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EXCHANGE RATE ECONOMICS

VOLUME I

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Exchange Rate Economics
Volume I

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Volume I

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Preface

Over the last 20 years or so, the economics of exchange rates has been an especially active area of international finance. This activity has led to an output encompassing theoretical models of the determinants of exchange rates, the empirical verification (or otherwise) of such models and the efficiency of foreign exchange markets. In these two volumes we bring together a selection of papers which, we believe, are representative of this vast literature.

Given the range of available papers at our disposal, making a selection proved to be an extremely difficult task; inevitably, we shall have excluded someone's favourite exchange rate paper. For this we apologize in advance.

We have grouped the essays under a number of different headings. Volume I, *Exchange Rate Determination: Theory and Evidence*, begins with a 'groundwork' section. This contains two of the foundation articles in the exchange rate canon as well as two key surveys which overview the whole literature. By their very nature these surveys could have appeared in almost any of the succeeding parts. Nine key theoretical contributions, from the asset approach to the exchange rate, appear in Part II. A further nine papers containing econometric evidence on the asset approach are grouped together in Part III. The first volume closes with four articles representing some key new directions in exchange rate research.

Volume II, *Foreign Exchange Market Efficiency*, brings together a number of different aspects of the efficiency literature. Part I contains seven empirical articles relating to the efficiency of the spot and forward markets. Since the consensus in the literature now seems to reject the simple efficient markets hypothesis (viewed as a joint hypothesis), a number of contributions which have attempted to rationalize this rejection are considered in Part II. A flavour of the 'news' literature is given in Part III. The final section of the book contains a total of ten papers which examine the validity of the key international interest rate and price level parity conditions.

In the Introduction to both volumes, we have surveyed what we believe to be the key elements of the exchange rate debate. The survey is designed to show how the papers contained in these two volumes fit into the exchange rate literature, as well as to provide a general guide.

In compiling these volumes, we have received helpful comments from Michael Dooley, Peter Isard and Richard Levich, although responsibility for any errors of omission or commission rests wholly on ourselves.

Introduction

The past two decades have seen an enormous growth in the literature on exchange rate economics. Given the importance attached to the exchange rate in the success or otherwise of an open economy, it is not surprising that exchange rate economics is one of the most heavily researched areas of the discipline. The period since the advent of generalized floating exchange rates in 1973 has generated a wealth of data on exchange rates and on the factors which supposedly determine them, giving econometricians and applied economists an unprecedented opportunity to test a number of propositions relating to foreign exchange markets. Exchange rate economics remains, however, an extremely challenging area in the sense that, despite this extensive research, a large number of unresolved issues still remain.

In this volume our aim as editors[1] is to provide a key to this literature by bringing together some of the most important papers in its development. In addition, we seek, in this Introduction, to provide a brief survey. In an attempt to optimize subjects to given space constraints, we confine ourselves to surveying the literature on exchange rate determination and, more briefly, on foreign exchange market efficiency. In particular, we examine the two main views of exchange rate determination that have evolved since the early 1970s: the monetary approach to the exchange rate (in flex-price, sticky-price and real interest differential formulations) and the portfolio balance approach. We then discuss the extant empirical evidence on these models and conclude by predicting how the future research strategy in the area of exchange rate determination is likely to develop. We also discuss the literature on foreign exchange market efficiency, on exchange rates and 'news', and on international parity conditions.

Theories of Exchange Rate Determination

At the most fundamental level, the exchange rate is simply the price of foreign currency which clears the foreign exchange market. Theories of exchange rate determination therefore differ only in their varying specifications of the supply of and demand for foreign exchange.

Early contributions to the postwar literature on exchange rate economics include Nurske (1944) and Friedman (1953), both to a large extent concerned with the role of speculation in foreign exchange markets. Nurske warns against the dangers of 'bandwagon effects' which may generate market instability.[2] Friedman's classic apologia of floating exchange rates (Chapter 1) is remarkable in its anticipation of much of the foreign exchange literature of the following two decades; it is still cited as the seminal article on stabilizing speculation. However, two of the most important contributions to the area of exchange rate modelling – those by Mundell and Fleming – did not appear until the 1960s.

