IMF WORKING PAPER

WP/87/32

INTERNATIONAL MONETARY FUND

Research Department

Strategies for Modeling Exchange Rates and Capital Flows in Multi-Country Macroeconomic Models

Prepared by Paul R. Masson*

Authorized for Distribution by Malcolm Knight

April 23, 1987

Abstract

The paper surveys exchange rate models, but in a way that differs from existing surveys because it focusses on alternatives available for inclusion in structural multi-country models. It emphasizes that non-structural time-series models or reduced forms are not useful in this context: what is needed are structural models that are theoretically consistent with the rest of the model, whether or not they outperform a random walk. Alternative exchange rate and capital flow specifications that are both tractable and satisfy world adding-up constraints are proposed, and the modeling of expectations is discussed.

JEL Classification Numbers: 2120, 4314

* An earlier version of this paper was prepared for presentation at the Economic Planning Agency, Tokyo, Japan in November 1986. I am grateful for comments by James Boughton, Richard Haas, Peter Isard, Warwick McKibbin, and by participants in a seminar at the Economic Research Institute of the EPA. I would also like to thank members of the model group of the EPA, and particularly Naohiro Yashiro, for their kind hospitality. The views expressed here are my own and do not represent those of the International Monetary Fund or the Economic Planning Agency.

Contents

I. Introduction

After an outpouring of research into exchange rate determination that was the natural consequence of a movement to generalized floating in 1973, there has been a tapering off in recent years as the initial hopes of adequately explaining fluctuations have not materialized. The first models concentrated on the relationship between the demand and supply of money and the nominal exchange rate, which was viewed as the relative price of national moneys (to use the catchy expression of Mussa (1976)). As the assumptions of these models were seen to be unduly restrictive, more general portfolio balance models were tried. Subsequent work focussed on expectations formation, and attempts to test for the existence of systematic risk premiums. In the 1980s, the persistent appreciation of the dollar caused researchers to look both at short-run speculative forces, whether due to "safe havens" or "speculative bubbles", and at the long-term determinants of real exchange rates, including national productivity levels and the stance of fiscal policy.

None of these models has proved to be robust. To quote Frenkel and Mussa (1985, p. 740), "... at the present stage the empirical evidence taken as a whole suggests the lack of a satisfactory structural model accounting for exchange rate behavior." Tests of forecasting performance have, in the main, concluded that model forecasts were dominated by the naive forecast of no change in the nominal exchange rate, that is, a random walk model (see Meese and Rogoff (1983a, 1983b, 1985), qualified somewhat by Boughton (1986)). These results are certainly consistent with the observation that exchange rates are essentially unpredictable: Isard (1980) decomposed exchange rate movements using an accounting identity framework, suggesting that most exchange rate movements resulted from "unexplained factors". Mussa (1979) similarly argued that 90 percent of exchange rate movements were unexpected. The lack of forecasting power of models is compounded by the failure of most models to explain variations ex post of exchange rates, that is, to explain the past: over different subperiods the models typically exhibit instability of coefficient estimates and low explanatory power.

What do these negative results imply for the incorporation of exchange rate determination blocks into large-scale, multi-country econometric models? Clearly it is not possible to throw up one's hands in dispair, and to ignore exchange rate models completely. Exchange rate movements are an essential transmission mechanism for shocks and for policy changes. For users of simulations of these models, it is important to have some confidence in the linkages through exchange markets. Furthermore, structural models cannot simply incorporate a random-walk model of the exchange rate; this amounts to cutting out of the model any exchange rate linkages. Therefore, the appropriate strategy must be to continue research into structural exchange rate models, and in the meantime to incorporate into the large model the exchange rate determination process that is most sensible on theoretical grounds, and on the basis of what limited empirical criteria we have for distinguishing between models, even if it does not have strong empirical support.

Consequently, this paper attempts to evaluate existing exchange rate models, mainly on the basis of how theoretically satisfactory they are, but also with an eye to their empirical performance. It has to be stressed that choices between alternative exchange rate blocks for inclusion in macroeconomic models have to be made in the context of their appropriateness for the overall structure of the model. They have to make sense when the whole model is simulated.

An implication of this is that a number of models are not of interest, because they are really semi-reduced forms that implicitly embody relationships that overlap with--but are not identical in specification to--equations that are already present in the larger model. An example is the monetary model, for which the coefficients embody estimates of money demand elasticities; typically, money demand equations will also appear separately in a large macro model, and if the monetary model is put into the model, the two sets of money demand estimates are unlikely to be the same. For this reason, some of the tests of explanatory power of these models are not relevant to the choice of what exchange rate relationships to include in the model. The fact that some of the building blocks that are already in the model do not perform well--for instance, if money demand is unstable--may therefore not be a reason for thinking that exchange rate linkages are an additional cause of uncertainty about model results, despite the poor performance of monetary models. The way exchange rates and capital flows are to appear in the model is a strategic choice, and one that should give a large weight to the internal consistency of the overall model.

The paper begins by describing the main alternative classes of models, sketching their theoretical rationale and empirical content. The appropriateness of each class for a multi-country model is discussed. Section III treats several questions concerning the internal consistency of exchange rate and capital flow blocks in multi-country models. Section IV then deals with an issue that is relevant for any exchange rate model, namely the modelling of expectations. An approach that allows rational expectations--or at least expectations that are roughly consistent with the model's solution path--to be implemented simply in large-scale models is presented. Section V then considers practical questions concerning the use of models with floating exchange rates and rational expectations in simulation and forecasting. The final section gives an assessment of the state of exchange rate modeling and suggests some directions where further work may be fruitful.

II. Alternative Models

There is now an abundant literature on exchange rate models, and there are a number of surveys that give discussions of their theoretical underpinnings as well as comparisons of their explanatory power (see for instance, Kohlhagen (1978), Isard (1978), Amano (1983), Meese and Rogoff (1983a, 1983b, 1985), Krueger (1983), Backus (1984), Branson and Henderson (1985), Frenkel and Mussa (1985), Levich (1985), and Boughton (1986b)). Therefore, this paper will not attempt to provide another such survey, but merely comment on the main alternatives for a large, multi-country model. The main alternatives considered here are variants of three main groups: monetary models, portfolio balance (stock) models, and balance of payments (flow) models.

1. Monetary models

The monetary model uses the assumption of equilibrium between the demand and supply of money in each country, and relationships linking price levels and interest rates of different countries, to derive a simple semi-reduced form for the exchange rate (see Frenkel (1976), Bilson (1979)). In its simplest form, it assumes that purchasing power parity (PPP) holds period-by-period, so that the domestic price level equals the foreign price level multiplied by the exchange rate; furthermore, parameters in the demand-for-money functions of the two countries (a world of only two countries being considered) are assumed to be identical. This allows the exchange rate equation to be written

$$e = (m-m^*) - a(y-y^*) + b(i-i^*) \qquad (1)$$

where e, m, and y are the logarithms of the exchange rate, money supply, and real income, respectively, i is the interest rate, and the foreign country variables are indicated by an asterisk.

Extensions to this simple formulation have involved allowing for short-run deviations from PPP, and introducing interest-rate parity (UIP) in such a way that expected exchange rates are taken into account. Uncovered interest parity requires that nominal interest rates i and i* differ by the expected change in the exchange rate, x, that is,

$$i = i^* + x \qquad (2)$$

If furthermore expected exchange rate changes are equal to actual inflation rate differentials, so

$$x = Dp - Dp^* \qquad (3)$$

where D is the differential operator, then we can express the interest differential in (1) in terms of differences in inflation rates, so

$$e = (m-m^*) - a(y-y^*) + b(Dp-Dp^*) \quad (4)$$

Such a formulation is less open to the objection that interest rates are likely to be correlated with the error term of (1).

If prices are sticky, then PPP does not hold continuously, and price levels adjust with a lag to their equilibrium levels. In such a model, the exchange rate may exhibit a dynamic adjustment which involves overshooting, as in Dornbusch (1976), since financial prices (interest rates and exchange rates) are flexible in the short run while goods prices are not. Long-run price levels will however be consistent with equality between money supplies and long-run demands for money, the latter depending on equilibrium real interest rates and inflation rates that equal money growth rates (provided real income growth is zero). Frankel (1979) assumes that the real exchange rate moves gradually to its long-run equilibrium (PPP) level according to a first order error-correction process with speed of adjustment c, and that expectations are formed on this basis. With the same assumptions as above, namely uncovered interest parity and identical money demand parameters, an exchange rate equation can be derived that includes both interest differentials and inflation differentials:

$$e = (m-m^*) - a(y-y^*) - (1/c)(i-i^*) + (1/c+b)(Dp-Dp^*) \quad (5)$$

where m, m*, y, and y* are now long-run equilibrium values.

