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Are Exchange Rates Excessively Variable?

The proponents of floating exchange rates before 1973 did not promise that exchange rates would necessarily be stable under such a system, but only that they would be as stable as the underlying macroeconomic fundamentals.[1] Nevertheless, the widespread feeling is that exchange rates have turned out to be more volatile than necessary. Many practitioners believe that exchange rates are driven by psychological factors and other irrelevant market dynamics, rather than by economic fundamentals. Support seems to have grown in the 1980s for "target-zone" proposals, or some other sort of government action to stabilize exchange rates.[2]

1. The Meaning of "Excessive Variability"

Economists have understood for some time that under conditions of high international capital mobility, currency values will move sharply and unexpectedly in response to new information. Even so, actual movements of exchange rates have been puzzling in two major respects. First, the proportion of exchange-rate changes that we are able to predict seems to be not just low, but zero. According to rational expectations theory we should be able to use our models to predict that proportion of exchange-rate changes that is correctly predicted by exchange market participants. Yet neither models based on economic fundamentals, nor simple time-series models, nor the forecasts of market participants as reflected in the forward discount or in survey data, seem able to predict better than the lagged spot rate. Also, the proportion of exchange-rate movements that

1. Friedman (1953).
2. See, for example, Williamson (1985).

can be explained even *after* the fact, using contemporaneous macroeconomic variables, is disturbingly low.

1.1. INTRODUCTION

Since structural models of exchange rates have little explanatory power, it will prove difficult to give a precise operational definition to excessive variability. Our approach to examining the issue of excessive variability is to return to the basics and ask what is actually known about the crucial building blocks of exchange-rate models. Three questions have yet to be satisfactorily answered. Question 1: How responsive are investors' demands for domestic and foreign assets to expected rates of return, that is, what is the degree of substitutability? Question 2: How do investors form expectations? In particular, how much weight do they give to the contemporaneous spot rate and how much to other factors? Question 3: How does the actual process governing the spot exchange rate correspond to the process embodied in investors' expectations, that is, are expectations rational? As we will see, these questions together contain some of the essential elements necessary to evaluate claims of excessive exchange-rate variability.

We will try to shed light on these questions by drawing on several areas of the existing empirical literature on the spot and forward exchange markets. Empirical topics to be covered, if only briefly, are nonstationarity of the nominal and real exchange rates, regression tests of exchange rate determination, forward market efficiency, variance-bounds tests and bubbles tests, portfolio optimization and the exchange risk premium, and expectations survey data.

However, we begin by considering the more general motivation for answering the three questions stated above: how knowing the answers to them might help answer whether exchange rate fluctuations have been unnecessarily large.

1.2. FACTORS IN DETERMINING "EXCESSIVE VARIABILITY"

In seeking to get a handle on the question of alleged excessive variability, we specify as general a model of the spot exchange rate as possible:

$$s = S(\ell, i - i^*, \Delta s^e, u). \quad (1)$$

We represent the interest differential by $i - i^*$, other fundamental determinants such as asset supplies by ℓ, investors' expected future change in the exchange rate by Δs^e, and any short-term random factors by u. Short-term movements that are thought to be unrelated to fundamentals must be interpreted as some combination of the last two terms.

The equation is so general that it could be interpreted as the old balance-of-payments flow approach to exchange rate determination, where ℓ represents factors affecting the current account and the other three variables are determinants of the capital account. We shall follow the stock approach here, however, in which the focus is on stocks of assets rather than flows.

We can impose additional structure on equation (1) by defining ℓ to be specifically the log of the supply of domestic assets minus the log of the supply of foreign assets, defining s to be the log of the spot price of foreign exchange, imposing homogeneity, and assuming also that the two components of expected returns enter with coefficients of equal magnitude:

$$s = \ell - L(i - i^* - \Delta s^e; u). \quad (2)$$

In equation (2), L is the relative demand for domestic assets, which depends positively on $rp \equiv i - i^* - \Delta s^e$, the risk premium or expected excess rate of return on domestic assets. In a portfolio-balance approach, for example, we could assume that the share of the portfolio allocated to foreign assets, x, is negatively related to the risk premium on domestic assets:[3]

$$x = A - B(rp). \quad (3)$$

Then (2) would hold, with

$$-L(\cdot) \equiv \log(x(\cdot)) - \log(1 - x(\cdot)),$$

and

$$dL/d(rp) = \left(\frac{1}{x} + \frac{1}{1 - x}\right)B. \quad (4)$$

We can now use equation (2) to consider the question of exchange rate variability. It seems that regardless of whether the fundamentals term ℓ is defined to include only money supplies or supplies of bonds and other assets also, one cannot in fact explain observed variability in s by variability in ℓ. This is the implication of both volatility tests and regressions

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3. In section 3.1 we will see that this linear form is the correct one for an asset demand function under the assumption of mean-variance optimization by investors.

of the spot rate against fundamentals such as asset supplies.[4] The same conclusion seems to hold as well if the fundamentals term ℓ is defined to include the current account.[5]

We are thus led to consider the other two terms in equation (2), which are determinants of asset demands rather than asset supplies: $i - i^*$ $- \Delta s^e$, and u. The expectations formation process is key to the question of variability, whether as a source of fluctuations or as "stabilizing speculation," moderating the effect of disturbances that originate in the other terms. A way of defining stabilizing expectations is that the expected future spot rate s^e_{t+1} gives a weight less than one to the contemporaneous spot rate, s_t, that it is a convex combination of the contemporaneous rate and other factors. We have the case of regressive expectations when the "other factor" is the equilibrium rate $\bar{s}_t$:

$$s^e_{t+1} = (1 - \theta)s_t + \theta(\bar{s}_t).$$

Or, in terms of expected depreciation,

$$\Delta s^e_{t+1} = -\theta(s_t - \bar{s}_t). \quad (5)$$

Stabilizing expectations are the case $0 < \theta < 1$, destabilizing expectations the case $\theta < 0$, and the borderline case is static expectations, $\theta = 0$.

It is important to note that equation (5) could be fully consistent with rational expectations in a variety of models. For example, regressive expectations can be rational in the sticky-price monetary ("overshooting") model of Dornbusch (1976), where the rational value of θ depends on the speed of adjustment of the price level, or static expectations could be rational if the true exchange rate process is a random walk, a result consistent with recent empirical findings.

Friedman (1953) argued persuasively that speculators who had a destabilizing effect ($\theta < 0$ in equation (5)) would be "buying high and selling low," and thus would lose money and be driven out of the market. In modern terms, he argued that destabilizing speculation would be incon-

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4. For example, Meese and Rogoff (1983a, 1983b).
5. Within the framework of equations (2) and (4), we can easily insert a role for the (cumulated) current account by defining the asset demand of residents of country i to be $x_i = A_i - B(rp)$, and aggregating:

$$x = \Sigma w_i A_i - B(rp), \quad (3')$$

where w_i is the share of world wealth held by residents of country i, which includes their cumulated claims on foreigners.

sistent with rational expectations. But the modern realization that one can have rational stochastic speculative bubbles, as in Blanchard and Watson (1982), in which each speculator stands to lose money if he does not go along with the others, has all but destroyed the classic Friedman argument.

A linearized form of the equation of spot rate determination (2) is now

$$s_t = \ell_t - \beta(i_t - i_t^* - \theta(\bar{s}_t - s_t)) + u_t, \quad (6)$$

where β is the degree of substitutability $dL/d(rp)$ (as, for example, in equation (4)).

Volatility will be unnecessarily high, in the sense that the variability of s will be high with ℓ and $i - i^*$ given, if the variability of u is high and if $\beta\theta$ is low. Indeed, if we were interested in the one-period effect of u_t alone, on the theory that this is the source of short-term uncertainty, then the conditional variance of s_t would be given by

$$\frac{1}{(1 + \beta\theta)^2} \operatorname{var}(u_t). \quad (7)$$

Equation (7) illustrates in a simple way a conflict that exists in discussions of excessive exchange rate volatility. Some economists, such as Tobin (1978), argue that exchange rates are too variable because financial markets are "excessively efficient," that capital sloshes back and forth among countries in response to trivial disturbances, and that a tax on foreign exchange transactions would reduce volatility. This view says that volatility is high because β, the degree of substitutability, is high. But there is another view, associated with McKinnon (1976), that exchange rates are too variable because of a "deficiency of stabilizing speculation," in other words, because β is too *low*. The apparent paradox can be resolved by noting that the variance is positively related to β (the Tobin case) if $\theta < 0$, (and $1 > -\beta\theta$), because in that case the expectations to which investors react are destabilizing. The variance is *negatively* related to β (the McKinnon case) if $\theta > 0$, because in that case expectations are stabilizing. To analyze the possible sources of exchange rate volatility, we need to consider *both* the degree of substitutability and whether expectations are stabilizing.

It is important to note that our definition of unnecessary variability is not a complete answer to the question of the welfare effects of government intervention. In order to evaluate arguments for or against government intervention to restrict exchange rate movements, one should specify an objective function, including such variables as output, infla-

tion, trade balance and investment, and try to judge whether letting the market determine the exchange rate is likely to result in a higher value of the objective function than any proposed plans to stabilize the exchange rate. Such questions are beyond the scope of this article.

Our interest here is only in the question of whether foreign exchange markets can fairly be said to be working well. If allegations are found justified that speculative bubbles, a failure of market efficiency, or random fluctuations are raising exchange-rate variability needlessly, then it could be said that the markets are not working well. The possibility might in that case exist of obtaining lower exchange-rate variability without cost. A wealth of empirical results can be brought to bear.

2. Random Walk Results

Various econometric approaches seem to end with the same conclusion, that the exchange rate follows a random walk. Here we will discuss the apparent inability to forecast future changes in the exchange rate using either

 (i) the past time series of the process itself (section 2.1),
 (ii) macroeconomic fundamentals (section 2.2), or
 (iii) the forward exchange market (section 2.3).

We then discuss what else, if anything, can be learned from the currently popular variance-bounds and bubbles tests (section 2.4).