The insight of the classic Mundell-Fleming model of exchange rate determination (Mundell 1968; Fleming 1962) was that net excess demand for foreign exchange is just the overall balance of payments (current plus capital account). Under a free float, this must be equal to zero in equilibrium. Combining this equilibrium condition with standard equilibrium conditions for the goods market (the IS curve) and the money market (the LM curve) allows the exchange rate (and the other endogenous variables, normally real output and the interest rate) to be calculated, as well as the comparative static effects of fiscal and monetary policy to be determined.

The integration of asset markets and capital mobility into open-economy macroeconomics is a major innovation of the Mundell-Fleming model. Nevertheless, it contains a fundamental flaw: it is cast almost entirely in flow terms. In particular, the model allows current account imbalances to be offset by flows across the capital account without any requirement of eventual stock equilibrium in the holding of net foreign assets. In papers dating from the 1950s, Polak (1957) and Johnson (1958) had stressed the distinction between stock and flow equilibria in the open-economy context. This was to become a hallmark of the monetary approach to balance of payments analysis (see, for instance, Frenkel and Johnson 1976) and, subsequently, of the monetary approach to the exchange rate (see, again, Frenkel and Johnson 1978).

Indeed, since an exchange rate is, by definition, the price of one country's money in terms of that of another, it is perhaps natural to analyse the determinants of that price in terms of the outstanding stocks of and demand for the two monies. This is the basic rationale of the monetary approach to the exchange rate (Frenkel 1976; Kouri 1976; Mussa 1976 and 1979: Chapters 5, 7, 6 and 3 respectively).

The Flexible Price Monetary Model

The early, flexible-price monetary model (FLPM) relies on the twin assumptions of (continuous) purchasing power parity (PPP) and the existence of stable money demand functions for the domestic and foreign economies. The (logarithm of the) demand for money may be assumed to depend on (the logarithm of) real income, y; the (logarithm of the) price level, p; and the level of the interest rate, r (foreign variables being denoted by an asterisk). Monetary equilibria in the domestic and foreign country respectively are given by

$$m_t^s = p_t + \phi y_t - \lambda r_t \tag{1}$$

$$m_t^{s*} = p_t^* + \phi^* y_t^* - \lambda^* r_t^*. \tag{2}$$

In the FLPM model, the domestic interest rate is, at least in the long run, exogenous because of the implicit assumption of perfect capital mobility – domestic interest rates are determined on world markets. Equilibrium in the traded goods market ensues when there are no further profitable incentives for trade flows to occur – that is, when prices in a common currency are equalized and PPP holds. The PPP condition is:

$$s_t = p_t - p_t^* \tag{3}$$

where s_t is the nominal exchange rate (domestic price of foreign currency). Thus, if PPP holds continuously, the logarithm of the real exchange rate, q_t, say ($q_t = s_t - p_t + p_t^*$), is zero. The world price, p^*, is exogenous to the domestic economy, being determined by the world money supply. The domestic money supply determines the domestic price level; hence the exchange rate is determined by relative money supplies. Algebraically, substituting (1) and (2) into (3) gives, after rearranging,

$$s_t = (m^s - m^{s*})_t - \phi y_t + \phi^* y_t^* + \lambda r_t - \lambda^* r_t^* \tag{4}$$

which is the basic FLPM equation. From (4), we can see that an increase in the domestic money supply, relative to the foreign money stock, will lead to a rise in s_t – that is, a fall in the value of the domestic currency in terms of the foreign currency. This seems intuitive enough. On the other hand, an increase in domestic output *appreciates* the domestic currency (s_t falls) – exactly the converse of what the Mundell-Fleming approach would predict. (In the latter approach, higher real income worsens the trade balance, as imports rise, and requires a *depreciation* to return to equilibrium.) Similarly, a rise in domestic interest rates depreciates the domestic currency (in the Mundell-Fleming model, this would lead to capital inflows and hence an *appreciation*).

