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Mundell-Fleming, and uncovered interest rate parity models**

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With full stock/flow accounting respected, the two-country open economy portfolio balance model has just two independent equations for asset market clearing. It can determine home and foreign interest rates but not the exchange rate. If asset market equilibria vary smoothly over time, the balance of payments equation in the Mundell-Fleming model is not independent and cannot set the exchange rate either. The familiar fixed reserves/ "floating rate" vs. endogenous reserves/"fixed rate" dichotomy does not exist, and "fundamentals-based" econometric models of the exchange rate are bound to fail. An alternative is a two-country IS/LM model with exchange rate dynamics added. Its dynamic properties under uncovered interest rate parity are briefly explored.

Key words: Exchange rate, Mundell-Fleming model

JEL classifications: F32, F41

For three decades, a central doctrine of open economy macroeconomics has been that the portfolio balance and Mundell-Fleming (or IS/LM/BP) models - the workhorses of international finance for policy and teaching purposes - both contain three independent equations that determine three variables: the home and foreign interest rates and the spot exchange rate.

The gist of this paper is that received wisdom is incorrect. If economic actors satisfy standard balance sheet and portfolio allocation restrictions, then setting the exchange rate is beyond the models' reach. The key reason why is that in the short run the home and foreign economies' nominal net foreign asset (or NFA) holdings are constant. Not only are one country's external assets the other's liabilities, but at a given exchange rate their net positions can only

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change over time via current account surpluses or deficits. In temporary equilibrium, each country's NFA constraint forces its money market to clear when its bond market is satisfied and vice-versa.

The arguments supporting these findings proceed in the Keynesian spirit of the models concerned. We begin in section 1 with an analysis of stock and flow accounts in a two-country macroeconomic system. Portfolio balance, Mundell-Fleming, and uncovered interest rate parity (UIP) exchange rate theories are quickly sketched in section 2. The inability of the portfolio balance model to set the exchange rate is demonstrated in section 3. Section 4 does the same for Mundell-Fleming. The independent temporary equilibrium conditions that do exist boil down to linked IS/LM models for the two countries, with activity levels and interest rates (X and X^* and i and i^* respectively) as the endogenous variables. Comparative static exercises become of interest, taking the spot exchange rate (e), its expected change over time (ε), and other variables as pre-determined. Examples for a "small" home country are presented in section 5. Section 6 sketches dynamic extensions under the assumption that UIP applies, and a few additional considerations appear in section 7.

Before jumping into the details, three methodological observations are worth adding. First, although no one seems to have noted it in the standard models, the irrelevance of the exchange rate to temporary equilibrium in open economy asset markets has been pointed out in other contexts, e.g. in a two-country growth model by Foley and Sidrauski (1971), an overlapping generations model by Kareken and Wallace (1981), and a computable general equilibrium model by Rosensweig and Taylor (1990).

Second, intertemporal optimization as surveyed by Obstfeld and Rogoff (1995) could be added to the analysis without altering the tenor of the results. In temporary equilibrium, intertemporal models incorporate portfolio balances and a real side macro model. Over time, they use Euler differential equations to determine the exchange rate via UIP and consumption levels via optimal saving rules a la Ramsey (1928). The Euler equations determine *changes* in consumption levels and the exchange rate by intertemporal arbitrage. They are not directly relevant to the discussion of temporary equilibrium in sections 3-5, which focuses on levels of

stocks and flows. In section 6, it is argued that the traditional interpretation of the portfolio balance model, if correct, would be inconsistent with the intertemporal arbitrage underlying UIP.

Comments about Ramsey rules appear in section 7.

Finally, the results here help explain why an enormous empirical literature finds that "fundamentals-based" models of the exchange rate have negligible predictive power. If the standard models cannot determine the spot rate, then econometric tests based upon them will almost certainly fail.

1. Accounting conundrums

Often the best way to attack a problem in economics is to make sure your accounting is right. Tables 1 and 2 attempt this task for international trade and financial relations. It is unfortunately true that full accounting in models containing real and financial sectors requires a wagonload of symbols. The details in both tables are needed to demonstrate the results that follow. They follow broadly from a scheme proposed by Godley (1996).

Table 1 sets out the home and foreign countries' flow accounts in the form of a spreadsheet or social accounting matrix (SAM). Table 2 presents the corresponding balance sheets. Since the emphasis is on external transactions, economic actors in each country are aggregated into just three groups - a private sector comprising households and non-financial business, government, and the banking system which consolidates commercial and central banks. Variables referring to the home and foreign private sectors are labeled with subscripts h and f respectively. The foreign country's stocks and flows are denoted by asterisks in both tables.

Tables 1 and 2 here

As shown in Table 2, the primary assets underlying the flow accounts in the SAM are capital stocks valued at their asset prices (qPK and $q^*P^*K^*$ where q and q^* are "valuation ratios" or levels of "Tobin's q ") and outstanding short-term bonds or T-bills issued by the two governments (T and T^* , with interest rates i and i^* respectively). Both banking systems carry a subscript b , but they are distinguished by their asset portfolios. The home system's assets are

home bonds T_b and foreign bonds as reserves with a value eR^* ; the foreign system holds foreign bonds T_b^* and home bonds as reserves with a local value R/e . The banks have zero net worth and their liabilities are the money supplies M and M^* respectively. In their portfolios, the private sectors hold the relevant capital stock qPK or $q^*P^*K^*$, both flavors of bonds, and the local form of money M or M^* .¹

In the SAM, the two main accounting conventions are that corresponding row and column totals are equal, and that in each country the entries in each row are valued at the same price. Accounts for the home country appear to the left, and for the foreign to the right. Cross-border flows are mediated by "Exchange conversions" between the two sides (the conversions also involve a sign change because an inflow to one country is an outflow from the other). The spot exchange rate, e , is the home currency price of foreign currency.

Output and income generation relationships appear toward the northwest of each country's section of the SAM. Real output levels are X and X^* in the home and foreign countries respectively, with prices P and P^* . The corresponding costs of production are broken down in columns (1) and (1*). Total values of output PX and P^*X^* include payments for nominal value-added (V and V^*) and imports (eP^*aX and Pa^*X^*/e). Both countries are assumed to have "workshop economies," in which imports are reworked for domestic and foreign sales, thus becoming elements of cost.² Real imports are scaled to outputs by coefficients a and a^* , which could depend on relative prices such as the real exchange rate eP^*/P in models of the neoclassical persuasion.

Rows (A) and (A*) show that outputs are used for the usual purposes - private consumption, government spending, investment, and exports. For future reference, note how exports in cells (A, 6) and (A*, 6*) are valued in local prices. The row and column totals in (A) and (1) and (A*) and (1*) are the same, in line with the accounting convention noted above.

Rows (B)-(D) and (B*)-(D*) show how incomes of the private sectors, governments, and banks are generated; their outlays and levels of saving appear in columns (2)-(4) and (2*)-(4*). In

rows (B) and (B*), the private sectors receive incomes from value-added and interest payments on their holdings of local and external bonds (for the home private sector, the receipts are iT_h and $ei^*T_h^*$ respectively). The simplest way to deal with interest incomes on bank assets is to assume that they are passed along to the private sectors. In row (D), for example, the home banking system has interest income $Y_b = iT_b + ei^*R^*$. It transfers these returns Π_b to the private sector in column (4): $\Pi_b = Y_b$. As a result of such maneuvers, savings of the banking systems are equal to zero in cells (G, 4) and (G*, 4*). The governments get their revenues from taxes on private incomes (τY_h and $\tau^* Y_f^*$) in rows (C) and (C*).

Rows (E)-(G) and (E*)-(G*) show the different sectors' flows of funds. The accounting convention is the "sources" of funds (saving and increases in liabilities) are positive and "uses" (increases in assets) are negative. The equation for the home private sector in row (E),

$$S_h - Pl - \dot{M} - \dot{T}_h - e\dot{T}_h^* = 0 ,$$

shows that it uses its saving S_h for capital formation Pl and increased holdings of home money \dot{M} , home bonds \dot{T}_h , and foreign bonds valued by the exchange rate $e\dot{T}_h^*$ (the "dot" over each variable stands for its change over time). Combined with differentiation of the home household balance sheet in Table 2, this flow of funds equation gives the change in nominal home private sector wealth as

$$\dot{\Omega} = S_h + \dot{e}T_h^* + (\dot{q}P + q\dot{P})K ,$$

i.e. $\dot{\Omega}$ is the sum of saving and capital gains (or losses) from changing asset prices.

Row (F) shows that home government saving S_g must be negative if it is issuing a positive flow of new bonds ($S_g = -\dot{T} < 0$ when $\dot{T} > 0$). In row (G), the fact that the banking system's saving has been set to zero means that the growth of the money supply responds solely to changes in bank assets, $\dot{M} = \dot{T}_b + e\dot{R}^*$.

