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8 Exchange Rate Economics: What's Wrong with the Conventional Macro Approach?

Robert P. Flood and Mark P. Taylor

To include a paper entitled as this one is in a volume devoted to an examination of the importance of market microstructure in foreign exchange markets is, to utilize a well-used phrase, to preach to the converted. The poor empirical performance of the major exchange rate models over the recent float is, moreover, extremely well documented (Frankel and Rose 1994; MacDonald and Taylor 1992; Taylor 1994). Nevertheless, it is important to have a formal statement of the theory and evidence relating to exchange rate models based on macroeconomic fundamentals as a ground-clearing exercise since only by stating what is wrong with the conventional macro approach can we hope to design models that fill the gaps left by the macro-based models. Thus, section 8.1 of this paper is devoted to a discussion of the theory and empirical evidence relating to the major macroeconomic exchange rate models developed during the last twenty years or so, including the flexible-price monetary model, the sticky-price, overshooting monetary model, the portfolio balance model, and the equilibrium model. In section 8.2, we provide a brief discussion of the theory and evidence relating to the speculative efficiency of foreign exchange markets.

Beyond this, however, we want to demonstrate that, while the macro fundamentals are clearly not capable of explaining all—or even most—of the variation in short-term nominal exchange rate movements, the research program of the last twenty years has nevertheless not been entirely fruitless. Our aim is thus to examine the macro fundamentals as a means of "setting the parameters" within which microstructural models might be constructed. Thus, in section

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8.3, we invert the question posed in the title of this paper and ask, What's right with the conventional macro approach? Using data on twenty-one industrialized countries for the floating-rate period, we show that, while the macro fundamentals may be a poor guide to variations in short-run exchange rate movements (where *the short run* is defined as one year or less), they may nevertheless have considerable explanatory power over longer horizons.

A final section concludes the discussion and tries to give an answer to the question that the title of this paper poses.

8.1 Theory and Evidence on Exchange Rate Models Based on Macro Fundamentals

In this section, we review briefly the theory and evidence pertaining to the four major exchange rate models based on conventional macro fundamentals: the monetary model, the sticky-price monetary model, the equilibrium model, and the portfolio balance model.[1] The monetary model is the simplest of the four and assumes that all goods are perfect substitutes, as are all interest-bearing assets, and that all markets clear continuously. The other three models relax, in various ways, some of the strong assumptions made in the monetary model and in some cases make explicit previously unarticulated assumptions. The sticky-price model makes two big changes from the monetary model: it adds multiple goods and allows slow adjustment of nominal goods prices. The equilibrium model also allows multiple goods, but it models asset preferences as depending on the covariation of real asset returns with the marginal utility of consumption for some assets and as determined by unmodeled constraints for other assets. Also, by paying explicit attention to individual and economy-wide constraints, the equilibrium model is intended to clarify the full effects of various policy options. Typically, equilibrium models require continuous goods market and asset market clearing. Portfolio balance models are distinguished by their preferred specification of asset demands and are eclectic with respect to goods market specifications. In portfolio balance models, different interest-bearing assets are not perfect substitutes so that uncovered interest rate parity does not hold and asset demands may be modeled along the lines suggested by Tobin (1969).

Evidently, these four classes of model are not mutually exclusive. They share many common structural elements, including the property that expectations of the future are potentially crucial for current decisions, and, more important, they all share the property that current and expected future macro fundamentals are always at the heart of exchange rate determination.

Prior to setting out the theory and evidence relating to these four models in detail, however, we consider what is probably the simplest and in many ways

1. Sections 8.1 and 8.2 draw on MacDonald and Taylor (1992) and Taylor (1994).

the most fundamental link between the exchange rate and macroeconomic fundamentals: purchasing power parity.

8.1.1 Purchasing Power Parity

Purchasing power parity (PPP) is one of the simplest macro fundamental exchange rate models that one can imagine. Absolute purchasing power parity implies that the exchange rate is equal to the ratio of the two relevant national price levels; relative purchasing power parity posits that changes in the exchange rate are equal to changes in relative national prices:

$$s_t = (p_t - p_t^*) + \xi_t. \tag{1}$$

and

$$\Delta s_t = (\Delta p_t - \Delta p_t^*) + \xi_t', \tag{2}$$

where s_t denotes the logarithm of the spot exchange rate (domestic price of foreign currency), and p_t and p_t^* denote the logarithms of suitably normalized national price levels for the domestic and foreign economies, respectively. The deviation from purchasing power parity is commonly referred to as the *real exchange rate,* defined here in logarithmic form:

$$\pi_t \equiv s_t - (p_t - p_t^*) \equiv \xi_t. \tag{3}$$

The professional consensus on the validity of purchasing power parity has shifted radically over the past two decades or so. Prior to the recent float, the consensus appeared to support the existence of a fairly stable real exchange rate—that is to say, the variance of ξ_t or ξ_t' was thought of as small relative to the variance in relative prices or relative inflation rates. The prevailing orthodoxy of the early 1970s, largely associated with the monetary approach to the exchange rate, assumed the much stronger proposition of continuous purchasing power parity—that is, that the variance of ξ_t or ξ_t' was identically equal to zero (see, e.g., Frenkel 1976; and Frenkel and Johnson 1978). Proponents of early monetary exchange rate models, moreover, argued that, while the exchange rate may apparently diverge from PPP when conventional price indices are used, the condition would be seen to hold if one could observe the "true" price indices that are relevant for deflating national monies, so that observed variation in ξ_t or ξ_t' was really due to variation in measurement errors.

In the mid- to late 1970s, in the light of the very high variability of real exchange rates, this extreme position was largely abandoned as the variability in observed deviations from PPP became so large that it became clear that they could not be due to measurement errors alone. Subsequently, studies published mostly in the 1980s, which could not reject the hypothesis of random-walk behavior in real exchange rates—that ξ_t or π_t followed a random walk (e.g., Adler and Lehmann 1983)—reduced further the confidence in purchasing power parity and led to the rather widespread belief that PPP was of little use empirically and that real exchange rate movements were highly persistent.

More recently, in an extension of this literature, researchers have tested for more general mean reversion or stationarity of the real exchange (where the alternative hypothesis is a more general unit root process rather than specifically a random walk) have interpreted the null hypothesis of stationarity as equivalent to the existence of long-run purchasing power parity. Relatedly, researchers have also allowed the slope coefficients on domestic and foreign prices to differ from unity by testing for cointegration between the nominal exchange rate and domestic and foreign prices. Early cointegration studies generally reported a failure of significant mean reversion of the exchange rate toward purchasing power parity for the recent floating experience (Taylor 1988; Mark 1990) but were supportive of reversion toward purchasing power parity notably for the interwar float (Taylor and McMahon 1988) and for the exchange rates of high-inflation countries (McNown and Wallace 1989). Very recent applied work on long-run purchasing power parity among the major industrialized economies has, however, been more favorable toward the long-run purchasing power parity hypothesis for the recent float (e.g., Cheung and Lai 1993; Lothian and Taylor 1994). A number of authors have argued that the data period for the recent float alone may simply be too short to provide any reasonable degree of test power in the normal statistical tests for stationarity of the real exchange rate (e.g., Frankel 1990).

8.1.2 The Flexible-Price Monetary Model

The monetary approach to the exchange rate, which emerged as the dominant exchange rate model at the start of the recent float in the early 1970s (e.g., Frenkel 1976), starts from the definition of the exchange rate as the relative price of two monies and attempts to model that relative price in terms of the relative supply of and demand for those monies. Assuming stable, log-linear money demand functions at home and abroad (all variables except interest rates expressed in logarithms), the demand for money, m, is assumed to depend linearly on real income, y, the price level, p, and the level of the nominal interest rate, i (foreign variables are denoted by an asterisk). Assuming continuous purchasing power parity ($\xi_t \equiv 0$ in [1]), and substituting out for relative prices, it is straightforward to derive the fundamental equation of the flexible-price monetary model:

$$s_t = m_t - m_t^* - \kappa(y_t - y_t) + \theta(i_t - i_t^*), \tag{4}$$

where κ and θ are the income elasticity and interest rate semielasticity of the demand for money (here assumed equal at home and abroad for expository purposes). By invoking the uncovered interest parity condition, we can substitute Δs_{t+1}^e for $(i_t - i_t^*)$ in order to emphasize the forward-looking nature of the model:

(5) $$s_t = \phi_t + \theta \Delta s^e_{t+1},$$

where ϕ_t is the monetary fundamental given by

(6) $$\phi_t = m_t - m^*_t - \kappa(y_t - y^*_t).$$

The rational expectations solution to (5) is

(7) $$s_t = (1 + \theta)^{-1} \sum_{i=0}^{\infty} \left(\frac{\theta}{1 + \theta}\right)^i E\left[\phi_{t+i} \mid \Omega_t\right],$$

where $E[\cdot \mid \Omega_t]$ denotes the mathematical expectation conditioned on the information set available at time t, Ω_t.[2] It is well known from the rational expectations literature, however, that equation (7) is only one solution to (5) from a potentially infinite set involving rational bubbles.

Note that the flexible-price monetary model is really just a purchasing power parity model of the exchange rate, where the proximate force driving relative prices is assumed to be relative excess demand for money.

The very high volatility of real exchange rates during the 1970s float, conspicuously refuting the assumption of continuous purchasing power parity, led to the development of two further models, the sticky-price monetary model and the so-called equilibrium model. Both of these can be viewed as extensions or modifications in some way of the flexible-price monetary model. Before examining the empirical evidence on the flexible-price monetary model, we give a brief exposition of the sticky-price monetary model.

8.1.3 The Sticky-Price Monetary Model

Sticky-price monetary models, due originally to Dornbusch (1976), allow short-term overshooting of the nominal and real exchange rates above their long-run equilibrium levels. This results as the "jump variables" in the system (exchange rates and interest rates) compensate for stickiness in other variables—notably goods prices. The essential characteristics of the sticky-price monetary model can be seen in a three-equation structural model in continuous time, holding foreign variables and domestic income constant (these are simplifying rather than necessary assumptions):

(8) $$\dot{s} = i - i^*,$$

(9) $$m = p + \kappa\bar{y} - \theta i,$$

(10) $$\dot{p} = \gamma[\alpha + \mu(s - p) - \bar{\psi} i - y].$$

Equation (8) is the uncovered interest parity condition expressed in continuous time and utilizing certainty equivalence because of the linearity of the model.

2. The other three models that we will present below may similarly be represented in terms of the entire expected future. We present that solution only for the model at hand and mention the succeeding models' deviations from the monetary model.