Variants of the monetary models described above have not been very successful, except in periods when monetary shocks were large, for instance during the German hyperinflation in the 1920's (Frenkel and Mussa (1985)). A recent article by Boughton (1986a) has tried to untangle the causes for lack of success of these models. He considers separately five hypotheses that are fundamental to monetary models: they require that 1) purchasing power parity "holds over some relevant time horizon", 2) uncovered interest parity holds continuously, 3) the demand for real money balances is a stable function of a small set of variables, 4) the supply of money is stable, and 5) "expectations are in some sense rational" (Boughton 1986a, p. 3). He concludes from his survey of empirical evidence that there are problems with all five hypotheses, but especially with purchasing power parity. There is now a wide consensus that deviations from purchasing power parity are large and persistent, and that the equilibrium real exchange rate need not be invariant across steady states (see Isard (1977) and papers in the May 1978 issue of the Journal of International Economics).

Tests of uncovered interest parity are more mixed, in part because of the lack of direct evidence concerning exchange rate expectations. Therefore, tests typically involve a joint hypothesis concerning UIP and the rationality of exchange rate expectations. Cumby and Obstfeld (1984) conclude that tests are not favorable to the UIP hypothesis, but that this rejection has to be qualified by uncertainties concerning expectations formation. Use of survey data in principle can help provide evidence of expectations formation; Frankel and Froot (1986) find that expectations errors are large and also seem to be systematic. They calculate exchange risk premiums implied by the expected exchange rates contained in the survey: the risk premiums are so large that they would seem to be inconsistent with UIP.

As for the stability of money demand, Boughton (1986a) argues that this hypothesis has fared rather better, but that exchange rate models have misspecified those functions or not made them sufficiently general. He argues that choosing the proper aggregate is important, and that broader aggregates are likely to be more stable than narrower ones. He contends that the demand functions implicit in monetary models of the exchange rate are not sufficiently general because they typically only include income, the price level, and nominal interest rates, and do not allow for general lag patterns. In addition, the constraint that parameters are equal for different countries is unlikely to be valid. As for money supply, Boughton argues that the typical assumptions of monetary models, that the stock of money is exogenous, is not justified, except for perhaps the Federal Republic of Germany and Japan (Boughton (1986a, p. 13)). He prefers to see more fully-specified financial models where a reaction function describes the behavior of the money supply.

The fifth hypothesis, concerning the rationality of expectations, is more difficult to confront directly. The survey evidence of Frankel and Froot (1986), cited above, does throw doubt on its validity. Boughton also questions the use of expectations mechanisms that assume a steady return to a constant PPP level. Another paper, Boughton (1984), argues that market participants may have no firm view of where the real exchange rate should go; hence it may be reasonable to assume static expectations for the real exchange rate.

How serious are these criticisms of the monetary model, and which of them are relevant to the implementation of such a model in a large, multi-country macro model? Empirical tests of the monetary model have typically had as goal a single equation, whose goodness of fit and stability could be used to evaluate the explanatory power of the theory; those tests therefore derived reduced-form equations. In contrast, what is needed for a large macro model is a structural equation describing exchange market behavior. It would of course be possible to include a (semi) reduced-form exchange rate equation in a structural model, but there would seem to be little rationale for doing so, unless one ensured that the structural equations behind it that overlapped with those already in the larger model were consistent with them. The question therefore arises as to what are the essential <u>structural</u> foundations of the monetary model.

Two of Boughton's concerns, the modelling of money demand and money supply, are easily taken into account by the multi-country model, provided it is a disaggregated structural model. Such a model would likely have a fully-developed financial sector; considerations relative to the choice of the proper aggregate and the modeling of reaction functions can in principle be resolved. The need to estimate a single exchange rate equation with relatively few explanatory variables in order to conserve degrees of freedom and to minimize collinearity was the reason for the restrictive assumptions made in most empirical monetary models. These considerations do not apply to the same extent to structural models. In any case, if one wants to test the explanatory power of the monetary model, one can estimate a small simultaneous system using full-information methods rather than estimating a reduced form. What remains of importance for a large-model implementation of the monetary approach is the stability of the money demand and supply process; but this hypothesis is already made in modelling the domestic financial sector.

Though rejection of the hypothesis of rationality of expectations may cause problems for the logical consistency of the model, it is no more fundamental to the monetary model than it is to other exchange rate models. What Boughton is in fact concerned with is expectations hypotheses that rely on PPP, either in the short run or in the long run: "expectations functions that are based on the notion that market participants have a view as to the PPP level of the exchange rate (and, implicitly, that they are willing to act on that view) also have some difficulty being reconciled with the empirical realities of the floating-rate period" (Boughton (1986a, p. 13)). It is clear that PPP itself, and expectations processes that depend on it, are rejected by the data. Other models of expectations formation will be considered in more detail below, in Section IV.

The remaining two hypotheses, uncovered interest parity and long-run purchasing power parity, are more fundamental. They permit the model to explain exchange rate fluctuations in terms of essentially monetary phenomena. If, on the contrary, long-run deviations from PPP are substantial, and they are systematically related to other variables, then the character of the model is fundamentally changed. The large and persistent real exchange rate movements in the 1980s suggest, for instance, that the term "fiscal model of the the exchange rate" may have some claim as well (for a model that has some success in explaining those movements in terms of fiscal policy shifts in the United States, Germany and Japan, see Masson and Knight (1986)). As for interest parity, if there is a risk premium which varies systematically, and in a substantial way, it may no longer be the case that monetary factors are dominant in exchange rate determination. Portfolio balance models, which endogenize the risk premium as a function of relative asset supplies, are considered below.

There is a distinction between the relevance of PPP and UIP in large multi-country models, however. PPP is less a theory of exchange rates than the result of the complex determination of national price levels. Unlike the law of one price, which may apply to individual goods across various markets and which has the force of an arbitrage condition which holds if certain frictions, i.e., transactions and transportation costs, are small, and if sufficient information is available, PPP is a macroeconomic relationship which depends on the dominance of monetary shocks relative to real disturbances. In a general equilibrium model, the long-run values of real variables may in principle be functions of exogenous variables; in general, therefore, there is no reason to expect that two steady-state equilibria would have the same real exchange rate. Furthermore, whether they are the same or not may depend as much on consumption behavior and the technology of aggregate supply than on the structure of exchange markets.

Uncovered interest parity, on the other hand, is closer to the essence of the exchange market because it is an arbitrage condition between financial assets denominated in different currencies. Typically, it is used to relate two short-term interest rates that directly reflect the monetary policy stance of the respective central banks. It is not in itself a theory of the exchange rate because it only relates expected <u>changes</u> in the exchange rate to interest differentials; it is consistent with any equilibrium <u>level</u> of the exchange rate, which itself is affected by the structure of the entire model. However, the monetary model supposes that those influences work their way through to the exchange market only through demands and supplies of money. Modeling exchange rates in large macroeconomic models involves a fundamental choice concerning the degree of substitutability between domestic and foreign assets, and the limiting case of perfect substitutability gives UIP. Nevertheless, imposing UIP is neither necessary nor sufficient to obtain that the exchange rate is determined solely by monetary phenomena in the long run.

2. Portfolio balance models

Portfolio balance models of exchange rate determination arose because of a number of features of monetary models that were considered unsatisfactory. First, it was felt that a concentration on monetary factors to the exclusion of real factors (except as they affected, in a transitory way, the demand for money), was unrealistic. In particular, it was felt that a current account deficit position should have some independent role in causing exchange rate depreciation, and exchange market intervention should have the opposite effect. Second, it was recognized that valuation effects would result from exchange rate movements to the extent that residents of a country held claims on non-residents in a foreign currency. The portfolio balance model accounts for the effects of exchange rate changes on the value of national wealth in domestic currency.

Finally, uncovered interest parity was seen as being too restrictive, and the Brainard-Tobin (1968) model in which assets can be imperfect substitutes had a natural generalization to the open economy.

