Inside Money and the Open Economy

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Abstract

This paper presents a model of a world economy with international capital mobility and non-substitutable national currencies. Despite flexible exchange rates, the model displays cross-country correlations in nominal and real magnitudes among which are: i) innovations in inflation and money stocks are correlated across countries; ii) real world output is correlated with the nominal world money stock; and iii) appreciations of the exchange rate are correlated with current account deficits. The essential feature of the model is that agents face a nontrivial choice between inside and outside money. Inside money represents real assets intermediated through banks. Therefore, real shocks affect the relative demand for inside and outside money (the money multiplier) and through this affect money stocks, price levels, and exchange rates. However, innovations in the monetary base do not lead to the same correlations between real and nominal variables.

1. Introduction

The belief that a system of flexible exchange rates helps prevent the international transmission of monetary disturbances was prevalent among economists from the 1950s through the advent of floating exchange rates in 1973.[1] Indeed, the argument that flexible exchange rates would insulate an economy from external influences was used persuasively by opponents of fixed-rate arrangements during discussions by the Committee of Twenty following the collapse of the Bretton Woods System.[2] Accumulating experience with floating rates, however, suggested by the late 1970s that flexible exchange rates do not insulate economies from monetary disturbances abroad.[3] As documented in McKinnon (1984), a growing body of evidence now indicates a pronounced pattern of comovement over time in the money supplies and business cycles of different countries.

Macroeconomists have assessed this evidence and have developed models to explain how nominal disturbances in one country might affect economic activity elsewhere under flexible exchange rates. As discussed in Flood and Hodrick (1986), these models generally specify distinct national money demand functions and provide mechanisms through which activist monetary policies are transmitted internationally and affect real economic activity.[4] Recent work by McKinnon (1984,

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[1] See, for example, Friedman (1953), Meade (1955), and Johnston (1972).

[2] See Williamson (1983) for details.

[3] See Sheehan (1987) and Dornbusch (1980) for details. The system of floating rates that evolved is, of course, a "dirty float" in which central banks intervene in foreign exchange markets in order to influence the values of currencies.

[4] Two different approaches have been taken in the literature. The first

1982), however, questions the specification of purely national money demand functions, proposing instead a world monetarist perspective that focuses on a suitable world monetary aggregate and a stable world-wide money demand function. McKinnon finds that the growth rate of this world monetary aggregate is more closely correlated with price inflation in the United States than is the growth rate of the domestic U.S. money supply.

In this paper we develop a framework that differs significantly from the models described by Flood and Hodrick (1986) and McKinnon (1982). Our approach highlights the endogenous reaction of money supplies, inflation rates and output levels to exogenous real disturbances. Unlike the approaches discussed in Flood and Hodrick, which provide mechanisms for monetary disturbances to have effects on real economic activity, our framework is in the spirit of the literature on real business cycles in which real disturbances affect real economic activity and produce comovements in nominal magnitudes.[5] In our model, these nominal comovements result from endogenous changes in the money multiplier, not the monetary base; in this way the model is consistent with the evidence of Cagan (1965) and King and Plosser (1984).

We are able to use this framework for understanding two important phenomena of the world economy under floating exchange rates. First, the observed positive correlation between the growth rate of an aggregate world money supply and national inflation rates is explained in terms of the endogenous

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approach extends the information-confusion model of Lucas (1972, 1975) to the open economy. Papers that take this approach include Saidi (1980) and Kimbrough (1983). The second approach builds on the overlapping nominal wage contracting framework of Gray (1976), Fischer (1977) and Taylor (1979). Papers of this type include Flood (1979) and Turnovsky (1976).

[5] See, for example, King and Plosser (1984) and Greenwood (1983).

reaction of national money supply multipliers to exogenous real disturbances. Second, the close correlation between national inflation rates observed during the 1970's is shown to depend on the occurence of world–wide shocks to real activity. Although McKinnon's work also highlights the endogenous reaction of national money supplies, he does so through the mechanism of government intervention in foreign exchange markets. In contrast, our analysis focuses on the endogenous adjustment of national money supplies which occurs as asset holders alter the composition of their portfolios in response to exogenous real disturbances.

The setting for our analysis is a simple two–country model of overlapping generations under a flexible exchange rate with perfect international capital mobility and no international currency substitution.[6] The stock of money in our model consists of both outside (fiat) money and inside money, deposits at banks backed by capital or loans to owners of capital. The model's money multiplier (determined from the ratio of deposits to currency) is endogenous, determined by the relative returns and transaction costs of inside and outside money. The price level, the inverse of the goods value of fiat money, is also determined by the relative demand for inside and outside money. Shocks to real economic parameters, such as the marginal product of capital, change the relative desirability of inside and outside money, thereby changing the money multiplier, the price level, and the total nominal money stock even without any change in the monetary base. Such shocks may also affect capital accumulation and so output, with a one–period lag. If these shocks are world–wide, the resulting changes to money and output occur in all countries, explaining two anomalous international phenomena: i) inflation rates are correlated across countries; and ii) real output across countries is positively

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[6] Greenwood and Williamson (1987) have developed independently a model of international economic fluctuations with many similar features.

correlated with the total nominal world money stock. In contrast, serially uncorrelated shocks to the stock of fiat money in any country affect the domestic price level without affecting the demand for money in either country and so do not affect the money multiplier, output, or the foreign price level.

