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INTERNATIONAL CAPITAL FLOWS UNDER FULL MONETARY EQUILIBRIUM: AN EMPIRICAL ANALYSIS

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ABSTRACT

This paper develops a theory of international capital flows based upon a monetary-equilibrium, rational-expectation theory of exchanged rate determination extended to include the official intervention and possible sterilization of its effects upon the monetary base that are part of the post-1973 system of limited flexibility of exchange rates. Capital flows are shown to depend only on the current expectation of a future relative excess money supplies once all arbitrage conditions are imposed along with rationality.

Empirical testing reveals that U.S. international capital flows respond with persistent, damped oscillations to growth of relative excess money. This phenomenon is a quantity adjustment corollary of "overshooting" of exchange rates in response to changes in relative excess money supply. Inclusion of a relative interest rate term along with measures of growth of relative excess money supply results in rejection of the hypothesis that such a variable provides any additional explanatory power regarding behavior of U.S. international capital flows.

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This paper develops a theory of international capital flows based upon the monetary-equilibrium, rational-expectation (MERE) theory of exchange rate determination, developed by Bilson (1979) and extended to include official intervention and sterilization by Makin (1980.a, 1980.b). The MERE approach to exchange rate determination clearly indicates that when the asset market arbitrage equilibrium condition (interest parity) is imposed along with rationality and conditions of market efficiency in the foreign exchange market, a monetary equilibrium expression for the exchange rate includes <u>only</u> the current expectation of a future relative excess money supplies and no interest rate terms.

The extended MERE exchange rate formulation provides for official intervention in foreign exchange markets and possible sterilization of resultant effects on the monetary base. This formulation combined with a basic balance of payments identity which sets the change in official reserves (intervention) equal to the sum of private capital flows and the current account, yields a theory of international capital flows in a world of less than freely flexible exchange rates. Capital flows, like exchange rates, are shown to depend only on the current expectation of all future relative excess money supplies once all arbitrage conditions are imposed along with rationality.[1] If growth of relative excess money supplies is assumed to follow a random walk, the extended MERE formulation implies a cyclical response of capital flows to changes in growth of relative excess money supplies.

Development and testing of the extended MERE approach to analysis of capital flows in a world of limited flexibility of exchange rates occupies much of this paper. Section 1 briefly describes major developments in the portfolio-asset approach to determination of international capital flows and their relationship to this study. Section 2 describes the theory of capital flows that is implied by the extended MERE approach to exchange rate behavior. Section 3 presents empirical tests of the theory. Some concluding remarks are presented in Section 4.

1. Developments in the Asset Approach to Analysis of Capital Flows

Two major developments have affected the manner in which models of capital flow behavior have been formulated to reflect the essential stock-adjustment nature of international capital flows. These are the work of Branson (1968, 1970) and Branson and Hill (1971) and the work of Kouri and Porter (1974).

Consider first the portfolio formulation of Branson *et al.*, (herafter BP). The BP formulation follows from Markowitz (1952) portfolio theory and yields an equilibrium expression for net holdings of financial claims on foreigners expressed in terms of interest rates, risk variables and wealth. It is based only on arbitrage possibilities among various financial assets with different risk-return properties. The extended MERE theory of capital flows is, like BP, an asset equilibrium model. However, it is based upon simultaneous arbitrage between money assets and goods as well as between money assets denominated in different currencies. And MERE results in an expression describing capital flows only in terms of growth of relative excess monies.

Although in recognizing the stock-equilibrating nature of international capital flows the BP formulation represented a significant conceptual advance in modeling of international capital flows, it proved difficult to implement econometrically. This was largely due to simultaneity and multicollinearity problems which arose from failure to consider capital flows in a general equilibrium context and failure to impose equilibrium arbitrage conditions that linked together separate interest rates which often appeared in estimated capital flow equations as independent, explanatory variables. Measures of risk and wealth, also called for under the stock equilibrium approach, proved difficult to find on the frequent, periodic basis necessary for estimation and so were typically omitted from empirical applications. Estimation was done under the BP approach but estimated coefficients measuring behavior such as responsiveness of capital flows to changes in interest rates tended to be highly unstable. This phenomenon, discussed in a survey of such works by Kohlhagen (1977) likely arose because of multicollinearity problems caused by a high degree of correlation among explanatory variables, particularly domestic and foreign interest rates, and because exchange rates and capital flows are appropriately viewed as simultaneously determined endogenous variables in a general equilibrium model of an open economy.

Kouri and Porter (1974) combined Branson's stock equilibrium formulation with the monetary-asset approach to the balance of payments developed originally by Hume (1752), extended by Johnson (1958), and Mundell (1968) and later more fully articulated by Dornbusch (1973) and others in Frenkel and Johnson (1976). They specified a model with three assets, domestic base money, domestic bonds and foreign bonds which permitted derivation of a reduced-form expression for capital flows in terms of changes in the domestic portion of the monetary base, the current account balance and changes in "foreign" interest rates, nominal income and wealth. Their particular specification, including the monetary base instead of the money supply, permitted testing of the hypothesis that capital flows tend partially to offset changes in the monetary base and thereby lessen ability to control the domestic money supply. The current account balance and capital flows were viewed in their fixed exchange rate model as sources of change in the foreign component of the monetary base. Their domestic economy was "small" and a price-taker in the bond market so that the domestic interest rate was taken as given. Only the "foreign" interest rate appeared in their estimated equations thereby eliminating a source of multicollinearity by making explicit virtually perfect correlation between domestic and foreign interest rates. Essentially, Kouri and Porter determined capital flows as the temporary flow which resolves disequilibrium in the asset-money market.

