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FORWARD DISCOUNT BIAS: IS IT AN EXCHANGE RISK PREMIUM?

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Abstract

A common finding is that the forward discount is a biased predictor of future exchange rate changes. We use survey data on exchange rate expectations to decompose the bias into portions attributable to the risk premium and expectational errors. None of the bias in our sample reflects the risk premium. We also reject the claim that the risk premium is more variable than expected depreciation. Investors would do better if they reduced fractionally the magnitude of expected depreciation. This is the same result that many authors have found with forward market data, but now it cannot be attributed to risk.

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1. Introduction

There is by now a 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 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. Some studies 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, 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 non-zero risk premium, but also as evidence that the variance of the risk premium is greater than the variance of expected depreciation. Bilson (1985) expresses the extreme form of this view, which he calls a new "empirical paradigm:" expected depreciation is always zero, and changes in the forward discount instead reflect changes in the risk premium. 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.

[1] References include Tryon (1979), Levich (1979), Bilson (1981), Longworth (1981), Hsieh (1984), Fama (1984), Huang (1984), Park (1984) and Hodrick and Srivastava (1984, 1986). For a recent survey of the literature and additional citations see Hodrick (1988).

But one cannot address without additional information the basic issues of whether systematic expectational errors or the risk premium are responsible for the repeatedly biased forecasts of the forward discount, let alone whether the risk premium is more variable than expected depreciation. In this paper we use survey data on exchange rate expectations in an attempt to help resolve these issues. The data come from three surveys: one conducted by American Express Banking Corporation of London irregularly between 1976 and 1985; another conducted by the *Economist*'s *Financial Report*, also from London, at regular six-week intervals since 1981; and a third conducted by Money Market Services (MMS) of Redwood City, California, every two weeks beginning in January 1983 and every week beginning in October 1984. Frankel and Froot (1985, 1987) discuss the data and estimate models of how investors form their expectations.[2] In this paper we use the surveys to divide the forward discount into its two components - expected depreciation and the risk premium – in order to shed new light on the large literature that finds bias in the predictions of the forward rate.

We want to be skeptical of the accuracy of the survey data, to allow for the possibility that they measure true investor expectations with error. Such measurement error could arise in a number of ways. We will follow the existing literature in talking as if there exists a single expectation that is homogeneously held by investors, which we measure by the median survey response. But, in fact, different survey respondents report different answers, suggesting that if there is a single true expectation, it is measured with error. Another possible source of measurement error in our expected depreciation series is that the expected future spot rate may not be recorded by the survey at precisely the same moment as the contemporaneous spot rate is recorded.[3] Our econometric tests allow for measurement error in the data, provided the error is random. There is an analogy with the rational expectations approach which uses *ex post* exchange rate changes rather than survey data, and assumes that the error in measuring true expected depreciation, usually attributed to "news," is random. One of our findings below is that the expectational errors made in predicting *ex post* sample exchange rate changes are correlated with the forward discount. This, of course, could

[2] Dominguez (1986) also uses the MMS surveys.

[3] To measure the contemporaneous spot rate, 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 period to construct reference sets. Both gave very similar results, so that only results from the former sample were reported. In the case of the *Economist* and MMS surveys, which constitute most of our data set, this issue hardly arises to begin with, as they were conducted by telephone on a known day.

be consistent with a failure of investor rationality, but it is also consistent with "peso problems," nonstationarities in the sample (such as a change in the process governing the spot rate), and learning on the part of investors.

The paper is organized as follows. In Section 2, we reproduce the standard regression test of forward discount bias. We then use the surveys to separate the bias into a component attributable to systematic expectational errors and a component attributable to the risk premium. Sections 3 and 4 in turn test the statistical significance of the component attributable to the risk premium and the component attributable to systematic expectational errors, respectively. Section 5 concludes.