The model, which extends work by Freeman and Huffman (1986) to the open economy, highlights an inherent difference between inside and outside money — that inside money represents real assets intermediated through banks. In this model purely domestic shocks that reduce the relative desirability of domestic fiat money lead to a depreciation of the exchange rate and stimulate the desire to hold capital in the form of inside money. In a world with international capital mobility, this increase in bank deposits leads to a current account surplus as banks lend to their counterparts abroad. The model, like that of Greenwood (1983), thus exhibits an endogenous correlation between the exchange rate and the current account that can not be exploited by activist monetary policy.

The model's environment and the resulting equilibrium conditions are presented in section 2. We present the choices facing agents concerning the composition of their money balances within the domestic economy, then establish the broader equilibrium conditions of an international economy with capital mobility and flexible exchange rates. In section 3 we examine the behavior and correlations over time of key economic variables in the two countries, especially output, the money stock, interest rates, the exchange rate, and the current account. In section 4 we demonstrate the ineffectiveness of stabilization policies that would attempt to exploit the observed correlations in an effort to combat the business cycle. In section 5 we discuss which features of our model lead to the results we find and we examine the sensitivity of our results to changes in our assumptions. Concluding remarks are presented in section 6.

2. The Model

The Domestic Economy: In each period $t \geq 1$ a continuum of two–period lived agents is born. Each agent at t acts to maximize his expected lifetime utility, given by $U(c_{1t}) + \beta E_t c_{2t}$, with $0 < \beta < 1$, where c_{it} represents consumption by a member of generation t in the i^{th} period of life and E_t represents the expectation operator conditioned on information available at t. The function U(.) is twice–continuously differentiable, increasing, and concave with $\lim_{c \to 0} U'(c) = \infty$.[7]

In each generation there are two types of agents: "regular" agents and "prominent" agents. Each regular agent i of generation $t \geq 1$ is endowed with y^i units of non–storable labor. Each unit of labor is used inelastically to produce one unit of the economy's sole consumption good. There is a continuum of regular agents in each generation, the size of which normalized to equal unity. In each generation $t \geq 1$ the distribution of endowments y^i is described by the uniform density function $\phi(y^i) = 1$ for $y_0 < y^i \leq y_1$ and $\phi(y^i) = 0$ otherwise. The parameters y_0 and y_1 are positive constants. The identity of a regular agent is costlessly known only to himself. Others can learn the identity of a regular agent born at t only at a fixed cost of γ_t units of the consumption good. The positive random variable γ_t is independently and identically distributed and its realization is known at t but not before.

Prominent agents are costessly identified by all. The number of prominent agents is sufficient to ensure a competitive equilibrium. They have no endowment of labor but have access to the following capital technology to which regular agents do not have access. A unit of the consumption good at t that is not consumed may be used to create a unit of capital. A unit of capital created at t produces x_t units of the consumption good at t + 1, at which time the capital completely disintegrates (a

[7] Primes will be used to denote derivatives.

depreciation rate of 100%). The gross rate of return on capital x_t is a function of the aggregate amount of capital created at t (K_t): $x_t = \alpha_t X(K_t)$. The parameter α_t is a independently and identically distributed positive random variable, the realization of which is observed by all at t but not before. The function X(.) is continuously differentiable and decreasing with $\lim_{K\to 0} X(K) = \infty$ and $X(K) > -X'(K)K$ for $K > 0$ (i.e., X(K)K is increasing in K or the elasticity of the gross interest rate with respect to capital is less than 1). The marginal product of capital is a function of the total capital, but any individual's behavior has a negligible effect on it; therefore, individuals take it as given.

There exists a fixed stock of fiat money, which is intrinsically useless, unbacked, noncounterfeitable, and costless to exchange. At the beginning of period 1, all fiat money is owned by the "current old", who may be considered generation 0. The current old live only in period 1 and seek only to maximize personal consumption in that period. To ensure a demand for fiat money, the government enforces a legal prohibition on the use of privately issued bearer notes.

Media of Exchange: The basic problem facing regular agents is how to arrange for consumption when they are not endowed. One option is to purchase fiat money from old agents to be sold for goods when the purchaser is himself old. A second option is to deposit goods with a prominent agent, who can create capital from which a return can be paid in the next period. In a competitive equilibrium, deposits will pay the rate of return on capital. To collect this return, the regular agent must return to the prominent agent and identify himself (an action that uses up γ_t goods). Recall that agents are legally prohibited from issuing notes or IOU's that are payable to the bearer.

We will interpret a deposit of goods with a prominent agent as a deposit at a bank or some similar financial intermediary. The cost, γ_t, may then be interpreted as the cost or inconvenience of identifying oneself in person at the bank or of

identifying oneself by the writing of a check. The legal restriction may be considered a prohibition on private banknotes.

The Domestic Equilibrium: The problem of a regular agent born at t and endowed with y who holds only inside money (bank deposits) is to choose non–negative consumption and real balances of inside money, h_t, to maximize $U(c_{1t}) + \beta E_t c_{2t}$ subject to

$$y = c_{1t} + h_t \quad \text{and} \quad x_t h_t - \gamma = c_{2t}. \tag{1}$$

The agent knows x_t when he makes his decision and treats it as given. The necessary and sufficient first order condition for a maximum is:

$$-U'(y - h_t) + \beta x_t = 0. \tag{2}$$

This first order condition implicitly defines a personal demand–for–inside–money function $h_t = h(y, x_t)$ with the positive first partial derivatives h_y and h_x.

