of a large number of identical country's producing and consuming nontraded goods. There are both real and monetary shocks in the model, shocks of both types being country-specific and temporary. Domestic credit policy is such that the monetary authorities attempt to keep the supply of domestic credit on a pre-announced path. Therefore, a negative monetary shock this period raises the expected rate of monetary growth since consumers anticipate a monetary correction over the next period to return the stock of domestic credit to its planned path.

The exchange rate regime affects the behavior of real exchange rates in the following manner. Suppose there is a negative shock to a country's money supply. Under fixed exchange rates this country-specific shock is absorbed by the balance of payments and has no effects on the country's real exchange rate. However, since shocks are temporary, a negative money supply shock raises the expected rates of currency depreciation and inflation as well as the domestic nominal interest rate under flexible exchange rates. A negative money supply shock thus alters the inflation tax rate when exchange rates are flexible and this adds to the variability of real exchange rates. Real exchange rate variability is greater under flexible exchange rates because country-specific shocks which alter the inflation tax rate, adding an additional source of real variability, under flexible exchange rates are absorbed by the balance of payments mechanism under fixed exchange rates. The difference in the monetary adjustment mechanism across alternative exchange rate regimes is thus by itself potentially able to explain the observed influence of the exchange rate regime on the behavior of real exchange rates.

The paper is organized as follows. The basic features of the world economy are introduced in Section II. The consumer's problem is treated in Section III. Equilibrium in the world economy is discussed in Section IV while Sections V and VI look at the characteristics of world equilibrium under fixed and flexible exchange rate regimes. The effects of the exchange rate regime on the behavior of real exchange rates are discussed in Section VII.

II. The World Economy

Consider a world economy comprised of $N + 1$ countries that are identical in all respects. For expositional purposes, the $N + 1$st country is taken to be the home country. Each country is small and thus takes world prices and interest rates as given and free trade prevails in the world's markets for goods and assets.

Each country produces and consumes both traded and nontraded goods. The home country's output of traded goods, y_{Tt}, is exogenously given but fluctuates randomly over time. Traded goods output is identically and independently distributed across time and across countries. That is, shocks to traded goods output are country-specific and serially uncorrelated. The density functions for traded goods output, however, are the same across countries. Mean traded goods output in any country in any period is y_T. The home country's output of nontraded goods in period t, y_{Nt}, is determined by the sector's labor input according to the production function

$$y_{Nt} = g(\ell_t), \tag{1}$$

where ℓ_t is period t labor supply. Labor's marginal product is positive and diminishing. [*i.e.*, $g'(\cdot) > 0$ and $g''(\cdot) < 0$.] The production function $g(\cdot)$ is the same for all countries.

The specification of production here, which treats only nontraded goods output as endogenous, considerably simplifies the exposition. The behavior of the output of traded goods might be explained by viewing traded goods as being produced by a fixed factor, capital say, whose productivity is subject to random shocks. Thought of in this way the model can be viewed as incorporating, in an extreme manner, the stylized fact that the production of nontraded goods is more labor intensive than is the production of traded goods. In any event, the basic results continue to hold for alternative specifications of the production technology.

Besides fluctuations in the output of traded goods, the only other shocks to the world economy are monetary shocks. These shocks are independent of the shocks to traded goods outputs and are identically and independently distributed across countries. The nature of these shocks is detailed below. However, it is worth noting here that, given the way money enters the model, monetary shocks have real effects. One implication of this is that even though the production functions for nontraded goods are the same across countries output levels will not be the same because different realizations of the monetary shocks affect labor supply.

The representative home country consumer is interested in maximizing lifetime utility which is given by

$$E_0\left\{\sum_{t=0}^{\infty}\beta^t\left[U(c_{Tt})+V(c_{Nt})-H(\ell_t)\right]\right\} \tag{2}$$

where c_{jt} represents consumption of good j, $0 < \beta < 1$ is the subjective discount factor, and $E_t[\cdot]$ denotes an expectation conditioned on the period t information set. This information set consists of all variables dated t and earlier. Consumers thus base their expectations not only on knowledge of current market prices and interest rates but also on current monetary shocks and shocks to traded goods output. The subjective discount factor β is the same for all countries as are the instantaneous utility functions $U(\cdot)$, $V(\cdot)$, and $H(\cdot)$. For both goods the marginal utility of consumption is positive and diminishing. [*i.e.*, $U'(\cdot)$, $V'(\cdot) > 0$ and $U''(\cdot)$, $V''(\cdot) < 0$.] The marginal disutility of labor is positive and increasing. [*i.e.*, $H'(\cdot) > 0$ and $H''(\cdot) > 0$.]

