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Authors
Frankel, Jeffrey A.
Froot, Kenneth A.

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UNIVERSITY OF CALIFORNIA, BERKELEY

Department of Economics

Berkeley, California 94720

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THREE ESSAYS USING SURVEY DATA ON EXCHANGE RATE EXPECTATIONS

Jeffrey A. Frankel
Kenneth A. Froot

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Abstract

Three papers use data from surveys of market participants, to measure exchange rate expectations without having to make arbitrary assumptions about the risk premium in the forward exchange market. The first paper estimates extrapolative, adaptive, and regressive models; it finds that expectations are stabilizing. The second considers the popular regression of ex post depreciation against the forward discount. The third examines the difference between short-term and long-term expectations. In each paper we reject the hypotheses that one can statistically infer expectations from ex post exchange rate changes, i.e., we find evidence of systematic expectational errors.

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Three Essays Using Survey Data on Exchange Rate Expectations

SUMMARY

Each of the three papers uses data on exchange rate expectations from three independent surveys of market participants, carried out by the American Express Bank Review (1976-85), The Economist Financial Report (1981-86), and Money Market Services, Inc. (1983-86). These data provide a way of measuring expectations without prejudging whether the exchange risk premium exists or whether systematic expectational errors occur within sample periods.

The first paper estimates models of extrapolative, adaptive, and regressive expectations, and in each case tests whether expectations are stabilizing (inelastic) or destabilizing (elastic). The second paper considers the regression, popular in the literature, of ex post depreciation against the forward discount. The third paper repeats the preceding tests but uncovers a striking difference between the behavior of expectations at short-term horizons (less than three months) and long-term horizons (up to one year). Each of the three papers rejects the hypothesis of static, or random-walk expectations; and each rejects the hypothesis that one can statistically infer expectations from ex post exchange rate changes, i.e., each finds evidence of systematic expectational errors.

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Using Survey Data to Test Standard Propositions Regarding Exchange Rate Expectations

Jeffrey A. Frankel

and

*Kenneth A. Froot**

Survey data provide a measure of exchange rate expectations superior to the forward rate in that no risk premium interferes. We estimate extrapolative, adaptive and regressive models of expectations. Static or "random walk" expectations and bandwagon expectations are rejected: current appreciation generates the expectation of future depreciation because variables other than the contemporaneous spot rate receive weight. In comparing expectations to the process governing the spot rate, we find statistically significant bias.

No variable is as ubiquitous in international financial theory and yet as elusive empirically as investors' expectations regarding exchange rates. In the past, expectations have been modelled in an ad hoc way, often by using the forward exchange rate. There is, however, a serious problem with using the forward discount as the measure of the expected change in the exchange rate, in that the two may not be equal. The gap that may separate the forward discount and expected depreciation is generally interpreted as a risk premium. Most of the large empirical literature testing the unbiasedness of the forward exchange rate, for example, has found it necessary either arbitrarily to assume away the existence of the risk premium, if the aim is to test whether investors have rational expectations, or else to assume that expectations are in fact rational, if the aim is to test propositions regarding the behavior of the risk premium.

We offer a new source of data to measure exchange rate expectations that avoids such problems: three independent surveys of the expectations held by exchange market participants. Between 1976 and 1985, American Express Banking Corporation (Amex) has polled a sample of 250-300 central bankers, private bankers, corporate treasurers and economists regarding their expectations of major exchange rates six months and twelve months into the future, approximately once a year. Since 1981, the Economist Financial Report, a newsletter associated with the Economist, has conducted at regular six week intervals a survey of 14 leading international banks regarding their expectations at three, six and twelve-month horizons. And since 1983, Money Market Services, Inc. (MMS), has conducted a similar survey on a weekly or bi-weekly basis, at a variety of short-term horizons. The first two surveys record expectations of five currencies against the dollar (the pound, French franc, mark, Swiss franc and yen), and the MMS data has been collected for four currencies (the pound, mark, Swiss franc and yen). In each survey, it is the median response that is reported.

In this paper we are interested principally in two questions: how best to describe the survey expectations in terms of simple models of investors' expectations formation; and whether investors' expectations are unbiased forecasts of the actual spot exchange rate process. Our aim here is not to develop any special new hypotheses of our own. But a theme which runs throughout our investigation is the stability of expectations. Do the data confirm the suspicions of some critics of floating exchange rates that expectations are characterized by bandwagon effects? Or, in line with many macro models of exchange rate determination, does a current appreciation of the currency by itself generate expectations of future depreciation?

The paper is organized as follows. Section I discusses the exchange rate survey data. In section II we present some simple but enlightening summary statistics from the surveys. In section III we attempt to describe the survey data by using several popular formulations for exchange rate expectations: extrapolative, adaptive, and regressive models. Section IV then investigates the behavior of the actual spot process and the rationality of the various expectations mechanisms considered in section III. In section V, we offer some thoughts on heterogeneity of exchange rate expectations. Finally, section VI gives our conclusions.

I. THE SURVEY DATA

Economists generally distrust survey data. It is a cornerstone of "positive economics" that we learn more by observing what people do in the marketplace than what they say. Nevertheless, alternative measures of expectations all have their own drawbacks. For this reason, closed-economy macro and financial economists have found survey data useful, in studies of expected inflation (where the Livingston survey has been the most popular), expected official announcements of the money stock and other macroeconomic variables (where MMS is the source), and firm inventory behavior and related topics (see Michael Lovell (1986)). To our knowledge, there had been no studies prior to this one using survey data on exchange rate expectations.[1] This might be considered surprising in light of the great interest in the subject, evident in the large literature on the forward market. One could even argue that the case for using survey data on exchange rate expectations is on firmer ground than the case for using survey data on inflation expectations. The respondents to the surveys participate more directly in the spot and forward exchange markets than the respondents to the Livingston survey participate in the goods markets: they are economists in the foreign-exchange trading room or the traders themselves in major international banks who have up-to-the-minute information on the values of the currencies covered. At the very least, these exchange rate survey data contain some useful information that warrants study. It seems likely that economists have not used the data in the past only because they have been unaware of its existence.

One limitation to the survey data should be registered from the start, the relatively small number of times the surveys were conducted as of early 1986: 12 dates for the Amex data, 38 for the Economist data, 47 for the 1983-84 MMS survey.[2] By pooling the cross-section of four or five currencies at each survey date, however, we achieve respectable sample sizes. The obvious contemporaneous correlation of error terms across currencies may be exploited, and we do so with two techniques. Seemingly Unrelated Regressions are used in cases where the error terms are serially uncorrelated, while Method of Moments estimators are employed when under the null hypothesis there is serial correlation.[3] In addition, there is considerable variety of forecast horizon in the data we employ. We estimate equations for the pooled data at three, six and twelve-month horizons for the Economist data, three-months for the MMS data, and six and twelve-months for the Amex data.

II. PRELIMINARY RESULTS

Before we set out to test the hypotheses of interest, some descriptive statistics and preliminary tests are in order.

A. The Magnitude of Expected Depreciation

First, the survey data can be used to shed some light on questions concerning the size of expected depreciation relative to the forward discount. In general the forward discount can be decomposed into expected depreciation and the risk premium:

$$fd_t = \Delta s^e_{t+1} + rp_t .$$

where fd_t is the log of the forward rate minus the log of the spot rate at time t (expressed in dollars per unit of foreign currency), and Δs^e_{t+1} is the log of the expected future spot rate minus the log of the current spot rate. Many models of exchange rate determination have made the simplifying (but extreme) assumption that expectations are static, for lack of a better alternative, i.e., that expected depreciation is zero:

$$\Delta s^e_{t+1} = 0 . \tag{1}$$

For example, William Branson, Hannu Halttunen and Paul Masson (1977) did so, giving as a reason that "we have very little empirical evidence on alternative, more complicated expectations mechanisms" (p. 308). The immortal Mundell-Fleming model of exchange rates under conditions of perfect capital mobility can be interpreted as having assumed static expectations, so that international arbitrage equated domestic and foreign interest rates.

More recently, this point of view has been, in a sense, vindicated by the work of Richard Meese and Kenneth Rogoff (1983). They have shown that the current spot exchange rate is a better predictor of the future rate than are standard monetary models, more elaborate time series models, or the current forward exchange rate; that is, that the exchange rate seems to follow a random walk. Similar empirical findings have turned up in other contexts. Many papers, such as John Bilson (1981) and Roger Huang (1984), have reported evidence that the rational expectation is closer to zero depreciation than to the forward discount. These authors did not explicitly conclude that the same is necessarily true of investors' expectations; they found support for the random walk model of the spot rate, but were relatively agnostic on investors' expectations.

Nevertheless, this work seems to imply that investors' expected depreciation is not a very interesting variable -- that it does not differ very much from zero and is not very responsive to changes in the contemporaneous information set. Bilson (1985) seems to express this point of view, holding that "actual or market forecasts of exchange rates" are unrelated to the forward discount. The position in the Bilson paper is, in effect, that the random walk holds not only as a description of the actual spot rate process but also as a description of investors' expectations formation. It follows that the risk premium constitutes the entire forward discount.

A very different impression of the relative importance of expected depreciation as a component of the forward discount is given by all three of our surveys. Table 1a shows, for each of the surveys, expected depreciation of the dollar against all currencies for which data are available. Most striking is that the survey expected depreciation is not only consistently positive, but is larger (often several times larger) than the expected depreciation implied by the contemporaneous forward discounts reported in Table 1b. An important feature of Table 1a is the apparent agreement across different surveys and forecast horizons. The corroboration of such large expected depreciation numbers suggests that the results are not due to the particularities of each survey's respondents. Table 2 shows the averages of alternative measures of expected depreciation by survey and by country. The forward discount numbers seem to imply that, on average, the dollar was expected to depreciate against the mark, Swiss franc and yen, to remain approximately unchanged against the pound, and to appreciate against the franc. The survey expectations, on the other hand, suggest that the results in Table 1a do not mask a great deal of variation across countries. Table 2 shows that the surveys consistently predicted substantial depreciation of the dollar against all five currencies surveyed. In every survey, expected depreciation is considerably smaller, however, for currencies that were selling forward at a smaller discount (or a larger premium).

These simple results provide some indication that market expectations are positively correlated, at least cross-sectionally, with the forward discount.

Such systematic relationships between expected depreciation and other contemporaneous variables suggest that there is more to investor expectations than is revealed by the random walk model of expectations.[4]

B. Unconditional Bias

The simplest possible test of rational expectations is to see if expectations are unconditionally biased, if investors systematically overpredict or underpredict the future spot rate. Tests performed in the 1970s clearly failed to find any unconditional bias.[5] But in the 1980s the dollar has consistently sold at a discount in the forward exchange market against the most important currencies, as is shown in Tables 1b and 2, and it was not until 1985 that the great, long-anticipated dollar depreciation began to materialize. Indeed, George Evans (1985) uses a nonparametric sign test on the forward rate prediction errors over the 1981-84 period and finds significant unconditional bias against the pound. Could there be unconditional bias in the survey data for this period as well?

Table 3 reports formal tests of unconditional bias. The MMS three-month data, available for the period January 1983 to October 1984, show statistically significant bias for all four currencies, even more than the three-month forward discount data during the same period. The Economist data is available through 1985, the first year of dollar decline. The bias is not quite statistically significant at the three-month and six-month horizons, but it is significant at the one-year horizon.[6] The general rule seems to be that when the forward discount is biased, the survey data are also biased, with the implication that the finding cannot be attributed to a risk premium. The presence of biasedness in the 1980s clearly arises from the episode of dollar appreciation that ended in February 1985. Respondents consistently overpredicted the future value of foreign currencies against the dollar in this period.

One explanation that could be suggested for such findings of biasedness is that the surveys measure investors' expectations with error. But it should be noted that if one is willing to assume that the measurement error is random, then the conclusions are unaffected. Under the null hypothesis, positive and negative measurement errors should average out, just like positive and negative prediction errors by investors.

Short of concluding that investors' expectations are not equal to the rationally expected value, one major possible explanation for findings of biasedness remains. It is that the standard errors in our tests are invalidated by the "peso problem" of non-normality in the distribution of the test-statistic. The peso problem arises when there is a small probability of a large change in the exchange rate each period -- such as results from a devaluation, a bursting of a speculative bubble, or a big change in fundamentals -- and when the sample size is not large enough to invoke the central limit theorem with confidence.[7 8]

The sensitivity of the direction and magnitude of the bias in prediction error is evident in the Amex survey, the only one available in 1976-79. These data show unconditional bias in the opposite direction in the earlier period, as do the forward rate data: respondents consistently underpredicted the value of foreign currencies against the dollar. When the entire Amex data set from 1976 to 1985 is used, prediction errors show no unconditional bias for either the survey data or the forward rate.

III. TESTS OF EXPECTATIONS FORMATION

The question of what mechanisms investors use to form expectations is of interest independent of the question of whether these mechanisms are rational, that is, whether they coincide with the mathematical expectation of the actual spot process. In this section we investigate alternative specifications of expectations, and in section IV we test for their rationality.

A number of simple formulations have traditionally been used. A general framework for expressing them comes from writing the investors' expected future (log) spot rate as a weighted average of the current (log) spot rate with weight $1-\beta$ and some other element, x_t, with weight β:

$$s^e_{t+1} = \beta x_t + (1-\beta)s_t \tag{2}$$

In examining different versions of equation (2), our null hypothesis will be that expectations are in fact static, i.e., that $\beta = 0$ (investors believe in the random walk). We choose interesting candidates for the "other element", x_t, as alternative hypotheses. The models we will consider are extrapolative expectations, adaptive expectations, and regressive expectations. They feature as the "other element" x_t: the lagged spot rate, s_{t-1}, the lagged expectation, s^e_t, and some notion of a long-run equilibrium level of the spot rate, $\bar{s}_t$, respectively.

One characterization of expectations formation often claimed by market participants themselves is that the most recent trend is extrapolated: if the currency has been depreciating, then investors expect that it will continue to depreciate.[9] Such "bandwagon" expectations are represented:

$$\Delta s^e_{t+1} = -g\Delta s_t \tag{3}$$

where Δs_t is the most recent observed change in the log of the exchange rate and g is hypothesized to be less than zero. (Again, static expectations would be the special case where $g = 0$.) It has long been a concern of critics of floating exchange rates that bandwagon expectations would render the system unstable. For example, Ragnar Nurkse (1944, p. 118):

> [Speculative] anticipations are apt to bring about their own realization. Anticipatory purchases of foreign exchange tend to produce or at any rate to hasten the anticipated fall in the exchange value of the national currency, and the actual fall may set up or strengthen expectations of a further fall.... Exchange rates under such circumstances are bound to become highly unstable, and the influence of psychological factors may at times be overwhelming.

Nurkse's view was challenged by Milton Friedman (1953), who argued that speculation would be stabilizing. "Speculation" can be defined as buying and selling of currency in response to expectations of exchange rate changes, as compared to the counterfactual case of static expectations. A property of bandwagon expectations is that the expected future spot rate as a function of the observed current spot rate has an elasticity that exceeds unity, as contrasted to static expectations, in which the elasticity is equal to unity. Because investors sell a currency that they expect to depreciate, it follows that under bandwagon expectations speculation is destabilizing.

The remaining three models we discuss go the opposite direction. They can all be subsumed under the label **inelastic**, or stabilizing, **expectations**: a change in the current spot rate induces a revision in the expected future level of the spot rate that, though it may be positive, is less than proportionate. An observed appreciation of the currency generates an anticipation of a future depreciation of the currency back, at least partway, toward its previously expected level. If speculators act on the basis of the expected future depreciation, they will put downward pressure on the price of the currency today; in other words, speculation will be stabilizing. One case of inelastic expectations is equation (3) with g greater than zero. An equivalent representation would be

$$s^e_{t+1} = (1-g)s_t + gs_{t-1} \tag{4}$$

where s_t is the logarithm of the current spot rate and g is hypothesized to be positive. The hypothesis is a simple form of **distributed lag expectations**. Obviously we could have longer lags as well.

In the tables below, we can interpret the regression error as random measurement error in the survey data. Under the joint hypothesis that the mechanism of expectations formation is specified correctly and that the measurement error is random, the parameter estimates are consistent. It should be noted that this joint hypothesis is particularly restrictive because the spot rate appears on the right-hand side; if a change in expected depreciation feeds back to affect both the contemporaneous spot rate and any element of the regression error, then the parameter estimates will be biased and inconsistent. Such simultaneous equation bias, however, is not a problem under our null hypothesis that expected depreciation is constant.

Table 4 reports the results of the Seemingly Unrelated Regressions[10] of the survey expected depreciation on the recent change in the spot rate, equation (3), which we call under the general title of extrapolative expectations, where $g > 0$ represents the case of distributed lag and $g < 0$ represents the case of bandwagon expectations.[11] Most of the slope parameters in the column labelled "g" in Table 4 are positive and significant at the one percent level. The evidence suggests that expectations are less than unit elastic with respect to the lagged spot rate, that is, expectations are stabilizing. For example, the point estimate of 0.04 in the three-month Economist data set implies an appreciation of 10 percent today generates an expectation of a 0.4 percent depreciation over the next three months, a rate of 1.6 percent per year.

The Durbin-Watson tests for serial correlation reported in Table 4 (except those for the Amex data sets) are the averages of the equation by equation OLS regressions used in the first step of the SUR procedure. For this reason, and since the Amex data are irregularly spaced and thus are not true time series, values of the DW test must be interpreted with caution. Nevertheless, the null hypothesis of no "serial" correlation is still appropriate, and the low reported values of the statistic suggest that the standard errors are suspect. To correct for serial correlation in the residuals, we used a generalized three stage least squares estimator that allows for contemporaneous as well as first order serial correlation of each country's residual.[12] These results for the Economist and

MMS data sets are reported beneath the uncorrected SUR estimates in Table 4.[13] While we find some evidence of serial correlation in the data, the corrected coefficients are similar in size, and the standard errors are even more unfavorable to the bandwagon hypothesis than in the uncorrected SUR regressions. The lone case of a negative point estimate for g, in the three-month MMS sample, loses its statistical significance under the correction for serial correlation.

Despite the rejection of bandwagon expectations in favor of the stabilizing distributed lag, it may still be true that psychological factors are important in foreign exchange markets. The absence of bandwagon effects in the data does not rule out the possibility of speculative bubbles. For example, rational bubbles which are constantly forming and popping would not yield systematic bandwagon effects in the spot rate.

Adaptive expectations are an old standby in the economist's arsenal of expectations models. The expected future spot rate is formed adaptively, as a weighted average of the current observed spot rate and the lagged expected rate:

(5) $$s^e_{t+1} = (1-\gamma_1)s_t + \gamma_1 s^e_t$$

where γ_1 is hypothesized between 0 and 1 for expectations to be inelastic.[14]

We report the results of regressing expected depreciation on the lagged survey prediction error in Table 5:

(5') $$\Delta s^e_{t+1} = \gamma_1(s^e_t - s_t).$$

Three of the six coefficients in the column labelled γ_1 are statistically significant. All three are positive, implying that expectations place positive weight on the previous prediction. The results in Table 5 provide evidence in favor of the hypothesis that expectations are stabilizing.[15] The DW statistics are again very low, particularly in the twelve-month data. When we use the three stage least squares correction for serial correlation, the coefficient is significant in three out of four data sets.

The **regressive expectations** model was made popular by Rudiger Dornbusch (1976b). It is a more elegant specification, consistent with dynamic models in which variables such as goods prices converge toward their long-run equilibrium values over time in accordance with differential equations, or, in discrete time, in accordance with difference equations:

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

Here $\bar{s}_t$ is the long-run equilibrium exchange rate, and ϑ (a number between 0 and 1 in this discrete-time version) is the speed at which s_t is expected to regress toward $\bar{s}_t$, as can perhaps be seen more clearly in the equivalent representation,

(7) $$\Delta s^e_{t+1} = -\vartheta(s_t - \bar{s}_t)\, .$$

The long-run equilibrium, $\bar{s}_t$, can itself change. It is normally assumed to obey Purchasing Power Parity, increasing proportionately in response to a change in the domestic money supply and price level.

In the econometric tests below, we try out two alternative formulations for $\bar{s}_t$. The simplest possible description of the long-run equilibrium is that it is constant over our sample. Thus we regress expected depreciation on the spot rate and constant terms for each country. The results are presented in Table 6. A second specification for the long-run value of the exchange rate is that given by purchasing power parity. In this case, $\bar{s}_t$ moves with relative inflation differentials instead of remaining constant:

(8) $$\bar{s}_t = s_0 + \log\left(\frac{P_t / P_0}{P^*_t / P^*_0}\right)$$

where s_0 is the log of the average nominal value of the foreign currency in terms of dollars, 1973-79, P_t and P^*_t are the current monthly levels of the US and Foreign CPIs, respectively, and P_0 and P^*_0 are the average levels of the US and foreign CPIs, 1973-79.

The general conclusions that come out of Tables 6 and 7 are identical. Four of the six data sets give significant weight to the long-run equilibrium, in each case positive. Investors expect the spot rate to regress toward its long-run equilibrium. Note that this is a stronger property than the fact, which we discovered in Tables 1a and 2, that investors have been forecasting large depreciation on average throughout the 1980s. Regressivity requires not only that investors expect a currency that is above its long-run level to depreciate, but also that they expect it to depreciate by more the farther it is above its equilibrium value. In Table 7, the Economist regressions at three-month, six-month and twelve-month horizons show that deviations from PPP are expected to decay at annual rates of $(1-0.9881^4)\approx5$ percent, $(1-0.9218^2)\approx15$ percent and 24 percent, respectively. This last figure implies that the expected half-life of PPP deviations is 2.5 years.

Clearly, if a high R^2 were our goal, more complicated models could have been reported. We estimated a more general specification for expectations, expanding the information set to include simultaneously the current and lagged spot rates, the long-run equilibrium rate and the lagged expected spot rate. We then tested the entire set of nested hypotheses, beginning with this general specification all the way to static expectations. In particular, we considered as alternatives to the simple models discussed above hybrid specifications such as "adaptive-bandwagon":

$$\Delta s^e_{t+1} = \gamma(s^e_t - s_t) - g\,\Delta s_{t+1}$$

The R^2s of these more complex permutations were higher than those reported in Tables 4 through 7. However, the best fits were for models which are unfamiliar compared with the popular formulations above. Furthermore, the strongest statistical rejections were those reported here, of static expectations against the simpler extrapolative, adaptive and regressive models; when estimating the hybrid models, by contrast, we were able statistically to accept the constraints implied by the simple models. For these reasons we do not report the results.

The central point of our analysis is to investigate the robustness of a rejection of static expectations, not to settle on any single model of expectations. The goodness-of-fit statistics in Tables 4 through 7, however, give us an opportunity to compare the fits of these simple alternative specifications. From this set of alternatives, the best model appears to be the distributed lag.

IV. ARE EXPECTATIONS FORMED RATIONALLY?

Now that we have an idea of the parameters describing the formation of investor expectations, we will see how well they correspond to the parameters describing the true process governing the spot rate. We could estimate first the mathematical expectation of the actual spot process conditional on each of the information sets considered in section III, and only then test for equality with the process governing investors' expectations. Here we report directly regressions of the difference between investor expectations and the realized spot rate — $\Delta s^e_{t+1} - \Delta s_{t+1}$, or equivalently, $s^e_{t+1} - s_{t+1}$ — against the same variables as in the preceding section. Under the null hypothesis the coefficient should be zero, and the error term should be uncorrelated with the right-hand-side variables, i.e., the spot rate prediction error should be purely random, as should be the case for any right-hand-side variables observed at time t. Furthermore, under the null hypothesis, the error term should be serially uncorrelated, which makes the econometrics easier. The logic is the same as in the existing literature of rational expectations tests, where expectations are measured by the forward rate rather than survey data, except that we are free of the problems presented by the risk premium.[16] Because a statistical rejection of the null hypothesis could in theory be due to the failure of the error term to have the proper normal distribution (the "peso problem" mentioned in section IIB), or could be due to a learning period following a "regime change," rather than to a failure of investors to act rationally, we will use the terms "systematic expectational errors" or "bias in the sample" to describe the alternative hypothesis in preference over a "failure of rational expectations."

In testing whether expectations are biased in the sample, there are added advantages in having first tested models of what variables matter for expectations. For those cases in which we fail to reject the null hypothesis, it helps to have an idea whether the right-hand-side variable is relevant to determining Δs^e_{t+1} and Δs_{t+1}; if not, the test for the presence of bias is not very powerful. For those cases when we do reject the null hypothesis, we will have a ready-made description of the nature of investors' bias. An explicit alternative hypothesis is lacking in most standard tests.

A. Econometric Issues

The tests of rational expectations below were performed by OLS with standard errors calculated using a method of moments procedure. The usual OLS standard errors are inappropriate because of the contemporaneous correlation across countries, and a sampling interval many times smaller than the forecast horizon. In the previous section, where expected depreciation is the regressand, a long forecast horizon and short sampling interval do not themselves imply that the error term is serially correlated, since expectations are formed using only contemporaneous and past information. When the prediction error is on the left-hand-side, however, we have the usual problem induced by overlapping observations: under the null hypothesis the error term, consisting of new information that becomes available during the forecast interval, is a moving average process of an order equal to the number of sampling intervals contained in the forecast horizon minus one.[17] The OLS point estimates remain consistent in spite of the serially correlated residuals. The method of moments estimate of the sample covariance matrix of the OLS estimate, $\hat{\beta}$ is:

$$\hat{\Theta} = (X_{NT}'X_{NT})^{-1}X_{NT}'\hat{\Omega}X_{NT}(X_{NT}'X_{NT})^{-1} \tag{9}$$

where X_{NT} is the matrix of regressors of size N (countries) times T (time). The $(i,j)^{th}$ element of the unrestricted covariance matrix, $\hat{\Omega}$ is:

$$\hat{\omega}(i,j) = \frac{1}{NT-k}\sum_{l=0}^{N-1}\sum_{t=k+1}^{T}\hat{u}_{t+lT}\hat{u}_{t-k+lT} \text{ for } mT-n \le k \le mT+n \;;\; m = 0,\ldots,N-1$$

$$= 0 \quad \text{otherwise}. \tag{10}$$

where n is the order of the MA process, $\hat{u}_{t+lT}$ is the OLS residual, and $k = |i-j|$. Such an unrestricted estimate of Ω uses many degrees of freedom; in the case of the Economist twelve-month data, $N = 5$ and $n = 8$, so that the covariance matrix has $N(N+1)n/2$ or 120 independent parameters. We instead estimated a restricted covariance matrix, $\tilde{\Omega}$ with typical element:

$$\tilde{\omega}(t+lT, t-k+pT) = \frac{1}{N-1}\sum_{l=0}^{N}\hat{\omega}(t+lT, t-k+pT) \quad \text{if } l = p \text{ and } -n \le k \le n$$

$$= \frac{2}{N(N-1)}\sum_{p=0}^{N-1}\sum_{l=0}^{N-1}\hat{\omega}(t+lt, t-k+pT) \quad \text{if } l \ne p \text{ and } -n \le k \le n$$

$$= 0 \quad \text{otherwise}. \tag{11}$$

These restrictions have the effect of averaging the own-currency and cross-currency autocorrelation functions of the OLS residuals, respectively, bringing the number of independent parameters down to $2n$.