The problem of a regular agent born at t and endowed with y who holds only fiat money is to choose non–negative consumption and real balances of fiat money, q_t, to maximize $U(c_{1t}) + \beta_t E_t(c_{2t})$ subject to

$$y = q_t + c_{1t} \quad \text{and} \quad \rho_t q_t = c_{2t} \tag{3}$$

where ρ_t is the real gross rate of return of fiat money purchased at time t. The necessary and sufficient first order condition for a maximum is:

$$-U'(y - q_t) + \beta_t E_t(\rho_t) = 0 \tag{4}$$

Again, this first order condition implicitly defines a personal demand–for–outside–money function $q_t = q(y, E_t\rho_t)$ with the positive first partial derivatives q_y and q_ρ.

It remains to describe the extent of the holding of inside and outside money in equilibrium. We will confine our attention to the most interesting case of an interior solution in which the equilibrium aggregate balances of inside money and of outside money are strictly positive and in which every agent holds positive real balances of either inside or outside money. A sufficient condition ensuring that someone will always prefer fiat money to deposits is that $x_t y^o < \gamma \quad \forall$ t. The assumption $\lim_{K \to 0} X(K)$

$= \infty$ guarantees that a positive amount of inside money is held in equilibrium (see Lemma 1 in the Appendix). Each agent at t will hold strictly positive money balances if $U'(y^o) < \beta\rho_t$.

The average rate of return, including transaction costs, of inside money acquired at time t is $(x_t h_t - \gamma)/h_t$ or $x_t - \gamma/h_t$, where h_t denotes the real quantity of inside money balances. Note that the average rate of return on inside money is an increasing function of an individual's inside money balances. Since regular agents differ only in the size of their endowment and since desired money balances are an increasing function of the endowment, inside money is more attractive the larger an agent's endowment. Since both inside and fiat money will be held in equilibrium and there is a continuum of endowments, we can identify a borderline endowment y_t^* above which all regular agents born in period t hold inside money and below which all hold fiat money. This reservation endowment is defined implicitly as the endowment at which the utility of an agent choosing inside money is just equal to the utility of an agent choosing fiat money:

$$U(y_t^* - h(y_t^*, x_t)) + \beta(x_t h(y_t^*, x_t) - \gamma) - U(y_t^* - q(y_t^*, E_t\rho_t)) - \beta E_t(\rho_t q(y_t^*, E_t\rho_t)) = 0 \qquad (5)$$

A final domestic equilibrium condition is the clearing of the market for fiat money. Define p_t as the price of a unit of the consumption good in units of fiat money and Q_t as total domestic real balancesof fiat money. Then the equality of supply and demand for domestic fiat money can be expressed as

$$M_t = p_t Q_t \equiv p_t \int_{y_o}^{y^*} q(y_t, E_t\rho_t)\, dy \quad . \qquad (6)$$

It follows that the rate of return of fiat money, when the nominal fiat money stock is fixed, is

$$\rho_t = p_t / p_{t+1} = Q_{t+1} / Q_t. \tag{7}$$

The International Economy: In addition to the domestic economy just described there is a similar foreign economy, which differs from the domestic economy only in the values of the environmental parameters α_t, β_t, and γ_t. In the foreign economy these parameters take on the values $\bar{\alpha}_t$, $\bar{\beta}_t$ and $\bar{\gamma}_t$, respectively. (Values of the foreign country will always be denoted by bars.) The consumption goods of both countries are perfect substitutes.

Regular agents are restricted by law to the money (inside or outside) of their own country. There exists an international capital market in that the IOUs of prominent agents are allowed to freely circulate between nations. Although regular agents are restricted to deposits in their own country, prominent agents are able to use these deposits to purchase assets in other countries because of the unrestricted market (for prominent agents) in international assets. As a result, an equilibrium condition of the world economy is the equality of the rates of return of capital in the two countries; i.e.,

$$x_t \equiv \alpha_t X(K_t) = \alpha_t \bar{X}(\bar{K}_t) \tag{8}$$

where K_t represents the domestic capital stock and $\bar{K}_t$ represents the foreign capital stock. The other international equilibrium condition is the equality of world bank deposits and world investment in capital:

$$K_t + \bar{K}_t = \int_{y^*}^{y_1} h(y, x_t)\, dy + \int_{\bar{y}^*}^{y_1} \bar{h}(\bar{y}, x_t)\, d\bar{y} = H_t + \bar{H}_t. \tag{9}$$

$$\text{where } H_t \equiv \int_{y^*}^{y_1} h(y, x_t)\, dy \quad \text{and} \quad \bar{H}_t \equiv \int_{\bar{y}^*}^{y_1} \bar{h}(\bar{y}, x_t)\, d\bar{y} \tag{10}$$

The foreign and domestic economies are joined through the international capital market, but the demand for money is determined separately in each country. It will therefore be convenient for the exposition of the model's equilibrium properties to organize the equilibrium conditions into three groups:

i) the world capital market [equilibrium conditions (8) and (9)];

ii) the domestic choice of money [equilibrium conditions (2), (4), (5), (6), and (7)], which can be more concisely summarized as the following —

$$Q - \int_{y_0}^{y^*} q(y, (Q^+/Q))\, dy = 0 \tag{11}$$

$$U(y^* - h(y^*, x)) + \beta(xh(y^*, x) - \gamma) - U(y^* - q(y^*, (Q^+/Q)) - \beta(Q^+/Q)q(y^*, (Q^+/Q)) = 0 \tag{12}$$

where all variables are evaluated at the current period (although the time subscripts have been suppressed to ease the notational burden) except Q^+, which denotes the current expectation of the value of Q in the next period;

iii) the foreign choice of money, which can be summarized in conditions (11) – (12) using the equivalent foreign values $\bar{y}^*$, $\bar{Q}^+$, $\bar{Q}$, $\bar{\gamma}$, and $\bar{\beta}$.