Equation (9) is a domestic money-market equilibrium condition, and equation (10) is a Phillips curve relation, relating domestic price movements to excess aggregate demand, where aggregate demand has an autonomous component, a component depending on international competitiveness, and a component that is interest rate sensitive.[3] If we use a bar to denote a variable in long-run (non-inflationary) equilibrium, we can reduce this system to a two-equation differential equation system:[4]

$$\begin{bmatrix} \dot{s} \\ \dot{p} \end{bmatrix} = \begin{bmatrix} 0 & 1/\theta \\ \gamma\mu & -\gamma(\mu + \Psi/\theta) \end{bmatrix} \begin{bmatrix} s - \bar{s} \\ p - \bar{p} \end{bmatrix}. \tag{11}$$

The coefficient matrix in (11) has a negative determinant, so the system has a unique convergent saddle path. The qualitative solution to (11) is shown in figure 8.1, where the saddle path slopes down left to right in (s, p)–space.

Monetary shocks will lead to overshooting in the model as the long-run equilibrium relative price level—and hence the saddle path—shifts, causing a discontinuous shift in the exchange rate onto the new saddle path, with prices initially constant. This is then followed by a slower movement of prices and the exchange rate toward the new equilibrium level.

Now consider the effects of a real shock to tastes for the domestic good as opposed to the foreign good. Say, for example, that there is a permanent shift in demand toward the home good, which would be represented by an increase in α. In terms of figure 8.1, the effect of the shift is to displace the equilibrium horizontally with the exchange rate fully and immediately making the adjustment to bring relative international prices into equilibrium. Unless the demand shift decays, there is no tendency for this disturbance's real effects to decrease over time.

A useful way to rewrite the model in discrete time is

$$s_t = \phi_t + z_t + \theta \Delta s^e_{t+1}, \tag{12}$$

where ϕ_t is a monetary fundamental comparable to that defined in (6) and

$$z_t = \theta r^*_t + (\psi/\mu) r_t + (r_t - r^*_t)(\lambda\mu) + (\bar{y} - \alpha)/\mu, \tag{13}$$

and where r_t is the real interest rate and z_t reflects real goods market influences on the nominal exchange rate for this case. It is immediately clear that shocks

3. For the sake of brevity, we are not distinguishing very carefully between the domestic price level, which includes domestic currency prices of imported goods, and the domestic currency price of domestic goods. If imported goods prices become sticky once they have been domestically priced, then the distinction is unimportant.

As in the Dornbusch (1976) presentation, we allow goods demand to depend apparently on the nominal rather than the real interest rate. We think of such a presentation in Dornbusch's terms as a semi-reduced form in which the inflation terms have been aggregated on the equation's left-hand side. Such complications have been clarified in the literature (Flood 1981), but none of them alter very much the basic results of the Dornbusch model.

4. Note that the level of the money stock is exogenous to the model, assumed under the control of the authorities. Thus, for any given level of the money stock, the perfect foresight equilibrium involves assuming $m = \bar{m}$.

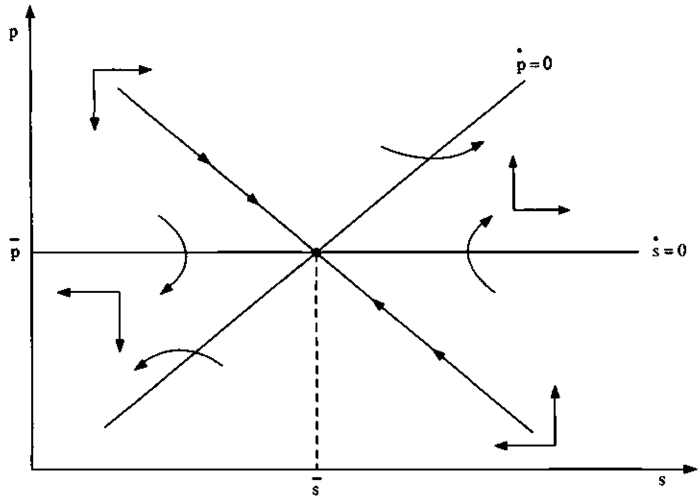

Fig. 8.1 The saddle path for the sticky-price monetary model

and influence z_t make the sticky-price monetary model's predictions diverge from those of the flexible-price monetary model, at least in the short run. To the extent that shocks to z_t are transitory, however, the differences between the monetary and the sticky-price models are transitory also.

8.1.4 Empirical Evidence on the Flexible-Price and Sticky-Price Monetary Models

Initial support for the flexible-price monetary model was provided by Frenkel (1976), who utilized data for the German mark/U.S. dollar exchange rate during the German hyperinflation of the 1920s. The subsequent accumulation of data for the 1970s float allowed estimation of the model for the major exchange rates during the recent float, and initial studies were also broadly supportive of the flexible-price monetary model (e.g., Bilson 1978; and Dornbusch 1976). Beyond the late 1970s, however, the flexible-price monetary model (or its real interest differential variant) ceases to provide a good explanation of variations in exchange rate data: the estimated equations break down, providing poor fits, exhibiting incorrectly signed coefficients, and failing general equation diagnostics (e.g., Frankel 1993).

The evidence for the sticky-price monetary model is also weak when the data period is extended beyond the late 1970s (Backus 1984). Another implication of the sticky-price monetary model is proportional variation between the real exchange rate and the real interest rate differential. This follows from the basic assumptions of the overshooting model: slowly adjusting prices and uncovered interest rate parity. A number of studies have failed to find strong evidence of this relation, notably Meese and Rogoff (1988), who could not find cointegration between real exchange rates and real interest rate differentials.

More recently, MacDonald and Taylor (1993, 1994) apply multivariate cointegration analysis and dynamic modeling techniques to a number of exchange rates and find some evidence to support the monetary model as a long-run equilibrium toward which the exchange rate converges, while allowing for complicated short-run dynamics. Since all the monetary models collapse to an equilibrium condition of the form (6) in the long run, these tests have no power to discriminate between the alternative varieties. The usefulness of the cointegration approach suggested by these studies should, moreover, be taken as at most tentative: their robustness across different data periods and exchange rates has yet to be demonstrated.

8.1.5 The Portfolio Balance Model

The key distinguishing feature of the portfolio balance model is the assumed imperfect substitutability between domestic and foreign assets.[5] Consider a simple model in which the net financial wealth of the private sector (W) is divided into three components: money (M), domestically issued bonds (B), and foreign bonds denominated in foreign currency and held by domestic residents (B^*). B can be thought of as a government debt held by the domestic private sector; B^* 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 (i.e., capital outflow and hence an increase in net foreign indebtedness to the domestic economy), the current account must give the rate of accumulation of B^* over time. With foreign and domestic interest rates given by i and i^* as before, we can write down our definition of wealth and simple domestic demand functions for its components as follows:[6]

$$W \equiv M + B + SB^*, \tag{14}$$

$$M = M(i, i^* + \hat{S}^e)W, \quad M_1 < 0, M_2 < 0, \tag{15}$$

$$B = B(i, i^* + \hat{S}^e)W, \quad B_1 > 0, B_2 < 0, \tag{16}$$

$$SB^* = B^*(i, i^* + \hat{S}^e)W, \quad B_1 < 0, B_2 > 0, \tag{17}$$

$$\dot{B}^* = T(S/P) + i^*B^*, \quad T_1 > 0, \tag{18}$$

where $\hat{S}^e$ denotes the expected rate of depreciation of the domestic currency.

Relation (14) is an identity defining wealth and (15), (16), and (17) are standard asset demand functions.[7] Equation (18) gives the rate of change of B^*, the

5. A comprehensive treatment of the portfolio balance model is given in Branson and Henderson (1985).

6. X_k denotes the partial derivative of $X(\cdot)$ with respect to the kth argument. The shift to uppercase letters here indicates that variables are in levels rather than logarithms. As throughout, interest rates are in percentage terms.

7. Note that, as is standard in most expositions of the portfolio balance model, 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).

capital account, as equal to the current account, which is in turn equal to the sum of the trade balance, $T(\cdot)$, and net debt service receipts, i^*B^*. The trade balance depends positively on the level of the real exchange rate (a devaluation improves the trade balance). The exchange rate is then determined by solving equations (14)–(18) for given levels of M, B, and B^*, normally assuming rational expectations. Disturbances to these stocks will result in movements in S in both the short run (solve [14]–[18] allowing the left-hand side of [18] to be nonzero) and the long run (impose the constraint that all asset levels are constant). More structure can be put on the model by assuming that the asset demand functions are determined by agents optimizing a function of the mean and variance of their end-of-period wealth.

8.1.6 Empirical Evidence on the Portfolio Balance Model

Log-linear versions of reduced-form portfolio balance exchange rate equations, using cumulated current accounts for the stock of foreign assets, have, however, been estimated for many of the major exchange rates for the 1970s float, with poor results: estimated coefficients are often insignificant, and there is a persistent problem of residual autocorrelation (e.g., Branson, Halttunen, and Masson 1977; Frankel 1993; see also Lewis 1988).

The imperfect substitutability of domestic and foreign assets that is assumed in the portfolio balance model is equivalent to assuming that there is a risk premium separating expected depreciation and the domestic-foreign interest differential, and in the portfolio balance model this risk premium will be a function of relative domestic and foreign debt outstanding. An alternative, indirect method of testing the portfolio balance model, therefore, is to test for empirical relations of this kind. Investigations of this kind have usually reported statistically insignificant relations (see Frankel 1982; and Rogoff 1984). In a recent study of the effectiveness of exchange rate intervention for dollar/mark and dollar/Swiss franc during the 1980s, Dominguez and Frankel (1993) measure the risk premium using survey data and show that the resulting measure can in fact be explained by an empirical model that is consistent with the portfolio balance model, with the additional assumption of mean-variance optimization on the part of investors. In some ways, the relative success of the Dominguez and Frankel (1993) study is consistent with the recent empirical literature on foreign exchange market efficiency, discussed below, which suggests the existence of significant foreign exchange risk premia and nonrational expectations.

8.1.7 The Equilibrium Model

Equilibrium exchange rate models of the type developed originally by Stockman (1980) and Lucas (1982) analyze the general equilibrium of a two-country model by maximizing the expected present value of a representative agent's utility, subject to budget constraints and cash-in-advance constraints (by convention, agents are required to hold local currency, the accepted me-

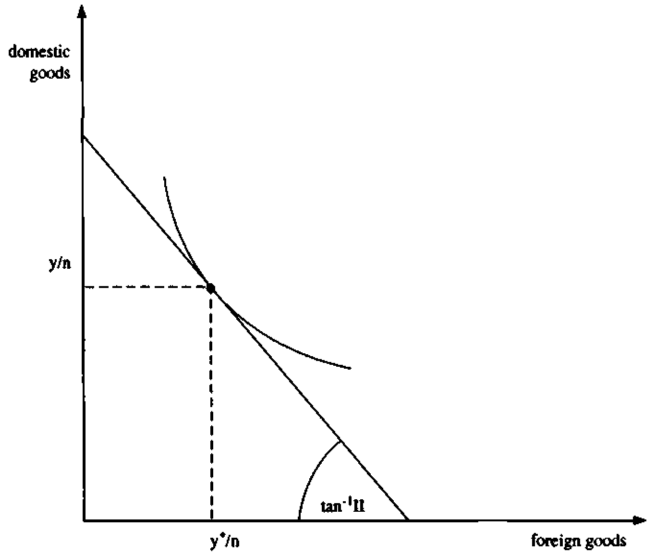

Fig. 8.2 A simple equilibrium exchange rate model

dium of exchange, with which to purchase goods).[8] In an important sense, equilibrium models are an extension or a generalization of the flexible-price monetary model to allow for multiple traded goods and real shocks across countries.