Besides international trade in goods there is also international trade in a wide variety of assets. There is trade in one-period nominal bonds with domestic nominal bonds offering a return of R_t in period $t + 1$ and nominal bonds denominated in country i's currency paying a return of R^*_{it}. There is also trade in claims to shares of each countries traded goods output. The ex-dividend price of domestic equities is q_t. Foreign equities are priced at q^*_{it}. There are also spot and forward markets for foreign exchange. The spot price of currency i in terms of the domestic currency is e_{it} and the forward price of currency i in terms of the domestic currency is f_{it}.

Trade in currencies is motivated by the fact that goods must be purchased with the seller's currency. That is, money holdings are motivated via cash-in-advance constraints as in Helpman [1981], Lucas [1982], and Stockman and Dellas [1989]. Following their convention, it is assumed that nominal interest rates in all currencies are always positive. This means that the cash-in-advance constraints will hold as equalities since there is no benefit to balance the opportunity cost of using money as a store of value.[1] At the start of each period previously contracted debts are settled, dividends are paid to equity holders, new debts are contracted, and trade in equities and currencies takes place. The asset markets then shut down and consumers enter the goods market part of the period. Goods are produced and sold to consumers, all transactions taking place in the seller's currency. Since asset markets are closed, consumers must use cash they have already acquired to purchase goods. The cash collected from the sale of goods during the period is then used to pay domestic consumers who own the firms in the non-traded sector (since nontraded equities are not explicitly introduced) and to finance next period's dividend payments on traded goods equities.

1. Svensson [1985] considers an open economy in which the timing of information and transactions gives rise to a precautionary demand for money so that the cash-in-advance constraints are not always binding. In such an environment money holdings vary inversely with the nominal interest rate rather than being unresponsive to interest rate changes as is the case here.

III. Consumer Optimization

The representative consumer's problem is to maximize lifetime utility as given by (2) subject to (1) and the sequence of budget constraints

$$\begin{aligned} c_{Tt} + p_t c_{Nt} + q_t' z_t + \frac{B_t}{P_{Tt}} + \frac{e_t' B_t^*}{P_{Tt}} &= (q_t' + d_t') z_{t-1} + \frac{P_{Nt-1} y_{Nt-1}}{P_{Tt}} \\ &+ \frac{(1+R_{t-1})B_{t-1}}{P_{Tt}} + \frac{e_t'(I + R_{t-1}^*)B_{t-1}^*}{P_{Tt}} + \left[\frac{f_{t-1}' - e_t'}{P_{Tt}}\right] A_{t-1} + \frac{T_t}{P_{Tt}} \end{aligned} \quad (3)$$

where P_{Tt} (P_{NT}) is the domestic currency price of traded (nontraded) goods, $p_t \equiv P_{Nt}/P_{Tt}$ is the relative price of nontraded goods, q_t is a vector of asset prices, z_{t-1} is the vector of assets held by the consumer at the start of the period, B_{t-1} is the amount of domestic currency bonds held at the start of the period, B_{t-1}^* the vector of foreign currency bond holdings, d_t the vector of dividends paid on assets, e_t and f_t vectors of spot and forward exchange rates, A_{t-1} the vector of net foreign currency sales in the forward market contracted at time $t-1$ and settled in period t, T_t a lump-sum monetary transfer, R_{t-1}^* an $N \times N$ diagonal matrix of nominal interest rates on foreign currency bonds, and I is the identity matrix.

In addition to nominal bonds denominated in each currency households also have access to equities which represent claims to a share of each countries traded goods output and to assets that are effectively indexed to each countries monetary transfer. These assets are included in the vector z_t. Since there are $N+1$ countries in the world there are $2N+2$ assets in this vector. The first $N+1$ assets in the vector z_t are the equities representing claims to a share of each countries traded goods output held by home country residents.