A problem with our estimate of $\tilde{\Omega}$ is that it need not be positive definite in small samples. Whitney Newey and Kenneth West (1985) offer a consistent estimate of Ω that discounts the jth order autocovariance by $1-(j/(m+1))$, and is positive definite in finite sample. For any given sample size, however, there is still a question of how large m must be to guarantee positive definiteness. In the subsequent regressions we tried $m = n$ (which Newey and West themselves suggest) and $m = 2n$; we report standard errors using the latter value of m because they were consistently larger than those using the former.

B. The Results

We now turn to the results of our tests of rationality within the three models examined in section III.

In Table 4 we found that if investors' expected future spot rate is viewed as a distributed lag of the actual spot rate, then the weight on the current spot rate is less than one and the weight on the lagged spot rate greater than zero. Is this degree of inelasticity of expectations rational? Or is the future spot rate more likely to lie in the direction of the current spot rate, as would be the case if the actual spot rate followed a random walk?

Table 8 shows highly significant rejections for three of the six data sets of the hypothesis that expectations exhibit no systematic bias. As in the case of unconditional bias, the results are immune to measurement error in the survey data, provided the error is orthogonal to the regressors. The Economist twelve-month data significantly overestimate the tendency for the spot rate to keep moving in the same direction as it had been, while the Amex data underestimate the tendency to keep moving in the same direction. The diversity of results is not primarily attributable to a difference between the two surveys. Table 4 showed similar parameters of expectations formation in the two surveys. Rather the difference is primarily attributable to the behavior of the actual spot process during the two different sample periods for which data are available. If one includes in the sample the years 1976-78, during which the

Amex data is available, then more extrapolative expectations would have been correct, because the dollar had a long run of declines followed by a long run of appreciation. But if one considers the period 1981-85 alone, less extrapolative expectations would have been correct, because first differences of the actual spot rate (though usually negative) were not positively serially correlated.[18] The conclusion is that the actual spot process is significantly different from investors' expectations, but it is also more complicated than a simple distributed lag with constant weights, whether correctly perceived by investors or not.

In Table 5 we found that investors' expectations can be viewed as adaptive. When investors make a prediction error, they revise their previous expectations most, though not all, of the way to the new observed spot rate. Would they do better to revise their expectation even farther, or less far? Assume that the true best predictor of the future spot rate is a weighted average of the current spot rate and the lagged expectation:

(12) $$s_{t+1} = (1-\gamma_2)s_t + \gamma_2 s_t^e + \varepsilon_{t+1}$$

Then investors' expectations would be rational if and only if γ_1 from equation (5) were equal to γ_2 from equation (12). Taking the difference of the two equations,

(13) $$s_{t+1}^e - s_{t+1} = (\gamma_1 - \gamma_2)(s_t^e - s_t) + \varepsilon_{t+1}$$

In Table 9 we regress the expectational error against the lagged expectational error as in equation (13). Such tests of serial correlation are a common way of testing for efficiency in the forward market.[19] In the context of adaptive expectations, we can see clearly what the alternative hypothesis is. Positive serial correlation is precisely the hypothesis that expectations are insufficiently adaptive; investors could avoid making the same error repeatedly if they revised their expectations all the way to the new spot rate. Negative serial correlation is the hypothesis that expectations are overly adaptive. Table 9 shows that expectations are insufficiently adaptive in four of six data sets. In two cases the tendency for investors to put too little weight on the current spot rate is highly significant statistically. In one case (the Economist twelve-month data), investors put too much weight on the current spot rate relative to the weight they place on the lagged expectation: these expectations appear to be overly adaptive.[20]

In Tables 6 and 7 we found that investors expected the spot rate to regress over the subsequent year toward a long-run equilibrium, at a rate of up to 24 per cent of the existing gap. In Tables 10 and 11 we test whether this regressive expectation is borne out by reality. An earlier version of this paper that included data only up to March 1985 showed that the Economist data were overly regressive. But now in both the Economist and MMS data the actual spot rate on average regressed toward equilibrium to an even greater extent than investors expected. In the case of the Economist twelve-month data, the highly significant coefficient is evidence that investors systematically underestimated the degree of regressivity. But the results are dominated by the peaking of the dollar in 1985. When the years 1976-78 are included (the Amex sample) there is on average no tendency for the spot rate to regress toward equilibrium. Again, the finding of systematic expectational errors is fairly robust, but the sign is sensitive to the precise sample period.

V. THOUGHTS ON "THE" EXPECTED EXCHANGE RATE

Several considerations suggest that, if we were to reject the hypothesis of rational expectations, the alternative hypothesis would have to be more complex than the simple models considered above. In Table 3, we found that investors systematically overpredicted the depreciation of the dollar in the 1980s, and systematically underpredicted its depreciation in the late 1970s. Similarly, there was a consistent tendency for investors to overestimate the speed of regression before 1985 and to underestimate it thereafter. Such findings suggest the possibility that the nature of the forecasting bias changes over time. Investors could even be rational, and yet make repeated mistakes of the kind detected here, if the true model of the spot process is evolving over time. There is nothing in our results to suggest that it is easy to make money speculating in the foreign exchange markets.

Another puzzle is that the gap between the forward discount and the expected rate of depreciation in the survey data is so large, an average of 7 percent for the Economist six-month data. To explain the gap as a risk premium would require (a) that assets denominated in other currencies were perceived in the early 1980s as riskier than assets denominated in dollars, and (b) that investors are highly risk-averse. An alternative is the possibility that investors do not base their actions on a single homogeneous expectation such as regressive expectations. If expectations are heterogeneous, then the forward discount that is determined in market equilibrium could be a convex combination of regressive expectations and other forecasts that are closer to static expectations.

There is a third clue that expectations are more complex than a simple homogeneous model, such as those estimated above. In our results, the three-month survey data exhibit a lower speed of regression toward the long-run equilibrium, even when annualized, than do the six-month data, and the six-month survey data exhibit a lower speed of regression than do the twelve-month data. This pattern in the term structure suggests the possibility that those investors who think longer-term tend to be the ones who subscribe to regressive expectations, and those who think shorter-term tend to be the ones who subscribe to forecasts that are closer to static expectations.

In the present paper we have treated exchange rate expectations as homogeneous, for the simple reason that almost all the literature, both theoretical and empirical, does so. Our goal here has been to test standard propositions about "the" expected rate of depreciation, whether it is non-zero, whether it is inelastic, whether it is rational, etc. But in fact, each forecaster has his or her own expectation. The Economist six-month survey, for example, reports a high-low range around the median response; it averages 15.2 percent for the five exchange rates.[21] Different models may be in use at one time. We believe that heterogeneous expectations and their role in determining market dynamics are important areas for future research.[22]

VI. CONCLUSIONS

To summarize our findings:

(1) Exchange rate expectations are not static. The observed nonzero forward discount numbers, far from being attributable to a positive risk premium on the dollar during the recent period, have understated the degree of expected dollar depreciation, which was consistently large and positive.

(2) Exchange rate expectations do not exhibit bandwagon effects. We find that the elasticity of the expected future spot rate with respect to the current spot rate is in general significantly less than unity; expectations put positive weight on the "other factor", regardless of whether it is the lagged spot rate (distributed lag expectations), lagged expected rate (adaptive expectations), or the long-run equilibrium rate (regressive expectations). The general finding of inelastic expectations is important because it implies that a current increase in the spot exchange rate itself generates anticipations of a future decrease, as in the overshooting model, which should work to moderate the extent of the original increase. Speculation is stabilizing.

(3) While expected depreciation is large in magnitude, the actual spot exchange rate process may be close to a random walk, giving rise to unconditional bias in the survey forecast errors during the 1980s. In view of point (2), a spot process that is close to a random walk would suggest that expectations are less elastic than is rational. Indeed, we find statistically significant bias conditional on, for example, lagged expectational errors. This is the same finding common in tests of efficiency in the forward exchange market, but it now cannot be attributed to a risk premium.

(4) The nature of the rejection of rational expectations strongly depends on the sample period. During the 1981-85 period, the actual spot process did not

behave according to investors' expectations that the currency would return toward its previous equilibrium, but after February 1985, the dollar depreciated at a rate in excess of what was expected. It seems likely that the actual spot rate process is more complicated than any of the models tested here.

(5) While the present paper adopted the standard theoretical and empirical framework that assumes homogeneous expectations, a number of clues suggest that investigating heterogeneous investor expectations would be a useful avenue for future research.

VII. DATA APPENDIX

In this appendix we briefly describe the construction of the Economist, Amex and MMS data sets more specifically.

The Economist Financial Review conducted 38 surveys beginning in June, 1981 through December, 1985. Surveys took place on a specific day on which the foreign exchange markets were open. Respondents were asked for their expectations of the value of the five major currencies against the dollar in three months, six-months and twelve-months time. We carefully matched a given day's survey results with that day's actual spot and forward rates, and with actual spot rates as close as possible to 90, 180, and 365 days into the future.

The Amex Bank Review has conducted 12 surveys beginning in January, 1976, through July 1985. Respondents were asked for their expectations of the value of the same five currencies in six-months and twelve-months time. The first three surveys, however, included only the pound and the mark. Future foreign exchange market realizations were matched in a manner similar to that used for the Economist data. Amex Bank surveys were conducted by mail, and hence it was impossible to pick specific days which were used by all respondents as reference points with any degree of certainty. Since exchange rates vary so much within a month, two methods of choosing the contemporaneous spot rate (and the corresponding future rates respondents were predicting) were employed. First, single days within the survey period were selected. Second, 30 day averages of daily rates were constructed to encompass the entire survey period. Since both methods yielded very similar quantitative results in the body of the paper, the results from the latter Amex data set are reported only in the NBER working paper version.

Between January, 1983 and October, 1984, MMS conducted 47 surveys (one each two weeks) of the value of the dollar against the pound, mark, Swiss franc and yen in three-months time. Matching of actual spot and forward rates was done in a manner similar to that used for the Economist survey.

Actual market spot and forward rates were taken from DRI. They represent the average of the morning bid and ask rates from New York. Lagged exchange rates (used for extrapolative expectations) are market rates approximately 90 days before survey dates.

Specific dates on which the surveys were conducted, and for which actual market data was obtained, are contained in Tables A1, A2 and A3 in Frankel and Froot (1986a).

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ENDNOTES

* Department of Economics, University of California, Berkeley, CA 94720, and Sloan School of Management, Massachusetts Institute of Technology, Cambridge, MA 02139, respectively. This is an extensively revised version of NBER Working Paper no. 1672. We would like to thank Barbara Bruer, John Calverly, Louise Cordova, Kathryn Dominguez, Laura Knoy, Stephen Marris, and Money Market Services, Inc. for help in obtaining data, the National Science Foundation (under grant no. SES-8218300), the Institute for Business and Economic Research at U.C. Berkeley, and the Alfred P. Sloan Foundation's doctoral dissertation program for research support. The data used in this paper are available on request from the authors.

1. Richard Levich (1979) studies the predictions of the exchange rate forecasting industry. For a recent study of exchange rate expectations using the MMS survey data, see Kathryn Dominguez (1986).

2. A second limitation of the Amex survey is that it is conducted by mail, and therefore precise dating of expectations was impossible. In response to this problem we used several alternative methods of dating in all our tests. It turns out that the dating method had a negligible effect on the results. See the data appendix for more detail.

3. In the NBER working paper version of this paper, we also estimated bootstrap standard errors, which are robust in small samples, with respect to estimators that are nonlinear in the residuals and with respect to a variety of nonnormal distributions. This technique has been omitted here both because the resulting standard errors were not very different from those obtained using more conventional methods and because we now have several times as many observations for the Economist data and we have added the MMS sample to the analysis.

4. Froot and Frankel (1986) decompose the variance of the forward discount into expected depreciation and the risk premium. In the present paper we are concerned only with the first moments.

5. See Bradford Cornell (1977), Alan Stockman (1978) and Frankel (1980).

6. For all data sets but the Amex 6-month, prediction errors are overlapping because the surveys are conducted more frequently than the forecast interval. The standard errors reported for each currency in Table 3 reflect the number of nonoverlapping intervals in each data set, and are thus upper bounds. Higher significance levels could be obtained by combining the results for different currencies. But the apparent low standard errors when all observations are simply pooled are misleading, as there is a definite correlation of errors across currencies at any point in time. The proper technique (SUR) for this problem is applied in the following section.

7. Calculations in Frankel (1985) undermine the hypothesis that the forward discount rationally reflected the 1981-85 path of dollar appreciation, even allowing for the possibility of a sudden large collapse in the dollar.

8. It should be noted that a fourth explanation sometimes given for findings of biasedness in the forward rate, after the existence of a risk premium, a failure of rational expectations and the peso problem, is the convexity term due to Jensen's Inequality (see Charles Engel (1984)). Note, however, that if exchange rates are log-normally distributed this convexity term is bounded above by the unconditional variance of the spot rate and is therefore small. For a log-normally distributed random variable, $X = e^x$, $E[X] = \int e^x f(x)dx = \exp[\mu + (1/2)\ \sigma^2]$ and $E\ [1/X] = \int e^{-x} f(x)dx = \exp[\mu - (1/2)\ \sigma^2]$, where

$$f(x) = \frac{1}{2\pi} \exp[\frac{-(x-\mu)^2}{2\sigma^2}].$$

Thus, $\log(E[X]) - \log(E[1/X]) = \sigma^2$, which is weakly greater than the conditional variance, provided that expectations are formed rationally. During the 1980s, $\sigma^2 = 0.02$ for the spot rate, so that Jensen's inequality is too small to explain the magnitude of the forward rate prediction errors, let alone the very large shift of about 18 percent between the late 1970s and early 1980s in Table 3.

9. See, for example, the discussion in Michael Dooley and Jeffrey Shafer (1983, pp. 47-8).

10. Due to the small number of observations in the Amex data sets, OLS rather than SUR was used to conserve degrees of freedom in this case.

11. We take the definition of extrapolative expectations from Mincer (1969).

12. See R. W. Parks (1967).

13. Because of irregular spacing, we could not correct the estimates for serial correlation in the Amex data sets.

14. Adaptive expectations have been considered by Pentti Kouri (1976), as a third alternative after static and rational expectations, as well as by Dornbusch (1976a) and many other authors.

15. An implication of any measurement error in the survey data is that the lagged prediction errors, which appear as regressors in Table 5, are also measured with error. Thus we would expect the point estimates of γ_1 to be biased toward zero. However, in view of the fact that the variance of actual spot rate changes is about 10 times larger than the variance of the survey expected depreciation (Froot and Frankel (1986), Table 3), we suspect that this bias is small.

16. In the NBER working paper version, we reported for purposes of comparison in all our tests results both using expectations measured by the forward discount and using expectations measured by the survey data.

17. For the original application of method of moments estimation to exchange rate data with overlapping observations, see Lars Hansen and Robert Hodrick (1980).

18. In the NBER working paper version, we report in each table separate regressions for the actual spot process.

19. See, for example, Dooley and Shafer (1983) and Hansen and Hodrick (1980).

20. Stephen Marris (1985, pp. 120-122) uses the Economist survey data and argues that expectations are overly adaptive in that a forecasting strategy of putting less weight on the contemporaneous spot rate would ultimately be vindicated in the long run.

21. Such heterogeneity across investors can still be compatible with a well-defined market expectation. Mark Rubinstein (1974) gives conditions under which agents with different beliefs may be aggregated to form a composite investor with preferences exhibiting rational expectations.

22. Possibilities in this line of research are contained in Roman Frydman and Edmund Phelps (1983) and Frankel and Froot (1986b).

Table 1a
SURVEY EXPECTED DEPRECIATION
OF THE DOLLAR AGAINST FIVE CURRENCIES

Data Set	1976-79	1981	1982	1983	1984	1985
MMS 3 Month				8.17	7.26	
Economist 3 Month		9.95	13.44	10.17	10.68	1.56
Economist 6 Month		8.90	10.31	10.42	11.66	3.93
AMEX 6 Month	1.20	7.60	10.39	4.19	9.93	1.16
Economist 12 Month		7.17	8.33	7.65	10.02	4.24
AMEX 12 Month	-0.20	5.67	6.86	5.18	8.47	3.60

Note : MMS data is the average of four currencies (the pound, mark, Swiss franc, and yen) and does not include the French franc.

Table 1b
FORWARD DISCOUNT
OF THE DOLLAR AGAINST FIVE CURRENCIES

Time Sample	1976-79	1981	1982	1983	1984	1985
MMS 3 Month				3.05	4.60	
Economist 3 Month		3.94	2.95	1.17	3.20	1.22
Economist 6 Month		3.74	3.01	1.10	3.21	0.84
AMEX 6 Month	1.06	4.49	5.21	1.48	4.39	0.02
Economist 12 Month		3.40	3.02	1.25	3.29	0.89
AMEX 12 Month	0.93	3.70	4.65	1.28	4.45	0.31

Notes: Forward discounts were recorded at the time each survey was conducted. See the data appendix for more detail. MMS data is the average of four currencies (the pound, mark, Swiss franc, and yen) and does not include the French franc.

Table 2
VARIOUS MEASURES OF EXPECTED DEPRECIATION
OVER THE FOLLOWING MONTHS
(% percent per annum)

FORECAST HORIZON	SURVEY SOURCE	DATES	SURVEY DATA N	SURVEY DATA E[s(t+1)]-s(t)	FORWARD DISCOUNT f(t)-s(t)	ACTUAL CHANGE N	ACTUAL CHANGE s(t+1)-s(t)
1 WEEK							
TOTAL	MMS	10/84-2/86	247	1.03		247	20.20
UK			62	-12.84		62	14.96
WG			62	2.84	NA	62	21.36
SW			61	8.84		61	20.10
JA			62	5.40		62	24.39
2 WEEKS							
TOTAL	MMS	1/83-10/84	187	4.22		187	-12.35
UK			47	-2.66		47	-16.15
WG			47	5.09	NA	47	-15.19
SW			46	6.10		46	-13.86
JA			47	8.40		47	-4.23
1 MONTH							
TOTAL	MMS	10/84-2/86	176	-2.63	1.23	176	20.82
UK			44	-11.91	-3.85	44	10.13
WG			44	-2.26	3.23	44	23.82
SW			44	0.67	3.74	44	21.76
JA			44	2.99	1.68	44	27.55
3 MONTHS							
TOTAL	MMS	1/83-10/84	187	7.76	3.75	187	-10.77
UK			47	4.46	0.37	47	-13.92
WG			47	8.33	4.68	47	-13.68
SW			46	9.62	6.13	47	-12.61
JA			47	8.68	3.85	47	-2.90
TOTAL	ECONOMIST	6/81-12/85	190	9.13	2.20	195	-0.84
UK			38	3.66	-0.06	38	-6.43
FR			38	5.17	-3.94	38	-4.43
WG			38	11.84	4.36	38	0.81
SW			38	12.30	5.99	38	1.47
JA			38	12.66	4.67	38	4.37
6 MONTHS							
TOTAL	ECONOMIST	6/81-12/85	190	9.30	2.22	180	-2.18
UK			38	4.19	0.14	36	-6.79
FR			38	4.69	-4.03	36	-6.29
WG			38	12.39	4.35	36	-0.96
SW			38	12.27	5.89	36	-0.36
JA			38	12.94	4.74	36	3.52
TOTAL	AMEX	1/76-8/85	51	3.87	2.07	51	5.98
Early Period		1/76-12/78	26	1.20	1.06	26	8.98
Later Period		6/81-8/85	25	6.66	3.12	25	2.86
12 MONTHS							
TOTAL	ECONOMIST	6/81-12/85	195	7.77	2.31	155	-6.42
UK			38	3.38	0.36	31	-9.47
FR			38	3.72	-3.63	31	-11.20
WG			38	10.67	4.24	31	-5.60
SW			38	10.41	5.91	31	-5.75
JA			38	10.67	4.66	31	-0.08
TOTAL	AMEX	1/76-8/85	51	2.81	1.88	46	2.02
Early Period		1/76-12/78	26	-0.20	0.93	26	8.85
Later Period		6/81-8/85	25	5.95	2.88	20	-6.86

Table 3
UNCONDITIONAL BIAS IN PREDICTIONS
OF FUTURE EXCHANGE RATES
(% percent per annum)

				SURVEY ERROR E[s(t+1)]-s(t+1)			FORWARD DISCOUNT ERROR f(t)-s(t+1)		
FORECAST HORIZON	SURVEY SOURCE	DATES	N	Mean	SD of Mean	t stat	Mean	SD of Mean	t stat
1 WEEK									
TOTAL	MMS	10/84-2/86	247	-19.17	8.17	-2.35			
UK			62	-27.79	19.87	-1.40		NA	
WG			62	-18.52	15.25	-1.21			
SW			61	-11.27	17.82	-0.63			
JA			62	-18.99	10.97	-1.73			
2 WEEKS									
TOTAL	MMS	1/83-10/84	187	16.57	3.37	4.92			
UK			47	13.49	6.70	2.01		NA	
WG			47	20.28	7.43	2.73			
SW			46	19.95	6.42	3.11			
JA			47	12.63	6.25	2.02			
1 MONTH									
TOTAL	MMS	10/84-2/86	176	-23.44	6.78	-3.46	-19.59	6.31	-3.10
UK			44	-22.04	15.19	-1.45	-13.98	13.26	-1.05
WG			44	-26.08	12.62	-2.07	-20.59	11.77	-1.75
SW			44	-21.09	13.96	-1.51	-18.02	13.12	-1.37
JA			44	-24.57	12.27	-2.00	-25.88	12.10	-2.14
3 MONTHS									
TOTAL	MMS	1/83-10/84	187	18.53	2.88	6.44	14.51	2.86	5.08
UK			47	18.38	5.91	3.11	14.29	5.90	2.42
WG			47	22.01	5.89	3.73	18.36	5.99	3.07
SW			46	22.23	5.20	4.28	18.74	4.85	3.86
JA			47	11.58	5.14	2.25	6.75	4.97	1.36
TOTAL	ECONOMIST	6/81-12/85	190	9.97	2.92	3.42	3.04	2.73	1.12
UK			38	10.09	6.66	1.51	6.37	5.88	1.08
FR			38	9.61	6.47	1.48	0.49	5.98	0.08
WG			38	11.02	6.45	1.71	3.55	5.90	0.60
SW			38	10.83	7.03	1.54	4.52	6.73	0.67
JA			38	8.29	5.95	1.39	0.30	5.84	0.05
6 MONTHS									
TOTAL	ECONOMIST	6/81-12/85	180	11.70	3.20	3.66	4.48	3.03	1.48
UK			36	11.32	6.71	1.69	7.10	6.24	1.14
FR			36	11.08	7.13	1.55	2.15	6.71	0.32
WG			36	13.56	7.16	1.89	5.36	6.63	0.81
SW			36	12.77	7.80	1.64	6.37	7.37	0.86
JA			36	9.76	6.84	1.43	1.41	6.65	0.21
TOTAL	AMEX	1/76-8/85	51	-2.11	2.82	-0.75	-3.92	2.61	-1.50
Early Period		6/76-12/78	26	-7.78	2.94	-2.65	-7.93	2.80	-2.83
Later Period		6/81-8/85	25	3.79	4.59	0.83	0.26	4.30	0.06
12 MONTHS									
TOTAL	ECONOMIST	6/81-12/85	155	14.83	2.23	6.64	9.00	2.39	3.77
UK			31	13.73	4.96	2.77	10.39	5.46	1.90
FR			31	15.10	4.75	3.18	7.20	5.09	1.41
WG			31	17.02	4.72	3.60	10.02	4.82	2.08
SW			31	16.73	5.06	3.31	12.13	5.41	2.24
JA			31	11.59	5.02	2.31	5.15	5.27	0.98
TOTAL	AMEX	1/76-8/84	46	0.71	2.52	0.28	0.04	2.30	0.02
Early Period		6/76-12/78	26	-9.05	3.20	-2.83	-7.92	3.36	-2.36
Later Period		6/81-8/84	20	13.40	1.07	12.52	10.38	1.10	9.42

Note: Degrees of freedom used to estimate standard deviation (SD) of the mean are the number of nonoverlapping observations for each data set.

TABLE 4
EXTRAPOLATIVE EXPECTATIONS
Independent variable: s(t-1) - s(t)

SUR Regressions(a) of Survey Expected Depreciation: E [s(t+1)] - s(t) = a + g(s(t-1) - s(t))

Data Set	Dates	coefficient(c) g	DW(b)	DF	t: g=0	R^2
Economist 3 Month	6/81-12/85	0.0416 (0.0210)	1.81	184	1.98 *	0.30
with AR(1) Correction		0.0463 (0.0195)		179	2.37 **	0.38
MMS 3 Month	1/83-10/84	-0.0391 (0.0168)	1.49	179	-2.32 **	0.37
with AR(1) Correction		-0.0298 (0.0203)		194	-1.46	0.19
Economist 6 Month	6/81-12/85	0.0730 (0.0225)	1.36	184	3.25 ***	0.54
with AR(1) Correction		0.0832 (0.0236)		179	3.53 ***	0.58
Amex 6 Month	1/76-8/85	0.2994 (0.0487)	1.89	45	6.15 ***	0.81
Economist 12 Month	6/81-12/85	0.2018 (0.0296)	1.47	184	6.82 ***	0.84
with AR(1) Correction		0.2638 (0.0251)		179	10.51 ***	0.92
Amex 12 Month	1/76-8/85	0.3796 (0.0798)	0.94	45	4.76 ***	0.72

Notes: Asymptotic standard errors are in parentheses.
(a) Amex 6 and 12 Month regressions use OLS due to the small number of degrees of freedom.
(b) The DW statistic is the average of the equation by equation OLS Durbin-Watson statistics for each data set.
(c) All equations are estimated allowing each currency its own constant term. To conserve space, estimates of these constant terms are omitted here, but are reported in Frankel and Froot (1986).
*, **, *** represent significance at the 10 percent, 5 percent and 1 percent levels, respectively.