2. The regression of forward discount bias

The most popular test of forward market unbiasedness is a regression of the future change in the spot rate on the forward discount:

$$\Delta s_{t+k} = \alpha + \beta f d_t^k + \eta_{t+k}^k, \tag{1}$$

where Δs_{t+k} is the percentage depreciation of the currency (the change in the log of the spot price of foreign exchange) over k periods and fd_t^k is the current k-period forward discount (the log of the forward rate minus the log of the spot rate). The null hypothesis is that $\beta = 1$. Some authors include $\alpha = 0$ in the null hypothesis as well. In other words, the realized spot rate is equal to the forward rate plus a purely random error term, η_{t+k}^k. A second but equivalent specification is a regression of the forward rate prediction error on the forward discount:

$$fd_t^k - \Delta s_{t+k} = \alpha_1 + \beta_1 f d_t^k + \eta_{t+k}^k, \tag{2}$$

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 (1) have rejected the null hypothesis, finding β to be significantly less than one. Often the estimate of β is close to zero or negative.[4] Authors disagree, however, on the reason for this finding of bias. Longworth (1981) and Bilson (1981), for example, assume that there is

[4] The finding that forward rates are poor predictors of future spot rates is not limited to the foreign exchange market. 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.

no risk premium, so that the forward discount accurately measures investors' expectations; they therefore interpret the bias as a rejection of the rational expectations hypothesis. Bilson describes the finding of β less than one as a finding of "excessive speculation," meaning that investors would do better to reduce the absolute magnitude of their expected exchange rate changes. In the special case of $\beta = 0$, the exchange rate follows a random walk, and investors would do better to choose $\Delta s^e_{t+k} = 0$. On the other hand, Hsieh (1984) and most others assume that investors did not make systematic prediction errors in the sample; they interpret the bias as evidence of a time-varying risk premium.

2.1. Standard results reproduced

We begin by reproducing the standard OLS regression results for (1) on sample periods that correspond precisely to those that we will be using for the survey data.[5] We report these results, in part, to show that the results obtained when we use the survey data below cannot be attributed to small sample size unless one is also prepared to attribute the usual finding of forward discount bias to small sample size.[6] Table 1 presents the standard forward discount unbiasedness regressions (equation (1)) for our sample periods.[7] Most of the coefficients fall into the range reported by previous studies. There is ample evidence to reject unbiasedness: most of the coefficients are significantly less than one. More than half of the coefficients are even significantly less than zero, a finding of many other authors as well. In the two MMS data sets, the coefficients have unusually large absolute values, but their standard errors are also large. The F-tests also indicate that the unbiasedness hypothesis fails in most of the data sets.

Are the commonly-found results in Table 1 the consequence of a risk premium or systematic expectational errors?

[5] DRI provided us with daily forward and spot exchange rates, computed as the average of the noon-time bid and ask rates.

[6] In these and subsequent regressions, we pool across currencies in order to maximize sample size. (The four currencies in the MMS survey are the pound, mark, Swiss franc and yen, each against the dollar. The other two surveys include these four exchange rates and the French franc as well.) We must allow for contemporaneous correlation in the error terms across currencies, in addition to allowing for the moving average error process induced by overlapping observations ($k > 1$). We report standard errors that assume conditional homoskedasticity, because in this case they were consistently larger than the estimated standard errors that allow for conditional heteroskedasticity. We also at times pool across different forecast horizons to maximize the power of the tests, requiring correction for a third kind of correlation in the errors. We are not aware of this having been done before, even in the standard forward discount regression. Each of these econometric issues is discussed at greater length in the NBER working paper version of this paper.

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

2.2. Decomposition of the forward discount bias coefficient

The survey data allow us to answer the question directly. 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. The probability limit of the coefficient β in (1) is:

$$\beta = \frac{\mathrm{cov}(\eta_{t+k}^k, fd_t^k) + \mathrm{cov}(\Delta s_{t+k}^e, fd_t^k)}{\mathrm{var}(fd_t^k)}, \tag{3}$$

where η_{t+k}^k is market participants' expectational error, and Δs_{t+k}^e is the market expectation. We use the definition of the risk premium

$$rp_t^k = fd_t^k - \Delta s_{t+k}^e, \tag{4}$$

and a little algebra to write β 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:

$$\beta = 1 - b_{re} - b_{rp}, \tag{5}$$

where

$$b_{re} = \frac{-\mathrm{cov}(\eta_{t+k}^k, fd_t^k)}{\mathrm{var}(fd_t^k)} \qquad b_{rp} = \frac{\mathrm{var}(rp_t^k) + \mathrm{cov}(\Delta s_{t+k}^e, rp_t^k)}{\mathrm{var}(fd_t^k)}.$$

