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ARE EXCHANGE RATES EXCESSIVELY VARIABLE?
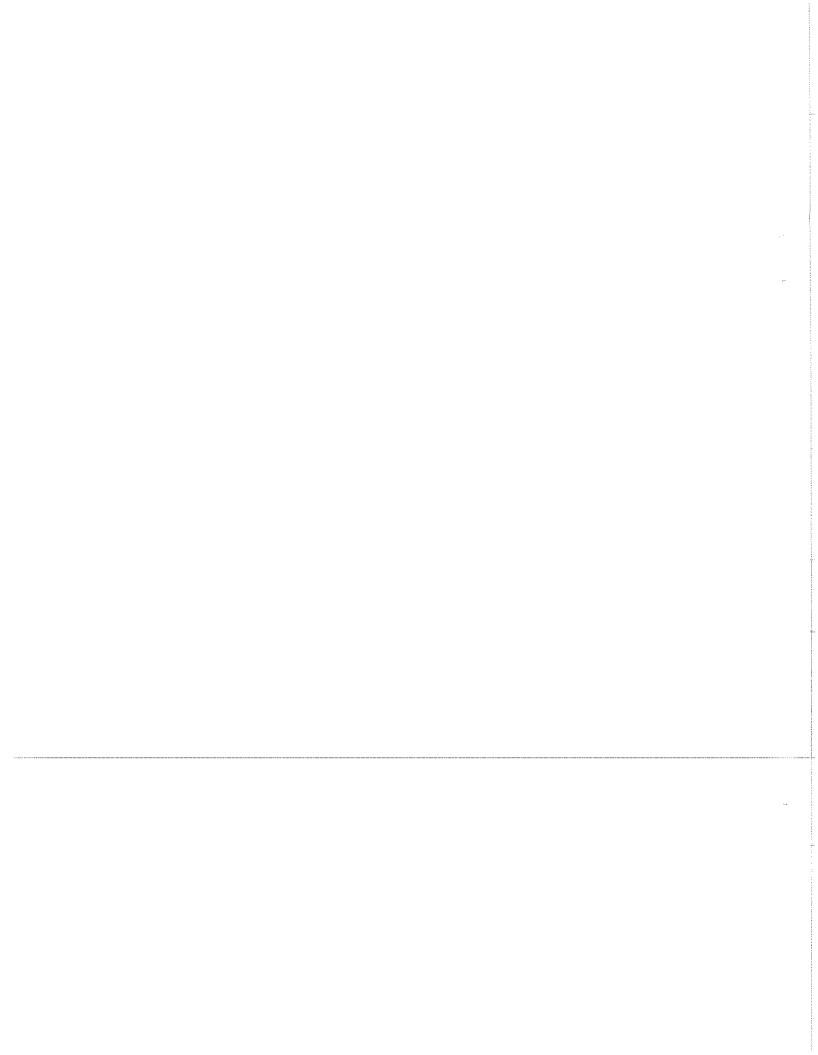
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Key words: Exchange rates, volatility, bubbles, fundamentals.

Abstract

"Unnecessary variation" is defined as variation not attributable to
variation in fundamentals. In the absence of a good model of macroeconomic
fundamentals, the question "are exchange rates excessively variable?," cannot
be answered by comparing the variance of the actual exchange rate to the
variance of a set of fundamentals. This paper notes the failure of regression
equations to explain exchange rate movements even using contemporaneous
macroeconomic variables. It notes as well the statistical rejections of the
unbiasedness of the forward exchange rate as a predictor of the spot rate. It
then argues that, given these results, there is not much to be learned from the
variance-bounds tests and bubbles tests.

The paper also discusses recent results on variation in the exchange risk
premiums arising from variation in conditional variances, both as a source of
the bias in the forward rate tests and as a source of variation in the spot rate.
It finishes with a discussion of whether speculators' expectations are
stabilizing or destabilizing, as measured by survey data. The paper concludes
that it is possible that exchange rates have been excessively variable -- as,
for example, when there are speculative bubbles -- but that if policy-makers
try systematically to exploit their credibility in order to stabilize exchange
rates, they may see their current credibility vanish.

Are Exchange Rates Excessively Variable?