Three international payments flows go in each direction, for a total of six. See rows (H)-(M) and (H*)-(M*). In terms of their national prices, exports of the home and foreign countries

(that is, foreign and home imports) take the values $Pa^* X^*$ and $P^* aX$ in cells (A, 6) and (A*, 6*). Between rows (I)-(I*) and (H*)-(H), home and foreign exports are converted to the other country's prices by the inverse of the exchange rate ($1/e$) and its level (e) respectively (together with the sign switches mentioned above) and then become imports in columns (1*) and (1).

Second, in column (7) the home private sector and banks hold foreign bonds in quantities T_h^* and R^* . The values of their interest receipts in home prices are $ei^* T_h^*$ and $ei^* R^*$. With $T_{ext}^* = T_h^* + R^*$ as home's gross foreign assets, its total interest income is $ei^* T_{ext}^*$ in cell (J, 7). After an exchange conversion between rows (J) and (J*), the foreign government's interest payments in local prices on its bonds held abroad count as a fiscal outlay $i^* T_{ext}^*$ in cell (J*, 3*). The home government's interest payments on its gross external liabilities $T_{ext} = T_f + R$ are treated analogously in column (7*), rows (K*)-(K), and column (3).

Finally, foreign asset holdings change over time, e.g. $\dot{T}_{ext} = \dot{T}_f + \dot{R}$ is the equation for foreign accumulation of the home government's bonds at home prices. The exchange conversion is between rows (L) and (L*), and column (10*) gives bond accumulation in foreign prices.

The transactions appearing in the SAM correspond to the usual categories in balance of payments accounts, i.e. trade in goods and services, factor payments, and movements of capital. In a formal model, the trade flows would be driven by activity levels and relative prices, and interest rates would adjust to make sure that asset markets (incorporating both foreign and home flows) clear. Interest rates on asset stocks would set the levels of factor payments.

As Godley (1996) emphasizes, an apparent puzzle in the SAM is the fact that while it includes numerous international transactions, there is no "balance of payments" per se. It is not obvious why all the cross-border flows with their exchange conversions should add up to some over-riding "balance," especially since all have their own separate determinants.

But the standard accounting does make sense. To see why, it is helpful to think in terms of net foreign assets N of the home country, which can be defined as

$$N = e(T_h^* + R^*) - (T_f + R) = eT_{ext}^* - T_{ext} \quad , \quad (1)$$

or (in the present example) home's holdings of foreign bonds valued at the spot exchange rate minus the value of its own bonds held abroad. In (1) it is clear that N follows from historically given gross asset and liability positions, i.e. its level is set by the home economy's history of current account deficits and surpluses and the ways in which they were financed. It is shown below that net foreign assets cannot "jump" in unconstrained fashion in temporary equilibrium - any change in the level of gross assets has to be met by an equal change in gross liabilities to hold N left unchanged. In this way, (1) becomes a binding constraint on macroeconomic adjustment.

Net foreign assets can take either sign (including holdings of equity, they were about -\$2 trillion for the US at century's end). As nominal magnitudes, N and its foreign counterpart $-N/e$ are subject to capital gains and losses due to movements in the exchange rate. These are discussed below, so for the moment we concentrate on quantity changes in N . Summing and substitutions among the rows and columns of the SAM give the following chain of equalities:

$$\begin{aligned} S_h + S_g - PI &= e(\dot{T}_h^* + \dot{R}^*) - (\dot{T}_f + \dot{R}) = \dot{N} \\ &= [Pa^* X^* + ei^* (T_h^* + R^*)] - [eP^* aX + i(T_f + R)] = -S_f \end{aligned} \quad (2)$$

where S_f stands for the home country's "foreign saving" or current account deficit (if the home country is saving less than it invests, then the rest of the world must be providing saving to make up the shortfall).

In the first line of (2) the sum of domestic sources of saving minus investment is equal to the increase in net foreign assets. In turn, in the second line \dot{N} is equal to the surplus on current account (trade plus factor payments) or $-S_f$. All presentations of an economy's "balance of payments" are rearrangements of equations like those in (2). What they are basically saying is that (apart from capital gains and losses), net foreign assets evolve over time in response to the current account. Decisions about how net assets are "stored" in terms of national portfolio allocations (including amounts held in the form of international reserves) are discussed below.

2. Determining exchange rates

Three standard exchange rate models are considered in this paper - portfolio balance, Mundell-Fleming, and UIP. A "floating" rate freely adjusting over time (perhaps with discontinuous "jumps") is the focus of attention.

UIP emerges from intertemporal foreign currency arbitrage as analyzed in the 1920s by Keynes (1923), among others. It gives a rule by which the exchange rate can be calculated as an asset price from expected changes in its value over time. UIP is intrinsically dynamic, because it is based on arbitrage of own rates of return over time.

If ε is the *expected* short-term change in the spot rate e , the UIP rule can be written as

$$e = \varepsilon / (i - i^*) \quad . \quad (3)$$

The current exchange rate should be equal to its expected change, capitalized by the difference between the two interest rates, $i - i^*$.³

In line with Keynes's (1936) predilections in Chapter 17 of *The General Theory*, (3) can be restated in the form of an own-rate of interest (after the standard approximation that $(\varepsilon / e)i^* \approx 0$ on the right-hand side),

$$i = i^* + (\varepsilon / e)(1 + i^*) \approx i^* + \varepsilon / e \quad . \quad (4)$$

That is, the home interest rate will exceed the foreign rate whenever the home currency is generally *expected* to depreciate or weaken. If $\varepsilon > 0$, a Japanese investor going into dollars subjectively anticipates that the dollar/yen spot rate will increase (making future conversion back to yen more costly) and has to be compensated by an American rate i that exceeds i^* . The "spread" between the interest rates will become greater as ε / e , the expected relative change in the exchange rate, rises.

In contrast with UIP's emphasis on expectations about spot exchange rates in the future, macro level theories concentrate on the exchange rate's linkages with aggregates such as the trade balance, the composition of asset portfolios, or the overall balance of payments. A floating rate is *supposed* to arrive at a level that "clears" macro balances. With the rate fixed, the balances may not achieve equilibrium in well-determined ways.

The two widely accepted Keynesian models incorporating the financial side of the balance of payments date from the 1960s and 1970s.⁴ The younger concentrates on "portfolio balances," and claims that the exchange rate along with the two bond interest rates is determined by equilibrium conditions in three of four relevant financial markets - for home and foreign moneys M and M^* and bonds T and T^* (the fourth market is supposed to clear by Walras's Law). It is shown below that this claim is incorrect because there is just one independently clearing asset market in each country.

The other model is usually attributed to Mundell (1963) and Fleming (1962). In an open economy described by a 3 x 3 system of equations, adjustment dynamics are based on the ideas that the output level responds to excess commodity demand from an IS relationship and the interest rate shifts in response to asset market imbalances in an LM. The floating rate is supposed to adjust when the balance of payments (or BP) does not clear. On the other hand, if the exchange rate is pegged then international reserves have to be the adjusting variable, making monetary policy endogenous. Solving all three equations simultaneously gives the usual stability and comparative static results.

The Mundell-Fleming "duality" between reserves and the exchange rate evidently presupposes that a balance of payments exists, with a potential disequilibrium that has to be cleared. But as we have already seen in connection with Table 1, the balance of payments is at most an accumulation rule for net foreign assets and has no independent status as an equilibrium condition - an argument spelled out in detail below. The Mundell-Fleming duality is irrelevant, and in temporary equilibrium the exchange rate does not depend on how a country operates its monetary (especially international reserve) policy.

The bottom line assessment of the portfolio balance and Mundell-Fleming models is that they are not satisfactory approaches to exchange rate determination. In contemporary markets it appears that the rate is extrinsic to macro equilibrium as it emerges from adjustments in variables such as interest rates or the general level of economic activity. A floating exchange rate is not a "price" that equilibrates markets. Apart, perhaps, from the markets in which its own future values are set via UIP or other intertemporal behavioral practices.

Evidently, dynamic considerations have to be brought in. Though it does not fit the data (Blecker, 2002), UIP is the obvious intertemporal model to consider. A formulation incorporating IS, LM, and UIP is presented in section 6. It generates cyclical dynamics, as opposed to the saddlepath jumps characteristic of more recently popular dynamic optimization models mentioned above.

3. Portfolio Balance

The portfolio balance model was introduced as a natural extension of Tobin's (1969) financial market analysis from closed to open economy macroeconomics. The basic idea was that a floating exchange rate should be determined by some contemporary market-clearing mechanism - the message of subsequent surveys such as those by Branson and Henderson (1985) and Isard (1995). In this section, we will see how this rather plausible notion fails. In other words, if it is not fixed by the authorities, the exchange rate is determined by forces beyond those contained in a temporary equilibrium asset allocation model.

The basic assumptions in this section are that:

Private sectors and banking systems at home and abroad are the only actors holding financial assets. They take the form of national money supplies and short-term government bonds or T-bills that pay home and foreign interest rates i and i^* respectively. The money supplies are backed by home and foreign bonds held by the two banking systems.⁵

Both private sectors and banks satisfy their balance sheet restrictions, i.e. the total values of their assets are always equal to the total values of their liabilities plus net worth.