TABLE 5
ADAPTIVE EXPECTATIONS
Independent variable: E(t-1)[s(t)] - s(t)

SUR Regressions(a) of Survey Expected Depreciation: $E[s(t+1)] - s(t) = a + \gamma_1 (E(t-1)[s(t)] - s(t))$

Data Set	Dates	coefficient(c) γ_1	DW(b)	DF	t: $\gamma_1=0$	R^2
Economist 3 Month	6/81-12/85	0.0798 (0.0203)	2.01	169	3.93 ***	0.63
with AR(1) Correction		0.0716 (0.0180)		164	3.97 ***	0.64
MMS 3 Month	1/83-10/84	-0.0272 (0.0215)	1.29	159	-1.26	0.15
with AR(1) Correction		-0.0234 (0.0234)		154	-1.00	0.10
Economist 6 Month	6/81-12/85	0.0516 (0.0161)	1.12	159	3.20 ***	0.53
with AR(1) Correction		0.0783 (0.0223)		154	3.52 ***	0.58
Amex 6 Month	1/76-8/85	-0.0702 (0.1200)	2.10	15	-0.58	0.04
Economist 12 Month	6/81-12/85	-0.0093 (0.0244)	1.10	139	-0.38	0.02
with AR(1) Correction		0.1890 (0.0301)		134	6.28 ***	0.81
Amex 12 Month	1/76-8/85	0.0946 (0.0212)	0.55	31	4.47 ***	0.69

Notes: Asymptotic standard errors are in parentheses.
(a) Amex 6 and 12 Month regressions use OLS due to the small number of degrees of freedom.
(b) The DW statistic is the average of the equation by equation OLS Durbin-Watson statistics for each data set.
(c) All equations are estimated allowing each currency its own constant term. To conserve space, estimates of these constant terms are omitted here, but are reported in Frankel and Froot (1986).
*, **, *** represent significance at the 10 percent, 5 percent and 1 percent levels, respectively.

TABLE 6
REGRESSIVE EXPECTATIONS I-
Independent variable: s(t)
Long Run Equilibrium Constant

SUR Regressions(a) of Survey Expected Depreciation: $E[s(t+1)] - s(t) = a - \theta s(t)$

Data Set	Dates	coefficient(c) θ	DW(b)	DF	t: θ=0	R^2
Economist 3 Month	6/81-12/85	0.0359 (0.0101)	1.56	184	3.55 ***	0.58
with AR(1) Correction		0.0226 (0.0109)		179	2.07 **	0.32
MMS 3 Month	1/83-10/84	0.0100 (0.0159)	1.46	179	0.63	0.04
with AR(1) Correction		0.0061 (0.0195)		174	0.31	0.01
Economist 6 Month	6/81-12/85	0.0764 (0.0127)	1.14	184	6.00 ***	0.80
with AR(1) Correction		0.0807 (0.0170)		179	4.73 ***	0.71
Amex 6 Month	1/76-8/85	-0.0000 (0.0235)	1.19	45	-0.00	0.00
Economist 12 Month	6/81-12/85	0.1724 (0.0161)	1.03	184	10.70 ***	0.93
with AR(1) Correction		0.1905 (0.0182)		179	10.48 ***	0.92
Amex 12 Month	1/76-8/85	0.0791 (0.0346)	0.48	45	2.29 **	0.37

Notes: Asymptotic standard errors are in parentheses.
(a) Amex 6 and 12 Month regressions use OLS due to the small number of degrees of freedom.
(b) The DW statistic is the average of the equation by equation OLS Durbin-Watson statistics for each data set.
(c) All equations are estimated allowing each currency its own constant term. To conserve space, estimates of these constant terms are omitted here, but are reported in Frankel and Froot (1986).
*, **, *** represent significance at the 10 percent, 5 percent and 1 percent levels, respectively.

TABLE 7
REGRESSIVE EXPECTATIONS II
Independent variable: $\bar{s}(t) - s(t)$
Long Run Equilibrium PPP

SUR Regressions(a) of Survey Expected Depreciation: $E[s(t+1)] - s(t) = a + \theta(\bar{s}(t) - s(t))$

Data Set	Dates	coefficient(c) θ	DW(b)	DF	$t:\theta=0$	R^2
Economist 3 Month	6/81-12/85	0.0223 (0.0126)	1.66	184	1.78 *	0.26
with AR(1) Correction		0.0119 (0.0133)		179	0.89	0.08
MMS 3 Month	1/83-10/84	-0.0207 (0.0146)	1.55	179	-1.41	0.18
with AR(1) Correction		0.0083 (0.0194)		174	0.43	0.02
Economist 6 Month	6/81-12/85	0.0600 (0.0159)	1.32	184	3.77 ***	0.61
with AR(1) Correction		0.0782 (0.0221)		179	3.54 ***	0.58
Amex 6 Month	1/76-8/85	0.0315 (0.0202)	1.22	45	1.56	0.21
Economist 12 Month	6/81-12/85	0.1750 (0.0216)	1.25	184	8.10 ***	0.88
with AR(1) Correction		0.2449 (0.0274)		179	8.93 ***	0.90
Amex 12 Month	1/76-8/85	0.1236 (0.0276)	0.60	45	4.48 ***	0.69

Notes: Asymptotic standard errors are in parentheses.
(a) Amex 6 and 12 Month regressions use OLS due to the small number of degrees of freedom.
(b) The DW statistic is the average of the equation by equation OLS Durbin-Watson statistics for each data set.
(c) All equations are estimated allowing each currency its own constant term. To conserve space, estimates of these constant terms are omitted here, but are reported in Frankel and Froot (1986).
*, **, *** represent significance at the 10 percent, 5 percent and 1 percent levels, respectively.

TABLE 8
RATIONALITY OF EXTRAPOLATIVE EXPECTATIONS
Independent variable: s(t-1) - s(t)

OLS Regressions of Survey Prediction Errors: E [s(t+1)] - s(t+1) = a + g (s(t-1) - s(t))

Data Set	Dates	coefficient g	DF	t: g=0	R^2	F test a=0, g=0
Economist 3 Month	6/81-12/85	0.2501 (0.1695)	184	1.48	0.19	1.06
MMS 3 Month	1/83-10/84	-0.2084 (0.1506)	182	-1.38	0.18	6.67 ***
Economist 6 Month	6/81-12/85	0.2449 (0.2904)	174	0.84	0.07	0.97
Amex 6 Month	1/76-8/85	1.0987 (0.3776)	45	2.91 ***	0.48	3.32 ***
Economist 12 Month	6/81-12/85	-0.6516 (0.2564)	149	-2.54 **	0.42	8.09 ***
Amex 12 Month	1/76-8/85	2.0001 (0.3667)	40	5.45 ***	0.77	5.28 ***

Notes: All equations are estimated allwing each currency its own constant term. To conserve space, estimates of the constants are omitted here, but are reported in Frankel and Froot (1986).
Method of Moments standard errors are in parentheses.
*, **, *** represent significance at the 10 percent, 5 percent and 1 percent levels, respectively.

TABLE 9
RATIONALITY OF ADAPTIVE EXPECTATIONS
Independent variable: E(t-1)[s(t)] - s(t)

OLS Regressions of Survey Prediction Errors: $E[s(t+1)] - s(t+1) = a + \gamma(E(t-1) [s(t)] - s(t))$

Data Set	Dates	coefficient γ	DF	t: γ=0	R^2	F test a=0, γ=0
Economist 3 Month	6/81-12/85	0.4296 (0.1395)	169	3.08 ***	0.51	3.39 ***
MMS 3 Month	1/83-10/84	-0.2289 (0.2207)	158	-1.04	0.11	6.35 ***
Economist 6 Month	6/81-12/85	0.0884 (0.2488)	149	0.36	0.01	1.52
Amex 6 Month	1/76-8/85	0.5571 (0.5227)	15	1.07	0.11	1.04
Economist 12 Month	6/81-12/85	-1.0310 (0.2452)	109	-4.20 ***	0.66	10.27 ***
Amex 12 Month	1/76-8/85	0.5972 (0.1007)	25	5.93 ***	0.80	8.05 ***

Notes: All equations are estimated allwing each currency its own constant term. To conserve space, estimates of these constants are omitted here, but are reported in Frankel and Froot (1986).
Method of Moments standard errors are in parentheses.
*, **, *** represent significance at the 10 percent, 5 percent and 1 percent levels, respectively.

TABLE 10
RATIONALITY OF REGRESSIVE EXPECTATIONS I
Independent variable: s(t)
Long Run Equilibrium Constant

OLS Regressions of Survey Prediction Errors: $E[s(t+1)] - s(t+1) = a - \theta s(t)$

Data Set	Dates	coefficient $-\theta$	DF	t: $\theta=0$	R^2	F test $a=0, \theta=0$
Economist 3 Month	6/81-12/85	-0.1686 (0.0934)	184	-1.80 *	0.27	1.20
MMS 3 Month	1/83-10/84	-0.0288 (0.1431)	182	-0.20	0.00	6.02 ***
Economist 6 Month	6/81-12/85	-0.3582 (0.1936)	174	-1.85 *	0.28	1.40
Amex 6 Month	1/76-8/85	-0.0427 (0.1647)	45	-0.26	0.01	2.07 *
Economist 12 Month	6/81-12/85	-0.4167 (0.1895)	149	-2.20 ***	0.35	6.54 ***
Amex 12 Month	1/76-8/85	0.1904 (0.2919)	40	0.65	0.05	0.36

Notes: All equations are estimated allwing each currency its own constant term. To conserve space, estimates of the constants are omitted here, but are reported in Frankel and Froot (1986).
Method of Moments standard errors are in parentheses.
*, **, *** represent significance at the 10 percent, 5 percent and 1 percent levels, respectively.

TABLE 11
RATIONALITY OF REGRESSIVE EXPECTATIONS II
Independent variable: s(t) - s(t)
Long Run Equilibrium PPP

OLS Regressions of Survey Predition Errors: $E[s(t+1)] - s(t+1) = a + \theta(s(t) - s(t))$

Data Set	Dates	coefficient θ	DF	$t: \theta=0$	R^2	F test $a=0, \theta=0$
Economist 3 Month	6/81-12/85	-0.2041 (0.1100)	184	-1.86 *	0.28	1.24
MMS 3 Month	1/83-10/84	-0.0335 (0.1387)	182	-0.24	0.01	6.01 ***
Economist 6 Month	6/81-12/85	-0.4344 (0.2252)	174	-1.93 *	0.29	1.49
Amex 6 Month	1/76-8/85	0.0343 (0.1643)	45	0.21	0.00	1.78
Economist 12 Month	6/81-12/85	-0.5090 (0.2227)	149	-2.29 **	0.37	6.48 ***
Amex 12 Month	1/76-8/85	0.4278 (0.2412)	40	1.77 *	0.26	0.85

Notes: All equations are estimated allwing each currency its own constant term. To conserve space, estimates of the constants are omitted here, but are reported in Frankel and Froot (1986).
Method of Moments standard errors are in parentheses.
*, **, *** represent significance at the 10 percent, 5 percent and 1 percent levels, respectively.

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Interpreting Tests of Forward Discount Unbiasedness Using Survey Data on Exchange Rate Expectations

Ken Froot

Sloan School of Management
Massachusetts Institute of Technology
Cambridge, Massachusetts 02139

Jeff Frankel

Department of Economics
University of California, Berkeley
Berkeley, California 94720

ABSTRACT

Survey data on exchange rate expectations are used to divide the forward discount into expected depreciation and a risk premium. Our starting point is the common test of whether the forward discount is an unbiased predictor of future changes in the spot rate. We use the surveys to decompose the bias into a portion attributable to the risk premium and a portion attributable to systematic prediction errors. The survey data suggest that our findings of both unconditional and conditional bias are overwhelmingly due to systematic expectational errors. Regressions of future changes in the spot rate against the forward discount do not yield insights into the sign, size or variability of the risk premium as is usually thought. We test directly the hypothesis of perfect substitutability, and find support for it in that changes in the forward discount reflect, one for one, changes in expected depreciation. The "random-walk" view that expected depreciation is zero is thus rejected; expected depreciation is even significantly more variable than the risk premium. In fact, investors would do better if they always reduced fractionally the magnitude of expected depreciation. This is the same result that Bilson and many others have found with forward market data, but now it cannot be attributed to a risk premium.

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Ken Froot

Sloan School of Management

Massachusetts Institute of Technology

Cambridge, Massachusetts 02139

Jeff Frankel

Department of Economics

University of California, Berkeley

Berkeley, California 94720

1. INTRODUCTION

The forward exchange rate is surely the jack-of-all-trades of international financial economics. Whenever researchers need a variable representing investor expectations of future spot rates, the forward rate is the first to come to mind. On the other hand, the forward rate is frequently used to measure the empirically elusive foreign exchange risk premium.

These two conflicting roles are most evident in the large literature testing whether the forward discount is an unbiased predictor of the future change in the spot exchange rate.[1] Most of the studies that test the unbiasedness

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[1] See, for example, Tryon (1979), Levich (1979), Bilson (1981a), Longworth (1981), Hsieh (1982), Fama (1984), Huang (1984), Park (1984) and Hodrick and Srivastava (1986). For a recent survey of the literature and additional citations see Boothe and Longworth (1986).

hypothesis reject it, and they generally agree on the direction of bias. They tend to disagree, however, about whether the bias is evidence of a risk premium or of a violation of rational expectations. For example, studies by Longworth (1981) and Bilson (1981a) assume that investors are risk neutral, so that the systematic component of exchange rate changes in excess of the forward discount is interpreted as evidence of a failure of rational expectations. On the other hand, Hsieh (1984) and others attribute the same systematic component to a time-varying risk premium that separates the forward discount from expected depreciation.

Investigations by Fama (1984) and Hodrick and Srivastava (1986) have recently gone a step further, interpreting the bias not only as evidence of a risk premium, but also as evidence that the variance of the risk premium is greater than the variance of expected depreciation. Bilson (1985) terms this view a new "empirical paradigm" because it incorporates an essentially static model of exchange rate expectations; changes in the forward discount predominantly reflect changes in the risk premium rather than changes in expected depreciation. Often cited in support of this view is the work of Meese and Rogoff (1983), who find that a random walk model consistently forecasts future spot rates better than alternative models, including the forward rate.

But one cannot address without additional information the basic issues of whether systematic expectational errors or the risk premium are alone responsible for the repeatedly biased forecasts of the forward discount (or whether it is some combination of the two), let alone whether the risk premium is the more variable. In this paper we use survey data on exchange rate expectations in an attempt to help resolve these issues. The surveys allow us to divide the forward discount into its two components - expected depreciation and the risk premium -- and to inspect separately the properties of each.

Though surveys of agents' expectations may in general be less desirable than data on agents' actual market behavior, in this case the merit of a new data source lies in what could not have been learned without it. One particular advantage of the surveys is that our estimates of the risk premium do not depend on the validity of any specific model or assumptions. As a consequence we can test directly whether investors regard assets denominated in different currencies as perfect substitutes. A second advantage is that, with the issue of the risk premium's existence tentatively resolved, we can then test the hypothesis of forward rate unbiasedness and come away with a clear idea of how much bias is due to the risk premium and how much is due to systematic expectational errors. A third advantage of the surveys (which cover a variety of sample periods and forecast horizons) is that they can help us gain a sense for the accuracy of earlier interpretations given to the large number of rejections of the forward rate unbiasedness hypothesis.

The paper is organized as follows. Section 2 presents some simple descriptive statistics from the survey data. Here the focus is primarily on the unconditional prediction errors of the forward discount. In section 3, we perform the standard (conditional) test of forward discount unbiasedness, and use the surveys to decompose the bias into a component attributable to systematic expectational errors and a component attributable to the risk premium. In section 4, we test formally whether the risk premium component is significantly different from zero, that is, we test whether investors regard positions in different currencies as perfect substitutes. In section 5, we test formally whether the expectational errors component is significantly different from zero, that is, we ask if the survey expectations are rational in the sense that they are formed in a manner consistent with the true spot process. Finally, section 6 offers our conclusions.

2. DESCRIPTIVE STATISTICS

Our exchange rate expectations data come from three independent surveys. The Economist Financial Report has conducted telephone interviews with currency traders or currency-room economists at 14 leading international banks one day each six weeks beginning in June, 1981. Respondents were asked for their expectations of the value of the pound, French franc, mark, Swiss franc and yen against the dollar in three, six and twelve months time. The second survey source is Money Market Services (MMS), Inc. Every two weeks from January 1983 to October 1984, MMS spoke by phone with an average of 30 currency traders and obtained their expectations of the value of the pound, mark, Swiss franc and yen at two-week and three-month horizons. From October 1984 to February 1986, MMS conducted its survey every week, asking for expectations one week and one month into the future. Finally, the Amex Bank Review (Amex) surveys 250-300 central and private bankers, corporate treasurers and finance directors, and economists, and records their expectations of the value of the pound, French franc, mark, Swiss franc and yen against the dollar at six-month and twelve-month horizons. Most of these data sets are discussed and analyzed in Frankel and Froot (1986).[2]

Naturally, the benefits that survey data provide do not come without possible costs. The presence of heterogeneous beliefs, the use of the median response, the lack of perfect synchronization, and the sheer volatility of the spot rate all make some measurement error in the survey data likely. We present results in section 4 which suggest that the surveys are surprisingly "clean". Nevertheless, we try to use only tests that are robust to the presence of random measurement error in the data.[3] In order to take advantage of the

[2] Another paper that uses the MMS data is Dominguez (1986).

[3] Also, we experimented with different approximations to the precise survey and forecast dates of the Amex survey, which was conducted by mail over a period of up to a month. We used the average of the 30 days during the survey and also the mid-point of the survey

complete sample of data available (the three sources contain over 1,450 data points), we used every available opportunity to raise our sample sizes. The data are frequently pooled across currencies. We also employ a method-of-moments estimation procedure which allows us to pool the data across different forecast horizons.

2.1. Decomposition of Forward Rate Prediction Errors

Perhaps the simplest test for whether the forward discount is an unbiased predictor of the future spot rate is a test for unconditional bias in the forward rate prediction errors. These errors are defined as:

$$fd_t^k - \Delta s_{t+k} = (fd_t^k - \Delta s_{t+k}^e) + (\Delta s_{t+k}^e - \Delta s_{t+k}) \equiv rp_t^k + \eta_{t+k}^k . \qquad (1)$$

where fd_t^k is the forward discount (the log of the current forward rate minus the log of the current spot rate, $f_t^k - s_t$) expressed in terms of domestic currency, and Δs_{t+k} and Δs_{t+k}^e are the log of the actual spot rate and expected spot rate k periods into the future, respectively, minus the log of the current spot rate. Equation (1) thus defines the risk premium, rp_t^k, as the expected excess return required by investors in order to hold an open position in domestic currency at time t and η_{t+k}^k as the expectational prediction error, realized at time $t+k$. If exchange rate risk is completely diversifiable and expectations are rational, then the forward rate prediction errors should be purely random.[4]

Table 1 reports the time series means of the forward discount, ex post change in the spot rate and the forward rate prediction error in equation (1), sampled on the days when surveys were conducted.[5] In several cases

period to construct reference sets. Both gave very similar results, so that only results from the former sample were reported.

[4] Under perfect substitutability, expected real, and not nominal, profits should be zero; the two differ because of Jensen's inequality (see Engel, 1984). We do not incorporate the effects of purchasing power uncertainty in this paper, however. One might expect the effects are small: the standard deviation of unexpected changes in the inflation rate are about 1/30 the size of the standard deviation in exchange rate changes (Litterman, 1980, and the results in Tables 1, 2 and 3 of this paper).

[5] DRI provided us with daily forward and spot exchange rates, computed as the average

(particularly the MMS three-month data and the Economist and Amex twelve-month data), we can reject the hypothesis that the forward rate is on average an unbiased predictor of the future spot rate.[6] The signs of the errors are clearly sensitive to the sample period; they are negative in the later MMS sample (October 1984 to February 1986) and in the Amex data from the late 1970s, but positive in between. Columns (1) and (2) of Table 1 show that such variation is due to substantial swings in average ex post exchange rate changes from sample period to sample period and not due to swings in the forward discount.

Without any additional information on investors' expected future spot rate, s^e_{t+k}, one would have to assume that the risk premium is zero in order to interpret equation (1) as a test of market efficiency. Alternatively, if one wishes to interpret equation (1) as a test for the existence of a risk premium, the assumption of rational expectations is required (i.e., η^k_{t+k} is serially uncorrelated and $E(\eta^k_{t+k} \mid rp^k_t) = 0$). Thus the results in Table 1 could be interpreted as evidence that investors made repeated forecasting mistakes during some the survey periods, <u>or</u> that investors distinguished between assets denominated in different currencies on the basis of risk (or else some combination of these polar points of view).[7]

In Table 2 we use the survey data to separate the forward rate prediction errors into the two terms on the right-hand-side of equation (1): the risk premium and expectational errors. Here the conclusions concerning the nature of

of the noon-time bid and ask rates.

[6] The Economist surveys, MMS one-month and three-month surveys, and the Amex twelve-month survey were conducted at intervals shorter than their respective forecast horizons. This implies that the prediction errors of the forward discount and of the survey expectations, in Tables 1 and 2 respectively, are not all independent, even under the hypothesis of rational expectations. For the Economist and MMS data, the standard deviation of the means were estimated by a method of moments procedure discussed in the following section. For the Amex data, confidence intervals were constructed assuming that the number of degrees of freedom is equal to the number of nonoverlapping observations. This latter procedure implies that t-tests reported for the Amex data are lower bounds.

[7] Other potential candidates for the non-zero forward rate prediction errors are the peso problem (but see Frankel, 1985) and the convexity term due to Jensen's inequality (see McCulloch, 1975).

each are surprisingly very different from those one might draw from Table 1. Note first that the means of the risk premia measured in the survey data are large, averaging around an annualized 5 percent and reaching 9 percent in several cases. Second, and perhaps even more striking, is that nothing about the sign or magnitude of the risk premia as measured by the survey data can be inferred from the forward discount prediction errors. In fact, the premia in column (1) of Table 2 are consistently <u>opposite</u> in sign from the forward rate errors.[8] Third, the risk premia often appear negatively correlated with the forward rate errors, not just across data sets, but <u>within</u> each data set as well. The first column of Table 3 reports correlation coefficients for each currency and survey: 21 of the 33 estimates are less than zero. Charts 1 through 4 show the time series of the forward rate errors and the survey risk premia for each of the data sets.[9] The graphs show how badly the forward prediction errors have measured the premia in the past.

Such a poor correspondence might suggest instead that the survey data are very imprecise measures of investors' true expectations. But, in the first place, it should be noted that findings of unconditional bias are unaffected by any measurement error in the survey data, provided the error is random. In the second place, we offer an explicit estimate of the magnitude of this measurement error component in section 4. In the third place, the degree to which the surveys qualitatively corroborate one another is striking. For example, the risk premium in the Economist data (Chart 1) is negative during the entire sample, except for a short period from late 1984 until mid-1985. The MMS three-month sample (Chart 2) reports that the risk premium did not become positive

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[8] This is the same as saying that the survey prediction errors are of the same sign as the forward rate errors, but have consistently larger absolute values.

[9] Graphs 1-3 use moving averages across all of the currencies included in the designated survey. The Amex data in Graph 4 were straightforward averages over the five currencies surveyed.

until the last quarter of 1984, while MMS one-month data (Chart 3) shows the risk premium then remained positive until mid-1985. That the surveys agree on the nature and timing of major swings in the risk premium is some evidence that the particularities of each group of respondents do not influence the results.

We can test whether the data statistically reject the hypothesis that the forward rate prediction errors are attributable entirely to the risk premia alone, assuming that the surveys measure expectations accurately. The tests for the significance of the mean survey prediction errors in Table 2 show that 27 out of 44 samples reject the hypothesis that the survey expectations are unbiased predictors of the future spot rate. This is a rejection of the equivalent hypothesis that the systematic component of the forward rate prediction errors is attributable entirely to the risk premium. We can also test whether the data statistically reject the hypothesis that the errors are attributable entirely to the existence of expectational errors alone. Table 2 shows that we can easily reject this hypothesis because the risk premium is significantly different from zero and of the opposite sign.

The survey data therefore suggest that an interpretation of the unconditional bias in the forward rate prediction errors that imposes rational expectations would lead to consistently incorrect conclusions with respect to the sign of the risk premium and the nature of its time-series variation. At the opposite extreme, the systematic portion of the errors could be interpreted solely as evidence of a failure of rational expectations, but then the forward rate errors would offer no evidence at all regarding the substantial risk premia recorded in the survey data. Either interpretation, or any combination of the two, would miss the fact that the survey risk premium is in the direction opposite to that indicated by the results in Table 1, that is, expectational errors are more than

100 percent responsible for the unconditional bias in the forward rate errors.

2.2. Variability of the Risk Premium and Exchange Rate Expectations

Survey data can also be used to shed some light on the relative volatility of expected depreciation and the risk premium. The recent papers by Fama (1984) and Hodrick and Srivastava (1986) argue that the risk premium is more variable than expected depreciation or, in the extreme formulation of Bilson (1985), that expected depreciation is zero. Such "random walk" expectations are not reflected in the survey data. Instead, all the data sets indicate that expected depreciation exhibits considerable variation, often more in fact than does the implied risk premium. Table 3 shows the variance of expected changes in the spot rate and the variance of the risk premia, for each data set and broken down by currency. The magnitude of ex post exchange rate changes (column (1)) dwarfs that of the forward discount (column (2)).[10] For example, the reported variance of annualized spot rate changes of 2 percent represents a standard deviation of about 14 percent. By comparison, the variance of expected depreciation is around .25 percent, a standard deviation of 5 percent.

The variance of expected depreciation is comparable in size to the variance of the risk premium, and is larger in 36 of the 40 samples calculated in Table 3. We test formally the Fama (1984) hypothesis that the variance of expected depreciation is less than the variance of the risk premium in section 4. Both are several times larger than the variance of the forward discount. Thus the relative stability of the forward discount masks greater variability in its two components, corroborating Fama's finding that the risk premium is negatively correlated with the expected change in the spot rate.[11]

[10] This empirical regularity has often been noted; e.g., Mussa (1979).

[11] This correlation is, however, biased downward by any measurement error that might be present in the surveys. If such error is purely random, then the covariance of expected depreciation and the risk premium may be written as $cov(\Delta s_{t+k}, rp_t) - var(\xi_{t+k})$, where Δs_{t+k} and rp_t are the "true" values of expected depreciation and of the risk premium, respectively, and ξ_{t+k} is the measurement error component of the survey.

3. USING THE SURVEY DATA IN THE FORWARD RATE UNBIASEDNESS REGRESSION

In tests of forward market unbiasedness, much attention has focused on the optimal weights placed on the forward rate versus the contemporaneous spot rate in predicting future spot rate changes. The equation most commonly used is a regression of the future change in the spot rate on the forward discount:

$$\Delta s_{t+k} = \alpha + \beta fd_t^k + \varepsilon_{t+k}^k \tag{2}$$

where the null hypothesis is that the weight on the forward rate is one and the constant term is zero, i.e., $\beta = 1$ and $\alpha = 0$. In other words, the realized spot rate is equal to the forward rate plus a purely random error term. A second but equivalent specification is a regression of the forward rate prediction error on the forward discount:

$$f_t^k - s_{t+k} = \alpha_1 + \beta_1 fd_t^k + \varepsilon_{1,t+k}^k \tag{2'}$$

where $\alpha_1 = -\alpha$ and $\beta_1 = 1-\beta$. The null hypothesis is now that $\alpha_1 = \beta_1 = 0$: the left-hand-side variable is purely random.