With the help of the survey data, both terms are observable. By inspection, $b_{re} = 0$ if there are no systematic prediction errors in the sample, and $b_{rp} = 0$ 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 2. First, b_{re} is very large in size when compared to b_{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, $b_{re} = 1.49$ and $b_{rp} = 0.08$. Second, while b_{re} is greater than zero in all cases, b_{rp} is sometimes negative, implying in (5) that the effect of the survey risk premium is to push the estimate of the standard coefficient β in the direction *above* one. In these cases, risk premia do not explain a positive share of the forward discount's bias. The positive values for b_{re}, 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. In sum, the risk premium appears to have little economic importance for the bias of the forward discount.[8]

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 2 are attributable to expectational errors, i.e., that the point estimates in column (1) are statistically significant; and (b) that they are attributable to the presence of the risk premium, i.e., that the point estimates in column (2) are statistically significant. We test these two (and several subsidiary) hypotheses in turn in subsequent sections.

2.3. The variance of expected depreciation vs. variance of the risk premium

Notice that for most of the sample periods in Table 1, β is significantly less than 1/2. It is precisely on the basis of such estimates that Fama (1984) and Hodrick and Srivastava (1986) have claimed that expected depreciation is less variable than the exchange risk premium. We state the Fama-Hodrick-Srivastava (FHS) interpretation of the results as:

$$\mathrm{var}(\Delta s_{t+k}^{e}) < \mathrm{var}(rp_t^k). \tag{6}$$

To see how they arrive at this inequality, we use the definition of the risk premium in (4) to write the FHS proposition as

$$\mathrm{var}(\Delta s_{t+k}^{e}) < \mathrm{var}(rp_t^k) + \mathrm{var}(fd_t^k) - 2\mathrm{cov}(fd_t^k, \Delta s_{t+k}^{e}),$$

or

$$\frac{\mathrm{cov}(fd_t^k, \Delta s_{t+k}^{e})}{\mathrm{var}(fd_t^k)} < \frac{1}{2}. \tag{6'}$$

The regression coefficient β, as given by (3), is

$$\beta = \frac{\mathrm{cov}(\Delta s_{t+k}, fd_t^k)}{\mathrm{var}(fd_t^k)}. \tag{7}$$

Under the assumption that the prediction error, η_{t+k}^k, is uncorrelated with fd_t^k, the coefficient β becomes the same as the ratio in the inequality (6'). Thus a finding of $\beta < 1/2$ satisfies the variance

[8] The results in Table 2 are not a consequence of aggregation. In the NBER working paper version, we report these results by currency for each data set in Table 2. There is little diversity in the results across currencies.

inequality in (6). Added intuition is offered by recalling the special case $\beta = 0$. This is the case identified by Bilson (1985): the variation in fd_t^k consists entirely of variation in rp_t^k, and not at all variation in Δs_{t+k}^e.

We can use expectations as measured by the survey data to investigate the FHS claim directly, without having to assume there is no systematic component to the prediction errors. Table 3 shows the variance of expected changes in the spot rate, as measured by the surveys, and the variance of the risk premia, for each data set. The variance of expected depreciation (column 3) is of the same order of magnitude as the variance of the risk premium (column 4), but is nevertheless larger in each of the samples.[9] Thus "random walk" expectations ($\Delta s_{t+k}^e = 0$) do not appear to be supported by the survey data. We test formally the Fama (1984) hypothesis that the variance of expected depreciation is less than the variance of the risk premium in section 3.

3. Does the risk premium explain any of the forward discount's bias?

In the previous section we offered point estimates of the bias in the forward discount, which suggested that more of the bias was due to a failure of rational expectations than to a time-varying risk premium. In this section we formally test whether the risk premium is correlated with the forward discount. In the next section we will formally test rational expectations.