Consumer maximization of (2) subject to (1) and (3) yields the following marginal conditions which must hold at an optimum:

$$U'(c_{Tt}) = \lambda_t, \quad (4)$$

$$V'(c_{Nt}) = \lambda_t p_t, \quad (5)$$

$$H'(\ell_t) = \beta P_{Nt} g'(\ell_t) E_t[\lambda_{t+1}/P_{Tt+1}], \quad (6)$$

$$\lambda_t q_{it} = \beta E_t\left[\lambda_{t+1}(q_{it+1} + d_{it+1})\right], \; i = 1, \ldots, 2N+2, \tag{7}$$

$$\lambda_t / P_{Tt} = \beta(1+R_t)E_t\left[\lambda_{t+1} / P_{Tt+1}\right], \tag{8}$$

$$\lambda_t e_{it} / P_{Tt} = \beta(1+R_{it}^*)E_t\left[\lambda_{t+1}e_{it+1} / P_{Tt+1}\right], \; i = 1, \ldots, N, \tag{9}$$

$$E_t\left[\lambda_{t+1}(f_{it} - e_{it+1}) / P_{Tt+1}\right], \; i = 1, \ldots, N, \tag{10}$$

where λ_t is the multiplier associated with the period t budget constraint.

Conditions (4) and (5) imply that within each period consumers choose their consumption of traded and nontraded goods so that the marginal rate of substitution between the two goods equals the relative price of nontraded goods:

$$V'(c_{Nt}) / U'(c_{Tt}) = p_t \tag{11}$$

The first-order conditions (4) and (7) imply that at an optimum

$$q_{it} = \beta E_t\left[\frac{U'(c_{Tt+1})(q_{it+1} + d_{it+1})}{U'(c_{Tt})}\right] \tag{12}$$

for $i = 1, \ldots, 2N+2$. This intertemporal condition is familiar from consumption based asset pricing models. In fact, by repeated substitution it can be seen that

$$q_{it} = \sum_{s=t}^{\infty} \beta^{s-t} \cdot E_t\left[U'(c_{Ts})d_{is} / U'(c_{Tt})\right], \; i = i, \ldots 2N+2.$$

This condition implies that, in terms of traded goods, asset prices are equal to the present value of their dividend stream.

The labor-leisure choice confronting consumers can be understood by using (8) and then (4) in (6) to obtain

$$\frac{H'(\ell_t)}{U'(c_{Tt})} = \frac{p_t g'(\ell_t)}{1+R_t} \tag{13}$$

Equation (13) highlights the channel through which monetary shocks have real effects in the model. In a barter economy the marginal rate of substitution between labor effort and traded goods, $H'(\ell_t)/U'(c_{Tt})$, would be set equal to the value of labor's marginal product in terms of traded goods, $p_t g'(\ell_t)$. However, in the monetary economy considered here the cash-in-advance constraint means that labor's earnings from goods produced and sold during period t are not available for consumption purposes until period $t+1$. As a consequence, workers view the effective real wage as being equal to the discounted value of labor's marginal product, $p_t g'(\ell_t)/(1+R_t)$, the discount factor being the nominal interest rate since the cash-in advance constraint requires that workers be paid in cash. There is thus an effective tax on labor at the rate $R_t/(1+R_t)$. Since this tax wedge is influenced by monetary policy through the effects of inflation on the nominal interest rate it is known as the inflation tax. In the world economy being considered here it is only via this inflation tax mechanism that monetary shocks have real effects.

Finally, equations (8)-(10) can be used to show that the covered interest parity condition,

$$1+R_t=(f_{it}/e_{it})(1+R_{it}^*) \tag{14}$$

holds at all times.

IV. Equilibrium in the World Economy

Equilibrium in the world economy requires that the markets for traded and nontraded goods clear. The home country's nontraded goods market clears when

$$c_{Nt}=y_{Nt}. \tag{15}$$

A similar condition must hold in all other countries. Equilibrium in the market for traded goods requires that the world supply of and demand for traded goods be equal and also that the the supply of and demand for each individual country's traded goods be equal. This latter condition, in conjunction with utility maximization on the part of consumers, implies that the goods market arbitrage conditions

$$P_{Tt}=e_{it}P_{iTt}^*\ ,\ i=1,\ \ldots,\ N, \tag{16}$$

hold in all periods.[2]