2.1. NONSTATIONARITY OF NOMINAL AND REAL EXCHANGE RATES

It is now widely recognized that the linear time-series representation of the natural logarithm of either spot or forward exchange rates is best described by a random walk process.[6] Formal statistical tests for the presence of a unit root in the autoregressive representation of the logarithms of spot and forward exchange rates were first conducted by Meese and Singleton (1982). These unit root tests, pioneered by Fuller (1976) and his students, are known to have low power against borderline stationary alternatives. However, we find the superior out-of-sample forecasting performance of the random walk model, over time-series models where the unit root is not imposed, to be powerful evidence in favor of the unit root null. Finally, more recent statistical tests of the unit root hypothesis that are robust to conditionally heteroskedastic disturbances (Phillips 1985)

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6. Poole (1967), Mussa (1979), and Meese and Rogoff (1983a, 1983b), among others.

also support the unit root hypothesis. This is an important methodological advance, since it is also widely recognized that exchange-rate variability tends to be episodic; see Cumby and Obstfeld (1984) for tests of conditional heteroskedasticity in nominal exchange rates.[7]

Nonstationarity in the nominal exchange rate does not create problems for standard theories of exchange rate determination. In the monetary models, if the money supply is nonstationary in levels, or even in changes, then the exchange rate will be nonstationary in levels or changes. We have only to be careful how we specify our econometric tests of nominal exchange rates, preferring first differences over levels in general. Nonstationarity in the real exchange rate is considered by some to be a more serious matter, however. If the real exchange rate follows a random walk, then there is no tendency to return to purchasing power parity (PPP), and seemingly no limit on how far out of line one country's prices can get from another's.

The empirical evidence against PPP in level form is overwhelming. The enormous real appreciation of the dollar in the early 1980s convinced any remaining doubters, but abundant statistical evidence was available before this episode. For example, Krugman (1978, 406) computed for the floating rate period July 1973–December 1976 standard deviations of the (logarithmic) real exchange rate equal to 6.0 percent for the pound/dollar rate and 8.4 percent for the mark/dollar rate. He also computed serial correlation coefficients for PPP deviations of .897 and .854, respectively, on a monthly basis, equal to .271 and .150 on an annual basis. The serial correlation coefficient is of interest because it is equal to one minus the speed of adjustment to PPP.

Table 1 shows annual statistics on the real exchange rate between the United States and Great Britain. During the floating rate period 1973–1984 there is a significant time trend and a standard deviation of 15.4 percent. The serial correlation in the deviations from PPP is estimated at .720, with a standard error of .248. (The equation estimated is $(er_{t+1} - \overline{er}_{t+1}) = AR(er_t - \overline{er}_t) + \varepsilon_{t+1}$, where er is the real exchange rate and $\overline{er}$ is the long-run equilibrium level, alternatively estimated as the sample mean or a time trend, and AR is the autoregressive coefficient.) This means that the estimated speed of adjustment to PPP is .280 per year and that one can easily reject the hypothesis of instantaneous adjustment. While this speed of adjustment is not so low as to be implausible as a point estimate, it is sufficiently low that one cannot reject the hypothesis that it is zero. In other words, one cannot reject the hypothesis that the autoregressive coefficient is 1.0.

7. We consider time-varying variances again in section 3.2.

A 95-percent confidence interval on the autoregressive coefficient covers the range 0.17 to 1.27 (in the no-trend case). If the null hypothesis is an autoregressive coefficient of 1.0, one cannot legitimately use the standard t-test derived from a regression where the right-hand variable is the level of the real exchange rate, because under the null hypothesis its variance is infinite. There are a number of ways of dealing with this nonstationarity problem. Here we simply apply the corrected Dickey-Fuller (1979) cumulative probability distribution for the t-test appropriate for this problem. The t-ratio to test an autoregressive coefficient of 1.0 is 1.13, which falls far short of the Dickey-Fuller 95-percent significance level, 3.00.

This failure to reject a random walk in the real exchange rate is the same result found by Roll (1979), Frenkel (1981, 699), and Adler and Lehman (1983), among others. Hakkio (1984) provides evidence of a unit root in the real exchange rate using the Dickey-Fuller (1979) statistical procedures. Most of these studies used monthly data rather than yearly, and the statistical procedures employed were generally not powerful enough to reject the random walk.[8]

A more promising alternative is to choose a longer time sample. The last column of table 1 presents an entire 116 years of U.S.–U.K. data. With this long a time sample, the standard error is reduced considerably.

8. Cumby and Obstfeld (1984, 146) used a Q-statistic to test for higher-order serial correlation in monthly real exchange rate changes and found none. However, they also found that expected inflation differentials are unrelated to expected exchange-rate changes, rejecting the random walk characterization of the real exchange rate. Huizinga (1986) is also able to reject the random walk.

Table 1   PURCHASING POWER PARITY BETWEEN THE UNITED STATES AND THE UNITED KINGDOM, 1869–1984

	1973–1984	1945–1974	1945–1984	1869–1984
Mean absolute deviation	.121	.075	.106	.093
Standard deviation	.154	.092	.146	.122
Time trend	−.001*	.006*	−.0004	.009
	(.0003)	(.002)	(.0022)	(.013)
Autoregression				
of deviations from mean	.720*	.706*	.829*	.860*
	(.248)	(.132)	(.090)	(.048)
of deviations from trend	.734*	.710*	.750*	.846*
	(.277)	(.133)	(.106)	(.050)

Source: Frankel (1986b)
Note: Standard errors are reported in parentheses.
*Significant at the 95 percent level.

The rejection of no serial correlation in the real exchange rate is even stronger than in the shorter time samples. More important, one is finally able to detect a significant tendency for the real exchange rate to regress to PPP, at a rate of 14 percent a year. The confidence interval for *AR* runs from .77 to .95, safely less than unity, and the t-ratio of 2.92 exceeds the Dickey-Fuller significance level of 2.89. The 116-year sample period includes a number of switches in the exchange rate regime; it would be desirable for future research on data sets of this length to allow for them.

If the speed of adjustment to PPP is indeed on the order of 20 percent a year, and the standard deviation of the real exchange rate is on the order of .15, then the standard deviation of new shocks is on the order of $\sqrt{(1 - .80^2)(.15^2)}$ = 9 percent. With such a large error term in the regression equation, it is not surprising that most econometricians have been unable statistically to reject zero adjustment using the data from a mere 14 years of post-1973 data. The tests simply have insufficient power. Thus in our view the evidence for a unit root in real exchange rates is much less convincing than the evidence for a unit root in nominal exchange rates, suggesting that PPP is still a reasonable anchor for long-run exchange rate expectations.

The implications of the nonstationarity of the logarithms of nominal exchange rates and the near nonstationarity of the real exchange rate for tests of spot rate determination, forward rate bias, and variance bounds will be discussed at the appropriate places in the next three subsections respectively.

2.2. REGRESSIONS OF EXCHANGE RATE DETERMINATION

Regressions of equations of exchange-rate determination were the first sort of tests to become popular in the mid-1970s. The flexible-price monetary model,[9] for example, was represented by the equation

$$s_t = m_t - \phi y_t + \lambda(i - i^*)_t + u_t, \quad (8)$$

where s_t is the log of the spot exchange rate (domestic currency/foreign), m_t is the log of the domestic money supply relative to the foreign, y_t is the log of domestic income relative to foreign, $(i - i^*)_t$ is the interest differential, and u_t is the regression error. The model is derived from the assumption of instantaneous adjustment and perfect substitutability in the goods market (implying purchasing power parity) as well as in the bond market (implying uncovered interest parity).[10] Under the assump-

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9. Frenkel (1976) and Bilson (1978).
10. This is the case where B in equation (3) is infinite.

tions, $(i - i^*)_t$ could as easily be replaced by the forward discount fd_t, or by investors' expected rate of depreciation Δs_t^e.

$$s_t = m_t - \phi y_t + \lambda(\Delta s_t^e) + u_t. \quad (9)$$

Intuitively, an increase in the relative supply of the domestic currency m_t will lower its value, or raise the price of foreign currency s_t. Anything that raises the relative demand for domestic currency, such as an increase in relative income y_t or a decrease in expected future capital losses Δs_t^e, will have the opposite effect.

Other authors argued that important elements were missing from the equation. As we saw in the last section, deviations from purchasing power parity are in fact very large. If they were purely random, they could just be subsumed in the regression error u_t (as could random shifts in money demand). But we also saw that they are in fact highly autocorrelated. If the deviations are thought to have an autocorrelation coefficient of 1, that is, if the real exchange rate is thought to follow a random walk, we have the version of the monetary model used by Meese (1986). The equation could simply be estimated on first differences. On the other hand, if deviations from PPP arise primarily from price-level stickiness and thus are thought to be damped over time, for example, to follow an $AR(1)$, and if expectations correctly reflect this tendency to return to long-run equilibrium, then a more complete model is needed. The real interest differential, which is equal to expected real depreciation, will be proportionate to the current deviation from equilibrium. In the sticky-price monetary model,[11] we can simply add the real interest differential $(i - \pi^e) - (i^* - \pi^{*e})$, to equation (8): when the interest differential rises without a rise in expected inflation (π^e), it attracts an incipient capital inflow that causes the currency to appreciate. The coefficient is $1/\theta$, where θ is the expected rate of adjustment of the spot rate to equilibrium.

Another alternative to the simple monetary model is the portfolio-balance model,[12] which relaxed the assumption of uncovered interest parity, and as a consequence introduced the stocks of bonds into the model. Some synthesis versions required only adding a variable for the cumulation of government deficits and current account deficits to the earlier equations.[13]

These models have all been grouped under the name "asset market approach" because they all assume that exchange rates are determined in

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11. Dornbusch (1976), Frankel (1979).
12. Branson (1977) and Girton and Henderson (1977), among others.
13. Frankel (1984), Hooper and Morton (1982).

financial markets in which investors are able to shift their asset holdings instantaneously. It is important to note that the models already build in a high degree of exchange rate volatility, even without any special factors such as irrational expectations, speculative bubbles, or an error term. In the flexible-price monetary model, for example, a 1-percent change in the money supply will have a more-than-proportionate effect on the contemporaneous exchange rate, if it leads investors to expect more money growth and currency depreciation in the future. (This has been called the magnification effect.)

In the sticky-price overshooting model of Dornbusch, even a onetime change in the money supply can have a more-than-proportionate effect, because it transitorily lowers the interest rate and as a result drives the value of the currency below the new long-run equilibrium level.[14] Sometimes, especially in policy circles, "overshooting" has been mistakenly invoked to support the idea that irrationality or speculative bubbles increase exchange rate variability. But most readers of the Dornbusch paper have realized that its beauty lies precisely in the fact that overshooting occurs even when investors behave well in the sense that their speculation equates the forward discount to the rationally expected rate of depreciation. Indeed, when expectations are rational in the Dornbusch model, the conditional variance of the spot rate is given by

$$\left(1 + \frac{1}{\lambda\theta}\right)^2 \sigma_\varepsilon^2, \quad (10)$$

where σ_ε^2 is the variance of changes in the money supply.[15] There is a sense in which this much volatility, if not necessarily optimal for the allocation of resources (a question on which we have declined to take a position), is a natural and inevitable consequence of money supply changes in a sticky-price world.

The econometric evidence from regression tests can only be interpreted as saying that either expected depreciation is not adequately captured by the forward discount (or interest differential), or else there is some other substantial error term u in an equation like (8) that will enter the variance of s in addition to the fundamentals variables. One can always postulate the existence of variables that must have been incorrectly

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14. Overshooting can occur also in the portfolio-balance model, where it can be viewed as the consequence of a finite rate of adjustment in the stock of claims on foreigners, just as in the monetary model overshooting can be viewed as the consequence of a finite rate of adjustment in the general price level.