In order to resolve these apparent paradoxes, one has to remember the fundamental role of relative money demand in the FLPM model. A relative rise in domestic real income creates an excess demand for the domestic money stock. As agents try to increase their (real) money balances, they reduce expenditure and prices fall until money market equilibrium is achieved. As prices fall, PPP ensures an appreciation of the domestic currency in terms of the foreign currency. An exactly converse analysis explains the response of the exchange rate to the interest rate – an increase in interest rates reduces the demand for money and so leads to a depreciation.

It is instructive to write the FLPM equation in two alternative but equivalent formulations. Assuming that the domestic and foreign money demand coefficients are equal ($\phi = \phi^*$, $\lambda = \lambda^*$), (4) reduces to:

$$s_t = (m - m^*)_t - \phi(y - y^*)_t + \lambda(r - r^*)_t. \tag{5}$$

A further assumption underlying the FLPM model is that uncovered interest parity holds continuously; that is, the domestic-foreign interest differential is just equal to the expected rate of depreciation of the exchange rate. Thus, using a superscript e to denote agents' expectations formed at time t, we may substitute Δs^e_{t+1} for $(r-r)^*_t$ in (5) to get

$$s_t = (m - m^*)_t - \phi(y - y^*)_t + \lambda \Delta s^e_{t+1}. \tag{6}$$

Thus, the expected change in the exchange rate and the interest differential, which reflect inflationary expectations, are interchangeable in this model. Some researchers relax the constraint that the income and interest rate elasticities are equal; as a sort of hybrid,

$$s_t = (m - m^*)_t - \phi y_t + \phi^* y_t^* + \lambda \Delta s^e_{t+1}. \tag{7}$$

Note also that (7) can be expressed as

$$s_t = (1+\lambda)^{-1}(m-m^*)_t - (1+\lambda)^{-1}\phi y_t + (1+\lambda)^{-1}\phi^* y_t^* + \lambda(1+\lambda)^{-1} s^e_{t+1}. \tag{8}$$

If expectations are assumed to be rational[3] then, by iterating forward, it is easy to show that (12) can be expressed in the 'forward solution' form

$$s_t = (1+\lambda)^{-1}\sum_{i=0}^{\infty}\left(\frac{\lambda}{1+\lambda}\right)^i \left[(m-m^*)^e_{t+i} + \phi y^e_{t+i} + \phi^* y^{*e}_{t+i}\right] \tag{9}$$

where it is understood that expectations are conditioned on information at time t. Equation (9) makes clear that the monetary model, with rational expectations, involves solving for the expected future path of the 'forcing variables' – that is, relative money and income. As is common in rational expectations models, the presence of the discount factor $\lambda/(1+\lambda) < 1$ in (9) implies that expectations of the forcing variables need not, in general, be formed into the *infinite* future, so long as the forcing variables are expected to grow at a rate less than $[(1+\lambda)/\lambda - 1]$.

The Sticky Price and Real Interest Differential Monetary Models

A problem with the early flexible-price variant of the monetary approach, however, is that it assumes *continuous* purchasing power parity (PPP), as in equation (3). Under continuous PPP, the *real* exchange rate – that is to say, the exchange rate adjusted for differences in national price levels – cannot vary, by definition. Yet a major characteristic of the recent experience with floating has been the wide gyrations in the real rates of exchange between many of the major currencies, bringing with them the very real consequences of shifts in international competitiveness (see Chapter 23). Clearly, therefore, the simple flexible-price monetary approach does not fit the facts of observation. An attempt to rehabilitate the monetary model in this respect led to the development of a second generation of monetary models, due originally to Dornbusch (Chapter 8). The 'sticky price' monetary model (SPM) allows for substantial overshooting of the nominal and real price-adjusted exchange rate above their long-run equilibrium (PPP) levels as the 'jump variables' in the system – exchange rates and interest rates – compensate for sluggishness in other variables, notably goods prices.