Analogously to the standard regression equation, we regress our measure of expected depreciation against the forward discount:

$$\Delta \hat{s}_{t+k}^e = \alpha_2 + \beta_2 fd_t^k + \epsilon_t^k. \tag{8}$$

The null hypothesis that the correlation of the risk premium with the forward discount is zero implies $\beta_2 = 1$. By inspection, $\beta_2 = 1 - b_{rp}$, so that a finding of $\beta_2 = 1$ would imply that the results in column (2) of Table 2 are not statistically different from zero. Besides the hypothesis that there is no time-varying risk premium, (8) also allows us to test the hypothesis of a mean-zero risk premium: $\alpha_2 = 0$. The hypothesis that the risk premium is identically zero is given by $\Delta s_{t+k}^e = fd_t^k$. How then should we interpret the regression error ϵ_t^k? It is the random measurement error in the surveys. That is, $\Delta \hat{s}_{t+k}^e = \Delta s_{t+k}^e + \epsilon_t^k$, where Δs_{t+k}^e is the unobservable market expected change in the spot rate. Note also that in a test of (8) using the survey data, the properties of the error

[9] Although random measurement error in the survey data would tend to overstate each of these variances individually, it does not affect the estimate of their difference.

term, ϵ_t^k, will be invariant to any "peso problems," which affect, rather, the *ex post* distribution of actual spot rate changes.[10]

Table 4 reports the OLS regressions of (8). In some respects the data provide evidence in favor of perfect substitutability of assets denominated in different currencies. Contrary to the hypothesis of a risk premium that is correlated with the forward discount, all but one of the estimates of β_2 are statistically indistinguishable from one. In the *Economist* and *Amex* data sets which aggregate across time horizons, the estimates are 0.99 and 0.96, respectively.[11] Expectations seem to move very strongly with the forward rate. In addition, the coefficients are estimated with much greater precision than the corresponding estimates in Table 1.

In terms of our decomposition of the forward discount bias coefficient, Table 4 shows that the values of b_{rp} in column 2 of Table 2 are statistically far from one but 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, we cannot reject the hypothesis that the risk premium explains *no* positive portion of the bias.

There is strong evidence of a constant term in the risk premium however: α_2 is large and statistically greater than zero. Each of the F-tests reported in Table 4 rejects the parity relation at a level of significance that is less than 0.1 percent. Charts 1-4 make apparent the high *average* level of the risk premium (as well as its lack of correlation with the usual measure of the risk premium, the forward discount prediction errors).[12] Thus the qualitatively small values of b_{rp} reported in Table 2 should not be taken to imply that the survey responses include no information about investors' expectations beyond that contained in the forward rate.[13]

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[10] Another way of stating the null hypothesis in (8) is the proposition that domestic and foreign assets are perfect substitutes in investors' portfolios. Assuming that covered interest parity holds, the forward discount fd_t^k is equal to the differential between domestic and foreign nominal interest rates $i_t^k - i_t^{*k}$. The null hypothesis then becomes a statement of uncovered interest parity: $\Delta s_{t+k}^e = i_t^k - i_t^{*k}$. In other words, investors are so responsive to differences in expected rates of return as to eliminate them. For tests of uncovered interest parity similar to the tests of conditional bias in the forward discount that we considered in section 2, see Cumby and Obstfeld (1981).

[11] For the *Economist* six-month and twelve-month and the *Amex* twelve-month data sets, the estimates of β_2 from (8) do not exactly correspond to $1 - b_{rp}$ in Table 2. This is because Table 4 includes a few survey observations for which actual future spot rates had not yet been realized, whereas these observations were left out of the decomposition in Table 2 for purposes of comparability. If we had used the smaller samples in Table 4, the regression coefficients would have been .92 and 1.03, for the *Economist* and *Amex* data sets, respectively.

[12] 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 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.

