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ALTERNATIVE APPROACHES TO GENERAL EQUILIBRIUM MODELING OF EXCHANGE RATES AND CAPITAL FLOWS: THE MCM EXPERIENCE

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Alternative Approaches to General Equilibrium Modeling of Exchange Rates and Capital Flows: The MCM Experience.

I. Introduction

Nearly a decade has passed since the international monetary system shifted from a regime of relatively fixed exchange rates to one of relatively flexible exchange rates among major industrial countries. Until recently any historical sample period long enough to provide meaningful statistical inference for quarterly macroeconomic modeling of open economies had to contend with this major shift in regimes. Sufficient data is available now to focus on the determination of quarterly movements in exchange rates in the present environment of relatively flexible rates. However, some theoretical issues concerning the structural modeling of exchange rates in macroeconometric models are yet to be resolved.

During the Bretton Woods era (pre-March 1973 for most countries) exchange market pressures particularly during "speculative" periods were manifest in large private capital flows that were financed by changes in official reserves. This close association between exchange market developments and capital flows had a lasting influence on modeling even after the regime changed and rates became more flexible. Models of exchange rate determination have focused on the balance of payments as a convenient empirical statement of changes in demand for and supply of foreign exchange. Following upon the earlier empirical work of Branson (1968) and Bryant and Hendershott (1970), among others, the initial version of the Federal Reserve Board Staff's Multicountry Model (MCM) modeled capital flows explicitly as an input into the process of exchange rate determination. As described in Berner et.al. (1976), each of the components of the balance of payments (including imports and exports of goods and services, as well as the various private and official gross capital flows) was modeled behaviorally, as a function of the exchange rate and other variables. The exchange rate, in turn, adjusted to equilibrate the balance of payments. A similar approach was adopted in the EPA World Economic Model, as described by Amano et.al. (1981).

Several factors have led us to reconsider this theoretical basis for exchange rate determination in the MCM. First, an important assumption underlying the structural modeling of the gross private capital flow components of the balance of payments is that financial assets are denominated in the currency of the country in which they are issued. That is, claims on foreigners must be denominated in foreign currency and liabilities to foreigners must be denominated in the home currency if capital account data in the balance of payments is to conform to the theory underlying asset demand equations. However, the rapid growth of Euro-currency markets and other financial developments during the 1970's has made this assumption increasingly untenable.

Second, a further problem facing structural modeling of gross capital flows is that a substantial part of the growth in gross claims and liabilities over the past decade has been the result of intermediation by residents of one country through the books of financial institutions located in another country, as reflected in the rapid growth of Euromarkets. Not only is it misleading to treat such claims and liabilities independently, but it is also difficult to quantify the institutional factors influencing changes in the scale of these transactions.

The third factor is our experience to date in attempting to estimate gross capital flow equations over the floating rate period. The early version of the MCM was estimated over a period of predominantly fixed exchange rates (1960-1975). The results, in terms of signs and significance of coefficients, generally conformed to theoretical priors, but in some cases the estimated equations led to implausible simulation properties in the model.[1/] Attempts to update the capital flow equations with data for the floating rate period alone (1973-81) were generally unsuccessful. Signs on coefficients frequently were inconsistent with theoretical priors.

In light of these factors, we have adopted as an interim measure an approach similar to Haas and Alexander's (1979) method of aggregating private capital flows into a net private capital flow equation, solving for the exchange rate, and estimating the resulting equation with the exchange rate as the dependent variable. While this approach, as embodied in the current version of the MCM, yields much more plausible simulation properties, it too has its drawbacks. In particular, gross claims and liabilities, which are needed to determine investment income payments and receipts, are not identified explicitly.[2/]

Our research on exchange rate determination and capital flows is therefore still actively in progress. Current efforts center on what would seem at first glance to be a quite different approach, involving the explicit modeling of domestic financial asset markets, as applied recently to the German case by Obstfeld (1982), as well as a more aggregated approach than Obstfeld employed.

The present paper serves two purposes. The first is to outline the theoretical basis for alternative approaches to exchange rate determination in a general-equilibrium multicountry model and to describe the empirical considerations that impinge upon the selection among alternative approaches. The second is to document the current process of exchange rate and capital flow determination in the MCM, while relating it to the previous version of the model as well as to further developmental work currently in progress.

The paper is organized as follows. Section II presents a brief overview of the MCM for those not familiar with its structure. Section III outlines the theoretical basis for three alternative approaches to exchange rate determination: the structural balance of payments approach (employed in the early version of the MCM), the net private capital or inverted capital account approach (used in the current MCM), and the bond market approach (which is the focus of our current research). This section establishes that all three approaches are theoretically consistent in that they can be derived from a common general equilibrium portfolio balance model. It also considers some of the empirical factors that have led us to select one approach over another. Section IV then summarizes our experience with the structural balance of payments approach in the early version of the MCM. Section V and Appendix B document the current version. Our conclusions and a brief description of work currently in progress are presented in Section VI.

II. Overview of the Multicountry Model

The Multicountry Model is a large-scale econometric model developed by the staff of the Division of International Finance at the

Federal Reserve Board. It consists of quarterly macro models of five countries -- Canada, Germany, Japan, the United Kingdom and the United States -- as well as abbreviated OPEC and rest-of-world sectors. Particular attention has been paid to international aspects of the model, but each country model is sufficiently developed to be used individually as well as fully linked with other countries in the model.

The single country models vary in size from 200 to 300 behavioral equations and identities, each including a domestic goods market (determining domestic income and expenditure components, potential output and the price level), a labor market, a money market and a complete international accounts sector. Within the international accounts, trade flows are disaggregated by country or region and commodity (between oil and other), while service transactions and capital flows are determined multilaterally.

When the country models are linked together and simulated, economic impulses are transmitted from one country to another through both goods markets (via trade flows, prices and exchange rates) and financial markets (via asset demands or capital flows, interest rates and exchange rates). Four bilateral exchange rates are determined in the model: the U.S. dollar rates of the Canadian dollar, pound sterling, Deutschemark and Japanese yen. In some cases (in the current version) weighted average or effective rates of a given currency against the other four are modeled explicitly. Each exchange rate is one of a number of price variables in the model that simultaneously clear all goods and asset markets. The process of exchange rate determination is examined in considerable detail in the following sections.

III. Theoretical Basis for Alternative Approaches to Exchange Rate and Capital Flow Determination

This section outlines the theoretical basis for the alternative approaches to the determination of exchange rates and capital flows embodied in the original, current (revised) and prospective future versions of the MCM. For convenience, we have labeled the approaches respectively: 1) the structural balance of payments approach, 2) the net private capital or inverted capital account approach, and 3) the structural bond market approach. It is shown that all three approaches are theoretically consistent in that they can be derived from the same underlying model. The selection of one approach over another, which has been governed largely by empirical considerations -- data availability, etc. -- and the "realism" or plausibility of simplifying restrictions, is also considered in this section, as well as in following sections.

To describe the three approaches and illustrate their theoretical consistency, we have written down a two-country model of markets for goods (and services), bonds (interest bearing financial assets) and money. The model is presented in Table 1, with definitions provided at the end of the table. The model is a simple extension of small open economy portfolio balance models that have become familiar in the literature over the past two decades.[3/] It serves our purposes as an abbreviated version of the theoretical structure underlying the MCM. The major simplifications include: 1) the labor market has been dropped, 2) total output is held exogenous, 3) private investment is assumed to be zero, 4) demands are aggregated over a number of components and 5) the model is reduced from five countries to two countries. None of these abstractions materially affect the theoretical results drawn below. In

Table 1. Two Country Model of Goods, Bonds and Money.