Jeffrey A. Frankel   Richard Meese

April 1987

OUTLINE

I. The Meaning of "Excessive Variability"

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 ecomomic 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]

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 propor-
tion 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. Second, the proportion
of exchange rate movements that can be explained even _after_ the fact, using
contemporaneous macroeconomic variables, is disturbingly low.

I.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 for 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. We find that there are three questions that have yet to be satisfactorily answered, and that are examined in this study. 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 be trying 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 non-stationarity 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.

I.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:

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

We represent the interest differential by $i-i^*$, other fundamental deter-
minants 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 com-
ponents of expected returns enter with coefficients of equal magnitude:

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

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]

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

Then (2) would hold, with

$$-L(\cdot) \equiv \log\bigl(x(\cdot)\bigr) - \log\bigl(1-x(\cdot)\bigr) \ , \quad \text{and}$$

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

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

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

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 inconsistent 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 doesn't 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

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

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

$$(7) \qquad \frac{1}{(1+\beta\theta)^2} \, \text{var}(u_t) \ .$$

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 welfare. 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, inflation, 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 paper.

Our interest here is only in the question 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. There is a wealth of empirical results that can be brought to bear.

II. Random Walk Results

A variety of different econometric approaches seem to end up at the same conclusion, that the exchange rate follows a random walk. In this part of the paper we discuss the apparent inability to forecast future changes in the exchange rate using either

(i) the past time series of the process itself (section II.1),

(ii) macroeconomic fundamentals (section II.2), or

(iii) the forward exchange market (section II.3).

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

II.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)) 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, pre-
ferring 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, 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, p. 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 1973–84 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

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* (.0003)	.006* (.002)	−.0004 (.0022)	.009 (.013)
Autoregression				
of deviations from mean	.720* (.248)	.706* (.132)	.829* (.090)	.860* (.048)
of deviations from trend	.734* (.277)	.710* (.133)	.750* (.106)	.846* (.050)

Note: Standard errors are reported in parentheses.

*Significant at the 95 percent level.

Source: Frankel (1986b)

this speed of adjustment is not so low as to be implausible as a point esti-
mate, it is sufficiently low that one cannot reject the hypothesis that it is
zero. In other words, one cannot reject the hypothesis that the autoregres-
sive coefficient is 1.0.

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 stan-
dard 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, p. 699), 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 statis-
tical 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. 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 $\sqrt{(1 - .80^2)(.15^2)}$ = 10 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 sub-sections respectively.

II.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

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

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

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

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, like 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, i.e., 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, e.g., 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 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 one 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

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

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 sub-
stantial 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 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, such as those discussed in later sections. 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 righthand-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, etc. 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 so much the poor fits? The first reason is 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 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 why 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 II.4 below.

Faced with poor econometric results for our models based on macro-economic 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.

II.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

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

Under the null hypothesis that the forward discount is an unbiased predictor

of actual depreciation, the coefficient b should be one.[20]

The null hypothesis in equation (11) is usually rejected. The coef-

ficient is significantly less than one; the implication is that one could

expect to make money by betting against the forward discount whenever it is

nonzero. Often the estimated coefficient is close to zero or even negative,

which would say that the forward discount does not even get the <u>direction</u> of

movement of the exchange rate right. Bilson (1981) interprets this finding as

"excessive speculation:" investors would do better if they would routinely

reduce 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 Part III.

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 indiscriminantly 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 statis-
tical 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 mis-forecast the appreciation of the dollar in 1981-84
because it could not know that the White House or Congress.would repeatedly
fail to correct the structural budget deficit." If investors repeatedly mis-
forecast 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 (1985b), 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 Part III.

II.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, p. 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 also been levelled at the variance-bounds tests applied to the stock market by Shiller (1981). But it has not entirely sunk 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 modelling 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:

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

Equation (9') could be estimated by McCallum's (1976) method of replacing $E_t s_{t+1}$ by the expost 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 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,

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

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:

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

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

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

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 non-trivial 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.