A simple equilibrium model can be sketched as follows. Consider a two-country, two-good world in which prices are flexible and markets are in equilibrium, as in the flexible-price monetary model, but in which, in contrast to the monetary model, agents distinguish between domestic and foreign goods in terms of well-defined preferences. Further, for simplicity, assume that all agents, domestic or foreign, have identical preferences. Then, given domestic and foreign output of y and y^*, respectively, the equilibrium relative price of foreign output, say Π, must be the slope of a representative agent's indifference curve at the point $(y^*/n,\ y/n)$ in foreign-domestic output per capita space (where $n/2$ is the number of individuals in each economy), as in figure 8.2. But the relative price of foreign output is the real exchange rate, which is defined in logarithmic form (π) by (3). Now consider log-linear domestic and foreign money demand functions for the representative agent:

(19) $$m_t = p_t + \kappa y_t,$$

(20) $$m_t^* = p_t^* + \kappa y_t^*,$$

8. For a more extensive, largely nontechnical exposition, see Stockman (1987). This literature is an offshoot of the real business cycle literature.

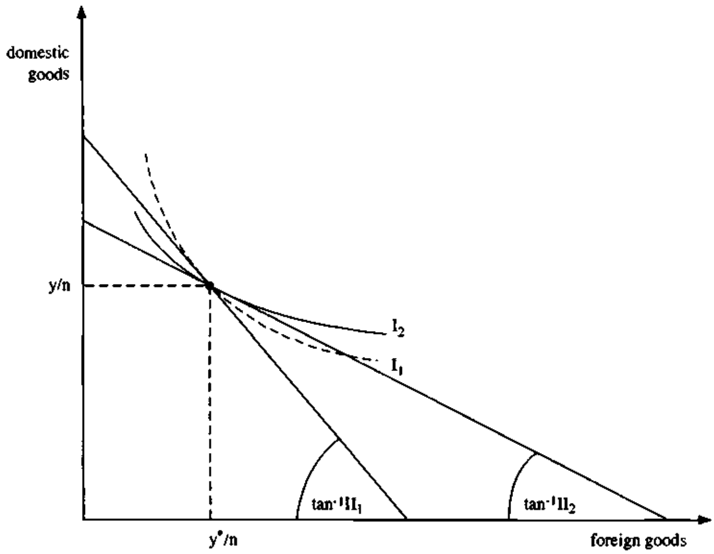

Fig. 8.3 The real exchange rate effect of a preference shift toward domestic goods in the equilibrium model

which, in an optimizing framework, can be interpreted as linearizations of expressions derived from maximizing the representative agent's utility function subject to a cash-in-advance constraint, assuming that government policy (and other influences on the constancy of parameters) remains constant. Combining these with the definition of the real exchange rate, (3), and solving for the nominal exchange rate, we can derive

$$s_t = m_t - m_t^* - \kappa(y_t - y_t^*) + \pi_t. \tag{21}$$

Equation (21) represents a very simple formulation of nominal exchange rate determination in the equilibrium model. At first sight, it appears to be a simple modification of the monetary model. Indeed, relative monetary expansion leads to a depreciation of the domestic currency as in the simple monetary model. However, as an example of a situation that it would be impossible to analyze in a flexible-price monetary model, consider an exogenous shift in preferences away from foreign goods toward domestic goods, represented as a flattening of indifference curves as in figure 8.3 (from I_1 to I_2). With per capita outputs fixed, this implies a fall in the relative price of foreign output (or, conversely, a rise in the relative price of domestic output)—Π falls (from Π_1 to Π_2 in fig. 8.3).[9] Assuming unchanged monetary policies, this movement in the

9. Note that uppercase pi denotes the real exchange rate, lowercase pi the logarithm of the real exchange rate.

real exchange rate will, however, be brought about entirely (and swiftly) by a movement in the nominal exchange rate without any movement in national price levels. Thus, demand shifts are capable of explaining the observed volatility of nominal exchange rates in excess of volatility in relative prices in equilibrium models. The fall in s, in this case matching the fall in π, will be observed as a decline in domestic competitiveness.[10]

8.1.8 Empirical Evidence on the Equilibrium Model

Although there is, in principle, no reason why a linearized version of the equilibrium model should not be estimated, advocates of this approach have preferred to point to the "consistency" of the model with the observed behavior of exchange rates. Well-known, stylized facts of the recent float include the high volatility and correlation of real and nominal exchange rates and the absence of strong mean-reverting properties in either series. As we noted above, equilibrium models are capable of explaining the variability of nominal exchange rates in excess of relative price variability (and hence the variability of real exchange rates), but so is the sticky-price monetary model. Some authors have argued, however, that the difficulty that researchers have experienced in rejecting the hypothesis of nonstationarity in the real exchange rate is evidence against the sticky-price model and in favor of equilibrium models since the former class of models requires some sort of long-run convergence of the real exchange rate toward PPP, while an equilibrium model characterized by random-walk innovations to taste and technology would generate a nonstationary real exchange rate. Explaining the persistence in both real and nominal exchange rates over the recent float within the framework of the sticky-price model, it is argued, involves assuming either implausibly sluggish price adjustment or else that movements in nominal exchange rates are due largely to permanent real disturbances (e.g., Stockman 1987).

This line of argument overlooks, however, the fact that *relative* shocks to tastes and technology between countries are more likely to be mean reverting (e.g., because of technology transfer). Moreover, as Frankel (1990) argues forcibly, noncontradiction is not the same as confirmation: simply being consistent with the facts is not enough to demonstrate the empirical validity of a theory.

One testable implication of the simplest equilibrium models is the neutrality of the exchange rate with respect to the exchange rate regime: since the real exchange rate is determined by real variables such as tastes and technology, its

10. In the simple equilibrium model that we have sketched here, we have implicitly made a host of simplifying assumptions. Chief among these is the assumption that individuals in either economy hold exactly the same fractions of their wealth in any firm, domestic or foreign. If this assumption is violated, then supply and demand shifts will alter the relative distribution of wealth between domestic and foreign residents as, e.g., one country becomes relatively more productive. This, in turn, will affect the equilibrium level of the exchange rate (Stockman 1987).

behavior ought to be independent of whether the nominal exchange rate is pegged or allowed to float freely. Using data for a large number of countries and time periods, however, researchers have invariably found that real exchange rates are significantly more volatile under floating nominal rate regimes (Stockman 1983; Mussa 1986; Baxter and Stockman 1989).

Although this evidence does, indeed, constitute a rejection of the simplest equilibrium models, it is possible that the evidence is to some extent confounded by the endogeneity of the choice of exchange rate regime—that is, countries experiencing greater real disturbances are more likely to choose flexible exchange rate systems. Moreover, Stockman (1983) also shows that the assumptions necessary for regime neutrality are in fact quite restrictive in a fully specified equilibrium model and include Ricardian equivalence, no wealth-distribution effects of nominal price changes, no real effects of inflation, no real effects of changes in the level of the money supply, complete asset markets, completely flexible prices, and identical sets of government policies under different exchange rate systems. Since it is unlikely that all these conditions will be met in practice, Stockman argues that only the simplest class of equilibrium models should be rejected and that equilibrium models should be developed that relax some or all of these assumptions. Moreover, Stockman (1988) argues that, because of the increased likelihood of countries with fixed exchange rates introducing controls on trade or capital flows, a disturbance that would tend to raise the relative price of foreign goods (e.g., a preference shift toward foreign goods) will raise the probability that the domestic country will, at some future point, impose capital or trade restrictions that will raise the future relative world price of domestic goods. With intertemporal substitution, this induces a higher world demand for domestic goods now, serving to offset partly the direct effect of the disturbance, which was to raise the relative price of the foreign good, and hence to reduce the resulting movement in the real exchange rate. Thus, countries with pegged exchange rates will experience lower volatility in the real exchange rate than countries with flexible exchange rates.

This discussion makes clear that the equilibrium model is not so much a model as a way of viewing the world in strictly equilibrium terms. In particular, it is not clear exactly what the proponents of this approach would accept as a decisive rejection of the model.

8.1.9 Forecasting with Macro-Based Exchange Rate Models

In a landmark paper, Meese and Rogoff (1983a) compare the out-of-sample forecasts produced by various macro-based exchange rate models with forecasts produced by a random-walk model, by the forward exchange rate, by a univariate regression of the spot rate, and by a vector autoregression. They use rolling regressions to generate a succession of out-of-sample forecasts for each model and for various time horizons. The conclusion that emerges from this study is that, on a comparison of root mean square errors (RMSEs), none of the asset market exchange rate models outperforms the simple random walk.[11] Further work by the same authors (Meese and Rogoff 1983b) suggested that the estimated models may have been affected by simultaneity bias. Imposing coefficient constraints taken from the empirical literature on money demand, Meese and Rogoff find that, although the coefficient-constrained asset reduced forms still fail to outperform the random-walk model for most horizons up to a year, combinations of parameter constraints can be found such that the models do outperform the random-walk model for horizons beyond twelve months. Even at these longer horizons, however, the models are unstable in the sense that the minimum RMSE models have different coefficient values at different horizons.

Although beating the random walk still remains the standard metric in which to judge empirical exchange rate models, researchers have found that one key to improving forecast performance based on economic fundamentals lies in the introduction of equation dynamics. This has been done in various ways: by using dynamic forecasting equations for the forcing variables in the forward-looking, rational expectations version of the flexible-price monetary model, by incorporating dynamic partial adjustment terms into the estimating equation, by using time-varying parameter estimation techniques, and—most recently—by using dynamic error correction forms (Throop 1993; MacDonald and Taylor 1993, 1994; Mark 1992).

8.2 Speculative Efficiency

In tandem with work on macro-based exchange rate models, there has developed a whole body of literature on the speculative efficiency of foreign exchange markets. This literature is important in the present context for at least three reasons. First, efficiency conditions such as uncovered interest parity are often used as building blocks in constructing macro-based exchange rate models. Second, the empirical literature of the efficiency of the foreign exchange market has thrown up a number of stylized facts (indeed, anomalies) that provide a challenge for models of foreign exchange market microstructure to explain. Third, and most important, a standard route by which market microstructure has traditionally been dismissed is via the assumption of market efficiency. If, indeed, smart speculators always tend to dominate in the foreign exchange market, as Friedman's classic apologia of floating exchange rates argues (Friedman 1953), then the aggregate behavior of foreign exchange markets can in fact be summarized by a handful of parity conditions that characterize the mar-

11. Meese and Rogoff (1983a) compare random-walk forecasts with those produced by the flexible-price monetary model, Frankel's (1979) real interest rate differential variant of the monetary model, and a synthesis of the monetary and portfolio balance models suggested by Hooper and Morton (1982).

ket equilibrium. For the purposes of market efficiency, the most important parity condition that researchers have considered is that of uncovered interest rate parity.