15. In Dornbusch, $1/\lambda\theta$ represents the amount of overshooting. For elaboration, see Frankel (1983, 42).

omitted. But it is fair to say that every equation that has been proposed, or that is likely to be proposed in the future, has a substantial error term left over. Much has been made (appropriately) of the models' inability to predict out-of-sample. But many of the regression estimates have shown very poor fits, not to mention unsensible coefficients, *within* the sample period as well.[16]

Unsensible coefficients are often attributable to endogeneity of right-hand-side variables. For example, negative coefficients on the money supplies can be attributed to central bank reaction to the exchange rate when setting monetary policy. Income, interest rates, and other variables are also almost certainly endogenous. Unsensible coefficients would in turn explain the inability to predict even directions of movement out-of-sample. Such econometric problems have encouraged many to go on to other testing procedures, which we will discuss later. But it is important to note at this stage that the endogeneity problems alone cannot explain the poor fits. To see this, one need not rely on instrumental variables estimates, which are only as good as the instruments used. One can impose a unit coefficient on the money supply and reasonable values on the other coefficients; the fits are still poor.[17] In the limit, if the error term u_t in the regression were indeed always close to zero, one should get a perfect fit regardless of whether the right-hand-side variables are determined in other equations. This is true even if sophisticated theories of the expectations term are built from rational expectations, speculative bubbles, and the like. Assuming expected depreciation is measurable by the forward discount, then some function of the forward discount and other fundamentals should give a good fit, unless there are large omitted factors.

Why emphasize the poor fits so much? The first reason is that it already gives us our first conclusion: no set of macroeconomic variables that has been proposed is capable of explaining a high percentage of variation in the exchange rate. One can always postulate, in the manner of "real business cycle theory" some unobservable portfolio shifts or productivity shocks that must be determining the exchange rate. But if the shocks cannot be measured or even described meaningfully, then they probably belong in the error term u. Our conclusion that the magnitude of u is large is evidence, for example, undermining any defense of exchange-rate variability made on the grounds that it is appropriate

16. For example, Meese and Rogoff (1983a), Backus (1984), and Frankel (1984). Somanath (1986) reports updated fit statistics for the above-mentioned models both in sample (1975–1982) and out of sample (1983).
17. Meese and Rogoff (1983b) try a grid of parameter values. Out-of-sample performance, while better than a random walk at horizons exceeding 18 months, is never good.

given changes in monetary policy. If all exchange rate changes were in truth explainable by changes in money supplies, either contemporaneous or anticipated, we would have much better results in our regressions of the monetary equation (1) than we do.

The second reason we flag here the poor fits and simultaneity problems is that some of the alternative tests that econometricians have turned to, though seemingly more sophisticated than these regressions, are very sensitive to the assumed behavior of the error term. These are the variance-bounds and bubbles tests, which are discussed in section 2.4.

Faced with poor econometric results for our models based on macroeconomic fundamentals, the proper response is to test components of the models in isolation. (It is *not* to test the models jointly with other assumptions!) Tests of unbiasedness in the forward market are one such approach, as almost all of the models include rational expectations as a key element, or at least as a special case. They are also thought to shed light on the question whether the forward discount can legitimately be used to measure expected depreciation. We now turn to these tests.

2.3. INTERPRETING TESTS OF BIAS IN THE FORWARD DISCOUNT

The literature testing the unbiasedness of the forward discount is by now truly voluminous. Typically, the ex post error made by the forward discount in predicting the change in the spot rate is regressed against information available at the beginning of the period, such as the lagged prediction error.[18] It often turns out that a statistically significant portion of the prediction errors can be explained using the available information, which constitutes a rejection of the null hypothesis of unbiasedness.

The most common test in this literature takes the information set on which expectations are conditioned to be the forward discount itself.[19] The regression equation is

$$\Delta s_{t+1} = a + b\, fd_t + \varepsilon_{t+1}. \quad (11)$$

Under the null hypothesis that the forward discount is an unbiased predictor of actual depreciation, the coefficient b should be one.[20]

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18. Dooley and Shafer (1983) and Hansen and Hodrick (1980) are two of the tests that take the available information to be the lagged prediction errors.
19. Studies regressing against the forward discount include Tryon (1979), Levich (1979), Bilson (1981), Longworth (1981), Fama (1984) and Huang (1984). Cumby and Obstfeld (1984) and Obstfeld (1986) regressed against the Euro-currency interest differential and again found that for most exchange rates the coefficient was significantly less than 1.0 and even less than zero.
20. Equivalently, in a regression of the prediction error $\Delta s_{t+1} - fd_t$ against fd_t, the coefficient under the null hypothesis should be zero.

The null hypothesis in equation (11) is usually rejected. The coefficient is significantly less than one; the implication is that one could expect to make money by betting against the forward discount whenever it is non-zero. Often the estimated coefficient is close to zero or even negative, which would say that the forward discount does not even get the *direction* of movement of the exchange rate right. Bilson (1981) interprets this finding as "excessive speculation": investors would do better if they would routinely reduced toward zero the magnitude of their expectations of exchange rate changes.

Most economists have not followed Bilson in the large step from the statistical finding of bias to the conclusion that the rational expectations hypothesis should be rejected. By far the most common explanation given is exchange risk. Risk-averse investors will demand some extra expected return for taking an open position in a currency that they perceive as riskier.[21] Whether or not the optimal statistical predictor equals the expectation that investors have in mind (rational expectations), if the investors' expectation is not in turn equal to the forward rate (because of a risk premium separating them), then the forward rate will be biased. This explanation is discussed at some length in section 3.

A serious obstacle to interpreting findings of forward rate bias as evidence against the joint hypothesis of rational expectations and risk neutrality is the "peso problem." It is widely known that the peso problem arises when there is the possibility of a large depreciation in the currency contingent on an exogenous event that may not have occurred in the sample period. In the context of the surprisingly sustained period of dollar appreciation in the early 1980s, with the forward market all the while forecasting a depreciation, it has been suggested that either the collapse of a rational speculative bubble or a sudden shift in the fiscal and monetary policy mix could be such an exogenous event. Unfortunately, the term "peso problem" is sometimes used indiscriminately to explain away any rejections of unbiasedness, leaving one to wonder why the test is run in the first place. It is important to remind ourselves of the familiar fact that standard statistical significance tests take into account the possibility of an event by chance failing to occur in the sample. (This assumes that the sample period was dictated by exogenous considerations such as data availability, as is the case in most of the tests.) One cannot say, for example, that "the forward market repeatedly misforecast the appreciation of the dollar in 1981–1984 because it could not know that

21. An exception is the unlikely case where, even though investors are risk averse, exchange rates are like the outcome of a bet on a football game in that they are completely uncorrelated with other rates of return (on all "outside" assets), so that exchange risk is completely diversifiable.

the White House or Congress would repeatedly fail to correct the structural budget deficit." If investors repeatedly misforecast fiscal policy in the same direction, that itself is a violation of the rational expectations hypothesis.

The correct interpretation of the peso problem is that, because of the possibility of a discretely large change in the exchange rate, a usually respectable number of observations might not in fact be large enough to give an approximately normal distribution to the coefficient estimate, with the result that the usual significance levels applied to the t-statistic may be inappropriate.[22] When one suspects that such a failure of normality may be a problem, one can rely on smaller significance levels or use tests that do not require that distributional assumption. Nonparametric tests of the dollar in the 1981–1985 period show that statistical rejections of unbiasedness need not necessarily depend on normality: the dollar repeatedly moved upward in value while the forward discount was predicting the reverse (Frankel 1985, Evans 1986).

If we leave behind the peso problem, the exchange risk premium remains the major explanation—short of a rejection of rational expectations—for the findings of bias in the forward rate. We will consider exchange risk in section 3.

2.4. VARIANCE BOUNDS AND BUBBLES TESTS

Variance bounds tests have been found intuitively appealing for two reasons. First, they have the appearance of more generality than regression tests. Second, they appear to hook up neatly with the popular feeling—which is the main motivation of the present study—that markets have been in some sense too volatile.

It has been pointed out repeatedly that the variance-bounds and bubbles tests require the assumption that the economic fundamentals have been correctly identified. Hamilton and Whiteman (1986) criticize the bubble tests on the grounds that "one can always relax restrictions on the dynamics of the fundamental driving variables so as to interpret what appears to be a speculative bubble as instead having arisen from rational agents responding solely to economic fundamentals not observed by the econometrician." Similarly, Meese (1986) and Flood, Hodrick, and Kaplan (1986, 32) argue that the tests are actually tests of the joint hypothesis of (i) a correct model, (ii) no regime changes, and (iii) no bubbles.

These criticisms have been leveled at the variance-bounds tests applied to the stock market by Shiller (1981). But it has not entirely sunk

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22. See Krasker (1980).

in, for the case of the foreign exchange market, how damaging is the dependence of the tests on having correctly specified the macroeconomic fundamentals. In the case of the stock market, at least modeling the price as the present discounted value of expected future dividends is fairly airtight, subject only to the possible problem of a risk premium.

We now spell out briefly the steps in deriving the bubbles test of West (1984), Meese (1986), and Casella (1985), starting from a model such as equation (9), and the perils that lie therein. If agents are assumed to have rational expectations, Δs_t^e can be replaced by $E_t(s_{t+1} - s_t)$ in the equation

$$s_t = m_t - \phi y_t + \lambda(E_t s_{t+1} - s_t) + u_t \quad (9')$$

Equation (9') could be estimated by McCallum's (1976) method of replacing $E_t s_{t+1}$ by the ex post realization s_{t+1} plus a random prediction error ε_{t+1} and then using an instrumental variables (IV) technique such as Generalized Method of Moments or Two-Step Two-Stage Least Squares. Equation (9') will hold—under the joint hypothesis of rational expectations and the rest of the model—regardless of whether there is a speculative bubble term or not.

To test the special case of no bubble, we estimate the model a different way. We solve for s_t as a function of expectations,

$$s_t = \frac{1}{1+\lambda} m_t - \frac{\phi}{1+\lambda} y_t + \frac{1}{1+\lambda}(E_t s_{t+1}) + \frac{1}{1+\lambda} u_t, \quad (12)$$

and continue to substitute recursively for expected future exchange rates. The well-known result is that the (no-bubble) solution for today's exchange rate can be written as the present discounted sum of the entire expected future path of monetary conditions:

$$s_t^* = \sum_{\tau=0}^{\infty} \left(\frac{\lambda}{1+\lambda}\right)^\tau \left(\frac{1}{1+\lambda}\right) E_t(m_{t+\tau} - \phi y_{t+\tau} + u_{t+\tau}). \quad (13)$$

For example, if far-sighted agents expect an increase in the money supply to take place four years in the future, it will have an effect on the exchange rate today.