	Home Country	Foreign Country
A. Market Equilibrium Conditions	Demand / Supply	Demand / Supply
1. Goods Markets	a) $C + \bar{G} - M/S + X^* = P\bar{Y}$	b) $C^* + \bar{G}^* - X^*S + M = P^*\bar{Y}^*$
2. Bond Markets	a) $B + B^* + \bar{B}^{G^*} = \Sigma D - L + \bar{F}^G/S - \int Z^G$	b) $F^* + F + \bar{F}^G = \Sigma D^* - L + B^{G*}S - \int Z^{*G}$
3. Money Markets	a) $L = \bar{L}$	b) $L^* = \bar{L}^*$
B. Behavioral Equations		
4. Private Expenditures	a) $C = C(Y, P, P^*, S, R)$	b) $C^*(Y^*, P^*, P, S, R^*)$
5. Demand for Other Country's Goods	a) $M/S = M(Y, P, P^*, S, R, B^*)$	b) $X^*S = X^*(Y^*, P^*, P, S, R^*, F)$
6. Demand for Own-Currency Bonds	a) $B = B(R, R^*, S, S^e, W, PY)$	b) $F^* = F^*(R, R^*, S, S^e, W^*, P^*Y^*)$
7. Demand for Other-Currency Bonds	a) $F/S = F(R, R^*, S, S^e, W, PY)$	b) $B^*S = B^*(R, R^*, S, S^e, W^*, P^*Y^*)$
8. Money Demand	a) $L = L(R, R^*, S, S^e, W, PY)$	b) $L^* = L^*(P, P^*, R, R^*, S, S^e, W^*, P^*Y^*)$

9. Exchange Rate Expectations

$$S^e = S^e(\ldots)$$

(Table 1 continued)

10. Taxes

a) $T = T(PY)$ b) $T^* = T^*(P^*Y^*)$

C. Identities

11. Government Deficits

a) $D = \bar{G} - T$ b) $D^* = \bar{G}^* - T^*$

12. Wealth Accumulation

a) $\Delta W = PY - T - C + Z$ b) $\Delta W^* = P^*Y^* - T^* - C^* + Z^*$

D. Other Conditions

13. Wealth Constraints

a) $W = B + F/S + L$ b) $W^* = B^*S + F^* + L^*$

14. Balance of Payments

a) $X^* - M/S + \Delta B^* - \Delta F/S + \Delta B^{G^*} - \Delta F^G/S = 0$ b) $X^*S - M + S\Delta B^* - \Delta F + S\Delta B^{G^*} - \Delta F^G = 0$

(Table 1 continued)

Definitions

B = Home private holdings of home-currency bonds, net of home private supply of those bonds; B^* is foreign private holdings of home currency bonds; B^{G^*} is foreign official holdings of home currency bonds.

C = Private expenditures (consumption)

D = Government budget deficit

F = Home private holdings of foreign currency bonds (stock); F^* is foreign private holdings of foreign currency bonds, net; F^G is home official holdings of foreign currency bonds

G = Government expenditures

L = Stock of high-powered money (currency plus reserves)

M = Home purchases of foreign goods and services (valued in foreign currency)

P = Price of home goods; P^* = price of foreign goods (in foreign currency)

R = Interest rate

S = Exchange rate, in terms of foreign currency/home currency

T = Tax receipts (net of transfers)

W = Private wealth

X^* = Foreign purchases of home goods and services (valued in home currency)

Y = Output (real income)

Z = Capital gains on holdings of foreign assets; $Z = F\Delta(\frac{1}{S})$; $Z^* = B\Delta S$; $Z^G = F^G\Delta(\frac{1}{S})$; $Z^{*G} = B^G\Delta S$

*	Superscript denotes foreign country variable
e	Superscript denotes expectations
G	Superscript denotes official holdings
"-"	Denotes exogenous variables
Σ	Denotes cumulation of flow (stock)
Δ	Denotes change in stock (flow)

particular, the results obtained for the two-country case can be generalized for models with more than two countries. However, several additional underlying assumptions do have a bearing on the results.

First, high powered money (currency plus reserves) is assumed to be held only in the country of issue. Second, all bonds denominated in a particular currency are assumed to be perfect substitutes, whether issued by the private sector or the government. Third, bonds are assumed to be issued in the currency of the home country only (i.e., residents of one country do not issue bonds denominated in the currency of another country). The last assumption is relaxed below, and as we shall see, it is especially important to selecting among the three modeling approaches.

The model consists of market equilibrium equations for domestic and foreign goods (equations 1a and 1b), domestic and foreign bonds (2a and 2b) and domestic and foreign currency (3a and 3b). Demand for goods (including services) includes private consumption plus government expenditures, $C + \bar{G}$, minus demand for foreign goods, M/S, plus foreign demand for domestic goods, X^*. The goods market in the foreign country is symmetrical, expressed in foreign currency (abstracting from c.i.f. - f.o.b. differentials on trade flows).

In the home bond market equilibrium (2a) home net private demand, B, plus foreign private and government demand, $B^* + B^{G^*}$, is equated with the outstanding stock of home government bonds. <u>Net</u> private demand in this case is defined as total private holdings of bonds minus bonds issued by the private sector.[4/] The stock of home government bonds is given by the cumulative home government deficit plus home government holdings of foreign currency bonds, minus high powered money minus cumulative capital gains on government holdings of foreign currency bonds.[5/] Increases in home official holdings of foreign bonds, F^G, net of foreign official holdings of home bonds, B^{G^*}, are the counterpart of combined intervention of the two countries to support the foreign currency. The money markets (3a and 3b) are represented by demands for and supplies of own-country high-powered money (currency plus reserves). Official intervention and money supplies are assumed exogenous in this simplified model; these variables can be endogenized through the introduction of policy reaction functions.

Equations (4a - 8b) are behavioral demand equations for goods, bonds and money. Goods demands are functions of own income and relative prices. In addition, home purchases of foreign goods and services, M/S, include interest payments to foreigners, so that their determinants include the home interest rate and the stock of home bonds held by foreigners. Foreign purchases of home goods and services are treated symmetrically. Bond and money demands are functions of expected relative rates of return on home and foreign assets (including expected exchange rate changes), own wealth, and a transactions demand variable (own nominal income).

Equation (9) identifies exchange rate expectations, which are discussed in detail in later sections. Government tax receipts and deficits are defined in equations (10a - 11b). Equations (12a) and (12b) define changes in home and foreign wealth as private savings (disposable income minus consumption) plus capital gains on the existing wealth stocks (Z).[6/] Equations (13a) and (13b) are home and foreign wealth constraints, equating private portfolio wealth with net private holdings of money and bonds valued in terms of the currency of the wealth holder.[7/] The wealth constraint is imposed on the asset demand equations in estimation to ensure consistency between private savings and asset accumulations in the model.

Of the six market equilibrium conditions in the model (1a - 3b), five are independent (by Walras' law). The five independent markets determine five market prices: P, P^*, R, R^* and the spot exchange rate, S. When the sixth market is dropped two behavioral equations identifying home and foreign demands in that market are dropped along with the market equilibrium condition. Those two demands are still identified, however, given the wealth constraints (13a) and (13b). The remaining 15 endogenous variables in the model: C, C*, M, X*, F, B*, L, L*, S^e, W, W*, T, T*, D and D*, are identified by the remaining 15 equations included in (4a) -(12b).

The balance of payments conditions (14a and 14b) are satisfied, ex-post, when all markets are in equilibrium. That is, when the goods, bonds and money markets are in equilibrium, the net flow of goods and assets, both private and official, must sum to zero. Hence, the balance of payments holds implicitly and is not needed explicitly to identify any variables in the model.[8/] (Note that one of the two balance of payments equations is redundant in any case.) As we shall see, however, under some of the approaches considered below, the balance of payments plays a more central role as an ex-ante equilibrium condition.