If the risk-neutral efficient markets hypothesis holds, then the expected foreign exchange gain from holding one currency rather than another (the expected exchange rate change) must be just offset by the opportunity cost of holding funds in this currency rather than the other (the interest rate differential). This is the uncovered interest rate parity condition:

$$\Delta_k s_{t+k} = i_t - i_t^*. \tag{22}$$

Researchers have most often tested uncovered interest rate parity by regression-based analyses of spot and forward exchange rates. Assuming covered interest parity, the interest rate differential should be just equal to the forward premium. Under rational expectations, the expected change in the exchange rate should differ from the actual change only by a rational expectations forecast error. Hence, the uncovered interest rate parity condition (26) can be tested by estimating a regression equation of the form

$$\Delta_k s_{t+k} = \alpha + \beta\,(f_t^{(k)} - s_t) + \eta_{t+k}, \tag{23}$$

where $f_t^{(k)}$ is the logarithm of the forward rate for maturity k periods ahead. If agents are risk neutral and have rational expectations, we should expect the slope parameter, β, to be equal to one and the disturbance term η_{t+k}—the rational expectations forecast error under the null hypothesis—to be uncorrelated with information available at time t. Empirical studies of (23), for a large variety of currencies and time periods, for the recent floating experience generally report results that are unfavorable to the efficient markets hypothesis under risk neutrality (e.g., Fama 1984). Indeed, it is a stylized fact that estimates of β, using exchange rates against the dollar, are generally closer to minus unity than plus unity (Froot and Thaler 1990).[12]

The rejection of the simple, risk-neutral efficient markets hypothesis may be due to the risk aversion of market participants or to a departure from the pure rational expectations hypothesis, or both. If foreign exchange market participants are risk averse, the uncovered interest parity condition (22) may be distorted by a risk premium. If the risk premium is time varying and correlated with the forward premium or the interest rate differential, this would confound efficiency tests of the kind outlined above (Fama 1984). This reasoning has led to a search for stable empirical models of the risk premium on the assumption of rational expectations. Because of the theoretical relation between risk and the second moments of asset price distributions, researchers have often tested

12. Alternatively, researchers have imposed $\beta = 1$ in equations such as (23) and tested the orthogonality of the error term, η_{t+k}, with respect to information available at time t. Such tests have also generally rejected the simple speculative efficiency hypothesis (see, e.g., Hodrick 1987).

for a risk premium as a function of the variance of forecast errors or of exchange rate movements (Frankel 1982; Domowitz and Hakkio 1985; Giovannini and Jorion 1989). In common with other empirical risk premium models, such as latent variables formulations (Hansen and Hodrick 1983), such models have generally met with mixed and somewhat limited success and have not been found to be robust when applied to different data sets and sample periods. In sum, it appears that, for credible degrees of risk aversion, empirical risk premium models have so far been unable to explain to any significant degree the variation in the excess return from forward market speculation.

An alternative explanation of the rejection of the simple efficient markets hypothesis is that there is a failure, in some sense, of the expectations component of the joint hypothesis. Examples in this group are the "peso problem" suggested by Kenneth Rogoff (1979), rational bubbles, learning about regime shifts (Lewis 1989), or inefficient information processing (as suggested, e.g., by John Bilson [1981]). The peso problem refers to the situation where agents attach a small probability to a large change in the economic fundamentals, which does not occur in sample. This will tend to produce a skew in the distribution of forecast errors even if agents' expectations are rational and thus may generate apparent evidence of nonzero excess returns from forward speculation. In common with peso problems, the presence of rational bubbles may also show up as nonzero excess returns even when agents are risk neutral. Similarly, when agents are learning about their environment, they may be unable fully to exploit arbitrage opportunities that are apparent in the data ex post. A problem with admitting peso problems, bubbles, or learning into the class of explanations of the forward discount bias is that, as noted above, a very large number of econometric studies—encompassing an even larger range of exchange rates and sample periods—have found that the direction of bias is the same, that is, that the estimated uncovered interest rate parity slope parameter, β in (23), is generally negative and closer to minus unity than plus unity.

A problem with much of the empirical work on the possible rationalizations of the rejection of the simple, risk-neutral efficient markets hypothesis is that, in testing one leg of the joint hypothesis, researchers have typically assumed that the other leg is true. For instance, the search for a stable empirical risk premium model has generally been conditioned on the assumption of rational expectations. Thus, some researchers have employed survey data on exchange rate expectations to conduct tests of each component of the joint hypothesis (Froot and Frankel 1989). In general, the overall conclusion that emerges from survey data studies appears to be that both risk aversion and departures from rational expectations are responsible for rejection of the simple efficient markets hypothesis.[13]

13. For surveys of the literature on foreign exchange risk premia, see Frankel (1988) and Lewis (1994).

8.3 What's Right with the Conventional Macro Approach?

In this section. we present some further empirical evidence on the relation between exchange rate movements and macroeconomic fundamentals by examining the purchasing power parity and uncovered interest rate parity conditions. using panel data for twenty-two countries.[14]

8.3.1 Purchasing Power Parity

Consider again the simple purchasing power parity equations (1) and (2). reproduced here with time-series disturbances ξ_t and ε_t and slope parameters β and γ:

(24) $$s_t = \beta(p_t - p_t^*) + \xi_t.$$

(25) $$\Delta s_t = \gamma(\Delta p_t - \Delta p_t^*) + \xi_t'.$$

Estimation of these relations (with a constant term added) for dollar/sterling and dollar/mark. using annual data for the period 1973–92. yields:[15]

dollar/sterling

(26) $$s_t = 0.671 + 0.734(p_t - p_t^*) + \hat{\xi}_t.$$
$$R^2 = 0.31.\ DW = 0.51.\ ADF = 2.25:$$

(27) $$\Delta s_t = \underset{(0.044)}{-0.039} - \underset{(1.266)}{0.235}(\Delta p_t - \Delta p_t^*) + \hat{\xi}_t'.$$
$$R^2 = 0.001.\ DW = 1.29:$$

dollar/mark

(28) $$s_t = -0.535 + 0.606(p_t - p_t^*) + \hat{\xi}_t.$$
$$R^2 = 0.30.\ DW = 0.85.\ ADF = 1.13:$$

(29) $$\Delta s_t = \underset{(0.046)}{0.009} + \underset{(0.861)}{0.408}(\Delta p_t - \Delta p_t^*) + \hat{\xi}_t'.$$
$$R^2 = 0.008.\ DW = 1.89.$$

14. We are. of course. not the first researchers to examine the PPP relation using panel data. Officer (1980). e.g.. finds a broadly proportional relation between the rate of depreciation and relative inflation for a similar group of countries to those examined below. for the period 1913–75. MacDonald (1988) uses a variety of estimation techniques on pooled annual time-series cross-sectional data for the G-5 countries plus Switzerland and provides evidence supportive of relative PPP.

15. The data used in this section are annual observations taken from the International Monetary Fund's International Financial Statistics CD-rom database: exchange rates are usually line ae. prices are CPI (line 64). output is real GDP (line 99b. r). and interest rates are mainly three-month Treasury bill rates (line 60c).

Figures in parentheses are heteroskedastic-consistent standard errors. R^2 denotes the coefficient of determination. DW the Durbin-Watson statistic. and ADF the augmented Dickey-Fuller statistic applied to the estimated residuals. The individual series were found to be approximately $I(1)$. so the estimated standard errors are not reported for the levels regressions.

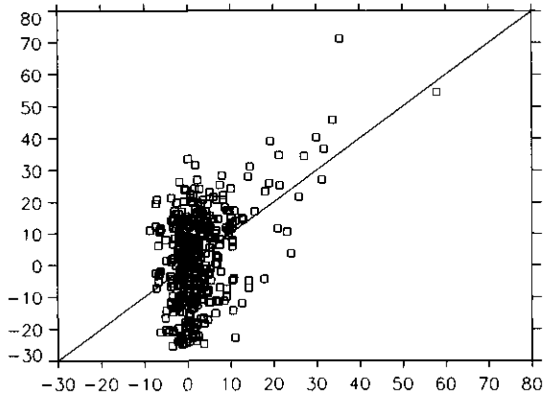

Fig. 8.4 Scatter plot of annual exchange rate change against annual inflation differential

These equations are typical of single-equation results reported in the literature for the recent floating-rate period: there is no apparent sign of cointegration of the exchange rate and relative prices, and relative inflation explains less than 1 percent of the time-series variation in the nominal exchange rate.

In figure 8.4, we have plotted the annual exchange rate change against the annual inflation differential for twenty-one industrialized countries against the United States for the period 1973–92.[16] This scatter plot is vaguely suggestive of a positive linear relation between the rate of depreciation and the inflation differential, especially for large inflation differentials.

In figure 8.5, we also plot the annual rate of depreciation against the United States, but this time using five-year averages (four for each country, corresponding to the periods 1973–77, 1978–82, and 1983–87, and 1988–92). Figure 8.5 appears to reveal a stronger medium-term relation between the exchange rate and relative inflation, in the sense that the scatter is much closer to the forty-five-degree line, albeit with one or two outliers. When the data are averaged over periods of ten or twenty years (figs. 8.6 and 8.7, respectively), the proportionality between average relative inflation and average depreciation becomes even more marked, as the scatter more or less collapses onto the forty-five-degree ray.

These visual impressions are largely confirmed by regression analysis, the full results of which are given in the appendix. By simply pooling the twenty years of data on annual changes, for example, we obtained the following pooled estimate:

16. The countries besides the United States included in the sample are Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Japan, the Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, and the United Kingdom. All data were taken from the IFS database.