Note that setting the price of foreign exchange to the present discounted sum of expected future monetary conditions (where the discount factor is $\lambda/(1+\lambda)$) is analogous to the model in the stock market that sets the price of equity to the present discounted value of expected future dividends (where the discount factor is one over one plus the real

interest rate). The major difference is that we are much less confident about having the right fundamentals in the foreign exchange market. In addition, estimation of equation (13) requires that the disturbance term u be uncorrelated with the appropriately dated fundamentals (or else that an IV procedure be utilized).[23]

Equation (13) gives only the particular fundamentals solution, which sets the coefficient on the speculative bubble term to zero. The intent of the bubbles tests is to test the equation against the alternative more general solution

$$s_t = s_t^* + \left(\frac{1 + \lambda}{\lambda}\right)^t a_t \quad (14)$$

where a_t is any stochastic process satisfying $E_t a_{t+\tau} = a_t$. The extra term can arise from self-fulfilling expectations: if everyone expects the dollar to appreciate, even if for a reason unrelated to fundamentals ("sunspots"), they will buy dollars and drive up the price, so that the expectation turns out to have been rational. In a single deterministic bubble of the sort Flood and Garber (1980) test for, a_t is a constant. But there are other possibilities. In the stochastic bubble model of Blanchard and Watson (1982) a_t has a probability of collapsing to zero each period.

The next step in the bubbles test is a nontrivial assumption in any context: some stable dynamic process must be assumed for the fundamentals variables m_t and y_t, such as a vector autoregression. Then the Hansen-Sargent (1980) prediction formula can be applied to (13) so that the expected future values of m_t and y_t are substituted out. This results in a multiple equation system with nonlinear cross equation constraints that we shall refer to as (13′).

The trick behind the bubbles test is the recognition that under the null hypothesis of "no bubble term" the estimator of the parameters of equations (13′) will be more efficient than the estimator of the parameters of equation (9′). Under the alternative hypothesis that there is a bubble term as in equation (14), the estimator of the parameters of equation (9′) will still be consistent, whereas the estimator of the parameters of equations (13′) will be inconsistent. Thus a Hausman (1978) specification test can be used to choose between the two possibilities.

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23. If u is known to be correlated with the monetary fundamentals but an appropriate instrumental variable is available, then equation (13) can still be estimated by the appropriate techniques, the same as the standard regression equation (8). Casella (1985), for example, allows for endogeneity of the money supply in her bubbles test of the German hyperinflation.

At least four propositions are being maintained when estimating the system (13'): (a) the macroeconomic model such as equation (8) is correct, (b) the interest differential or forward discount is an unbiased predictor in the sense of equaling the realization within the sample period, up to a random prediction error (this requires rational expectations, no peso problem or regime changes, and no risk premium), (c) there are no bubbles, and (d) the dynamic model assumed for the explanatory variables is correct. Assumptions (a) and (b) are also maintained when estimating (9'). Thus the bubbles test procedure only makes sense if diagnostic checks of the estimated fit of (9') do not indicate misspecification, and standard procedures indicate the validity of (d). Testing proposition (c) while maintaining (a) and (b) has the obvious difficulty that if the null hypothesis is rejected one does not know why. But in the present context, it seems particularly tenuous, since propositions (a) and (b) can be tested individually, and few people interpret the evidence as supporting them.

We now consider the weaknesses of variance-bound tests. Repeat equation (1), or in its incarnation as the monetary model equation (9), as

$$s_t = \ell_t + \beta(s_{t+1}^e - s_t),$$

where β is the sensitivity of the current spot rate to the expected change in the spot rate (the same as λ, the semielasticity of money demand, in the monetary model), and ℓ_t denotes the fundamentals. The results from Meese and Singleton (1983) allow us to deduce

$$\mathrm{var}(s_t) \le \mathrm{var}(\ell_t), \quad (15)$$

in the absence of exchange market bubbles. The most standard application (for example Huang 1981) would take the variances of both sides of equation (13) assuming all disturbances u_t are zero. The variance bound in (15) can be written in terms of conditional variances or, if equation (9') holds in first differences with u_t as the structural disturbance, then a bound analogous to (15) holds for the first difference of s_t and ℓ_t. Thus nonstationarity of the exchange rate or fundamentals will not undermine the following discussion. The relation (15) makes it clear that it is meaningless to compare the variability of s_t with an individual component of ℓ_t unless ℓ_t contains a single variable, or we know all the values of the structural parameters on the variables in ℓ_t and the covariances between all the fundamentals. Actual variance-bounds tests of (1) are generally uninteresting because they test whether the variance of a linear combination of the variables in ℓ_t is an upper bound on the variance of s_t,

and the tests are conditioned on knowing the correct variables and the correct values of the structural coefficients. While it is true that the Generalized Method of Moments (GMM) methodology of Hansen (1982) can be used to construct a statistical test of (15) that incorporates the sampling variability of the estimated parameters, this has not been done in the exchange rate context. We believe that such an exercise is futile since it is already known that asset market models of exchange-rate determination fit poorly.

A more obvious problem with variance-bounds tests can be seen from the application of variance-bounds procedures to tests of forward rate bias. Recall that the unbiasedness equation

$$\Delta s_{t + 1} = a + b(fd_t) + \varepsilon_{t + 1} \quad (16)$$

with b = 1 implies

$$\text{var}(\Delta s_{t + 1}) \geq \text{var}(fd_t). \quad (17)$$

The variance-bounds test has *no* power to detect the alternative $\text{cov}(fd_t, \varepsilon_{t + 1}) = \text{cov}[fd_t, (s_{t + 1} - f_t)] > 0$, since (17) would hold a fortiori. The most common empirical finding in regression tests of (16) is that $\text{cov}(\Delta s_{t + 1}, fd_t) < 0$ which also implies that $\text{cov}(fd_t, \varepsilon_{t + 1}) < 0$.[24] However, the variance of the left-hand side of (17) is typically so much larger than the variance of the right-hand side that a test of (17) fails to uncover a significant negative covariance of the forward discount with the forecast error $\varepsilon_{t + 1}$. An example is the published results in Huang (1984). His regression tests of (16), reported in his table 1 (p. 157), indicate two rejections of b = 1 when $\hat{b} < 0$ and one rejection of b = 1 when $\hat{b} > 0$, out of a total of nine currencies. In his following table 4 (p. 160), none of the variance-bounds tests rejects (17) for the same currencies and sample periods. It is true that all of Huang's point estimates of the bound

$$\text{var}(\Delta s_{t + 1}) \geq \text{var}(\varepsilon_{t + 1})$$

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24. Fama (1984) and Hodrick and Srivastava (1986) provide evidence of $\hat{b} < 0$ on different data sets. Note that

$$\text{cov}[(f_t - s_t), (s_{t + 1} - f_t)] = \text{cov}[(f_t - s_t), (s_{t + 1} - s_t) - (f_t - s_t)]$$
$$= -\text{var}(f_t - s_t) + \text{cov}[(f_t - s_t), (s_{t + 1} - s_t)].$$

The sum of the last two terms is less than zero whenever $\hat{b} < 0$.

are violated, but few of the violations are statistically significant. These "small sample" results illustrate the large-sample theoretical results of Frankel and Stock (1987) who show that even the most powerful conditional volatility test is only equivalent to the analogous regression test in terms of asymptotic power. See also Froot (1987) for further discussion.

3. The Exchange Risk Premium

We are interested in the size and variability of the risk premium for two reasons. First, if the size and variability are thought to be small, as argued in Frankel (1986a), then it is difficult to attribute the results of regression tests of forward rate unbiasedness (described in section 2.3), or the results of variance bounds tests (described in section 2.4), to the risk premium. This would leave only the explanation that expectations cannot be assumed rational in the sense of lending themselves to representation by the ex post sample distribution.

Even if expectations are thought to be rational, there is a second motivation for looking at the variability of the risk premium. Since the risk premium in equation (2), together with the substitutability parameter β, can be a key determinant of the exchange rate, estimating the variability of the risk premium will help us analyze the sources of variability in the spot rate s_t. Here we will be particularly interested in the effects on s_t when there is an exogenous change in asset supplies ℓ_t, expectations Δs_t^e, or the substitutability parameter β.

Until relatively recently, empirical work on the risk premium was limited almost entirely to the estimates of bias in the forward market's prediction of future spot rates discussed in section 2.3. The problem was that rational expectations had to be assumed a priori in order to interpret the systematic component of the prediction errors as equal to the risk premium. For those who were willing to make this assumption, the conclusion was that the risk premium is large and variable. For example, the finding of zero coefficients in the regression of exchange rate changes against the forward discount implied that the rationally expected rate of depreciation was zero (random walk), and 100 percent of the forward discount was made up by the risk premium, rather than by expected depreciation. Since the dollar's forward discount against the mark or yen has moved over a range of roughly 2 percent to 4 percent in recent years, this would imply that the risk premium was substantial in both magnitude and variability.

It has been argued that if the systematic component of the prediction errors is indeed properly interpreted as the risk premium, then it ought

to be related statistically to those variables on which theory tells us that the risk premium depends. We now turn to the theoretical determinants of the risk premium and the corresponding econometric tests.

3.1. IMPLICATIONS OF PORTFOLIO OPTIMIZATION WITH CONSTANT VARIANCE

If investors maximize single-period utility that is a function of mean and variance of end-of-period wealth, asset demands can be written as a linear function of expected relative rates of returns

$$x = A - B\,rp, \quad (3')$$

where A is the minimum variance portfolio, $B^{-1} = \rho\Omega$, and rp is the risk premium. The parameter ρ is the coefficient of relative risk aversion and Ω is the variance (covariance matrix in general) of exchange returns. Several authors [25] have inverted equation (3') without imposing the theoretical restrictions of mean-variance analysis, and have attempted to explain the ex post risk premium (forecast errors) by variables to which portfolio balance theory says that the risk premium should be related. This line of research has uniformly found no relation between rp and x.

Using the constraints implied by mean-variance analysis, and reasonable coefficient estimates for the parameters in (3'), Frankel (1986a) has argued that the exchange rate risk premium (and also its variability) must be very small. The argument can be summarized as follows. The unconditional monthly variance of the relative return on dollars over the period August 1973–August 1980 is roughly .001. If we take .001 as an upper bound on the conditional variance of relative dollar returns, and two as the coefficient of risk aversion, then the term $[\rho\Omega]$ is .002. An increase in the supply of foreign assets equal to 1 percent of the portfolio would only require an increase in the risk premium of .002 percent per month or 2.4 basis points per annum! The argument does, however, assume that the conditional variance of returns is constant; we take up this subject in the next subsection.