Most tests of equation (2) have rejected the null hypothesis, finding β to be significantly less than one. The range of point estimates has been wide, from about -2.8 to 0.8. Coefficients that are positive, but less than one, imply that the optimal predictor of the spot rate puts positive weight on both the forward rate and the contemporaneous spot rate. A coefficient of zero is the random walk hypothesis: the forward discount is of no help in forecasting future spot rate changes.[12] Least appealing, but nevertheless not unusual, are findings of

[12] Findings of this kind are not limited to investigations of foreign exchange markets. In their study of the expectations hypothesis of the term structure, for example, Shiller, Campbell and Schoenholtz (1983) conclude that changes in the premium paid on longer-term bills over short-term bills are useless for predicting future changes in short-term interest rates.

significant negative coefficients, which indicate that the spot rate tends to move in the direction opposite to that predicted by the forward discount.

As in the previous section, tests of equation (2) are joint tests of rational expectations and no exchange risk premium. Without other information, however, researchers have been forced to focus on one alternative hypothesis at the expense of the other. For example, one could ignore the risk premium and interpret the forward rate as representing investors' expectations. In this context, Bilson (1981b) proposed that the alternative of β less than one be termed "excessive speculation", because it would imply that investors could do better on average if they were to reduce fractionally their forecasts of exchange rate changes, and that the alternative of β greater than one be termed "insufficient speculation", because it would imply that investors could do better if they were to raise multiplicatively the magnitude of their forecasts of exchange rate changes.

The most popular alternative hypothesis in regressions of equations like (2), however, is that domestic and foreign securities are imperfect substitutes because of risk. As we have already mentioned, Fama (1984), Hodrick and Srivastava (1986) and Bilson (1985) argue that coefficients close to zero in such regressions can be viewed as evidence of a risk premium that is more variable than are expectations. By taking probability limits, the slope coefficient β in equation (2) can be rewritten as:

$$\beta = \frac{\mathrm{cov}(\Delta s_{t+k}, fd_t^k)}{\mathrm{var}(fd_t^k)} = \frac{\mathrm{cov}(\Delta s^e_{t+k}, fd_t^k)}{\mathrm{var}(\Delta s^e_{t+k}) + 2\mathrm{cov}(\Delta s^e_{t+k}, rp_t^k) + \mathrm{var}(rp_t^k)}$$

$$= \frac{\mathrm{var}(\Delta s^e_{t+k}) + \mathrm{cov}(\Delta s^e_{t+k}, rp_t^k)}{\mathrm{var}(\Delta s^e_{t+k}) + 2\mathrm{cov}(\Delta s^e_{t+k}, rp_t^k) + \mathrm{var}(rp_t^k)} \qquad (3)$$

where the second equality follows from assuming rational expectations. If $\beta < ½$

as is usually found, it follows that $\text{var}(rp_t^k) > \text{var}(\Delta s_{t+k}^e)$. Accordingly, Bilson (1985 p. 63) interprets the accumulated results of such regressions as evidence that "most of the variation in the [forward] premium reflects variation in the risk premium rather than variation in the expected rate of appreciation." Indeed, the growing body of evidence that β is insignificantly different from zero does not permit one to reject the extreme view that expectations are totally unrelated to the forward rate, in other words, that all variation in the forward discount is attributable solely to variation in the risk premium.

3.1. Econometric Issues

Before turning to our own estimates of equation (2), we pause briefly to mention several important econometric issues.

Estimation of equation (2) (and most of the equations we estimate later), is performed using OLS. We stack different countries, and in some cases, different forecast horizons into a single equation. The complicated correlation pattern of the residuals, however, renders the OLS standard errors incorrect in finite samples. Several types of correlation are present.

First, there is serial correlation induced by a sampling interval shorter than the corresponding forecast horizon (up to eight times). This is the usual case in which overlapping observations imply that, under the null hypothesis, the error term is a moving average process of an order equal to the frequency of sampling interval divided by the frequency of the horizon, minus one. Hansen and Hodrick (1980) propose using a method of moments (MoM) estimator for the standard errors in precisely the application studied here.

Second, in order to take advantage of the fact that the surveys covered four or five currencies simultaneously, we pooled the regressions across countries. This type of pooling induces contemporaneous correlation in the residuals.[13] Normally, Seemingly Unrelated Regressions should be used to exploit this correlation efficiently. We use SUR later; here, however, the serial correlation induced by overlapping observations makes SUR inconsistent.

The basic model may be written as:

$$y_{t,i}^{k} = x_{t-k,i}^{k}\beta + \nu_{t,i}^{k} \tag{4}$$

where k is the number of periods in the forecast horizon and i indexes the currency. We account for the two types of correlation in the residuals with a MoM estimate of the covariance matrix of $\hat{\beta}$:

$$\hat{\Theta}^{1} = (X_{NT}'X_{NT})^{-1}X_{NT}'\hat{\Omega}X_{NT}(X_{NT}'X_{NT})^{-1} \tag{4'}$$

where X_{NT} is the matrix of regressors of size N (countries) times T (time). The (i,j)th element of the unrestricted covariance matrix, $\hat{\Omega}$ is:

$$\hat{\omega}(i,j) = \frac{1}{NT-k}\sum_{l=0}^{N-1}\sum_{t=k+1}^{T}\hat{\nu}_{t+lT}\hat{\nu}_{t-k+lT} \text{ for } mT-n\le k\le mT+n\ ;\quad m=0,\ldots,N-1$$

$$= 0 \qquad \text{otherwise}\,. \tag{5}$$

where n is the order of the MA process, $\hat{\nu}_{t+lT}$ is the OLS residual, and $k = |i-j|$. In some cases, this unrestricted estimate of Ω uses well over 100 degrees of freedom.[14] We therefore estimated a restricted covariance matrix, $\tilde{\Omega}$ with typical element:

$$\tilde{\omega}(t+lT,\, t-k+pT) = \frac{1}{N-1}\sum_{l=0}^{N}\hat{\omega}(t+lT,\, t-k+pT) \quad \text{if } \lambda = p \text{ and } -n\le k\le n$$

$$= \frac{2}{N(N-1)}\sum_{p=0}^{N-1}\sum_{l=0}^{N-1}\hat{\omega}(t+lt,\, t-k+pT) \quad \text{if } \lambda\ne p \text{ and } -n\le k\le n$$

[13] Each currency in our pooled regressions was given its own constant term. This modeling strategy seemed most reasonable in view of the differences across currencies in the magnitudes of both ex post spot rate changes and the forward discount (see Table 1).

[14] The number of independent parameters in the covariance matrix does not affect the asymptotic covariance, as long as these parameters are estimated consistently (see Hansen

$= 0$ otherwise . (6)

These restrictions have the effect of averaging the own-currency and cross-currency autocorrelation functions of the OLS residuals, respectively, bringing the number of independent covariance parameters down to $2n$.

Tests of forward discount unbiasedness also provide an opportunity to aggregate across different forecast horizons (though we are unaware of anyone who has done this, even with the standard forward discount data), adding a third pattern of correlation in the residuals. Such stacking seems appropriate in this case because we wish to study the predictive power of the forward discount generally, rather than at any particular time horizon. Moreover, a MoM estimator which incorporates several forecast horizons has appeal beyond the particular application studied here because it is computationally simpler than competing techniques and at the same time can be more efficient than single k-step-ahead forecasting equations estimated with MoM.

To demonstrate the precise nature of the correlation induced by such aggregation, consider the stochastic process, Y_t, which is stationary and ergodic in first differences and has finite second moments. We denote the k period change in y from period $t-k$ to t as y_t^k, and the h period change as $y_t^h = \sum_{i=0}^{n-1} y_{t-ik}^k$, where $h = nk$ for any positive integer n.[15] We then define the innovations, ν_t^k and ν_t^h as:

$$\nu_t^k = y_t^k - E(y_t^k \mid \varphi_{t-k}) \tag{7}$$

(1982)). Nevertheless, one suspects that the small-sample properties of the MoM estimator worsen as the number of nuisance parameters to be estimated increases.

[15] The following example can easily be generalized to allow h and k to be any positive integers. It is also possible to combine in a similar fashion more than two different forecast horizons. Indeed, we combine three horizons in the Economist data estimates in the regressions below. Because these extensions yield no additional insights and come at the cost of more complicated algebra, however, we retain the simple example above.

$$\nu_t^h = y_t^h - E(\,y_t^h \mid \varphi_{t-h})$$

where φ_t includes present and lagged values of the vector of right-hand-side variables, x_t^k. These facts allow us to write the covariance matrix of the innovations as:

$$\Sigma = E\left[\begin{bmatrix}\nu_t^k \\ \nu_t^h\end{bmatrix}[\nu_t^{k\prime}\nu_t^{h\prime}]\right] = \begin{bmatrix}\Delta^k & \Delta^{hk} \\ \Delta^{hk\prime} & \Delta^h\end{bmatrix} \tag{8}$$

where the (i,j)th element of each submatrix of Σ is equal to the corresponding autocovariance function, evaluated at $q = i - j$:

$$\begin{aligned}\Delta_{i,j}^k = E(\,\nu_t^k\nu_{t+q}^k) &= \lambda_q^k \text{ if } |q| < k \\ &= 0 \text{ otherwise ,}\end{aligned} \tag{9}$$

$$\begin{aligned}\Delta_{i,j}^h = E(\,\nu_t^h\nu_{t+q}^h) &= \lambda_q^h \text{ if } |q| < h \\ &= 0 \text{ otherwise ,}\end{aligned}$$

$$\begin{aligned}\Delta_{i,j}^{hk} = E(\,\nu_t^k\nu_{t+q}^h) &= \lambda_q^{hk} \text{ if } 0 \le q < k \\ = E(\,\nu_t^k\nu_{t+q}^h) &= \lambda_q^{hk} \text{ if } -h < q < 0 \\ &= 0 \text{ otherwise .}\end{aligned} \tag{10}$$

In this context consider the aggregated model:

$$\mathbf{y}_t = \mathbf{x}_t\beta + \nu_t \tag{11}$$

where $\mathbf{y}_t' = [y_{t+k}^{k\prime} \;\; y_{t+h}^{h\prime}]$, $\mathbf{x}_t' = [x_t^{k\prime} \;\; x_t^{h\prime}]$ and $\nu_t' = [\nu_{t+k}^{k\prime} \;\; \nu_{t+h}^{h\prime}]$. The OLS estimate of β then has the usual MoM estimate of the sample covariance matrix:

$$\hat{\theta}^2 = (\mathbf{x}_{2NT}'\mathbf{x}_{2NT})^{-1}\mathbf{x}_{2NT}'\hat{\Sigma}\mathbf{x}_{2NT}(\mathbf{x}_{2NT}'\mathbf{x}_{2NT})^{-1}$$

where $\hat{\Sigma}$ is a consistent estimate of Σ, and is formed by using the OLS residuals to estimate the autocovariance and crosscovariance functions in equations (9) and (10).

One might think that by stacking forecast horizons, as we do in equation (11), greater asymptotic efficiency always results than if only the shorter-term forecasts are used, in other words, that $\hat{\theta}^1 - \hat{\theta}^2$ is positive semidefinite. After all, the sample size has doubled, and the only additional estimates we require are nuisance parameters of the covariance matrix. This intuition would be correct for efficient estimation strategies, such as maximum likelihood. But because OLS weights each observation equally, the MoM covariance estimates reflect the average precision of the data. It follows that if the longer-term forecasts are sufficiently imprecise relative to the shorter-term forecasts, the precision of the estimate of β drops: we could actually lose efficiency by adding more data. In the appendix we demonstrate this potential loss in asymptotic efficiency, and show how it is related to the disparity in forecast horizons. Efficiency is most likely to increase if the longer-term forecast horizon is a relatively small multiple of the shorter-term horizon. Indeed, in the forthcoming regressions we find a marked increase in precision from stacking across forecast horizons when $n = 2$ (in the Economist and Amex samples), but little or no increase in precision when $n = 4$ or 6 (in the MMS samples).

Finally, the above MoM estimates of the covariance matrix need not be positive definite in small samples. Newey and West (1985) offer a corrected estimate of the covariance matrix that discounts the jth order autocovariance by $1 - (j/(m+1))$, making the covariance matrix positive definite in finite sample. Nevertheless, for any given sample size, there remains the question of how small m must be to guarantee positive definiteness. In the upcoming regressions we tried $m = n$ (which Newey and West themselves suggest) and $m = 2n$; we report standard errors using the latter value of m because they were consistently larger than those using the former.[16]

[16] For the two aggregated MMS data sets in Table 8 below, a value of $m = n$ was used after finding that $m = 2n$ resulted in a nonpositive semi-definite covariance matrix. This correction reduced the standard errors in these two regressions by an average of only 3 percent.

3.2. Results

Table 4 presents the standard forward discount unbiasedness regressions (equation (2)) for our sample periods.[17] Most of the coefficients fall into the range reported by previous studies. Note that in the Economist and Amex data sets, in which forecasts horizons were stacked, the standard errors fell in the aggregated regressions by 14 and 31 percent, respectively, in comparison with regressions that used the shorter-term predictions alone. In terms of the point estimates, all but one of the data sets indicate that the optimal predictor of the future spot rate places negative weight on the forward rate, and more than half of the coefficients are significantly less than zero. There is ample evidence to reject unbiasedness. In the two MMS data sets, which cover shorter sample periods of 14 and 21 months, respectively, the coefficients have unusually large absolute values, lending support to the observation by Gregory and McCurdy (1984) that the regression relation in equation (2) may be unstable. The F-tests also indicate that the unbiasedness hypothesis fails in most of the data sets.

At this point, we could interpret the results as reflecting systematic prediction errors. Under this interpretation, it follows that agents would do better by placing more weight on the contemporaneous spot rate and less weight on other factors in forming predictions of the future spot rate, the view discussed by Bilson (1981b). On the other hand, we could interpret the results as evidence of a time-varying risk premium. Then the conclusions would be that changes in expected depreciation are not correlated (or are negatively correlated) with changes in the forward discount and, from equation (3), that the variance of the risk premium is greater than the variance of expected depreciation.

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[17] Regressions were estimated with dummies for each country, which we do not report to save space. For the regressions which pool over different forecast horizons (marked Economist Data and Amex Data), each country was allowed its own constant term for every forecast horizon.

3.3. Decomposition of the Forward Rate Unbiasedness Coefficient

The survey data, however, let us go a step further with the results of Table 4: we can now allocate part of the deviation from the null hypothesis of $\beta = 1$ to each of the alternatives: failure of rationality and the presence of a risk premium. Using the fact that the (log) forward discount can be written as the sum of expected depreciation plus the risk premium,

$$fd_t^k = \Delta s_{t+k}^e + rp_t^k \tag{12}$$

we can decompose the probability limit of the coefficient β in equation (2) into:

$$\beta = \frac{cov(\eta_{t+k}^k, fd_t^k) + cov(\Delta s_{t+k}^e, fd_t^k)}{var(fd_t^k)} \tag{13}$$

where η_{t+k}^k is the expectational prediction error defined in equation (1). With a little algebra, β can then be written as equal to 1 (the null hypothesis) minus a term arising from any failure of rational expectations, minus another term arising from the risk premium:

$$\beta = 1 - \beta_{re} - \beta_{rp} \tag{14}$$

where

$$\beta_{re} = \frac{\text{cov}(\eta_{t+k}^k, fd_t^k)}{\text{var}(fd_t^k)}$$

$$\beta_{rp} = \frac{\text{var}(rp_t^k) + \text{cov}(\Delta s_{t+k}^e, rp_t^k)}{\text{var}(fd_t^k)}.$$

With the help of the survey data, both terms are observable. By inspection, $\beta_{re} = 0$ if there are no systematic prediction errors in the sample, and $\beta_{rp} = 0$ if there is no risk premium (or, somewhat more weakly, if the risk premium is uncorrelated with the forward discount).

The results of the decomposition are reported in Table 5a. First, β_{rs} is very large in size when compared to β_{rp}, often by more than an order of magnitude. In all of the regressions, the lion's share of the deviation from the null hypothesis consists of systematic expectational errors. For example, in the Economist data, our largest survey sample with 525 observations, β_{rs} = 1.49 and β_{rp} = 0.08. Second, while β_{rs} is greater than zero in all cases, β_{rp} is sometimes negative, implying in equation (14) that the effect of the survey risk premium pushes the estimate of the standard coefficient β in the direction above one. In these cases, the risk premia do not explain a positive share of the forward discount's bias. The positive values for β_{rs}, on the other hand, suggest the possibility that investors tended to overreact to other information, in the sense that respondents might have improved their forecasting by placing more weight on the contemporaneous spot rate and less weight on the forward rate. Third, to the extent that the surveys are from different sources and cover different periods of time, they provide independent information, rendering their agreement on the relative importance and sign of the expectational errors all the more forceful. To check if the level of aggregation in Table 5a is hiding important diversity across currencies, Table 5b reports the decomposition for each currency in every data set. Here the results are the same: expectational errors are consistently large and positive, and the risk premium appears to explain no positive portion of the bias.

While the qualitative results above are of interest, we would like to know whether they are statistically significant, whether we can formally reject the two obvious polar hypotheses: a) that the results in Table 4 are attributable entirely to expectational errors; and b) that they are attributable entirely to the presence of the risk premium in the survey data. We test these hypotheses in turn in the following sections.

4. A Direct Test of Perfect Substitutability

We consider first a test of whether the bias introduced by the risk premium, β_{rp}, is statistically significant. The most direct test is a regression of the survey expected depreciation against the forward discount:

$$\Delta\overline{s}^{e}_{t+k} = \alpha_2 + \beta_2 fd^k_t + \varepsilon_{2,t} \tag{17}$$

where the null hypothesis is that no risk premium separates the two, $\alpha_2 = 0$ and $\beta_2 = 1$. Strictly speaking, the expected future spot rate exactly equals the forward rate if assets are perfect substitutes, so that we should interpret the regression error $\varepsilon_{2,t}$ as measurement error in the surveys. Thus, $\Delta s^e_{t+k} = \Delta\overline{s}^e_{t+k} - \varepsilon_{2,t}$, where $\Delta\overline{s}^e_{t+k}$ is the unobservable "true" market expected change in the spot rate. Note that if the null hypothesis holds, we can use the R^2 from equation (17) to obtain an estimate of the relative importance of the measurement error component in the survey data.[18]

To see that a test of $\beta_2 = 1$ is equivalent to a test of $\beta_{rp} = 0$, note that the OLS estimate of β_2 converges in probability to:

$$\beta_2 = 1 - \frac{var(\overline{rp}^k_t) + cov(\Delta\overline{s}^e_{t+k}, \overline{rp}^k_t)}{var(fd^k_t)} \tag{18}$$

$$= 1 - \beta_{rp}$$

where $\overline{rp}^k_t$ is the survey risk premium less any measurement error, i.e., the "true" market risk premium, $fd^k_t - \Delta\overline{s}^e_{t+k}$. Equation (17) may also be used to test the Fama (1984) hypothesis regarding the size of the variance of expected depreciation relative to the variance of the risk premium. A little algebra yields:

[18] Note also that in a test of equation (17) using the survey data, the properties of the error term, $\varepsilon_{2,t}$, will be invariant to any "peso problems," which affect instead the *ex post* distribution of actual spot rate changes.

$$\beta_2 = \frac{\mathrm{var}(\Delta\overline{s}^e_{t+k}) - \mathrm{var}(\overline{rp}^k_t)}{\mathrm{var}(fd^k_t)} + \tfrac{1}{2}. \tag{19}$$

Equation (19) says that if β_2 is significantly greater than ½, the variance of expected depreciation exceeds that of the risk premium. The qualitative finding in Table 3, column (6), that the variance of expected depreciation is the greater can thus be tested formally. Although measurement error in the survey data would tend to overstate both of these variances, it does not affect the estimate of their difference (equation (19)). This point is evident from equation (17), in which the measurement error $\varepsilon_{2,t}$ is conditionally independent of the estimate of β_2 as long as it is random, i.e., $E(\varepsilon_{2,t} \mid fd^k_t) = 0$.

Under mild assumptions, equation (17) may also be interpreted as a direct test of uncovered interest parity. If we rule out the presence of riskless arbitrage opportunities, then by covered interest parity the forward discount exactly equals the excess return paid on domestic securities relative to foreign securities:

$$i^k_t - i*^k_t = fd^k_t$$

where i^k_t and $i*^k_t$ are the domestic and foreign interest rates on instruments which mature in k periods. Uncovered interest parity is thus the hypothesis that the interest differential is equivalent to investors' expectations of future depreciation.[19]

4.1. Results

Table 6 reports the OLS regressions of equation (17). In some respects the data provide evidence in favor of perfect substitutability. All of the estimates of β_2 are statistically indistinguishable from one (with the sole exception of the

[19] For tests of uncovered interest parity similar to the tests of conditional bias in the forward discount that we considered in section 3, see Cumby and Obstfeld (1981).

MMS three-month sample). In the Economist and Amex data sets which aggregate across time horizons, the estimates are 0.99 and 0.96, respectively.[20] Expectations seem to move very strongly with the forward rate. With the exception of the MMS data, the coefficients are estimated with surprising precision. As we might expect, however, the large magnitudes of the risk premia discussed in section 2 cause us to reject perfect substitutability. Each of the F-tests reported in Table 6 reject the parity relation at a level of significance that is less than 0.1 percent.

In terms of our decomposition of the forward rate unbiasedness regression, Table 6 shows the values of β_{rp} in column 2 of Table 5a are not significantly different from zero. Thus the rejection of unbiasedness found in the previous section cannot be explained entirely by the risk premium at any reasonable level of confidence. Indeed, in spite of the fact that the survey risk premium has substantial magnitude (Table 2), we cannot reject the hypothesis that the risk premium explains no positive portion of the bias.

Table 6 also reports a t-test of the hypothesis that $\beta_2 = \frac{1}{2}$. In six out of nine cases the data strongly reject the hypothesis that the variance of the true risk premium is greater than or equal to that of true expected depreciation; we have rather $\text{var}(\overline{\Delta s^e_{t+k}}) > \text{var}(\overline{rp^k_t})$. In addition, equation (18) and the finding that $\beta_2 = 1$ together imply that:

$$\text{var}(\overline{rp^k_t}) + \text{cov}(\overline{\Delta s^e_{t+k}}, \overline{rp^k_t}) = 0\,. \qquad (19')$$

Thus we cannot reject the hypothesis that the covariance of true expected depreciation and the true risk premium is negative (as Fama found), nor can we

[20] For the Economist six-month and twelve-month and the Amex twelve-month data sets, the estimates of β_2 from equation (17) do not exactly correspond to $1 - \beta_{rp}$ in Tables 5a and 5b. This is because Table 6 includes a few survey observations for which actual future spot rates have not yet been realized, whereas these observations were left out of the decomposition in Tables 5a and 5b for purposes of comparability. If we had used the smaller samples in Table 6, the regression coefficients would have been .92 and 1.03, for the Economist and Amex data sets, respectively.

reject the extreme hypothesis that the variance of the true risk premium is zero.

Note that the R^2's in Table 6 are relatively high. Under the null hypothesis that true expected depreciation exactly equals the forward discount, one could interpret these results as evidence that the measurement-error component of the survey data is relatively small. For example, under this interpretation of the R^2 statistics, measurement error accounts for about 10 percent of the variability in expected depreciation from the Economist survey.[21] The presence of a time-varying risk premium uncorrelated with the forward discount, however, implies that the disturbance term, $\varepsilon_{2,t}$, will not be purely measurement error but will also include variation of the risk premium around its mean. In this case a second interpretation of the R^2 measure is possible: that it overstates the measurement error component of the surveys. Indeed, the low values of the Durbin-Watson statistics reported in Table 6 seem to suggest the presence in the OLS residuals of a risk premium which is serially correlated but uncorrelated with the forward discount.

In Table 7 we correct for the potential serial correlation problem by employing a Three-Stage-Least-Squares estimator that allows for contemporaneous correlation (SUR) as well as first order auto-regressive disturbances. 3SLS is consistent here because there are no overlapping observations -- predictions by the forward rate and the surveys are observed contemporaneously -- and it has the advantage of being asymptotically efficient. The results reported in Table 7 show that this correction does not change the nature of the results; all but one of the coefficients remain close to one, and there is clear evidence that the variance of expected depreciation is greater than that of the risk

[21] Recall, however, that the R^2 measures in Table 6 include the explanatory power of the constant terms for each currency and forecast horizon.

premium (while there is no evidence for the alternative that the variance of the risk premium is greater).[22]

5. Tests of Rational Expectations

In this section we test to see whether the interpretation of the standard bias findings in section 3 as evidence of systematic prediction errors can be supported. While in section 2 we found evidence that investors err in their unconditional forecasts of future changes in the spot rate, here we focus instead on whether investors tend to place too little weight on the contemporaneous spot rate and too much on all other information. Tests of rational expectations which address this question typically regress future prediction errors of the forward discount on subsets of the contemporaneous information set. As we have already noted, these tests are only valid in the absence of a risk premium. Consequently, we use here the prediction errors of the survey data instead.[23]

5.1. A Test of Excessive Speculation

Perhaps the most powerful test of rational expectations is one which asks whether investors would do better if they placed more or less weight on the contemporaneous spot rate as opposed to <u>all</u> other variables in their information set. This test is performed by a regression of the expectational prediction error on expected depreciation:

$$s^{e}_{t+k} - s_{t+k} = \alpha + d\Delta s^{e}_{t+k} + v^{k}_{t+k} \qquad (20)$$

where the null hypothesis is $\alpha = 0$ and $d = 0$.[24] This is the equation that Bilson

[22] Unfortunately, the highly irregular spacing of the Amex data sets did not permit an auto-regressive correction in this case.

[23] Frankel and Froot (1986) test whether the survey expectations place too little weight on the contemporaneous spot rate and too much weight on specific pieces of information such as the lagged spot rate, the long-run equilibrium exchange rate, and the lagged expected spot rate.

[24] To see how the alternative in equation (20) is too much or too little weight on all variables in the information set other than the contemporaneous spot rate, assume expectations are formed as a linear combination of the current spot rate, s_t, and all other vari-

(1981b) and others had in mind, which we already termed a test of "excessive" speculation, with the difference that we are measuring expected depreciation by the survey data instead of by the ambiguous forward discount.