The intuition underlying the overshooting result in the SPM model is relatively straightforward. Imagine the effects of a cut in the nominal UK money supply. Since prices are sticky in the short run, this implies an initial fall in the real money supply and a consequent rise in interest rates in order to clear the money market. The rise in domestic interest rates then leads to a capital inflow and an appreciation of the nominal exchange rate (that is, a rise in the value of domestic currency in terms of foreign currency) which, given sticky prices, also implies an appreciation of the real exchange rate. Foreign investors are aware that they are artificially forcing up the exchange rate and that they may therefore suffer a foreign exchange loss when the proceeds of their investment are reconverted into their local currency.[4] However, so long as the *expected* foreign exchange loss (expected rate of depreciation) is less than the *known* capital market gain (the interest differential), risk-neutral investors will continue to buy sterling assets. A short-run equilibrium is achieved when the expected rate of depreciation is just equal to the interest differential (uncovered interest parity holds). Since the expected rate of depreciation must then be non-zero for a non-zero interest differential, the exchange rate must have overshot its long-run equilibrium (PPP) level. In the medium run, however, domestic prices begin to fall in response to the fall in money supply. This alleviates pressure in the money market (the real money supply rises) and domestic interest rates begin to decline. The exchange rate then depreciates slowly in order to converge on the long-run PPP level. This model therefore explains the paradox that countries with relatively high interest rates tend to have currencies whose exchange rate is expected to depreciate. The *initial* rise in interest rates leads to a steep appreciation of the exchange rate, after which a slow depreciation is expected in order to satisfy uncovered interest parity.

The Dornbusch overshooting model has been further developed by Buiter and Miller in Chapter 9 who, *inter alia*, allow for a non-zero rate of core inflation and consider the impact of natural resource discoveries on output and the exchange rate.

Frankel argues in Chapter 15 that a shortcoming of the Dornbusch formulation of the SPM monetary model (Chapter 8) is that it does not allow a role for differences in secular rates of inflation. His model is therefore an attempt to allow for this defect, the upshot being an exchange rate equation which includes the real interest rate differential as an explanatory variable – the real interest differential (RID) variant of the monetary model.

The sticky-price monetary model is clearly an advance over the simple (continuous PPP) monetary model in that it more closely explains the facts of observation. It is, however, fundamentally monetary in that attention is focused on equilibrium conditions in the money market. Monetary models of the open economy are able to do this by assuming perfect substitutability of domestic and foreign non-money assets, but *non*-substitutability of monies (see Calvo and Rodriguez in Chapter 10 and Girton and Roper (1981) for a relaxation of this assumption). The markets for domestic and foreign non-money assets can then be aggregated into a single extra market ('bonds') and excluded from explicit analysis by the application of Walras' Law. This 'perfect substitutability' assumption is relaxed in the portfolio balance model of exchange rate determination. In addition, the portfolio balance model is stock-flow consistent in that it allows for current account imbalances to have a feedback effect on wealth and hence on long-run equilibrium (see Chapters 11 and 12; also Branson 1983 and 1984; Isard 1980).

The Portfolio Balance Model

In common with the FLPM and SPM models, the level of the exchange rate in the portfolio balance model (PBM) is determined, at least in the short run, by supply and demand in the markets for financial assets. The exchange rate, however, is a principal determinant of the current account of the balance of payments. Now, a surplus (deficit) on the current account represents a rise (fall) in net domestic holdings of foreign assets which in turn affects the level of wealth; this in turn affects the level of asset demand, which again affects the exchange rate. Thus, the PBM is an inherently dynamic model of exchange rate adjustment which includes in its terms of reference asset markets, the current account, the price level and the rate of asset accumulation. Seminal contributions to the literature on the PBM have been by Allen and Kenen (1977), Branson (Chapter 11), Dornbusch and Fischer (Chapter 12) and Isard (1980).