Apart from capital gains and losses induced by jumps in the exchange rate, total net foreign assets N (or $-N/e$) held by banks and the private sector in each country are constant in the short run. The reason is already clear from equation (2) above, which shows that N can only change over time in response to a surplus or deficit on current account.

A portfolio balance model is assumed to re-equilibrate in the short run to shocks such as operations of the monetary authorities and exogenous shifts in asset preferences. In the new temporary equilibrium, portfolio compositions may shift. In line with their key role in clearing asset markets, home and foreign interest rates are taken as the main endogenous variables.

Under these hypotheses, it will be shown that if the two markets for bonds clear, then so will the two markets for national moneys and vice versa. There are just two independent asset market equilibrium conditions in the system.

Traditionally, portfolio balance models are set up to deal with only the financial side of an open economy. Following this practice, capital stocks are ignored in the rest of this section. In the home banking system, the stock of M changes with open market operations in home T-bills (purchases and sales of bonds by the banking authorities) and shifts in the level of reserves. That is, M responds to its asset base as manipulated by banks. Notation to represent such interventions is introduced below. Many presentations treat banking system *liabilities* as pre-determined. But since T_b and R^* can jump in the short run, just setting M instead of considering shifts in its underlying *assets* mis-specifies the analysis.

For algebraic convenience, asset holdings are set up as shares of private sector wealth levels Ω and Ω^* . The shares can depend on interest rates, wealth levels themselves, the level of economic activity, the exchange rate, its expected change, and other variables. The home excess demand and supply functions can be written as

$$\mu\Omega - M = 0 \quad , \quad (5)$$

$$T_h - \eta\Omega = 0 \quad , \quad (6)$$

and

$$eT_h^* - \phi\Omega = 0 \quad . \quad (7)$$

Similarly, asset balance equations for the foreign private sector are

$$\mu^*\Omega^* - M^* = 0 \quad , \quad (5^*)$$

$$T_f / e - \eta^*\Omega^* = 0 \quad , \quad (6^*)$$

and

$$T_f^* - \phi^*\Omega^* = 0 \quad . \quad (7^*)$$

If the private sectors respect their balance sheets, the demand proportions must satisfy the restrictions $\mu + \eta + \phi = 1$ and $\mu^* + \eta^* + \phi^* = 1$.

There are four asset market equilibrium conditions. Two state that excess demands for money vanish in (5) and (5*). The others set excess supplies for the two flavors of T-bills equal to zero,

$$T - T_h - T_f - T_b - R = T - \eta\Omega - e\eta^*\Omega^* - T_b - R = 0 \quad (8)$$

and

$$T^* - T_h^* - T_f^* - T_b^* - R^* = T^* - \phi\Omega/e - \phi^*\Omega^* - T_b^* - R^* = 0 \quad (8^*)$$

Finally, as noted above the home economy's net foreign assets N are defined by equation (1). To explore the implications, we can use home's gross external assets and liabilities as already defined in connection with Tables 1 and 2, $T_{ext}^* = T_h^* + R^*$ and $T_{ext} = T_f + R$. Then N is set in the "point-slope" representation of (1) in Figure 1. Its controlling variables are the exchange rate and historically given levels \bar{T}_{ext}^* and \bar{T}_{ext} of external claims. Exchange rate changes generate capital gains or losses in N . Devaluation or a higher value of e rotates the "External assets" line representing (1) counter-clockwise around the $(\bar{T}_{ext}^*, \bar{T}_{ext})$ point, bidding up home's net foreign assets in home (N) and foreign (N/e) currency terms.⁶ The line also constrains external asset positions when they jump away from their initial values if the model's temporary equilibrium is perturbed. The totals T_{ext}^* and T_{ext} have to rise or fall together to hold N constant. This simultaneous increase in home's foreign assets and liabilities is directly analogous to a firm running up deposits at a bank from which it takes a loan, a standard practice in most lending operations. Because N is defined by e , \bar{T}_{ext}^* , and \bar{T}_{ext} in (1), it is argued below that the equation cannot sensibly be "solved" for the exchange rate.

FIGURE 1

Uniformly in the literature, the portfolio balance model has been set up with the balance sheet identities $\Omega = M + T_h + eT_h^*$ and $\Omega^* = M^* + T_f/e + T_f^*$ used to define levels of wealth. Then Ω and Ω^* are plugged into asset market balances which are solved for the interest and

exchange rates. This algorithm makes sense insofar as private wealth is pre-determined at any time by a history of capital gains and saving flows (instantaneous capital gains due to a contemporary exchange rate movement can also be taken into account). But the standard formulation leaves out the fact that asset holdings of the private sectors are not fully free to vary. Besides Walras's Law, they are constrained by the balance sheets of the banking systems and (especially) the NFA constraint. These restrictions make dependent two and not just one of the market equilibrium conditions (5), (5*), (8), and (8*), raising from zero to one the degrees of freedom available to the underlying triple of variables i , i^* , and e .

One way to incorporate balance sheet restrictions into Tobin-style models is to express the wealth levels Ω and Ω^* in the market balance equations in terms of national primary assets.⁷ Walras's Law takes a step in that direction. It can be written as

$$(M - \mu\Omega) + e(M^* - \mu^*\Omega^*) + (T - \eta\Omega - e\eta^*\Omega^* - T_b - R) + e[T^* - (\phi\Omega/e) - \phi^*\Omega^* - T_b^* - R^*] = 0.$$

If the banking systems satisfy their balance sheets and the "adding up" restrictions $\mu + \eta + \phi = 1$ and $\mu^* + \eta^* + \phi^* = 1$ on portfolio allocations apply, this equation reduces to

$$\Omega + e\Omega^* = T + eT^* \quad , \quad (9)$$

or worldwide wealth is equal to the value of outstanding government debt.

Equation (9) is familiar but not immediately helpful since it does not pin levels of national wealth. To determine Ω and Ω^* explicitly it suffices to assume that either (8) or (8*) holds, or that at least one bond market clears. Along with the maintained assumption that there are "no black holes" in balance sheets, if (8) holds then we can write the balance sheet for the home private sector in the forms

$$\Omega = M + T_h + eT_h^* = (T_b + eR^*) + (T - T_f - T_b - R) + eT_h^* = T + e(R^* + T_h^*) - (T_f + R)$$

or from (1),

$$\Omega = T + N \quad . \quad (10)$$

Substitution into Walras's Law (9) then gives

$$\Omega^* = T^* - N/e \quad . \quad (10^*)$$

Each nation's wealth is made up of its outstanding government debt plus its net foreign assets. By shifting the values of N and N/e (as discussed above), changes in the exchange rate affect Ω and Ω^* . Home devaluation raises home and reduces foreign wealth.

Now we can use (10) and (10*) to show that equations (5) and (8) for money and T-bill market balance in the home country are equivalent (similar manipulations work for the foreign country as well). With (10) setting Ω , equation (5) for money demand-supply balance becomes

$$\mu(T + N) = M = T_b + eR^* \quad . \quad (11)$$

Using (10) and (10*), equation (8) for the bond market can be written as

$$\eta(T + N) + e\eta^*(T^* - N/e) = T - T_b - R \quad . \quad (12)$$

Formulas (11) and (12) superficially look different, but a few quick substitutions show that they are the same. To get (11) from (12), for example, one can substitute for R from (1), rearrange the resulting expression, and impose the condition $\eta + \phi + \mu = 1$. This result parallels the standard finding that in a closed economy if the bond market clears then so does the money market. The net foreign asset constraint is the bridge that allows this reasoning to be extended to a two-country capital market.

As already noted, equation (1) enters the system as a binding restriction on spot transactions in external securities. Consider a shift in foreign preferences toward home bonds, so that T_f and T_{ext} jump up. If the foreign country's reserves R stay constant, then some element in the term $e(T_h^* + R^*) = eT_{ext}^*$ has to jump up as well. The obvious candidate is R^* . To acquire more home bonds, the foreign private sector must transfer foreign bonds that it holds across the frontier, valued at the spot rate e . They will immediately show up in home's international reserves, as T_{ext}^* and T_{ext} slide up from their initial values \bar{T}_{ext}^* and \bar{T}_{ext} along the External assets line in Figure 1. More reserves feed immediately into an increase in home's money supply. Empirically, reserve upswings after capital inflows that lead to growth of the money supply are frequently observed. Since the Southern Cone crises around 1980, they have been a familiar precursor to emerging market debt cycles touched off by surging capital inflows.

Although recent experience underlines the practical difficulties, in principle such a monetary expansion can be controlled. This observation leads to a comment made by readers of previous versions of this paper. They accepted the equivalence of each country's two asset market balances, but sought to preserve the traditional portfolio balance model by banning reserve changes. For example, one reader wrote that "...the exchange rate could float and each country's central bank could control both components of its monetary base. *The exchange rate would adjust so as to keep net foreign assets N constant.* This is the outcome under flexible rates. Note that it determines perfectly the current exchange rate..." [emphasis added].