Our tests are reported in Table 8. The findings consistently indicate that $d > 0$, so that investors could on average do better by giving more weight to the contemporaneous spot rate and less weight to other information they deem pertinent. In other words, the excessive speculation hypothesis is upheld. F-tests of the hypothesis that there are no systematic expectational errors, $a = d = 0$, reject at the one percent level for all of the survey data sets.

The results in Table 8 would appear to constitute a resounding rejection of rationality in the survey expectations. Up until this point, our test statistics have been robust to the presence of random measurement error in the survey data. But now, under the null hypothesis, measurement error biases toward one our estimate of d in equation (20). The test of $d = 0$, therefore, may be less stringent than the usual probability values would imply. To demonstrate this effect, suppose that expected depreciation as recorded by the survey is equal to the market's true expectation, $\Delta\bar{s}^{e}_{t+k}$, plus an error term:

$$\Delta s^{e}_{t+k} = \Delta\bar{s}^{e}_{t+k} + \xi_t \tag{21}$$

where ξ_{t+k} is iid and $E(\xi_t \mid \Delta\bar{s}^{e}_{t+k}) = 0$. The actual spot rate change can then be expressed as the sum of the true market expectation plus a prediction error:

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ables in the information set, I_t:

$$s^{e}_{t+k} = \pi_1 I_t + (1-\pi_1)s_t$$

If the actual process is:

$$s_{t+k} = \pi_2 I_t + (1-\pi_2)s_t - \nu^{k}_{t+k}$$

Then equation (20) can be rewritten as

$$\Delta s^{e}_{t+k} - s_{t+k} = \alpha + (\pi_1 - \pi_2)(I_t - s_t) + \nu^{k}_{t+k}\,. \tag{20'}$$

Rational expectations is the case in which the coefficient $\pi_1 - \pi_2$ is zero. A positive value implies $\pi_1 > \pi_2$: investors put insufficient weight on s_t and too much weight on other information.

$$\Delta s_{t+k} = \Delta \bar{s}^{e}_{t+k} + \eta^{k}_{t+k} . \tag{22}$$

Using these facts, the coefficient d in equation (20) converges in probability to:

$$d = \frac{\text{var}(\xi_t) - \text{cov}(\eta^{k}_{t+k}, \Delta \bar{s}^{e}_{t+k})}{\text{var}(\xi_t) + \text{var}(\Delta \bar{s}^{e}_{t+k})} . \tag{23}$$

Measurement error therefore biases our OLS estimates toward one. Indeed, in the limiting case in which the measurement error accounts for all of the variability of expected depreciation in the survey -- in other words, that no information at all about the "true" market expectation is contained in the surveys -- the parameter estimate would be statistically indistinguishable from one. In Table 8, 13 of 15 estimates of d are <u>greater</u> than one; in five cases the difference is statistically significant. This result suggests that measurement error is not the source of our rejection of rational expectations. However, stronger evidence may be obtained.

5.2. Another Test of Excessive Speculation

One way to get around the uncertainty introduced by this added source of noise is to use the projection of the survey expectations onto investors' information set as the right-hand-side variable in equation (20). Thus we seek a proxy for the survey expectations. The candidate must be highly correlated with the survey expected depreciation, and conditionally independent of the measurement error, $E(\xi_t \mid fd^{k}_{t}) = 0$. In view of the results from section 4, the forward discount seems eminently qualified. The usual instrumental variables estimation procedure is not necessary in this case because the null hypothesis is that $d = 0$. Thus we run the OLS regression:

$$s^{e}_{t+k} - s_{t+k} = \alpha_1 + \beta_1 fd + \varepsilon^{k}_{1,t+k} \tag{24}$$

and perform a test of rationality, $\alpha_1 = \beta_1 = 0$.

Equation (24) has additional relevance in the context of our decomposition of the forward rate unbiasedness regression in section 3: the coefficient, β_1, is precisely equal to the deviation from unbiasedness due to systematic prediction errors, β_{re}. Thus equation (24) can tell us whether the large positive values of β_{re} found in column (1), Tables 5a and 5b are statistically significant.

Table 9 reports OLS regressions of equation (24). We now see that the point estimates of β_{re} in Tables 5a and 5b are measured with precision. The data continue to reject statistically the hypothesis of rational expectations, $\alpha_1 = 0, \beta_1 = 0$. They reject $\beta_1 = 0$, in favor of the alternative of excessive speculation. (Because the measurement error has been purged, the levels of significance are necessarily lower than those of Table 8.) Thus the result that β_{re} is significantly greater than zero seems robust across different forecast horizons and different survey samples. In terms of the decomposition of the typical forward rate unbiasedness test in Table 5a, we can now reject the hypothesis that all of the bias is attributable to the survey risk premium. Put differently, it is still not possible to reject the hypothesis that all the bias consists of repeated expectational errors made by survey respondents, and that no positive portion of the bias can attributed to the survey risk premium.

6. CONCLUSIONS

(1) The survey data indicate that forward rate prediction errors do not give insight into the nature of the risk premia as commonly thought. In all three surveys, the errors exhibit unconditional bias of a sign opposite to estimates of the risk premium from the survey data. The premia are large in absolute value, and are statistically different from zero. We can reject the hypothesis that systematic unconditional mistakes made by the forward rate in predicting the future spot rate are due entirely to a failure of rational expectations. But at the other extreme, the hypothesis that the forward rate prediction errors can be explained by the risk premium alone is rejected.

(2) Expected depreciation is more variable than both the forward discount and the risk premium. The first finding corroborates Fama's (1984) conjecture that expected depreciation and the risk premium are negatively correlated. The second finding rejects the hypothesis that the variance of expected depreciation is less than the variance of the risk premium, let alone the more extreme random-walk hypothesis that the variance of expected depreciation is zero.

(3) Direct tests of perfect substitutability across assets denominated in different currencies produce mixed results. We find evidence against a time-varying risk premium, in the respect that changes in expected depreciation are on average matched, one for one, with changes in the forward discount. In terms of point (2), changes in the forward discount appear to be unrelated to changes in risk. The hypothesis of no risk premium fails in our regressions, however, because the level of expected depreciation is significantly different from the forward discount by a constant term. In short, while the survey data do support the existence of a substantial risk premium, they suggest that the many previous citations of forward discount bias as evidence for the exchange

risk premium may have been misplaced.

(4) While changes in the forward discount reflect changes in expected depreciation, they seem to be, if anything, negatively related to future spot rate changes. Significantly negative coefficients in regression tests of forward discount unbiasedness, a common finding in many previous tests, are also found here. The survey data indicate that this large and significant deviation from unbiasedness is overwhelmingly due to repeated forecasting mistakes made by survey respondents. As in the unconditional case in point (1), we are unable to reject the hypothesis that the conditional deviation from unbiasedness is due entirely to a failure of rational expectations. We are able to reject the competing hypothesis that the deviation from unbiasedness is purely a consequence of the risk premium. The implication is that, when forming their expectations, investors would do better to put more weight on the contemporaneous spot rate, and less weight on all other variables on which they rely. This is the same result that Bilson and many others have found with forward market data; but now it cannot be attributed to a risk premium.

7. APPENDIX

In this appendix we show how the asymptotic efficiency of the method-of-moments estimator is affected by aggregating over forecast horizons. Consider the model:

$$y^k_{t+k} = x^k_t \beta + \varepsilon^k_{t+k} \tag{A1}$$

where $y^k_{t+k} = Y_{t+k} - Y_t$ and the error term is orthogonal to the present and past values of x and y, $E(\varepsilon^k_{t+k} | x^k_t, x^k_{t-1}, \cdots, y^k_t, y^k_{t-1}, \cdots) = 0$. Our example below considers the simple case of a single regressor, x^k_t, but may easily be extended to a vector of righthand-side variables. Define the iid innovations $v_{t+k} = E(y^k_t | x^k_t, x^k_{t-1}, \cdots, y^k_t, y^k_{t-1}, \cdots)$ and $\eta_{t+k} = E(x^k_t | x^k_t, x^k_{t-1}, \cdots, y^k_t, y^k_{t-1}, \cdots)$. If x and y are jointly covariance stationary, then the Wold decomposition implies that:

$$y^k_{t+k} = \sum_{i=0}^{\infty} \delta_i v_{t+k-i} + \sum_{i=0}^{\infty} \gamma_i \eta_{t+k-i} + D^k_y \tag{A2}$$

$$E(y^k_{t+k} | \varphi_t) = \sum_{i=k}^{\infty} \delta_i v_{t+k-i} + \sum_{i=k}^{\infty} \gamma_i \eta_{t+k-i} + D^k_y$$

where D^k_y is the deterministic component of y, and φ_t includes past and present values of x and y. We are primarily concerned with the case in which x^k_t is the best unbiased forecast of y^k_{t+k}. That is, under the null hypothesis of forward discount unbiasedness, fd^k_t is an efficient predictor of the future spot rate change, Δs_{t+k}. Thus we assume that x^k_t already contains all relevant information for forecasting y^k_{t+k}, so that $E(y^k_{t+k} | \varphi_t) = E(y^k_{t+k} | x^k_t)$.

We define analogously the h period change in Y_{t+h} as $y^h_{t+h} = \sum_{j=0}^{n-1} \sum_{i=0}^{h-jk-1} y^k_{t+h-jk-i}$, where $h \equiv nk$. Using equations (A1) and (A2) we then have:

$$y^h_{t+h} = \sum_{j=0}^{n-1}\sum_{i=0}^{\infty}\delta_i v_{t+h-jk-i} + \sum_{j=0}^{n-1}\sum_{i=0}^{\infty}\gamma_i \eta_{t+h-jk-i} + D^h_y \tag{A2'}$$

$$E(y^h_{t+h}\,|\,\varphi_t) = \sum_{j=0}^{n-1}\sum_{i=h-jk}^{\infty}\delta_i v_{t+h-jk-i} + \sum_{j=0}^{n-1}\sum_{i=h-jk}^{\infty}\gamma_i \eta_{t+h-jk-i} + D^h_y \;.$$

These facts imply that the k and h period prediction errors, ε^k_{t+k} and ε^h_{t+h}, respectively, are stationary with finite second moments. If we assume that $q^k_t = \varepsilon^k_{t+k}x^k_t$ and $q^h_t = \varepsilon^h_{t+h}x^h_t$ are stationary with finite variance, then $E(q^k_t q^k_{t+j}) = 0$ for $j \geq k$, and $E(q^h_t q^h_{t+j}) = 0$ for $j \geq h$. Thus q^k_t can be expressed as a $k-1$ order moving average process:

$$q^k_t = \sum_{i=0}^{k-1} a_i \nu_{t+k-i} \tag{A3}$$

Similarly, from equation (A2') we have that q^h_t may be written as a $h-1$ order moving average process:

$$q^h_t = \sum_{j=0}^{n-1}\sum_{i=0}^{h-1} d_i \nu_{t+h-jk-i} \tag{A3'}$$

$$= \sum_{j=0}^{n-1}\sum_{i=0}^{k}(c_{h-jk-i} + a_{k-i})\nu_{t+h-jk-i} \tag{A4}$$

where $c_{h-jk-i} = \sum_{m=j}^{n-2} d_{(n-m)k-i}$. The covariance generating function for q^k_t is denoted by $\lambda^a(z)$, where

$$\lambda^a(z) = \sum_{s=1-k}^{k-1}\lambda^a_s = \sigma^2_\nu \sum_{s=1-k}^{k-1}\sum_{j=0}^{k-1} a_j a_{j+s} \,. \tag{A5}$$

Using equation (A4), the covariance generating function for q^h_t can be written as:

$$\lambda^d(z) = \lambda^c(z) + \frac{n(n+1)}{2}\lambda^a(z) + \frac{n(n-1)}{2}\lambda_0^a + 2\lambda^{ac1}(z) \qquad \text{(A5')}$$

where $\lambda^{ac1}(z)$ is a complicated generating function of the a_i's and c_i's which we need not specify here. Finally, the covariance generating function, $\lambda^{ad}(z) = \sigma_v^2 \sum_{s=1-h}^{h-1} \sum_{j=0}^{h-1} a_j d_{j+s}$ can be rewritten as:

$$\lambda^{ad}(z) = \frac{(n+1)}{2}\lambda^a(z)\frac{(n-1)}{2}\lambda_0^a + \lambda^{ac2}(z) \qquad \text{(A6)}$$

where $\lambda^{ac2}(z)$ is another generating function of the a_i's and c_i's.

Now consider the asymptotic MoM covariance matrix of $\sqrt{T}(\hat{\beta} - \beta)$ from equation (A1):

$$\Theta^1 = (\lambda_0^k)^{-2}\lambda^a(z) \qquad \text{(A7)}$$

where $\lambda_0^k = \lim_{t\to\infty} T^{-1}\sum_{t=1}^{T} x_t^k x_t^k$. If we add in the longer-term forecast data, our model is that of equation (11) above, with asymptotic covariance matrix:

$$\Theta^2 = (\lambda_0^h + \lambda_0^k)^{-2}(\lambda^d(z) + \lambda^a(z) + 2\lambda^{ad}(z)) \qquad \text{(A8)}$$

By substitution, we have that $\Theta^1 > \Theta^2$ if and only if:

$$\frac{\lambda_0^h}{\lambda_0^k}\left[1 + \frac{\lambda_0^h}{\lambda_0^k}\right] \qquad \text{(A9)}$$

$$> n^2\, ½\left[1 + \frac{\lambda_0^a}{\lambda^a(z)}\right] + n\, ½\left[3 + \frac{\lambda_0^a}{\lambda^a(z)}\right] + \frac{\lambda^a(z) + \lambda^c(z) + 2(\lambda^{ac1}(z) + \lambda^{ac2}(z)) - \lambda_0^a}{\lambda^a(z)}$$

Equation (A9) says that the variance of the longer-term data, λ_0^h, must increase at a rate the same as or greater than the relative forecasting interval, n, if we are to gain by adding longer-term forecasts to data sets of only shorter-term forecasts. Thus as the forecasting interval increases, we require correspondingly greater variability of the regressors in order to compensate for the greater variability of the forecast errors.

One might think that the result in equation (A9) is a consequence of weighting the more imprecise longer-term predictions equally with the predictions of shorter-term. Perhaps if we downweighted the longer-term data, we would always gain in efficiency. It turns out that this is not the case. In the remaining space, we construct a consistent, optimally weighted estimator and show that the efficiency of this estimator may still worsen asymptotically by adding in the longer-term forecasts.

In most circumstances, GLS represents the optimal weighting strategy when the data have different levels of precision. GLS is, however, inconsistent when used on a model with overlapping observations. Thus we consider instead a weighted least squares estimator which is optimal within a class of consistent estimators. Consider a transformation of the model in equation (11), which stacks the shorter- and longer-term data:

$$W\mathbf{y}_t = W\mathbf{x}_t\beta + W\nu_t \tag{A10}$$

where W is a diagonal matrix. The MoM estimate of β in equation (A10), $\hat{\beta}_W$, will be consistent for any arbitrary diagonal matrix W. To see this, note that the MoM estimate of equation (A10), $\hat{\beta}_W$, may be written as:

$$\sqrt{T}(\hat{\beta}_W - \beta) = \left[\frac{\mathbf{x}_{2NT}'W^2\mathbf{x}_{2NT}}{T}\right]^{-1} \frac{\mathbf{x}_{2NT}'W^2\nu}{\sqrt{T}} \tag{A11}$$

$$= \left[\frac{1}{T}\sum_{i=1}^{2T} x_i^2 w_{ii}^2\right]^{-1} \frac{1}{\sqrt{T}}\sum_{i=1}^{2T} x_i\nu_i w_{ii}^2$$

The final term in equation (A11) converges in probability to zero, provided that the error term in equation (A10) is conditionally independent of the contemporaneous value of the regressor, $E(\nu_t | \mathbf{x}_t) = 0$ (this is just the Gauss-Markov assumption required for the consistency of OLS in estimating equation (A10)). Suppose now that we choose W optimally in order to maximize the gain in efficiency from adding longer-term forecasts to our shorter-term data. That is:

$$\max_{W} \; \Theta^1 - \Theta^3 . \tag{A12}$$

where Θ^3 is the MoM asymptotic covariance matrix of $\hat{\beta}_W$:

$$\Theta^3 = (\mathbf{x}_{2NT}' W^2 \mathbf{x}_{2NT})^{-1} \mathbf{x}_{2NT}' W^2 \Omega W^2 \mathbf{x}_{2NT} (\mathbf{x}_{2NT}' W^2 \mathbf{x}_{2NT})^{-1} \tag{A13}$$

By normalizing the weight on every shorter-term data point to one, it is straightforward to show that the optimal weight placed on each longer-term observation is:

$$w_h^* = \left[\frac{\lambda_0^h \lambda^a(z) - \lambda_0^k \lambda^{ad}(z)}{\lambda_0^k \lambda^d(z) - \lambda_0^h \lambda^{ad}(z)} \right]^{1/2} . \tag{A14}$$

Note that w_h^* will always be positive if the data sets are uncorrelated, i.e. if $\lambda^{ad}(z) = 0$. In other words, appropriately weighted independent information can always improve efficiency, no matter how imprecise the new information may be. But, the nature of the correlation between contemporaneous longer-term and shorter-term predictions implies that the optimal weight given to longer-term data may be zero. In particular, w_h^* will be zero if the numerator in equation (A14) becomes negative. This occurs if n is too large in comparison with the relative variance of the longer-term forecasts. Using equations (A5'), (A6) and (A14), it can be shown that a sufficient condition for w_h^* to be zero is:

$$\frac{(n+1)}{2} > \frac{\lambda_0^h}{\lambda_0^k} . \tag{A15}$$

Thus, while the standard errors reported in the text indicate that for small values of n one may obtain improvements in efficiency, this result is not likely to apply MoM estimation of data with considerably longer forecast horizons, even when the data are downweighted to account for the greater variance of the longer-term forecast errors. It is worth stressing in closing that this potential loss in efficiency is a direct consequence of our limited information MoM estimation strategy. Full information techniques, such as maximum likelihood estimation, will consistently achieve nonzero gains in asymptotic efficiency with the addition of longer-term data.

Table 1
SPOT AND FORWARD MARKET SUMMARY STATISTICS
(% percent per annum)

				(2) FORWARD DISCOUNT f(t)-s(t)	(1) ACTUAL CHANGE s(t+1)-s(t)	(1)-(2) FORWARD DISCOUNT PREDICTION ERROR f(t)-s(t+1)	
FORECAST HORIZON	SURVEY SOURCE	DATES	N	Mean	Mean	Mean	t stat
1 WEEK							
TOTAL	MMS	10/84-2/86	247		20.20		
UK			62		14.96		
WG			62	NA	21.36		
SW			61		20.10		
JA			62		24.39		
2 WEEKS							
TOTAL	MMS	1/83-10/84	187		-12.35		
UK			47		-16.15		
WG			47	NA	-15.19		
SW			46		-13.86		
JA			47		-4.23		
1 MONTH							
TOTAL	MMS	10/84-2/86	176	1.23	20.82	-19.59	
UK			44	-3.85	10.13	-13.98	-1.27
WG			44	3.23	23.82	-20.59	-1.87 *
SW			44	3.74	21.76	-18.02	-1.64
JA			44	1.68	27.55	-25.88	-2.35 **
3 MONTHS							
TOTAL	MMS	1/83-10/84	187	3.75	-10.77	14.51	6.30 ***
UK			47	0.37	-13.92	14.29	3.00 ***
WG			47	4.68	-13.68	18.36	3.85 ***
SW			46	6.13	-12.61	18.74	3.93 ***
JA			47	3.85	-2.90	6.75	1.42
TOTAL	ECONOMIST	6/81-12/85	190	2.20	-0.84	3.04	0.81
UK			38	-0.06	-6.43	6.37	1.14
FR			38	-3.94	-4.43	0.49	0.09
WG			38	4.36	0.81	3.55	0.63
SW			38	5.99	1.47	4.52	0.81
JA			38	4.67	4.37	0.30	0.05
6 MONTHS							
TOTAL	ECONOMIST	6/81-12/85	180	2.30	-2.18	4.48	1.06
UK			36	0.31	-6.79	7.10	1.12
FR			36	-4.14	-6.29	2.15	0.34
WG			36	4.40	-0.96	5.36	0.85
SW			36	6.01	-0.36	6.37	1.01
JA			36	4.93	3.52	1.41	0.22
TOTAL	AMEX	1/76-8/85	51	2.07	5.98	-3.92	-1.50
Early Period		1/76-12/79	26	1.06	8.98	-7.93	-2.83 ***
Later Period		6/81-8/85	25	3.12	2.86	0.26	0.06
12 MONTHS							
TOTAL	ECONOMIST	6/81-12/85	195	2.58	-6.42	9.00	3.85 ***
UK			31	0.92	-9.47	10.39	3.22 ***
FR			31	-4.00	-11.20	7.20	2.23 **
WG			31	4.42	-5.60	10.02	3.10 ***
SW			31	6.38	-5.75	12.13	3.75 ***
JA			31	5.17	-0.08	5.25	1.63
TOTAL	AMEX	1/76-8/85	46	2.06	2.02	0.04	0.02
Early Period		1/76-12/79	26	0.93	8.85	-7.92	-2.36 **
Later Period		6/81-8/85	20	3.52	-6.86	10.39	9.42 ***

Notes: Standard errors of means are computed using method of moments. Amex standard errors, however, are calculated using the number of nonoverlapping observations and are thus upper bounds. Multi-country test statistics are F-tests of the hypothesis that all means are zero. *, **, ***, represent significance at the 10, 5, and 1 percent levels, respectively.

Table 2
SURVEY DATA SUMMARY STATISTICS
(% percent per annum)

FORECAST HORIZON	SURVEY SOURCE	DATES	N	(1) RISK PREMIUM f(t)-E[s(t+1)] Mean	(1) RISK PREMIUM f(t)-E[s(t+1)] t stat	(2) SURVEY PREDICTION ERROR E[s(t+1)]-s(t+1) Mean	(2) SURVEY PREDICTION ERROR E[s(t+1)]-s(t+1) t stat	(1)+(2) FORWARD DISCOUNT PREDICTION ERROR f(t)-s(t+1) Mean
1 WEEK								
TOTAL	MMS	10/84-2/86	247			-19.17	1.01	
UK			62			-27.79	-1.69	
WG			62		NA	-18.52	-1.13	NA
SW			61			-11.27	-0.69	
JA			62			-18.99	-1.16	
2 WEEKS								
TOTAL	MMS	1/83-10/84	187			16.57	2.79 **	
UK			47			13.49	2.00 *	
WG			47		NA	20.29	3.00 ***	NA
SW			46			19.95	2.95 ***	
JA			47			12.63	1.87 *	
1 MONTH								
TOTAL	MMS	10/84-2/86	176	3.86	3.05 ***	-23.44	1.47	-19.59
UK			44	8.06	2.58 ***	-22.04	-1.94 *	-13.98
WG			44	5.49	2.25 **	-26.08	-2.30 **	-20.59
SW			44	3.07	1.24	-21.09	-1.86 *	-18.02
JA			44	-1.31	-0.68	-24.57	-2.16 **	-25.88
3 MONTHS								
TOTAL	MMS	1/83-10/84	187	-4.01	-10.98 ***	18.53	7.72 ***	14.51
UK			47	-4.08	-7.62 ***	18.38	3.95 ***	14.29
WG			47	-3.65	-5.39 ***	22.01	4.73 ***	18.36
SW			46	-3.49	-3.51 ***	22.23	4.78 ***	18.74
JA			47	-4.82	-7.57 ***	11.58	2.49 **	6.75
TOTAL	ECONOMIST	6/81-12/85	190	-6.92	-13.69 ***	9.97	0.73	3.04
UK			38	-3.72	-3.04 ***	10.09	1.61	6.37
FR			38	-9.11	-9.36 ***	9.61	1.54	0.49
WG			38	-7.48	-6.90 ***	11.02	1.76 *	3.55
SW			38	-6.31	-6.70 ***	10.83	1.73 *	4.52
JA			38	-7.99	-6.37 ***	8.29	1.33	0.30
6 MONTHS								
TOTAL	ECONOMIST	6/81-12/85	180	-7.22	-25.94 ***	11.70	0.95	4.48
UK			36	-4.21	-6.36 ***	11.32	1.65	7.10
FR			36	-8.94	-14.18 ***	11.08	1.62	2.15
WG			36	-8.20	-13.04 ***	13.56	1.98 *	5.36
SW			36	-6.40	-9.98 ***	12.77	1.86 *	6.37
JA			36	-8.34	-15.40 ***	9.76	1.42	1.41
TOTAL	AMEX	1/76-8/85	51	-1.81	-3.19 ***	-2.11	-0.75	-3.92
Early Period		1/76-12/78	26	-0.14	-0.17	-7.78	-2.65 **	-7.93
Later Period		6/81-8/85	25	-3.54	-5.79 ***	3.79	0.83	0.26
12 MONTHS								
TOTAL	ECONOMIST	6/81-12/85	195	-5.83	-28.13 ***	14.83	7.46 ***	9.00
UK			31	-3.34	-5.43 ***	13.73	4.39 ***	10.39
FR			31	-7.90	-17.86 ***	15.10	4.83 ***	7.20
WG			31	-7.00	-18.48 ***	17.02	5.45 ***	10.02
SW			31	-4.60	-10.69 ***	16.73	5.35 ***	12.13
JA			31	-6.33	-15.25 ***	11.59	3.71 ***	5.25
TOTAL	AMEX	1/76-8/85	46	-0.67	-1.29	0.71	0.28	0.04
Early Period		1/76-12/78	26	1.13	1.71 *	-9.05	-2.83 ***	-7.92
Later Period		6/81-8/85	20	-3.02	-6.12 ***	13.40	12.52 ***	10.33

Notes: Standard errors for the survey prediction errors are computed using method of moments. Amex standard errors, however, are calculated using the number of nonoverlapping observations and are thus upper bounds. Multi-country test statistics are F-tests of the hypothesis that all means are zero. *, **, ***, represent significance at the 10, 5, and 1 percent levels, respectively.