Empirically, Kouri and Porter found evidence that supports the asset-equilibrium approach to capital flows determination. Changes in the monetary base tended to be somewhat offset by capital flows, and a rise in income change which elevates growth of money demand and tended to produce an accommodating capital inflow. The foreign interest rate variable was not significant. In effect, money served as the wealth variable in "monetary-approach" models and therefore Kouri and Porter escaped the problem of trying to measure some broader wealth aggregate. The risk variable received little explicit attention in their study, being represented by a dummy variable. Results of the Kouri and Porter study suggested that a measure of excess money supply is the best single variable to include in a parsimonious attempt to explain capital flows and that omission of heretofore ubiquitous interest rate(s) will not significantly lower explanatory power.

As useful as the Kouri and Porter approach was, it did not fully integrate asset market arbitrage conditions and implications of market efficiency and rationality into a theory of international capital flows appropriate for a world of limited flexibility of exchange rates. In such a world, exchange rate adjustments and capital flows combine to resolve stock-disequilibria in money markets suggesting a need for simultaneous consideration of exchange rate and capital flow behavior. This is the basis of the extended MERE approach to behavior of international capital flows.

2. A Monetary-Equilibrium, Rational-Expectations Theory of Capital Flows

Overview

Development of the theory of capital flows to be tested here requires first, that the MERE theory of exchange rate behavior postulated by Bilson (1979) be extended following Makin (1980.a, 1980.b) to incorporate official,"leaning-against-the-wind" intervention in foreign exchange markets and possible sterilization of effects of intervention on the monetary base. Once this is done, some simple manipulation of a basic balance of payments identity and an intervention equation enable a capital flows corrollary of the extended MERE theory of exchange rate behavior. An additional advantage of this approach is that it employs the differenced log form of the extended MERE expression for the exchange rate. This particular formulation will be seen to bypass the need to represent explicitly the "real" exchange rate changes which measure large and persistent deviations from purchasing power parity (PPP) where the log levels of real exchange rates have tended to follow a random walk.

Log linear equations for money supply and money demand are specified, with the latter including explicit provision for representation of intervention and sterilization behavior. Then, equating money supply and money demand, imposing interest parity and purchasing power parity and setting the forward exchange rate equal to the expected spot rate, a rational solution for the exchange rate is obtained in terms of current expectations about all future excess money supplies. A full enunciation of the joint hypothesis being tests with this formulation, along with evidence on tests of each of the separate hypotheses is presented in Makin (1980.b).

Money Demand

Begin with a log linear money demand function of the form:

$$m_t - p_t = k + ay_t - br_t \quad (1)$$

where:

m = log of money supply ($m_t^s = m_t^d = m_t$);

p_t = log of the price level;

y_t = log of real income;

r_t = log of (1+i) (i = nominal interest rate);

$(a>0)$ = income elasticity of money demand;

$(b>0)$ = minus the negative elasticity of money demand with respect to (1+i);[2]

k = constant.

If an identical "foreign" money demand function is specified with "*" superscripts indicating foreign values, subtracting from (1) the foreign equivalent of (1) gives, setting $k = k^*$:

$$\underline{m}_t = p_t - p_t^* + a\underline{y}_t - b(r - r^*) \quad (2)$$

where

$$\underline{m}_t = (m_t - m_t^*)$$

$$\underline{y}_t = (y_t - y_t^*)$$

Money Supply: Sterilization and Intervention

Money supply is represented by a log linear money "production function" which determines money supply in terms of domestic and foreign assets of the central bank. For country 1, let:

$$M_1^s = D_1^{j_1} \; X_1^{j_2} \tag{3}$$

where:

M_1^s = money supply;

D_1 = domestic assets of central bank in country "1";

X_1 = foreign exchange reserves of central bank in country "1";

j_1 = elasticity of money supply with respect to D_1;

j_2 = elasticity of money supply with respect to X_1.

In logs (3) becomes:

$$m_{1_t} = j_1 d_1 + j_2 x_1 \tag{4}$$

Sterilization links d negatively to reserves

$$d_{1_t} = de_{1_t} - (1-st_1)\, x_{1_t} \tag{5}$$

where

de_{1_t} = log of autonomous portion of domestic assets of central bank in country 1;

st_1 = sterilization coefficient in country 1 [$st_1 = 0$ implies full sterilization; $st_1 = 1.0$ implies zero sterilization and $d_{1_t} = de_{1_t}$].