Structural Balance of Payments

As shown by Stevens (1976), the balance of payments equation can be substituted as an ex-ante equilibrium condition for any of the other equilibrium conditions in the model. When this substitution is made, two markets are dropped from the model, one by Walras' law and the other by substitution for the balance of payments equation. However, any transaction in either of the two dropped markets that appears in the balance of payments must still be modeled explicitly in order to identify all of the components of the balance of payments ex-ante.

In the early version of the MCM, the balance of payments was substituted for the domestic bond market equilibrium condition (2a), and the foreign bond market equilibrium condition was dropped by Walras' law.[9/] Neither of the own-currency bond demand equations (6a) and (6b) was estimated. However, equations for both domestic holdings of foreign bonds (7a) and foreign holdings of domestic bonds (7b) were estimated in order to identify ex-ante the capital flow components of the balance of payments. (These bond holdings were also needed to identify interest payments and receipts in equations (5a) and (5b).

In brief, the structural balance of payments approach involves estimating behavioral equations for each of the components of the balance of payments, while dropping demand equations for own-country bonds. The balance of payments equation becomes an equilibrium condition that identifies one of the five market clearing prices in the model. While prices are determined simultaneously by the five equilibrium conditions, the exchange rate has its greatest impact on transactions that enter into the balance of payments. It is thus convenient to think of the exchange rate as adjusting primarily to clear the balance of payments. However, significant problems can arise in structural modeling of the balance of payments, as discussed below.

Net Private Capital or Inverted Capital Account Approach.

The net or inverted capital account approach is a simple extension of the structural balance of payments approach. This involves making the same balance of payments substitution as outlined above. It then goes at least one and possibly two steps further by: 1) aggregating foreign demand for home bonds minus home demand for foreign bonds into a single equation for net home private liabilities to foreigners, and 2) solving that equation for the exchange rate.

The underlying asset demand equations, (7a) and (7b), written with the expected signs of coefficients over corresponding variables are:

<u>Home claims on foreigners</u>

(7a) $F/S = F(\overset{-}{R}, \overset{+}{R^*}, \overset{+}{S}, \overset{-}{S^e}, \overset{+}{W}, \overset{-}{PY})$

<u>Home liabilities to foreigners</u>

(7b') $B^* = B^{*\prime}(\overset{+}{R}, \overset{-}{R^*}, \overset{-}{S}, \overset{+}{S^e}, \overset{+}{W^*}, P^*Y^*)$

(where, S, which appears on the left-hand side of (7b) in Table 1, has been moved to the right-hand side in (7b').

Home demand for foreign bonds is expected to vary directly with the foreign interest rate and inversely with the home interest rate and the expected appreciation of the home currency (S^e/S). The expected signs on foreign demand for home bonds is just the opposite. Both bond demands are expected to vary negatively with own real income and prices (which determine transactions demand for money) and positively with own wealth.

Subtracting (7a) from (7b') yields an equation for private liabilities to foreigners net of private claims on foreigners (hence "net private capital"):

$$(15)\quad B^* - F/S = BF\,(\overset{+}{R},\ \overset{-}{R^*},\ \overset{-}{S},\ \overset{+}{S^e},\ \overset{+}{W^*},\ \overset{-}{W},\ \overset{\mp}{P^*Y^*},\ \overset{+}{PY})$$

The "inverted capital account approach" involves solving (15) for S, to obtain:

$$(16)\quad S = S\,(\overset{+}{R},\ \overset{-}{R^*},\ \overset{+}{S^e},\ \overset{+}{W^*},\ \overset{-}{W},\ \overset{-}{P^*Y^*},\ \overset{+}{PY},\ \overset{-}{(B^*-F/S)}),$$

The selection between (15) and (16) is based largely on empirical considerations, as discussed in Section V.

When either (15) or (16) is added to the model, it replaces the capital account equations for claims and liabilities (7a) and (7b). In this case, if the stocks of claims and liabilities are to be identified separately (e.g., for purposes of identifying investment income receipts and payments), another equation must be added to the model.

Bond Market Approach.

In terms of the model presented in Table 1, this approach is straightforward. It involves dropping one of the markets by Walrus's law and estimating all the behavioral equations in the model. For example, the foreign bond market (including the equilibrium condition (2b) and the demand equations determining F/S and F^*) can be dropped. In this case, the home bond market equilibrium condition remains and behavioral equations for both home and foreign holdings of home bonds, (6a) and (7b), must be modeled explicitly. The home bond market equilibrium condition then serves to determine one of the five market prices including the exchange rate (hence the label "bond market approach"). In this approach the balance of payments equation per se does not play a role in determining the exchange rate or any other market price. It could not in any case, since one of the components of the capital account (F/S) is not modeled explicitly. Both F/S and F^* are identified implicitly, however, by the home and foreign wealth constraints so that the balance of payments identity does hold implicitly.

A simplification of the bond market approach applied to the above example involves aggregating bond demands to estimate a single behavioral equation for total domestic and foreign demand for home bonds. This approach has been outlined by Frankel (1982). (For future reference we label this the "aggregate bond market approach".) The home and foreign demand equations, (6a) and (7b), are rewritten:

$$(17) \quad B = B\,(\overset{+}{R},\ \overset{-}{R^*},\ \overset{-}{S},\ \overset{+}{S^e},\ \overset{+}{W},\ \overset{-}{Y},\ \overset{-}{P},\ \overset{-}{P^*})$$

$$(18) \quad B^* = B^*\,(\overset{+}{R},\ \overset{-}{R^*},\ \overset{-}{S},\ \overset{+}{S^e},\ \overset{+}{W^*},\ \overset{-}{Y^*},\ \overset{-}{P},\ \overset{-}{P^*})$$

Aggregation yields:

$$(19) \quad B + B^* = B'\,(\overset{+}{R},\ \overset{-}{R^*},\ \overset{-}{S},\ \overset{+}{S^e},\ \overset{+}{W},\ \overset{+}{W^*},\ \overset{-}{Y},\ \overset{-}{Y^*},\ \overset{-}{P},\ \overset{-}{P^*})$$

This approach has an appeal for cases in which data on the supply (stock) of government bonds are more readily available than data on home and foreign private holdings of bonds, which is often the case. However, by dropping one of the bond demand equations, and removing the distinction between B and B^*, F and F^* cannot be identified through the home and foreign wealth constraints. F and B^* are still needed to determine investment income receipts and payments, which enter into income determination. This can be achieved by adding the balance of payments equation (to determine changes in the stock of net private foreign assets $\Delta(F-B^*)$) and a behavioral equation for either B^* or F. While this could still result in significant errors in the predicted scale of F and B^*, the error in the net stock $(F-B^*)$ would be limited to cumulative errors in the prediction of other components of the balance of payments, which may be easier to model.

Relaxing the Currency Denomination Assumption.

To this point we have assumed that bonds are denominated only in the currency of the country in which they are issued. If this assumption holds, it allows us to employ capital account data from the balance of payments in estimating equations (7a) and (7b), so that $\Delta F/S$ is equal to changes in private claims on foreigners and ΔB^* is equal to changes in liabilities to private foreigners. However, when residents of one country issue debt denominated in foreign currency the concepts measured in the balance of payments do not conform to the theoretical model. In this case claims on foreigners may include home currency bonds as well as foreign currency bonds, while liabilities to foreigners may include foreign currency bonds as well as home currency bonds. In bond demand equations estimated with this data, the expected signs of coefficients on relative rate of return variables (interest rates and expected exchange rate changes) become ambiguous.[10/] As discussed in the next section, such ambiguity can lead to significant problems in simulation exercises. Moreover, international capital flows may not capture total changes in holdings of foreign currency, since home residents can hold foreign currency bonds issued at home.[11/] In brief, when the currency denomination assumption does not hold, the link between capital flows and exchange market pressure is broken.