A further novel feature of the PBM is that it allows one to distinguish between short-run equilibrium (supply and demand equated in asset markets) and the dynamic adjustment to long-run equilibrium (a static level of wealth with no tendency of the system to move over time). In the short run, on a day-to-day basis, the exchange rate is determined purely by the interaction of supply and demand in asset markets. During this period, the level of financial wealth (and the individual components of that level) can be treated as fixed. In its simplest form, the PBM divides net financial wealth of the private sector (W) into three components: money (M), domestically issued bonds (B), and foreign bonds denominated in foreign currency (F). B can be thought of as government debt held by the domestic private sector; F is the level of net claims on foreigners held by the private sector. Since under a free float a current account surplus on the balance of payments must be exactly matched by a capital account deficit (that is, capital outflow and hence an increase in net foreign indebtedness to the domestic economy), the current account must give the rate of accumulation of F over time.

With foreign and domestic interest rates given by r and r* as before, we can express our definition of wealth and simple domestic demand functions for its components as follows:[5]

$$W = M + B + SF \tag{10}$$

$$M = M(r,r^*)W \quad M_r < 0,\ M_{r*} < 0 \tag{11}$$

$$B = B(r,r^*)W \quad B_r > 0,\ B_{r*} < 0 \tag{12}$$

$$SF = F(r,r^*)W \quad F_r < 0,\ F_{r*} > 0 \tag{13}$$

Relation (10) is an identity defining wealth. The major noteworthy characteristics of equations (11) to (13) are that, as is standard in most expositions of the PBM, the scale variable is the level of wealth, W, and the demand functions are homogeneous in wealth; this allows them to be written in nominal terms (assuming homogeneity in prices and real wealth, prices cancel out).[6]

This provides a simple framework for analysing the effect of, for example, monetary and fiscal policy on the exchange rate. Thus, a contractionary monetary policy (M down) reduces nominal financial wealth (through (10)) and so reduces the demand for both domestic and foreign bonds (through (12) and (13)). As foreign bonds are sold, the exchange rate appreciates (the foreign price value of domestic currency rises). The effects of fiscal policy (operating through changes in B) on the exchange rate are more ambiguous, depending on the degree of substitution between domestic and foreign bonds.

Branson (1983, 1984) has also extended this model to incorporate rational expectations.

Empirical Evidence on Exchange Rate Models

We shall divide our discussion of the empirical evidence on exchange rate models into three parts. The first part deals with the evidence on the various monetary exchange rate models using data from the interwar years and from the recent float before 1978. The second part relates to the empirical evidence on monetary models including more recent data from the current float. In part three the empirical evidence on the portfolio balance model of the exchange rate will be examined.

The First-Period Tests of the Monetary Models

The empirical evidence on the various formulations of the monetary exchange rate model – the flexible-price (FLPM), sticky-price (SPM) and real interest differential (RID) specifications – can be divided into two periods. The 'first-period' evidence relates to studies of the interwar years and of the recent float prior to 1978. This first-period evidence is largely supportive of the monetary model. The 'second-period' evidence, covering the years of the recent float extending beyond the late 1970s, is not so supportive of the monetary model.

One of the first tests of equation (7) was conducted by Frenkel (Chapter 5) for the German mark-US dollar exchange rate during the period 1920–23. Since this period corresponds to the German hyperinflation, Frenkel argues that domestic monetary impulses will overwhelmingly dominate equation (7); thus domestic income and foreign variables can be dropped, and attention focused simply on the effects of German money and the expected inflation (operating through expected depreciation). Frenkel reports results supportive of the FLPM during this period.