Key economic measures: To compare the time series of the model to those of the real world we need to define measures of output, the money stock, and the exchange rate. Domestic real output at t (gross domestic product) is defined to be the sum of output at t from domestic labor and capital:

$$GDP_t = \int_{y_0}^{y_1} y\,dy + x_t K_{t-1} = \int_{y_0}^{y_1} y\,dy + \alpha_t X(K_{t-1})\,K_{t-1} \qquad (13)$$

Note that because the labor decision is trivial, output is solely a function of the previous period's capital stock.

The domestic nominal money stock at t is the sum at t of deposits at domestic intermediaries and domestic currency (fiat money) or:

$$MS_t = M_t + p_t \int_{y^*}^{y_1} h(y, x_t)\,dy \qquad (14)$$

$$= M_t (1 + H_t/Q_t) \qquad (15)$$

from the market clearing condition for fiat money $p_t Q_t = M_t$. Notice that for a given stock of domestic fiat money, the domestic total nominal money stock is determined by the ratio of inside to outside money, H_t/Q_t.

The exchange rate e_t will be defined as the value of a unit of the foreign country fiat money in terms of the domestic country fiat money; i.e.,

$$e_t = p_t/\bar{p}_t \qquad (16)$$

Accordingly, an increase (decrease) in the exchange rate (e_t) represents a depreciation (appreciation) of the domestic currency.

The current account surplus in period t for the domestic economy is defined as the difference between gross national product and national expenditure:

$$CA_t \equiv GNP_t - C_t - I_t \qquad (17)$$

where GNP_t is simply the sum in period t of gross domestic product and net interest receipts from abroad:

$$GNP_t \equiv \int_{y_0}^{y_1} y\,dy + x_t K_t + [x_t - 1][H_{t-1} - K_{t-1}]. \tag{18}$$

The first two terms in equation (18) represent gross output produced domestically, while the last term captures the interest paid on the economy's net claims to foreign capital. By substituting into (17) for gross national product [from (18)] and for consumption and investment from the individual's budget constraints, we obtain (after cancelling and rearranging terms):

$$CA_t \equiv [H_t - K_t] - [H_{t-1} - K_{t-1}] \tag{19}$$

Note that the current account surplus is exactly equal to the rate at which the domestic economy acquires net claims to foreign capital. We will focus on this description of the current account[8] in discussing trade flows in Section II.

The real interest rate at t is $x_t \equiv \alpha_t X(K_t)$ and the expectation at t of the domestic rate of inflation is $E_t(Q_t/ Q_{t+1})$. If shocks to the real value of fiat money balances are serially uncorrelated, expected inflation is an increasing function of current real balances, Q_t. From the above definitions the domestic nominal interest rate $E_t(Q_t/ Q_{t+1})\, x_t = E_t(Q_t/ Q_{t+1})\, \alpha_t X(K_t)$ can be constructed.

There are, of course, foreign country equivalents (to be denoted by bars) of

[8]This description of the current account is also used in Persson and Svensson (1985).

each of these measures.

3. The Behavior of Economic Aggregates Over Time

World shocks and cross-country correlations: We can now describe properties of the equilibrium time series under a variety of stochastic shocks. Let us begin our examination of the time series properties of this model with the case of random disturbances to the marginal product of capital. To strip this case to its essentials, let us start by assuming that the marginal product of capital, x_t, is a serially uncorrelated random variable unrelated to the size of the current (domestic or world) capital stock (i.e., $X(K_t) = 1$ and $x_t = \alpha_t$, where α_t is a serially uncorrelated random variable). We will assume that all values of x_t are such that there is a positive demand for both fiat money and deposits in both national economies. Define the innovation at t in a variable to be the difference between the realized value at t and the variable's expected value.

Proposition 1: A positive innovation in the marginal product of capital created at t causes: i) a contemporaneous increase in the domestic money stock; ii) a contemporaneous increase in the price level of every nation; iii) a contemporaneous increase in the world capital stock; and iv) a subsequent increase in world output.

The underlying explanation of these results is quite simple. (The actual proof is presented in the Appendix.) In each country the increase in the marginal product of capital makes capital more desirable, encouraging a larger capital stock, which produces more output in the subsequent period. In addition to these real effects, there is a change in the composition of money balances in every country. Inside money, with a rate of return linked to that of capital, is now more attractive; that is,

more agents will choose to hold deposits backed by capital instead of currency (unbacked fiat money) and those who would have held capital anyway will choose to hold more of it. This expands the money multiplier [1 + H/Q] and so the total nominal money stock. At the same time the reduced demand for fiat money lowers its value, raising the price level.

An economy with a history of shocks to the marginal product of capital would display some of the interesting time series that may seem puzzling in today's economies. The total nominal national money stocks are positively correlated across countries, as are the national price levels despite flexible exchange rates and the absence of changes in the monetary base. In addition, changes in total world output follow the world–wide (but endogenous) expansion of the total money stock.. Moreover, the total world nominal money stock is positively correlated with subsequent total world output.