In addition to goods market equilibrium, equilibrium in the world economy also requires that world asset markets clear. This requires that all of the claims to each countries traded goods output be held, that bond markets clear, and that the demand for and supply of each currency be equal. Given that the cash-in-advance constraints hold with equality, and that goods markets clear, the demand for the domestic currency is simply $P_{Tt}y_{Tt} + P_{Nt}y_{Nt} = P_{Tt}(y_{Tt} + p_t y_{Nt})$. Money market equilibrium thus requires that

$$M_t = P_{Tt}(y_{Tt} + p_t y_{Nt}) \ ,$$

where M_t is the period t money supply. Given the symmetry between countries in the model, it should be apparent that the home country's trade weighted exchange rate can be defined as

$$e_t \equiv \frac{1}{N} \cdot \sum_{i=1}^{N} e_{it} \ .$$

Using this and the traded goods market arbitrage condition (16), the condition for money market equilibrium can conveniently be written as[3]

$$M_t = e_t P^*_{Tt}(y_{Tt} + p_t y_{Nt}) \ , \qquad (17)$$

where $P^*_{Tt} \equiv (\sum e_{it}P^*_{iTt}) / (\sum e_{iT})$ is the "average" foreign currency price of traded goods facing the home country. Conditions similar to (17) must hold abroad for the markets for all foreign currencies to clear.

In the next two sections of the paper the focus is on the behavior of real exchange rates under fixed and flexible exchange rate regimes. Under a fixed exchange rate regime the exchange rate is pegged by the monetary authorities and the money supply adjusts endogenously via the balance of

2. Conditions (16) imply that goods market arbitrage holds between any pair of countries. For instance, $P^*_{jTt} = (e_{it}/e_{jt})P^*_{iTt}$. Triangular arbitrage in the foreign exchange market implies that e_{it}/e_{jt} is the price of currency i in terms of currency j.

3. Writing the money market equilibrium condition in this manner is convenient because it allows for a discussion of "the" nominal exchange rate even though there are in fact numerous nominal exchange rates for each currency.

payments mechanism in order to maintain money market equilibrium.[4] By contrast, under a flexible exchange rate regime the money supply is chosen by the monetary authorities and the exchange rate, e_t, adjusts to clear the money market.

Although the adjustment mechanism differs across regimes, the monetary authority is able to control the supply of domestic credit under both fixed and flexible exchange rates. Hence, monetary policy consists of a choice of an exchange rate regime *and* a domestic credit rule. The domestic credit rule is taken to be the same under both fixed and flexible exchange rates. It is assumed that in the initial period the monetary authority in each country announces a planned path for domestic credit but that the realized levels of domestic credit in any period are subject to random shocks. However, consumers expect that the monetary authority will act to correct these random fluctuations in the following period in order to return the supply of domestic credit to the preannounced path. The preannounced path for domestic credit is the same across countries, in the sense that there is a common planned growth rate of domestic credit in all countries, and the distribution of random shocks is the same across countries.

These assumptions about monetary policy mean, for example, that under a flexible exchange rate system, where international reserves are not needed to fix the exchange rate, the money supply process is given by

$$M_t = (1+\omega_t)M_t^0 \tag{18}$$

where M_t^0 is the money stock initially planned for period t and ω_t is the (proportional) shock to the period t money supply. The money shock ω_t is serially uncorrelated. The money supply rule (18) implies that when today's money supply is low, *i.e.* when $\omega_t < 0$, the expected rate of growth of the money supply over the next period will be high since the monetary authority is expected to return the money supply to the initially planned level for next period. To see this formally, note that

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4. The model's symmetry can be maintained by thinking of the fixed exchange rate system as being supported by a gold standard where all countries are committed to pegging the price of gold in terms of their own currency rather than by a reserve-currency system.

$$E_t\left[\frac{M_{t+1}-M_t}{M_t}\right]=\frac{(1+\omega_t)^{-1}M_{t+1}^0-M_t^0}{M_t^0}\ .$$

This negative relationship between the shock to the current money stock and the expected money supply growth rate plays a key role in the results concerning the correlation between real and nominal exchange rates under a flexible exchange rate regime that are established in Section VI of the paper.

V. Equilibrium under a Fixed Exchange Rate Regime

The symmetry across countries, particularly the fact that they are assumed to follow the same domestic credit policies, means that a fixed exchange rate system is viable provided that the planned growth rate of domestic credit is not too high. For this to be the case, the growth rate of domestic credit must not exceed the equilibrium world real interest rate.[5] When this condition is met, central banks throughout the world will always be solvent and thus will always be able to borrow international reserves in order to defend their fixed exchange rates when random events, both real and monetary, lead to sustained periods of balance of payments deficits.