A number of researchers have estimated FLPM equations for the more recent experience with floating exchange rates. For example, Bilson (1978) tests the FLPM for the German mark-UK pound exchange rate (with the forward premium, fp_t, substituted for Δs^e_{t+1} and without any restrictions on the coefficients on domestic and foreign money), over the period January 1972 through April 1976. Incorporating dynamics into the equation and using a Bayesian estimation procedure, Bilson reports results in broad accordance with the monetary approach. Hodrick's (1978) tests of the FLPM for the US dollar-German mark and UK pound-US dollar over the period July 1972 to June 1975 are highly supportive of the FLPM (see Chapter 13). Putnam and Woodbury (1979), estimating equation (5) for the sterling-dollar exchange rate over the period 1972–74, report that most of the estimated coefficients are significantly different from zero at the 5 per cent significance level and all are correctly signed according to the FLPM. However, the money supply term is significantly different from unity.

Dornbusch (1979) also reports results broadly supportive of the FLPM for the mark-dollar exchange rate over the period March 1973 to May 1978, in a specification incorporating the *long-term* interest rate differential. Although Dornbusch here introduces the long-term interest rate differential as an econometric expedient, an interpretation may be placed on this term which is consistent with Frankel's RID equation as discussed above. Thus Frankel, in his implementation of the RID model for the mark-dollar exchange rate over the period July 1974 to February 1978 (Chapter 15), uses a long bond interest differential as an instrument for the expected inflation term on the assumption that long-term real rates of interest are equalized. Frankel argues that since the coefficients on the interest rate and expected inflation terms are both significant, the extreme FLPM and SPM models should both be rejected in favour of his RID model.

The Second-Period Tests of the Monetary Models

Although the monetary approach appears reasonably well supported for the period up to 1978, the picture alters dramatically once the sample period is extended. For example, estimates of the RID model reported by Dornbusch (1980), Haynes and Stone (1981), Frankel (Chapter 19) and Backus (1984) cast serious doubt on its ability to track the exchange rate in-sample:

few coefficients are correctly signed (many are wrongly signed), the equations have poor explanatory power as measured by the coefficient of determination, and residual autocorrelation is a problem. In particular, estimates of monetary exchange rate equations for the German mark-US dollar for this period often report coefficients which suggest that a relative increase in the domestic money supply leads to a rise in the foreign currency value of the domestic currency (exchange rate appreciation). This latter phenomenon – the price of the mark rising as its supply is increased – has been labelled by Frankel (1982a) as the 'mystery of the multiplying marks'.

How can one explain this poor performance of the monetary approach equations for the second half of the floating sample? Rasulo and Wilford (1980) and Haynes and Stone (1981) have suggested that the root of the problem may be traced to the constraints imposed on relative monies, incomes and interest rates. The imposition of such constraints may be justified on the grounds that if multicollinearity is present, constraining the variables will increase the efficiency of the coefficient estimates. However, Haynes and Stone (1981) show that the subtractive constraints used in monetary approach equations are particularly dangerous because they may lead to biased estimates and also (in contrast to additive constraints) to sign reversals.

An alternative explanation for the poor performance of the monetary model in the second period has been given by Frankel (1982a). He attempts to explain the mystery of the multiplying marks by introducing wealth into the money demand equations. The justification for this inclusion is that Germany was running a current account surplus in the late 1970s which was redistributing wealth from US to German residents (thus increasing the demand for marks and reducing the demand for dollars) independently of other arguments in the money demand functions. By including home and foreign wealth (defined as the sum of government debt and cumulated current account surpluses) in his empirical equation, and by not constraining the income, wealth and inflation terms to have equal and opposite signs, Frankel reports a monetary approach equation which fits the data well and in which all variables, apart from the income terms, are correctly signed and most are statistically significant.