Intervention links reserves to the exchange rate where:

$$x_1 = - \gamma_1 s \tag{6}$$

γ_1 measures the elasticity of official reserves with respect to the exchange rate, s. The faster currency 1 depreciates (a rise in s) the faster country one reserves are lost (and the faster "foreign" reserves rise). If analogous expressions apply for country 2, ("rest of world") then $\underline{m}_t$, the relative money supply term for countries 1 and 2, can be written as:

$$\underline{m}_t = \underline{de}_t + \phi s_t \tag{7}$$

where:

$$\underline{de}_t = j_1\, de_{1_t} - j_1^*\, de_{2_t}$$

$$\phi(\leq 0) \equiv [-\gamma_1(j_2 - j_1(1-st_1)) - \gamma_2(j_2^* - j_1^*(1-st_2))]$$

If intervention dominates sterilization so that currency depreciation lowers x_1 and raises x_2 then ϕ is unambiguously negative. If sterilization eradicates intervention's affect on the monetary base $\phi = 0$. In this case $\underline{m}_t = \underline{de}_t$ and there is no need to take account of either intervention or sterlization in modeling the money supply. From (7) it is clear that the value of all reduced-forms describing the impact upon the exchange rate of exogenous variables are linked to "ϕ." And "ϕ" in turn depends upon intervention and sterilization policy parameters γ_i and st_i (i = 1,2) which may change over time.

Equations (2) and (7) along with purchasing power parity, interest parity and the condition that the forward rate is an unbiased measure of the public's expected spot rate enable a rational MERE solution for the exchange rate.

A Solution for the Exchange Rate

Interest parity is written as:

$$f_t - s_t = r_t - r_t^* \tag{8}$$

where f_t is the log of the forward domestic currency price of foreign currency as of time "t" for time "t+1." Here "r's" refer to one plus nominal interest rates on instruments of term "t" to "t+1." The simple efficient market hypothesis states that under conditions of risk neutrality, zero transactions costs, rational use of information and competitive markets:

$$f_t = E_t\ [s_{t+1} | \text{information}_t] \tag{9}$$

Equation (9) sets the forward rate at "t" for time "t+1" equal to the mathematical expectation of the spot rate at time "t+1" conditional on the information set available at time "t."

Equations (8) and (9) imply:

$${}_t s^e{}_{t+1} - s_t = r_t - r_t^* \tag{10}$$

where ${}_t s^e{}_{t+1} \equiv E_t[s_{t+1} | \text{information}_t]$. Equation (10) can be substituted into equation (2) for $(r-r^*)$ while PPP sets $p_t - p_t^* = s_t$. These substitutions along with expressions for money supply behavior enable a rational solution for the exchange rate of the form:[3]

$$s_t = [\frac{1}{1-\phi}]\ [(1+W_d)\ \underline{de}_t - Wd\ \underline{de}_{t-1}]$$

$$- [\frac{a}{1-\phi}]\ [(1+W_y)\ \underline{y}_t - W_y\ \underline{y}_{t-1}] \qquad (11)$$

where AR-1 processes define growth of exogenous variables

$$\Delta\underline{de}_t = \rho_d\ \Delta\underline{de}_{t-1} + u_{d_t} \qquad (12.a)$$

$$\Delta\underline{y}_t = \rho_y\ \Delta\underline{y}_{t-1} + u_{y_t} \qquad (12.b)$$

and

$$W_j(j=d,y) = \frac{b\rho_j}{(1-\phi)+b(1-\rho_j)} = \frac{b}{(1-\phi)}\ (\text{with } \rho_j=1)$$

With ρ_j all equal one (growth of exogenous variables a random walk), letting a = 1.0, the result is a basic form of the extended MERE model useful for elucidating its basic features:

$$s_t = [1/(1-\phi)][(1+b')[RXM]_t - b'[RXM]_{t-1}] \qquad (13)$$

where $b' \equiv [b/(1-\phi)]$.

where RXM $\equiv$ [$\underline{de}$ - $\underline{y}$] or relative excess money supply.

Equation (13) implies a cyclical response of the exchange rate to relative excess money supply (RXM). If sterilization cancels the impact of intervention on the monetary base (ϕ=0), the elasticity of the exchange rate with respect to RXM is (1+b), implying an initial "overshoot" of amount "b" which is subsequently removed at t-1. Sharpness of the cyclical response of the exchange rate to RXM is proportional to the interest elasticity of money demand. This result is most easily understood by first noting that interest parity, PPP and unbiasedness of the forward rate as a predictor of the expected spot rate together imply that Fisher equations describe nominal interest rates in each country.[4] These conditions are all implicit in (13). Given these conditions a rise in RXM is exacerbated by a drop in money demand at home relative to abroad which in turn results from higher nominal interest rates at home relative to abroad. The latter results from a relative increase in expected inflation at home. The size of the additional negative effect on money demand depends on the size of b, the interest elasticity of money demand. In short a rise in RXM feeds on itself by causing anticipated inflation which lowers steady-state money demand. Therefore the exchange rate must depreciate by more than a change in RXM to reduce domestic excess money supply. Once the initial overshoot reduces steady state real money balances at home, the extra pressure on the exchange rate is removed and the overshoot portion of depreciation disappears.