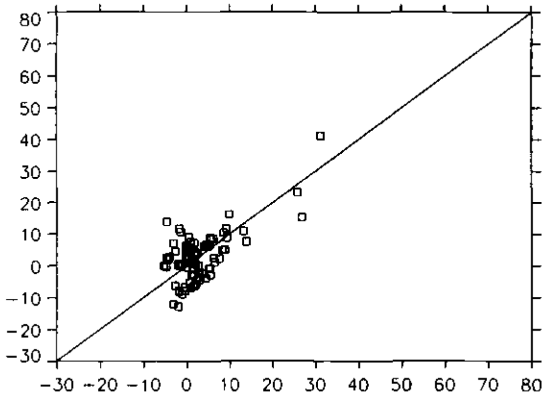

Fig. 8.5 Scatter plot of five-year average exchange rate change against five-year average inflation differential

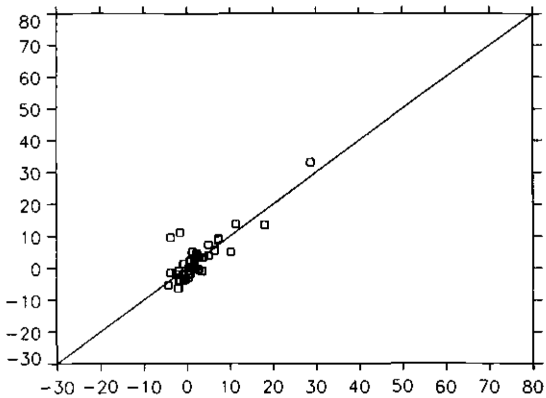

Fig. 8.6 Scatter plot of ten-year average exchange rate change against ten-year average inflation differential

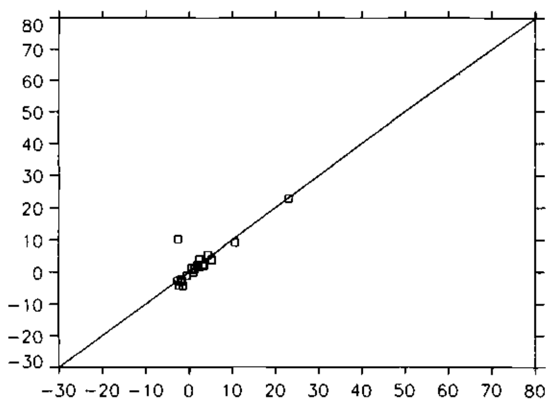

Fig. 8.7 Scatter plot of twenty-year average exchange rate change against twenty-year average inflation differential

$$\text{(30)} \qquad \Delta s_t = \underset{(0.007)}{0.022} \underset{(0.108)}{-0.109}(\Delta p_t - \Delta p_t^*) + \hat{\xi}_t',$$

$R^2 = 0.003$, pooled data, annual changes, whole sample, $N = 420$.

Clearly, there appears to be little gained from pooling the annual changes, with less than 1 percent of the pooled variation in the rate of depreciation being explained by relative inflation. However, in a pooled regression consisting of the four five-year average annual rates of depreciation for each country against the corresponding five-year average annual inflation differential, we obtained

$$\text{(31)} \qquad \overline{\Delta s_t} = \underset{(0.742)}{0.356} + \underset{(0.159)}{0.807} (\overline{\Delta p_t} - \overline{\Delta p_t^*}) + \hat{\xi}_t',$$

$R^2 = 0.432$, pooled data, five-year-average changes, whole sample, $N = 84$.

Equation (31) explains over 40 percent of the pooled variation in the rate of depreciation, the slope coefficient is strongly significantly different from zero but insignificantly different from unity, and the intercept term is insignificantly different from zero. Moreover, ordering the data in increasing order of absolute magnitude of the difference in five-year average annual inflation rates, we obtained for the fourth quartile

$$\text{(32)} \qquad \overline{\Delta s_t} = \underset{(2.077)}{-0.764} + \underset{(0.227)}{0.960}(\overline{\Delta p_t} - \overline{\Delta p_t^*}) + \hat{\xi}_t',$$

$R^2 = 0.695$, pooled data, five-year-average changes, fourth quartile, $N = 21$.

Nearly 70 percent of the pooled variation in the rate of depreciation is explained, and the point estimate of the slope coefficient is very close to unity. The results for the fourth quartile using five-year averages are broadly echoed for the whole-sample estimates using ten- and twenty-year averages. For the ten-year averages, for example, we obtained

$$\text{(33)} \qquad \overline{\Delta s_t} = \underset{(0.722)}{0.165} + \underset{(0.129)}{0.967}(\overline{\Delta p_t} - \overline{\Delta p_t^*}) + \hat{\xi}_t',$$

$R^2 = 0.693$, pooled data, ten-year-average changes, whole sample, $N = 21$.

The strength of the relative PPP relation in the time-averaged data is quite intriguing, and we provide an interpretation of these results below. Before doing so, however, we present the results of analyzing the uncovered interest parity relation using panel data.[17]

8.3.2 Uncovered Interest Rate Parity

Although it is not unusual to use low-frequency data when examining purchasing power parity, researchers are usually much more fastidious in their treatment of data for efficiency conditions such as uncovered interest rate par-

17. Although, as noted above, we are not the first researchers to examine PPP using panel data, we are unaware of any previous study that applies time-averaged panel data to study the uncovered interest rate parity relation.

ity and covered interest rate parity (see, e.g., Hodrick 1987; Taylor 1988, 1989). This is for good reasons—namely, that tiny mismatches or imperfections in the data may be mistaken for arbitrage opportunities that, although small in size, would nevertheless be highly profitable for a foreign exchange market participant moving around very large sums of money. In the present context, however, we are concerned with looking at uncovered interest rate parity in very broad terms, to see whether interest differentials have *any* relation with exchange rate movements.[18] Clearly, our results should be taken as indicative only.

Again using annual data for the same group of twenty-one countries plus the United States for the floating-rate period, 1973–92, we constructed the annual interest rate differential, using three-year government bond rates, and the three-year rate of exchange rate depreciation against the U.S. dollar.[19] For the pooled data, we obtained the following results:

$$(34) \qquad \Delta_3 s_{t+3} = \underset{(1.656)}{2.599} + \underset{(0.195)}{0.596}(i_t - i_t^*) + \hat{\eta}_t,$$

$$R^2 = 0.066, \text{ pooled data, annual data, whole sample,}$$

$$N = 420, \ \chi^2(1) = \underset{(0.038)}{4.72},$$

where figures in parentheses below coefficient estimates are method-of-moments corrected standard errors, and $\chi^2(1)$ is a Wald test statistic for the null hypothesis that the slope coefficient is unity (figures below it in parentheses denote the marginal significance level). Equation (34) is typical in the sense that the R^2 is low and the slope coefficient significantly different from unity at the 5 percent level. It is, however, untypical in that the slope coefficient is positive.

To investigate the effects of the size of the interest differential on the performance of the uncovered interest parity condition, we ordered the data by the size of the absolute interest differential and reestimated the relation for each of the four quartiles. For the first quartile (i.e., smallest values of $|i_t - i_t^*|$), we obtained

$$(35) \qquad \Delta_3 s_{t+3} = \underset{(3.243)}{4.159} - \underset{(1.343)}{2.999}(i_t - i_t^*) + \hat{\eta}_t,$$

$$R^2 = 0.036, \text{ pooled data, first quartile, } N = 105, \ \chi^2(1) = \underset{(0.003)}{8.851},$$

18. The view that forward premia or interest differentials have little relation with exchange rate movements appears to be a widespread conclusion of the literature: "Forward premia contain little information regarding subsequent exchange rate changes. As emphasized by Dornbusch (1980), Mussa (1979), and Frenkel (1981), exchange rate changes over the recent period of floating seem to have been largely unanticipated" (Cumby and Obstfeld 1984, 139).

19. Because the interest rates are expressed in annualized terms, it was appropriate to multiply them by three in order to put them into three-year terms. We used ordinary least squares with a method-of-moments correction to the estimated covariance matrix to allow for heteroskedasticity and moving-average errors.

which exhibits the characteristic negative slope coefficient and a lower R^2.

For the second quartile, the result was

$$\Delta_3 s_{t+3} = \underset{(1.732)}{5.208} - \underset{(0.475)}{0.798}(i_t - i_t^*) + \hat{\eta}_t \tag{36}$$

$R^2 = 0.024$, pooled data, second quartile, $N = 105$, $\chi^2(1) = \underset{(0.000)}{14.345}$,

which shows a very typical slope coefficient estimate that is closer to minus unity than plus unity and an even smaller R^2.

For the third quartile, we obtained

$$\Delta_3 s_{t+3} = \underset{(2.841)}{-1.405} + \underset{(0.329)}{0.609}(i_t - i_t^*) + \hat{\eta}_t, \tag{37}$$

$R^2 = 0.046$, pooled data, third quartile, $N = 105$, $\chi^2(1) = \underset{(0.235)}{1.409}$,

while, for the fourth quartile (i.e., the largest values of $|i_t - i_t^*|$), the resulting estimate was

$$\Delta_3 s_{t+3} = \underset{(7.460)}{11.121} + \underset{(0.273)}{0.520}(i_t - i_t^*) + \hat{\eta}_t \tag{38}$$

$R^2 = 0.079$, pooled data, fourth quartile, $N = 105$, $\chi^2(1) = \underset{(0.079)}{3.087}$.

It is interesting to note that, for the third and fourth quartiles, the slope coefficient is insignificantly different from unity at the 5 percent level. However, although there is some improvement in the goodness of fit, the R^2's are still quite low, and the slope coefficients are not in fact significantly different from zero at the 5 percent level.

As in the analysis of PPP, the next step was to average the data temporally. Using pooled five-year averages for the data for the whole sample, we obtained the following estimate:

$$\overline{\Delta_3 s_{t+3}} = \underset{(2.020)}{0.632} + \underset{(0.171)}{0.751}(\overline{i_t - i_t^*}) + \hat{\eta}_t, \tag{39}$$

$R^2 = 0.190$, pooled data, five-year averages, whole sample,
$N = 84$, $\chi^2(1) = \underset{(0.145)}{2.124}$.

Equation (39) is quite impressive in the sense that the goodness of fit has risen dramatically from the unaveraged cases—by a factor of twenty-five or more. Moreover, the slope coefficient is now strongly significantly different from zero and insignificantly different from zero at the 5 percent level. These effects with respect to the goodness of fit and the slope coefficient are even more marked when we consider the results of running the same regressions using data that have been time averaged over ten or twenty years:

$$\overline{\Delta_3 s_{t+3}} = \underset{(1.942)}{0.706} + \underset{(0.111)}{1.075}(\overline{i_t - i_t^*}) + \hat{\eta}_t, \tag{40}$$

$R^2 = 0.400$, pooled data, ten-year averages, whole sample, $N = 42$, $\underset{(0.497)}{\chi^2(1) = 0.461}$;

$$\overline{\Delta_3 s_{t+3}} = \underset{(1.556)}{-2.721} + \underset{(0.293)}{1.481}(\overline{i_t - i_t^*}) + \hat{\eta}_t, \tag{41}$$

$R^2 = 0.772$, pooled data, twenty-year averages, whole sample, $N = 42$, $\underset{(0.100)}{\chi^2(1) = 2.697}$.

Given the plethora of results on uncovered interest rate parity that have found little or no empirical connection between interest rates and the exchange rate or, if anything, have found negative covariation between the interest differential or forward premium and the rate of depreciation, these results are very striking and quite intriguing. Moreover, as we noted above, we have used a ready-made data set from the IFS (International Financial Statistics, International Monetary Fund) and have not spent a great deal of time worrying about aligning maturity dates, checking that the instruments are identical in all relevant respects across countries, and so on. These shortcomings in the data set would be most relevant if we did *not* find evidence of uncovered interest rate parity in the averaged data; as it is, they serve only to underscore the strength of the relation that we appear to be unearthing.

8.3.3 Interpretation

In this section, we have shown that very simple macro fundamentals—relative inflation or relative interest rates—have poor explanatory power with respect to variations in exchange rate movements even over the one-year horizon. Taking five-, ten-, and twenty-year averages, however, we found that a strong proportionality between average exchange rate depreciation and average movements in the fundamentals begins to emerge. The analysis is thus indicative of something that Rick and Ilsa knew long ago: the fundamental things apply as time goes by. Moreover, the analysis also suggests that the variation of deviations from the fundamentals appears to be inversely related to the size of the movements in the underlying fundamentals.