Available data suggest that the assumption is violated significantly in some cases. As indicated in Table 2, nearly 75 percent of Germany's private claims on foreigners are denominated in marks, while nearly 40 percent of its liabilities to foreigners are denominated in currencies other than marks. Other data indicate that well over 80 percent of U.S. private claims on foreigners are denominated in dollars.[12/]

This evidence alone does significant damage, but the estimation of separate capital account equations for changes in claims on foreigners and liabilities to foreigners faces yet another problem. In many cases it is not realistic to assume that these gross flows as recorded in the balance of payments accounts are independent of each other. Banks and corporations are both the major holders of claims and issuers of liabilities and the two sides of the same institution's balance sheet are likely to be interrelated. For example, the rapid growth of U.S. bank loans to nonoil LDC's after 1973 was related to the inflow of OPEC deposits. Another example is the frequent booking of loans by banks to residents of the same country at their offshore offices, which inflates both capital inflows and outflows. Such transactions, termed "round tripping", are generally influenced by institutional factors that are not readily quantifiable.

Table 2

Currency Denomination of German Foreign Claims & Liabilities
(Stock at end of 1980, billions of DM)

	Denominated in DM	Denominated in Other Currencies
Claims on Foreigners		
Short Term Bonds	28.7	29.2
Long Term Bonds	90.3	7.5
Short Term Domestic Enterprises	6.6	6.1
Long Term Domestic Enterprises	4.7	4.2
Credit Terms & Advance Payments	68.3	25.3
Total Claims	198.6	72.3
Liabilities to Foreigners		
Short Term Bonds	43.8	34.1
Long Term Bonds	52.8	11.8
Short Term Domestic Enterprises	33.1	9.4
Long Term Domestic Enterprises	15.8	11.2
Credit Terms & Advances Payments	39.7	25.1
Total Liabilities	185.2	91.6

Source: Statistical Supplement to the Monthly Report of the Deutsche Bundesbank Series 3 Balance of Payments Statistics Tables 7 & 8. December 1980.

In brief, these empirical problems raise significant doubts about any approach to general-equilibrium exchange rate modeling that is based on the estimation of traditional gross structural capital account equations. This points to the structural balance of payments approach in particular, but could also affect the bond market approach, since it too requires the estimation of home demand for foreign assets.

Several possible solutions exist. First, in the structural balance of payments approach, one could estimate equations for capital flows disaggregated by currency of denomination. This would remove the ambiguity of signs on coefficients, but it would not get around the institutional or round-tripping problem. In any event, this approach is feasible for only one or two countries for which such disaggregated data are available (Germany and perhaps Japan).

A second alternative is to employ the disaggregated bond market approach. Since bond demands are expressed net of bond supplies, this avoids the round-tripping problem as well as the currency denomination problem. However, since it requires data on bond holdings disaggregated by currency, it too can be applied only in one or two cases.

A third alternative is to use the aggregate bond market approach, which does not require estimation of any capital account equations. The only adjustments to the model (in addition to those outlined above for this approach) involve: 1) defining foreign private demand for home bonds as net foreign private supply of those bonds, and 2) adding foreign government supply of home bonds to the right hand side of equation (2a).

A fourth alternative is the net private capital or inverted capital account approach. A behavioral equation for <u>net</u> private capital flows as defined in the balance of payments can be derived from the bond market approach without introducing ambiguity into the coefficients on relative rates of return. This is shown in Appendix A. By netting claims against liabilities, this approach, too, solves the problem concerning institutional factors that cause claims and liabilities to grow jointly.

While the second, third and fourth solutions all handle the round-tripping problem (an advantage over the first, which does not), they also have a drawback. Under these three approaches the stocks of claims on foreigners and liabilities to foreigners are not identified separately. These stocks are needed in order to determine investment income receipts and payments. Some approximation would have to be made in order to determine these receipts and payments. One possibility is to model net investment income receipts as a function of net claims. The costs of doing so might not be significant, since gross receipts and payments are not required for income determination. In cases where capital account data disaggregated by currency of denomination are not available, some approximation of this disaggregation, based on whatever information is available (intermittent survey data, etc.), would have to be made.

Finally, in order to net bond supplies against demands, as is done in the latter three solutions, it must be assumed that bonds denominated in the same currency are perfect substitutes, even if issued in different countries. That is, differences in political risk or default risk across countries are not significant. This may not be too strong an assumption for the group of major industrial countries included in the MCM. The assumption allows us to aggregate behavioral equations across bonds issued in different currencies, and to net privately issued home currency bonds against home holdings of home currency bonds issued in other countries.

Our experience with the various approaches to exchange rate and capital flow determination in working with the MCM is summarized in the next three sections.

IV. Exchange Rate and Capital Flow Determination in the Early Version of the MCM.

As discussed in the previous section, the original version of the MCM employed the structural balance of payments approach. The U.S. bond market was dropped by Walras' law, and in each of the other country models the balance of payments equation was substituted for the domestic bond market. In each case, equations for nondirect capital flows generally were disaggregated by short term and long term claims and liabilities of the bank and nonbank sectors. Direct investment flows were modeled separately. Official capital flows were identified in most cases by intervention reaction functions (which performed a smoothing role).[13/] The exchange rate was identified implicitly -- it essentially adjusted to clear the balance of payments.

The nondirect capital flow equations were derived as first differences of the following stock-demand functional forms for claims and liabilities:

Claims on Foreigners

$$(20)\qquad (F_i/S)/W = \alpha_0 - \alpha_1\,(L)R_S - \alpha_2\,(L)R_L + \alpha_3\,(L)R_S^* + \alpha_4\,(L)R_L^*$$

$$- \alpha_5\,(S^e - S)/S - \alpha_6\,(S^f - S)/S + \alpha_7\,X^*/W$$

Liabilities to Foreigners

$$(21)\qquad B_i^*/W^* = \beta_0 + \beta_1\,(L)\,R_S + \beta_2\,(L)\,R_L - \beta_3\,(L)\,R_s^* - \beta_4\,(L)\,R_L^*$$

$$+ \beta_5\,(S^e - S)/S + \beta_6\,(S^f - S)/S + \beta_7\,MS/W^*,$$

where F_i and B_i^* are disaggregated claims and liabilities, (L) denotes a lag operator, R_S and R_L are short-term and long-term interest rates, S^f is the forward exchange rate and other variables are as defined in Table 1. The coefficients are included with their expected signs.

In most cases foreign variables were defined as U.S. variables; in some cases weighted averages of four countries (including the US) were employed. Homogeneity of responses to changes in the components of the relative rates of return was not imposed, and separate interest rate terms were included with lags of up to 10 quarters in some cases. The import and export variables were included to capture trade credit. Exchange rate expectations were proxied by relative prices (assuming expected long run purchasing power parity) and in some cases changes in official reserves. Note that both the expected change in the exchange rate and the forward premium were included. The empirical implementation of these equations varied across countries. In some cases they were estimated in stock form as shown, in other cases in flow form (by multiplying the equation by wealth and taking the first difference of the equation). Some of the determinants were dropped in various cases; dummy variables were added in a number of cases.[14/]

In simulation exercises with the early MCM, several exchange rates exhibited dynamic instability, particularly in the absence of intervention reaction functions. This behavior was traced to estimated coefficients in both the current account and capital account equations. Private foreign asset demands (as well as current account flows) generally had very low responsiveness to changes in exchange rates. Meanwhile, coefficients on interest rates were proportionately greater than those on exchange rates. In addition the distributed lags on interest rates meant that an interest rate shock had continuing effects on asset demands. To illustrate the effects of these properties on exchange rate and capital flow determination, a monetary shock that raised interest rates induced a large (and continuing) incipient capital inflow. This potential inflow had to be either accomodated by large-scale official intervention or offset by an appreciation of the home currency proportionately much greater than the rise in the domestic interest rate.[15/] In the absence of the smoothing effects of endogenized official intervention, the Canadian model, as well as the German and Japanese models, exhibited exchange rate behavior that seemed implausible and in some cases explosive in longer run (7-8 year) simulations.[16/] This exchange rate behavior, of course, had significant impacts elsewhere in the model.