Considering each of these rationales in turn, it is not the case that UIP necessarily rules out real determinants of exchange rates. Instead, as has been suggested above, it was the way early monetary models specified price determination that caused real variables to have no effect. A more general model of the supply and demand for goods could also provide a vehicle for balance of payments variables to affect exchange rates. If consumption depends on wealth, then the transfer of wealth through current account surpluses and deficits will affect equilibrium exchange rates even if UIP holds. Second, though valuation effects are potentially important, it turned out that getting data on the currency of denomination of the relevant stocks was a substantial complication for the empirical implementation of the model. Furthermore, it is possible that an accounting exchange rate that is different from the latest actual market value may be used to value foreign assets and liabilities. Finally, though uncovered interest parity may not hold, it is not necessarily the case that deviations from interest parity are explained by relative asset supplies in a systematic way. It could be the case, for instance, that portfolio preferences shift in an unpredictable way, or that assets are perfectly substitutable at a given risk premium (so that relative asset stocks do not matter), but that the risk premium depends on other factors, such as safe haven effects and political risk (Dooley and Isard (1986)).

Despite these considerations, the portfolio balance model serves as a useful conceptual framework, because it provides a simple way of linking a general short-run financial model with a longer-run equilibrium that reflects goods market developments. A simple version of this model for a small open economy is given in Branson, Halttunen and Masson (1977):

$$M = m(i,\ i^{*}+x)W \tag{6}$$

$$B = b(i,\ i^{*}+x)W \tag{7}$$

$$eF = f(i,\ i^{*}+x)W \tag{8}$$

$$W = M + B + eF \tag{9}$$

where here e is the level, not the logarithm, of the exchange rate, x its expected rate of change, M and B are the domestic money and bond stocks (assumed held solely by domestic residents), F is net claims on foreigners (assumed denominated in foreign currency), W is net domestic wealth, and i and i^* are domestic and foreign interest rates. Equations (6) and (7) can be solved for the domestic interest rate as a function of the return on foreign assets and the money/bond ratio (Dornbusch (1980)):

$$i = g(i^* + x, M/B) \quad (10)$$

Furthermore, from (8),(9) and (10), we can solve for eF:

$$eF = f(i, i^*+x)/[1 - f(i, i^*+x)] = h(i^*+x, M, B) \quad (11)$$

where the function h depends on f and g, and the partial derivatives of h are $h_1 > 0$, $h_2 > 0$, but h_3 can have either sign. The long-run factors come into play when a dynamic equation is added to explain the change in F, which is just the current account balance. The trade balance is assumed to depend on the real exchange rate and real absorption A, and investment income is equal to the current stock of net claims multiplied by the foreign interest rate:

$$DF = T(eP^*/P, A) + r^*F \quad (12)$$

Over time, a current account surplus will add to the stock of net foreign claims, and, from equation (11), lead ceteris paribus to an appreciation of the exchange rate. However, the exchange rate itself will feed back onto the trade balance, tending to reduce the current account surplus. In long-run equilibrium the stock of net claims on foreigners and the exchange rate must be such that both financial equilibrium and goods market equilibrium prevail.

The model of (11) and (12) is not in fact closed, as price levels are not explained. Furthermore, it ignores an important linkage, of wealth onto domestic absorption and hence onto the current account. The stability of the adjustment process of a model with such wealth effects is discussed in Masson (1981), where, however, the effect of the real exchange rate on trade flows is ignored. There, instead of (12), the current account equation takes the form

$$DF = T(W/e) + r^*F \quad (13)$$

The interesting possibility is raised that valuation effects may lead to instability in the adjustment process if the home country, instead of being a net creditor in foreign currency ($F > 0$), is a net debtor ($F < 0$).

The portfolio balance model, as specified above, embodies some quite stringent restrictions. For instance, the elasticity of the exchange rate to the net foreign asset position is minus one; if net claims were not all denominated in foreign currency, then this restriction would be loosened. In early empirical applications of the model, not all the restrictions were in fact imposed; instead, typically a semi-reduced equation of the form

$$e = e(M, B, F, r^*) \quad \text{or} \quad e = e(M, B, F, M^*, B^*, F^*)$$

was estimated; since the two countries do not constitute the whole world, F and F* are not equal, and can be included as separate regressors. Initial tests (Branson, Halttunen and Masson (1977, 1979)) seemed promising, but later results (Martin and Masson (1979), Backus (1984), among others) indicated that coefficients could be unstable and also threw some doubt on the significance of net claims positions in explaining exchange rates. The reduced-form estimation approach made it difficult to disentangle the effects of the various assumptions that were made, as was the case for tests of the monetary model.

Later empirical testing of the portfolio balance model came to be focussed on a key question, namely whether the relative supplies of domestic and foreign assets affect the relationship between expected returns on those assets. Suppose that we write equation (8) in linear form as follows:

$$eF/W = f_1 i + f_2(i^*+x) \tag{14}$$

where $f_1 < 0$ and $f_2 > 0$, and we assume that B and F are perfect substitutes, so $|f_1|$ and $|f_2|$ go to infinity. In this case, from (14),

$$i = i^* + x,$$

which is just our uncovered interest parity condition. Tests of the portfolio balance model have taken UIP as the null hypothesis, and have tested it against the alternative hypothesis

$$i - i^* - x = j(F, B, \ldots) \tag{15}$$

The risk premium is captured by the function j, which depends on asset supplies if the portfolio balance model is correct, and if assets are not perfect substitutes.

It should be noted that formulation (15) is not a completely general representation of the model, since it assumes that $|f_1| = |f_2|$. We know that the partial derivatives of the demand equations in (6)-(8) must sum to zero across the whole portfolio, i.e.

$$m_1 + b_1 + f_1 = 0 \tag{16}$$

$$m_2 + b_2 + f_2 = 0 \tag{17}$$

Typically it is assumed that money demand responds negatively to both interest rates; furthermore, it is reasonable to assume that the cross responses of domestic and foreign bond demands are equal, so $f_1 = b_2$. If this is so then $f_2 > - f_1$ and the restrictions embodied in (15) are not valid.

It should also be noted that the discussion so far has focussed on currency risk; another source of risk will be country risk (Dooley and Isard (1980)). These two sorts of risk are often confused in empirical models, because of the difficulty in obtaining data on the stocks of assets classified both by the country of the issuer and by currency denomination.

There have been a number of tests using equations of the form of (15). Frankel (1982a, 1982b) and Rogoff (1984) use data since 1973 for various bilateral exchange rates of G-5 countries. In no cases were their results supportive of the hypothesis that the differential in returns on domestic and foreign assets depends on the stocks of assets in the relevant currencies, on relative wealth stocks, or on cumulated current account positions. A further body of work was carried out under the auspices of the Working Group on Exchange Market Intervention, which was established at the Versailles G-7 summit in June 1982 to contribute to an understanding of the effects of intervention. For sterilized intervention to be effective--over and above any influence it may have on exchange rate expectations, for instance by signalling the intentions of the authorities to use other instruments--there must be some influence of asset stocks on relative returns to domestic and foreign assets. Since sterilized intervention is essentially a swap of domestic bonds for foreign bonds, leaving both money supplies unchanged, effectiveness of intervention requires less than perfect substitutability between domestic and foreign bonds.

In one of the studies produced for the Working Group--Danker, Haas et. al. (1985)--the degree of substitutability was tested in two ways: by directly estimating bond demand equations as functions of rate of return differentials between domestic and foreign-currency-denominated assets, and by estimating an equation like (15). In a bond-demand equation, the coefficient of the rate of return differential measures the degree of substitutability; however, in the limiting case of perfect substitutability, the coefficient tends to infinity, and the bond demand equation breaks down. In this case, an equation of the form of (15) is appropriate instead, and a test of the significance of the arguments of the function j should reject the hypothesis of a systematic risk premium. The two forms were estimated using data for Canada, the Federal Republic of Germany, and Japan, and their bilateral exchange rates against the U.S. dollar. Results quoted in Danker, Haas, et. al. (1985) indicate that for two of the countries, Canada and Germany, the joint hypothesis of perfect substitutability could be rejected, while for Japan it could not. Furthermore, in the Canadian case, there was no evidence that the portfolio balance model, as captured by (15), had any support. Only for Germany did there seem to be a significant correlation between the exchange risk premium and the supply of real bonds.