Our interpretation of these results is that, while the nominal exchange rate is extremely hard to distinguish from a random walk even at the one-year horizon, a simple macro fundamentals–based model outperforms the random walk at horizons of five years or longer. To see this clearly, note that the n-year average annual change in the exchange rate is defined as

(43) $$(1/n)\sum_{i=0}^{n}\Delta s_{t+i} = (1/n)(s_{t+n} - s_t).$$

Thus, finding that the n-year average exchange rate change is explained by macro fundamentals is equivalent to finding that the n-year-ahead random-walk forecast is beaten in sample by a simple macro fundamentals model.

The results also tell us something about the nature of deviations from the fundamentals. The change in the exchange rate can be defined as the sum of a component that is explained by movements in the macro fundamentals (such as relative inflation or relative nominal interest rates, or whatever macro variables that, in turn, determine them), F_t, and a component that is unexplained by the macro fundamentals, U_t:

(43) $$\Delta s_t \equiv F_t + U_t.$$

When Δs_t is averaged over periods of five years or more, the estimated slope coefficient from a regression of Δs_t onto F_t tends toward unity, and the R^2 rises dramatically, a result that holds for both the PPP and the UIP (uncovered interest rate parity) analyses. This implies that the variance of the movement in the exchange rate unexplained by the macro fundamentals declines dramatically over periods of five years or more, which must mean that the year-by-year time-series errors cancel out approximately:

(44) $$(1/n)\sum_{i=0}^{n} U_{t+i} \approx 0, \quad \text{for } n > 5 \text{ years.}$$

Thus, there appears to be little effect from omitting U_t from the regressions using averaged data. However, the fact that the estimated slope coefficient in the regressions using annual, unaveraged data is quite different from the estimates obtained using the averaged data suggests that the unexplained component is correlated with the component of the change explained by the macro fundamentals at the annual level:

(45) $$\mathrm{Corr}(F_t, U_t) \neq 0.$$

One interpretation of our results is that averaging U_t provides a filter that vastly reduces the variance of the disturbance term and that much of this reduction is in terms of reduced covariation of the residual with the fundamental. This covariance, of course, would also be reduced if we had truly exogenous fundamentals or instruments for the fundamentals.

Thus, our analysis suggests the following. First, short-run deviations of the exchange rate, from the path consistent with the macro fundamentals alone, are responsible for the greater proportion of the short-run variation in nominal exchange rates. Second, these deviations apparently cancel out over periods of five years or more. Third, and perhaps most puzzling, the deviations appear to be correlated with the fundamentals themselves in the annual data.

8.4 Conclusion: What's Wrong with the Conventional Macro Approach?

The empirical work summarized in sections 8.1 and 8.2 suggests that, for industrial countries during "normal times" (i.e., when they are not experiencing economic pathologies such as a hyperinflation), conventional macro fundamental models of exchange rate behavior are incapable of explaining the greater proportion of the variation in nominal exchange rate movements. It is apparent that there are important influences, not on the list of standard macro fundamentals, that affect short-run exchange rate behavior, and standard macro-based models perform poorly when subjected to standard time-series econometric testing—typically providing poor in-sample fits and miserable postsample predictive performance. Hence, there seems to be little professional disagreement with the view that, as a guide to the short-run behavior of the major exchange rates, exchange rate models based on macro fundamentals have largely failed.

The macro-based models have, to some extent, been rehabilitated in studies that have used cointegration or error-correction-type models to forecast the exchange rate. These studies, however, in common with recent cointegration studies on exchange rates and purchasing power parity, provide evidence for the view that it is the longer-run or low-frequency movements in exchange rates that are correlated with the traditional macro fundamentals, while the shorter run movements are poorly understood or, to use the applied researcher's euphemism, "noisy."

Some generic evidence on the relevance of economic fundamentals for short-run exchange rate behavior is provided in a recent study by Flood and Rose (1993). Observing the increased volatility of exchange rates under floating as opposed to fixed exchange rate regimes, these authors argue that any tentatively adequate exchange rate model should have fundamentals that are also much more volatile during floating-rate regimes. In fact, they find little shift in the volatility of economic fundamentals suggested by flexible-price or sticky-price monetary models across different nominal exchange rate regimes for a number of OECD exchange rates. Similar evidence is reported by Baxter and Stockman (1989). More generally, a number of studies have noted that, under the recent float, nominal exchange rates have shown much greater variability than important macroeconomic fundamentals such as price levels and real incomes (e.g., Dornbusch and Frankel 1988; Frankel and Froot 1990; Marston 1989).[20] Again, this suggests that there are speculative forces at work in

20. Some analyses suggest that exchange rate volatility can change dramatically across regimes even though the volatility of the macro fundamentals does not. This point was crucial, e.g., in the Dornbusch (1976) overshooting model and in the Krugman (1991) target zone model. In both these models, and in rational expectations models in general, the Lucas critique applies, and the form of the reduced-form relation between the exchange rate and the fundamentals is not invariant

the foreign exchange market that are not reflected in the usual menu of macroeconomic fundamentals: given the exhaustive interrogation of the macro fundamentals in this respect over the last twenty years, it would seem that our understanding of the short-run behavior of exchange rates is unlikely to be further enhanced by further examination of the macro fundamentals. And it is in this context that new work on the microstructure of the foreign exchange market seems both warranted and promising.

The results of the research program into the speculative efficiency of the foreign exchange market also have important implications for the new research program into the microstructure of foreign exchange markets as well as the more conventional, macro-based approach. In particular, the rejection of the simple speculative efficiency hypothesis as applied to the foreign exchange market and the stylized empirical fact of a negative covariation between the rate of depreciation and the forward premium challenges conventional, macro-based approaches to the foreign exchange market since it suggests that one cannot take for granted many of the efficiency conditions that are typically subsumed in macro-based exchange rate models. Even under the assumption of risk aversion alongside that of rational expectations, the stylized fact of the so-called negative discount bias is very hard to explain (Fama 1984). Moreover, the evidence, from studies employing survey data, that foreign exchange market participants are neither risk averse nor conform to the rational expectations hypothesis suggests that the heterogeneity of agents' expectations across the foreign exchange market—itself highlighted in some recent survey data studies—may itself be an important feature determining short-run exchange rate behavior. The processes by which information is obtained and disseminated throughout markets is not amenable to analysis within a standard macro approach but is clearly of major importance given heterogeneity of agents' expectations and information sets (see, e.g., Lyons 1995). Information processing may also be at the root of the contagion in volatility across foreign exchange markets that has been documented.[21] Moreover, the finding that a high proportion of foreign exchange market participants deliberately use analytic techniques that ignore macro fundamentals (i.e., "technical" or "chartist" analysis), especially over shorter horizons (Taylor and Allen 1992), underscores the importance of allowing for the interaction of diverse forces in the short-run determination of exchange rates (Goodhart 1988; Frankel and Froot 1990).

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to the policy regime. To circumvent this well-known critique as well as the possibility that the presence of exchange rate bubbles may be regime dependent, Flood and Rose (1993) studied exchange rate and fundamentals volatility in structural equations rather than reduced-form expressions so that their conclusions are close to immune to the Lucas critique and bubbles issue. We say "close to immune" because it could be that exchange rate policy change results in structural coefficient drift, but this would be a thin reed on which to base exchange rate models.

21. So-called meteor showers (Engle, Ito, and Lin 1990).

The additional empirical results reported in this paper underscore the view that empirical work on macro-based exchange rage models has been hampered by "contamination" of the data with a high degree of short-run noise. Industrial countries are different from each other, but the differences in exchange rate fundamentals change very slowly through time, while exchange rate time series show comparatively huge variation. To investigate this question, we work with a panel of data on twenty-two industrialized countries (including the United States) during the recent floating exchange rate era. In our investigation, we suppress noisy time-series variation in a series of steps. We first study two very simple exchange rate relations, relative purchasing power parity and uncovered interest rate parity, with annual data, then with five-year averaged, ten-year averaged, and, finally, twenty-year averaged data. Formally, as we temporally average the data, we also temporally average the time-series disturbances until, eventually, they disappear, leaving us with a cross-sectional model apparently purged of temporal noise. We find that the simple fundamentals models work extremely well in the pure cross section, with inflation or interest rate differentials explaining a very high proportion of the cross-sectional variation in exchange rate movements. We have, therefore, provided some additional evidence that the macro fundamentals should not be dismissed entirely. It is clear that the macro fundamentals in an important sense "set the parameters" within which exchange rates move but that these parameters are very broad indeed over the short run. Developing microstructural models of short-run exchange rate movements within these wide parameters is the challenge that researchers in this field now face.

Appendix
Detailed PPP Regression Results

Table 8A.1 Annual Changes

$\Delta s_t = \alpha + \gamma(\Delta p_t - \Delta p_t^*) + \varepsilon_t$

Sample	N	Estimates Method	$\hat{\alpha}$	$\hat{\gamma}$	$F(\gamma = 1)$	R^2
Whole	420	OLS	.022	−.109	152.012	.003
			(.007)	(.108)	(.000)	
Whole	420	WLS	.026	−.112	529.266	.011
			(.008)	(.048)	(.000)	
Q1	105	OLS	.012	1.254	.017	.004
			(.015)	(1.979)	(.900)	
Q1	105	WLS	.015	1.534	.100	.011
			(.015)	(1.691)	(.750)	
Q2	105	OLS	.030	.820	.065	.011
			(.013)	(.706)	(.800)	
Q2	105	WLS	.027	.523	.426	.001
			(.014)	(.730)	(.520)	
Q3	105	OLS	.029	−.259	10.683	.004
			(.014)	(.385)	(.001)	
Q3	105	WLS	.028	−.310	11.175	.003
			(.015)	(.391)	(.001)	
Q4	105	OLS	.018	−.102	83.408	.006
			(.018)	(.121)	(.000)	
Q4	105	WLS	.027	−.114	146.526	.014
			(.020)	(.092)	(.000)	

Note: OLS stands for ordinary least squares and WLS for weighted least squares, using the absolute values of the regressor as weights. Q*i* denotes results for the *i*th quartile of the pooled sample when it is ordered according to the absolute magnitude of the regressor (so that Q4 contains the largest absolute values of the regressor). Figures in parentheses below coefficient estimates are estimated standard errors (and are heteroskedasticity robust for the OLS results); those below test statistics are marginal significance levels.