CHART 1

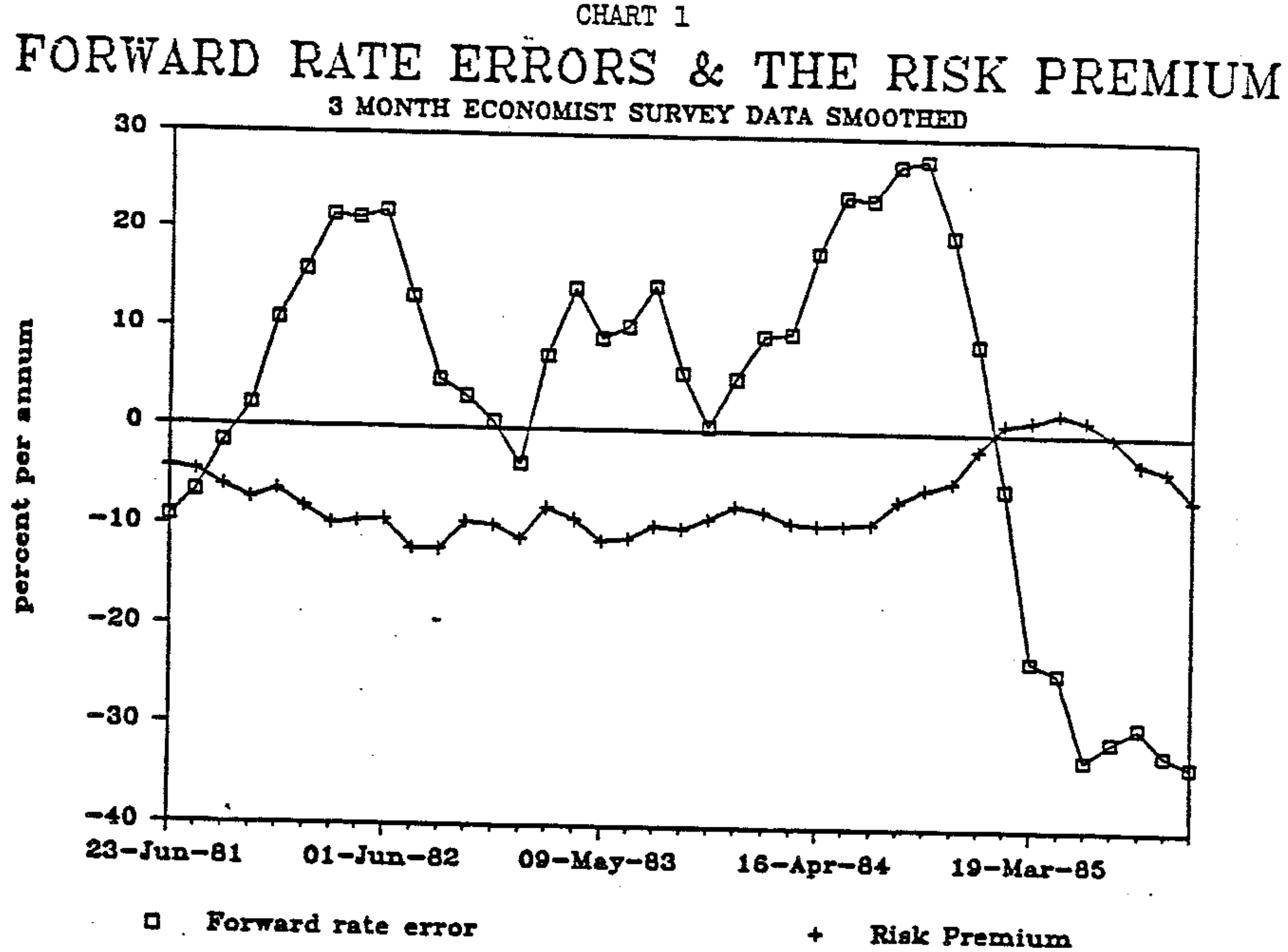

CHART 3

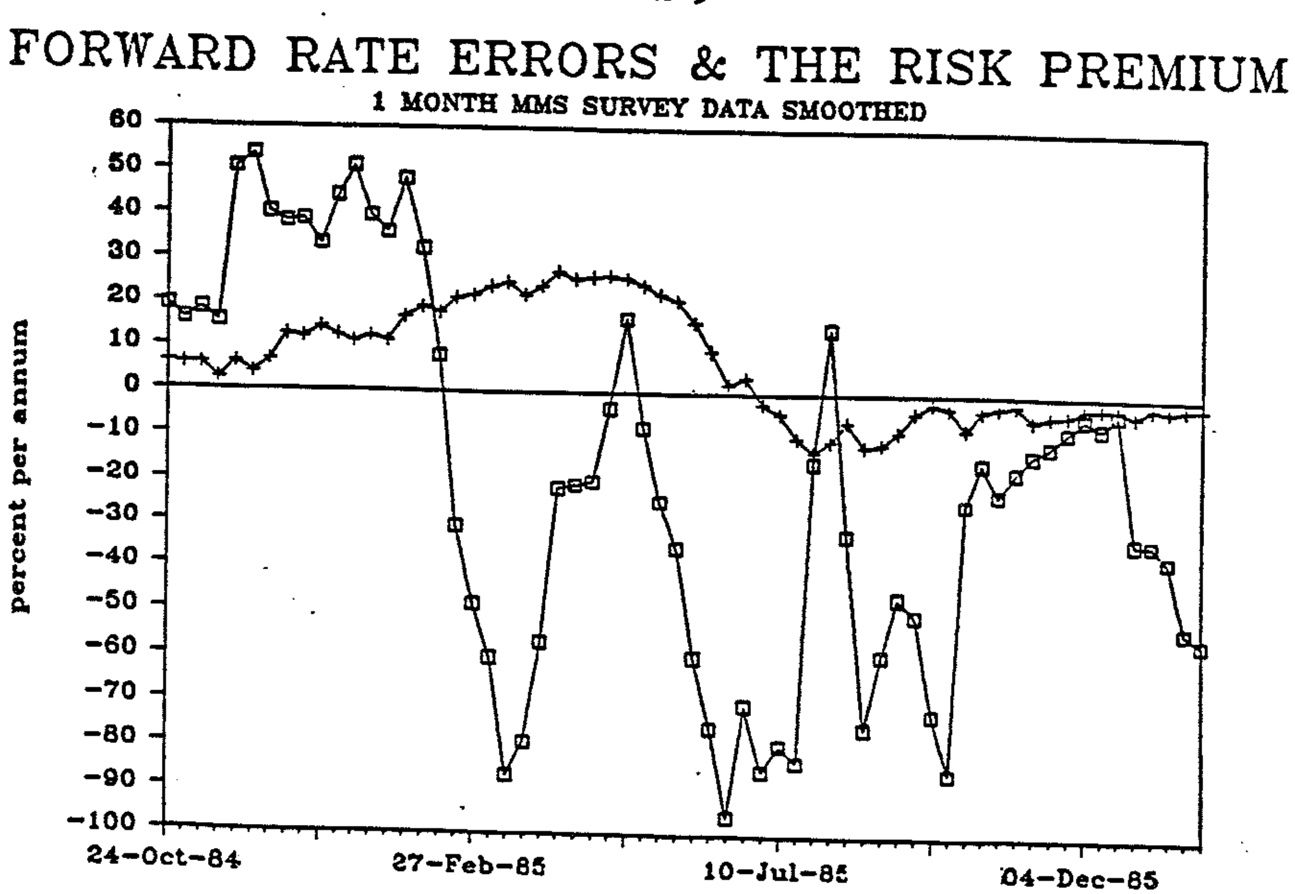

CHART 2

FORWARD RATE ERRORS & THE RISK PREMIUM

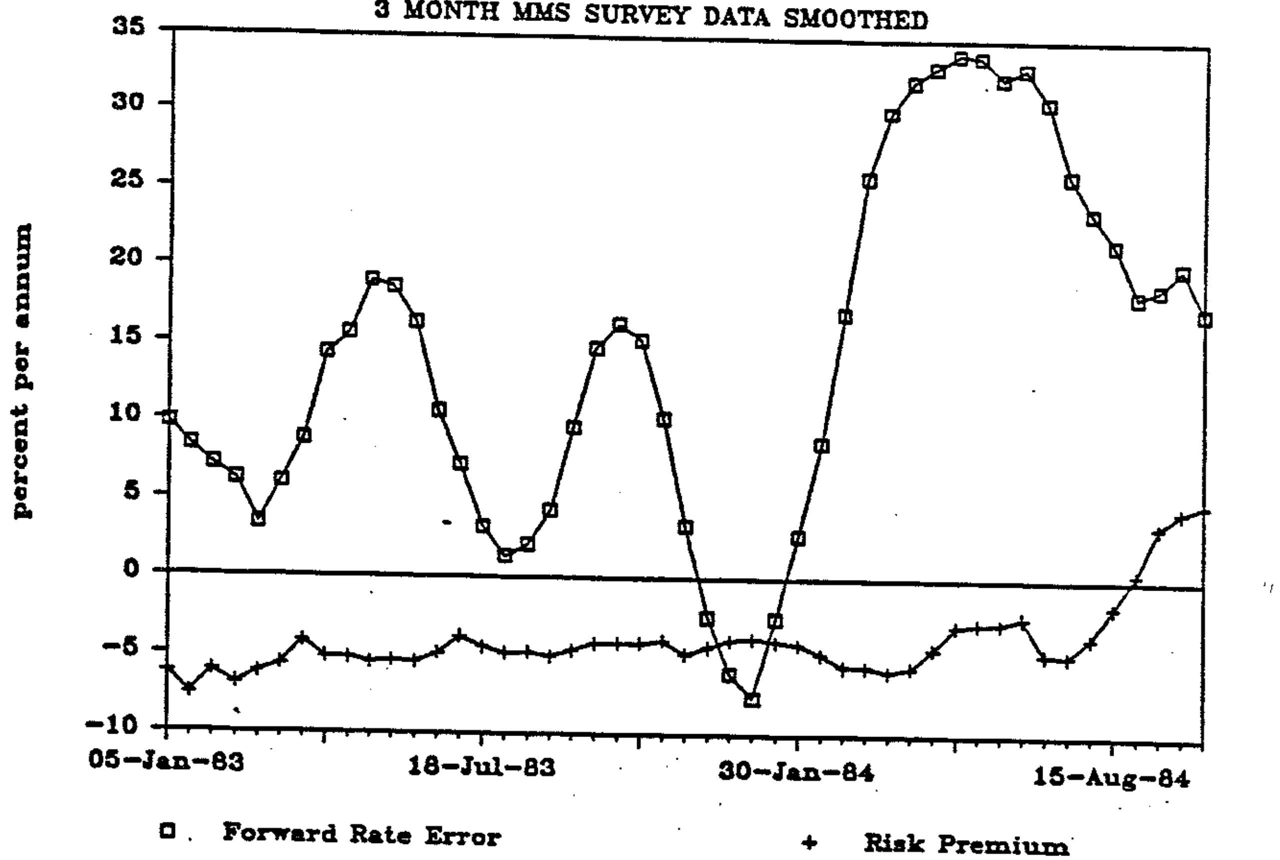

CHART 4

FORWARD RATE ERRORS & THE RISK PREMIUM

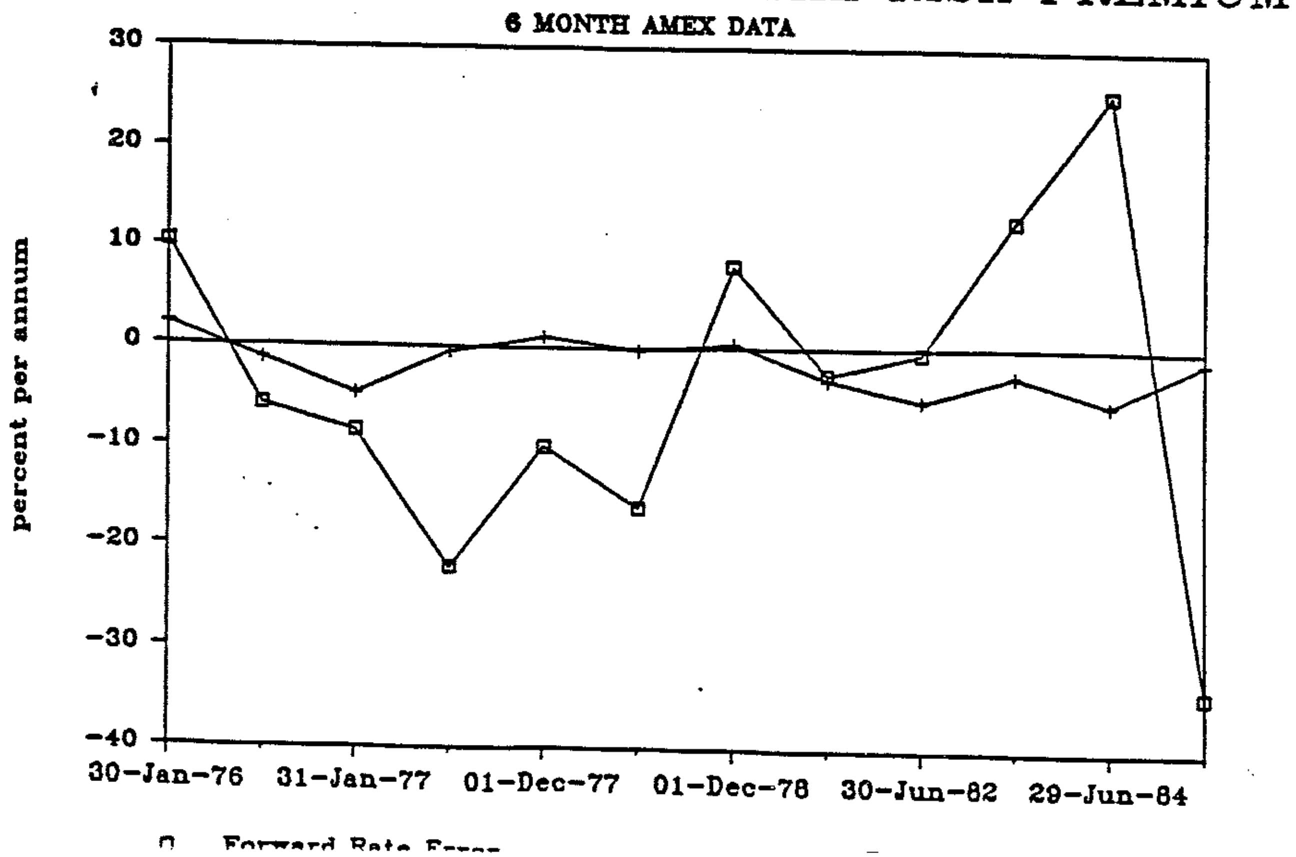

Table 3
COMPARISON OF VARIANCES OF EXPECTED DEPRECIATION
AND THE RISK PREMIUM
(% percent per annum)

FORECAST HORIZON	SURVEY SOURCE	DATES	N	(1) p(rp,fer) [a]	(2) Var(ds)	(3) Var(fd)	(4) Variance of E[ds(t+1)]	(5) Variance of rp(t)	(6) (4)-(5)
1 WEEK									
TOTAL	MMS	10/84-2/86	247		2.756		0.346		
UK			62		3.809		0.429		
WG			62	NA	2.506	NA	0.251	NA	NA
SW			61		3.271		0.404		
JA			62		1.564		0.264		
2 WEEKS									
TOTAL	MMS	1/83-10/84	187		0.703		0.113		
UK			47		0.765		0.111		
WG			47	NA	0.886	NA	0.122	NA	NA
SW			46		0.640		0.114		
JA			47		0.533		0.084		
1 MONTH									
TOTAL	MMS	10/84-2/86	176	-	2.295	0.008	0.258	0.240	0.018
UK			44	-0.226	2.839	0.002	0.359	0.358	0.001
WG			44	-0.047	2.091	0.000	0.224	0.219	0.005
SW			44	-0.060	2.595	0.001	0.228	0.224	0.004
JA			44	0.076	1.696	0.001	0.129	0.137	-0.008
3 MONTHS									
TOTAL	MMS	1/83-10/84	187		0.610	0.014	0.067	0.062	0.005
UK			47	0.100	0.647	0.004	0.036	0.034	0.002
WG			47	0.192	0.702	0.002	0.045	0.054	-0.009
SW			47	0.095	0.447	0.002	0.118	0.116	0.002
JA			47	0.028	0.470	0.004	0.036	0.048	-0.012
TOTAL	ECONOMIST	6/81-12/85	190		1.651	0.051	0.178	0.121	0.056
UK			38	-0.327	1.433	0.014	0.188	0.142	0.046
FR			38	-0.255	1.783	0.037	0.092	0.090	0.002
WG			38	-0.234	1.567	0.004	0.129	0.111	0.017
SW			38	-0.128	2.006	0.011	0.109	0.084	0.025
JA			38	0.093	1.440	0.020	0.198	0.149	0.049
6 MONTHS									
TOTAL	ECONOMIST	6/81-12/85	190		2.004	0.093	0.173	0.082	0.091
UK			38	-0.271	1.554	0.021	0.110	0.077	0.033
FR			38	-0.255	2.251	0.050	0.097	0.072	0.025
WG			38	-0.352	1.913	0.006	0.082	0.070	0.013
SW			38	-0.265	2.345	0.016	0.087	0.070	0.017
JA			38	-0.096	1.798	0.033	0.101	0.053	0.048
TOTAL	AMEX	1/76-8/85	51		1.659	0.111	0.134	0.084	0.051
UK			12	-0.065	1.395	0.074	0.131	0.035	0.096
FR			9	-0.179	1.583	0.033	0.074	0.039	0.035
WG			12	-0.265	1.347	0.025	0.150	0.094	0.056
SW			9	-0.424	2.213	0.043	0.183	0.110	0.072
JA			9	-0.223	1.679	0.056	0.095	0.028	0.067
12 MONTHS									
TOTAL	ECONOMIST	6/81-12/85	195		1.368	0.155	0.215	0.092	0.123
UK			38	0.444	1.319	0.027	0.132	0.113	0.019
FR			38	0.404	1.432	0.058	0.092	0.069	0.023
WG			38	0.198	1.088	0.008	0.071	0.057	0.014
SW			38	0.409	1.340	0.023	0.078	0.058	0.020
JA			38	0.326	1.086	0.046	0.115	0.052	0.063
TOTAL	AMEX	1/76-8/85	51		1.446	0.192	0.195	0.129	0.066
UK			12	-0.293	1.315	0.111	0.198	0.071	0.127
FR			9	-0.251	1.180	0.055	0.040	0.020	0.020
WG			12	-0.781	0.768	0.039	0.223	0.164	0.064
SW			9	-0.415	1.949	0.064	0.178	0.195	-0.018
JA			9	0.195	2.564	0.085	0.109	0.065	0.044

Notes: a p is the correlation coeficient and fer represents the forward rate prediction error. For the six-month and twelve-month Economist and twelve-month Amex data sets, columns (1) and (2) contain 2, 7 and 1 fewer [illegible]

TABLE 4
TESTS OF FORWARD DISCOUNT UNBIASEDNESS

OLS Regressions of ds(t+1) on fd(t)

Data Set	Dates	$\hat{B}$	t: $\hat{B}=0$	t: $\hat{B}=1$	R^2	DF	F test $\hat{a}=0$, $\hat{B}=1$	Prob > F
Economist Data	6/81-12/85	-0.5684 (1.0171)	-0.56	-1.54	0.16	509	2.12	0.007
Econ 3 Month	6/81-12/85	-1.2090 (1.1596)	-1.04	-1.91 *	0.01	184	1.29	0.262
Econ 6 Month	6/81-12/85	-1.9819 (1.4445)	-1.37	-2.06 **	0.07	174	1.47	0.191
Econ 12 Month	6/81-12/85	0.2892 (1.2733)	0.23	-0.56	0.29	149	3.23	0.005
MMS 1 Month	10/84-2/86	-14.5529 (6.0000)	-2.43 **	-2.59 **	0.21	171	2.67	0.024
MMS 3 Month	1/83-10/84	-6.2540 (2.1508)	-2.91 ***	-3.37 ***	0.50	183	12.01	0.000
AMEX Data	1/76-7/85	-2.2107 (0.9623)	-2.30 **	-3.34 ***	0.23	86	2.60	0.007
AMEX 6 Month	1/76-7/85	-2.4181 (1.2608)	-1.92 *	-2.71 ***	0.26	45	2.42	0.041
AMEX 12 Month	1/76-7/85	-2.1377 (1.0549)	-2.03 **	-2.97 ***	0.21	40	1.66	0.157

Notes: Method of Moments standard errors are in parentheses. * Represents significance at the 10% level, ** and *** represent significance at the 5% and 1% levels, respectively.

TABLE 5a
COMPONENTS OF THE FAILURE OF THE UNBIASEDNESS HYPOTHESIS
IN REGRESSIONS OF dS(t+1) ON FD(t)

Data Set	Approximate Dates	N	Failure of Rational Expectations (1) $\hat{B}_{re}$	Existence of Risk Premium (2) $\hat{B}_{rp}$	Implied Regression Coefficient 1-(1)-(2) $\hat{B}$
Economist Data	6/81-12/85	525	1.49	0.08	-0.57
Econ 3 Month	6/81-12/85	190	2.51	-0.30	-1.21
Econ 6 Month	6/81-12/85	180	2.99	0.00	-1.98
Econ 12 Month	6/81-12/85	155	0.52	0.19	0.29
MMS 1 Month	10/84-2/86	176	15.39	0.16	-14.55
MMS 3 Month	1/83-10/84	188	6.07	1.18	-6.25
AMEX Data	1/76-7/85	97	3.25	-0.03	-2.21
AMEX 6 Month	1/76-7/85	51	3.63	-0.22	-2.42
AMEX 12 Month	1/76-7/84	46	3.11	0.03	-2.14

TABLE 5b
COMPONENTS OF THE FAILURE OF THE UNBIASEDNESS HYPOTHESIS
IN REGRESSIONS OF dS(t+1) ON FD(t)

Data Set	Approximate Dates	N	Failure of Rational Expectations (1) $\hat{B}_{re}$	Existence of Risk Premium (2) $\hat{B}_{rp}$	Implied Regression Coefficient 1-(1)-(2) $\hat{B}$
ECON 3 MONTH	6/81-12/85	190	2.51	-0.30	-1.21
UK		38	7.31	-1.11	-5.20
FR		38	-1.75	0.47	2.28
WG		38	7.69	-1.64	-5.05
SW		38	5.03	-0.63	-3.40
JA		38	4.66	-0.73	-2.93
ECON 6 MONTH	6/81-12/85	180	2.99	0.00	-1.98
UK		36	7.04	-0.17	-5.87
FR		36	-1.31	0.21	2.10
WG		36	10.16	-0.38	-8.77
SW		36	5.75	-0.01	-4.74
JA		36	4.69	-0.18	-3.51
ECON 12 MONTH	6/81-12/85	155	0.52	0.19	0.29
UK		31	1.87	0.93	-1.79
FR		31	-1.45	0.16	2.29
WG		31	-0.13	0.16	0.96
SW		31	0.96	0.25	-0.21
JA		31	3.09	-0.04	-2.05
MMS 1 MONTH	10/84-2/86	176	15.39	0.16	-14.55
UK		44	21.23	0.06	-20.28
WG		44	10.34	-8.95	-0.39
SW		44	13.15	-2.89	-9.26
JA		44	4.58	7.10	-10.68
MMS 3 MONTH	1/83-10/84	188	6.07	1.18	6.25
UK		47	7.90	0.27	-7.16
WG		47	4.96	2.52	-6.48
SW		47	7.90	0.09	-6.98
JA		47	3.43	2.14	-4.57
AMEX 6 MONTH	1/76-7/85	51	3.63	-0.22	-2.42
UK		12	2.76	-0.15	-1.60
FR		9	1.09	-0.03	-0.06
WG		12	4.78	-0.63	-3.15
SW		9	5.53	-0.33	-4.20
JA		9	4.58	-0.10	-3.48
AMEX 12 MONTH	1/76-7/84	46	3.11	0.03	2.14
UK		11	2.53	-0.09	-1.45
FR		8	0.48	0.32	0.20
WG		11	3.53	-0.40	-2.13
SW		8	3.99	0.38	-3.37
JA		8	5.36	0.12	-4.49

TABLE 6
TESTS OF PERFECT SUBSTITUTABILITY

OLS Regressions of E[ds(t+1)] on fd(t)

Data Set	Dates	B	t: B=.5	t: B=1	R	DF	DW	F test a=0, B=1	Prob > F
Economist Data	6/81-12/85	0.9880 (0.1465)	3.33 ***	-0.08	0.89	554	1.44	28.61	0.000
Econ 3 Month	6/81-12/85	1.3037 (0.2557)	3.14 ***	1.19	0.70	184	1.56	16.55	0.000
Econ 6 Month	6/81-12/85	1.0326 (0.1694)	3.14 ***	0.19	0.89	184	1.37	52.06	0.000
Econ 12 Month	6/81-12/85	0.9286 (0.1499)	2.86 ***	-0.48	0.91	184	1.44	65.82	0.000
MMS 1 Month	10/84-2/86	0.8416 (1.7275)	0.20	-0.09	0.21	171	1.02	6.79	0.000
MMS 3 Month	1/83-10/84	-0.1816 (0.4293)	-1.59	-2.75 ***	0.73	182	1.50	14.60	0.000
AMEX Data	1/76-7/85	0.9605 (0.2495)	1.85 *	-0.16	0.64	91	0.74	5.38	0.000
AMEX 6 Month	1/76-7/85	1.2165 (0.2085)	3.44 ***	1.04	0.71	45	1.45	6.32	0.000
AMEX 12 Month	1/76-7/85	0.8770 (0.2755)	1.37	-0.45	0.61	45	0.51	8.10	0.000

Notes: Method of Moments standard errors are in parentheses. * Represents significance at the 10% level, ** and *** represent significance at the 5% and 1% levels, respectively.

TABLE 7
TESTS OF PERFECT SUBSTITUTABILITY

3SLS Regressions of E[ds(t+1)] on fd(t)

Data Set	Dates	B	t: B=.5	t: B=1	average p(1)	DF	Prob > F a=0, B=1
Economist 3 Month	6/81-12/85	0.8723 (0.1327)	2.81 ***	-0.96	0.13	184	0.000
Economist 6 Month	6/81-12/85	0.8768 (0.0780)	4.83 ***	-1.58	0.32	184	0.000
Economist 12 Month	6/81-12/85	0.8378 (0.0793)	4.26 ***	-2.04 **	0.27	184	0.000
MMS 1 Month	10/84-2/86	-1.1535 (1.0445)	-1.58	-2.06 **	0.21	171	NA
MMS 3 Month	1/83-10/84	0.4672 (0.3354)	-0.10	-1.59	0.33	179	0.000

(1) Average p is the mean across countries of the first order auto-regressive coefficients.
Notes: Asymptotic standard errors are in parentheses. * Represents significance at the 10% level, ** and *** represent significance at the 5% and 1% levels, respectively.