Two possible solutions to those simulation properties were considered. The first was to mask the instability by tightening the official intervention functions. The Japanese EPA World Economic Model has employed this technique, as described in Amano et.al. (1981). When exchange rate changes reach a given value per quarter, official intervention cuts in to eliminate further change. This solution had the appeal of stabilizing simulations without having to undertake structural reforms of the model. However, if the intervention constraint was binding, exchange rate determination ultimately would be in official hands, which returns us to a more or less fixed exchange regime. This might have been a plausible assumption in some cases but to the extent that the intervention rule masked structural errors in the model, it would have yielded misleading signals about the amount of intervention required in the case of particular policy shocks. The second solution, adopted in the MCM, was to begin to reestimate and restructure certain parts of the model, as described in the next section.

V. Exchange Rate Determination in the Current Version of the MCM.

Revision of the process of exchange rate and capital flow determination in the early version of the MCM has gone through several phases. First, an attempt was made simply to update the existing equations in the model, estimating them over the managed floating rate period since 1973Q2 (the starting point was somewhat earlier for Canada). The original equation specifications generally performed poorly over this period -- signs of key coefficients were often reversed and statistical significance fell. The second step was to impose a number of constraints on the gross flow equations. In particular, the components of relative rates of return were constrained to be the same (with appropriate signs), the lags on interest rates and the forward premium were dropped, and alternative expectations variables were tested. These changes still failed to yield reasonable results.

In light of these empirical results and an increasing awareness of some of the theoretical problems with the estimation of gross capital account equations discussed in Section III, we adopted the net private capital approach, which led to the inverted capital account specification. The explicit theoretical derivation of this approach was as follows. Equations for total gross nondirect claims and liabilities were written:

$$(22) \quad F/S = \alpha_1 W - \alpha_2 (R - R^* + \log (S^e/S))W$$

$$(23) \quad B^* = \beta_1 W^*/S + \beta_2 (R - R^* + \log (S^e/S))W^*/S$$

Under the assumption that $\alpha_2 = \beta_2$ (the home response to a change in relative rates of return is the same as the foreign response), the following equation for net liabilities to foreigners can be derived by subtracting (22) from (23):

$$(24) \quad B^* - F/S = - \alpha_1 W + \beta_1 W^*/S + \alpha_2 (R - R^* + \mathrm{LOG} (S^e/S))$$

$$(W + W^*/S)$$

Equation 24 was estimated for each of the four non-U.S. countries in the MCM (Canada, Germany, Japan and the U.K.). Foreign variables were defined alternatively as U.S. variables and as weighted averages of four other countries (including the U.S.). Two alternative approaches were employed to identify the expected exchange rate: 1) using the realized future spot exchange rate (based on McCallum's (1976) rational expectations approach) for estimation purposes, and 2) specifying expectations structurally using Hooper and Morton's (1982) approach. The expected exchange rate in the latter case is specified as a function of relative prices, relative expected inflation rates and the home country's cumulative current account lagged one period:

$$(25) \quad \mathrm{LOG}\ S^e = \gamma_0 + \gamma_1\ \mathrm{LOG}\ (P^*/P) + (\dot{P}^{e^*} - \dot{P}^e) + \gamma_2\ \Sigma(M/S - X^*)_{-1}$$

where $\dot{P}$ is the inflation rate and definitions are otherwise the same as in Table 1. Finally, (24) was estimated using ordinary least squares, and instrumental variables.

The results were generally disappointing. The key coefficient α_2 was never significant with the expected sign.[17/] It was recognized that if domestic and foreign bonds are perfectly substitutable, (24) could not be estimated because γ_2 would be infinite. To test for this case the equation was inverted by solving for S. The result for the structural expectations case (after substituting (25) into (24)) was a complex nonlinear specification, of which we took the following linear approximation:

$$(26) \quad \log S = \delta_0 + \delta_1\ (R - R^* + \dot{P}^{e^*} - \dot{P}^e) + \delta_2\ \Sigma\ (M/S - X^*)_{-1} - \delta_3 W$$

$$+ \delta_4 W^* - \delta_5 (B^* - F/S)$$

Our linear approximation in the rational expectations case is written:

$$(27) \quad \log S = \Theta_0 + \Theta_1 (R - R^* + S_{+1}) - \Theta_2 W + \Theta_3 W^* - \Theta_4 (B^* - F/S)$$

S still appears in the last term on the right hand side of (26) and (27) because net liabilities to foreigners are computed from balance of payments data in which claims on foreigners are denominated in the home currency. It can be shown that if home and foreign assets are perfectly substitutable, the last three terms on the right-hand side of both equations drop out. (This implies that changes in asset supplies (e.g., through intervention) and wealth have no effect on the exchange rate.[18/])

A number of alternative versions of (26) and (27) were estimated for each country paralleling the alternatives tried for (25) as discussed above. In addition, two-step two-stage least squares, as described in Cumby et.al. (1982) was employed in estimation.

The results of this round of estimation for equation (26) produced the equations that are employed in the current interim version of the MCM. These equations are reported in Appendix B in the same form in which they appear in the model. (Definitions of variables are given at the end of the appendix.)

In three of the four countries (except Canada) weighted averages were used for exchange rates and other foreign data. The weights are proportional to each country's share of total world trade.

The interest rate and expectations variables (relative prices, inflation rates and cumulative current accounts) generally yielded coefficients with the expected sign and at least marginal significance. The UK was an exception; therefore a number of the coefficients were constrained based on the results obtained for other countries. The long run relative price coefficient was constrained to 1.0 in all cases (based on theoretical priors). The cumulative current account term varied across countries. In the Canadian case the cumulative basic balance was used, and in other cases the cumulative OPEC current account (weighted by factors equal to one-half of each country's share in OPEC's imports) was added to the cumulative current account to adjust for transitory savings in current accounts due to oil price shocks.

However, the coefficients on wealth variables and net foreign liabilities were generally statistically insignificant, often with the wrong sign. However, when the net foreign liabilities variable was included in flow form it yielded the expected sign, although still with low statistical significance. (In this case official intervention, which is reflected in changes in net private liabilities, has only a transitory one period impact on the exchange rate.) These results are consistent with the perfect substitutability of assets--except in the short run, perhaps reflecting adjustment lags--and therefore tend to reject the portfolio balance theory underlying the model. In this case selection among the alternative approaches to modeling exchange rates and capital flows outlined in Section III is irrelevant, since all of these are based on the portfolio balance view. One is tempted to conclude that exchange rates should be modeled explicitly as a function of interest rates and factors affecting expectations alone. This would be consistent with the monetary approach, as developed by Dornbusch (1976), Frankel (1979) and others. In this case net private capital flows would be determined residually by the balance of payments equation (with perfect substitutability of assets, any shock to the current account would be automatically financed by private capital flows).

This view is troublesome for two reasons. First, not only does the portfolio balance model have a strong theoretical appeal, but it has also been applied empirically with some success to domestic financial markets.[19/] Second, and of more immediate importance to the present case, is the significance of cumulative current accounts in determining exchange rates in the estimated equations. If assets were perfect substitutes at all horizons (the assumption underlying the monetary approach), it would be irrational for market participants to expect the current account to affect the exchange rate. The results shown in the equations in Appendix B are in this sense contradictory.

VI. Conclusions and Plans for Future Research

We conclude, first, that there are potentially severe conceptual problems with implementing the structural balance of payments approach to modeling exchange rates and capital flows. Except in one or two countries for which requisite data are available, separate equations for claims and liabilities in the capital account cannot be estimated in a fashion that is consistent with underlying theory. This conclusion is based on 1) our experience with such capital account equations in the early version of the MCM, 2) our assessment of effects of bonds being issued in more than one currency and 3) the effects of institutional factors ("round-tripping", etc.) that are difficult to model.