Certain aspects of the world economy's real equilibrium under fixed exchange rates are quite straightforward. In the initial period, $t = 0$, all countries are identical. The real and monetary shocks that occur during the period are temporary in nature and thus do not affect any country's future prospects. In light of this, each country will purchase an equal share of each country's traded goods equities. Furthermore, this argument can be repeated for any future period implying that portfolio shares will not change over time. That is, equilibrium equity holdings for home country consumers are $z_t \equiv (z_{1t}, \dots, z_{N+1t}) = [\,1/(N+1), \dots, 1/(N+1)\,]$.[6] The same equity portfolio is held by all foreign consumers.

As a consequence of these asset market transactions, each country will consume its share of world traded goods output in each period. Since traded

5. See Obstfeld [1986] for the derivation and discussion of this result.
6. See Lucas [1982] and Stockman and Dellas [1989]. This is the only equity portfolio that satisfies the transversality conditions associated with the consumer's problem.

goods market shocks are country specific, each country's traded goods consumption will be constant and equal to the mean level of traded goods output, y_T. The availability of traded goods equities means that each country's consumption of traded goods is divorced from its country-specific realization of traded goods output.

Given that a sustainable fixed exchange rate regime is in effect, the potential impact of domestic credit shocks on the home economy will be eliminated by the balance of payments mechanism. In particular, actual and expected rates of inflation as well as the home nominal interest rate will depend on the world average rate of domestic credit expansion and not on the realized rate of domestic credit expansion in the home country. Realized levels of domestic credit will instead affect the balance of payments. For example, a low realization of ω_t leads to a low money supply and thus requires a balance of payments surplus to restore money market equilibrium.

Since the world economy is comprised of a large number of countries with identical domestic credit plans, the world average growth rate of domestic credit will be constant and equal to the planned rate of domestic credit expansion in each individual country. This means that nominal interest rates will be constant over time. The key implication of this is that under fixed exchange rates a country's own domestic credit shocks do not have any real effects. This can be seen from equation (13) which captures the inflation tax channel through which monetary policy influences real activity. Since the nominal interest rate is constant and determined by world market conditions, and since the home country has no perceptible impact on these conditions given that it is a small country, the inflation tax mechanism is effectively shutoff as a channel through which domestic monetary policy can influence real variables under a fixed exchange rate regime. (Of course changes in world monetary conditions would have real effects via the inflation tax channel.)

These results imply that under a fixed exchange rate system the real exchange rate is constant. To see this formally, note that (11), (13), (14), (15), and the facts that $c_{Tt} = y_T$ and $y_{Nt} = g(\ell_t)$ imply that in equilibrium

$$\frac{V'[g(\ell_t)]}{U'(y_T)} = p_t \quad \text{and} \quad \frac{H'(\ell_t)}{U'(y_T)} = \frac{p_t g'(\ell_t)}{1+R_t^*} \ ,$$

where use has been made of the fact that $f_{it} = e_{it+1} = e_{it}$ and all foreign nominal interest rates share the common value R_t^* due the fixed exchange rate regime. These two conditions can be solved for the equilibrium relative price of nontraded goods and equilibrium labor supply. Since, as just noted, the nominal interest rate is constant over time, the equilibrium relative price of nontraded goods and equilibrium labor supply are constant under fixed exchange rates.

Fluctuations in the real exchange rate are inversely related to changes in the relative price of nontraded goods but since the relative price of nontraded goods is constant under a fixed exchange rate regime so too is the real exchange rate. This result reflects the interaction of the menu of available assets, the exchange rate regime, and the nature of real and monetary shocks in the world economy. All shocks have been taken to be both temporary and country-specific. The fixed exchange rate regime smooths out the potential real effects of country-specific monetary shocks while the availability of equities allows for real shocks to be smoothed. The constancy of the real exchange rate under a fixed exchange rate system provides a useful benchmark against which to compare a flexible exchange rate regime.[7]

VI. Equilibrium under a Flexible Exchange Rate Regime

Suppose now that the world monetary system is based on a system of flexible exchange rates. In this case the equilibrium equity portfolio and consumption of traded goods is the same as under fixed exchange rates. However, the nominal exchange rate is now the adjustment mechanism that maintains money market equilibrium. This turns out to have important implications for the behavior of the real exchange rate.