Note that any shock changing the relative desirability of inside and outside money should lead to changes in the money multiplier, affecting the total money supply and the price level on the nominal side of the economy and the stock of intermediated capital and output from that capital on the real side of the economy. While we present here only the case of shocks to the marginal product of capital, similar correlations would be observed in economies featuring shocks to transaction costs (γ), preferences (β), the distribution of endowments, or anything else bearing on the relative demand for inside and outside money.

Country–specific shocks: When the shocks buffeting the economy are specific to one country, our model economy generates predictions concerning the correlations of exchange rates and the current account as well as money and output. Let us begin with the case of a small country experiencing random, serially uncorrelated transaction costs foreseeable one period in advance. The assumption

of a small country in a world economy with perfect capital mobility implies that the real interest rate is constant and unaffected by changes in domestic asset holding.

Proposition 2: A positive innovation in the domestic transaction cost of a small country causes a reduction in the domestic values of the total money stock, the price level, and the current account and causes an appreciation of the exchange rate.

A positive innovation in the domestic transaction cost will increase real balances of fiat money and decrease real balances of inside money. [This can be established by the application of the implicit function theorem to equilibrium conditions (11) and (12) as done in the proof of Proposition 1 presented in the Appendix.] Together they imply that a positive innovation in γ leads to a decrease in the money multiplier and the total money stock [from (15)]. The increase in real balances of fiat money implies a reduction in the domestic price level [from (6)] and thus an appreciation of the exchange rate [from (16)]. The decrease in real deposits represents a decrease in the domestic desire to hold capital. Because of perfect capital mobility and the "small" size of the domestic country, this does not lead to a reduction of domestic output as investment from abroad will replace any shortfall in the domestic desire to invest. In this way the innovation in γ leads to a current account deficit [from (19)]. Note that the foreign economy is unaffected because the domestic economy is so small that it does not (significantly) alter the real interest rate or world capital holding. Since the markets for fiat money are separated by the legal prohibitions on holding foreign fiat money, the only means by which domestic shocks could be transmitted abroad is through the international capital market.

Proposition 3: A positive innovation in the domestic transaction cost of a large country causes: i) decreases in the domestic values of the total money stock and the price level; ii) increases in the foreign values of the total money stock and the price level; iii) a decrease in the domestic current account; and iv) an appreciation of the domestic currency.

In the case of a large country, therefore, the effects of domestic shocks will be felt abroad. An increase in one country's transaction cost, for example, will lead to a reduction in domestic capital holding because of a reduction in the public preference for deposits (as in the small country case). This reduces the world capital stock and subsequent world output. The smaller world capital stock implies a higher world real interest rate, which affects the composition of money balances in the foreign country by making deposits more attractive, increasing the foreign money multiplier, money stock, and price level. As in the small country case, the country with a reduction of desired capital holding will experience a current account deficit as capital flows into the economy to (partially) replace the reduction in domestically owned capital.

In the large country case, country–specific shocks lead to a negative correlation between the price levels of two countries, the opposite of the positive correlation of world–wide shocks. Like the case of world–wide shocks, however, shocks specific to a large country can affect world holdings of capital and, through this, world output. The correlation between the world money stock and world output is not clear in this case, as the money stocks and price levels of the two countries move in opposite directions.

For purposes of exposition we have presented here only the case of fluctuations in the transaction cost. Of course, fluctuations in anything affecting the anticipated rate of return of inside or outside money will affect the composition of

money balances and thus the total money stock, the price level, the holding of (intermediated) capital, and the current account. Among possible sources of economic fluctuations are changes in the anticipated rates of growth of population, endowments, or fiat money creation (see Proposition 5) or changes in the total demand for money (e.g., changes in the discount rate β) or in the size distribution of endowments.

Changes in the monetary base: The monetary fluctuations described above resulted from endogenous fluctuations the the money multiplier. Those who take seriously monetary aggregates like M_1 and M_2 that include both inside and outside money believe that the correlation between such measures and real variables must be essentially the same whether money stock fluctuations result from changes in the money multiplier or changes in the monetary base. Let us therefore examine the behavior of this economy in response to changes in the total nominal money stock caused by changes in the fiat money stock.

Let us first suppose that the domestic monetary base (M_t) changes according to the rule $M_t = z_t M_{t-1}$ ($t \geq 1$) where z_t is a serially uncorrelated random variable independent of any other exogenous disturbances. The realization of z_t is not known before t. Assume in particular that $E_{t-i}\, z_t = z^*$, a constant greater than 1. Let us also assume that z_t is always greater than one and that this expansion of the fiat money stock is used to finance government purchases of the consumption good, which are disposed of in a way that does not affect the utility of any agent.

Proposition 4: In both countries, output, the interest rate, and the current account are entirely uncorrelated with serially uncorrelated innovations to the monetary base.

The intuition underlying Proposition 4 is sufficiently obvious that no formal proof is presented. Notice that the attractiveness of fiat money depends on its expected rate of return, which is a function of the expected rate of future fiat money creation (z^*) but not the current realization of the fiat money stock. Since the future money supply growth rate is unrelated to the current realization of the fiat money stock, the real values of current money decisions (H_t and Q_t) as well as capital, output, the interest rates (real and nominal), and the current account are unaltered by the unanticipated innovation in the fiat money stock.