There are at least two fatal errors in this argument. One is that the banking system does have tools at its disposal to control both components T_b and eR^* of the money supply with N constant and no need for a floating rate. The other problem is that if one simply follows the reader and postulates constant reserves without specifying what the banking system does to hold them steady, then an exchange rate that varies to satisfy the NFA constraint generates implausible results.

To see how the home banking system can control its asset position, suppose that the interest rates i and i^* adjust to clear the excess supply functions for home and foreign bonds. These relationships shift in response to changes in the spot exchange rate (through substitution effects and its wealth effects on N , $-N/e$, Ω , and Ω^*), the expected change in the exchange rate (via substitution effects), levels of wealth and output, etc. Continuing with the example above, assume that the foreign demand functions for foreign and home bonds shift from $\phi^* \Omega^*$ and $\eta^* \Omega^*$ to $\phi^* \Omega^* - \Delta^*$ and $\eta^* \Omega^* + \Delta^*$ respectively. Home's immediate capital inflow makes its reserves and money supply increase by $e\Delta^*$. It is well known (Isard, 1995) that home's central bank can counter such a shock to portfolio holdings in at least two ways. It can offset the reserve increase by selling a quantity $e\Gamma^*$ of foreign bonds and using the proceeds to buy home bonds (perhaps with the help of the foreign central bank), and reverse the monetary expansion by selling a quantity Λ of home bonds in a domestic open market operation.

After these portfolio adjustments, the home bond market balance can be written as

$$T - [\bar{T}_b + e\Gamma^* - \Lambda] - R - \eta\Omega - e(\eta^*\Omega^* + \Delta^*) = 0 \quad (8a)$$

where \bar{T}_b stands for the *initial* level of banking system holdings of home bonds and

$[\bar{T}_b + e\Gamma^* - \Lambda]$ is the level after the interventions, and the foreign balance as

$$e(T^* - T_b^* - R^*) - \phi\Omega - e(\phi^*\Omega^* - \Delta^*) = 0 \quad (8a^*)$$

From (1) extended to include Δ^* and Γ^* , the *new* level of reserves is

$$eR^* = N - \phi\Omega + R + e(\eta^*\Omega^* + \Delta^*) - e\Gamma^* \quad (1a)$$

To hold home banks' bond stock at \bar{T}_b , the authorities can de-monetize (or "sterilize") the effects of their foreign bond sale by setting $\Lambda = e\Gamma^*$ in the bracketed term on the left-hand side of (8a). Then after a substitution from (1a) into (8a*) to remove terms in eR^* , we get the simultaneous equations

$$T - \bar{T}_b - R - e\Delta^* - \eta\Omega - e\eta^*\Omega^* = 0 \quad (13)$$

and

$$(10^*) \quad e(T^* - T_b^*) - N - R + e\Gamma^* - e(\phi^* + \eta^*)\Omega^* = 0 \quad (13^*)$$

Assuming existence conditions are satisfied, for any value of e (13) and (13*) will solve for i and i^* as functions of Δ^* and Γ^* . Plugging the interest rate solutions into ϕ and η^* in (1a) gives

$$eR^* = N + R + f(\Delta^*, \Gamma^*) + e(\Delta^* - \Gamma^*) \quad (1b)$$

as a reduced form. The function $f(\Delta^*, \Gamma^*)$ gauges the amount by which Γ^* would have to differ from Δ^* to hold R^* to its initial value. Although practical applications could prove difficult, (1b) shows that for a given Δ^* the central bank can use Γ^* to steer R^* to the level it desires. Net foreign assets stay constant and bond markets clear via changing interest rates, with no need for e to be an endogenous variable "dual" to the policy-determined stock of reserves.⁸

Of course, following the reader's suggestion above one might simply postulate that reserves do not change, without taking into consideration tools such as Λ and Γ^* that the banking authorities can use to make this situation come about (this was the theoretical stance taken by Mundell and Fleming in setting up their model, which the reader carried over to portfolio

balance). It might then look reasonable to assume that e adjusts to hold N constant in (1) if the system is perturbed. But there are difficulties.

One is that in the real world (as opposed to optimal growth models in which asset prices can jump to hold net worth constant), it is hard to find cases in which wealth determines the values of its components, especially in the short run. The nominal net worth of a household, firm, nation, or the world is *determined* by its real asset positions and the relevant asset prices. For players individually and in the aggregate, their net worth does *not* determine asset valuations - causality runs the other way.

Further, in empirical practice, (1) or (1a) would not be a good "third equation" for the exchange rate because the impact of a jump in T_f (with the other variables in the equation held constant) would be to *increase* the value of e . This depreciation could reverse if portfolio compositions shift strongly with e , or when feedback through the bond markets is taken into account. However, it is disturbing. Capital inflows are supposed to strengthen, not weaken, the local currency. The portfolio balance model, traditionally interpreted, gives the expected appreciation. If the two interest rates varied to clear each country's money market (with reserve levels and money supplies held constant by assumption), then the third equation could be the home country bond balance (8) or (8a). Under standard assumptions discussed below, one would have $\partial\eta/\partial e > 0$ and $\partial(e\eta^*)/\partial e > 0$ so (absent a strong wealth effect via Ω^*) e would decline in response to an exogenous portfolio shift of the sort discussed above. Trying to save the model by replacing dependent equation (8) with independent (1) subverts its original intent.

To close, it makes sense to work through the short-run comparative static implications of the equilibrium conditions (13) and (13*), with home and foreign interest rates as the endogenous variables. In home's financial markets, changes in i and i^* are usually assumed to have effects with opposite signs. A higher level of i will reduce excess demand for home money and excess supply of home bonds, with a higher i^* working the other way. If home and foreign bonds are close substitutes in (8a) or (13), then the Home bond market schedule in Figure 2 will have a slope of a bit more than 45 degrees.

Figure 2

With the effects of the net foreign asset constraint in the foreign bond market taken into account in (13*), interest rate effects are likely to have the *same*, negative sign. In (13*), $(\phi^* + \eta^*)\Omega^* = (1 - \mu^*)\Omega^*$ and presumably foreign money demand $\mu^*\Omega^*$ declines with increases in both i and i^* . For a "small" home country, the Foreign schedule representing (13*) will have a slightly negative slope if changes in i have minor effects on i^* .

Obvious comparative static shifts to consider are an expansionary open market operation (with home's central bank buying local T-bills), a capital inflow and an exchange of foreign for home bonds as discussed above, and movements in the expected and current exchange rates.

In (8a), an open market bond purchase (a negative Δ) reduces the left-hand side, forcing i to decline. The Home schedule shifts left, reducing the home and (marginally) raising the foreign rate. The bond swap (a positive Γ^*) shifts the Home schedule rightward and the Foreign schedule up. The home rate rises. The shift in the foreign rate is ambiguous, but if $e\Gamma^*$ is offset by an equal Δ in (8a), i^* will rise because the Home schedule does not shift. A capital inflow Δ^* compensated by these maneuvers shifts the home schedule left. Higher external demand for home bonds strengthens their price, forcing a lower asset return i and a higher i^* . To offset the lower rate, the home central bank would have to use Δ and Γ^* to shrink the money base. Without such an intervention, if UIP rules the capital inflow will make the exchange rate appreciate over time (see footnote 8 and section 6).

Faster expected devaluation ε will presumably reduce the desired share of home bonds in the foreign portfolio, η^* . From (13), the home interest rate will have to rise (the Home schedule moves to the right) to restore market balance. In (13*), if foreign wealth-holders switch even partially from home's bonds into foreign money, the $(\phi^* + \eta^*)$ term will become negative, shifting the Foreign schedule upward. In the new equilibrium, i will rise and there will be an ambiguous (probably small) shift in i^* .

In both (13) and (13*), dimensionally alert asset-holders will deflate expected depreciation by the current exchange rate e to create a rate of return ε / e comparable to the others in the model. For a given ε , a discrete (jump) devaluation of the spot rate e will increase η^* , forcing i to decline and i^* to shift either way. These responses could be reversed by devaluation's effects on various terms in the market balance and net foreign asset equations, but in keeping with most of the literature we ignore such wealth effects.

Finally, stocks of bonds and the real side of the economy with its transactions demands notwithstanding, in an extreme case the *only* relevant arguments in the home asset equation (13) could be i , i^* , e , and ε . Although uncovered interest rate parity applies to expectations about future values of the spot rate, the literature often postulates that contemporaneous partial derivatives force these four variables to be related in a UIP form such as $-i + (i^* + \varepsilon / e) = 0$. Because foreigners know as much about arbitrage as do home-dwellers, this formula would be their asset market equation too. The whole world would have just one asset relationship. Non-market or institutional forces would have to set most asset prices and rates of return. This situation is far from the original goal of the portfolio balance model to determine all financial variables by contemporary market-clearing only.