Before turning to a formal presentation of the results, it is useful to sketch the intuition underlying them. For example, assume that there is a negative shock to the current home money supply so that it is is lower than

7. Changing the nature of either the real or monetary shocks would, of course, change this feature of the fixed exchange rate equilibrium. For example, if traded goods output shocks had a common component as well as a country-specific component the relative price of nontraded goods, and hence the real exchange rate, would vary over time reflecting the temporary changes in the relative scarcity of traded goods.

was previously expected. Given the money supply rule (18), this shock is accompanied by an increase in the expected rate of growth of the home money supply so that the money stock can return to its planned path. These changes tend to appreciate the nominal exchange rate and to lower the domestic price level (relative to previously expected values). However, since the expected future money stock is not affected by the shock to the current money supply, future levels of the nominal exchange rate and prices are unchanged. Therefore, the expected rate of depreciation of the home currency and the expected rate of home inflation tend to rise in response to the current money shock. This in turn raises the domestic nominal interest rate, altering the relative price of nontraded goods and domestic labor supply via the inflation tax channel.

To see this formally, note that, using (16), (6) can be rewritten as

$$H'(\ell_t) = x_t e_t p_t g'(\ell_t) \tag{19}$$

where $x_t \equiv \beta P^*_{Tt} E_t[\lambda_{t+1}/P_{Tt+1}]$. The term x_t does not depend on the realized value of current period domestic shocks since the country is small, and hence cannot influence P^*_{Tt}, and since the shocks are temporary, and thus do not affect current expectations of future conditions as summarized by $E_t[\lambda_{t+1}/P_{Tt+1}]$.[8] In addition, consumer equilibrium and equilibrium in the market for nontraded goods require that the relative price of nontraded goods satisfy the condition

$$V'[g(\ell_t)]/U'(y_T) = p_t\,. \tag{20}$$

Equations (19) and (20) imply that the equilibrium relative price of nontraded goods and the equilibrium labor supply are functions of the nominal exchange rate (as well as x_t and y_T which are suppressed since they are independent of domestic shocks). The implied functions are

$$p_t = p(e_t) \quad \text{and} \quad \ell_t = \ell(e_t)\,, \tag{21}$$

where

8. The x_t term will change over time if money growth causes nominal prices to rise over time.

$$\frac{\partial p_t}{\partial e_t} = \frac{V'' x_t p_t (g')^2}{U' \cdot (H'' - x_t e_t p_t g'') - V'' \cdot (g')^2 x_t e_t} < 0 \ ,$$

$$\frac{\partial \ell_t}{\partial e_t} = \frac{U' x_t p_t g'}{U' \cdot (H'' - x_t e_t p_t g'') - V'' \cdot (g')^2 x_t e_t} > 0 \ ,$$

Changes in the level of the nominal exchange rate have real effects as captured by (21) because they are associated with changes in rates of money growth, the rate of depreciation of the home currency, and the rate of inflation which alter the nominal interest rate thereby shifting the inflation tax rate $R_t/(1+R_t)$.

However, the nominal exchange rate itself is an endogenous variable under a system of flexible exchange rates, adjusting to maintain money market equilibrium in the face of both real and monetary shocks. The money market equilibrium condition (17) requires that the nominal exchange rate satisfy the condition

$$e_t = \frac{M_t}{P^*_{Tt}\left\{y_{Tt} + p(e_t) g\left[\ell(e_t)\right]\right\}} \ , \tag{22}$$

where use has been made of (1) and (21).

From (22) it is apparent that a negative shock to the money supply creates an excess demand for money. In order to restore money market equilibrium the domestic currency will have to appreciate (*i.e.* e_t will fall) unless the price elasticity of demand for nontraded goods is very low. This can be seen by noting that, as captured by the left-hand side of (22), an appreciation of the domestic currency works to restore money market equilibrium in the face of a negative money supply shock by directly lowering the demand for money. However, indirectly an appreciation of the nominal exchange rate works to raise the demand for money if the price elasticity of demand for nontraded goods is less than one. In this case, the rise in the relative price of nontraded goods associated with the increased inflation tax arising from a nominal exchange rate appreciation, recall (21), works to raise the value of nontraded goods output thereby increasing the demand for money. If this indirect effect is strong enough the nominal exchange rate will actually depreciate in response to a negative money supply shock. The conventional result, that a negative money supply shock leads to an appreciation of the nominal exchange rate, holds so long as the direct effects of an exchange rate change on the demand for money dominate the the indirect effects. This must be true if the price elasticity of demand for nontraded goods exceeds one and will be true so long as this price elasticity is not too low.[9]

Under these same conditions a positive shock to the home country's traded goods output also causes an appreciation of the nominal and real exchange rates. Such a shock generates an excess demand for money by raising the value of home country output. Therefore, given the level of the money supply, the exchange rate must adjust to restore money market equilibrium. The exchange rate adjustment alters the relative price of nontraded goods in accord with (21). Again the reason is that the shock alters not only the level of the exchange rate but also the expected rates of depreciation and inflation thereby influencing the domestic nominal interest rate and the inflation tax rate. So long as the price elasticity of the demand for nontraded goods is not too low an appreciation of the nominal exchange rate will maintain money market equilibrium following a positive shock to the home country's traded goods output.