A further explanation for the failure of monetary approach equations may be traced to the relative instability of the money demand functions underlying monetary approach exchange rate equations. Indeed, a number of single-country money demand studies strongly indicate that there have been shifts in velocity for the measure of money utilized by the above researchers (see Artis and Lewis 1981 for a discussion). In Frankel (Chapter 19), shifts in money demand functions are incorporated into the empirical equation by introducing a relative velocity shift term $(v-v^*)$ which is modelled by a distributed lag of $[(p+y-m)-(p^*+y^*-m^*)]$. Including the $(v-v^*)$ term in the estimating equation for five exchange rates leads to most of the monetary variable coefficients becoming statistically significant and of the correct signs. However, significant first-order residual autocorrelation remains a problem in all of the reported equations.

Driskell and Sheffrin (1981) argue that the poor performance of the monetary model can be traced to the failure to account for the simultaneity bias introduced by having the expected change in the exchange rate (implicitly) on the right-hand side of monetary equations. One potential method of circumventing such simultaneity is offered by the rational expectations solution of the monetary model, which effectively gives an equation purged of the interest differential-forward exchange rate effect. Recently a number of researchers have begun to test this version of the model, with some degree of success. For example, Hoffman and

Schlagenhauf (Chapter 14) implement a version of the 'forward solution' FLPM formulation (equation (9)) by specifying a time series model for the stochastic evolution of the fundamentals. The equation is estimated jointly with time series models for relative money and income for the French franc, the German mark and the UK pound against the US dollar. Hoffman and Schlagenhauf compute likelihood ratio tests for the validity of the rational expectations hypothesis as well as the validity of this hypothesis *plus* the coefficient restrictions implied by the FLPM (such as the unitary coefficient on relative money supplies). Although the expectations restrictions are not rejected for any of the countries, the FLPM restrictions are rejected for Germany. Kearney and MacDonald (1987), carrying out a similar procedure for the Australian dollar-US dollar, find they cannot reject the restrictions implied by the rational expectations-FLPM model.

The rational expectations solution to the FLPM has spawned further empirical work which seeks to test for the presence of speculative bubbles. It is well known from the rational expectations literature that equation (9) is only one solution to (7) from a potentially infinite sequence.[7] If we denote the exchange rate given by (9) as $\hat{s}_t$ then it is straightforward to demonstrate[8] that equation (7) has multiple rational expectations solutions, each of which may be written in the form

$$s_t = \hat{s}_t + b_t \tag{14}$$

where b_t – the 'rational bubble' term – satisfies

$$b^e_{t+1} = \lambda^{-1}(1+\lambda)b_t.$$

Meese (1986) attempts to test for bubbles by applying a version of the Hausman (1978) specification test suggested by West (1985) for present value models. The test involves estimating a version of equation (7) (which produces consistent coefficient estimates regardless of the presence or otherwise of rational bubbles) and a closed-form version of (9) (which produces consistent coefficient estimates only in the absence of bubbles). Hausman's specification test is used to determine if the two sets of coefficient estimates of ß are significantly different. If they are, then this is suggestive of the existence of a speculative bubble. For the dollar-yen, dollar-mark and dollar-sterling exchange rates (monthly data over the period October 1973 to November 1982), Meese in fact finds that the two estimates of ß are significantly different and therefore rejects the no-bubbles hypothesis. Kearney and MacDonald (1987) apply a version of this methodology to the Australian-US dollar exchange rate and find they cannot reject the no-bubbles hypothesis.

An alternative way of testing for bubbles has been to adopt the variance bounds test methodology originally proposed by Shiller (1979) in the context of interest rates. This may be illustrated in the following way. If we define the *ex post* rational or perfect foresight exchange rate as that given by replacing expected future values of money and income in (9) with their actual values:

$$s^*_t = (1+\lambda)^{-1}\sum_{i=1}^{\infty}\left(\frac{\lambda}{1+\lambda}\right)^i\left[(m-m^*)_{t+i} - \phi y_{t+i} + \phi^* y_{t+i}\right]$$

then s^*_t will differ from $\hat{s}_t$ by a rational forecast error, u_t (so that $s^*_t = \hat{s}_t + u_t$). Given that