TABLE 8
TESTS OF EXCESSIVE SPECULATION

Regressions of E[s(t+1)]-s(t+1) on E[ds(t+1)]

Data Set	Dates	B	t: B=0	t: B=1	R	DF	DW	F test a=0, B=0	Prob > F
Economist Data	6/81-12/85	1.0162 (0.4104)	2.48 **	0.04	0.49	509		4.79	0.000
Econ 3 Month	6/81-12/85	1.6141 (0.4664)	3.46 ***	1.32	0.26	184		2.91	0.010
Econ 6 Month	6/81-12/85	2.5325 (0.6746)	3.75 ***	2.27 **	0.41	174		3.54	0.002
Econ 12 Month	6/81-12/85	-0.3005 (0.5241)	-0.57	-2.48 **	0.67	149		6.32	0.000
MMS 1 Week, 1 Month	10/84-2/86	1.2561 (0.3544)	3.54 ***	0.72	0.24	414		6.07	0.000
MMS 1 Week	10/84-2/86	1.1476 (0.2939)	3.90 ***	0.50	0.14	242	1.84	3.97	0.002
MMS 1 Week, SUR	10/84-2/86	0.7858 (0.1109)	7.09 ***	-1.93 *	0.18	239		12.42	0.000
MMS 1 Month	10/84-2/86	1.3068 (0.4741)	2.76 ***	0.65	0.28	171		3.11	0.010
MMS 2 Week, 3 Month	1/83-10/84	1.0494 (0.3159)	3.32 ***	0.16	0.59	365		7.87	0.000
MMS 2 Week	1/83-10/84	1.0594 (0.2870)	3.69 ***	0.21	0.23	182	1.74	5.40	0.000
MMS 2 Week, SUR	1/83-10/84	1.0469 (0.1813)	5.77 ***	0.26	0.16	179		9.42	0.000
MMS 3 Month	1/83-10/84	1.0465 (0.3895)	2.69 ***	0.12	0.63	182		7.59	0.000
AMEX Data	1/76-7/85	2.6082 (0.5123)	5.09 ***	3.14 ***	0.23	86		4.71	0.000
AMEX 6 Month	1/76-7/85	2.5693 (0.7358)	3.49 ***	2.13 **	0.37	45		4.22	0.002
AMEX 12 Month	1/76-7/85	2.6382 (0.5812)	4.54 ***	2.82 ***	0.50	40		4.24	0.002

Notes: All regressions except those marked SUR are estimated using OLS, with Method of Moments standard errors (in parentheses). SUR regressions report asymptotic standard errors. Durbin-Watson statistics are reported for data sets in which the forecast horizon is equal to the sampling interval. * Represents significance at the 10% level, ** and *** represent significance at the 5% and 1% levels, respectively.

TABLE 9
TESTS OF RATIONAL EXPECTATIONS

OLS Regressions of E[s(t+1)]-s(t+1) on fd(t)

Data Set	Dates	B	t: B=0	R	DF	F test a=0, B=0	Prob > F
Economist Data	6/81-12/85	1.4903 (1.0580)	1.41	0.48	509	4.75	0.000
Econ 3 Month	6/81-12/85	2.5127 (1.2918)	1.95 *	0.14	184	1.31	0.256
Econ 6 Month	6/81-12/85	2.9866 (1.5974)	1.87 *	0.28	174	1.46	0.194
Econ 12 Month	6/81-12/85	0.5174 (1.2290)	0.42	0.67	149	6.01	0.000
MMS 1 Month	10/84-2/86	15.3945 (6.3520)	2.42 **	0.20	171	2.54	0.030
MMS 3 Month	1/83-10/84	6.0725 (2.3392)	2.60 **	0.66	182	11.93	0.000
AMEX Data	1/76-7/85	3.2452 (1.1675)	2.78 ***	0.33	86	2.69	0.005
AMEX 6 Month	1/76-7/85	3.6346 (1.3437)	2.70 ***	0.26	45	3.30	0.009
AMEX 12 Month	1/76-7/85	3.1081 (1.2954)	2.40 **	0.25	40	1.48	0.210

Notes: Method of Moments standard errors are in parentheses. * Represents significance at the 10% level, ** and *** represent significance at the 5% and 1% levels, respectively.

Short-term and Long-term Expectations of the Yen/Dollar Exchange Rate: Evidence from Survey Data

Jeffrey A. Frankel
Department of Economics
University of California
Berkeley, CA. 94720

Kenneth A. Froot
Sloan School of Management
Massachusetts Institute of Technology
Cambridge, MA 02139

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Abstract

Three surveys of exchange rate expectations allow us to measure directly the expected rates of return on yen versus dollars. Expectations of yen appreciation against the dollar have been (1) consistently large, (2) variable, and (3) greater than the forward premium, implying that investors were willing to accept a lower expected return on dollar assets. At short-term horizons expectations exhibit bandwagon effects, while at longer-term horizons they show the reverse. A 10 percent yen appreciation generates the expectation of a further appreciation of 2.4 percent over the following week, for example, but a <u>depreciation</u> of 3.4 percent over the following year. At any horizon, investors would do better to reduce the absolute magnitude of expected depreciation. The true spot rate process behaves more like a random walk.

I Introduction

With most of Japan's restrictions on international capital flows recently removed, the yen is now properly thought of as subject to the asset-market model of exchange rates; the demand for yen versus dollars responds instantaneously to the expected rates of return on the two assets. The most evident component of variation in recent years has been interest rates. The differential between U.S. and Japanese interest rates can be used to explain the increased demand for dollars and the sharp appreciation of the dollar against the yen from 1979 to 1984, and the subsequent reversal in 1985-86.[1] But the other major determinant of the expected return differential, the expected rate of future appreciation of the yen, is much less easily observed than interest rates.

One view is that the expected rate of depreciation can be measured by the discount in the forward market. According to this view, the 3 per cent yen-dollar forward discount that prevailed in the early 1980's represented investors' expectations that the dollar would in the future depreciate, presumably back toward some equilibrium level. One implication is that investors acting on this expectation -- "speculators" -- had a lower demand for dollars during the strong-dollar period than they would have had acting solely on the basis of the interest differential or other factors; in other words, speculation was stabilizing.

An alternative view is that the expected rate of depreciation is much closer to zero than to the forward discount. Many empirical studies

[1]Many papers discuss the role of the interest rate in determining the yen/dollar exchange rate, especially since the 1979-80 liberalization. Four examples are Amano (1986), Ishiyama (1985), Ito (1986) and Johnson and Loopesko (1986).

have found that the rationally, or mathematically, expected rate of depreciation is close to zero, i.e., that the exchange rate follows a random walk; so there is a prima facie case that the same is true of investor expectations. If expected depreciation is zero ("static expectations"), then there is no stabilizing effect in the form of speculators selling a currency when it is strong. A more extreme view is that there is a bandwagon effect: at each point during the 1980-84 period, the appreciation of the dollar against the yen generated expectations of further future appreciation, notwithstanding the fact that the dollar was selling at a forward discount against the yen. It would follow from this view that speculators --again, defined as investors acting on the basis of expectations of exchange rate changes-- drove the yen/dollar rate to a higher level than would have otherwise prevailed. It would follow that speculators have exaggerated the reverse swing in 1985-86 as well. Whether expectations are stabilizing or destabilizing in this sense is one of the questions examined in this paper.

Another question, which would be of particular interest to policy-makers if one were to conclude that exchange rates have been undesirably unstable, is whether government intervention in the foreign exchange market offers a way of affecting the exchange rate even in the absence of a change in macroeconomic policy. The question of whether intervention can have an effect, even if sterilized so as to leave the money supply unchanged, is generally thought to depend on the question whether yen and dollar assets are imperfect substitutes in investors' portfolios. Under the special case in which assets are perfect substitutes, investors will be willing to absorb indefinitely-large quantities into their portfolios, as long as the assets pay the going rate of return, with no effect on the price of the asset. The condition one would like to test is uncovered interest parity: risk-neutral investors drive the yen interest rate into equality with the dollar interest rate corrected for expected depreciation.

Exchange rate expectations are crucial for each of these important questions, and for others as well. Measuring investors' expectations is always difficult. Probably the most commonly-used measure of expected depreciation is the forward discount, which arbitrage (in the absence of barriers to capital flows) in turn equates to the interest differential. But using the forward discount or interest differential prejudges the question of perfect substitutability. The other common approach is to assume that market expectations can be measured as the mathematical expectation of the realized exchange rate within the sample period, conditional on some particular information set. But this approach too prejudges much.

This paper proposes a third measure, survey data on exchange rate expectations, to answer various questions of interest regarding the yen/dollar market. The data come from three sources. The American Express Bank Review surveys 250-300 central bankers, private bankers, corporate treasurers, and economists once a year, with some surveys going back to 1976. The Economist's Financial Report has conducted telephone surveys of currency traders and currency-room economists at 14 leading international banks each six weeks since June 1981. Money Market Services, Inc. (MMS), has also been surveying approximately 30 currency traders by telephone every two weeks since January 1983, and every week since October 1984. These data are discussed and analyzed in Frankel and Froot (1985) and Froot and Frankel (1986).[2] The results reported in the present paper are new, in two respects. First, they focus exclusively on the yen/dollar rate, where the earlier two papers examined simultaneously the yen, pound, mark, French franc and Swiss franc. Secondly, they distinguish between short-term expectations on the one hand--at horizons of one week, two weeks or one month--as reported in the MMS survey, and long-term expectations on the other hand--at horizons of six months or twelve months--as reported in the other two surveys. The short-term and long-term expectations turn out to behave very differently.

In section 2 we relate expected depreciation as measured by the surveys to the forward discount, in order to test the hypothesis of perfect substitutability. In section 3 we investigate some standard models of expectations formation--distributed lag, adaptive, and regressive expectations. In each case one motivation is to see if expectations are stabilizing, versus the alternative of static or even bandwagon expectations. In each case a second motivation, which we pursue in section 4, is to test whether the expectations formation process is similar to the process describing the mathematical expectation of the actual spot rate, that is, whether the expectations are unbiased conditional on the

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[2]The first paper investigates how investors form expectations from the contemporaneous spot rate and other variables. The second paper investigates the standard regression equation of exchange rate changes against the forward discount. Both papers include tests of the proposition that the expectations measured in the survey are unbiased.

particular information set. Included here is a test of the proposition that investors would do better in forming their expectations if they put more weight on the contemporaneous spot rate and less weight on other variables. Finally in section 5 we briefly summarize our findings.

II. The Forward Discount: Risk Premium or Expected Depreciation?

Our first question is whether investors treat assets denominated in yen and dollars as perfect substitutes. If positions in different currencies were perfectly substitutable, investors would be indifferent between holding open positions in foreign assets and selling the assets forward. This would imply that the forward discount exactly equals the expected depreciation of the currency:

$$(1) \qquad \Delta s^e_{t+k} = fd^k_t$$

where fd is the forward discount at term k (the log of the current forward rate minus the log of the current spot rate) and Δs^e_{t+k} is the log of the expected spot rate k periods into the future minus the log of the current spot rate. On the other hand, if investors need to be rewarded for exposure to the additional risk of holding an open position in the foreign currency, they will demand a risk premium in addition to the forward rate:

$$(2) \qquad \Delta s^e_{t+k} = fd^k_t - rp^k_t.$$

Because both expected depreciation, Δs^e, and the risk premium rp, are unobservable, additional information or assumptions are required to isolate them. If, for example, we were to assume that realized future spot rates are unbiased measures of expected spot rates, then we could estimate expected depreciation (and therefore the risk premium) from the time-series of realized depreciation.[3] A second method of identification would be to assume the validity of a particular model of investor portfolio optimization (such as Hodrick and Srivastava (1984) or Frankel (1982)) and use it to obtain estimates of the risk premium. A third approach, the one taken in this paper, is to employ survey data on expected depreciation. While surveys of agents' expectations may in many contexts be less desirable than data on their actual market behavior, the surveys are direct estimates that do not require us to assume any particular model of expected depreciation or of the risk premium.

First we look at simple averages over the sample period. (Below we will consider variation over time.) In Table 1 we present the time-series means for each set of survey data. The results are ordered by length of forecast horizon, from the shortest-term one-week expectations, to the longer-term one-year expectations. The surveys cover a wide variety of sample periods as well. In the first column, averages of actual depreciation are reported. During the periods of the one-week and one-month MMS surveys, from October 1984 to February 1986, the dollar depreciated against the yen at an annual rate of 27.5 percent. During the

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[3]Perfect substitutability, or uncovered interest parity (which, given covered interest parity, is an equivalent condition), is tested for Japan versus the United States by Ito (1984) and McKenzie (1986).

period covered by the three-month MMS surveys as well as the three, six and twelve month Economist surveys, the rate of depreciation is much smaller.

Column (2) reports corresponding averages of the survey expected depreciation. It is clear that the time-series means of realized depreciation perform very poorly as measures of the investors' expectations reported in the surveys. In contrast to the considerable swings in the sign and magnitude of average actual spot rate changes, the survey consistently called for upward movements in the value of the yen against the dollar. The expectations are the same in sign, but larger in magnitude than the time-series averages of the forward discount reported in column (3).

The last column in table 1 presents the risk premium on dollar denominated assets as implied by the surveys. Strikingly, during both periods of appreciation and periods of depreciation the risk premium is negative. Far from regarding the two assets as perfect substitutes, investors appear to be willing to sacrifice the substantially higher expected returns from holding yen in order to hold dollars. Indeed, the magnitudes are surprisingly large. In the three-month Economist data, for example, respondents expected they could earn an additional 7.99 percent per annum on assets denominated in yen as compared with dollars. It is hard to justify such large exchange risk premia using the theory of optimal portfolio choice with conventional estimates of risk-aversion (Frankel 1985, and Mehra and Prescott 1985).

One explanation proposed for why investors were willing to hold dollars at lower expected rates of return is that the U.S. provided a "safe

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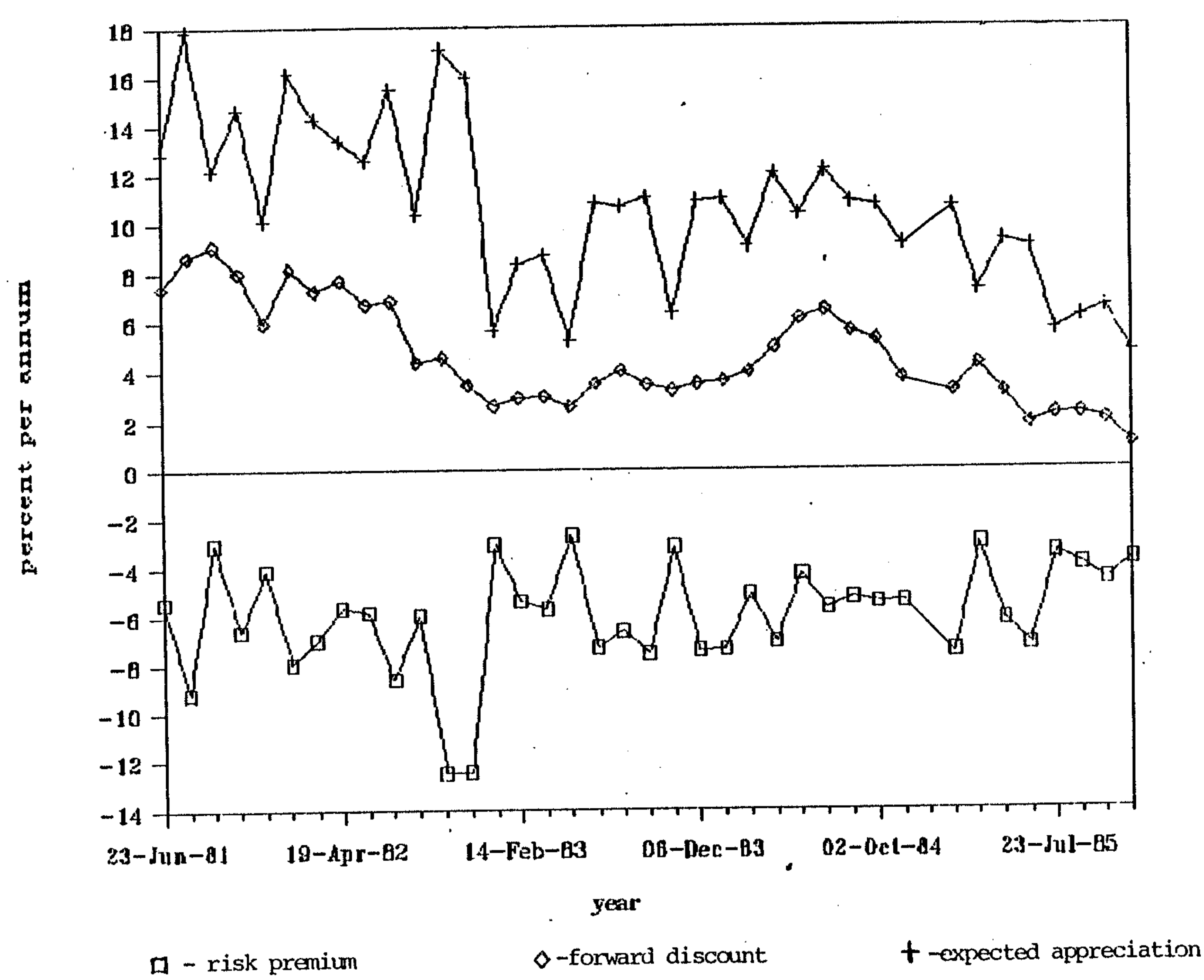
Table 1
VARIOUS MEASURES OF EXPECTED DEPRECIATION OF THE $/YEN RATE
average over sample period (% percent per annum)

FORECAST HORIZON	SURVEY SOURCE	DATES	N	(1) ACTUAL CHANGE s(t+1)-s(t)	N	(2) SURVEY DATA E[s(t+1)]-s(t)	(3) FORWARD DISCOUNT f(t)-s(t)	(3)-(2) RISK PREMIUM f(t)-E[s(t+1)] rp(t)
1 WEEK	MMS	10/84-2/86	62	24.39	62	5.40	NA	NA
2 WEEKS	MMS	1/83 10/84	47	-4.23	47	8.40	NA	NA
1 MONTH	MMS	10/84 2/86	44	27.55	44	2.99	1.68	-1.31
3 MONTHS	MMS	1/83-10/84	47	-2.90	47	8.68	3.85	4.82
	ECONOMIST	6/81 12/85	38	4.37	33	12.66	4.67	7.99
6 MONTHS	ECONOMIST	6/81 12/85	36	3.52	38	12.94	4.74	8.20
12 MONTHS	ECONOMIST	6/81 12/85	31	0.08	33	10.57	4.56	6.01

FIGURE 1

SURVEY APPRECIATION OF THE YEN AGAINST THE DOLLAR

12-Month Economist Survey Data



haven" from capital controls and other political risks (for example, Dooley and Isard, 1985; but see Frankel and Froot, 1986). Grounds for this argument seem especially lacking vis-á-vis the yen: Japan was not directly involved in either the Latin American debt crisis or concerns of "Europessimism", and the 1980's have been a period during which Japanese financial markets have been steadily liberalized, if anything reducing fears of prospective capital controls. Furthermore, only exchange rate risk should in theory be relevant, not factors relating to the political jurisdiction of Japan, because the spot and forward rates are determined offshore in the Euromarket. But whatever the reason, table 1 suggests that investors distinguish between assets denominated in different currencies, demanding a higher return on the yen than on dollars. This is also clear in Figure 1.

While the evidence so far indicates that a risk premium exists, it is not necessarily evidence that the risk premium varies over time. The proposition that the risk premium is time-varying rather than constant comes out of most of the conventional empirical literature on the forward market, as well as the theory of optimizing investors, and is also a property of models in which sterilized foreign exchange intervention has important effects.

Thus we would also like to know whether changes in the forward discount indicate a changing risk premium. The degree to which changes in the forward discount reflect changes in the risk premium can be inferred from a regression of expected depreciation on the forward discount:

(3) $\Delta s^{e}_{t+k} = \alpha + \beta fd^{k}_{t} + \varepsilon^{k}_{t+k}.$

The null hypothesis in equation (3) is that assets are perfect substitutes, i.e., $\alpha=0$ and $\beta=1$. The coefficient, β, converges in probability to:

$$b = \text{cov}\ (\Delta s^{e}_{t+k}, fd^{k}_{t})\ /\ \text{var}\ (fd^{k}_{t})$$

$$= 1 - [\ \text{cov}\ (rp^{k}_{t}, fd^{k}_{t})\ /\ \text{var}\ (fd^{k}_{t})\ ]\ .$$

A finding that β is near zero or less than zero is evidence that changes in the forward discount reflect changes in the risk premium, while a finding that β is near one is evidence that such changes in the forward discount reflect something else, namely equivalent changes in expected depreciation.[4]

The conventional approach to testing equation (2) uses ex post spot rate changes to infer the behavior of the unobservable market expected depreciation. Under the assumption of rational expectations, the future spot rate realizations are viewed as noisy measures of investors' expectations. This noise is assumed to be uncorrelated with the forward discount, and therefore can be identified with the residual term in equation (3). Table 2 reports estimates of equation (3), using ex post

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[4]Fama (1984), Hodrick and Srivastava (1984, 1986) and Froot and Frankel (1986) discuss whether changes in the forward discount primarily reflect changes in the risk premium or in expected depreciation.

changes in the spot rate as the lefthand-side variable.[5] All of the point estimates of b are less than zero, and most are significantly less than one. The conventional approach would therefore seem to imply that changes in the forward discount predominantly reflect changes in the risk premium.

Our alternative test of equation (3) uses the survey expected depreciation on the lefthand side, in place of the actual spot rate change. The existence of heterogeneous beliefs, the use of the median survey response, and the lack of perfect synchronization, are reasons to suspect that the surveys may also be noisy estimates of market expectations. Now the error term in the regression equation may be interpreted as measurement error in the surveys. We make the assumption that this measurement error is random, which is analogous to the assumption of rational expectations used in the conventional technique above, i.e., that the expectation error is random.

Though the two approaches are analogous, there are several reasons to prefer the surveys to the actual spot rate data in tests of equation (3). The first is that, under the hypothesis that both actual spot rates and the surveys contain only the market expectation plus purely random noise, the noise element in actual spot rate changes turns out to be

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[5]All of the regressions in this paper are estimated using OLS. The Economist surveys, MMS one-month and three-month surveys, and the AMEX twelve-month survey were conducted at intervals shorter than their respective forecast horizons. This implies that the error term in equation (2) is serially correlated even under the null hypothesis. Consistent estimates of the standard errors were obtained by the usual method of moments procedure (see Hansen and Hodrick (1980), or Froot and Frankel (1986) for a more detailed description). For additional information on the construction of the data sets used in this paper, see the appendix to Frankel and Froot (1985).

TABLE 2
TESTS OF FORWARD DISCOUNT BIAS
Independent variable: f(t) - s(t)

OLS Regressions of Spot Rate Changes: s(t+1) - s(t) = a + b (f(t) - s(t))

Data Set	Dates	coefficient b	t: b=1	DF	R^2	F test a=0, b=1
MMS 1 Month	10/84-2/86	-10.6755 (13.0329)	-0.90	42	0.08	2.54 *
MMS 3 Month	1/83-10/84	-4.5720 (2.9337)	-1.90	45	0.29	3.45 **
Economist 3 Month	6/81-12/85	-2.9255 (1.5865)	-2.47 **	36	0.40	3.06 *
Economist 6 Month	6/81-12/85	-3.5070 (1.7502)	-2.58 **	34	0.42	3.36 **
Amex 6 Month	1/76-8/85	-3.4777 (1.6026)	-2.79 *	7	0.46	4.38 *
Economist 12 Month	6/81-12/85	-2.0517 (1.3853)	-2.20 **	29	0.35	13.25 ***
Amex 12 Month	1/76-8/85	-4.4862 (1.3590)	-4.04 **	6	0.64	8.65 **

Actual and expected exchange rates are in terms of dollars per yen.
* Represents significance at the 10 percent level. ** Represents significance at the 5 percent level. *** Represents significance at the 1 percent level. R^2 corresponds to an F test on all nonintercept parameters. Standard errors are method of moments estimates.

much larger than the noise element in the surveys. In Froot and Frankel (1986, table 3) we report estimates of the variances of actual and survey expected spot rate changes and find that the former is greater by a factor of 7 to 10. This implies that, for any given sample, a more precise estimate of b may be obtained by using the surveys. A second reason to prefer the surveys is that they free us from imposing the restriction that there are no systematic prediction errors in the sample, a proposition that we would like to be able to test rather than impose.
Such systematic errors, which the conventional technique must assume away, could occur because of a failure of rational expectations, or because important events which affect expectations did not happen to occur a representative number of times in the sample (the "peso problem"), rendering the ex post distribution of spot rate changes a biased estimator of the ex ante distribution.

Tests of equation (3) using the survey data on the lefthand side are reported in table 3. In each of the seven data sets the estimates of b are greater than those in table 2. In most cases we cannot reject the hypothesis that b equals one. In other words, we cannot reject the hypothesis that the survey risk premia reported in table 1 do not vary over time. There is not even much sign that the risk premium on yen had an exogenous downward trend during the 1981-85 period, as it would under the hypothesis that internationalization was causing investors around the world to become more willing to hold yen. (Figure 1 shows, on the negative axis, the risk premium on dollars, i.e., the forward discount or interest differential minus the expected appreciation of the yen.) In all cases,

TABLE 3
TESTS OF PERFECT SUBSTITUTABILITY
Independent variable: f(t) - s(t)

OLS Regressions of Survey Expected Depreciation: E [s(t+1)] - s(t) = a + b(f(t) - s(t))

Data Set	Dates	coefficient b	t: b=1	coefficient a	t: a=0	DW(2)	DF	R^2	F test a=0, b=1	
MMS 1 Month	10/84-2/86	-6.0982 (1.9942)	-3.56 ***	0.0109 (0.0031)	3.49	1.16	42	0.58	6.58	0.003
MMS 3 Month	1/83-10/84	-1.1402 (0.4438)	-4.82 ***	0.0327 (0.0044)	7.37	1.20	40	0.72	55.61	0.000
Economist 3 Month	6/81-12/85	1.7299 (0.4417)	1.65	0.0113 (0.0060)	1.88	1.91	36	0.23	22.44	0.000
Economist 6 Month	6/81-12/85	1.2254 (0.2065)	1.09	0.0356 (0.0056)	6.39	1.45	36	0.12	121.25	0.000
Amex 6 Month	1/76-8/85	1.0988 (0.2654)	0.37	0.0031 (0.0080)	0.39	0.35	7	0.02	0.98	0.422
Economist 12 Month	6/81-12/85	1.1821 (0.1749)	1.04	0.0515 (0.0090)	5.75	2.00	36	0.11	132.24	0.000
Amex 12 Month	1/76-8/85	0.7621 (0.3181)	-0.75	0.0176 (0.0175)	1.01	0.20	7	0.06	0.54	0.604

Actual and expected exchange rates are in terms of dollars per yen.
* Represents significance at the 10 percent level. ** Represents significance at the 5 percent level. *** Represents significance at the 1 percent level. R^2 corresponds to an F test on all nonintercept parameters.

however, we can reject the hypothesis of perfect substitutability, a=0 and b=1 jointly. In other words, the risk premium does show up in the constant term.