Implications of Extended MERE for Capital Flows

Further testable implications of MERE and perhaps a more thorough comprehension of observable behavior can be obtained by expanding it to develop a hypothesis about behavior of international capital flows. The basic balance of payments identity sets the (positive) change in official reserves ΔR (intervention) equal to the sum of net surplusses in private capital flows, PK, and the current account, CA.

$$\Delta R_t = PK_t + CA_t \tag{14}$$

Recall that the intervention equation (6) can be differenced in log form to link the rate of change of reserves to the rate of change of the exchange rate:

$$\Delta x_t = \frac{\Delta R}{R} = - \gamma_1 \; \Delta s_t \tag{6.a}$$

Rearranging (14), dividing through by R and substituting from equation (13) for Δs_t (where CA_t is viewed as a disturbance term, e_t) gives:

$$\left(\frac{PK}{R}\right)_t = \left[\frac{-\gamma(1+b')}{(1-\phi)}\right]\left[\Delta(RXM)_t\right] + \left[\frac{\gamma b'}{(1-\phi)}\right]\left[\Delta(RXM)_{t-1}\right] + e_t \tag{15}$$

Equation (15) indicates that the extended MERE model of exchange rate behavior implies a cyclical (outflow-inflow) response of private capital flows to a change in the <u>growth</u> of relative excess money.

This result is a straightforward extension of the extended MERE theory of exchange rate behavior. Notice first that with freely flexible exchange rates, (γ=0) Δ(RXM) produces no impact on capital flows. This follows because the exchange rate is absorbing all adjustment pressure in the face of an excess money supply. "Leaning-against-the-wind" (γ>0) prevents full adjustment of the exchange rate to its perceived equilibrium level and so some of the excess money supply pressure is relieved by a capital outflow which rises with the degree of intervention measured by γ.[5] The outflow also rises with b (interest elasticity of money demand) which in turn determines underlying pressure on the exchange rate. Finally, as more sterilization drives (negative) ϕ toward zero, outflows pick up in anticipation of prolonged pressure on the exchange rate arising from chronic relative excess money.

The lagged inflow of capital on response to a rise in growth of RXM indicated by (15) is the quantity-adjustment counterpart of the cyclical response of the exchange rate to RXM described earlier. Because rational projection of RXM into the future requires a reduction in the equilibrium stock of money demanded, a temporary price (exchange rate) overshoot is required to reduce the stock of money held. Once completed the overshoot pressure is removed and the overshoot is reversed. With intervention this results in a capital inflow.

PPP and "Real" Exchange Rate Movements

Equation (15) constitutes a test of the extended MERE model of exchange rate behavior in first difference form augmented with "leaning-against-the-wind" intervention. The MERE expression for Δs_t required to yield equation (15) avoids some of the difficulties associated with failure of purchasing power parity to hold in log level form. Suppose we write PPP as:

$$s_t = (p_t - p_t^*) + q_t \qquad (16)$$

where q_t is the log of the "real" exchange rate. If q_t follows a random walk:

$$q_t = q_{t-1} + v_t \tag{17}$$

where v_t = "white noise" residuals from an AR-1 model on q_t ($v \sim n,\sigma_v^2$). Then, given (16) and (17):

$$\Delta s_t = \Delta(p-p^*)_t + v_t \tag{18}$$

Equation (18) indicates that PPP is satisfied by first differencing logs whenever the "real" exchange rate, q, follows a random walk. During the sample period to be investigated here it is not possible to reject the hypothesis that q followed a random walk for major exchange rates such as the U.S. dollar prices of DM and yen.[6]

The implication of these observations on the real exchange rate is clear. Testing the extended MERE model by investigating behavior of capital flows automatically implies testing the differenced log form of that model which is in turn more likely to avoid the widely observed failure of exchange rate levels to behave according to PPP. Alternatively, direct tests of exchange rate behavior under the extended MERE formulation ought to be in first-difference form as in Caves and Feige (1980) and Makin (1980.b).

3. Testing the Theory: U.S. International Capital Flows

Raw Data and Sample Period

Commerce Department data on private U.S. capital flows published in the Survey of Current Business is employed to test the theory outlined in Section 2. U.S. financial capital flows include net changes in claims reported by U.S. banks and non-banks and net changes in overall ownership of foreign securities. These items together with direct investment comprise total private capital flows in the U.S. balance of payments scheme.

A continuous quarterly series on total U.S. private capital flows is available beginning in 1969: I. The sample employed in this study consists of quarterly, seasonally unadjusted data running from 1969: I through 1980: II. The 46 quarterly observations are drawn from data available as of October, 1980.[7]

Some investigators, including Branson (1968), have suggested that the statistical discrepancy category in the U.S. balance of payments accounts is in reality composed largely of unrecorded capital flows. Empirical tests reported in Makin and Nelson (1980) do not permit rejection of this hypothesis. In view of this finding and those by other investigators, measurement of actual capital flows as recorded flows only would result in an errors-in-variables problem. Therefore the measure of actual capital flows employed here is the sum of recorded capital flows and statistical discrepancy.

The major explanatory variable indicated by equation (15) is a measure of growth of relative excess money, that is, growth of U.S. excess money relative to growth of "rest of world" (ROW) excess money. A measure of U.S. excess money growth is easy to obtain. Growth of "new" M_3 less growth of industrial production is employed here.[8] An adequate measure of ROW excess money growth is harder to obtain. Various weighted averages of excess money growth for major industrial countries added only insignificantly to the explanatory power of U.S. excess money growth alone. A number of difficulties arise in trying to obtain comparable series, suitable for aggregation across major industrial countries. Some weighting scheme has to be devised as well and it is not clear that a fixed weighting scheme over time is appropriate.