[13] In Table 2 of the NBER working paper version of this study, we reported mean values of the risk premium as measured

We can also use (8) to test formally the FHS hypothesis that the variance of the risk premium is greater than the variance of expected depreciation. This is the inequality (6), which we found to be violated by point estimates in Table 3. The probability limit of the coefficient β_2 is:

$$\beta_2 = \frac{\text{cov}(\Delta \hat{s}^e_{t+k}, fd^k_t)}{\text{var}(fd^k_t)} = \frac{\text{cov}(\Delta s^e_{t+k}, fd^k_t)}{\text{var}(fd^k_t)}, \tag{9}$$

where we have used the assumption that the measurement error ϵ^k_t is uncorrelated with the forward discount fd^k_t. It follows from (9) that only if $\beta_2 < 1/2$ does the FHS inequality (6') hold; if β_2 is significantly greater than 1/2, the variance of expected depreciation exceeds that of the risk premium.

Table 4 reports a t-test of the hypothesis that $\beta_2 = 1/2$. 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 $\text{var}(\Delta s^e_{t+k}) > \text{var}(rp^k_t)$. Indeed, the finding that $\beta_2 = 1$ implies that the risk premium is uncorrelated with the forward discount:

$$\text{var}(rp^k_t) + \text{cov}(\Delta s^e_{t+k}, rp^k_t) = 0. \tag{10}$$

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

Under the null hypothesis that there is no time-varying risk premium and the regression error ϵ_t in (8) is random measurement error, we can use the R^2's from the regressions to obtain an estimate of the relative importance of the measurement error component in the survey data. The R^2 statistics in Table 4 are relatively high, suggesting that measurement error is relatively small. For example, under this interpretation of the R^2s, measurement error accounts for about 10 percent of the variability in expected depreciation from the *Economist* data. For a standard of comparison, the R^2 for the same sample period in Table 1, which uses *ex post* exchange rate changes as a noisy measure of expectations, implies that 84 percent of the variability in the measure is noise.[14]

by the survey data. They were different from zero at the 99 percent level for almost all survey sources, currencies and sample periods.

[14] In Table 6 of the NBER working paper version, we correct for the potential serial correlation problem in the *Economist* and MMS data sets by employing a Three-Stage-Least-Squares estimator that allows for contemporaneous correlation (SUR) as well as first order auto-regressive disturbances. This procedure does not substantively change the conclusions.

4. Do expectational errors explain any of the forward discount's bias?

In the previous section we formally tested the hypothesis that there exists no time-varying risk premium that could explain the findings of bias in the forward discount. In this section we formally test the hypothesis that there exist systematic expectational errors that *can* explain those findings.

4.1. 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 all other variables in their information set.[15] This test is performed by a regression of the expectational prediction error on expected depreciation:

$$\Delta \hat{s}^e_{t+k} - \Delta s_{t+k} = a + d\Delta \hat{s}^e_{t+k} + v^k_{t+k}, \tag{11}$$

where the null hypothesis is $a = 0$, $d = 0$, and the error term is the measurement error in the surveys less the unexpected change in the spot rate, $v^k_{t+k} = \epsilon^k_t - \eta^k_{t+k}$. This is the equation that Bilson (1981) and others had in mind, which we already termed a test of "excessive" speculation (see equation (2)), with the difference that we are now measuring investors' expected depreciation by the survey data instead of by the ambiguous forward discount.

Our tests are reported in Table 5. The findings consistently indicate that $d > 0$, so that investors could on average do better by giving more weight to the contemporaneous spot rate. 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 5 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 because the surveys have appeared only on the left-hand side of the equation. But now the surveys appear also on the right-hand side; as a result, under the null hypothesis, measurement error biases toward one our estimate of d in (11). In the limiting case in which the measurement error accounts for all of the variability of expected depreciation in

[15] Frankel and Froot (1986, 1987) 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.

the survey, the parameter estimate would be statistically indistinguishable from one. In Table 6, 13 of 15 estimates of d are *greater* 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, we shall now see that stronger evidence can be obtained.