Table 8A.2 **Five-Year Averages**

$\overline{\Delta s}_t = \alpha + \gamma(\overline{\Delta p}_t - \overline{\Delta p}_t^*) + \varepsilon_t$

Sample	N	Estimates Method	$\hat{\alpha}$	$\hat{\beta}$	$F(\gamma = 1)$	R^2
Whole	84	OLS	.356	.807	1.490	.432
			(.742)	(.159)	(.220)	
Whole	84	WLS	−.108	−.955	.463	.812
			(.984)	(.064)	(.490)	
Q1	21	OLS	.592	1.927	.362	.065
			(1.109)	(1.539)	(.540)	
Q1	21	WLS	−.474	1.908	.489	.100
			(1.165)	(1.298)	(.490)	
Q2	21	OLS	−.344	.202	1.128	.004
			(1.264)	(.751)	(.290)	
Q2	21	WLS	−.523	.327	.767	.012
			(1.344)	(.769)	(.390)	
Q3	21	OLS	.510	−.223	11.262	.019
			(1.287)	(.364)	(.001)	
Q3	21	WLS	1.221	−.202	12.188	.039
			(1.327)	(.344)	(.002)	
Q4	21	OLS	−.764	.960	.031	.695
			(2.077)	(.227)	(.860)	
Q4	21	WLS	−2.050	1.059	.171	.837
			(2.684)	(.143)	(.680)	

Note: OLS stands for ordinary least squares and WLS for weighted least squares, using the absolute values of the regressor as weights. Q*i* denotes results for the *i*th quartile of the pooled sample when it is ordered according to the absolute magnitude of the regressor (so that Q4 contains the largest absolute values of the regressor). Figures in parentheses below coefficient estimates are estimated standard errors (and are heteroskedasticity robust for the OLS results); those below test statistics are marginal significance levels.

Table 8A.3 Ten-Year Averages

$$\overline{\Delta s}_t = \alpha + \gamma(\overline{\Delta p}_t - \overline{\Delta p}_t^*) + \varepsilon_t$$

Sample	N	Estimates Method	$\hat{\alpha}$	$\hat{\gamma}$	$F(\gamma = 1)$	R^2
Whole	42	OLS	.165	.967	.062	.693
			(.722)	(.129)	(.800)	
Whole	42	WLS	−.086	1.058	.977	.931
			(.855)	(.059)	(.330)	
H1	21	OLS	−.333	.866	.035	.082
			(.775)	(.721)	(.850)	
H1	21	WLS	−.020	.880	.038	.095
			(.916)	(.619)	(.850)	
H2	21	OLS	.887	.924	.221	.753
			(1.258)	(.162)	(.643)	
H2	21	WLS	−.125	1.060	.495	.933
			(1.349)	(.085)	(.490)	

Note: OLS stands for ordinary least squares and WLS for weighted least squares, using the absolute values of the regressor as weights. H1 denotes results for the first half of the pooled sample when it is ordered according to the absolute magnitude of the regressor and H2 the second half of the ordered sample (so that H2 contains the largest absolute values of the regressor). Figures in parentheses below coefficient estimates are estimated standard errors (and are heteroskedasticity robust for the OLS results); those below test statistics are marginal significance levels.

Table 8A.4 Twenty-Year Averages

$$\overline{\Delta s}_t = \alpha + \gamma(\overline{\Delta p}_t - \overline{\Delta p}_t^*) + \varepsilon_t$$

Sample	N	Estimates Method	$\hat{\alpha}$	$\hat{\gamma}$	$F(\gamma = 1)$	R^2
Whole	21	OLS	.224	.905	.673	.735
			(.911)	(.116)	(.410)	
Whole	21	WLS	.152	.957	.476	.957
			(.824)	(.062)	(.500)	
H1	10	OLS	−.779	1.353	4.003	.864
			(.278)	(.177)	(.050)	
H1	10	WLS	−.806	1.323	3.881	.890
			(.265)	(.164)	(.080)	
H2	11	OLS	1.402	.819	1.013	.686
			(1.851)	(.179)	(.310)	
H2	11	WLS	.580	.935	.455	.952
			(1.423)	(.097)	(.517)	

Note: OLS stands for ordinary least squares and WLS for weighted least squares, using the absolute values of the regressor as weights. H1 denotes results for the first half of the pooled sample when it is ordered according to the absolute magnitude of the regressor and H2 the second half of the ordered sample (so that H2 contains the largest absolute values of the regressor). Figures in parentheses below coefficient estimates are estimated standard errors (and are heteroskedasticity robust for the OLS results); those below test statistics are marginal significance levels.

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Comment Andrew K. Rose

There are basically two parts to this paper. The first (and larger) part is a survey of the conventional international macroeconomic literature on floating exchange rates. This work, closely related to a series of papers by Ronald MacDonald and Taylor, is a well-balanced, thorough survey of the evidence on exchange rate determination. The authors survey four classes of theoretical models of exchange rate determination and show that the empirical performance of these models is quite poor. I find the work eminently reasonable and have very little to add.

The second part of the paper is relatively short but innovative and interesting. The authors assemble a panel of data on exchange rates and monetary fundamentals for over twenty countries in the period since the collapse of the Bretton Woods regime. The authors show that pooling the annual observations provides only very weak evidence of tendencies to purchasing power parity (PPP). However, moving to coarser time frequencies seems to give much stronger evidence of PPP. For instance, using five-year averages gives a higher regression coefficient in a regression of the exchange rate change on the inflation differential than a similar regression estimated with annual differences (the goodness of fit improves as well). Averaging the data over ten years improves matters even more. This is true despite the fact that time-averaged data have fewer outliers than finer-frequency data (as is obvious from the dimensions of figs. 8.5–8.7). It is also true despite the fact that the sample span of the data (in terms of both country and time coverage) stays constant when moving between frequencies. In this, as in many contexts, less is more; throwing away short-run variation in exchange and inflation rates leads to a fit more consistent with one's theoretical priors. It is interesting that throwing away

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within-country time-series variation (and increasing the proportion of between-country variation) not only does not hurt the regression analysis but positively helps matters.

I find this result quite interesting. It clearly implies (as the authors point out) that there is a nontrivial correlation between the regression disturbance and the inflation differential that leads to a biased coefficient at the annual frequency. But what is the source of this correlation? Perhaps the authors have found out only that (price index) measurement error is fatal in such simple regressions at short- and medium-run frequencies. On the other hand, this kind of regression has been criticized by a number of economists in that it is not based on any underlying theoretical model of either price or exchange rate adjustment so that the regression coefficients are not structural parameters; in addition, there is no obvious alternative hypothesis posed. Exploring this result further, and trying to pin down the source of the correlation, remains an interesting and important task for future research. However, unlike many comparable tasks in international macroeconomics, it is a manifestly promising avenue of research since the results are consistent with the prior beliefs of many economists (including me), namely, that theories like PPP work well in the long run but are barely detectable in the short run.

Thus, this paper has performed two valuable tasks. First, it has demonstrated the lack of empirical success of conventional macroeconomic exchange rate models. Second, it has produced an interesting set of results on model fit in both the short and the long run. However, my one criticism of it is that the authors could be more forceful in pinning down the specific failures of the macroeconomic approach to exchange rates that can potentially be answered with microstructure analysis. We have the opportunity to set the agenda for microstructural work; it is important to lend focus to this emerging literature at an early stage. Here is my wish list of important topics in which we should be interested (many are related):

1. First is the role of noise trading and bubbles. Can microstructural work explain the evidence of apparent excessive volatility in floating foreign exchange markets (derived from news regressions, the poor fit of macro equations, and potentially the literature on deviations from uncovered interest parity)? Can noise trading explain the high volume on foreign exchange markets? How about the apparent short-run near irrelevance of macroeconomic factors?

2. What leads to the heterogeneous beliefs manifestly apparent in foreign exchange markets? Is the source of the heterogeneity disagreements about macroeconomic phenomena, models of the economy, or something completely different?

3. How does intervention fit in? Why is it taken so seriously by both market participants and central banks when the macroeconomic presumption is that sterilized intervention is almost irrelevant? Is there a microstructural reason why intervention should be kept secret?

4. Can microstructure analysis shed light on how the credibility of a foreign exchange authority (trying to limit exchange rate fluctuations) is determined? We know that macroeconomic phenomena are not all that important.

5. Can microstructure analysis explain the apparent preference of central banks for fixed or managed exchange rates? In general, how are issues of regime choice affected by micro features?

6. What is the behavior of market participants like in times of "unusual" activity, especially speculative attacks and hyperinflations? For instance, are micro phenomena relevant in precipitating or exacerbating speculative attacks?

7. Can microstructure analysis shed light on the apparent evidence of "contagion/infection" effects witnessed during the 1992–93 exchange rate mechanism crisis? In general, what are the spillovers between different foreign exchange markets? Are there externalities between these and other asset markets?

8. Do the microstructural features of foreigu exchange markets have important consequences for hedging? If so, are there important effects on international trade flows?

9. Can microstructure explain the well-established large and persistent deviations from uncovered interest parity?

In summary, the paper by Flood and Taylor is a valuable contribution in two respects: it provides a clean survey of the floating exchange rate literature, and it provides some intriguing new evidence on short- and long-run exchange rate behavior. The authors have convincingly demonstrated that macroeconomic models have not provided a satisfactory answer to the key question of exchange rate determination. However, it is still my belief that the macroeconomic analysis was after the right question, and I would urge us all to keep our collective eyes on the prize: Why do floating exchange rates fluctuate so much? Why do fixed exchange rates both persist the way they do and collapse? And what are the consequences for all this for international trade, macroeconomic policy, and foreign exchange market policies?

Comment Lars E. O. Svensson

Flood and Taylor's paper is a fine survey of theories of exchange rate determination and empirical tests of these theories. It also presents interesting results in favor of long-run purchasing power parity.

One of the main points of the survey is to emphasize the by now well-known

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situation that existing theories cannot predict and explain short-run exchange rate movements during floating exchange rate regimes and, more specifically, that existing theories cannot outbeat a random walk.

This unfortunate situation refers to floating exchange rates. I would like to add that, for fixed exchange rate regimes, the situation is different, in a particular aspect. Real-world fixed exchange rates usually have bands within which exchange rates fluctuate; the Bretton Woods system had a bandwidth of ± 1 percentage point; previously ERM (exchange rate mechanism), the European exchange rate cooperation, had a bandwidth of either ± 2.25 or ± 6 percentage points, whereas after the July 1993 crisis the bandwidth was increased to ± 15 percentage points (with the exception of the Dutch gulden/deutsche mark exchange rate). It turns out that it is much easier to explain and predict exchange rate movements within such bands than to predict freely floating exchange rates.

Table 8C.1 (from Svensson [1993, table 3]; see that paper for details) shows typical regression results for fixed exchange rate regimes with bands. The table shows, for six ERM currencies, regressions of the rate of depreciation within the band during the next three months (relative to the deutsche mark) on the current exchange rate (x), the currency's three-month Euro interest rate (i), and the deutsche mark three-month Euro rate (i^*). The intercepts are allowed to differ across periods between realignment dates. If exchange rates within bands were martingales, the R^2's in these equations would be close to zero, and the coefficients of exchange rates and interest rates would not be significantly different from zero. Instead, we see that the R^2's lie between 0.26 and 0.62 and that all coefficients for the exchange rate are negative and significantly different from zero (Newey-West standard errors are reported within parentheses). When the currency is weak, it will on average appreciate. This is of course just mean reversion within the band, which perhaps is not so surprising.