In view of these problems and in the interest of obtaining data of consistent quality without enduring long and variable reporting lags for some countries' data, an alternative measure of ROW excess money growth was sought. An initial thought was that actual ROW inflation provides a simple measure of ROW excess money growth. But ROW inflation involves all of the aggregation problems just alluded to. If commodity arbitrage is operative, actual U.S. inflation ought to measure the consequences of ROW excess money growth. In addition, such a number has the advantage of ready availability and avoidance of complex aggregation problems. These considerations led to employment of U.S. actual inflation as a proxy for ROW excess money growth. The result is a measure of relative excess money growth equal to growth of "new," U.S. M_3 less growth of U.S. industrial production less the rate of U.S. (CPI) inflation.[9] Alternatively, one could view this construct as a measure of incipient excess dollars where the ratio of dollar assets to the flow of real commodities is rising faster than the current rate of depreciation of dollars against commodities.

Exchange Rate Regime Changes

Obviously the 1969-80 sample period spans various nominal exchange rate regimes from "fixed" to "floating." Such nomenclature may exaggerate the extent of changes in the exchange rate regime during our sample period. While significant changes in foreign exchange market intervention policy of central banks did occur during this period, exchange rates were never rigidly fixed or freely flexible. Rather the preannounced intervention policy of the Bretton Woods regime evolved, during the period from August, 1971 to March, 1973, to an era of unannounced intervention policy. Throughout the period, large scale intervention by central banks in foreign exchange markets has meant that capital flows have served to eliminate such disequilibria in markets for internationally traded assets as are not eliminated by constrained movement of exchange rates.

Examination of the raw series measuring the sum of U.S. private capital flows and statistical discrepancy (KSD) reveals that movement away from the Bretton Woods system after 1971 is accompanied by a marked increase in variability of KSD about the sample mean over the 1969: I - 1980: II sample period. Deflating the series by nominal

GNP effectively stabilizes the variance. Alternatively, as suggested by equation (15), it would be appropriate to employ the total stock of official reserves as a scale variable to remove heteroschedasticity. Some experimentation revealed that a reserve asset variable did not eliminate heteroschedastic disturbances as effectively as did nominal GNP. Therefore the dependent variable employed in estimated equations was the ratio of U.S. private capital flows plus statistical discrepancy to U.S. nominal GNP.

Within the quarter that a sharp change in the exchange rate regime occurs, however, there may still result large capital flows in response to changed expectations about optimal portfolio holdings. Within our sample period, such changes did occur during the third quarter of 1971 (end of gold exchange standard) and the first quarter of 1973 (end of Smithsonian System). A separate dummy variable for each of these quarters is included in equations estimated for capital flows. The effect is to acknowledge significant changes in the exchange rate regime under the hypothesis that the initial stock-adjustment effects of such changes upon capital flows are largely over within a quarter.

Capital Controls

In addition to changes in intervention policy within the sample period, U.S. controls on capital flows were in place until January, 1974. It remains an empirical question as to whether such controls had any effect on actual capital flows. No significant change was detected after 1974 in behavior of residuals for estimated capital flows equations reported below. This may be due to avoidance of capital controls which led actual capital flows to appear in the statistical discrepancy category.[10]

Estimation Results

Transfer function estimation procedures following Box and Jenkins (1970) were employed to estimate capital flow equations. This methodology enables parsimonious representation of possible lengthy, cyclical distributed-lag effects running from growth of relative excess money to capital flows along with simultaneous pre-filtering of capital flows by means of an AR, MA or ARMA model. Under this specification excess money supply must improve on the ability of past values of capital flows to explain future capital flows. This constitutes a more stringent test of the theory since any correlation between past capital and past growth of relative excess money will tend to lower the explanatory power of a distributed lag on growth of relative excess money.

In effect, estimation of equation (15), given modifications of dependent and independent variables just discussed, amounts to estimation of the elasticity of U.S. capital flows (as a share of GNP) with respect to relative excess money growth. In addition to relative excess money growth, dummy variables for 1971-III and 1973-I are included along with a univariate noise model on capital flows.

Table 1 reports on estimation of the transfer function model of U.S. capital flows. Numerator parameters at lags zero and one (0-n. and 1-n.) and first and third order denominator parameters (1-dn. and 3-dn.) describe a cyclical distributed-lag impact of relative excess

TABLE 1

U.S. PRIVATE INTERNATIONAL CAPITAL FLOWS
INCLUDING STATISTICAL DISCREPANCY
[DEFLATED BY U.S. NOMINAL GNP: 1969-I-1980-II]
(t-Statistics in Parentheses)

$R^2(\bar{R}^2) = 0.69\ (0.62)$ $F(8,34) = 9.28$

	0-n.	1-n.	1-dn.	3-dn.	Total Gain
U.S. Excess Money:					
	-0.1302 (2.25)	-0.0617 (-0.89)	1.1491 (10.19)	-0.4518 (4.57)	-0.226
Dummies: 1971-III:					
	-7.283 (4.79)				-7.283
1973-I:					
	-8.561 (5.34)				-8.561
Noise Model:	AR-3	MA-4			
	0.6127 (4.33)	-0.6644 (4.44)			
Constant:	-1.8363 (1.36)				

money growth on capital flows. Figure 1 displays the full distributed lag. Translated into capital flows, the estimated parameters indicate roughly a "one-for-one" rule whereby a one percent rise in relative excess money growth causes a capital outflow, over the contemporaneous and four subsequent quarters, of about $1.0 billion (1980 dollars). The "total gain" for the relative excess money variable as a result of subsequent cyclical inflows and outflows over about four years leaves a net outflow of about $0.6 billion. Subsequent cycling persists after four years as indicated in Figure 1, but at a low level.