Hansen and Hodrick (1983), and Hodrick and Srivastava (1984, 1986), among others, have attempted to draw an inference regarding the magnitude and variability of the risk premium using a more general intertemporal utility valuation model of the risk premium. In this setting a linear equation relating asset supplies to the risk premium would only obtain if

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25. Rogoff (1984), Dooley and Isard (1982) among others. Frankel (1982) goes on to impose the theoretical restrictions on B.

investors' preferences were logarithmic or asset returns are intertemporally independent. We would not a priori expect to be able to explain the risk premium by relative asset shares alone, so these models offer an alternative theory of *rp*.

Implications of the intertemporal model of the premium have been tested by Hansen and Hodrick (1983), Hodrick and Srivastava (1984, 1986), and Cumby (1986), among others. Empirical work is typically conducted assuming that conditional second moments of exchange return do not vary across time. While statistical tests of the "consumption beta" model usually indicate a rejection of the model, qualitative features of the data are explained by this paradigm; see the discussion in Cumby (1986). We now turn to the implications of time variation in return second moments on variability of the risk premium and in turn on the variability of the spot rate.

3.2. IMPLICATIONS OF TIME-VARYING RETURN COVARIANCES

A number of authors have in effect argued that the assumption of a constant covariance matrix of exchange returns should be relaxed.[26] Pagan (1986) argues, in a context where the conditional variance changes over time, that there may be some points when it exceeds the sample variance (.01 on an annual basis), and that the risk premium at such a point will exceed the upper bound claimed in Frankel (1986a). But if one allows the conditional variance to vary over time, then one can still apply the upper bound to the *average* conditional variance and therefore to the average risk premium. If the conditional variance is 10 times larger than .01 one period in ten (for example, when the preceding squared realization was particularly large), then it is true that a 1 percent change in the portfolio in that period will change the risk premium by as much as 0.2 percent per annum, and that the magnitude of the risk premium could be as large as 20 percent per annum (if close to 100 percent of the portfolio is in one asset or the other). But in the other nine periods out of ten, these magnitudes would have to be zero for the variance to average out to .01.

When we allow for return variances to vary over time, variation in the risk premium derives from this extra source and can thus exhibit additional volatility. This point is made by Giovannini and Jorion (1987a). If we are interested in the question of how large an effect foreign exchange

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26. Frankel (1982, 260) describes this assumption as one made for convenience, to focus on variation in asset supplies and the risk premium, with variation in the variances and covariances considered a priority for future research.

intervention has on average, then the observation that the conditional variance and the risk premium may at times be higher and at times lower may not be very relevant. But for other questions, such as explaining the variability of the exchange rate, the observation that the risk premium changes over time is quite relevant.

Recent work by Cumby and Obstfeld (1984), Hsieh (1984), Domowitz and Hakkio (1985), and Giovannini and Jorion (1987a), rejects the hypothesis that the conditional variance of exchange returns is constant over time. Supporting evidence is provided by implicit variances extracted from options data in studies by Lyons (1986) and Hsieh and Manas-Anton (1986): these estimated variances, which are to be thought of as characterizing investors' conditional beliefs, clearly vary over time.

Giovannini and Jorion (1987a) specify the conditional variance as a function of the levels of domestic and foreign interest rates. Their aim is to argue that their model of variation in the conditional variance corresponds to large variation in the risk premium, in contrast to Frankel (1986a). But they appear to have stumbled into a (remarkably common) pitfall in their calculations: their estimates imply a true variance of the monthly risk premium equal to 1.1×10^{-4}, not 1.1 (Giovannini and Jorion, 1987b).

Perhaps the most popular approach to modeling the conditional variance of returns is to employ variants of Engle's (1982) autoregressive conditional heteroskedasticity (ARCH) process. In the context of the single period mean-variance model, Engel and Rodrigues (1987) show how to extend the econometric procedure of Frankel (1982) to account for time variation in return second moments. However, the basic message is unaltered when the Engel-Rodrigues procedure is employed. Given conventional estimates of the degree of risk-aversion, variation in the theoretical determinants of the risk premium is unable to explain the observed behavior of the forward discount under rational expectations.

Suppose we wish to consider the implications of time variation in return second moments for the question of exchange-rate determination.[27] We can infer the effects of changes in exchange-rate return variance on the demand for asset shares by looking at our equation for the optimally diversified portfolio:

$$x_t = A - (\rho \Omega_t)^{-1} r p_t \quad (3')$$

27. The following analysis parallels Poterba and Summers (1986) who conduct a similar exercise for stock prices.

Using equations (2) and (3') we can calculate the effect on the spot rate of a once-and-for-all change in the variance of exchange returns Ω_t holding the interest differential $i_t - i_t^*$ constant:[28]

$$\frac{ds_t}{d\Omega_t}\bigg|_{(i_t - i_t^*) - (s_{t+1}^e - s_t)} = +\left(\frac{1}{x_t} + \frac{1}{(1-x_t)}\right)\left(\frac{rp_t}{\rho\Omega_t^2}\right). \quad (18)$$

This analysis can be justified by assuming that the composition of monetary and nonmonetary assets is varied in whatever way is necessary to hold the interest differential constant. Since the change in Ω_t is permanent we know that the effect on tomorrow's spot rate will be the same as the effect on today's spot rate. Thus the risk premium $(i_t - i_t^* - (s_{t+1}^e - s_t))$ is held fixed in this experiment. The analysis is in the same spirit as our earlier attempts to quantify loosely the effects of changes in the disturbance term u_t in (2), and in expectations, when macroeconomic fundamentals are held constant.

The sign of the effect, equation (18), of the return variance on the spot rate depends on the sign of the initial risk premium. If the foreign asset initially pays a positive risk premium over the domestic asset (because the supply that must be held exceeds the demand constituted by the minimum-variance portfolio A; rp_t as we have defined it is negative), then the permanent increase in uncertainty reduces the demand for foreign assets and thus reduces their price s_t. The effect on s_t is zero if the initial risk premium is zero. But the effect can be very large in magnitude if the initial risk premium is nonzero, for example if the initial risk premium is on the order of .03 (as it might be if the entire 3 percent discount at which the dollar sold against the mark or yen in the early 1980s is attributed to a risk premium rather than to expected depreciation). For our benchmark parameter values ($x_t = \frac{1}{2}$, $\Omega_t = .01$ on an annual basis, and $\rho = 2$), we can calculate the linearized effect on the spot rate s_t of a change in Ω_t. Consider a permanent increase in the annual variance Ω_t from .01 to .02. Such a shock will have a possible linearized effect on s_t of roughly $(-4)\left[\frac{.03}{2(.01)^2}\right].01 = -600\%$, a large number.

A purely transitory disturbance to Ω_t will have an effect that is very much smaller than that calculated above: calculations based on (18) are mitigated by the presence of a second term that arises because the spot

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28. For simplicity we are leaving out the effect of a change in the return variance on the minimum variance portfolio A via the convexity term.

rate is expected to go back to its previous level in the future.[29] If we consider moving average as well as autoregressive models for Ω_t, in which the initial shock to the variance dies out gradually over time, then the algebra is considerably more complicated than for the transitory disturbance. In this case there is a third effect: the rational expectation of an effect on the spot rate next period when the innovation to the variance will have only partially died out. In these models the effect of a shock to Ω_t on the exchange rate lies between the effects of a permanent and transitory change in Ω_t; see Appendix.[30]

4. Survey Data and Heterogeneous Expectations

Of the factors suggested as determining "excessive variability" in section 1, we have considered the role of fundamentals versus the disturbance term, and we have considered risk and the degree of substitutability. We have still to consider the role of expectations per se. The idea of destabilizing speculation—that investors, responding to nonzero expectations of exchange-rate changes, work to raise the variability of the exchange rate—is what is often meant by descriptions of the market as excessively variable. The variance-bounds tests and bubbles tests at first sounded like a promising way to shed light on questions of destabilizing speculation and bandwagons. More simply, we could compare the variance when Δs^e in equation (9) is constrained to zero with the unconstrained variance: this is the test for "destabilizing speculation" performed by

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29. Suppose $\Omega_t = \Omega_0 + \delta_t$, where δ_t is now a purely transitory disturbance to Ω_t. The effect of δ_t on the exchange rate will be considerably smaller than that implied by (18). Besides the direct effect on Ω_t from (18) we must recognize that the spot rate in the subsequent period will return to its previous level, so that the risk premium will rise by the full amount of the increase in s_t. Taking account of this second offsetting term we get:

$$\frac{ds_t}{d\delta_t} = \left(\frac{1}{x_t} + \frac{1}{1 - x_t} \right) \left[\frac{rp_t}{\rho \Omega_t^2} - \left(\frac{1}{\rho \Omega_t} \right) \frac{ds_t}{d\delta_t} \right]$$
$$\rightarrow \frac{ds_t}{d\delta_t} \approx \frac{rp_t}{\Omega_t}.$$

Note that the effect on expectations is much more important than the portfolio valuation effect, due to the high degree of substitutability. Again, if the initial risk premium is close to zero, the effect on a change in the return variance is close to zero. But if the initial risk premium is .03 and we consider a transitory change in Ω_t from .01 to .02, the change in the spot rate will be roughly $-(.03/.01)(.01) = -.03$, or a 3 percent appreciation of the less risky currency.

30. Note that the mean-variance model (3') used to derive (18) is less applicable when Ω_t varies over time.

Kohlhagen (1979) and Eichengreen (1981). But, as we argued in section 2, we are not at all confident about having specified the fundamentals correctly, which means that there is no new information to be gained from these tests.

At the end of section 1 we suggested that the best way to get at the question of whether speculation is destabilizing or not is to consider whether expected future depreciation responds positively or negatively to a current change in the exchange rate. If a current depreciation, originating in fundamentals or anywhere else, generates anticipations of further depreciation, speculators will sell the currency and thereby exaggerate the depreciation. If it generates anticipations of future *appreciation*, back in the direction of some long-run equilibrium, speculators will buy the currency and thereby dampen the depreciation. We now consider this question of how expectations are formed.

4.1. MEASURING STABILIZING AND DESTABILIZING EXPECTATIONS

Two alternative ways of measuring expected exchange-rate changes are common in the literature. The first is the forward discount. The second is ex post changes in the sample period, allowing only for a purely random error term. The first is valid only if there is no time-varying risk premium, and the second only under the rational expectations assumption (including the absence of regime changes, peso problems, and the like).

What is sorely needed is an alternative to measuring expected depreciation either by ex post exchange-rate changes or by the forward discount, one that does not require prejudging either the unbiasedness of expectations or the existence of the risk premium. A good candidate for such a measure is offered by surveys of the exchange rate expectations of market participants. One such survey has been conducted every six weeks since 1981 by the *Economist*-affiliated *Financial Report*. The data are discussed and analyzed at length in Frankel and Froot (1985, 1986, 1987) and Froot and Frankel (1986).