Another recent study, Holtham (1984), did have some success in estimating a multi-country version of a portfolio balance model that imposes various strong restrictions on the form of asset demands. This international financial block has been incorporated into the OECD's INTERLINK model, which contains models for 23 industrial countries and 8 non-OECD regions. The exchange rate model is used for 17 of the industrial countries. The form of the equation for the expected change in the log of each country j's effective exchange rate $E(Deff_j)$ is as follows:

$$E(Deff_j) = a_j + b(i_j - i_j^*) + c_j F_j / V \quad (18)$$

where F_j is country j's cumulated current account, V is a proxy for world wealth, where b is the same for all countries. There are also restrictions on the coefficients a_j and c_j which will be discussed more fully below, in section III. When estimated over a subset of OECD countries, using semi-annual data from 1973 to 1981 and an instrumental variables procedure for the rationally-expected exchange rate in the following period (needed for E(Deffj)), equation (18) yielded estimates for c_j that were only just statistically significant at the 5 percent level. Furthermore, the value of b was estimated to be about unity, as would be expected from UIP.

An evaluation of the portfolio balance model is difficult at this stage. Early estimation results, using as they did reduced-form models, were open to the same difficulties in interpretation as the monetary approach. They embodied over-stringent restrictions on demand functions, and solved out for money market equilibrium, eliminating interest rates from the estimating equation. It subsequently became clearer that the key feature of the portfolio balance model was in explaining deviations from uncovered interest parity in terms of the relative stocks of interest-bearing assets denominated in different currencies. Tests of the model in this form have generally given negative results, possibly because of difficulties in obtaining the appropriate asset stock data. On the other hand, there is also evidence that UIP does not generally hold. Given the plausibility of the portfolio balance model, it seems reasonable to continue to use it as a maintained hypotheses until there is evidence of other general explanations of deviations from UIP. Important work in this area is being pursued by Dooley and Isard (1986).

3. Balance of payments models

Balance of payments models are often associated with an earlier tradition of fixed exchange rates in which capital flows were either not modeled or were modeled as flow equations whose stock consequences were not taken into account. However, the term is used more generally here to refer to models that do not have an explicit exchange rate equation but rather solve for the exchange rate implicitly from the market-clearing condition that current account flows, capital flows and intervention (if present) sum to zero. The importance of providing mechanisms for models to achieve stock equilibrium, and developing the consequences for transmission mechanisms, has been stressed by Branson (see, for instance, Branson (1974)). Balance of payments models can take account of these considerations, and recent contributions have done so, for instance Fair (1979), and Amano (1983).

Balance of payments models also allow for imperfect capital mobility, that is, for a situation where asset markets (and, in particular, markets for international claims) are slow to adjust. Imperfect capital mobility must be distinguished from imperfect asset substitutability, discussed above, which implies that rates of return on different assets will differ even after all adjustment has occurred. All the variants discussed above in the context of monetary and portfolio balance models can be considered as special cases of balance of payments models with perfect capital mobility. Uncovered interest parity corresponds to both perfect asset substitutability and to perfect capital mobility; it could be operationalized in a simulation model by specifying that capital flows respond to interest differentials with a very high elasticity, but do not depend on other variables. Underlying a portfolio balance equation are asset demand equations: the first difference of these equations could serve as the capital flow equations. In addition to these two cases, balance of payments models allow taking into account more complicated dynamic processes, for instance gradual adjustment to desired capital stock positions. If capital flows are less than perfectly mobile, allowing J-curve effects on merchandise trade flows will also influence short-run fluctuations in the exchange rate. The dynamics of exchange rate adjustment to shocks may be quite dependent on the degree of capital mobility (Frenkel and Rodriquez (1982)).

The very flexibility of flow models of the balance of payments may lead modelers to "miss the forest for the trees", however. The attention given to asset market models of exchange rates (see the Scandinavian Journal of Economics, 1976, no. 1 for a range of early articles on the subject) derived from dissatisfaction with ad hoc dynamics and the inadequate modeling of expectations of traditional balance of payments models. Asset market models, whether monetary or portfolio balance, stress that the exchange rate is determined in a speculative market, that is, a market where transactions costs are low and expectations are important, and that it should be considered an asset price. Like other asset prices, for instance stock prices, it can exhibit discrete jumps in response to new information, and even in the absence of trading, as all market participants revise their expectations. In such circumstances, the flows through the exchange market may be essentially irrelevant to interpreting exchange rate movements. Instead, one should model the asset price directly, as a function of new information, including possibly information on asset supplies.

A corollary to this argument is that capital flows may be very large at times, and also very erratic. It may therefore be extremely difficult to estimate capital flow equations with sensible properties. For instance, as was mentioned above, in the case of perfect asset substitutability the stock demand for foreign bonds equation breaks down. The same applies to a capital flow equation when capital mobility is infinite. Econometric results seem to indicate, furthermore, that the estimate of the degree of capital mobility that results from capital flow equations is much lower than estimates where the exchange rate (or a rate of return differential) is the dependent variable (see, for instance, a comparison of results for the two specifications in Holtham (1984)). There is independent evidence that capital mobility is quite high among the group of major industrial countries that do not have capital controls, which now includes most of the G-7 countries. Moreover, the degree of capital mobility is undoubtedly higher now that it was in the earlier years of generalized floating: since 1979, both the United Kingdom and Japan have reduced restrictions on external transactions, and more recently there has been an explosion of new financial instruments permitting investors to take positions in different currencies.

Nevertheless, balance of payments models with fleshed-out trade and capital flow determination have some clear advantages over reduced-form models. They allow both goods market and asset market effects on exchange rates, in a conceptually similar way to the portfolio balance model but with much more flexibility in specification. They permit differences in regimes across countries, including pure float, managed float, and pegging to a single currency or a basket of currencies. Moreover, they allow margins of fluctuations around parities, and can account for different intervention strategies in a flexible way.

III. Issues in Ensuring Internal Consistency in Multi-Country Models

World models that are closed, and account for all countries' balances of payments and exchange rates, face restrictions across countries that must be considered in modeling international linkages. It is clear conceptually that trade and service flows should sum to zero, as an export of one country corresponds to an import of another. Similarly, a capital flow entry, if consistently measured, should show up in an offsetting way in two countries, and correspondingly, the net claims positions of countries on foreigners must also sum to zero. Though there are measurement problems that make these identities not hold in published data--for instance, the world current account discrepancy is currently between $50 and $100 billion--this fact should not lead to ignoring the logical restrictions implied by treating the world as a closed economy. The model should produce the result that marginal changes in those balance of payments variables, for a given change in an exogenous variable, sum to zero, even if their baseline levels require adjustment to make them add up.

In models of a single economy, there is an extensive literature that considers the implications of adding-up constraints on demand functions. Brainard and Tobin (1968) show that if all asset demand functions are to take the same form, then the fact that asset demands sum to total wealth implies that there are adding-up constraints on various coefficients. There are similar restrictions for multi-country models. Armington (1969) and Hickman and Lau (1973) propose different functional forms for goods demands that give sensible results while satisfying the world adding up constraint. Samuelson (1973) decomposes the determination of trade flows into two stages: first total imports into each market are determined, and then that market is divided up into exports from each country to that market, on the basis of endogenous trade shares. The fact that trade shares sum to unity ensures the satisfaction of the world adding up constraint that the sum of imports equals the sum of exports.

The implications of adding-up constraints on asset demand equations in a global economy have received less attention, probably because the asset market models that have been estimated have typically considered only a pair of countries or have not been closed, so that some country's portfolio is residually determined (for an early multi-country portfolio balance model, see Martin and Masson (1979)). In the monetary model, if UIP and PPP hold bilaterally then they also hold for any arbitrarily weighted average ranging across countries. Since no behavioral parameters are involved, there is no question of consistency between the model and the adding up constraints, provided that weights used sum to unity.