It is also clear from Table 1 that large U.S. capital outflows over and above what were implied by relative excess money growth conditions resulted from events in 1971-III and 1973-I. Estimated outflows of about $7.8 billion and $10.8 billion respectively within each of these quarters seem large, but it should be remembered that during 1971-III especially foreign central banks were supporting the dollar very heavily in a manner that prevented exchange rate adjustments required for a move to equlibrium. Japan alone accumulated $5-$6 billion during 1971-III. The first quarter of 1973 was also a period of very heavy intervention.

The noise model on capital flows includes a third order autoregressive terms [AR-3] and a fourth-order moving average term [MA-4]. As indicated earlier, relative excess money growth and dummy variables are explaining the residuals from the univariate noise model. As such, any correlation between relative excess money and past capital flows will tend to bias against finding significant explanatory power for

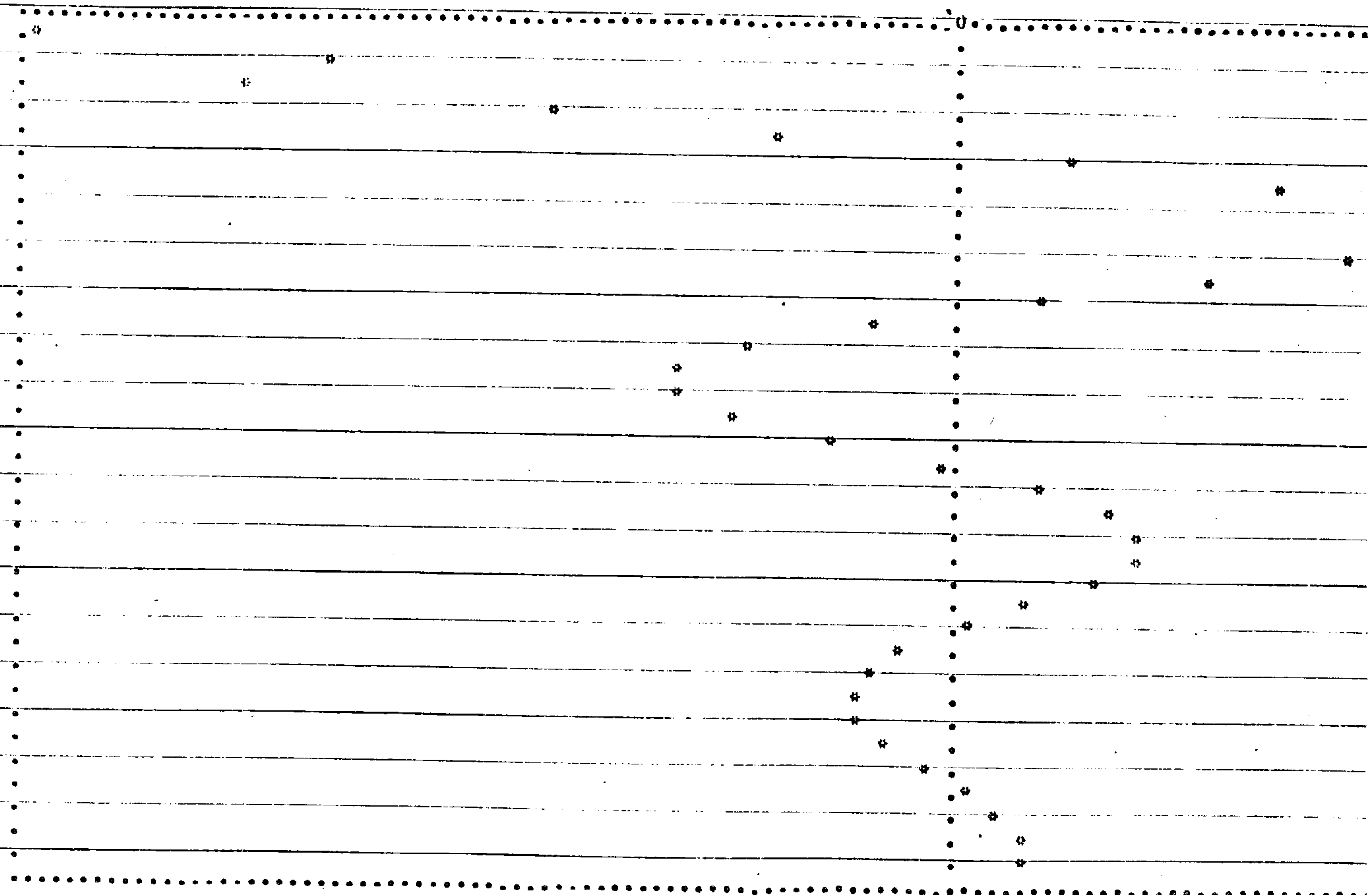
Figure 1

EXOGENOUS VARIABLE NO. 1 : %M MINUS %Y + %P

R(DELTA) = 3   S(OMEGA) = 1

DISTRIBUTED LAG WEIGHTS   RANGE = -.1302   TO .6437E-01

0	-.1302
1	-.8787E-01
2	-.1010
3	-.5721E-01
4	-.2604E-01
5	.1609E-01
6	.4568E-01
7	.6219E-01
8	.6437E-01
9	.5414E-01
10	.3412E-01
11	.1112E-01
12	-.1283E-01
13	-.3015E-01
14	-.3422E-01
15	-.3427E-01
16	-.3150E-01
17	-.1840E-01
18	-.3495E-02
19	.1022E-01
20	.2009E-01
21	.2566E-01
22	.2572E-01
23	.1819E-01
24	.9754E-02
25	.4697E-03
26	-.7653E-02
27	-.1220E-01
28	-.1539E-01
29	-.1623E-01
30	-.1136E-01
31	-.4979E-02
32	.7601E-03
33	.5603E-02
34	.8572E-02
35	.9531E-02



STEADY STATE GAIN = -.2271

relative excess money. In view of this fact, the strong explanatory power of relative excess money growth is more impressive than it would be if an OLS equation indicated that relative excess money growth "explained" some part of capital flows. Further, if the theory summarized in equation (15) is correct, this result also supports the hypothesis that the measure of relative excess money growth being employed here is a good proxy for actual relative excess money growth.

Response Pattern of Capital Flows to Relative Excess Money Growth

The oscillatory response of capital flows to relative excess money supply growth is suggested by the extended MERE model of capital flows developed in Section 2. Still, the result presented there reflects a very simple (AR-1) process on growth rates of exogenous variables. Other, more complex representations may be appropriate. Further, intervention and sterilization policies may play a crucial role in extending the oscillatory response of capital flows to excess money supply conditions in a manner like that displayed in Figure 1. More specifically, capital flows are seen here as the response to conditions where official intervention in foreign exchange markets prevents adjustment of an exchange rate to its equilibrium level while, simultaneously, the impact upon the monetary base of the intervention activity is sterilized. A reversal of policy comes when authorities realize that the market's evaluation of the equilibrium exchange rate differs from their own and that this coupled with intervention and sterilization implies a chronic disequilibrium reflected in chronic capital flows.