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 equalling 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 semi-elasticity of money demand, in the monetary model), and ℓ_t denotes the fundamentals. The results from Meese and Singleton (1983) allow us to deduce

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

in the absence of exchange market bubbles. The most standard application (e.g. 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

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

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

The variance bounds test has $\underline{no}$ power to detect the alternative $cov(fd_t, \varepsilon_{t+1}) = cov[fd_t, (s_{t+1} - f_t)] > 0$, since (17) would hold $\underline{a}$ $\underline{fortiori}$. The most common empirical finding in regression tests of (16) is that $cov(\Delta s_{t+1}, fd_t) < 0$ which also implies that $cov(fd_t, \varepsilon_{t+1}) < 0$.[24] However, the variance of the lefthand side of (17) is typically so much larger than the variance of the righthand side that a test of (17) fails to uncover a significant negative covariance of the forward discount with the forecast error ε_{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 reject (17) for the same currencies and sample periods. It is true that all of Huang's point estimates of the bound

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

are violated, but none of the violations is statistically significant.
These "small sample" results illustrate the large-sample theoretical results
of Frankel and Stock (1987) who show that the most powerful conditional
volatility test is equivalent to the analogous regression test in terms of
asymptotic power. See also Froot (1987) for further discussion.

III. 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 II.3),
or the results of variance bounds tests (described in section II.4), to the
risk premium. This would leave only the explanation that expectations
cannot be assumed rational in the sense of lending themselves to represen-
tation 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 para-
meter β, can be a key determinant of the exchange rate, estimating the
variability of the risk premium will help us analyze the sources of varia-
bility 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 II.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.

III.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:

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

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% of the portfolio would only require an increase in the risk premium of .002% 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 conduct 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 suplies to the risk premium would only obtain if 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 our atten-
tion to the implications of time variation in return second moments on vari-
ability of the risk premium and in turn on the variability of the spot rate.

III.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 we allow 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 one 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 big an effect foreign exchange 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 investor's 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 fallen 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 Rodriguez (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-Rodriguez 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:

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

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]

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

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 $\left(i_t - i_t^* - (s_{t+1}^e - s_t)\right)$ 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 non-zero, 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

$$(-4)\left[\frac{.03}{2(.01)^2}\right].01 = -600\% \text{ , a large number.}$$

A purely transitory disturbance to Ω_t will have an effect which 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 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 1.[30]

IV. Survey Data and Heterogeneous Expectations

Of the factors suggested as determining "excessive variability" in section I of this paper, 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 non-zero 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 Kohlhagen (1979) and Eichengreen (1981). But, as we argued in section II, 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 Part I 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. In this part of the paper we consider this question of how expectations are formed.

IV.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, etc.).

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 pre-judging 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 (1985,6,7) 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 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,

TABLE 2
REGRESSIVE EXPECTATIONS

Independent variable: $\bar{s}(t) - s(t)$

$\bar{s}$ measured by PPP

SUR Regressions(1) of Survey Expected Depreciation:

$$E\big(s(t+1)\big) - s(t) = a + \theta\big(\bar{s}(t) - s(t)\big)$$

Data Set	Dates	Coefficient $\hat{\theta}$	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	151	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 Month	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

(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.

 *   represents significance at the 10 percent level.
 ** represents significance at the 1 percent level.

R^2 corresponds to an F test on all nonintercept parameters.

The results are reported in Frankel and Froot (1986).

Constant terms for each currency were included in the regressions, but not reported above.

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 II.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 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 don't 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 conducted since 1983 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 <u>appreciation</u> 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 big 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 III.

IV.2. Conclusion

Since measurable fundamental variables do not adequately explain movements in exchange rates, it is tempting to argue that there must exist fundamentals 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, macro-economic policy, for example the monetary/fiscal policy mix and interest

rates, has large effects. We have not explored these effects and the resulting policymaking tradeoff between the exchange rate and other macroeconomic objectives in this paper.

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 I.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 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 percent depreciation of the dollar. While the fall in demand for

dollars could be explained as a rational re-evaluation of the future expan-
sionariness of U.S. monetary policy, 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, i.e., 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 can't be rational if investors do not agree on a single
expectation. A second implication follows from the high degree of substitu-
tability (for an average value of the variance) that we found in section
III: 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 Treasury Secretary and the Chairman of the Federal Reserve, and their Japanese and German 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 1

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.