In considering consistency in portfolio balance and balance of payments models, a useful starting point is the OECD's INTERLINK model. Assume a world of n countries, with each country's government issuing bonds in its own currency, but residents of each country holding claims on all governments, including their own (the INTERLINK model also allows for claims of each country on the private sectors of other countries--see Holtham (1984)). Let B_{ij} be claims of residents of i on country j, W_i the wealth of country i, and F_i its net claims on foreigners, all of which expressed in a common numeraire currency. We postulate that asset demands, as ratios to a country's wealth, are linear in expected returns r_k, where $r_k = i_k + x_k$ includes both interest and the expected change in the value of currency k relative to the numeraire. We can also express each country i's wealth as a proportion s_i, which is assumed not to depend endogenously on the exchange rate, of world wealth V. Valuation effects are thus ignored here, as is money as a component of wealth; the model is therefore not a completely general portfolio balance model. The demand for claims of i on j can be written as follows:

$$B_{ij} = [a_{ij}+\sum_k(b_{ijk}r_k)]W_i \qquad (19)$$

Since $\sum_j(B_{ij}) = W_i$ (20)

it follows that the following restrictions apply to the coefficients of (19):

$$\sum_j(a_{ij}) = 1 \quad \text{and} \quad \sum_j(b_{ijk}) = 0, \text{ for all } k \qquad (21)$$

In practice, it is very difficult to get reliable data for bilateral claims positions. Furthermore, if the model included 10 countries, for instance, it would have to account for 45 bilateral positions. Where data exist, they are very difficult to interpret, since, for instance, the residence of the holder of a portfolio managed by a bank or investment company may be very hard to determine. Therefore, we want to be able to aggregate to an equation for the country's overall net claim position. The overall position F_i can be derived from (19):

$$F_i = \sum_j(a_{ij}W_i - a_{ji}W_j) + \sum_k[\sum_j(b_{ijk}W_i - b_{jik}W_j)]r_k \qquad (22)$$

It embodies both country i's demand for foreign assets and other countries' demands for its assets. Expressing (22) alternatively in terms of shares of world wealth, where $W_i = s_iV$,

$$F_i = \sum_j(a_{ij}s_i - a_{ji}s_j)V + \sum_k[\sum_j(b_{ijk}s_i - b_{jik}s_j)]r_kV \qquad (23)$$

It can be seen that both the intercept term in (23) and the coefficients of the interest rates depend on all the countries' demand coefficients, weighted by shares of world wealth.

Under two conditions, equation (23) reduces to a simpler formula in which the coefficient b_{ik} on each interest rate is a constant that does not change over time,

$$F_i = [a_i + \sum_k(b_{ik}r_k)]V \qquad (24)$$

although the intercept a_i may vary over time. These conditions are: 1) the shares of world wealth s_i do not vary over time (in which case a_i is also a constant), or 2) asset preferences are the same in all countries in the sense that all assets are substitutes to the same degree in all portfolios (though there may be different propensities to hold different assets, as measured by the a_{ij}). In this case, for any i and h,

$$b_{ijk} = b_{hjk} \quad \text{for all } j, k \qquad (25)$$

Furthermore, if either of the above conditions is satisfied, net claims can be expressed in terms of the difference between the return r_i on country i's asset and a fixed-weighted average of foreign returns r^*_i, is defined as follows:

$$r^*_i = \sum_k (w_{ik} r_k),$$

where $w_{ik} = -b_{ik}/b_{ii}$ for k not equal to i, and $w_{ii} = 0$. Therefore,

$$F_i = [a_i + b_{ii}(r_i - r^*_i)]V \qquad (26)$$

Since the b_{ik} are negative for i not equal to k, all w_{ik} used in the calculation of r* are positive.

Neither restriction is particularly appealing. Since world wealth V is the sum of all government bonds outstanding, and $W_i = B_i + F_i$, it is not in general possible for the share $s_i = W_i/V$ to be constant, given an arbitrary change in B_i, even if F_i can be written as in equation (24). As for the assumption that asset preferences are the same in all countries, it is more likely that each country's holdings of assets are heavily biased toward those denominated in the home currency. In any case, if asset portfolios are the same, it would be preferable to estimate asset demands for a world portfolio directly, using data for outside asset stocks denominated in each currency, rather than using balance of payments data that mixes assets and liabilities in different currencies. In such a "world portfolio model", demands for the liabilities of each country i (assumed denominated in currency i) might take the form

$$B_i = [a_i + \sum_j b_{ij} r_j]V \qquad (27)$$

and the only restrictions required for global consistency would be the natural adding-up constraints for the global portfolio, namely

$$\sum_i a_i = 1 \quad \text{and} \quad \sum_i b_{ij} = 0 \text{ for all j.}$$

It is a specification like (26) that is used in the INTERLINK model. There is an interesting consequence of using such a specification for the appropriate definition in this model of effective exchange rates. We can express (r-r*) as the sum of an interest differential (i-i*) and the expected change in the log of the effective exchange rate, E(Deff):

$$r_i - r^*_i = i_i - i^*_i + E(Deff_i) \qquad (28)$$

where the log of the effective exchange rate is defined as

$$eff_i = e_i - \sum_j (w_{ij} e_j) \qquad (29a)$$

and the foreign interest rate as

$$i^*_i = \sum_j (w_{ij} i_j) \tag{29b}$$

Both interest rates and exchange rates are to be weighted in the same way for the purposes of modeling the capital account, and the weights are functions of the asset demand parameters and of shares of world wealth. Thus there is no direct relationship between the proportion of outstanding assets accounted for by assets denominated in a particular currency and the weights that are appropriate here for calculating effective exchange rates.

However, this result is specific to a model in this form--where asset demands as proportions of wealth are linear in rates of return. Other functional forms might imply that relative asset supplies entered into the weighting matrix. It is also true that the effective exchange rate relevant for financial transactions need not be the same as the one relevant for trade flows; for the latter variable, trade shares and trade elasticities will be important determinants. A properly-specified multi-country model would allow translation from one definition of effective exchange rates to the other, since, given the value of a mumeraire currency, the (n-1) independent effective exchange rates imply (n-1) bilateral exchange rates, which can be reweighted in any way desired.

The above example illustrates two important points: 1) the implications of global adding up constraints for the consistency of the model depend very much on the underlying behavioral hypotheses, in this case the form of demand functions; and 2) the restrictions that are needed for all asset demands to take the same form may be quite stringent, which was the case above even though the model was an extremely simple version of the portfolio balance model.

The stringency of the restrictions on the asset demands in the INTERLINK model is largely due to the desire to work with <u>net</u> asset stocks and to reduce the model to a single exchange rate equation for each country. An alternative strategy open to balance of payments models is to model ex ante <u>capital outflows</u> as representing the portfolio preferences of the country acquiring the assets, but to model <u>capital inflows</u> by the financing needs of the country issuing the bonds. A country's financing needs result from the excess of a country's investment, plus desired acquisition of foreign claims, over domestic saving:

$$\Delta L_i = I_i - S_i + \Delta A_i \tag{30}$$

Now, using time series for total claims on foreigners, desired asset accumulation (in the numeraire currency) could be taken to be a function of interest rates and national wealth,

$$A_i = f_i(r_1, \ldots, r_n, W_i/e_i) \tag{31}$$

Furthermore, a matrix of weights (possibly endogenous) could be used to allocate total claims on foreigners among the various countries:

$$A_{ij} = w_{ij}A_i \tag{32}$$

The balance of payments clearing condition would then require that a country's financing needs were satisfied by other countries' desired acquisition of claims, that is

$$\Delta L_i = \sum_j A_{ji} = \sum_j w_{ji}A_j \tag{33}$$

Exchange rates would move to clear n-1 countries' balances of payments, as given by (33): excess financing needs would lead to a depreciation of the currency, and through adjustment of expected rates of return and valuation effects, would induce the needed net inflow.

The increased flexibility of the balance of payments model here, and use of <u>gross</u> capital flows or stocks, allow a more sensible model to be specified. It is no longer necessary to require asset supplies to reflect exactly the same portfolio preferences as asset demands, and to impose further assumptions in order to remove the effects of wealth shares from the estimated equations. Gross claims equations can reflect the stock of national wealth, as they should, and the functional form can differ from country to country (for instance, in some cases it may reflect a lagged adjustment to a desired stock). Global consistency is ensured by the fact that the matrix $[w_{ij}]$ which allocates a country's total claims among individual countries has rows that sum to one, and by exchange rate movements that make capital inflows (plus official sales of foreign exchange, if any) equal to the current account deficit plus gross capital outflows.

The above formulation describes a world in which all exchange rates are floating and countries face perfect capital markets. It may be appropriate to treat some countries or regions differently. For instance, the above framework would allow the treatment of developing countries as facing a financing constraint, so that an excess of financing needs over available capital inflows would bring about an adjustment of their imports (or a loss of reserves, if $\Delta A_i<0$):

$$M_i + \Delta A_i = X_i + \Delta L_i \tag{34}$$

This example thus illustrates the greater flexibility of balance of payments models, and their greater ease in satisfying global consistency conditions.