The last line of table 2 reports a regression of regressive expectations with expected depreciation at a one-year horizon measured by the *Economist* survey data. It shows a highly significant expectation of regression toward equilibrium, at a rate of about 17 percent per year. For example, a 10 percent appreciation today generates the expectation of a 1.75 percent depreciation over the subsequent year. This expected speed of adjustment to PPP is in the range of the actual speeds of adjustment estimated in table 1.

Other tests reported in Frankel and Froot (1987), Dominguez (1986), and Froot and Frankel (1986), show that the prediction error made by the

Table 2 REGRESSIVE EXPECTATIONS

Data set	Dates	Coefficient Θ	$t: \Theta = 0$	DW(2)	DF	R^2
MMS 1 week	10/84–2/86	-0.0283 (0.0080)	-3.53**	2.10	219	0.58
MMS 2 week	1/83–10/84	-0.0299 (0.0079)	-3.78**	2.15	179	0.61
MMS 1 month	10/84–2/86	-0.0782 (0.0134)	-5.84**	1.40	1.51	0.79
MMS 3 month	1/83–10/84	-0.0207 (0.0146)	-1.41	1.55	179	0.18
Economist 3 month	6/81–12/85	0.0223 (0.0126)	1.78*	1.66	184	0.26
Amex 6 month	1/76–8/85	0.0315 (0.0202)	1.56	1.22	45	0.21
Economist	6/81–12/85	0.0600 (0.0159)	3.77**	1.32	184	0.61
Amex 12 month	1/76–8/85	0.1236 (0.0276)	4.48**	0.60	45	0.69
Economist 12 month	6/81–12/85	0.1750 (0.0216)	8.10**	1.25	184	0.88

Independent variable: $\bar{s}(t) - s(t)$
$\bar{s}$ measured by PPP
SUR regressions(1) of Survey expected depreciation:
$E[s(t+1)] - s(t) = a + \Theta[\bar{s}(t) - s(t)]$

Note: (1) Amex 6- and 12-month regressions use OLS due to the small number of degrees of freedom.
(2) The DW statistic is the average of the equation by equation OLS Durbin-Watson statistics for each data set.
*Significant at the 10 percent level.
**Significant at the 1 percent level.
R^2 *corresponds to an F test on all nonintercept parameters.*
The results are taken from Frankel and Froot (1986).
Constant terms for each currency were included in the regressions, but not reported above.

survey numbers is not random. The tests constitute a rejection of rational expectations (jointly with the hypothesis of no regime changes or other peso problem) that is free from any concerns about the risk premium. Generally, the true spot process behaves more like a random walk than the survey respondents realize. In terms of the language attributed to Bilson (1981) in section 2.3 above, there is excessive speculation: investors would generally do better to reduce their expectations of exchange-rate changes toward zero. In terms of the specific regressive expectations model estimated in table 2, survey respondents overestimate the speed of return to equilibrium.

One might think that such a failure of rational expectations would be evidence of the sort we are looking for, that "exchange markets are not working properly." But a tendency for speculators to expect the exchange rate to regress toward the equilibrium at a faster rate than is correct is *stabilizing*. An increase in the value of the currency, due in the context of equation (2) to an increase in the interest differential $i-i^*$ or the error term u, for example, will be damped because of the effect on expectations. Earlier we saw that the variability of the exchange rate in the Dornbusch overshooting model is inversely related to the value of θ.[31]

One cannot work with the survey data on expectations without pondering the issue of heterogeneous expectations. Almost all of the exchange-rate literature, theoretical as well as empirical, presupposes that market participants all share the same expectation. But the truth is that people disagree. Disagreement can explain the very high volume of trading in the spot and forward exchange markets. The *Financial Report* shows quite a range of variation in the survey responses; the high-low spread for the six-month expectations averages 15.2 percent. (The regressions reported in the tables here are based on the median response.)

The possibility of heterogeneous expectations introduces another possible source of variability into the exchange rate: the market in the aggregate may shift over time the weights it assigns to different forecasting mechanisms, for example the weight assigned to regressive versus bandwagon expectations. The market may increase the weight it gives to one of these formulations if it has recently been forecasting better than the other. This could happen if portfolio managers update in a Bayesian way the weights they place on the forecasts of different models. Alternatively, it could happen when those investors who bet correctly gain wealth and receive more weight in the market in the next period. As the weight

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31. If we ask what happens when the *true* speed of regression to PPP is held constant but investors have a higher *expected* speed of regression θ, it turns out that the effect is still to reduce variability. The effect on the conditional variance is shown in Frankel (1983).

placed by the market on different expectations shifts, the aggregate demand for foreign currency and therefore the exchange rate will change over time. Even if no single forecaster holds destabilizing bandwagon expectations, any factor pushing up the value of the currency, such as an increase in $(i - i^*)$ or u_t, will produce a drawn-out appreciation as the weight placed on the optimistic forecasts gradually increases. Although none of the actors in such a model is satisfying the rational expectations assumption in the sense of knowing the complete process that is driving the exchange rate, neither is any of the actors behaving foolishly. Putting more weight on bandwagon expectations than on regressive expectations would have given the right answer in the case of the dollar from 1981 to February 1985, for example, but would have lost the investor a lot of money thereafter. In such a changing world it is difficult to see what variables it would be "rational" for the investors to grant more weight.[32]

There exists some evidence for the idea that forecasters do not concur on a single stabilizing sort of expectations model as nicely as the estimates of regressive expectations described above would suggest. Money Market Services, Inc., has since 1983 conducted a weekly survey of currency traders as to their forecasts at shorter-term horizons than the *Economist* survey. Estimates of regressive expectations on these two sets of survey data, together with a third conducted by the *American Express Bank Review* irregularly between 1976 and 1985, are reported in table 2. The nine data sets are ordered by forecast horizon. The results are striking. Although the longer-term forecasts are strongly regressive, the shorter-term forecasts show precisely the reverse: a 10 percent appreciation today generates the expectation of 0.78 percent further *appreciation* over the next month. This suggests the possibility that the forecasters who subscribe to bandwagon expectations ("chartists," or technical analysts, who use time-series analysis to extrapolate past trends) tend to be traders with a shorter-term outlook, while those who subscribe to regressive expectations ("fundamentalists," who forecast a return to macroeconomic equilibrium) tend to be economists with a longer-term outlook. A small change in the weight that the market gives to two such different forecasts could have a large effect on the exchange rate, especially if asset demands are as sensitive to expected rates of return as was suggested by the substitutability arguments in section 3.

4.2. CONCLUSIONS

Since measurable fundamental variables do not adequately explain movements in exchange rates, it is tempting to argue that there must exist fun-

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32. For further elaboration on how such a model can work, see Frankel and Froot (1986).

damentals of which market investors are aware but the econometrician is not. Such an argument might be supported by any evidence that the market could predict future exchange rates better than the models; but there is no such evidence. Expectations measured by the forward exchange market (or by survey data) contain no useful information for predicting exchange-rate changes.

One need not explain all the fluctuations in the exchange rate to evaluate the scope for government policy.[33] Policy makers could affect the foreign exchange market through three different channels. First, macroeconomic policy, for example the monetary/fiscal policy mix and interest rates, has large effects. We have not explored these effects and the resulting policy-making trade-off between the exchange rate and other macroeconomic objectives in this article.

Second, Tobin (1978) and Dornbusch (1986) have argued that a tax on international borrowing or on other foreign exchange transactions would reduce the extent to which investors could react to small changes in the attractiveness of different countries' assets, and would thereby reduce exchange-rate volatility. As we noted in section 1.2, this argument requires that expectations be destabilizing. If expectations are instead stabilizing, then a decrease in the degree of substitutability would increase exchange-rate volatility rather than the reverse.

Third, others argue that central banks should intervene in foreign exchange markets to dampen fluctuations. Foreign exchange intervention of course affects the exchange rate to the extent it changes the relevant macroeconomic fundamentals, particularly nonsterilized intervention that allows the change in reserves to change the money supply. But effects via current macroeconomic fundamentals should be subsumed in the first category above. If foreign exchange intervention is to have an independent effect, particularly if sterilized intervention is to have a substantial effect, it will be via investor expectations of future exchange rate changes. The strongest case for steps toward reform of the floating rate system would be made if one could demonstrate that expectations are destabilizing, producing bandwagons in the exchange rate, and that a change in government policy might alter these expectations even without altering asset supplies, for example, by bursting a speculative bubble. The announcement on September 22, 1985, that the G-5 had decided at the Plaza Hotel to work to bring the dollar down caused an instant 5 per-

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33. Dornbusch (1986) points out that someone who believes that exchange markets are not efficient need not necessarily believe that the government could do better, any more than someone who, like Tobin (1978), believes that the markets are efficient need necessarily believe in laissez-faire.

cent depreciation of the dollar. While the fall in demand for dollars could be explained as a rational reevaluation of the expectation that U.S. monetary policy would become expansionary, it might also be explained as the bursting of a bubble. Our theories of rational speculative bubbles have virtually nothing to say about what causes the price to jump from one bubble path to another. But this is precisely the sort of effect for which many proponents of a more activist policy are looking. Proponents of a target zone argue that the stabilizing effect would be even greater if the government announced a change in policy regime, rather than a one-time initiative of the sort that took place at the Plaza.

The key question, then, seems to be the behavior of investor expectations. In particular, much hinges on whether expectations when left to themselves are destabilizing. The question whether the true spot process matches up with the expected one, that is, whether expectations are rational, is not as directly relevant. The evidence appears to be that expectations are stabilizing, at least at horizons greater than three months. The survey data at a one-year horizon reported in table 2, for example, show that a 10 percent appreciation today generates an expected future depreciation of about 1.7 percent. If speculators are investing on the basis of these expectations, then they are acting to stabilize the exchange rate.

Survey data at short horizons show quite different results, however. It seems likely that expectations are in fact heterogeneous. One consequence is that "the" expectation cannot be rational if investors do not agree on a single expectation. A second implication follows from the high degree of substitutability (for an average value of the variance) that we found in section 3: small changes in the weights that the market assigns to competing exchange rate forecasts will produce large changes in portfolio preferences and thus large changes in the exchange rate. This source of exchange-rate variability could be classed as a speculative bubble in the sense that it arises from self-confirming changes in expectations rather than from fundamentals, though it is not the rational speculative bubble that has been extensively studied recently.