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

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

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

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

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

Combining these results we obtain

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

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

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 $\frac{ds_t}{d\delta_t} = -63.3$. Therefore, the linearized effect on the spot rate of a .01 change in Ω_t is an approximately 63% 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,

$$\Omega_t = \alpha\Omega_{t-1} + \delta_t \quad \text{with} \quad |\alpha| < 1 \ , \quad \frac{ds^e_{t+1}}{d\delta_t} = \phi_t\left[\frac{r\rho_t}{\Omega_t}\,\alpha + \frac{ds^e_{t+2}}{d\delta_t}\right]. \quad \text{Therefore,}$$

$$\frac{ds_t}{d\delta_t} = \phi_t\,\frac{r\rho_t}{\Omega_t}\left[1 + \alpha\phi_t + \alpha^2\phi_t^2 + \ldots\right] = \phi_t\frac{r\rho_t}{\Omega_t}\left(\frac{1}{1-\alpha\phi_t}\right). \quad \text{If} \quad \alpha = .9, \quad \text{then}$$

$$\frac{ds_t}{d\delta_t} \approx -30\% \quad \text{for a .01 change in} \quad \Omega_t \quad \text{assuming our benchmark parameter}$$

values.

Footnotes

[1]Friedman (1953).

[2]See, for example, Williamson (1985).

[3]In Section III.1 below, 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.

[4]For example, Meese and Rogoff (1983a,b).

[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:

(3') $x = \sum_i w_i A_i - B(rp)$, where w_i is the share of world wealth held by residents of country i, which includes their cumulated claims on foreigners.

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

[7]We consider time-varying variances more in section III.2.

[8]Cumby and Obstfeld (1984, p. 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.

[9]Frenkel (1976) and Bilson (1978).

[10]This is the case where B in equation (3) is infinite.

[11]Dornbusch (1976), Frankel (1979).

[12]Branson (1977) and Girton and Henderson (1977), among others.

[13]Frankel (1984), Hooper and Morton (1982).

[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, $\frac{1}{\lambda\theta}$ represents the amount of overshooting. For elaboration, see Frankel (1983, p. 42).

[16]For example, Meese and Rogoff (1983a), Backus (1984), and Frankel (1984). Somanath (1986) reports updated fit statistics for the above-mentioned models both insample (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.

[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 (1975), 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.

[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.

[22]See Krasker (1980).

[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.

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

$$cov\left[(f_t - s_t), (s_{t+1} - f_t)\right] = cov\left[(f_t - s_t), (s_{t+1} - s_t) - (f_t - s_t)\right]$$
$$= -var(f_t - s_t) + cov\left[(f_t - s_t), (s_{t+1} - s_t)\right] \quad . \quad \text{The sum of the last two}$$

terms is less than zero whenever $\hat{b} < 0$.

[25]See Frankel (1982), Rogoff (1984), Dooley and Isard (1982) among others.

[26]Frankel (1982, p. 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.

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

[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.

[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.

[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).

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

[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.

References

Adler, M. and B. Lehman. 1983. "Deviations from Purchasing Power Parity in the Long Run." Journal of Finance 39, 5 (December): 1471-1487.

Backus, D. 1984. "Empirical Models of the Exchange Rate: Separating the Wheat from the Chaff." Canadian Journal of Economics 17: 824-6.

Bilson, J. 1978. "Rational Expectations and the Exchange Rate." In The Economics of Exchange Rates: Selected Readings, edited by Jacob Frenkel and Harry Johnson. (Reading: Addison-Wesley).

Bilson, J. 1981. "The Speculative Efficiency Hypothesis." Journal of Business 54 (July): 433-51.

Blanchard, O. and M. Watson. 1982. "Bubbles, Rational Expectations and Financial Markets." NBER Working Paper, No. 945.

Branson, W. 1977. "Asset Markets and Relative Prices in Exchange Rate Determination." IIES Seminar, Paper No. 66.

Casella, A. 1985. "A New Test for Price Level Bubbles." M.I.T. mimeo.

Cumby, R. 1986. "Is it Risk? Explaining Deviations From Uncovered Interest Parity." New York University mimeo.

Cumby, R. and M. Obstfeld. 1984. "International Interest Rate and Price Level Linkages Under Flexible Exchange Rates: A Review of Recent Evidence." In Exchange Rate Theory and Practice, edited by J. Bilson and R. Marston. (Chicago: University of Chicago Press.)