However, mean reversion is not the end of the story. We also see that the coefficient for the own-currency Euro interest rate is negative and significant in four cases out of six, whereas the coefficient for the foreign interest rate is positive and significant in two cases. This sign pattern is consistent with central banks engaging in interest rate smoothing. When the domestic-currency interest rate (or the interest rate differential relative to the deutsche mark) is high, the currency will in the future on average appreciate relative to the deutsche mark. This expected appreciation will prevent the domestic-currency interest rate from being even higher. Put differently, by inducing an expected appreciation of the currency, the central bank prevents the domestic interest rate from being even higher.

This association between high interest rate differentials and future expected *appreciation* within the band may appear to be counter to uncovered interest parity, which predicts an association between high interest rate differentials and future expected *depreciation*. However, the latter association is between high interest rate differentials and expected *total* depreciation, including re-

Table 8C.1 **Exchange Rate Depreciation within the Band: Three Months**

	(1) BF/DM	(2) DK/DM	(3) FF/DM	(4) IL/DM	(5) IP/DM	(6) NG/DM
Intercepts:						
13 March 1979	13.13	18.56	2.42	1.47	...	7.85
	(1.81)	(2.78)	(1.88)	(5.07)		(1.07)
24 September 1979	16.98	...	−2.66	8.79	...	−.08
	(2.66)		(3.12)	(8.29)		(1.09)
30 November 1979		15.28				
		(4.02)				
23 March 1981				7.95		
				(10.82)		
5 October 1981	21.70	16.08	2.86	12.03	18.02	
	(2.51)	(3.90)	(4.33)	(10.19)	(4.19)	
22 February 1982	24.54	17.84				
	(2.35)	(3.71)				
14 June 1982	20.16	16.76	1.06	8.76	16.21	
	(2.53)	(4.16)	(3.72)	(7.66)	(3.38)	
21 March 1983	13.60	9.80	−.88	4.44	9.56	1.13
	(1.97)	(2.55)	(2.48)	(6.30)	(2.84)	(.67)
22 July 1985				5.99		
				(4.71)		
7 April 1986	12.54	13.80	2.83	2.81	12.46	
	(1.52)	(2.07)	(1.67)	(4.39)	(2.23)	
4 August 1986					13.00	
					(2.16)	
12 January 1987	9.40	10.83	.54	6.39	7.30	
	(1.50)	(2.44)	(1.97)	(3.84)	(2.08)	
8 January 1990–9 April 1992				3.30		
				(7.51)		
Coefficients:						
x	−1.25	−2.12	−1.90	−1.42	−1.75	−2.74
	(.26)	(.28)	(.36)	(.39)	(.42)	(.55)
i^{τ}	−1.33	−1.04	−.11	−.29	−.80	−.94
	(.21)	(.23)	(.22)	(.22)	(.21)	(.31)
$i^{*\tau}$	.37	.22	.37	.02	.18	.84
	(.12)	(.18)	(.20)	(.78)	(.15)	(.27)
Diagnostics:						
N	2,743	2,686	2,802	2,624	2,211	3,039
R^2	.62	.56	.43	.26	.55	.52
σ	1.8	2.6	2.7	4.3	2.3	1.6

Note: OLS with Newey-West standard errors within parentheses (τ lags, $\tau = 65$). Regressand is $(x_{t+\tau} - x_t)/\tau dt$ (%/year), $\tau dt = 63/261$; regressors are x_t(%), i_t^{τ} (%/year), and $i_t^{*\tau}$ (%/year), where x is ln(BF/DM), . . . , ln(NG/DM), i_t^{τ} is the τ maturity BF, . . . , NG Euro interest rate, and $i_t^{*\tau}$ is the τ maturity DM Euro interest rate. A vertical bar for a realignment date indicates that the corresponding currency was not realigned and that the estimate straight above applies. Interest rates for IP were not available before October 1981. The second regime for Danish krone/deutsche mark is too short to be estimated. For details, see Svensson (1993). BF = Belgian franc; DM = deutsche mark; DK = Danish krone; FF = French franc; IL = lira; IP = Irish pound; NG = Dutch gulden.

alignments, whereas the former is between high interest rate differentials and expected depreciation *relative to central parity*. For a sample period during which a realignment is expected with some probability but does not occur owing to the shortness of the sample (the peso problem), high interest rate differentials will be associated with future realized total appreciation, even if expectations are rational. If expectations are not rational but exaggerate the probability of a realignment, for instance, in a situation in which a central bank is struggling to establish the credibility of a fixed exchange rate regime, high interest rate differentials will be associated with future total realized appreciations also for longer sample periods. Thus, central banks' interest rate smoothing within exchange rate bands may contribute to the often observed empirical rejection of uncovered interest parity.

Additional evidence for interest rate smoothing within exchange rate bands is presented in figure 8C.1 (from Svensson [1994, fig. 2d]; see that paper for details). The top panel's thin curve shows a time series of deviations from central parity of the Swedish krona (relative to the currency basket that the krona was pegged to prior to May 1992 when the pegging to the ECU [European currency unit] began). The horizontal dotted lines show the bandwidth, ± 1.5 percentage points. The thin curves in the second and third panels from the top show the Swedish krona and currency basket one-month interest rates, respectively. The curve in the fourth panel from the top shows estimates of the market's realignment expectations (expected rates of realignment). Whereas the thin curves show the actual historical development of these series, the thick curves in the first and second panels from the top show the result of a simulation where the central bank faces historical disturbances but pursues an optimal policy according to an objective function that puts certain weight on both exchange rate and interest rate smoothing.

Let us look at just one incident. In the fall of 1990, expectations of a devaluation rose dramatically. In the fourth panel from the top, we see that the expected rate of realignment peaked in the fall of 1990. Everything else equal, this would show up in a one-to-one increase in the domestic-currency interest rate. Instead, we see in the second panel from the top that the domestic interest rate increased by much less (the actual increase and the optimal increase coincide in this incident). As can be seen in the top panel, Sveriges Riksbank allowed the krona to depreciate within the band (somewhat less than the optimal policy). This created an expected appreciation for the krona that dampened the effect of the increased realignment expectations on the domestic interest rate. The resulting expected rate of appreciation of the krona is displayed in the fifth panel from the top.

Hence, in contrast to what is the case for floating exchange rates, for exchange rates within bands exchange rate movements can be both predicted and to some extent explained, for instance, in terms of central banks smoothing interest rates. Of course, it would be better to be able to predict and explain movements of floating exchange rates and in general to explain exchange rate

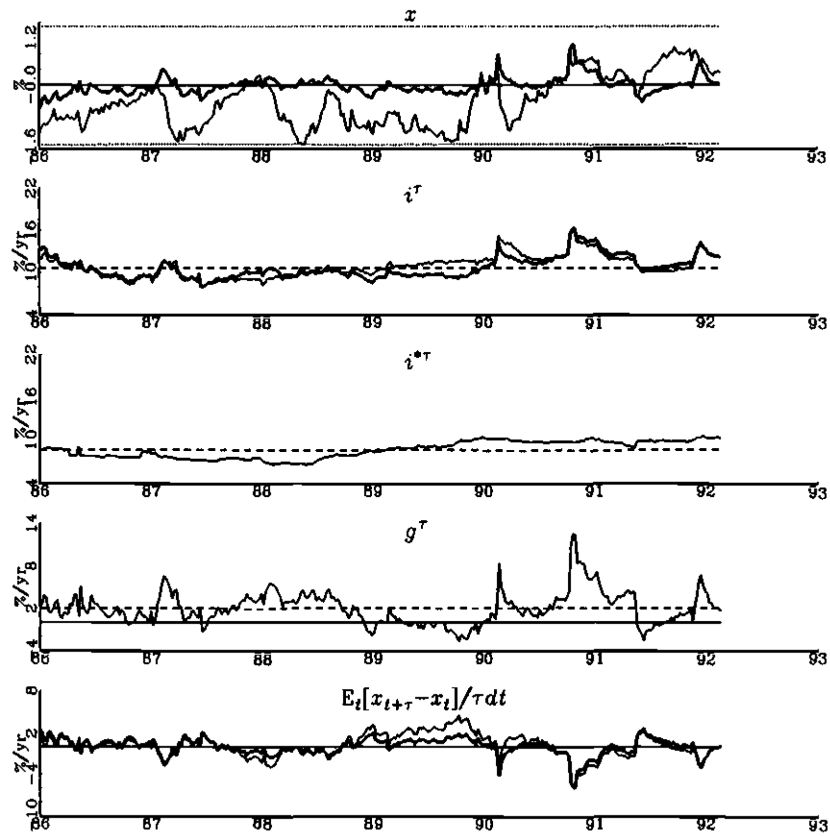

Fig. 8C.1 Evidence of interest rate smoothing

Note: x is percentage deviation of exchange rate from central parity; i^{τ} and $i^{*\tau}$ are domestic and foreign one-month interest rates, respectively; g^{τ} is expected rate of realignment; τ equals four weeks, dt = one week. Thin curve: actual. Thick curve: optimal. Dashed line: mean. For details, see Svensson (1994).

levels in terms of levels of other contemporaneous macro variables, but it is still of some interest that exchange rate movements within bands are systematic and also not exclusively characterized by mean reversion.

I missed in Flood and Taylor's survey a discussion of international macro problems or puzzles where a microstructure approach might help. A list of such problems/puzzles is discussed extensively in Andrew Rose's comment on Flood and Taylor. Let me just mention two such problems/puzzles that are on my own wish list.

The effects on exchange rates of sterilized central bank intervention may be suitable to analyze with a microstructure approach. Most macro studies find little or no effect of sterilized intervention. If they are correct, why do central banks keep doing it? Some studies emphasize a signaling effect, namely, that sterilized interventions signal future nonsterilized interventions. If the signaling effect is the important one, why are central banks often secretive about their interventions? And why aren't there better ways to signal changes in future monetary policy?

Some central bank officials have suggested to me that herd behavior in the foreign exchange market may be exploited by central banks. If the central bank secretly through intermediaries can convey the impression that someone other than the central bank is suddenly starting to buy the currency, the herd might follow. This way the central bank would then be able to push or pull the exchange rate in desired directions. These issues might be suitable for a microstructure approach.

Another such issue is speculative attacks, in particular, central banks' defense against speculative attack. For instance, during the dramatic defense of the Swedish krona in September 1992, with a 500 percent overnight rate, the foreign exchange market for kronor and the Swedish Treasury bills market seemed paralyzed. Instead of a strong inflow of kronor, very little trade occurred. Huge spreads were quoted on Swedish T-bills, indicating that no one wanted to trade. One reason is that it became almost impossible to price a short-term bill since the uncertainty about the future overnight rate was enormous. Who knew whether it would come down to reasonable levels within three, seven, or fourteen days? A related issue is to what extent the increased practice of trading rules, dynamic hedging, etc. affects central banks' defense against speculative attack. As the paper by Garber and Spencer (chap. 6 in this volume) demonstrates, this is another suitable area for a microstructure approach.

References

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