As Krugman (1985) has argued, when the market has temporarily "lost its moorings" it is possible that a more activist policy can restore the anchor to expectations. Investors might be persuaded to expect more of a tendency to return to equilibrium. But central bank governors and finance ministers of major countries will only be able to affect expectations if they have credibility. They did not have credibility in 1973. In this sense the breakdown of the fixed exchange-rate system was inevitable. They have more credibility today; this much is clear from the market's sensitivity to every utterance of the Secretary of the Treasury and the Chairman of the Federal Reserve Board, and their Japanese and Ger-

man counterparts. Whether this credibility would still be there if policy makers tried to exploit it more systematically with a reform of the world monetary system is another question, especially if one allows for the usual politicization of any process of choosing targets for an economic price that affects people's livelihoods.

APPENDIX

Consider an ARIMA (0,1,1) model for Ω_t; $\Omega_t = \Omega_{t-1} + \delta_t - \alpha\delta_{t-1}$ with $0 < \alpha < 1$. The linearized effect on s_t of a shock δ_t to Ω_t can be obtained from the following expression.

$$\frac{ds_t}{d\delta_t} = \left(\frac{1}{x_t} + \frac{1}{1-x_t}\right)\left[\frac{rp_t}{\rho\Omega_t^2}\frac{d\Omega_t}{d\delta_t} - \frac{1}{\rho\Omega_t}\left(\frac{ds_t}{d\delta_t} - \frac{ds_{t+1}^e}{d\delta_t}\right)\right]$$

$$= \phi_t\left[\frac{rp_t}{\Omega_t} + \frac{ds_{t+1}^e}{d\delta_t}\right], \text{ where } \phi_t = \left(1 + \rho\Omega_t\Big/\left(\frac{1}{x_t} + \frac{1}{1-x_t}\right)\right)^{-1},$$

a number slightly less than one. Now assuming the initial position represented an equilibrium we can take Ω_t, x_t and rp_t to be constant so that

$$\frac{ds_{t+1}^e}{d\delta_t} = \left(\frac{1}{x_{t+1}} + \frac{1}{1-x_{t+1}}\right)\left[\frac{rp_{t+1}}{\rho\Omega_{t+1}^2}(1-\alpha) - \frac{1}{\rho\Omega_{t+1}}\left(\frac{ds_{t+1}^e}{\alpha\delta_t} - \frac{ds_{t+2}^e}{d\delta_t}\right)\right]$$

$$= \phi_t\left[\frac{rp_t}{\Omega_t}(1-\alpha) + \frac{ds_{t+2}^e}{d\delta_t}\right].$$

Likewise, $\dfrac{ds_{t+2}^e}{d\delta_t} = \phi_t\left[\dfrac{rp_t}{\Omega_t}(1-\alpha) + \dfrac{ds_{t+3}^e}{d\phi_t}\right].$

Combining these results we obtain

$$\frac{ds_t}{d\delta_t} = \phi_t\frac{rp_t}{\Omega_t}[1 + (1-\alpha)\phi_t + (1-\alpha)\phi_t^2 + \ldots]$$

$$= \phi_t\frac{rp_t}{\Omega_t}\left[1 + (1-\alpha)\left(\frac{1}{1-\phi_t} - 1\right)\right]$$

Using our benchmark values for x_t, rp_t, Ω_t and ρ, $\phi_t = (1.005)^{-1}$. If we assume that $\alpha = .9$, then $ds_t/d\delta_t = -63.3$. Therefore, the linearized effect on the spot rate of a .01 change in Ω_t is an approximately 63 percent appreciation of the less risky currency. (The value of $\alpha = .9$ is taken from empirical work reported in the unabridged version of this paper.)
    For the case where Ω_t follows an AR(1) process,

$$\Omega_t = \alpha\Omega_{t-1} + \delta_t \text{ with } |\alpha| < 1, \quad \frac{ds_{t+1}^e}{d\delta_t} = \phi_t\left[\frac{rp_t}{\Omega_t}\alpha + \frac{ds_{t+2}^e}{d\delta_t}\right].$$

Therefore,

$$\frac{ds_t}{d\delta_t} = \phi_t \frac{rp_t}{\Omega_t} [1 + \alpha\phi_t + \alpha^2\phi_t^2 + \ldots] = \phi_t \frac{rp_t}{\Omega_t} \left(\frac{1}{1 - \alpha\phi_t}\right).$$

If $\alpha = .9$, then $ds_t/d\delta_t \approx -30$ percent for a .01 change in Ω_t, assuming our benchmark parameter values.

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Comment

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When the title question of this article is put to me my first response is to ask, "compared to what?" What is the ruler I should use to decide that exchange rates are or are not excessively variable? This is a common but poorly posed question that I do not think economists are in a position to answer. There are, however, some closely related questions that economists can use their standard tools to confront.

1. One way to change this question so that economists can answer it was shown by Meese and Rogoff (1983a,b) who asked "Do any exchange-rate models (even giving them an information advantage) outpredict a random walk?" Their answer, unfortunately, was that the current generation of exchange-rate models "predict" consistently worse than a random walk except at long horizons. I will return to the relation of the Meese-Rogoff methods to the present article shortly.

2. A second way to change the question is to ask the implied policy question directly: "What kind of exchange-market policy should the United States adopt?" This question is addressable with an economist's toolkit only in the context of an explicit unrejected model of choice. This is, I think, what the article's title brings to mind but it is not a question the article seeks to answer so I will leave it alone.

The present article's approach is, to some extent, along the lines of my first question and it is along these lines that I will structure my comments.

A Quick Review of Meese-Rogoff Dick Meese and Ken Rogoff (M-R) used a variety of techniques to try to assess the out-of-sample forecasting

properties of typical exchange-rate models. A caricature of their methodology is the following:

STEP 1: Set up an exchange-rate model such as

$$s = a_0 + a_1m + a_2y + a_3(i - i^*) + a_4(TB - TB^*) + u$$

where s = log of domestic currency price of foreign currency
m = log of relative money supplies
y = log of relative output
i = domestic nominal interest rate
i^* = foreign nominal interest rate
TB = domestic trade balance
TB^* = foreign trade balance
u = a disturbance term
a_i = $(i = 0,1,2,3,4)$ coefficients.

STEP 2: Use some (appropriate) method to find values for the as.

STEP 3: "Forecast" the exchange rate using ex post–realized values of m,y,i,i^*,TB and TB^*.

STEP 4: Compare the above "forecasts" with some other forecasts (the horse race), for example, VAR forecasts, the forward rate, or the forecast of a random walk.

What M-R find is that nothing can outforecast a random walk at short horizons (less than 18 months).

Some Perspective on Exchange-Rate Model Failure   There is currently no exchange-rate model that predicts exchange rates well out of sample and even the in-sample performance of many exchange-rate models can be bizarre. I would like to comment briefly on two distinct types of failing models:

I: SEMIREDUCED-FORM MODEL FAILURE

In this class I place the failure of models such as Frankel's (1979) model and the M-R models. The failure of these models is very damaging to currently popular ways of thinking about exchange rates because these models rely on few auxiliary assumptions. It is, therefore, relatively unlikely that these models are rejected because auxiliary assumptions are incorrect.

II: REDUCED-FORM MODEL FAILURE

Reduced-form models incorporate the assumptions of semireduced form models plus additional assumptions allowing the researcher to construct exchange-rate reduced-form equations. Reduced-form models, therefore, include more auxiliary assumptions in the null, and model rejection leads less clearly to new research directions.

Among the auxiliary assumptions often used in exchange-rate models are the following: a. Rational expectations; b. No risk premium; c. Reasonably correct identification of agent's beliefs about forcing processes based on the econometrician's information set (no "peso-problems" or "process switching"); d. Correct solution choice if multiple solutions are consistent with the model (no bubbles or sunspots). Tests of the in-sample sensibleness or out-of-sample forecasting accuracy of reduced-form models are therefore muddled by possible inaccuracies of auxiliary assumptions. It is incorrect to think that any of the auxiliary assumptions listed above can be in any important way responsible for the M-R results. The M-R results can come from many sources, some of which are identified in the article under consideration, but not from errors in the auxiliary assumptions required for obtaining a reduced form.

Some Contributions of Frankel-Meese

Given that both the semireduced form and the reduced-form models work badly, we need to think about appropriate research directions. First, it is clear that the semireduced-form exchange-rate models need to be altered in some way. Second, auxiliary assumptions that can be investigated without maintaining some exchange-rate model can be checked. The second direction, while requiring less of an inspiration than the first, is not as obviously fruitful. It may turn out, for example, that an important auxiliary assumption of an eventually rejected semireduced-form model is irrelevant to obtaining reduced forms in a new generation of unrejected semireduced-form models. Frankel and Meese hedge their bets by pursuing both directions.

The article investigates several research directions, but the two of most interest to me are the following: (1) directions suggested by simulating the reaction of exchange-rate levels to unexpected time-variation in higher moments of the joint distribution of exchange rates and other variables; and (2) directions suggested by considering exchange-rate forecast survey data.

DIRECTION 1:   Having changes in higher moments matter for exchange-rate determination does not show up explicitly in M-R, although it might

be incorporated in several ways. One method would be to have the *as* in (1) depend explicitly on agents' estimates of higher moments of the joint distribution of exchange rates and other variables. To do this one would need to model how agents learn about these moments and the econometrician, in his estimation, would account for the agents' learning. Another way to pursue this same method is to allow the estimated coefficients in (1) to change as constrained only by the data during estimation. M-R do this without much luck.

A second method would be to include simulated values of the agent's beliefs about the moments directly as right-hand-side variables in M-R-style forecasting equations. This could be thought of as a linearization of the exchange-rate equation and might be less susceptible to functional-form misspecification than the first part of the first method.

DIRECTION 2: Exchange-rate forecast survey data gives the economist some direct observations on agents' beliefs about what the exchange rate will do in the future. Unfortunately, models that were constructed with no exchange-rate expectations survey data in mind are almost always predicated on homogenous beliefs and therefore provide no guidance on how to deal with data in which there is a dispersion of beliefs. Using the survey data in a satisfactory way will eventually require modeling the factors responsible for the dispersion of beliefs. Once such a well-articulated exchange-rate model allowing heterogenous beliefs is constructed, we can allow the model to tell us how to make use of the survey data.

Until such a model is constructed, a shortcut, which may anticipate later results, would be to stick some facts about the distribution of beliefs into an M-R equation. For example, one might include in the equation a measure of the central tendency of the distribution of the forecasts and a measure of the forecast dispersion.

Some Additional Research Directions

Frankel and Meese have identified some useful research directions concerning exchange-rate determination. I am not sure, however, that even if these directions pan out we will be much closer to answering the original question "Are Exchange Rates Excessively Variable?" I would hope that if these research directions do pan out then people will quit asking us such difficult questions about exchange rates. But if we keep getting asked in spite of the new research I would like to have some quantification of how well we can do in predicting or explaining exchange rates as compared with a wide variety of other prices. What I expect we will find is that there is a broad range in our ability to forecast and explain prices.