Dickey, D. and W. Fuller. 1979. "Distribution of the Estimators for Autoregressive Time Series with a Unit Root." Journal of American Statistical Association 74 (June): 427-31.

Dominguez, K. 1986. "Expectations Formation in the Foreign Exchange Market: New Evidence from Suvey Data." Economic Letters.

Domowitz, I. and C. Hakkio. 1985. "Conditional Variance and the Risk Premium in the Foreign Exchange Market." Journal of International Economics 12: 257-276.

Dooley, M. and P. Isard. 1982. "A Portfolio Balance Rational-Expectations Model of the Dollar-Mark Exchange Rate." Journal of International Economics 12: 257-76.

Dooley, M. and J. Shafer. 1983. "Analysis of Short-Run Exchange Rate Behavior: March 1973 to November 1981." In Exchange Rate and Trade Instability: Causes, Consequences, and Remedies, edited by D. Bigman and T. Taya. (Washington, D.C.: International Monetary Fund).

Dornbusch, R. 1976. "Expectations and Exchange Rate Dynamics." Journal of Political Economy 84 (December): 1161-74.

_____. 1986. "Flexible Exchange Rates and Excess Capital Mobility." Brookings Papers on Economic Activity 1: 209-26.

Eichengreen, B. 1981. "Did Speculation Destabilize the French Franc in the 1920s?" Explorations in Economic History 19 (January): 71-100.

Engel, C. and A. Rodriguez. 1987. "Tests of International CAPM with Time Varying Covariances." Unpublished mimeo.

Engle, R. 1982. "Autoregressive Conditional Heteroskedasticity with Estimates of the Variance of United Kingdom Inflation." Econometrica 50 (July): 987-1007.

Evans, G. 1986. "A Test for Speculative Bubbles and the Sterling-Dollar Exchange Rate: 1981-84." American Economic Review 76: 621-636.

Fama, E. 1984. "Forward and Spot Exchange Rates." Journal of Monetary Economics 14: 319-338.

Flood, R. 1981. "Explanations of Exchange-Rate Volatility and Other Empirical Regularities in Some Popular Models of the Foreign Exchange Market." Carnegie-Rochester Conference Series on Public Policy, No. 15: 219-50.

Flood, R. and P. Garber. 1980. "Market Fundamentals versus Price-Level Bubbles: The First Tests." Journal of Political Economy 88: 745-70.

Flood, R.; Hodrick, R.; and P. Kaplan. 1986. "An Evaluation of Recent Evidence on Stock Market Bubbles." NBER Working Paper.

Frankel, J. 1979. "On the Mark: A Theory of Floating Exchange Rates Based on Real Interest Differentials." American Economic Review: 610-22.

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

_____. 1983. "The Effect of Excessively Elastic Exchange Rate Expectations in the Dornbusch Overshooting Model." Journal of International Money and Finance.

_____. 1984. "Tests of Monetary and Portfolio-Balance Models of Exchange Rate Determination." In Exchange Rate Theory and Practice, edited by J. Bilson and R. Marston. (Chicago: University of Chicago Press.)

_____. 1985. "The Dazzling Dollar." Brookings Papers on Economic Activity 1: 199-217.

_____. 1986a. "The Implications of Mean-Variance Optimization for Four Questions in International Macroeconomics." Journal of International Money and Finance (Supplement): S53-75.

_____. 1986b. "International Capital Mobility and Crowding Out in the U.S. Economy: Imperfect Integration of Financial Markets or of Goods Markets." In How Open is the U.S. Economy?, edited by R. Hafer. (Lexington: Lexington Books).

Frankel, J. and K. Froot. 1985. "Using Survey Data to Test Some Standard Propositions Regarding Exchange Rate Expectations." NBER Working Paper No. 1672 (August). Abridged in American Economic Review (Forthcoming; March 1987).

_____. 1986. "Explaining the Demand for Dollars: International Rates of Return and the Expectations of Chartists and Fundamentalists." Economics Working Paper, No. 8603, U.C. Berkeley (June). Abridged in Economic Record (Forthcoming).