4. Mundell-Fleming

Compared to portfolio balance, the Mundell-Fleming model is an accounting mare's nest. It puts a *flow* commodity market balance (the IS curve) together with a *stock* asset market equilibrium (the LM curve), and throws in part of (2) above as a BP relationship. Will this last equation be satisfied when commodity and asset markets are in balance?

In this section, the answer is shown to be "Yes," regardless of central bank interventions. The BP equation is *not* independent, i.e. there cannot be an external imbalance for an exchange rate adjustment to remove.

To demonstrate this result, the key assumption is that asset market balances are satisfied continuously over time, i.e. the existence of stock equilibria implies that flow equilibria exist as well. The relevant specification is in terms of flow-of-funds relationships from Table 1

which when supplemented by terms for capital gains and losses are time-derivatives of balance sheets in Table 2.⁹ The equilibrium condition needed from the real side is savings-investment balance. We will assume that adjustment mechanisms exist to generate the relevant equality in IS equation (16) below.

To be consistent with the presence of investment in cells (A, 5) and (A*, 5*) of the SAM in Table 1, private sectors must now be allowed to hold capital stocks. In the home economy the three asset demand functions (5)-(7) continue to apply, along with a stock demand for capital

$$\kappa\Omega - qPK = 0 \quad ,$$

with $\mu + \eta + \phi + \kappa = 1$. The valuation ratio q adjusts to clear this equation, and may also enter as an argument in the investment demand function. This brusque treatment of capital finance could be considerably expanded as in Franke and Semmler (1999), but it suffices in terms of our present preoccupations with the exchange rate and balance of payments.

The immediate task is to show how Mundell-Fleming flow equations relate to portfolio balance. The following discussion focuses on relationships among the flows in Table 1 and the definitions of the change in home's net foreign assets in (2). It is consistent with any equilibrium theory of asset accumulation and portfolio choice - Keynesian, intertemporal optimization, or otherwise.

The first point to recall is that from (2), foreign savings S_f is equal to the current account deficit,

$$S_f = [eP^* aX + i(T_f + R)] - [Pa^* X^* + ei^* (T_h^* + R^*)] \quad , \quad (14)$$

and the flows of funds of the rest of the world with the home economy become

$$S_f + [e(\dot{T}_h^* + \dot{R}^*) - (\dot{T}_f + \dot{R})] = 0 \quad . \quad (15)$$

Foreign savings and flow capital inflows to home's private sector and central bank are the foreign country's sources of funds. Flow acquisitions of home's securities by its private sector and banks are the uses.

In other words, S_f equals the increase in home's foreign debt ($\dot{T}_f + \dot{R}$) less the increase in its foreign holdings $e(\dot{T}_h^* + \dot{R}^*)$. For this Mundell-Fleming BP relationship to be independent, it must be possible for the home economy's increase in net foreign assets (the bracketed term in (15)) to *differ* from its current account surplus $-S_f$ when home and foreign IS and LM relationships are satisfied. Only in such circumstances will the exchange rate or some other variable have play to restore the balance of payments to temporary equilibrium.

It is easy to see that this situation normally does not arise. First note that the sum of the flow of funds in rows (E)-(G) in Table 1 and (15) gives

$$S_h + S_g + S_f - Pl = 0 \quad (16)$$

or macroeconomic saving-investment balance applies. Because equality in (16) is assumed to be assured by real side IS equilibrium, only three of the four flows of funds (including (15)) can be independent relationships. They are further constrained by flow clearing of asset markets. The relevant equations appear in columns (8)-(10) and (9*)-(10*) in the SAM, together with associated exchange conversions.

All asset markets can be assumed to clear in flow terms if the interest rates i and i^* are free to adjust, the banks satisfy their flows of funds restrictions, and the results of last section apply. Then the proof that the balance of payments must clear is trivial. Substitutions through the flows of funds under the assumption that commodity markets are in equilibrium (i.e. (16) is valid) immediately produce equation (15).

There is no need for the exchange rate or anything else to vary to ensure that this equality will hold. In the textbook diagram, BP *always* passes through the IS/LM intersection, regardless of the value of e . As in the portfolio balance model, the triple intersection will occur whether or not central banks use flow transactions such as $\dot{\Gamma}^*$ and $\dot{\Lambda}$ (which could be incorporated in the foregoing accounting in straightforward fashion) to regulate changes in their holdings of home and foreign bonds.

It may be helpful to explore the implications of this result in more intuitive terms. If equality did *not* hold in (15), then in the double-entry bookkeeping of the flows of funds and flow

asset balances some other equality would have to be violated. For example, suppose that the home country is running up external arrears by not meeting contracted payment obligations on outstanding debt so that the current account surplus $-S_f$ falls short of the bracketed term in (15). There are two possible forms of repercussion on home's flow asset market balances and flows of funds. One is that some other flow of funds relationship is not satisfied. The other is that if home's domestic flows of funds equalities hold, then some flow asset market balance must fail to clear.

Consider the second case. The obvious counterpart to a non-clearing balance of payments is the domestic bond market in columns (9) and (10*) and rows (L) and (L*) of the SAM. The run-up in external arrears would be reflected into a flow excess supply of home bonds - foreigners are not picking up enough domestic securities to provide home the wherewithal to meet its external obligations. Under such circumstances (as discussed above), a spot devaluation of appropriate magnitude could be expected to erase the excess supply through a substitution effect and remove the disequilibrium.

The rub is that if home's other financial markets are in equilibrium then this sort of adjustment is unnecessary - we know from the analysis of the portfolio balance model that if the home money market clears then so will the market for bonds. And with both money and bond markets in balance, there is no room in the accounting for an open balance of payments gap.

The other possibility is that the non-clearing balance of payments is reflected into another flow of funds relationship subject to the equilibrium condition (16). For example, one can imagine and even observe - as in recent Asian, Latin American, and Russian experiences - situations in which the home country is running up external arrears at the same time as the domestic private sector is undertaking investment projects that aren't working out (the sum of the terms in row (E) exceeds zero). An exchange rate realignment might even reverse such simultaneous build-ups of external and internal bad debt. But at the macroeconomic level such situations are unusual. A normal, well-regulated banking sector at home is not in the business of providing non-performing loans to corporations. In harmonious times, the balance of payments emerges automatically from output and asset market equilibria.

Finally, taking exchange rate movements into account, net foreign assets evolve according to the relationship

$$\dot{N} = e(\dot{T}_h^* + \dot{R}^*) - (\dot{T}_f + \dot{R}) + \dot{e}(T_h^* + R^*) \quad (17)$$

If \dot{N} were pre-determined, then (17) could be treated as an "extra" equation to be solved for \dot{e} in a "floating rate" case in which central banks use flow interventions like $\dot{\Gamma}^*$ and $\dot{\Lambda}$ to control \dot{R}^* and \dot{R} . But in line with the discussion of (1) above, there are no obvious economic forces that would make \dot{N} anything but the passive sum of the variables on the right-hand side. Even if \dot{N} were pre-determined, faster capital inflows \dot{T}_f in (17) would in counter-intuitive fashion speed up exchange rate depreciation \dot{e} . The usual Mundell-Fleming floating rate story does not emerge naturally from consistent stock-flow accounting.

5. IS/LM comparative statics

The model thus reduces to linked IS/LM systems for the two countries. Financial markets are described by equations (8a) and (13*), which clear (after home central bank interventions and other shocks) via adjustments in i and i^* . Commodity markets are described by (16) and its analog in the foreign country. Saving and investment functions can be assumed to respond to the usual variables - interest rates, activity levels, profit rates emerging from the technology and institutions underlying V and V^* , perhaps q and q^* , and so on.

For present purposes, it makes sense to see how a Keynesian version behaves, with activity levels in both countries determined by effective demand. Because BP equations are not independent, the spot exchange rate has to be taken as a pre-determined variable in the short run. We also assume that the home country is "small" in commodity markets, in that the foreign country's reserves stay constant, and in the sense of Figure 2.

Table 3 gives signs of responses of commodity excess demand and bond excess supply functions to the endogenous variables - output levels X and X^* and interest rates i and i^* in the two-country model - as well as to e and ε . The IS row shows that as usual home excess demand is reduced by increases in both X and i . Higher foreign output X^* stimulates home

demand via exports while changes in the foreign interest rate i^* are assumed to have no direct effects. In line with the possibility of contractionary devaluation (Krugman and Taylor, 1978), a higher value of e may either reduce or increase home's aggregate demand. Faster expected depreciation ε has no direct effect.

Table 3

In the LM row, by increasing transactions demand for money, a higher X raises the excess supply of home T-bills, while a higher i cuts it back. Increases in X^* and i^* also raise excess supply, while e and ε have the effects discussed in connection with Figure 2. Foreign IS* and LM* schedules are not affected by output and interest rate changes in a small home country, and the remaining signs in the last two rows are analogous to those already discussed.