This neutrality of the monetary base is not obtained when the rate of fiat money creation is known in advance. To see this, take the case where $E_{t-1}z_t = z_t$ and $E_{t-i}z_t = z^*$ for $i > 1$. To begin simply, let us take the case of a small domestic country.

Proposition 5: A positive innovation, anticipated one period in advance, in next period's rate of domestic fiat money creation for a small country causes an increase in the domestic price level, a decrease in the exchange rate, and an decrease in the domestic current account.

The underlying causes of these correlations are like those examined in Proposition 2. The anticipation of a higher than normal rate of fiat money creation leads domestic agents to anticipate a poor return on fiat money. Therefore, fewer agents choose to hold their money balances in the form of fiat money. This drop in the demand for domestic fiat money shows itself in domestic increases in the money multiplier, the total money stock, the price level, and in a depreciation of the exchange rate. The increase in capital holding resulting from the increase in deposits will lead to a surplus in the current account [from (19)] and an increase in domestic transaction costs.

In the case of a large domestic economy, the shift from outside to inside money would make itself felt in foreign economies as the expansion of domestic desired capital lowered the world real interest rate. This would decrease the demand for deposits in the foreign country and increase the demand for currency, resulting in a decrease in the foreign total money stock and price level.

It follows from Proposition 5 that serially correlated shocks to the monetary base of a large domestic economy will affect real variables such as world capital, world output, and the current account because today's realization of the monetary base will be helpful in forming expectations of next period's rate of fiat money creation. If the fiat money shocks are positively serially correlated, a positive innovation in the domestic monetary base will increase the use of deposits in the domestic country, causing an increase in the domestic current account and (for a large domestic country) increases in current world capital and subsequent world output. Of course, a positive innovation in the monetary base will have the opposite effects if the monetary base is negatively serially correlated.[9]

4. Stabilization Policies

When macroeconomic aggregates of the real world behave like those of this model economy, appeals for stabilization policies are often heard. Consider two examples. The observed correlation between the world money stock and world output leads one to wonder whether one could reduce fluctuations in world output by reducing fluctuations in the world money stock [see McKinnon (1984)] just as advocates of monetarism in a closed economy argue that stabilizing the money stock will stabilize domestic output [Friedman (1968)]. Similarly, a correlation between

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[9] See Greenwood and Williamson (1987) for a more detailed study of serially correlated innovations in fiat money creation in a similar model.

exchange rates and the trade balance leads one to ask whether fluctuations in the trade balance can be reduced by a policy that uses the government's control over the money stock to stabilize exchange rates. From our work in section 3 we can examine the effectiveness of such stabilization policies.

Consider first the correlation between the world money stock and world output caused by a history of shocks to the productivity of capital (Proposition 1) in both countries. A view of the world that we might call "world monetarism" would say that it is only the total money stock that matters; it follows from this view that we can compensate for a reduction of the world stock of inside money by increasing the world stock of fiat money, thus eliminating the contraction of output historically linked to a decline in the total money stock. From Proposition 4, however, we know that a serially uncorrelated innovation in the stock of fiat money in either country will have no effect on output or any other real variable; therefore, exogenous changes in the stock of fiat money designed to compensate for endogenous fluctuations in the money multiplier will be unable to reduce fluctuations in output even though they can completely eliminate the fluctuations in the total world money stock. What "world monetarism", like its closed economy counterpart, fails to notice when it looks only at monetary aggregates like M_1 and M_2 is that inside money represents intermediated real assets, which are likely to have far different correlations with output and other real variables than fiat money, which are intrinsically useless and unbacked pieces of paper. The world money stock is in part an endogenous variable and so may be correlated with world output only because both money and output are reacting to some third force. Therefore, the historically observed correlation between money and output, even the precedence of innovations in money to innovations in output, does not imply that the changes in the money stock cause the changes in output. Certainly, a historical correlation between inside money and output does not imply any link between fiat money and output.

Next consider the negative correlation between the current account and the exchange rate, exhibited when there are purely domestic shocks to the public's relative preference for inside and outside money, such as the shocks to transaction costs examined in Proposition 2. The link between the current account and the exchange rate is often said to be causal. For example, the claim is frequently made that an appeciation of the exchange rate makes domestic goods more expensive relative to foreign goods, leading to a trade deficit. The cure implied by such an interpretation of events is to forestall any change in the exchange rate with an opposing innovation in the fiat money stock; more generally, it is taken to imply that whenever it wishes, the government can stimulate net exports with an increase in fiat money designed to reduce the exchange rate. We know from Proposition 4, however, that such innovations in the monetary base will do nothing to change the balance of trade, although they will change the exchange rate. Again we must realize that in this economy the correlation between a nominal variable like the exchange rate and a real variable like the current account occurs as both react to some more primal cause (in this example, a change in domestic transaction costs). It can not be exploited by a deliberate innovation in the monetary base, which can have only nominal effects.

5. Remarks on the Assumptions Underlying the Model

The key feature of our model is the endogenous selection of the composition of agents' money balances, the choice between inside and outside money. Most analyses of domestic or international monetary questions ignore the fundamental difference between money in the form of intermediated real assets and unbacked pieces of paper issued by governments. Once this inherent difference is acknowledged, we recognize that the money stock is an endogenous variable determined in part by the deposit to currency ratio. This ratio is a real variable and

thus likely to exhibit correlations with other real variables as they fluctuate over the business cycle, correlations that have nothing to do with the other component of the total money stock — the stock of fiat money. It is our belief that any model featuring inside money as intermediated real assets will display correlations between the total nominal money stock and real variables that fluctuate over the business cycle, correlations that will disappear when it is the stock of a purely nominal asset, fiat money, that fluctuates.