_____. 1987. "Using Survey Data to Test Standard Propositions Regarding Exchange Rate Expectations." American Economic Review 77.

Frankel, J. and J. Stock. 1987. "Regression vs. Volatility Tests of Foreign Exchange Markets." Journal of International Money and Finance 6: 49-56.

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

_____. 1981. "The Collapse of Purchasing Power Parity During the 1970's." European Economic Review 16: 145-65.

Friedman, M. 1953. "The Case for Flexible Exchange Rates." In Essays in Positive Economics, edited by Milton Friedman. (Chicago: University of Chicago Press): 157-203.

Froot, K. 1987. "Tests of Excessive Variability in Asset Markets." Sloan School of Management, M.I.T. (April).

Froot, K. and J. Frankel. 1986. "Interpreting Tests of Forward Discount Bias Using Survey Data on Exchange Rate Expectations." NBER Working Paper, No. 1963 (June).

Fuller, W. 1976. Introduction to Statistical Time Series. (New York: Wiley).

Giovannini, A. and P. Jorion. 1987a. "Interest Rates and Risk Premia in the Stock Market and in the Foreign Exchange Market." Journal of International Money and Finance (March).

_____. 1987b. "Foreign-Exchange Risk Premia Volatility Once Again." Columbia University, mimeo.

Girton, L. and D. Henderson. 1977. "Central Bank Operations in Foreign and Domestic Assets under Fixed and Flexible Exchange Rates." In The Effects of Exchange Rate Adjustments, edited by P. Clark, D. Logue, and R. Sweeney: 151-79. (Washington: U.S. Government Printing Office).

Hakkio, C. 1984. "A Re-examination of Purchasing Power Parity: A Multi-Country and Multi-Period Study." Journal of International Economics 17 (November): 265-78.

Hamilton, J. and C. Whiteman. 1986. "The Observable Implications of Self-Fulfilling Expectations. Journal of Monetary Economics.

Hansen, L. 1982. "Large Sample Properties of Generalized Method of Moments Estimators." Econometrica.

Hansen, L. and R. Hodrick. 1980. "Forward Exchange Rates as Optimal Predictors of Future Spot Rates: An Econometric Analysis." Journal of Political Economy 88: 828-53.

_____. 1983. "Risk Averse Speculation in the Forward Foreign Exchange Market: An Econometric Analysis of Linear Models." In Exchange Rates·

and International Macroeconomics, edited by J. Frenkel. (Chicago: University of Chicago Press).

Hansen, L. and T. Sargent. 1980. "Formulating and Estimating Dynamic Linear Rational Expectations Models." Journal of Economic Dynamics and Control.

Hausman, J. 1978. "Specification Tests in Econometrics." Econometrica 46: 1251-71.

Hodrick, R. and S. Srivastava. 1984. "An Investigation of Risk and Return in Forward Foreign Exchange." Journal of International Money and Finance 3: 5-29.

_____. 1986. "The Covariation of Risk Premiums and Expected Future Spot Exchange Rates." Journal of International Money and Finance. (Supplement): S5-22.

Hooper, P. and J. Morton. 1982. "Fluctuations in the Dollar: A Model of Nominal and Real Exchange Rate Determination." Journal of International Money and Finance 1: 39-56.

Hsieh, D. 1984. "Tests of Rational Expectations and No Risk Premium in Forward Exchange Markets." Journal of International Economics 17: 173-84.

Hsieh, D. and L. Manas-Anton. 1986. "Empirical Regularities in the Deutsch Mark Futures Options." Center for Research in Security Prices, Working Paper No. 189. University of Chicago.

Huang, R. 1981. "The Monetary Approach to Exchange Rate in an Efficient Foreign Exchange Market." Journal of Finance: 31-41.

_____. 1984. "Some Alternative Tests of Forward Exchange Rates as Predictors of Future Spot Rates." Journal of International Money and Finance 3, 2 (August): 153-67.

Huizinga, J. 1986. "An Empirical Investigation of the Long Run Behavior of Real Exchange Rates." University of Chicago mimeo.

Kohlhagen, S. 1979. "On the Identification of Destabilizing Speculation." Journal of International Economics 9 (August): 321-40.