Given the assumptions of Table 3, it is easy to work out how X and i respond to the other variables. (For simplicity, we consider only direct effects of e and ε in the IS and LM rows, without solving through IS* and LM*.) Increases in both i^* and ε reduce X and raise i . Even if home and foreign bonds are close substitutes in home portfolios as in Figure 2, it will be true that $\partial i / \partial i^* < 1$ because the fall in X reduces excess supply of T-bills. A higher X^* puts pressure on home financial markets and bids up i . The effect on X is ambiguous - increased export sales vs. domestic demand contraction due to a higher interest rate.

If devaluation is expansionary, a higher e raises X but has an ambiguous impact on i . The interest rate will rise if the output increase is strong and/or the wealth and substitution effects of devaluation on home asset equilibrium are weak. A weaker currency is supposed to take pressure off interest rates, but that outcome does not have to happen.

If devaluation is contractionary, it unambiguously reduces i . The feedback effect on effective demand leaves the final response of X unclear. Exchange *appreciation* in this case will be associated with a higher interest rate and possibly a reduction in output. Strong exchange rates, high interest rates, and slow growth have been characteristic of many semi-industrialized

economies in the 1990s. If the fall in e is the driving force (perhaps because exchange appreciation is pursued as an anti-inflationary tool), the output and interest rate responses may reflect a situation in which effective demand is reduced or not strongly stimulated by devaluation.

So what happens to the balance of payments while these changes are going on? As in the portfolio balance model, reserve changes (as manipulated by central banks) will be the accommodating variables in both countries when their current accounts (driven largely by IS adjustments and interest rate changes) and holdings of external T-bills (driven by portfolio choices) shift over time. In the medium run, the current account will be the "autonomous" component of the balance of payments, so long as asset markets clear smoothly. Unless foreign portfolio preferences shift away from home's T-bills as its current account deficits or debt-service obligations become "too large," there is nothing in the model to prevent a country from running an external deficit indefinitely. Perhaps the United States since the 1980s is a case in point.

6. UIP and Dynamics

To summarize the last three sections, the exchange rate is not set by temporary macro equilibrium conditions. It must evolve over time subject to rules based on expectations about its values in the future. In a world of shifting and perhaps unstable expectations, no simple dynamic theory is likely to emerge. The best candidate is UIP and it does not reliably fit the data. However, because UIP relies on arbitrage arguments which "should be true" and has interesting dynamic properties, a scenario based upon it is worth sketching as an illustration of the sorts of results that a standard hypothesis can generate in conjunction with a demand-driven IS/LM-based growth model operating along Keynesian lines. Of course, other model "closures" or causal structures are possible.¹⁰

Under myopic perfect foresight (or MPF) about changes in the exchange rate with $\varepsilon = \dot{e} = de/dt$, the UIP formula (3) or (4) can be restated as a differential equation

$$\dot{e} = e(i - i^*) \quad . \quad (18)$$

In the two-country IS/LM system the interest rates i and i^* are functions of the exchange rate and other variables. A long-run "equilibrium" rate \bar{e} , which may or may not easily be attained, is defined by the condition $i = i^*$.

Together with the IS/LM model, (18) makes up a well-defined dynamic system. On the right-hand side, i and i^* are functions of e , \dot{e} , and other variables Q , so (18) becomes $\dot{e} = f(e, \dot{e}, Q)$. This equation can be converted to the standard form $\dot{e} = g(e, Q)$. Assuming MPF, if the portfolio balance model really did have three independent equations among i , i^* , e , \dot{e} , and other variables, it would itself be a dynamic system for the exchange rate, inconsistent in general with UIP (not to mention full intertemporal arbitrage and optimization).¹¹

Differential equations incorporating MPF in growth and financial models are usually unstable. An asset price feeds back positively into its own rate of growth, giving rise to saddlepath dynamics (under appropriate transversality conditions) or a bubble. However, at an initial equilibrium at which $i = i^*$ and $e = \bar{e}$, $d\dot{e}/de < 0$ in (18) if devaluation reduces the home interest rate as discussed above. This local stability opens up possibilities for cyclical exchange rate dynamics not present in most MPF formulations.¹²

Before turning to that, however, it is worth noting how UIP supports standard Mundell-Fleming conclusions. From the comparative statics discussed above, a capital inflow with the money supply held constant is likely to make i fall and i^* rise. If the differential equation (18) is stable, the exchange rate will decline over time, driving the interest rates back together. The "floating rate" scenario of a capital inflow leading to appreciation applies dynamically, except that e is not floating in the traditional sense, but is being determined in forward markets via UIP.

As an illustration of a full dynamic system, we can trace how the exchange rate interacts with home country government debt. The relevant state variable from the IS/LM system is $D = T/PK$, in which T is the outstanding stock of T-bills, P is the home price level, and K is the home capital stock. Ignoring depreciation, K increases over time according to the rule $\dot{K} = I = gK$ where I is the level of investment undertaken by business and g is the growth rate of K . Indeed, g can be treated as the model's investment function. As noted above, it can be assumed to depend on the interest rate i , the output/capital ratio $u = X/K$ as a measure of "capacity utilization," and the profit rate $r = \pi u$, where π is the share of profits in total income. Alternatively, the valuation ratio q can be taken as the principal argument of the function g .

The time derivative of T is $\dot{T} = \gamma PK + iT$ where γ is the government's "primary deficit" (outlays apart from interest payments less revenue) as scaled to the value of the capital stock. Using the foregoing information, a differential equation for D becomes

$$\dot{D} = \gamma + [(i - \hat{P}) - g]D \quad , \quad (19)$$

where $\hat{P} = \dot{P}/P$ is the inflation rate. The steady state value of the debt/capital ratio is $\bar{D} = \gamma/[g - (i - \hat{P})]$. As is well-known, an economy with $\gamma > 0$ can only sustain a stable debt/capital ratio when its capital stock growth rate exceeds the real rate of interest. This condition has tended to fail recently in industrialized economies (and fail strongly in developing debtor countries such as Argentina!). We will assume, however, that at least some of the time g can exceed $(i - \hat{P})$.

Another complication is that the components of the bracketed term on the right-hand side of (19) depend on D . A higher value is analogous to an increase in T in (8). Excess supply of T-bills goes up, forcing their interest rate i to rise. In most IS/LM models with an inflation equation adjoined, the inflation rate \hat{P} and growth rate g would go down. The derivative of the bracketed term in (19) with respect to D would be positive, which could make the total derivative $d\dot{D}/dD$ positive around a steady state with $\bar{D} > 0$. This potentially unstable case is the focus of the following discussion.

Effects of the exchange rate e on \dot{D} in (19) go through the interest rate directly, as well as through shifts in g and \hat{P} induced by interest and output changes. If $\partial i / \partial e < 0$ in the IS/LM system, we get a direct negative impact of e on \dot{D} . If the inflation and growth rates rise with a lower i , it is clear that $d\dot{D}/de < 0$. Finally, because a higher D increases i , $d\dot{D}/dD > 0$ in (18).

Figure 3 is a phase diagram for the system (18)-(19) in which there is a chance for cyclical stability. The initial equilibrium at which $\dot{D} = \dot{e} = 0$ resides at point A. Suppose that there is a permanent monetary expansion, driving down i . To bid up the interest rate again, D would have to rise and e to fall. The curves shift as illustrated.

Figure 3

Along the dynamic trajectory, the lower interest rate initially sets off exchange appreciation and a declining debt/capital ratio. The falling exchange rate begins to push up the interest rate, increasing the bracketed term in (19) until D starts to rise at point B. Both variables are now putting upward pressure on the interest rate. When i rises above i^* in (18), the exchange rate begins to depreciate. The trajectory may or may not converge to the new equilibrium at E.¹³ Even if it does, the economy is likely to go through cycles. An initial monetary contraction would create a depreciation-then-appreciation exchange rate history. Since the late 1970s, the secular US external deficit has been accompanied by (so far) two such cycles with periods exceeding 10 years.

7. Conclusions

One should not take results from a two-dimensional dynamic system too seriously, but the foregoing narrative illustrates that a properly specified open economy macro model does contain interesting possibilities. Moreover, they would carry over to intertemporal models which incorporate UIP, but replace effective demand with Say's Law and derive a private savings (= investment) rate from a Ramsey-style dynamic optimization. Even with these changes, intertemporal models have to satisfy accounting relationships like those in Tables 1 and 2. Their dynamics cannot be less complicated than the trajectory of Figure 3, and as sketched in footnote 12, outright instabilities are also possible. There is no reason to expect monotonic or saddlepoint "stability."

This observation differs strikingly from early predictions based on the portfolio balance and Mundell-Fleming models. In one familiar example based on the former, suppose that the home country runs a current account deficit. Its reserves will fall, leading to monetary contraction and a higher interest rate. If UIP applies, the exchange rate will depreciate over time, presumably leading to a better trade performance and a new long-run equilibrium in which the current account is balanced and exchange and interest rates are stable. In the traditional model "... stock-flow

adjustments in the presence of capital mobility will generally move the exchange rate in the right direction to eliminate a current account deficit in the long run" (Blecker, 1999, p. 57).