Second, several alternatives to the structural balance of payments approach exist, some of which involve aggregation (such as estimating net capital flow equations), and some of which involve a more fundamental restructuring of the underlying model (such as specifying a domestic bond market explicitly). In cases where capital account data disaggregated by currency of denomination are not available, interest income receipts and payments cannot be modeled explictly, and some approximation must be made in estimation.

Third, work has progressed on the approach of estimating net capital account equations normalized on the exchange rate. The results of this work to date, as reflected in the current (interim) version of the MCM, suggest that shifts in asset supplies (portfolio balance considerations) do not have a significant, lasting effect on exchange rates. However, the results are not internally consistent. Whereas intervention does not have a significant impact on exchange rates, current account deficits do.

For this reason work is currently underway to pursue some of the other approaches in this paper. In particular, for countries for which data are available (Germany and possibly Japan) a disaggregated bond market approach is being tested. In addition, an aggregate bond demand equation is being estimated for all of the MCM countries, using available data on the total outstanding stocks of government bonds. Other refinements being undertaken include an effort to take into account changes in the market prices of bonds in calculating bond stocks and wealths, and further experimentation with exchange rate expectations equations.

Appendix A

The purpose of this appendix is to show that an equation for net private capital flows (ie., changes in claims on foreigners net of liabilities to foreigners), is consistent with an aggregation of net private bond demands, and therefore avoids the problem of ambiguity of signs on coefficients that can arise in the structural capital account approach (ie., modeling changes in claims and liabilities separately) when data on claims and liabilities disaggregated by currency of denomination are not available.

To show this, we adopt a two-country model in which private residents and governments of both countries can issue and hold bonds denominated in the currencies of both countries. The various bond holding and issuing possibilities are summarized in the following chart.

Sector Issuing Bond	Sector Holding Bond: Home Priv.	Home Govt.	For. Priv.	For. Govt.
Home Priv.	- -	-, F_P^G	B_P^{P*}, F_P^{P*}	B_P^{G*}, -
Home Govt.	B_G^P, F_G^P	- , -	B_G^{P*}, F_G^{P*}	B_G^{G*}, -
For. Priv.	B_{P*}^P, F_{P*}^P	- , F_{P*}^G	- -	B_{P*}^{G*}, -
For. Govt.	B_{G*}^P, F_{G*}^P	-, F_{G*}^G	B_{G*}^{P*}, F_{G*}^{P*}	- -

Subscripts denote the sector issuing the bond and superscripts the sector holding the bond; "*" denotes foreign sectors; absence of "*" denotes home sectors. For convenience, foreign currency bonds (F) as well as home currency bonds are valued in home currency units. Note that each sector's holdings of bonds issued by itself net out; also we abstract from government holdings of own-currency private bonds, which do not affect the results discussed below.

Home private claims on foreigners (CF) and home liabilities to private forigners (LF), as defined in the balance of payments accounts, are written:

<u>Private claims on foreigners</u>

A.1 $CF_P = F^P_{P*} + F^P_{G*} + B^P_{P*} + B^P_{G*}$

<u>Liabilities to private foreigners</u>

A.2 $LF_P = B^{P*}_P + B^{P*}_G + F^{P*}_P + F^{P*}_G$

When separate demand functions for LF_P and CF_P are estimated the signs of the rate of return variables are ambiguous because demand for bonds denominated in different currencies are mixed together. To show how modeling net claims minus liabilities can avoid this ambiguity, the terms in equations A.1 and A.2 must be rearranged and supply functions must be used instead of demand functions for certain components. This substitution is permissible if markets are assumed in equilibrium: quantity supplied will equal quantity demanded.

(Note that in principle, the ambiguity of signs on the rate of return variables in the claims equation (A.1), for example, could be eliminated by treating that equation as an aggregation of home demand for foreign currency bonds plus foreign <u>supply</u> of home currency bonds. However, this specification would require identifying the separate scale variables for both home country gross demand and foreign country gross supply. It is unclear which scale variables are appropriate for determining each gross flows because the scale of assets and liabilities is interrelated. By contrast, in the net capital account approach outlined below we can assume that the private <u>net</u> demand (demand minus supply) of each country for assets denominated in the other country's currency is a function of its own wealth.)

The net capital account approach involves subtracting (A.2) from (A.1) to derive an equation for net claims minus liabilities (NETCF):

$$\text{A.3} \quad NETCF = F^{P}_{P*} + F^{P}_{G*} + B^{P}_{P*} + B^{P}_{G*} - B^{P*}_{P} - B^{P*}_{G} - F^{P*}_{P} - F^{P*}_{G}$$

Next, rearranging the right-hand side of A3 into three groups of terms yields:

$$\text{A.3'} \quad NETCF = (F^{P}_{P*} + F^{P}_{G*} - F^{P*}_{P}) - (B^{P*}_{P} + B^{P*}_{G} - B^{P}_{P*})$$

$$+ (B^{P}_{G*} - F^{P*}_{G})$$

Finally, we add and subtract from the right-hand-side of (A.3') each of the following terms: F^{P}_{G}, home private holdings of foreign currency bonds issued by the home government, F^{G}_{P}, home government holdings of foreign currency bonds issued by home residents, and B^{P*}_{G*} and B^{G*}_{P*}, the analogous terms for foreigners. Rearranging again, yields:

$$\text{A.3"} \quad NETCF = (F^{P}_{P*} + F^{P}_{G*} + F^{P}_{G} - F^{P*}_{P} - F^{G}_{P})$$

$$- (B^{P*}_{P} + B^{P*}_{G} + B^{P*}_{G*} - B^{P}_{P*} - B^{G*}_{P*})$$

$$+ [(B^{P}_{G*} + B^{P*}_{G*}) - (F^{P*}_{G} + F^{P}_{G}) - B^{G*}_{P*} + F^{G}_{P}]$$

The first group of terms on the right-hand side of (A.3") can be modeled as the total home private demand for foreign currency bonds minus the home private supply of foreign currency bonds. (Note that foreign currency bonds both issued and held by the home private sector, F^{P}_{P}, cancel out and do not appear in this net demand expression.) This net demand varies positively with the foreign interest rate and negatively with the home interest rate and expected appreciation of the home currency. The second group of terms on the right hand side of (A.3") equals the net foreign private demand for home currency bonds, which varies in just the opposite direction with the rate of return variables. Since foreign net demand enters negatively into the equation, however, no ambiguity with respect to signs on rates of return arises between the first two groups.

The third group of terms includes the foreign-currency bonds issued by each government ("Carter bonds" for example) and official holdings of foreign currency denominated claims on their own private sectors. For analytical purposes these terms should be combined with official monetary capital flows reported in the balance of payments accounts. The terms could be treated exogenously or modeled as part of intervention policy. Data on Carter-type bonds are available in some but not all cases.