Assuming then that the price elasticity of demand for nontraded goods is not too low, the money market equilibrium condition (22) implies that

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9. Formally, note that the money market equilibrium condition (22) requires that the instantaneous proportional change in the exchange rate in response to a money supply shock satisfy

$$\hat{e}_t = \left[1 + \theta_N(\eta_{pe} + \eta_{y\ell}\eta_{\ell e})\right]^{-1} \bullet \hat{M}_t \ ,$$

where θ_N is the share of nontraded goods in output, a hat denotes a proportional hange in a variable, and η_{ab} is the elasticity of a with respect to b. Thus, for example, $\eta_{y\ell}$ is the elasticity of nontraded goods output with respect to labor supply as implied by (1). Using (1), (8), (11), (21), and the fact that $c_{Tt} = y_{Tt}$ in equilibrium, it can be shown that the previous expression can be rewritten as

$$\hat{e}_t = \frac{\hat{M}_t}{1 + \theta_N \eta_{pe}(1 - \eta_{Np})} \ ,$$

where $\eta_{Np} \equiv (-p_t U'/y_{Nt}v'') > 0$ is the price elasticity of demand for nontraded goods. [The demand for nontraded goods is implicitly given by (11) with $c_{Tt} = y_{Tt}$.] If the term $1 + \theta_N\eta_{pe}(1 - \eta_{Np})$ is positive then a negative money supply shock leads to an appreciation of the nominal exchange rate. This must be the case if $\eta_{Np} > 1$. [Recall from (20) that $\eta_{pe} < 0$.] Only if $\eta_{Np} << 1$ can the opposite result occur and a negative money supply shock result in a depreciation of the nominal exchange rate.

$$e_t = e(\underset{(+)}{M_t}, \underset{(-)}{y_{Tt}}) \ , \tag{23}$$

where the signs under each argument represent the effects of that variable on the nominal exchange rate. (These signs would be reversed if the price elasticity of demand for nontraded goods were taken to be low enough.) Finally, using (23) in (21) the effects of money supply and traded goods output changes on the relative price of nontraded goods are given by

$$p_t = \rho(\underset{(-)}{M_t}, \underset{(+)}{y_{Tt}}) \equiv p\left[e(M_t, y_{Tt})\right] \ . \tag{24}$$

(These signs would be reversed if the price elasticity of demand for nontraded goods were taken to be low enough.)

It is worth pointing out here that, although the qualitative effects of changes in the money supply and the output of traded goods on real and nominal exchange rates depend on the price elasticity of the demand for nontraded gods, condition (21) implies that the nominal exchange rate and the relative price of nontraded goods must move in opposite directions in response to these types of shocks. This is because the channel through which nominal exchange rate movements influence the relative price of nontraded goods in the model is the inflation tax channel. Temporary shocks which appreciate (depreciate) the nominal exchange rate are associated with increases (decreases) in the expected rates of inflation and currency depreciation that raise (lower) the domestic nominal-interest rate. Therefore, when the nominal exchange rate appreciates (depreciates) the inflation tax rate increases (decreases). This leads to a reduced (greater) labor supply and output of nontraded goods thereby raising (lowering) their relative price and appreciating the real exchange rate.

VII. Real Exchange Rates and the Exchange Rate Regime

As noted in the introduction, two widely accepted empirical facts generally dominate discussions of the effects of the exchange rate regime on the behavior of real exchange rates. First, the real exchange rate is more variable under a system of flexible exchange rates than it is under a fixed exchange rate system. This appears to be true even when the potential impact of differences in real and nominal shocks across alternative exchange rate regimes are taken into account. Second, real and nominal exchange rate movements are positively correlated under flexible exchange rates. The model outlined in the previous sections of the paper is consistent with these two empirical observations.