Notice that it is essential to our analysis that there is a nontrivial choice between inside and outside money. If fiat money is held only to satisfy a nonvarying, binding reserve requirement, the money multiplier can not fluctuate and so will display no correlation with other real variables. These correlations can be observed, however, even in an economy featuring required reserves of fiat money if excess reserves are sometimes held (the constraint is not always binding) or if there is a nontrivial and varying choice between two forms of money, each subject to a different reserve requirement.[10]

Also essential for our results is that the national economies are linked, either because the envrionmental shocks affect both countries directly (as in Proposition 1) or because the two economies are linked through international capital mobility (Propositions 2 and 3).

Other assumptions are not essential to the model's conclusions. Most obvious is the assumption that all capital is intermediated. Consider instead a version of the model where "prominent agents" as well as "regular agents" have endowments and wish to save. Prominent agents will create capital on their own, without the help of

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[10]We may think of the example we present as an extreme version of an economy with differing reserve requirements on different forms of money — just note that the legal prohibition on private banknotes may be interpreted as a 100% reserve requirement for money in the form of currency.

intermediaries. In such an economy, environmental changes that make capital more desirable (for example) will increase holdings of both intermediated and unintermediated capital, which will both increase subsequent output. At the same time, the increase in intermediated capital will increase the current nominal money stock and the price level. The presence of unintermediated capital does nothing to alter these correlations with nominal variables. Environmental changes that affect only the choice between inside and outside money (such as a change in the transaction cost) will lead directly to changes only in the stock of intermediated capital. While the effects on capital, output, and the current account of such a change will be of a smaller magnitude than in the case where both types of capital were affected, so long as some capital is intermediated, changes affecting the choice between inside and outside money will be linked to changes in the capital stock and thus to real variables like output and the current account that depend on capital holdings.

Other assumptions were also chosen in order to simplify the description of the environment. The cause of the illiquidity of capital is not important so long as some form of intermediation will allow it to serve as backing for inside money. More generally, the source of the demand for money is not crucial. Models with money balances in the utility function or models requiring the advance acquisition of money for all purchases will have similar implications so long as some of what is defined to be money is intermediated capital. The money demand functions of the model [from equations (11) and (12)] are similar to those found in most models — they are increasing functions of income (y) and the rate of return of money (x or ρ). The important cross-country correlations arise from endogenous changes in the composition of money balances [equation (15)], not from the level of total money balances nor from the reason those balances are held.

6. Summary

This paper has developed a theoretical framework that provides an explanation for the international comovements of money supplies, inflation rates, and output levels across countries. By highlighting the distinction between inside and outside money, our approach draws attention to the endogenous adjustment of national money supplies which occurs as asset holders alter the composition of their portfolios in response to exogenous real disturbances. In this manner, our framework is similar to models of real business cycles in which real disturbances affect real economic activity and produce comovements in nominal magnitudes. As in real business cycle models, the endogenous correlations between nominal and real magnitudes in our model can not be exploited by activist monetary policies and the stabilization of nominal measures of total money will not lead to a stabilization of the real variables with which they may be historically correlated.

Using this framework, we have characterized the effects of both world-wide and country-specific shifts in productivity and transactions costs on output, inflation, and money supplies across countries. A central implication of our analysis is that the international transmission of monetary disturbances linked to changes in real output occurs through simultaneous changes in the money supply multiplier of different countries. This stands in marked contrast to approaches such as world monetarism where changes in the monetary base are assumed to directly affect real activity.

APPENDIX

Lemma 1: In an equilibrium with valued fiat money ($Q > 0$), the real rate of return on deposits exceeds the real rate of return on fiat money [$x = \alpha X(K) > Q^+/Q$] and the capital stock is positive.

Proof: It cannot be that $\alpha X(K) \leq Q^+/Q$. There is a transaction cost γ attached to the use of inside money. Therefore, if $\alpha X(K) \leq Q^+/Q$ the rate of return of fiat money would dominate that of inside money for every agent, implying that $K = 0$. But $X(0) = \infty$, which is greater than Q^+/Q, which must be finite since $Q > 0$ and Q^+ can be no greater than the finite total endowment of goods.

Lemma 2: In equilibrium, $h^* \equiv h(y^*, x) > q^* \equiv q(y^*, E\rho)$.

Proof: From Lemma 1, $x > Q^+/Q$. From the first order conditions (2) and (4), $x = U'(y^*-h^*)/\beta$ and $Q^+/Q = U'(y-q^*)/\beta$. Therefore, $U'(y^*-h^*) > U'(y^*-q^*)$, implying that $h^* > q^*$.

Proof of Proposition 1:

From the equilibrium conditions (11) and (12) we can determine the effect of an innovation in x on the domestic choice of money as represented by Q and y^*. Applying the implicit function theorem to (11) and (12) we find that

$$\frac{\partial Q}{\partial x} = \frac{-\begin{vmatrix} 0 & -q^* \\ \beta h^* & U'(y^*-h^*) - U'(y^*-q^*) \end{vmatrix}}{\begin{vmatrix} 1+(Q^+/Q^2)Q_\rho & -q^* \\ \beta(Q^+/Q^2)q^* & U'(y^*-h^*) - U'(y^*-q^*) \end{vmatrix}}$$

$$= \frac{-\beta h^* q^*}{[1+(Q^+/Q^2)Q_\rho][U'(y^*-h^*) - U'(y^*-q^*)] \; + \; \beta(Q^+/Q^2)q^{*2}} \qquad (A.1)$$

where $Q_\rho \equiv \int_{y_0}^{y^*} \frac{\partial q(y,Q+/Q)}{\partial \rho} \, \partial y.$

Note that in the proof of Lemma 1 we established that $U'(y^*-h^*) - U'(y^*-q^*)$, which is positive. It follows that $\frac{\partial Q}{\partial x} < 0$. Since $p = Q/M$, it follows that $\frac{\partial p}{\partial x} > 0$.