Consider a concrete example of this basic idea. Suppose that a rise in money growth creates pressure for what would, under freely flexible exchange rates, result in an overshoot depreciation of local currency. However, the central bank, considering such depreciation excessive, intervenes to support the home currency. Foreign exchange is sold from official holdings to satisfy excess demand in the market. The contractionary impact upon the monetary base is offset through sterilization since the authorities see such "excessive" pressure as being only temporary. Capital outflows will result under these conditions if market participants perceive that such levels of intervention and sterilization do not represent sustainable, equilibrium values. In effect, foreign currency will be viewed as a bargain and capital outflows will likely accelerate as the strains on official foreign exchange reserves make imminent reversal likely.

This combination of events will lead authorities eventually to reverse their stance. Of course this usually occurs only after a protracted delay which consumes large amounts of foreign exchange reserves. The delay follows because the authorities had thought that outflows were to be temporary and therefore were tempted to wait for a market turnaround. Since the policy reversal occurs often in a crisis atmosphere with foreign exchange reserves depleted, it has to be overdone. Money is tightened sharply and, in order to rebuild reserves, the exchange rate is not allowed to appreciate to its long run equilibrium value. Foreign exchange is purchased, at a price above that at which it was sold during the expansionary phase of domestic monetary policy, and the impact on the monetary base sterilized. Again market participants perceive that such levels of intervention and sterilization do not represent sustainable, equilibrium values. Capital inflows result as domestic currency is viewed by foreigners as a bargain at prevailing exchange rates. The inflow phase ends once restoration of reserves and/or pressures to allow more money growth result in an end to sterilization of inflows or even a new phase of monetary stimulation. In the latter case the cycle may be repeated, although somewhat irregularly over an extended period of time.

The key to cyclical capital flows lies with maintenance of official intervention and sterilization policies which market participants do not expect to persist. This implies that policy-makers do not follow error-learning behavior and on net are consistently losing money to private foreign exchange market participants who are able to buy and sell foreign exchange at favorable prices. Consistent losses by central banks on foreign exchange market intervention would therefore be consistent with our hypothesis. In a recent study by Taylor (1980) it is reported that: "from 1973 to 1979 (within our sample period) the combined losses of the central banks of France, Germany, Italy, Japan, Switzerland, the United Kingdom and the United States have exceeded $10 billion... ." This finding is consistent with our scenario whereby cyclical behavior of capital flows persists throughout our sample period due to the presence of irrational official participants in the foreign exchange markets.

Testing for Additional Explanatory Power of Interest Rates

Inclusion of an interest rate term in the equation reported in Table 1 results in decisive rejection of the hypothesis that, in the presence of relative excess money growth, additional explanatory power comes from the rate of change of U.S. interest rates relative to the rate of change of a major, foreign (DM) interest rate.[11] More precisely, the contemporary relative interest term was insignificantly different from zero (t = 0.35) while the rest of the parameter estimates reported in Table 1 were largely unaffected. The Chi-Square test of cross correlations between residuals from the estimated equation and the pre-whitened interest differentials for lags zero through twelve quarters was s(0,12) = 6.05. This result decisively rejects the notion of any additional explanatory power coming from a distributed lag on the interest differential term.