IV. Modeling Expectations

A number of alternative assumptions concerning expectations have been used in empirical exchange rate models. Early models used adaptive or static expectations, while more recent work has used as its null hypothesis the assumption of rationality, that is, the efficient use of available information. For the purposes of constructing an exchange rate/balance of payments block in a large multi-country model, it is important to distinguish between the way expectations are modeled in estimation and in simulation. In estimation, the goal is to obtain values of underlying parameters that are unbiased and have other desirable statistical properties. It is possible that this may be achieved through survey data or proxies for expectations; instrumental variables may also help solve econometric problems. In simulation, however, the model has to be closed, and a good deal of structure on the exchange rate model per se will be brought in through the way expectations link exchange rates with other parts of the model.

Mechanistic backward-looking expectations are unlikely to be satisfactory either in estimation or in simulation, though they may be defended for unconditional forecasting. The main alternatives under this heading are error-correction mechanisms of first or higher order (Hendry and Richard (1983)), including adaptive expectations as a special case, and vector autoregressions (Sargent(1979a)). The latter, because they contain no exogenous variables and impose no restrictions, are a useful benchmark in forecasting. The former have been defended in some cases as being rational. For instance, in the Dornbusch (1976) model, the real exchange rate converges smoothly to its long-run equilibrium level; Frankel (1979) assumes that expectations are formed on this basis. In more complicated models, it is impossible to characterize the dynamic adjustment path of the exchange rate in such a simple way, however.

In the simulation model itself, it is important to be able to simulate the current effects of future policies, to the extent they are anticipated today. Therefore, backward-looking mechanistic schemes are not satisfactory, nor are expectations surveys or proxies, since they are not endogenous to the model. Thus the assumption of rationality may lead to a different strategy in estimation and in simulation; in estimation, limited information methods such as instrumental variables (see McCallum (1976)) may yield unbiased estimators, but in simulation it is important to implement rationality in a full-information way, so that all the relationships in the model are taken into account (for its use also in estimation, see Sargent (1979b) and Wickens (1982)).

Calculation of fully-rational solutions to large non-linear multi-country models may however be prohibitively expensive, especially since there are likely to be other variables with rational expectations in the model (see, for instance, the discussion in Taylor (1986)). Masson and Richardson (1986) implement an approximately model-consistent version of exchange rate expectations for the U.S. dollar effective rate by constructing a small, linear version of INTERLINK model that collapses it into a two-country model for the United States and an aggregate of the rest of the world. The number of exogenous variables is kept to a minimum, and, as implemented, includes only a single measure of monetary policy and one of fiscal policy, in each of the two economies. However, the dynamics can be as general as necessary to capture adequately the dynamics of the larger model. Because the resulting model is linear, a closed-form forward solution of the model can be written down, in which the exchange rate next period depends on this period's values of all the state variables and on the whole future path of monetary and fiscal policy variables. Given an assumed path for those variables, the equation for the expected exchange rate--assumed equal to next period's rate--can be coded into the model. It permits simulations of expected future changes in those exogenous variables, and it captures as well the effects of the state variables as they are calculated by the larger model, thus providing endogenous linkages to major macroeconomic variables.

There are several advantages to such a procedure, in addition to the saving of computational expense that has already been mentioned. First, it permits expectations to be consistent with a general equilibrium model, rather than depending on arbitrary assumptions about return to PPP. Second, the the small version, or maquette of the large multi-country model, is of interest in itself, because it is a vehicle for understanding the properties of the larger model. Third, it provides structure to an exchange rate model that may be on the face of it seem extremely simple. For instance, it is not the case that uncovered interest parity provides no role for current account surpluses and deficits in the determination of exchange rates : if the current account is a state variable, then it will appear in the dynamic equation for exchange rate expectations, and hence for the exchange rate. To illustrate the last point with an exchange rate and current account model (that assumes that goods prices are fixed), suppose that the net claim position F is described by a discrete time adjustment equation such as

$$F = f(F_{-1}, e) \qquad (35)$$

The model is closed by an interest parity condition,

$$i = i^* + e_{+1} - e \qquad (36)$$

by aggregate demand equations that depend on e and F, as well as the home interest rate,

$$y = y(e, F, i) \quad \text{and} \quad y^* = y^*(e, F, i^*),$$

and by two demand-for-money functions that are renormalized on the interest rates at home and abroad, respectively:

$$i = i(m, y) \quad \text{and} \quad i^* = i^*(m^*, y^*)$$

Then, provided the functions are linear we can derive a solution (see Blanchard and Kahn (1980)) for exchange rate expectations of the form

$$e_{+1} = g(F, \sum_{i=0}^{\infty} (a_i m_{+i}), \sum_{i=0}^{\infty} (b_i m^*_{+i})) \tag{37}$$

where the function g is linear and where the weights a_i and b_i depend on the parameters of the structural model. Under certain assumptions about the exogenous money supplies, for instance that at some point in the future they settle down to constant growth rates, the infinite sums can be collapsed to a small number of terms. In simulation, equation (37) would be added to the model, and would permit implementation of forward-looking expectations.

Methods for reducing large models to compact maquettes are described in Masson (1986). The technique was used in the mid-1970s at the Federal Reserve to construct a smaller version of the MPS model. Deleau, Malgrange and Muet (1984) have also used this technique to study the dynamics and long-run properties of French macroeconomic models. Haas and Masson (1986) present a small two-country model that is mainly derived from simulations of the Federal Reserve's MCM model; that maquette, called MINIMOD, is non-linear, so an analytical expression for exchange rate expectations cannot be derived. However, it can be simulated relatively inexpensively given its small size, and hence has some advantages over its larger parent.

V. Simulation and Forecasting with Models with Rational Exchange Rate Expectations

It was argued above that specifying models with forward-looking exchange rate expectations which are made to be consistent with the model's solution for future periods is a desirable strategy. There is however a special feature of such models that must be taken into account in its use: one must be clear on the time information is made available to agents in the model. The problem arises most acutely if the model is to be used for unconditional forecasting. Since future values of exogenous variables must be specified, then an assumption must be made as to what values are anticipated by the agents are being modeled. It is not impossible, for instance, that policy changes may be planned that have not yet been announced, in which case the users of the model might have a different information set than those outside. 1/

1/ It is also true that if there are regime changes, as opposed to policy shocks within a prevailing regime, then the private sector's behavior may well be modified, in ways that are usually not captured by models. Typically, the private sector might not have full knowledge of how the new regime operated, and a period of learning would occur during which forecasting errors might be systematically biased.

Typically model forecasts are not used uncritically, but rather some judgement is applied to produce constant-term adjustments to various equations. If this is done for a rational expectations model, then it is quite conceivable that one reason why the forecaster's judgement differs from the model results is that his forecast incorporates some uncertainty concerning future paths of exogenous variables. Unless the model embodies some measure of uncertainty in its behavioral equations, therefore, the use of constant-term adjustments may implicitly contradict the assumption that future exogenous variables are correctly anticipated.

Once an unconditional forecast is made, typically the model user wants to look at alternative scenarios that reflect changes to exogenous variables. Here again the question of knowledge of private agents comes up. Does the change to the exogenous variable come as a complete surprise, or was it partially anticipated in the baseline scenario? One assumption is that all contingencies are in fact to some extent allowed for, and that it is not legitimate to perform a simulation where a policy change was previously anticipated but, from the moment the policy change was made, its effects were known with certainty. This suggests that it may be useful to simulate the model with alternative versions for expectations formation. A backward looking, adaptive expectations scheme may be of some value if it takes time for agents to acquire the information about a change in policy or to be convinced that the change is permanent.

VI. Assessment of the Current Status of Exchange Rate Modeling and Directions for Further Research

It is clear that exchange rate modeling has responded only subsequently to events that were perceived to be important. Features were incorporated into models to explain the past, rather than anticipating how the system of floating exchange rates would evolve. The proponents of floating rates in the 1960s and early 1970s emphasized the system's presumed properties of helping countries insulate themselves from external nominal shocks and of permitting a country to run an independent monetary policy and to choose its inflation rate. It is natural that the early exchange rate models concentrated on monetary factors and purchasing power parity. For some countries, especially Italy and the United Kingdom in the 1973-76 period, such models achieved a degree of success, since their inflation rates were considerably above those of their neighbors. However, it became clear that real exchange rates were also fluctuating, and the model of Dornbusch (1976) explained how sticky goods prices might produce such a result in what was still essentially a monetary model.