Appendix B

Estimated Exchange Rate Equations (Based on Inverted Capital Account Approach) used in Current Version of the MCM.
(t-ratios in parentheses)

1. US Dollar/Canadian Dollar Exchange Rate Equation.

$$\begin{aligned}\mathrm{LOG(CER)} = {} & \underset{(3.75)}{.427} - \underset{(-1.30)}{.0026}\ \mathrm{CDNETPK} + \underset{(4.23)}{.0063}\ (\mathrm{CRS} - \mathrm{URS}) \\ & + \underset{(6.15)}{.885}\ \mathrm{LOG}(\mathrm{CER}_{-1}) - \underset{(-2.40)}{.272}\ \mathrm{LOG}(\mathrm{CER}_{-2}) - \underset{(-3.97)}{4.00}\left(\frac{\mathrm{CNW}}{\mathrm{UNW}}\right) \\ & + \underset{(1.23)}{.00204}\ \mathrm{CUMBB} + \underset{(1.89)}{.018}\ \mathrm{CDUM}\end{aligned}$$

Sample Period 1970 Q4 - 1980 Q2

$\bar{R}^2 = 0.98$ SER = 0.010 DW = 2.37

2. Weighted Average German Mark Exchange Rate Equation.

$$\begin{aligned}\mathrm{LOG(GERFW)} = {} & \underset{(-.11)}{0.010} + \mathrm{LOG}(\mathrm{GFPFW1}_{-1}/\mathrm{GP1}_{-1}) + \underset{(1.63)}{0.009}\ (\mathrm{GRS} - \mathrm{GINF} \\ & - \mathrm{GFRSFW} + \mathrm{GFINFFW}) + \underset{(2.56)}{0.001}\ (\mathrm{GCCURAB}_{-1} + 0.055\ \mathrm{ONW}_{-1} \cdot 2.2) \\ & - \underset{(0.456)}{0.0001}\ \mathrm{GDNETPK} \cdot 4\end{aligned}$$

Sample Period 1973 Q1 - 1980 Q4

$\bar{R}^2 = 0.792$ SER = 0.039 DW(0) = 1.87 RHO1 = 0.432

3. Weighted Average Japanese Yen Exchange Rate.

$$\begin{aligned} LOG(JERFW) = &\underset{(-55.99)}{-5.479} + LOG(JFPFW1_{-1}/JP1_{-1}) + 0.0025(JRS - JINF \\ &- JFRSFW + JFINFFW) + \underset{(1.72)}{0.00002}(JCCURAB_{-1} \\ &+ 0.075\ ONW_{-1}/0.0033) - \underset{(-0.81)}{.00001}\ JDNETPK \end{aligned}$$

Sample Period 1973 Q2 - 1980 Q3

R^2 = -0.089 SER = 0.048 DW(0) = 1.32 RHO1 = 0.825

4. Weighted Average UK Pound Exchange Rate

$$\begin{aligned} \Delta LOG(EERFW) = &\underset{(1.16)}{0.01227} + \Delta(LOG(EFPFW1_{-1}/EP1_{-1})) + 0.0025\Delta(ERS - EINF \\ &- (EFRSFW - EFINFFW)) + 0.0016\Delta(ECUMBBAL_{-1} + 0.0045ONW_{-1} \\ &+ 0.474) - \underset{(-.573)}{0.00144}\Delta EDNETPK \end{aligned}$$

Sample Period 1973 Q1 - 1980 Q4

$\bar{R}^2$ = -0.471 SER = 0.0449 DW(0) = 2.15 RHO1 = 0.257

Definitions

CDUM	Canadian Political Dummy Variable
CUMBB	Cumulated Canadian Basic Balance
CER	Canadian Dollar Exchange Rate
CNETPK	Canadian Stock of Net Short Term Private Liabilities To Foreigners
CNW	Canadian Wealth (Net Worth)
CRS	Canadian Short Term (3 month) Interest Rate
ECUMBBAL	UK Cumulative Current Account Balance
EDNETPK	Change in Net UK Private Liabilities To Foreigners
EER	Dollar/UK Pound Exchange Rate
EERFW	Weighted Average Yen Exchange Rate, Using FRB Multilateral Trade Weights

$$= \quad (EER^{.23} \,.\, (EER/CER)^{.09} \,.\, (EER/JER)^{.14} \,.\, (EER/JER)^{.25})^{1.492}$$

EFINFFW — Expected Foreign Inflation Rate, (UK Model), One Quarter Ahead, Based on Fixed FRB Trade Weights

$$= \quad (EFPFW1/EFPFW1_{-4} - 1) \,.\, 100$$

EFPFW — UK Weighted Average Price Level, Based on FRB Multilateral Trade Weights

$$= \quad (UP^{.23} \,.\, CP^{.09} \,.\, GP^{.21} \,.\, JP^{.14})^{1.492}$$

EFPFW1 — Expected Value of EFPFW One Quarter Ahead

$$= \quad -0.001 + 1.554\ EFPFW - 0.162\ EFPFW_{-1} + -0.40EFPFW_{-2}$$

$$- \quad 0.027\ EFPFW_{-3} - 0.184\ EFPFW_{-4} + 0.224\ EFPFW_{-5}$$

EFRSFW — Foreign Short Term Interest Rate (UK model), Based on Multilateral FRB Trade Weights

$= 0.343\ URS + 0.134\ CRS + 0.313\ GRS + 0.21\ JRS$

EINF — Expected UK Inflation Rate, One Quarter Ahead

$= (EP1/EP1_{-4} - 1).100$

EP — UK Absorption (Total Expenditure) Deflator

EP1 — Expected Value of EP, One Quarter Ahead

$= -0.01 + 1.36\ EP - 0.476\ EP_{-1} + 0.379\ EP_{-2} + 0.196\ EP_{-3}$

$- 0.875\ EP_{-4} + 0.438\ EP_{-5}$

ERS — Short Term (3 month) UK Interest Rate

GCCURAB — Cumulative German Current Account Balance

GDNETPK — Change in Net German Private Liabilities To Foreigners

GER — Dollar/Mark Exchange Rate

GERFW — Weighted Average DM Exchange Rate, using FRB Multilateral Trade Weights

$= (GER^{.25} . (GER/CER)^{.09} . (GER/EER)^{.12} . (GER/JER)^{.4})^{1.72}$

GFINFFW — Expected Weighted Average Foreign Inflation Rate, German Model

$= ((GFPFW1/GFPFW1_{-4}) - 1) \cdot 100$

GFPFW — Expected Foreign Price Level (German Model), Based on Fixed FRB Trade Weights

$= (UP^{.23} . CP^{.09} . EP^{.12} . JP^{.14})^{1.724}$

GFPFW1 = Expected Value of GFPFW, One Quarter Ahead

$= -0.002 + 1.647\ GFPFW - 0.542\ GFPFW_{-1} + 0.005\ GFPFW_{-2}$

$$+ \quad 0.163\ GFPFW_{-3} - 0.725\ GFPFW_{-4} + 0.460\ GFPFW_{-5}$$

GFRSW Weighted Average Foreign Short Term Interest Rate, German Model, Using FRB Multilateral Trade Weights

$$= \quad 0.40\ URS + 0.155\ CRS + 0.21\ ERS + 0.241\ JRS$$

GINF Expected German Inflation Rate, One Quarter Ahead

$$= \quad (GP1/GP1_{-4} - 1) \cdot 100$$

GP German Absorption (Total Expenditure) Deflator

GP1 Expected Value of GP, One Quarter Ahead

$$= \quad -0.002 + 1.004\ GP + 0.30\ GP_{-1} - 0.248\ GP_{-2} + 0.095\ GP_{-3}$$

GRS Short Term Interest Rate (3 month Frankfurt Money Market Rate)