This comforting story follows the pattern of Hume's price/specie flow chronicle in asserting that the existence of a current account deficit stimulates price adjustments such as depreciation that will make the deficit disappear. But in fact, there is *no* reason for such adjustments to happen. In (18), a floating exchange rate has no fundamentals such as a real rate of return or a trade deficit that can make it self-stabilizing.

As one referee observed, this observation helps explain why "... all fundamentals-based exchange rate models ... were doomed to fail empirically." The evidence is well summarized by Frankel and Rose (1995). Although most of the emphasis herein has been on Keynesian specifications, points raised above apply to widely used monetarist econometric models as well. They usually start out correctly by postulating just two equations linking money demand to the interest rate and price level in the home and foreign countries (the exchange rate and its expected change are not included as arguments in these functions, though from the analysis herein they should be). The models add the assumption that money markets clear via price adjustments with supplies pre-determined, i.e. price levels are set by the equation of exchange modified for interest rate effects. Purchasing power parity is then used as an "extra equation" to determine the exchange rate from the two national price levels. Because neither a tight link between an economy's money supply and its price level nor PPP is ever strongly supported by the data, it is scarcely surprising that these formulations failed. Similar observations apply to extensions based on UIP, rational expectations, gradual price adjustment, etc.

The bottom line is that e can only float against its own expected future values and interest rates. In the real world such expectations are determined in part by intrinsically unpredictable and non-rational forces. In open economy macroeconomics more generally, having one temporary equilibrium condition fewer than has been supposed opens up a range of possibilities for exchange rate determination. They should be explored.

Notes

1. Unrealistically, the private sector in each country is assumed to hold only the local money. It is straightforward to deal with the general case by using more symbols, but the SAM already has too many!

2. Other specifications such as treating imports as negative exports or additional components of consumption demand are possible, but would not change the main results to be presented below.

3. For the moment, ε can be interpreted in a Keynesian sense as summarizing the market's perceptions or views about how the exchange rate is likely to shift over time; a more contemporary interpretation in terms of myopic perfect foresight appears in section 6 below. Also note that ε stands for an absolute as opposed to a percentage change per unit of time in e (the latter interpretation appears frequently in the literature)

4. The macro relationships that must be considered in the contemporary world relate to both the current and capital accounts. Before and in the first decades after World War II, it made sense to concentrate only on the *trade* account. A model proposed 40-odd years ago by Salter (1959) and Swan (1960) does contain a plausible exchange rate fundamental - the traded/non-traded goods price ratio. As far as trade is concerned, the exchange rate can be interpreted as becoming increasingly over-valued when this internal price ratio falls. But for the industrialized countries at least, payments related to trade are now such a tiny share of total external transactions that the model is obsolete (Eatwell and Taylor, 2000). In turn, Salter-Swan was the culmination of a long string of models of the trade account, which assumed that capital flows were exogenous. They included an elasticities approach (featuring "Marshall-Lerner conditions" on trade elasticities), an absorption approach, and analysis of internal vs. external balance which led to Salter-Swan. A monetary approach to the balance of payments worked out in the 1950s and 1960s fed into the portfolio balance and Dornbusch models discussed below, as well as many econometric attempts to predict shifts in the spot rate (see section 7). Williamson and Milner (1991) is a solid mainstream summary of all this history.

5. We stick with the standard literature in assuming that the monetary authorities intervene to control their holdings of assets. A Post Keynesian scenario in which interest rates are set exogenously and money supplies adjust would be straightforward to work through.

6. The diagram presupposes that the home country is a net creditor at the ruling exchange rate. To get to the net debtor case, the External assets schedule can be rotated clockwise via exchange appreciation until it crosses the vertical axis above the origin.

7. Another way is to linearize three asset market balance equations around an initial equilibrium and attempt to solve them for "small" changes in i , i^* , and e , subject to the accounting restrictions mentioned in the text. After great labor, the Jacobian matrix of this system will turn out to be singular. Such an exercise was the genesis of this paper.

8. The interest rate changes could induce shifts in the exchange rate over time. On the basis of the comparative static results below, it seems likely that the compensated capital inflow discussed in the text will make i fall and i^* rise. Under UIP and myopic perfect foresight (section 6), the exchange rate would tend to appreciate, $\dot{e} < 0$.

9. To keep the analysis simple, all variables are assumed to be continuously differentiable functions of time. In practice, both stock and flow variables can change discontinuously. But if in so doing they obey all relevant balance sheet and income statements, the transition from portfolio balance to Mundell-Fleming accounting goes through. The extensive theory and notation required to deal with such eventualities as well as changes in prices is best avoided here. Foley (1975) and Burgstaller (1994) take up the complications. In theory, accounting consistency between stock and flow variables is a means for linking the future to the present; in practice (in discrete time) it will be observed in sectoral balance sheet and flow of funds accounts because they are constructed that way.

10. For example, both the well-known model by Dornbusch (1976) and the one herein stand on IS and LM (but not BP) foundations. But for Dornbusch, output is set by Say's Law (perhaps transiently relaxed by "sticky price" short-term output dynamics); the money market balance is combined with UIP and regressive exchange rate expectations around purchasing power parity or PPP (an "extra equation") to make e depend on the real money supply M/P ;

changes in P over time are driven by the difference between aggregate demand and output; and since this difference is non-zero away from the steady state the short-run current account is endogenous and implicitly offset by capital flows or reserve movements which are sterilized to let the central bank control M . Because it obeys PPP and the quantity theory in the long run, the model is much more closely tied to "fundamentals" than the one presented in the text.

11. As observed by Branson and Handerson (1985), there were many papers in the 1970s and early 1980s devoted to dynamic analysis of a portfolio balance model augmented by IS and BP relationships. A typical "finding" was that the dynamic system could be unstable if home country net foreign assets were negative. Unfortunately this literature was flawed because it assumed the spot rate could be set by portfolio balances and also treated the BP equation as being an independent restriction on the dynamic system.

12. For example, the Dornbusch model uses "rational" regressive expectations on e and a fixed i^* to determine i via UIP and introduces unstable dynamics in the price inflation equation. For future reference, a possible instability in (18) due to expectational effects in asset demands is worth noting. With MPF, \dot{e} equals expected depreciation ε and (as noted in the text), shows up as a determinant of the interest rates on the right-hand side of (18). Differentiation gives $d\dot{e}/de = (i - i^*) + e[\partial i/\partial e + (\partial i/\partial \dot{e})(d\dot{e}/de)]$ where the $\partial i/\partial \dot{e}$ term comes from the IS/LM system. Minor manipulation shows that $d\dot{e}/de = [1 - e(\partial i/\partial \dot{e})]^{-1} e(\partial i/\partial e)$. When $0 < e(\partial i/\partial \dot{e}) < 1$ (the traditional inelastic expectations story), the UIP differential equation is locally stable. But strong expectational effects could make $d\dot{e}/de > 0$ even when di/de is negative.

13. That is, a critical point E of the system (18)-(19) in Figure 3 can be a stable or unstable focus.

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Table 2: Balance Sheets for Two Countries

<i>Home Country</i>						
<i>Private Sector</i>		<i>Banking System</i>		<i>Government</i>		
M	Ω	T_b	M			
	T_h	eR^*				
				T		
				eT_h^*		
				qPK		
 <i>Foreign Country</i>						
<i>Private Sector</i>		<i>Banking System</i>		<i>Government</i>		
M^*	Ω^*	T_b^*	M^*			
	T_f^*	R/e				
				T^*		
				T_f/e		
				$q^*P^*K^*$		

Table 3: Signs of Market Responses in a Linked IS/LM Model

	X	i	X^*	i^*	e	ε
IS	-	-	+	0	\pm	0
LM	+	-	+	+	-	+
IS*	0	0	-	-	\pm	0
LM*	0	0	+	-	+	-