In a similar fashion we can find $\frac{\partial y^*}{\partial x}$.

$$\frac{\partial y^*}{\partial x} = \frac{-\beta h^*[\,1 + (Q^+/Q^2)Q_\rho]}{[1+(Q^+/Q^2)Q_\rho][U'(y^*-h^*) - U'(y^*-q^*)] \; + \; \beta(Q^+/Q^2)q^{*2}} < 0 \qquad (A.2)$$

We can also find $\frac{\partial H}{\partial x}$. From (10), $H = \int_{y^*}^{y_1} h(\,y, x)\, dy$ so that

$$\frac{\partial H}{\partial x} = \int_{y^*}^{y_1} \frac{\partial h(\,y, x)}{\partial x} dy + \frac{\partial y^*}{\partial x}(-h^*) \qquad (A.3)$$

From our work above we know that $\partial y^*/\partial x < 0$; from (2) we find that

$$\frac{\partial h}{\partial x} = -\beta/U'' > 0 \qquad (A.4)$$

Therefore, $\partial H/\partial x > 0$. By the same operations we can establish that $\partial \overline{H}/\partial x > 0$. Now recall that $MS = (1 + H/Q)$. Since $\partial H/\partial x > 0$ and $\partial Q/\partial x < 0$, it must be that $\partial MS/\partial x > 0$. Again, by the same reasoning $\partial \overline{MS}/\partial x > 0$.

Since $\partial H/\partial x > 0$ and $\partial \overline{H}/\partial x > 0$, we have from (9) that the total world capital stock is an increasing function of x. World output in the subsequent period is an

increasing function of both x and world capital. Therefore, it too is an increasing function of current x.

Proof of Proposition 2:

From the equilibrium conditions (11) and (12) we can determine the effect of an innovation in γ on the domestic choice of money as represented by Q and y^*. Applying the implicit function theorem to (11) and (12) we find

$$\frac{\partial Q}{\partial \gamma} = \frac{\beta q^*}{[1+(Q^+/Q^2)Q_\rho][U'(y^*-h^*) - U'(y^*-q^*)] + \beta(Q^+/Q^2)q^{*2}} > 0 \qquad (A.5)$$

$$\frac{\partial y^*}{\partial \gamma} = \frac{\beta[1+(Q^+/Q^2)Q_\rho]}{[1+(Q^+/Q^2)Q_\rho][U'(y^*-h^*) - U'(y^*-q^*)] + \beta(Q^+/Q^2)q^{*2}} > 0 \qquad (A.6)$$

The reduction of the price level and total money stock and the appreciation of the exchange rate follow directly from the increase in real balances of fiat money, Q [see equations (6), (14), and (16)]. From (10)

$$\frac{\partial H}{\partial \gamma} = (-h^*)\frac{\partial y^*}{\partial \gamma}, \qquad (A.7)$$

which represents a decrease in the holding of capital by domestic agents. Since we have assumed the domestic economy is "small", there is no change in world capital or the marginal product of capital, implying a current account deficit from (19).

Proof of Proposition 6:

When the rate of fiat money creation at time t is known one period in advance, the expected rate of return on fiat money acquired at t can be found from (6) and (7) to be $Q^+/Q_t z_t$ [or Q^+/Qz when subscripts are omitted]. We can now write the equilibrium conditions (11) and (12) as:

$$Q - \int_{y_o}^{y^*} q(y, (Q^+/Qz))\, dy = 0 \qquad (A.8)$$

$$U(y^*-h(y^*, x)) + \beta(xh(y^*, x) - \gamma) - U(y^*-q(y^*, (Q^+/Qz)) - \beta(Q^+/Qz)q(y^*, (Q^+/Qz)) = 0 \qquad (A.9)$$

Applying the implicit function theorem to (A.8) and (A.9) we find

$$\frac{\partial Q}{\partial z} = \frac{-[U'(y^*-h^*) - U'(y^*-q^*)]\,(Q^+/Qz^2)Q_\rho - (\beta Q^+/Qz^2)q^{*2}}{[1+(Q^+/Q^2z)Q_\rho][U'(y^*-h^*) - U'(y^*-q^*)] + \beta(Q^+/Q^2z)q^{*2}} < 0 \qquad (A.10)$$

$$\frac{\partial y^*}{\partial z} = \frac{-\beta(Q^+/Qz^2)q^*[1+(Q^+/Q^2z)Q_\rho] - \beta(Q^+/Q^2z)q^*Q_\rho/z^2}{[1+(Q^+/Q^2z)Q_\rho][U'(y^*-h^*) - U'(y^*-q^*)] + \beta(Q^+/Q^2z)q^{*2}} < 0 \qquad (A.11)$$

The rest follows straightforwardly following the steps shown in the proof of Proposition 2 above.

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