Once we have data on that range we can begin studying our successes and failures in a way that might lead to an eventual correction of the failures.

Whatever is found when systematically comparing exchange-rate volatility with volatility in other asset prices, I think we need to ask ourselves some of the following questions: a. Have flexible exchange rates in other episodes been inexplicably more variable than other asset prices? b. Is exchange-rate model failure correlated with other aspects of the economy? c. Do exchange-rate models work particularly badly during periods when money demand or money supply seem to be shifting around? d. If policy authorities were to fix exchange rates, where would the exchange-rate variance go?

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Comments

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This article is a very full and competent survey of work testing exchange-rate models; the title is really an excuse for this since the authors come up with no viable model capable of generating welfare-loss measures. Let me first consider their main conclusions, and then make some general comments.

Monetary ("structural") models have failed in and out of sample, they say, building mainly on work by Meese. Hence "fundamentals," as seen by economists, do not explain exchange-rate movements. To which my response is that the models reviewed are narrow, limited to three behavioral equations: demand for money, a real exchange-rate autoregression, and uncovered interest parity. Coefficients are constrained to be symmetric across countries, output and interest differentials are exogenous, velocity is unaffected by banking deregulation, and so on. But a model of the exchange rate is a macro model in which the exchange rate is just another endogenous variable like consumption, inflation, and unemployment. The models reviewed are hardly in this category.

Their second conclusion is that the nominal exchange rate is a random walk, the real exchange rate an autoregression (at least when they use 116 years' data, though not with less). Yet these two propositions are strictly inconsistent (unless price differentials and the real exchange rate were cointegrated, which there is no reason to believe is the case). Of the two, the second is more persuasive, since the real exchange rate will in a macro model regress toward some relative price equilibrium, itself probably following a random walk forced by such variables as tax rates; this would suggest that it follows overall a time-series process that is once integrated and has autoregressive and moving average orders of at least one. Had the authors fitted such a process, perhaps they would have had better results for their shorter postwar samples. As for the nominal exchange rate, since *every* shock in the economy will impinge on it, and longer-lived shocks with particular impact, its change is likely to have a high variance, and discrimination between a random walk and a once-integrated autoregressive moving average process will be, as the authors agree, very poor.

Their third conclusion is conventional by now, that there are time-varying risk premia in the forward rate; putting that together with their random walk model of the spot rate, they add that it would pay speculators to bet on the spot against the forward. If, however, the forward rate embodies a risk premium, only speculators less risk-averse than the market will do so; the average speculator would be well advised to refrain.

They rightly dismiss tests for bubbles, on the grounds that one cannot distinguish a bubble from an omitted fundamental. But their review of the survey data indicates that expectations are short-run extrapolative even though long-term regressive; this they interpret as evidence of expectations heterogeneity ("bandwagon effects" occurring as one group after another catches on to a change in the situation). My concern about these surveys is whether they capture the views of the important market players; after all, if, as the data show, these participants were expecting the dollar to fall in 1982, why didn't they push it down then? Presumably because those who took the portfolio decisions were not impressed.

At the end of all this, the authors leave us with essentially no view at all of what determines the exchange rate, real or nominal. This I find hard to take. A "random walk" time-series model may generate conditional forecasts of a high-variance variable that are as good as those of a structural model, but this does not reject the structural model; the time-series model is an alternative representation of the structural model and the time-series error variance will only be slightly higher than the true structural model error variance, but it only requires small misspecification of the structural model to reverse the ordering (Salmon and Wallis

Figure 1 NOMINAL EXCHANGE RATE (1975 = 100)

Nominal Exchange Rate
(1975=100)
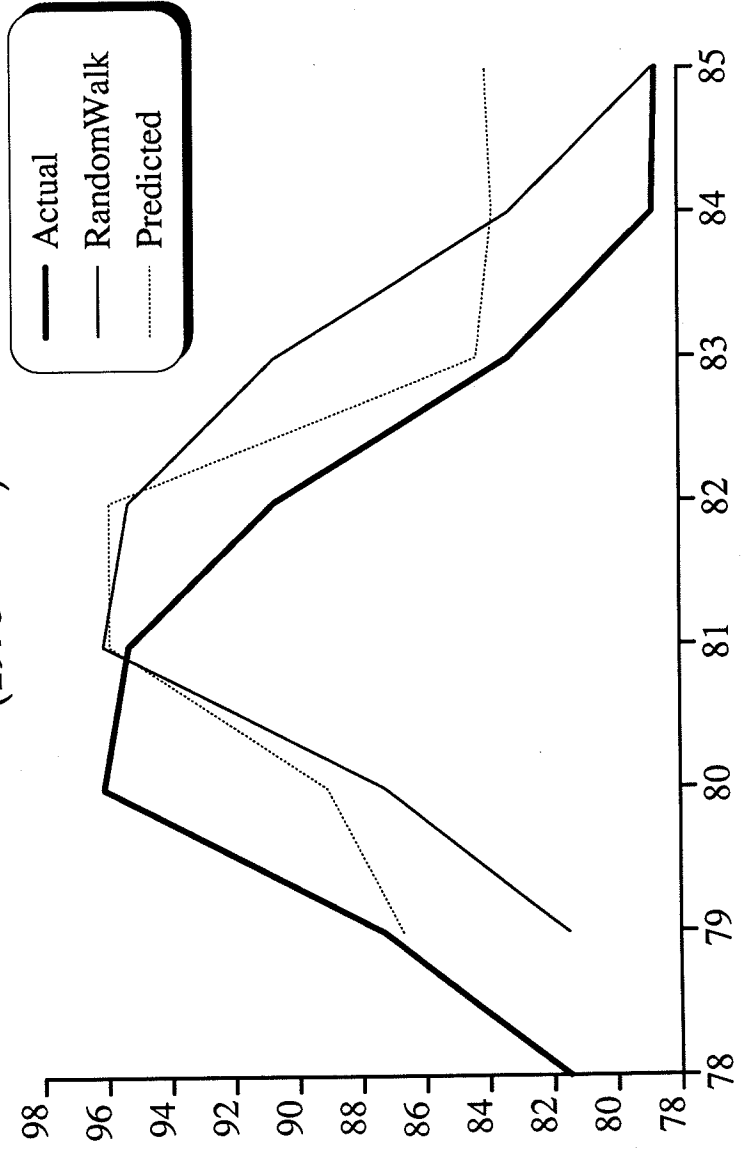
1982). Ex post analysis may be more informative. For an example, see figure 1, a chart of the ex post prediction of sterling's trade-weighted spot rate by the Liverpool model of the United Kingdom over the last seven years (Minford et al. 1984); the random walk forecast is also shown. It is apparent that the structural model can provide an "explanation" of the exchange rate that beats the "pure noise" explanation of the random walk. So the model is useful as an account of what structural factors could lie behind these movements. (By structure, I have a preference for the "shallow" structure of this model for empirical purposes, over "deep" alternatives. But that is a detail.)

The best empirically based macro theory we have, I suggest, is one in which aggregate demand and supply relationships interact under rational expectations to generate a saddlepath toward the equilibrium, itself propelled as a random walk. Such a model reconciles reduced-form evidence of high autoregressive and unit roots (as reported by Frankel and Meese), with evidence from simple structural equations not covered in their article. As for bubbles and expectations heterogeneity, the former is an antitheory since it violates terminal conditions required to make sense of rational expectations models, and the latter seems to be too intractable to be a candidate yet for a viable theory.

In all, this is an extremely useful article but its theoretical nihilism is not warranted.

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Discussion

Maurice Obstfeld was pessimistic about the possibility of developing an endogenous theory of bubbles and of developing its policy implications. He also questioned Frankel and Meese's definition of destabilizing speculation. He did not see how one could usefully define the concept without specifying the economic environment in which agents are assumed to be operating. Further, the Friedman argument that destabilizing speculation implies that the speculators lose money is sometimes right. Finally, he was puzzled by the use of PPP as a benchmark for long-run equilib-

rium. On both theoretical and empirical grounds, PPP is not expected to hold in general; rather it is the exception.

Martin Bailey pointed out that the Tobin tax on foreign exchange transactions is intended to affect investors' effective horizons by making very short-term transactions expensive. The purpose of the tax is to discourage myopic speculation and to encourage making portfolio decisions on the basis of longer-term fundamentals.

The random walk view of the real exchange rate was defended by John Campbell. One can write the real exchange rate as the sum of (i) the infinite sum of expected real exchange rates plus (ii) the infinite sum of expected risk premia plus (iii) the long-run equilibrium real exchange rate. Empirical evidence suggests that most of the movement in the real exchange rate is attributable to changes in (iii), that is, permanent shocks. If such permanent shocks exhibit random walk behavior, then the real exchange rate follows a random walk. Investigating the movement of the long-run equilibrium exchange rate is more important than looking at the behavior of expectations.

Robert Barro questioned the claim by Frankel and Meese that monetary disturbances have real effects. This is not obvious and needs to be explained.

Kenneth Singleton stressed the importance of taking heterogeneous expectations into account. Analysis of trading in currency markets with heterogeneously informed large traders leads to consideration of strategic informed trading or forecasts of forecasts of others, as discussed by Townsend. When incorporated in a model in a structured way, heterogeneous expectations have strong implications for the time-series properties of the exchange rate. These models can imply more volatility in the exchange rate than models with homogeneous expectations.

In reply, Jeffrey Frankel clarified the article's claim about the random walk of the exchange rate. That claim holds for univariate representations. In a multivariate system, some other variables can help predict the nominal exchange rate. Responding to Obstfeld's comment on PPP, he stressed that the key question asked is whether the exchange rate has a tendency to regress in the long run toward some equilibrium, not necessarily a constant level, nor necessarily PPP. The evidence from 116 years of data shows a significant tendency to regress toward the equilibrium. Because the speed of regression is slow the regression is not visible in only 13 years of data.

Answering Barro's question about the real effects of monetary disturbances, he referred to a result by Engle and Frankel on the effects of money stock announcements. When the Federal Reserve's announced

money supply in the previous week is larger than generally expected, the dollar tends to go down and the nominal interest rate tends to go up.

Frankel was as puzzled as Minford by the fact that although the survey data in 1982 show that people expected the dollar to come down, they must have nonetheless increased their demand for dollars at that time, causing the dollar to appreciate. One tentative explanation by Froot and Frankel focuses on heterogeneous expectations in the market. Suppose people differ in the speed at which their expectations regress toward the long-run equilibrium. Perhaps traders in 1983–1984 listened to people with low regression speeds ("chartists") more than to those with high regression speeds ("fundamentalists"), because chartists had been doing better than fundamentalists recently.

He agreed with Obstfeld on the difficulty of modeling endogenous bubbles, but he also pointed out that we might be restricting the form of bubbles too much. An extra term in the perfect foresight solution is not the only definition of the bubbles.