Consider first the variability of the real exchange rate under fixed and flexible exchange rate regimes. It was demonstrated earlier that when the world economy is operating under a fixed exchange rate system the relative price of nontraded goods, and hence the real exchange rate, is constant. However, under a flexible exchange rate system the real exchange rate varies in response to both real and nominal shocks. To see this, recall from (24) that the relative price of nontraded goods in the home country varies inversely with shocks to the domestic money supply and directly with shocks to the domestic output of traded goods. At the same time similar fluctuations are occurring abroad. Thus both home and foreign shocks have an impact on bilateral real exchange rates. However, since both real and monetary shocks are country-specific, the effects of foreign shocks on the home country's real exchange rate washout when considering the the trade-weighted real exchange rate. That is, due to the country-specific nature of real and monetary shocks in the model, the variability of each individual country's real exchange rate reflects only the underlying variability of its own country-specific shocks.

Since the real exchange rate is constant under fixed exchange rates but fluctuates in response to both real and monetary disturbances under flexible rates, the model clearly is consistent with the observed higher variability of real exchange rates under a system of flexible exchange rates than under a system of fixed exchange rates. The reason the model predicts a higher variability of real exchange rates under a flexible exchange rate regime than under a floating exchange rate regime is a direct consequence of the different adjustment mechanisms under the two regimes. Under a fixed exchange rate regime country-specific shocks are absorbed by the balance of payments and do not directly affect domestic inflation rates or nominal interest rates. Instead, inflation rates and nominal interest rates depend on world average conditions (*e.g.* average rates of growth of output and domestic credit). The balance of payments mechanism which maintains money market equilibrium under fixed exchange rates thus absorbs the effects of country-specific shocks that would otherwise affect the inflation tax rate and add to the variability of real exchange rates.

By contrast, when exchange rates are flexible the exchange rate replaces the balance of payments as the adjustment mechanism that maintains money market equilibrium and country-specific real and monetary shocks alter domestic inflation rates and nominal interest rates. The result is wider fluctuations in inflation tax rates and greater variability of real exchange rates under flexible exchange rates.

It should be stressed that the model highlights the inherent tendency for real exchange rates to exhibit greater variability under flexible exchange rates than under fixed exchange rates that arises purely as a consequence of the difference in adjustment mechanisms across regimes. Simply put, under fixed exchange rates the balance of payments absorbs the effects of country-specific shocks, both real and monetary, eliminating them as a potential source of real exchange variability. However, under flexible exchange rates country-specific shocks influence domestic inflation tax rates and serve as an additional source of real exchange rate variability.

The tendency for real and nominal exchange rates movements to be positively correlated under flexible exchange rates is also captured by the model as can be seen from (21). This result reflects the temporary nature of real and monetary shocks and the fact that monetary shocks have real effects via the inflation tax channel. Due to their temporary nature, shocks that tend to appreciate (depreciate)-the nominal exchange rate also serve to raise (lower) expected rates of currency depreciation and inflation and to raise (lower) the nominal interest rate. As a result, the increase (decrease) in the inflation tax rate that accompanies an appreciation (depreciation) of the nominal exchange rate lowers (raises) the supply of labor and the output of nontraded goods. This in turn leads to an increase (decrease) in the relative price of nontraded goods and an appreciation (depreciation) of the real exchange rate.

The model outlined here thus captures the stylized facts that real exchange rates are more volatile under flexible exchange rates than under fixed exchange rates and that real and nominal exchange rates movements are positively related under flexible exchange rates. It does so without assuming asymmetries across countries or, more importantly, in the types of other policies adopted along with the exchange rate regime. Inherent tendencies for the exchange rate regime itself to affect the behavior of real exchange rates are, therefore, highlighted by the model. The ability of the model to produce the first of these stylized facts simply reflects the fundamental difference of the adjustment mechanism across exchange rate regimes. The model produces results consistent with the second stylized fact because of the interaction of temporary shocks and the emphasis on the inflation channel as the way in which nominal variables exert real effects.

Of course, the nature of the underlying shocks in the model presented here has been chosen to highlight in the simplest possible manner how an equilibrium model of real and nominal exchange rate determination can generate results consistent with the stylized facts about exchange rate regimes and the behavior of real exchange rates. Other types of shocks, such as permanent shocks to output or contemporaneous correlation of output shocks across countries, could be added to the model without eliminating the general tendency for the exchange rate regime to influence real exchange rate behavior in the manner described here. However, the actual ability of the model to fit the stylized facts would depend on certain conditions being satisfied in terms of elasticities and the relative importance of various shocks so that the forces stressed here continue to dominate. Ultimately then, the ability of equilibrium models like the one outlined here to explain the observed behavior of real exchange rates is an empirical question.

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