Krasker, W. 1980. "The 'Peso Problem' in Testing the Efficiency of Forward Exchange Markets." Journal of Monetary Economics 6: 269-76.

Krugman, P. 1978. "Purchasing Power Parity and Exchange Rates: Another Look at the Evidence." Journal of International Economics 8: 397-407.

_____. 1985. "Is the Strong Dollar Sustainable?" In The U.S. Dollar-Recent Developments, Outlook, and Policy Options, (Kansas City: Federal Reserve Bank).

Levich, R. 1979. "On the Efficiency of Markets for Foreign Exchange." In International Economic Policy: Theory and Evidence, edited by R. Dornbusch and J. Frenkel. (Johns Hopkins).

Longworth, D. 1981. "Testing the Efficiency of the Canadian-U.S. Exchange Market Under the Assumption of No Risk Premium." Journal of Finance 36 (March): 43-49.

Lyons, R. 1986. "Tests of the Foreign Exchange Risk Premium Using the Expected Second Moments Implied by Options Pricing." M.I.T. mimeo.

McCallum, B. 1976. "Rational Expectations and the Natural Rate Hypothesis: Some Consistent Estimates." Econometrica 44: 43-52.

McKinnon, R. 1976. "Floating Exchange Rates 1973-74: The Emperor's New Clothes." Carnegie-Rochester Conference Series on Public Policy, No. 3: 79-114.

Meese, R. 1986. "Testing for Bubbles in Exchange Rates: A Case of Sparkling Rates?" Journal of Political Economy: 345-73.

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

_____. 1983b. "The Out-of-sample Failure of Empirical Exchange Rate Models: Sampling Error or Misspecification?" In Exchange Rates and International Macroeconomics, edited by J. Frenkel. (Chicago: University of Chicago Press).

Meese, R. and K. Singleton. 1982. "On Unit Roots and the Empirical Modeling of Exchange Rates." Journal of Finance (September): 1029-35.

_____. 1983. "Rational Expectations and the Volatility of Floating Exchange Rates." International Ecoomic Review: 721-33.

Mussa, M. 1979. "Empirical Regularities in the Behavior of Exchange Rates and Theories of the Foreign Exchange Market." Carnegie-Rochester Series on Public Policy, No. 11: 9-57.

Obstfeld, M. 1986. "How Integrated are World Capital Markets? Some New Tests." NBER Working Paper, No. 2075.

Pagan, A. 1986. "A Note on the Magnitude of Risk Premia." University of Rochester, mimeo.

Phillips, P. C. B. 1985. "Time Series Regression with Unit Root." Cowles Foundation Discussion Paper, No. 740.

Poole, W. 1967. "Speculative Prices as Random Walks: An Analysis of Ten Time Series of Flexible Exchange Rates." Southern Economic Journal 33: 468-78.

Poterba, J. and L. Summers. 1986. "The Persistence of Volatility and Stock Market Fluctuations." American Economic Review 76,5 (December): 1142-51.

Rogoff, K. 1984. "On the Effects of Sterilized Intervention: An Analysis of Weekly Data." Journal of Monetary Economics 14: 133-50.

Roll, R. 1979. "Violations of Purchasing Power Parity and Their Implications for Efficient International Commodity Markets." In International Trade and Finance, Vol. 1, edited by M. Sarnat and G. Szego. (Cambridge: Ballinger).

Shiller, R. 1981. "Do Stock Prices Move Too Much to be Justified by Subsequent Changes in Dividends?" American Economic Review 71: 421-36.

Somanath, V. S. 1986. "Efficient Exchange Rate Forecasts: Lagged Models Better than the Random Walk." Journal of International Money and Finance: 195-220.

Tobin, J. 1978. "A Proposal for International Monetary Reform." Eastern Economic Journal 4, 3-4 (July/October): 153-9. Reprinted in his Essays in Economics 1985. (Cambridge: M.I.T. Press): 488-94.

Tryon, R. 1979. "Testing for Rational Expectations in Foreign Exchange Markets." Federal Reserve Board International Finance Discussion Papers, No. 139.

West, K. 1984. "A Specification Test for Speculative Bubbles." Princeton University mimeo, revised 1986.

Williamson, J. 1985. The Exchange Rate System. (Washington, D.C.: Institute for International Economics).