JCCURAB Cumulative Japanese Current Account Balance

JDNETPK Change in Net Japanese Private Liabilities To Foreigners

JER Dollar/Yen Exchange Rate

JERFW Weighted Average Yen Exchange Rate, Using FRB Multilateral Trade Weights

$$= \quad (JER^{.23} \cdot (JER/CER)^{.09} \cdot (JER/EER)^{.12}$$

$$\cdot \ (JER/GER)^{.21})^{1.538}$$

JFINFFW Expected Foreign Inflation Rate, One Quarter Ahead Japanese Model

$$= \quad (JFPFW1/JFPFW1_{-4} - 1) \cdot 100$$

JFPFW Weighted Average Foreign Price Level, Using FRB Multilateral Trade Weights, Japanese Model

$$= (UP^{.23} \cdot CP^{.09} \cdot EP^{.12} \cdot GP^{.21})^{1.538}$$

JFPWL Expected Value of JFPFW, One Quarter Ahead

$$- 0.006 + 1.439\ JFPFW - 0.202\ JFPFW_{-1} - 0.168\ JFPFW_{-2}$$

$$+ 0.277\ JFPFW_{-3} - 0.781\ JFPFW_{-4} + 0.448\ JFPFW_{-5}$$

JFRSFW Weighted Average Foreign Short-Term Interest Rate, Using Multilateral Trade Weights, Japanese Model

$$= 0.354\ URS + 0.138\ CRS + 0.185\ ERS + .323\ GRS$$

JINF Expected Japanese Inflation Rate, One Quarter Ahead

$$= (JP1/JP1_{-4} - 1)\ .100$$

JP Japanese Absorption (Total Expenditure) Deflator

JP1 Expected Value of JP, One Quarter Ahead

$$= 0.0048 + 1.901\ JP - 1.052\ JP_{-1} + 0.385\ JP_{-2} - 0.464\ JP_{-3}$$

$$+ 0.191\ JP_{-4} + 0.040\ JP_{-5}$$

JRS Japanese Short Term (3 month) Interest Rate

ONW Cumulative OPEC Current Account

UNW US Wealth (Net Worth)

URS US 3 Month CD Interest Rate

Footnotes

1/ For example, relatively small monetary shocks were observed to induce extremely large, and in some cases explosive exchange rate movements in the model. See Hooper et.al. (1981).

2/ The balance of payments condition identifies only net private foreign assets. The stocks claims on foreigners and liabilities to foreigners still must be identified in order to determine the investment income receipts and payments on those stocks. For this purpose the current MCM retains the earlier version of either the claims or liabilities equation, depending upon the particular country. With one side (eg. claims) thus identified, the other side (liabilities) is then derived from the cumulative flow of net private foreign assets.

3/ Such models were introduced in the early 1960's by Mundel (1963) and Fleming (1962); see Henderson (1982) for a more recent example.

4/ Home private bond demand, B, expressed net of home private bond supply. To see that net home private demand plus foreign demand for home currency bonds is equal to the supply of home government ("outside") bonds, the market for private home currency bonds can be written:

$$(F.1) \quad DB_p + DB_p^* + DB_p^{G^*} = SB_p$$

where DB_p is gross home demand for privately issued domestic currency bonds, DB_p^* and $DB_p^{G^*}$ are foreign private and official demands, and SB_p is total supply (based on the assumptions that B_p is supplied domestically only and is not held by the home government). Similarly, the market for government home currency bonds is:

$$(F.2) \quad DB_G + DB_G^* + DB_G^{G^*} = SB_G$$

Summing (F.1) and (F.2) to get total demands and supplies of home currency bonds yields:

$$(F.3) \quad DB_p + DB_G + DB_p^* + DB_G^* + DB_p^{G^*} + DB_G^{G^*} = SB_p + SB_G$$

Next, aggregating demands for government and private bonds and rearranging yields:

$$(F.4) \quad DB_{p+G} - SB_p + DB_{p+G}^* + DB_{p+G}^{G^*} = SB_G,$$

which is equivalent to equation (2a) in Table 1, given that $DB_{p+G} - SB_p$

is net private demand for home currency bonds (B), and SB_G is equal to D - L + F^G/ S.

5/ This assumes that the government deficit is financed by bonds and high powered money, and abstracts from changes in government liquid assets (deposits at banks, etc.).

6/ Capital gains are limited to foreign exchange gains or losses. For simplicity bonds are measured at nominal values rather than market prices.

7/ This model abstracts from private fixed capital, which can affect the results to the extent that private equities are substitutable for government bonds in private portfolios. This abstraction is generally adopted in empirical applications, due to the absence of data on rates of return on private fixed capital (equities).

8/ To show that the balance of payments identity is not a necessary equilibrium condition but an ex-post identity that holds by definition when all markets are in equilibrium, we need only derive that identity from the other equations in the model. This is done as follows: First, substitute equation (12a) into the first difference of (13a) for ΔW, to obtain the home private sector's budget constraint:

$$(F.5) \quad PY - T - C + Z = \Delta B + \Delta F/S + \Delta L + Z$$

(Note that $\Delta(F/S) = \Delta F/S + Z$, where Z is limited to foreign exchange gains or losses). Second, solve the first difference of the bond market equilibrium condition (2a) for ΔL, and substitute the result into (F.5):

$$(F.6) \quad \Delta B + \Delta F/S + D + \Delta F^G/S - \Delta B - \Delta B^* - \Delta B^{G^*} + Z = PY - T - C + Z$$

Next, substitute into (F.6) both the right hand side of (11a) for D and the solution for PY obtained in the goods market equilibrium condition (1a), yielding:

$$(F.7) \quad \Delta B + \Delta F/S + G - T + \Delta F^G/S - \Delta B - \Delta B^* - \Delta B^{G*} + Z = C + G - M/S + X^* - T - C + Z$$

which collapses to

$$(F.8) \quad \Delta F/S + \Delta F^G/S - \Delta B^* - \Delta B^{G*} = -M/S + X^*$$

rearranging, we have the balance of payments identity:

$$(13a) \qquad X^* - M/S + \Delta B^* - \Delta F/S + \Delta B^{G*} - \Delta F^{G}/S = 0$$

This issue has been considered elsewhere in Stevens (1976) and Dooley (1974).

9/ In fact, among the five countries included in the MCM, the balance of payments substitution was made for four of the countries and the bond market in the fifth country (the United States) was dropped by Walras' law.

10/ To see this, suppose, that claims on foreigners (CF) consist of home currency bonds issued abroad (B_*) as well as foreign currency bonds issued abroad (F), so that:

$$(F.9) \qquad CF = F/S + B_*$$

Behavioral equations for F/S and B_* are much the same as (7a) and (7b):

$$(F.10) \qquad F/S = F\,(\overset{-}{R},\ \overset{+}{R^*},\ \overset{+}{S},\ \overset{-}{S^e},\ \overset{+}{W},\ \overset{-}{PY})$$

$$(F.11) \qquad B_* = B_*\,(\overset{+}{R},\ \overset{-}{R^*},\ \overset{-}{S},\ \overset{+}{S^e},\ \overset{+}{W},\ \overset{-}{PY})$$

Substituting (7a) and (F.11) into (F.10) yields:

$$(F.12) \qquad CF = CF\,(\overset{?}{R},\ \overset{?}{R^*},\ \overset{?}{S^e},\ \overset{+}{W},\ \overset{-}{PY})$$

See Appendix A for more on this point.

11/ This is a problem only to the extent that the foreign bonds were issued by the home government (as in the Canadian case in particular), since privately issued bonds would be netted out of private home demand in the net private demand specification.

12/ At the end of 1980, 97 percent of U.S. bank and nonbank claims on foreigners (excluding stocks and long term bonds) were denominated in dollars. These claims accounted for 80 percent of total portfolio (nondirect) claims, and it is likely that a significant portion of the remainder (largely long term bonds) also were dollar denominated. Source: Federal Reserve Bulletin, July 1982, and Department of Commerce, Survey of Current Business, August 1981.

13/ In most cases changes in reserves were expressed as a function of exchange rate changes and lagged reserves.

14/ Exchange rate and capital flow determination in the original version of the MCM are described in considerable detail in Stevens et.al. (1982). See also Stevens et.al. (1980).

15/ With exchange rate expectations relatively sluggish in the model, the appreciation of the home currency induced an expected depreciation, which tended to offset the rise in home interest rates.

16/ See Hooper et.al (1981) for details.

17/ See Haas et.al (1980) for a sample of these results.

18/ See Hooper et.al. (1981) or Symansky et.al. (1981).

19/ See, for example, Roley (1980).

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