4. Concluding Remarks

A rational, monetary-equilibrium theory of exchange rate behavior determines exchange rates in terms of currently anticipated values of relative excess money supply. In a world of limited flexibility of exchange rates, the same theory determines international capital flows in terms of growth of relative excess money supplies.

The interest rates which traditionally have played a dominant role in portfolio-based theories of capital flows are redundant in a full equilibrium model. This is because capital flows register the response to changes in the *relative* outlook regarding the ability of different monies to store purchasing power over commodities and the relevant exogenous variables affecting this outlook are quantities of different monies relative to available commodities. An econometric corrollary of this view of capital flows is the opportunity it affords to avoid simultaneity and multicollinearity problems which abound in efforts to estimate capital flows largely in terms of changes in interest rates with some risk or wealth proxies possibly included.

Among the more interesting empirical results obtained in testing the theory put forward here was the finding that U.S. international capital flows respond with persistent, damped oscillations to growth of relative excess money. This phenomenon is a quantity adjustment corrollary of exchange rate "overshooting" of exchange rates in response to changes in relative excess money supply. Central banks which have a record of persistently accelerating money growth can expect overshooting in response to current actual money growth as soon as past behavior comes to be extrapolated into the future. Intervention efforts to cut exchange rate depreciation will result in capital outflows which can in turn trigger a series of events consistent with persistent and yet somewhat irregular oscillation of such flows as sterilization and intervention policy are changed over time.

More generally the results presented here are meant to suggest new directions for empirical research on international capital flows. Success in this area has so far been modest despite the important theoretical breakthroughs represented by the portfolio approach of Branson (1968) and the monetary analysis by Kouri and Porter (1974). Promise lies with the rational-monetary-equilibrium approach to exchange rate determination coupled with an understanding of the role of capital flows as residual shock absorbers when exchange market intervention prevents full price adjustment to a currently perceived change in the future path of excess money supply conditions.

FOOTNOTES

* I owe special thanks to Charles Nelson without whose help this paper would not have been written. Responsibility for any errors is mine.

1. Purchasing power parity (PPP) or commodity arbitrage is included among the arbitrage conditions. As noted by Dornbusch (1980) and others, large "real" exchange rate movements, particularly among U.S. dollar exchange rates during the 1970's, have caused significant deviations from PPP. It will be seen below that this deviation from PPP in levels of prices and exchange rates presents no difficulty for empirical testing of the extended MERE model of capital flows which requires only that the differenced log form of PPP is satisfied.

2. "b" will be slightly below interest elasticity of money demand with respect to "i," with the difference falling as i rises. The "1+i" formulation turns out to be particularly convenient for capturing interest parity and introduces no substantive changes in the nature of money demand.

3. The general form of the rational solution for the exchange rate before capturing behavior of exogenous variables in specific AR-1 form given by (12.a) and (12.b) is (where a=1.0; c=(b-ϕ)):

$$s_t = \frac{1}{1+c} \sum_{j=0}^{\infty} \left[\frac{b}{1+c}\right]^j \left[{}_t(\underline{de} - \underline{y})^e_{t+j}\right] \qquad (11.a)$$

where

$$\left(\frac{b}{1+c}\right)^n \to 0 \text{ as } n \to \infty.$$

(11.a) determines the current, spot exchange rate in terms of current expectations of all future relative excess money supplies, ${}_t(\underline{de} - \underline{y})^e_{t+j}$.

4. This condition holds given a constant ratio of domestic to foreign real interest rates.

5. This effect is mitigated by the rise in negative "ϕ" as "γ" rises.

6. For monthly data running from June, 1970 through December, 1979 differenced "q" for Germany and Japan leave white noise residuals. Relevant Box-Pierce tests for autocorrelations are:

   [Germany] Q(12)=17.9, Q(24)=25.7, Q(36)=34.6;

   [Japan] Q(12)=11.7, Q(24)=22.0, Q(36)=26.4.

7. All data on capital flows is drawn from the Survey of Current Business. Data is frequently revised and series definitions are redefined at times. The latter accounts for the necessity to begin the sample in 1969-IV if a continuous, consistent series on total U.S. capital flows is to be employed.

8. Both series are seasonally unadjusted. This permits estimation of pre-filters on excess money which reflect seasonal patterns implicit on the raw data and not those imposed by some pre-specified seasonal filter.

   New M_3 was selected because it includes the large time deposits at commercial banks which are likely to be held by investors whose regular portfolio management includes attention to an international array of interest rates.

9. The producer price index was tried as well with little impact on results.

10. A number of reports on effects of U.S. capital control programs presented at a U.S. Treasury-sponsored conference in December, 1972 found little impact of U.S. capital controls on overall capital flows and U.S. monetary independence. Such input may have been instrumental in reaching the decision to end capital control programs in January, 1974.

11. The interest rate variable was the rate of change of the 3 month dollar interest rate in the euromarket less the rate of change of the 3 month euro-DM rate, with both series drawn from the Harris Bank tape.

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