Another feature that was not expected by the proponents of floating rates, namely large and persistent current account imbalances, inspired work on portfolio balance models, which provided a channel by which balance of payments could affect exchange rates even if they did not have consequences for money stocks. It seemed plausible that a country running current account deficits would be increasing the supply of assets denominated in its own currency, and that this would lead to a decrease in the price of those assets, that is, a depreciation of its exchange rate. The experience of U.S. dollar depreciation in the late 1970s did not support this interpretation, however, as U.S. current account deficits were more than offset by purchases of dollars by foreign central banks.

The experience of the first half of the 1980s also did not support the portfolio balance model: from 1983 onward the United States was running large current account deficits but the U.S. dollar was appreciating almost continuously. This led economists to incorporate other mechanisms into their models, in particular the effects of fiscal policy on a country's saving/investment balance and the existence of "safe havens".

The above discussion suggests that exchange rate modelers have been fighting yesterday's battles. Perhaps as a result, exchange rate movements have been explained with partial equilibrium models where one feature is accented, or if a complete model is specified, it is of an extremely simple form so as to yield a single, easily testable exchange rate equation. In these circumstances, it is not surprising that the changing nature of shocks to which economies have been subject has inevitably led the model that explained yesterday's fluctuations to fail to explain today's. It is important to think of the exchange rate in the context of a general equilibrium model; instead of an "exchange rate model", one has a simultaneous system whose properties reflect a number of relationships, and which contains many endogenous variables, one of which being the exchange rate. Working in such a framework, it is clear that many shocks affect the exchange rate, and also that the long-run equilibrium exchange rate depends on exogenous variables rather than being determined by, for instance, PPP.

It is also perhaps a mistake to be too concerned by lack of success in forecasting exchange rates. It is now commonplace not to expect to be able to forecast stock prices any better than implied by a normal relationship relative to returns on interest-bearing assets. It should not be surprising that exchange rate forecasts are no different, and in particular, that models do not usually outperform the forward premium in forecasting; given small interest differentials for major currencies relative to ex-post exchange rate changes, consistent success in forecasting those ex-post changes would imply very large returns. Arbitrage would surely not allow such extra-normal returns to persist for long.

There are three areas where progress would considerably enhance our understanding of exchange markets: expectations, the effects of structural changes and innovations in financial markets, and the causes of changes in the perceived riskiness of various assets. In the first area, expectations, it has been argued above that the null hypothesis of rational expectations is a natural one to make, and that it should be implemented in large-scale multi-country models. Logical consistency would suggest that in the absence of an explicit model of expectations, the model itself provides the best guess as to what the future will bring. It is unlikely of course that this is an adequate representation of reality, and explicit models of learning behavior are needed. It would be preferable to consider models where agents gradually revise their views about the future on the basis of both observed variables and announcements of future events. Furthermore, the assumption that all agents have the same expectations is unrealistic, and some interesting phenomena require diversity of opinion. It would be interesting to explore the effects of varying degrees of consensus on such things as the thinness of markets and exchange rate volatility.

The second area, structural change and financial innovation, already occupies a good number of researchers. There are a number of questions that are still to be answered, however. One is the effect of the increased ease with which positions in different currencies can be taken or transformed. In recent years, foreign currency options markets have sprung up, interest rate swaps allow maturity transformations outside of the channels of financial intermediation, exchange rate swaps permit a liability in one currency to be transformed into another, and there have been other innovations in international financial markets such as note issuance facilities and revolving underwriting facilities. If the effect of these changes has been to decrease the cost of arbitrage, then it may well be the case that the effects of asset stocks on relative rates of return (if they existed before) have become smaller.

However, increases in the degree of substitutability of assets do not imply shifts in asset preferences that have become less important, for instance relative to changes in merchandise trade competitiveness, in explaining exchange rate movements. However, further work is needed in systematically modeling asset preferences: this is the third area where work is warranted. Shifts in the demand for assets are clearly the main force behind observed exchange rate movements, and it is important to gain a better understanding of why the perceived riskiness of assets changes. To do so, one must work in an intertemporal framework where the current and future actions of governments in taxing and borrowing play important roles. If a government runs a large budget deficit, then it may induce a deterioration of the country's saving-investment position, requiring capital inflows and associated current deficits. If the position of the government is thought to be unsustainable, however, a view must be taken as to an eventual change in policies. Whether that change involves monetization of deficits or fiscal restraint will have quite different implications for the exchange rate. It seems that confidence in the government can shift suddenly, and hence that exchange rates also can move in response. A better understanding of these factors would help us to interpret observed exchange rate behavior, if not to forecast future movements.

References

Amano, Akihiro, "Approaches to Exchange Rate Determination and the Implications of Structural Balance of Payments Approach for International Macroeconomic Interdependence," presented to the First International Conference on Monetary Policy in Our Times, Bank of Japan, Tokyo, June 22-24, 1983.

Armington, Paul S., "A Theory of Demand for Products Distinguished by Place of Production," Staff Papers, International Monetary Fund (Washington), Vol. 26 (1969), pp. 159-78.

Backus, David, "Empirical Models of the Exchange Rate: Separating the Wheat from the Chaff," Canadian Journal of Economics, Vol. 17 (Nov. 1984), pp. 824-46.

Bilson, John F. O., "Rational Expectations and the Exchange Rate," in K. Brunner and A. Meltzer, eds., Policies for Employment, Prices and Exchange Rates, Carnegie-Rochester Conference Series on Public Policy, Vol. 11 (Amsterdam: North Holland, 1979).

Blanchard, Olivier Jean and Charles M. Kahn, "The Solution of Linear Difference Models Under Rational Expectations," Econometrica, Vol. 48 (July 1980), pp. 1305-11.

Boughton, James M., "Exchange Rate Movements and Adjustment in Financial Markets: Quarterly Estimates for Major Currencies," Staff Papers, International Monetary Fund (Washington), Vol. 31 (September 1984), pp. 445-68.

_____ (1986a), "The Monetary Approach to Exchange Rates: What Now Remains?," International Monetary Fund (manuscript, February 1986).

_____ (1986b), "Tests of the Performance of Reduced-Form Exchange Rate Models," forthcoming in Journal of International Economics, (1986).

Brainard, William C. and James Tobin, "Pitfalls in Financial Model Building," American Economic Review, Vol. 58 (May 1968), pp. 99-122.

Branson, William H., "Stocks and Flows in International Monetary Analysis," in A. Ando, R. Herring, and R. Marston, eds., International Aspects of Stabilization Policy, Federal Reserve Bank of Boston Conference Series No. 12, (1974), pp. 27-50.

_____, Hannu Halttunen, and Paul Masson, "Exchange Rates in the Short Run: The Dollar-Deutschemark Rate," European Economic Review, Vol. 10 (1977), pp. 303-24.

Branson, William H., Hannu Halttunen, and Paul Masson, "Exchange Rates in the Short Run: Some Further Results," European Economic Review, Vol. 12 (1979), pp. 395-402.

Branson, William H., and Dale W. Henderson, "The Specification and Influence of Asset Markets," in R. Jones and P. Kenen, eds., Handbook of International Economics, Vol. 2 (Amsterdam: North-Holland, 1985), pp. 749-805.

Clinton, Kevin, "Pitfalls in Financial Model Building: Comment," American Economic Review, Vol. 63 (December 1973), pp. 1003-04.

Cumby, Robert E. and Maurice Obstfeld, "International Interest Rate and Price Level Linkages under Flexible Exchange Rates: A Review of Recent Evidence," in J. Bilson and R. Marston, eds., Exchange Rate Theory and Practice, (Chicago: University of Chicago Press, 1984).

Danker, Deborah J., Richard D. Haas, et. al., "Small Empirical Models of Exchange Market Intervention: Applications to Germany, Japan and Canada," Federal Reserve Board Staff Study No. 135 (Washington, D.C., 1985).

Deleau, Michel, Pierre Malgrange, and Pierre-Alain Muet, "A Study of Short Run and Long Run Properties of Macroeconomic Dynamic Models by Means of an Aggregative Core Model," in P. Malgrange and P.-A. Muet, eds., Contemporary Macroeconomic Modelling, (London: Blackwell, 1984).