To summarize, in Table 3, as in Table 1, it appears that the ex post depreciation may be a very poor measure of expected depreciation. Table 3 provides evidence that changes in the forward discount reflect primarily changes in expected depreciation rather than changes in the risk premium.

III. Models of expected depreciation

The results from the first three tables suggest that there is information on expectations in the surveys which is not contained in either realized spot rates or forward rates. We may thus gain new insights by using this data source to reexamine several old formulations of exchange rate expectations that are standard to the literature.[6]

A general framework for testing various specifications of expectations is to model expectations of the future spot rate as giving some weight to the contemporaneous spot rate as well as some weight to other variables in investors' information set. In each case below, our null hypothesis will be that of static expectations: investors place a weight of one on the contemporaneous spot rate and a weight of zero on the other information, so that expected depreciation is zero. The alternative hypothesis depends on the precise variable chosen to represent the "other" information. Suppose, for example, that investors assign a weight of g to

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[6]The tests reported in this section are similar to those reported in Frankel and Froot (1985) for the dollar against five other currencies. But they did not include the results for the shorter-term forecast horizons.

the lagged spot rate and a weight of 1-g to the current spot rate in forming their expectations of the future spot rate:

(4) $$s^e_{t+k} = (1-g)\, s_t + g s_{t-k},$$

where s_t is the logarithm of the current spot rate. Subtracting s_t from both sides we have that expected depreciation is proportional to the most recent change in the spot rate:

(5) $$\Delta s^e_{t+k} = -g\,(s_t - s_{t-k}).$$

We term the model in equation (5) extrapolative expectations. If investors place positive weight on the lagged spot rate, so that g is positive, then equation (4) says that investors' expected future spot rate is a simple distributed lag. On the other hand, if investors tend to extrapolate the most recent change in the spot rate, so that g is negative, then equation (5) may be termed "bandwagon" expectations. In this latter case a current appreciation by itself generates expectations of further future appreciation. By defining "speculation" as the buying and selling of yen in response to non-zero expected exchange rate changes, we can interpret a finding of $g>0$ as implying that speculation is stabilizing and a finding of $g<0$ as implying that speculation is destabilizing.

Table 4 reports regression estimates of equation (5), using the survey expected depreciation as the lefthand-side variable. The regression error can be interpreted as random measurement error. Under the joint hypothesis that the mechanism of expectations formation is specified

TABLE 4
EXTRAPOLATIVE EXPECTATIONS
Independent variable: s(t-1) - s(t)

OLS Regressions of Survey Expected Depreciation: E [s(t+1)] - s(t) = a + g(s(t-1) - s(t))

Data Set	Dates	coefficient g	t: g=0	DW(2)	DF	R^2
MMS 1 Week	10/84-2/86	-0.2391 (0.0490)	-4.88 ***	1.78	53	0.73
MMS 2 Week	1/83-10/84	-0.1138 (0.0546)	-2.08 **	1.32	44	0.33
MMS 1 Month	10/84-2/86	-0.1208 (0.0436)	-2.77 ***	1.76	42	0.46
MMS 3 Month	1/83-10/84	-0.0694 (0.0231)	-3.00 ***	1.21	40	0.50
Economist 3 Month	6/81-12/85	0.1429 (0.0523)	2.73 ***	1.65	36	0.45
Economist 6 Month	6/81-12/85	0.1783 (0.0501)	3.56 ***	1.07	36	0.58
Amex 6 Month	1/76-8/85	0.2907 (0.1124)	2.59 **	NA	7	0.43
Economist 12 Month	6/81-12/85	0.3421 (0.0664)	5.15 ***	1.41	36	0.75
Amex 12 Month	1/76-8/85	0.4412 (0.1702)	2.59 **	NA	7	0.43

Actual and expected exchange rates are in terms of dollars per yen.
* Represents significance at the 10 percent level. ** Represents significance at the 5 percent level. *** Represents significance at the 1 percent level. R^2 corresponds to an F test on all nonintercept parameters.

correctly and that measurement error is random, the parameter estimates are consistent. It should be noted that the joint hypothesis is a particularly strong assumption because the spot rate appears on the right-hand-side; if a change in expected depreciation feeds back to affect both the contemporaneous spot rate and any element of the regression error, then the estimate of g will be biased and inconsistent. However this is not a problem under our null hypothesis that expected depreciation is constant.

The findings are once again ordered by the length of the forecast horizon. It is immediately evident that the shorter-term expectations -- one week, two weeks and one month -- all exhibit large and significant bandwagon tendencies: that $g < 0$. In the one-week expectations, for example, an appreciation of 10 percent in one week generates the expectation that the spot rate will appreciate another 2.4 percent over the next seven days.

In contrast with the shorter-term expectations, the longer-term results all point toward distributed lag expectations, the stabilizing case. Each of the regressions at the 6 and 12 month forecast horizons estimate g to be significantly greater than zero.[7] The Economist 12 month data, for example, imply that a current 10 percent appreciation by itself generates an expectation of 3.4 percent depreciation over the coming 12 months. Thus longer-term expectations feature a strongly positive weight

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[7]In Frankel and Froot (1986), we correct for the low Durbin-Watson statistics in similar regressions using five different currencies (and those in Tables 6 and 7) using a three stages least squares estimation technique which allows for first order serial correlation in the residuals. The technique is not repeated here since the corrected results obtained in that paper are very similar to the uncorrected OLS estimates.

on the lagged spot rate rather than complete weight on the contemporaneous spot rate, and in this sense are stabilizing.

A second popular specification for the expected future spot rate is that it is a weighted average of the current spot rate and the long-run equilibrium spot rate, $\bar{s}$:

$$(6) \qquad s^e_{t+k} = (1-\theta)\, s_t + \theta\, \bar{s}_t,$$

or in terms of expected depreciation:

$$(7) \qquad \Delta s^e_{t+k} = \theta\, (\bar{s} - s_t)$$

If θ is positive, as, for example, in the Dornbusch (1976) overshooting model, the spot rate is expected to move in the direction of $\bar{s}$. Expectations are therefore regressive. Alternatively, a finding of $\theta < 0$ implies that investors expect the spot rate to move away from the long-run equilibrium.

Table 5 presents tests of equation (7). Estimates of changes in $\bar{s}$ were calculated using CPI's to measure changes in the relative price levels in the U.S. and Japan, under the assumption of purchasing power parity (PPP). Once again, there is strong evidence that shorter-term expectations are formed in a manner different from longer-term expectations. The shorter forecast horizons all yield estimates of that θ are negative, additional evidence that shorter term speculation may be destabilizing. Indeed, the 1-week data suggest that the contemporaneous deviation from the

TABLE 5
REGRESSIVE EXPECTATIONS
Independent variable: $\bar{s}(t) - s(t)$
Long Run Equilibrium PPP

OLS Regressions of Survey Expected Depreciation: $E[s(t+1)] - s(t) = a + \theta(\bar{s}(t) - s(t))$

Data Set	Dates	coefficient θ	t: θ=0	DW(2)	DF	R^2
MMS 1 Week	10/84-2/86	-0.0415 (0.0119)	-3.49 ***	1.96	53	0.58
MMS 2 Week	1/83-10/84	-0.0936 (0.0203)	-4.61 ***	1.85	44	0.70
MMS 1 Month	10/84-2/86	-0.0752 (0.0190)	-3.96 ***	1.48	42	0.63
MMS 3 Month	1/83-10/84	-0.1670 (0.0371)	-4.51 ***	1.56	40	0.69
Economist 3 Month	6/81-12/85	-0.0237 (0.0568)	-0.42	1.54	36	0.02
Economist 6 Month	6/81-12/85	-0.0363 (0.0574)	-0.63	0.94	36	0.04
Amex 6 Month	1/76-8/85	0.0222 (0.0480)	0.46	NA	7	0.02
Economist 12 Month	6/81-12/85	0.0802 (0.0857)	0.94	0.96	36	0.09
Amex 12 Month	1/76-8/85	0.1192 (0.0585)	2.04 *	NA	7	0.32

Actual and expected exchange rates are in terms of dollars per yen.
* Represents significance at the 10 percent level. ** Represents significance at the 5 percent level. *** Represents significance at the 1 percent level. R^2 corresponds to an F test on all nonintercept parameters.

long-run equilibrium is expected on average to grow by 3 percent over the subsequent seven days. In other words, short-term expectations are explosive. What about the longer-term horizons? In Frankel and Froot (1985) we found a highly significant speed of regression at the longer-term horizons. The longer-term estimates of θ in table 5 do not, however, exhibit regressivity for the yen that is as highly significant. Only the American Express 12-month data, which is available as far back as 1976, shows an estimate that is significant even at the 10 percent level. It may be that relative CPI's are not the appropriate indicator of the equilibrium yen/ dollar rate. It has been suggested that due to rapid productivity growth in Japan, Japanese producers gain in international competitiveness even to the extent that PPP is observed to hold. Marston (1986) demonstrates that even though estimates of real exchange rate changes using CPIs show real appreciation of the yen against the dollar over the last decade, estimates using manufactured goods prices give a very different answer. [8]

The final specification we consider is adaptive expectations. In this case, agents are hypothesized to form their expectation of the future spot rate as a weighted average of the current spot rate and the lagged expected spot rate:

$$(8)\ s^e_{t+k} = (1-\gamma)\ s_t + \gamma\ s^e_t.$$

[8]See also Krugman (1986) and Johnson and Loopesko (1986).

Expected depreciation is now proportional to the contemporaneous prediction error:

(9) $\Delta s^e_{t+k} = \gamma\ (s^e_t - s_t).$

Table 6 reports estimates of equation (9). Once again, the weight placed on the variable other than the contemporaneous spot rate, in this case the lagged expectation, is sensitive to the forecast horizon of the surveys. Shorter-term expectations again appear to be strongly destabilizing, while the longer-term expectations are significantly stabilizing. For example, the one-week data indicate that an unanticipated appreciation of 10 percent by itself generates an expectation of continued appreciation over the subsequent seven days of 1.3 percent. At the other extreme, the Economist twelve month data suggest that an unanticipated appreciation of 10 percent generates an offsetting expectation of depreciation of 1.5 percent over the subsequent year.

The results of Tables 4, 5, and 6 suggest that in all three of our standard models of expectations--extrapolative, regressive and adaptive--short-term and long-term expectations behave very differently from one another. Longer-term expectations consistently appear to be stabilizing, while shorter-term forecasts seem to have a destabilizing nature. Within each of the above tables, it is as if there are actually two models of expectations operating, one at each end of the spectrum of forecast horizons, and a blend in between.

TABLE 6
ADAPTIVE EXPECTATIONS
Independent variable: E(t-1)[s(t)] - s(t)

OLS Regressions of Survey Expected Depreciation: E [s(t+1)] - s(t) = a + γ(E(t-1)[s(t)] - s(t))

Data Set	Dates	coefficient γ	t: γ =0	DW(2)	DF	R^2
MMS 1 Week	10/84-2/86	-0.1289 (0.0529)	-2.44 **	1.31	53	0.40
MMS 2 Week	1/83-10/84	-0.0744 (0.0487)	-1.53	1.21	44	0.21
MMS 1 Month	10/84-2/86	-0.0911 (0.0458)	-1.99 *	1.62	42	0.31
MMS 3 Month	1/83-10/84	-0.0535 (0.0372)	-1.44	1.03	40	0.19
Economist 3 Month	6/81-12/85	0.1422 (0.0542)	2.62 **	1.91	36	0.43
Economist 6 Month	6/81-12/85	0.1208 (0.0376)	3.21 ***	1.14	36	0.53
Economist 12 Month	6/81-12/85	0.1502 (0.0543)	2.77 **	1.73	36	0.46

Actual and expected exchange rates are in terms of dollars per yen.
* Represents significance at the 10 percent level. ** Represents significance at the 5 percent level. *** Represents significance at the 1 percent level. R^2 corresponds to an F test on all nonintercept parameters.

It may be that each respondent is thinking to himself or herself, "I know that in the long run the exchange rate must return to the equilibrium level dictated by fundamentals. But in the short run I will ride the current trend a little longer. I only have to be careful to watch for the turning point and to get out of the market before everyone else does." If this is the logic of the typical investor, then he is acting irrationally; it is not possible for everyone to get out before everyone else. But so far we have not presented any evidence that the actual spot process behaves differently from investors' expectations. We consider such evidence in the following section.[9]

IV. Rationality of the Survey Expectations

Now that we have a sense for the behavior of the survey expected depreciation, we turn to an analysis of whether the predictable component of the true spot process behaves in the same way, i.e., whether expectations are rational. One way to proceed would be to re-estimate each of the models given in equations (5)-(8), only now using realized depreciation as the lefthand-side variable. The hypothesis that expectations are rational would imply that these regressions should yield

[9] One possibility is that the MMS short-term survey is picking up predominantly the expectations of floor traders, people who buy and sell currency on a short-term basis, and that the other two, longer-term, surveys are picking up predominantly the expectations of investors who have a longer-term perspective. Under this interpretation, it may be that the traders have developed the habit of ignoring economic fundamentals in their expectations formation, rather going with time series trends (as in "chartism" or "technical analysis"), and that the latter group pays more attention to fundamentals. The chartist/fundamentalist dichotomy and its implications for the determination of the value of the dollar in the 1980s are pursued in Frankel and Froot (1986).

coefficients that are statistically indistinguishable from those obtained earlier using the surveys on the lefthand side. A more direct way to test the same hypothesis is to regress the difference between the survey expectation and the actual future spot rate, the survey prediction error, on each set of regressors in equations (5)-(8). Under the null hypothesis that expectations are rational, this prediction error should be purely random (conditionally independent of all information available at time t) and therefore should be uncorrelated both with the righthand-side variables and with past errors. We test whether the coefficients are jointly zero.

Table 7 reports regressions of the survey prediction errors on the most recent change in the spot rate. The estimated F statistics give some evidence of systematic expectational errors: five of the nine data sets reject the joint hypothesis that both the constant and slope coefficients equal zero. In view of the discussion in the previous section, an inspection of the slope coefficient, g, can help us to determine whether investors place the correct weight on the lagged spot rate. A finding of $g_1>0$ would indicate that expectations are "insufficiently" extrapolative: investors give too much weight to the lagged spot rate and too little weight to the contemporaneous spot rate relative to what is rational. Conversely, a finding of $g_1<0$ would indicate that expectations are "overly" extrapolative. Table 7 suggests that predictions at the shorter forecast horizons tend to be overly extrapolative, while those at the longer horizons are insufficiently extrapolative. Such a pattern suggests that the contrast in Table 5 between the behavior of short-term and long-term expectations is too

TABLE 7
BIAS IN EXTRAPOLATIVE EXPECTATIONS
Independent variable: s(t-1) - s(t)

OLS Regressions of Survey Expectational Errors: E [s(t+1)] - s(t+1) = a + g(s(t-1) - s(t))

Data Set	Dates	coefficient g	t: g=0	DF	R^2	F test a=0, g=0
MMS 1 Week	10/84-2/86	-0.0118 (0.1378)	-0.09	60	0.00	1.48
MMS 2 Week	1/83-10/84	-0.1950 (0.1588)	-1.23	45	0.14	2.83 *
MMS 1 Month	10/84-2/86	-0.1344 (0.2671)	-0.50	42	0.03	2.56 *
MMS 3 Month	1/83-10/84	-0.1432 (0.1737)	-0.82	45	0.07	3.58 **
Economist 3 Month	6/81-12/85	0.2303 (0.1895)	1.22	36	0.14	1.87
Economist 6 Month	6/81-12/85	0.1533 (0.3603)	0.43	34	0.02	1.25
Amex 6 Month	1/76-8/85	1.2549 (0.5948)	2.11 *	7	0.33	2.44
Economist 12 Month	6/81-12/85	-0.1588 (0.3730)	-0.43	29	0.02	5.68 ***
Amex 12 Month	1/76-8/85	2.4287 (1.0234)	2.37 *	6	0.38	3.84 *

Actual and expected exchange rates are in terms of dollars per yen.
* Represents significance at the 10 percent level. ** Represents significance at the 5 percent level. *** Represents significance at the 1 percent level. R^2 corresponds to an F test on all nonintercept parameters. Standard errors are method of moments estimates.

extreme relative to what the actual process generating spot rate changes would predict. Few estimates of g_1, however, are significantly different from zero. There is thus not enough evidence so far to conclude that, at any of the reported forecast horizons, investors place too little or too much weight on the lagged spot rate relative to what is rational.

In Table 8 we test whether investors' expectations give the correct weight to the long-run equilibrium spot rate, $\bar{s}$. Here the results are surprisingly consistent across all of the forecast horizons: expectations seem to be insufficiently regressive in that they give less weight to $\bar{s}$, and therefore more weight to the contemporaneous spot rate, than does the true process governing the behavior of the spot rate. In Table 9 we perform the analogous test using lagged expectational errors on the righthand side. In this case, the alternative hypotheses are that expectations are either overly or insufficiently adaptive. As in Table 7, the results in Table 9 do not suggest any clear tendency on the part of investors to give too much or too little weight to the most recent expectational prediction error.

The tests of rational expectations presented so far in Tables 7-9 are appropriate when we take as given the specific models of expectations formation discussed in the previous section. Each regression was designed to test whether investors assign the correct weight to a single element in their information set when predicting the level of the yen/dollar rate. If, however, both expectations and the true spot process depend on other unspecified information, then the above tests of rationality are not necessarily the most enlightening nor the most powerful.

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TABLE 8
BIAS IN REGRESSIVE EXPECTATIONS
Independent variable: $\bar{s}(t) - s(t)$
Long Run Equilibrium PPP

OLS Regressions of Survey Expectational Errors: $E[s(t+1)] - s(t+1) = a + \theta_1(\bar{s}(t) - s(t))$

Data Set	Dates	coefficient θ_1	$t: \theta_1=0$	DF	R^2	F test $a=0, \theta_1=0$
MMS 1 Week	10/84-2/86	-0.0299 (0.0297)	-1.01	55	0.10	1.28
MMS 2 Week	1/83-10/84	-0.2250 (0.0701)	-3.21 ***	45	0.53	7.63 ***
MMS 1 Month	10/84-2/86	-0.0502 (0.1145)	-0.44	37	0.02	1.52
MMS 3 Month	1/83-10/84	-0.6576 (0.2765)	-2.38 **	45	0.39	6.53 ***
Economist 3 Month	6/81-12/85	-0.3040 (0.1932)	-1.57	36	0.22	2.38
Economist 6 Month	6/81-12/85	-1.0635 (0.3180)	-3.34 ***	34	0.55	7.81 ***
Amex 6 Month	1/76-8/85	-0.1809 (0.2255)	-0.80	7	0.07	0.46
Economist 12 Month	6/81-12/85	-1.2991 (0.3076)	-4.22 ***	29	0.66	41.93 ***
Amex 12 Month	1/76-8/85	-0.0809 (0.5907)	-0.14	6	0.00	0.07

Actual and expected exchange rates are in terms of dollars per yen.
* Represents significance at the 10 percent level. ** Represents significance at the 5 percent level. *** Represents significance at the 1 percent level. R^2 corresponds to an F test on all nonintercept parameters. Standard errors are method of moments estimates.

TABLE 9
BIAS IN ADAPTIVE EXPECTATIONS
Independent variable: E(t-1)[s(t)] - s(t)

OLS Regressions of Survey Expectational Errors: E [s(t+1)] - s(t+1) = a + γ_1(E(t-1)[s(t)] - s(t))

Data Set	Dates	coefficient γ_1	t: γ_1=0	DF	R^2	F test a=0, γ_1=0
MMS 1 Week	10/84-2/86	0.0306 (0.1351)	0.23	54	0.01	0.52
MMS 2 Week	1/83-10/84	0.0961 (0.1411)	0.68	44	0.05	1.74
MMS 1 Month	10/84-2/86	-0.0722 (0.2519)	-0.29	33	0.01	2.30
MMS 3 Month	1/83-10/84	-0.1010 (0.2969)	-0.34	39	0.01	2.11
Economist 3 Month	6/81-12/85	0.4088 (0.1985)	2.06 **	33	0.32	3.38 **
Economist 6 Month	6/81-12/85	0.0668 (0.3691)	0.18	29	0.00	1.35
Economist 12 Month	6/81-12/85	-0.6171 (0.3175)	-1.94 *	21	0.30	11.74 ***

Actual and expected exchange rates are in terms of dollars per yen.
* Represents significance at the 10 percent level. ** Represents significance at the 5 percent level. *** Represents significance at the 1 percent level. R^2 corresponds to an F test on all nonintercept parameters. Standard errors are method of moments estimates.

A more robust test would ask whether expectations assign too little weight to the contemporaneous spot rate and (by default) too much weight to all other variables in their information set. This test is performed by regressing the survey prediction error on the survey expected depreciation:

(10) $$s^e_{t+k} - s_{t+k} = a + b\,(s^e_{t+k} - s_t) + \varepsilon_{t+k},$$

and testing the hypothesis that the coefficients are jointly zero. The alternative hypothesis is that investors place too much (or too little) weight on variables other than the contemporaneous spot rate relative to what is rational. Following Bilson (1981), we term this alternative hypothesis "excessive speculation", because investors could improve their forecasts by consistently reducing toward zero their expectations of depreciation.

Table 10 reports our estimates of equation (10). Here we find much more evidence of systematic expectational errors in the surveys. All but one of the data sets reject the hypothesis that the constant and slope parameter are jointly zero. Four of the seven estimates of b are also statistically different from zero, so there is considerable evidence of excessive speculation. Unlike the results of the preceding tests of rationality, our estimates here are uniformly positive and do not appear related to the length of forecast horizon. In every case we are also unable to reject the hypothesis that b=1, which would imply that the expectations contain no useful information at all as to the future spot rate, i.e., that the spot rate follows a random walk.

TABLE 10
TESTS OF EXCESSIVE SPECULATION
Independent variable: E[s(t+1)] - s(t)

OLS Regressions of Survey Expectational Errors: E [s(t+1)] - s(t+1) = a + b (E[s(t+1)] - s(t))

Data Set	Dates	coefficient b	t: b=0	DF	R^2	F test a=0, b=0
MMS 1 Month	10/84-2/86	0.7798 (0.7864)	0.99	42	0.10	3.28 **
MMS 3 Month	1/83-10/84	1.5406 (0.7762)	1.98 *	45	0.30	5.29 ***
Economist 3 Month	6/81-12/85	0.9918 (0.4887)	2.03 **	36	0.31	3.35 **
Economist 6 Month	6/81-12/85	2.4283 (0.9202)	2.64 **	34	0.44	5.43 ***
Amex 6 Month	1/76-8/85	3.3718 (1.3126)	2.57 **	7	0.42	3.55 *
Economist 12 Month	6/81-12/85	0.9446 (0.7600)	1.24	29	0.15	8.27 ***
Amex 12 Month	1/76-8/85	2.8767 (2.0187)	1.43	6	0.18	1.52

Actual and expected exchange rates are in terms of dollars per yen.
* Represents significance at the 10 percent level. ** Represents significance at the 5 percent level. *** Represents significance at the 1 percent level. R^2 corresponds to an F test on all nonintercept parameters. Standard errors are method of moments estimates.

We mentioned earlier the possibility of measurement error in the survey data. In any of the regression equations where the expectations variable appears only on the lefthand side, namely the cases of extrapolative expectations (Tables 4 and 7) and regressive expecations (Tables 5 and 8) random measurement error does not impair the regression estimates. But in the case of adaptive expectations (Tables 6 and 9), as well as in the present case of excessive speculation (Table 10), the expectations variable appears also on the righthand side of the equation, so that measurement error would affect the estimates.

When the issue of possible random measurement error in these regression equations is addressed the results are qualitatively unchanged. In the test for excessive speculation we can eliminate the problem of measurement error (so long as it is random) by using the forward discount as the righthand-side variable. Table 11 again shows systematic expectational errors: investors could do better by routinely betting against the forward discount.[10]

[10]See Froot and Frankel (1986) for further explanation. In the case of estimating adaptive expectations, we would argue that the bias introduced, though nonzero, is small, because the variance of actual spot rate changes is approximately 10 times larger than the variance of expected depreciation (Table 3, ibid.).

TABLE 11
TESTS OF EXCESSIVE SPECULATION
Independent variable: f(t) - s(t)

OLS Regressions of Survey Expectational Errors: E [s(t+1)] - s(t+1) = a + b (f(t) - s(t))

Data Set	Dates	coefficient b	t: b=0	DF	R^2	F test a=0, b=0
MMS 1 Month	10/84-2/86	4.5774 (13.0150)	0.35	42	0.01	2.27
MMS 3 Month	1/83-10/84	3.4318 (3.3256)	1.03	45	0.11	4.34 **
Economist 3 Month	6/81-12/85	4.6555 (1.6314)	2.85 ***	36	0.48	5.61 ***
Economist 6 Month	6/81-12/85	4.6857 (1.8431)	2.54 **	34	0.42	5.22 **
Amex 6 Month	1/76-8/85	4.5764 (1.6430)	2.79 **	7	0.46	4.15 *
Economist 12 Month	6/81-12/85	3.0911 (1.3131)	2.35 **	29	0.38	13.25 ***
Amex 12 Month	1/76-8/85	5.3625 (1.2316)	4.35 ***	6	0.68	9.99 **

Actual and expected exchange rates are in terms of dollars per yen.
* Represents significance at the 10 percent level. ** Represents significance at the 5 percent level. *** Represents significance at the 1 percent level. R^2 corresponds to an F test on all nonintercept parameters. Standard errors are method of moments estimates.

V. Conclusions

(1) The survey data on exchange rate expectations appear to contain new information about market expectations which is not apparent from either ex post spot rate changes or the forward discount. Our measures show that, despite the large swings in the value of the yen in the 1980s, the surveys consistently called for a large appreciation of the yen against the dollar.

(2) These measures of expected appreciation are also substantially in excess of the forward premium. An implication is that investors were willing to accept a lower expected rate of return on dollar assets than on comparable assets denominated in yen.

(3) Contrary to what is commonly assumed in most models in which sterilized foreign exchange intervention is effective, variation in the forward discount does not reflect a statistically significant degree of variation in the risk premium.

(4) Variation in the forward discount primarily reflects, instead of changes in the risk premium, changes in expected depreciation.

(5) The expectations given in the short-term surveys exhibit bandwagon effects, which could imply that short-term speculation is destabilizing.

(6) Expectations at longer-term horizons, in contrast, appear to put less than full weight on the contemporaneous spot rate and positive weight on

several other variables such as the lagged spot rate, the long-run equilibrium spot rate, and the lagged expected spot rate.

(7) Investors could improve both their short-term and their long-term forecasts by reducing the absolute magnitude of expected depreciation toward zero. This finding of "excessive speculation" would follow from the result that expected depreciation is not zero together with the popular hypothesis that the true spot process follows a random walk.

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