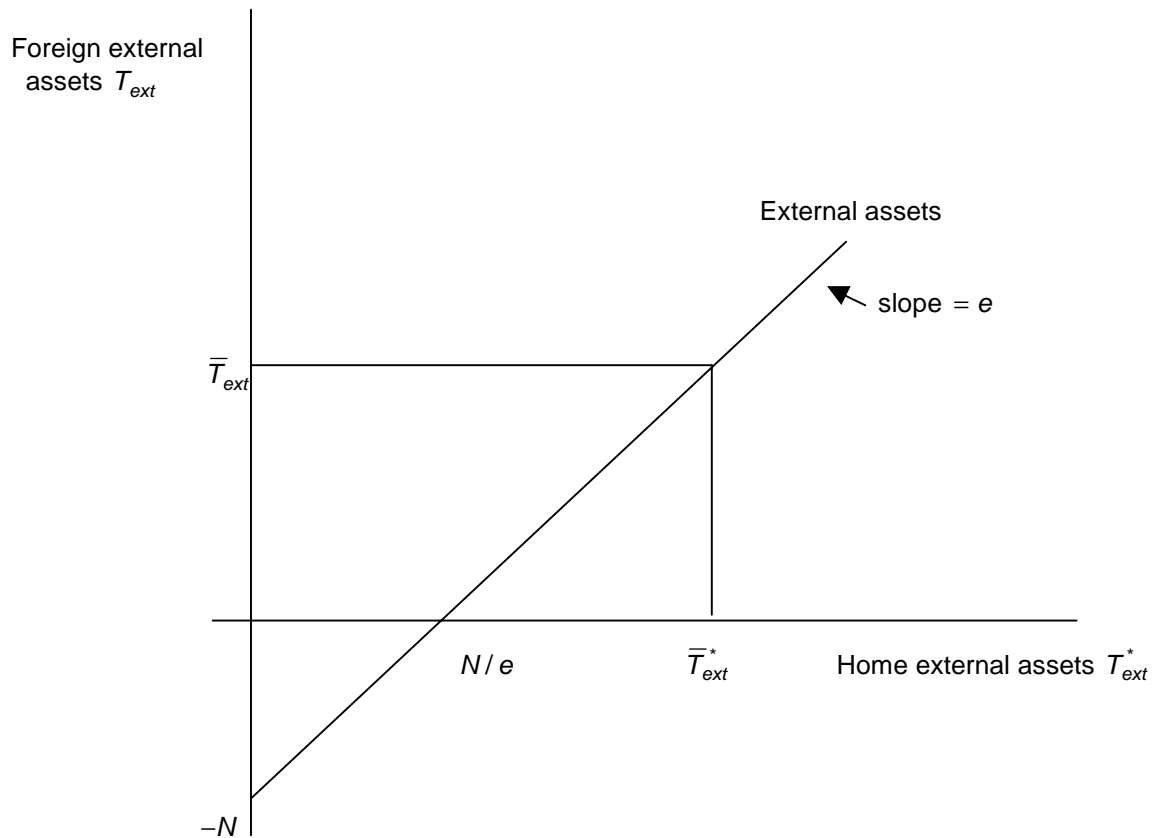


Figure 1

Determination of net foreign assets from initial external holdings

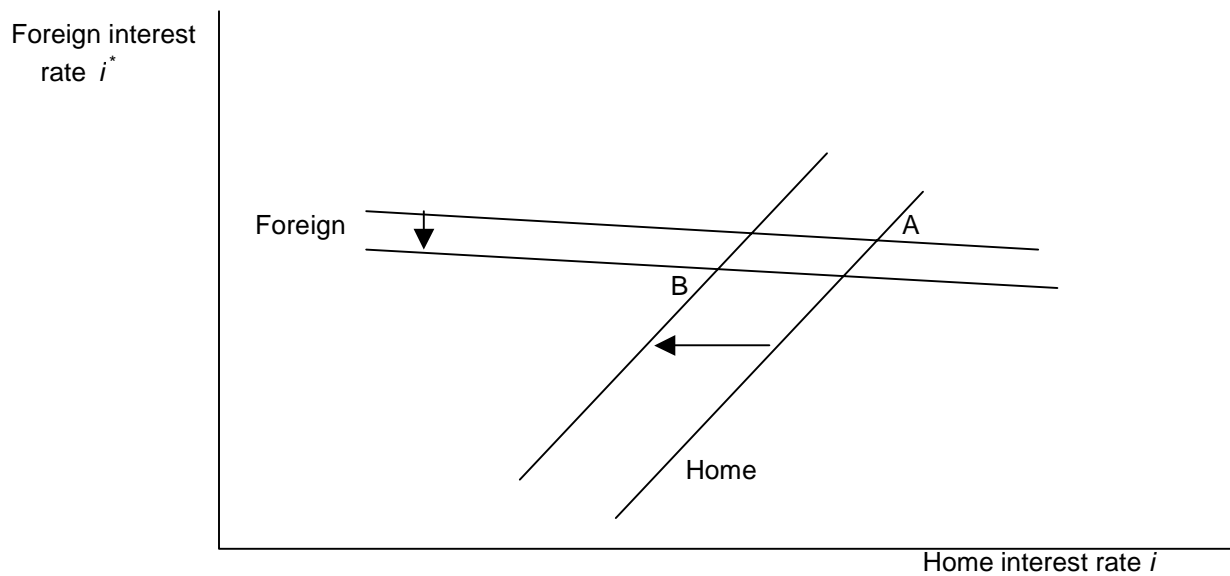


Figure 2

Effects of devaluation of the home currency. Home monetary expansion is similar, except that only the Home schedule shifts.

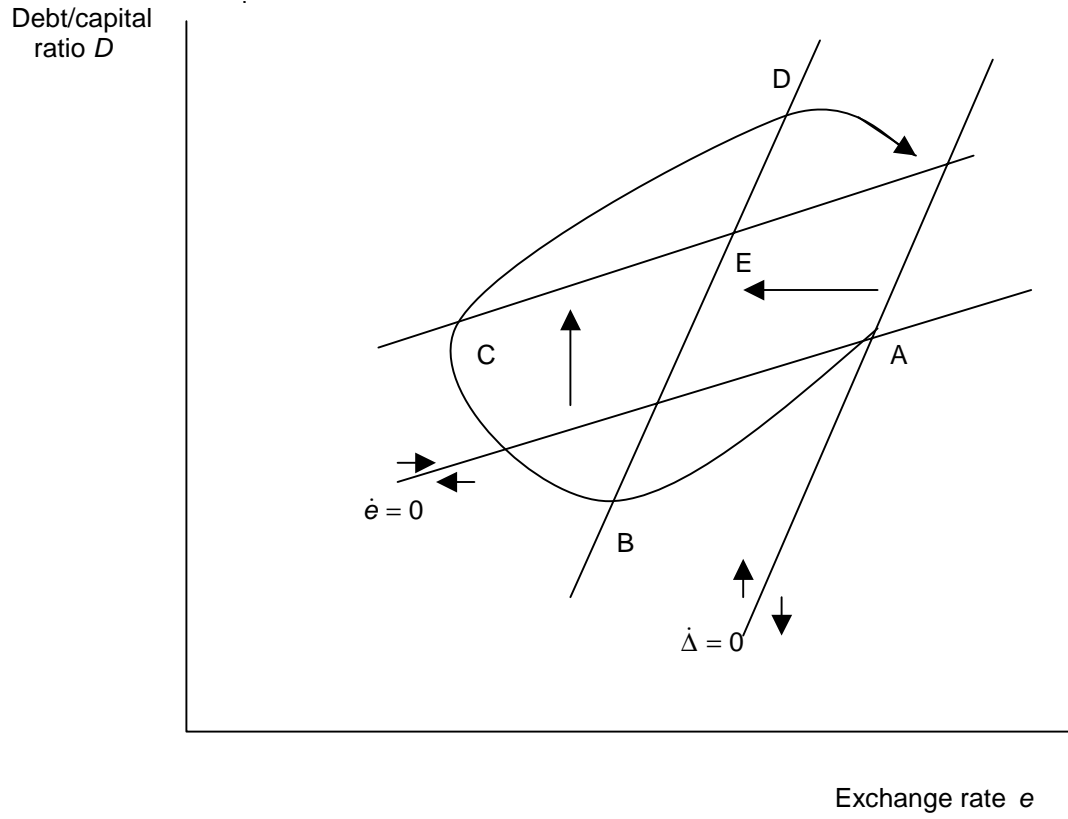


Figure 3

Adjustment dynamics for the exchange rate and debt/capital ratio after a "permanent" monetary expansion.

Table 1: A Two-Country SAM with Trade and

	Output Costs (1)	Current home expenditures				Home ext. receipts		Changes in home claims			Exchange conversions		
		Private (2)	Gov't. (3)	Banks (4)	Cap. form. (5)	Exports (6)	Foreign interest (7)	Money (8)	Home bonds (9)	For. bonds (10)	Totals (11)	For. to Home	Home to For.
Output (A)		PC	PG		PI	$Pa^* X^*$					PX		
<u>Incomes</u>													
Private (B)	V		iT_h	Π_b					$ei^* T_h^*$			Y_h	
Gov't. (C)		τY_h										Y_g	
Banks (D)			iT_b						$ei^* R^*$			Y_b	
<u>Flows of funds</u>													
Private (E)		S_h			$-PI$			$-\dot{M}$	$-\dot{T}_h$	$-e\dot{T}_h^*$		0	
Gov't. (F)			S_g						\dot{T}			0	
Banks (G)				0				\dot{M}	$-\dot{T}_b$	$-e\dot{R}^*$		0	
<u>External</u>													
Imports (H)	$eP^* aX$												e
Exports (I)						$-Pa^* X^*$							$1/e$
Int. in (J)									$-ei^* T_{ext}^*$				e
Int. out (K)			iT_{ext}										$1/e$
Change (L) in ext. liab.									$-\dot{T}_{ext}$				$1/e$
Change (M) in ext. assets										$e\dot{T}_{ext}^*$			e
Totals (N)	PX	Y_h	Y_g	Y_b	0	0	0	0	0	0			