Dooley, Michael P. and Peter Isard, "Tax Avoidance and Exchange Rate Determination", International Monetary Fund (manuscript, January 1986).

_____, and _____, "Capital Controls, Political Risk and Deviations from Interest Rate Parity," Journal of Political Economy, Vol. 88 (April 1980), pp. 370-84.

Dornbusch, Rudiger, "Expectations and Exchange Rate Dynamics," Journal of Political Economy, Vol. 84 (Dec. 1976), pp. 1161-76.

_____, "Monetary Policy under Exchange-Rate Flexibility," Managed Exchange Rate Flexibility: The Recent Experience, Federal Reserve Bank of Boston, Conference Series No. 20 (1979), pp. 90-122.

Fair, Ray C., "On Modelling the Economic Linkages among Countries," in R. Dornbusch and J. A. Frenkel, eds., International Economic Policy: Theory and Evidence, (Baltimore: Johns Hopkins University Press, 1979).

Frankel, Jeffrey A. (1982a), "A Test of Perfect Substitutability in the Foreign Exchange Market," Southern Economic Journal, Vol. 49, (October 1982), pp. 406-16.

_____ (1982b), "In Search of the Exchange Risk Premium: A Six-Currency Test Assuming Mean-Variance Optimization," Journal of International Money and Finance, Vol. 1 (1982), pp. 255-74.

_____, "On the Mark: A Theory of Floating Exchange Rates Based on Real Interest Differentials," American Economic Review, Vol. 69 (1979), pp. 610-22.

_____, and Ken Froot, "Using Survey Data to Test Standard Propositions Regarding Exchange Rate Expectations," University of California at Berkeley, Research Papers in Economics No. 86-11 (May 1986).

Frenkel, Jacob A., "A Monetary Approach to the Exchange Rate: Doctrinal Aspects and Empirical Evidence," Scandinavian Journal of Economics, Vol. 78 (1976), pp. 200-24.

_____, and Michael L. Mussa, "Asset Markets, Exchange Rates and the Balance of Payments," in R. Jones and P. Kenen, eds., Handbook of International Economics, Vol. 2 (Amsterdam: North-Holland, 1985), pp. 679-747.

_____, and Carlos A. Rodriguez, "Exchange Rate Dynamics and the Overshooting Hypothesis," Staff Papers, International Monetary Fund (Washington), Vol. 29 (March 1982), pp. 1-30.

Haas, Richard D. and Paul R. Masson, "Minimod: Specification and Simulation Results," forthcoming in Staff Papers, International Monetary Fund (Washington), Vol. 33 (December 1986).

Hendry, David F. and Jean-Francois Richard, "The Econometric Analysis of Economic Time Series," International Statistical Review, Vol. 51 (1983), pp. 111-63.

Hickman, B. and L. Lau, "Elasticities of Substitution and Export Demand in a World Trade Model," European Economic Review, Vol. 4 (1982), pp. 347-80.

Holtham, Gerald, "Multinational Modelling of Financial Linkages and Exchange Rates," OECD Economic Studies, No. 2 (Spring 1984), pp. 51-92.

Hooper, Peter, Richard D. Haas, et. al., "Alternative Approaches to General Equilibrium Modeling of Exchange Rates and Capital Flows: The MCM Experience," Zeitschrift fur Nationalokonomie, Suppl. 3, (1983), pp. 29-60.

Isard, Peter, "The Empirical Modeling of Exchange Rates: An Assessment of Alternative Approaches," International Monetary Fund (mimeograph, June 6, 1986).

_____, Exchange Rate Determination: A Survey of Popular Views and Recent Models, Princeton Studies in International Finance, No. 42 (1978).

_____, "Factors Determining Exchange Rates: The Roles of Relative Price Levels, Balances of Payments, Interest Rates and Risk," Federal Reserve Board, International Finance Discussion Papers No. 171, December 1980.

_____, "How Far Can We Push the 'Law of One Price'?," American Economic Review, Vol. 67 (1977), pp. 942-48.

Kohlhagen, Steven W., The Behavior of Foreign Exchange Markets--A Critical Survey of the Empirical Literature (New York: NYU Graduate School of Business Administration, 1978).

Krueger, Anne O., Exchange Rate Determination, (Cambridge, U.K.: Cambridge University Press, 1983).

Ladenson, Mark L., "Pitfalls in Financial Model Building: Some Extensions," American Economic Review, Vol. 61 (March 1971), pp. 179-86.

Levich, Richard M. "Empirical Studies of Exchange Rates: Price Behavior, Rate Determination and Market Efficiency," in R. Jones and P. Kenen, eds., Handbook of International Economics, Vol. 2 (Amsterdam: North-Holland, 1985), pp. 979-1040.

Martin, John P. and Paul R. Masson, "Exchange Rates and Portfolio Balance," NBER Working Paper No. 377, 1979.

Masson, Paul R., "Dynamic Stability of Portfolio Balance Models of the Exchange Rate," Journal of International Economics, Vol. 11 (1981), pp. 467-77.

_____, "The Methodology of Creating Minimodels from Large Structural Macroeconomic Models," forthcoming in R. Bryant, D. Henderson, G. Holtham, P. Hooper and S. Symansky, eds., Empirical Macroeconomics for Interdependent Economies, (Washington, D.C.: The Brookings Institution, 1986).

_____, and Malcolm Knight, "The International Transmission of Fiscal Policies in Major Industrial Countries," Staff Papers, International Monetary Fund (Washington), Vol. 33 (September 1986), pp. 387-438.

Masson, Paul R. and Peter Richardson, "Exchange Rate Expectations and Current Balances in the OECD INTERLINK System," in P. Artus and O. Guvenen, eds., International Macroeconomic Modelling for Policy Decisions (Dordrecht: Nijhoff, 1986), pp. 53-77.

McCallum, Bennett T., "Rational Expectations and the Natural Rate Hypothesis: Some Consistent Estimates," Econometrica, Vol. 44, (1976), pp. 43-52.

Meese, Richard A. and Kenneth Rogoff (1983a), "Empirical Exchange Rate Models of the Seventies: Do They Fit Out-Of-Sample?," Journal of International Economics, Vol. 14 (February 1983), pp. 3-24.

_____, and _____ (1983b), "The Out-of-Sample Failure of Empirical Exchange Rate Models: Sampling Error of Misspecification?," in J. Frenkel, ed., Exchange Rates and International Macroeconomics, (Chicago: University of Chicago Press, 1983), pp. 67-112.

_____, and _____ "Was It Real? The Exchange Rate-Interest Differential Relation, 1973-84," Federal Reserve Board, International Finance Discussion Papers No. 268, August 1985.

Mussa, Michael L., "Empirical Regularities in the Behavior of Exchange Rates and Theories of the Foreign Exchange Market," in K. Brunner and A. Meltzer, eds., Policies for Employment, Prices and Exchange Rates, Carnegie-Rochester Conference Series on Public Policy, Vol. 11 (Amsterdam: North-Holland, 1979).

_____, "The Exchange Rate, the Balance of Payments and Monetary and Fiscal Policy under a Regime of Controlled Floating," Scandinavian Journal of Economics, Vol. 78 (1976), pp. 229-48.

Rogoff, Kenneth, "On the Effects of Sterilized Intervention: An Analysis of Weekly Data," Journal of Monetary Economics, Vol. 14 (September 1984), pp. 133-50.

Samuelson, Lee, "A New Model of World Trade," OECD Occasional Studies, (Paris: OECD, 1973).

Sargent, Thomas J. (1979a), "Estimating Vector Autoregressions Using Methods Not Based on Explicit Economic Theories," Federal Reserve Bank of Minneapolis Quarterly Review, Vol. 3 (Summer 1979), pp. 8-15.

_____ (1979b), "A Note on Maximum Likelihood Estimation of the Rational Expectations Model of the Term Structure," Journal of Monetary Economics, Vol. 5 (January 1979), pp. 133-43.

Taylor, John B., "The Treatment of Expectations in Large Multicountry Econometric Models," Stanford University (manuscript, February 1986).

Wickens, M.R., "The Efficient Estimation of Econometric Models with Rational Expectations," Review of Economic Studies, Vol. 49 (January 1982), pp. 55-67.