4.2. Another test of excessive speculation

Another test of rational expectations, which is free of the problem of measurement error, is to replace $\Delta\hat{s}^e_{t+k}$ on the right-hand side of (11) with the forward discount fd^k_t:

$$\Delta\hat{s}^e_{t+k} - \Delta s_{t+k} = \alpha_1 + \beta_1 fd^k_t + v^k_{t+k}. \tag{12}$$

There are several reasons for making the substitution in (12). We know from our results in section 3 that expected depreciation is highly correlated with fd^k_t. Because fd^k_t is free of measurement error, it is a good candidate for an "instrumental variable." Indeed, if we as econometricians can look up the precise forward discount in the newspaper, we can also do so as prospective speculators. A finding of $\beta_1 > 0$ in either equation (9) or (13) suggests that a speculator could have made excess profits by betting against the market. But the strategy to "bet against the market" is far more practical if expressed as "bet against the (observable) forward discount" than as "do the opposite of whatever you would have otherwise done."

Equation (12) has additional relevance in the context of our decomposition of the forward rate unbiasedness regression in section 2: the coefficient, β_1, is precisely equal to the deviation from unbiasedness due to systematic prediction errors, b_{re}. Thus (12) can tell us whether the large positive values of b_{re} found in column (1) of Table 2 are statistically significant.

Table 6 reports OLS regressions of (12). We now see that the point estimates of b_{re} in Table 2 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 5.) The result that b_{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 2, we can now reject statistically the hypothesis that all of the bias is attributable to the survey risk premium. Also, we cannot reject the hypothesis that all

of the bias is due to repeated expectational errors made by survey respondents. This finding need not mean that investors are irrational. If they are learning about a new exchange rate process, or if there is a "peso problem" with the distribution of the error term, then one could not expect them to foresee errors in the sample period, even though the errors appear to be systematic *ex post.*

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TABLE 3

COMPARISON OF VARIANCES OF EXPECTED DEPRECIATION AND THE RISK PREMIUM

($x\ 10^2$ per annum)

FORECAST HORIZON	SURVEY SOURCE	DATES	N	(1) Variance of $\Delta s(t)$	(2) Variance of fd(t)	(3) Variance of Δs^e	(4) Variance of rp(t)	(5) (3)-(4)
1 WEEK	MMS	10/84-2/86	247	2.756	NA	0.346	NA	NA
2 WEEKS	MMS	1/83-10/84	187	0.703	NA	0.113	NA	NA
1 MONTH	MMS	10/84-2/86	176	2.285	0.008	0.258	0.240	0.018
3 MONTHS	MMS	1/83-10/84	187	0.610	0.014	0.067	0.062	0.005
	ECONOMIST	6/81-12/85	190	1.651	0.051	0.178	0.121	0.056
6 MONTHS	ECONOMIST	6/81-12/85	190	2.004	0.093	0.173	0.082	0.091
	AMEX	1/76-8/85	51	1.658	0.111	0.134	0.084	0.051
12 MONTHS	ECONOMIST	6/81-12/85	195	1.368	0.155	0.215	0.092	0.123
	AMEX	1/76-8/85	51	1.446	0.192	0.195	0.129	0.066

Note: The variance of the forward rate prediction error and its correlation with the risk premium are reported in the NBER Working Paper.

TABLE 4
TESTS OF PERFECT SUBSTITUTABILITY

OLS Regressions of Δs^{e}_{t+k} on fd^{k}_{t}

Data Set	Dates	β	t: β=.5	t: β=1	R^2	DF	DW	F test α=0, β=1	F probability
Economist Data	6/81-12/85	0.9880 (0.1465)	3.33 ***	-0.08	0.89	554	1.44	29.61	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.

Regressions aggregate over all currencies. Constant terms were estimated for each currency, but are not reported to save space.

TABLE 5
TESTS OF EXCESSIVE SPECULATION

Regressions of $\Delta \hat{s}^{e}_{t+k} - s_{t+k}$ on $\Delta \hat{s}^{e}_{t+k}$

Data Set	Dates	β	t: β=0	t: β=1	R^2	DF	DW	F test α=0, β=0	F probability
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	0.23	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	192	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.

Regressions aggregate over all currencies. Constant terms were estimated for each currency, but are not reported to save space.

CHART 1

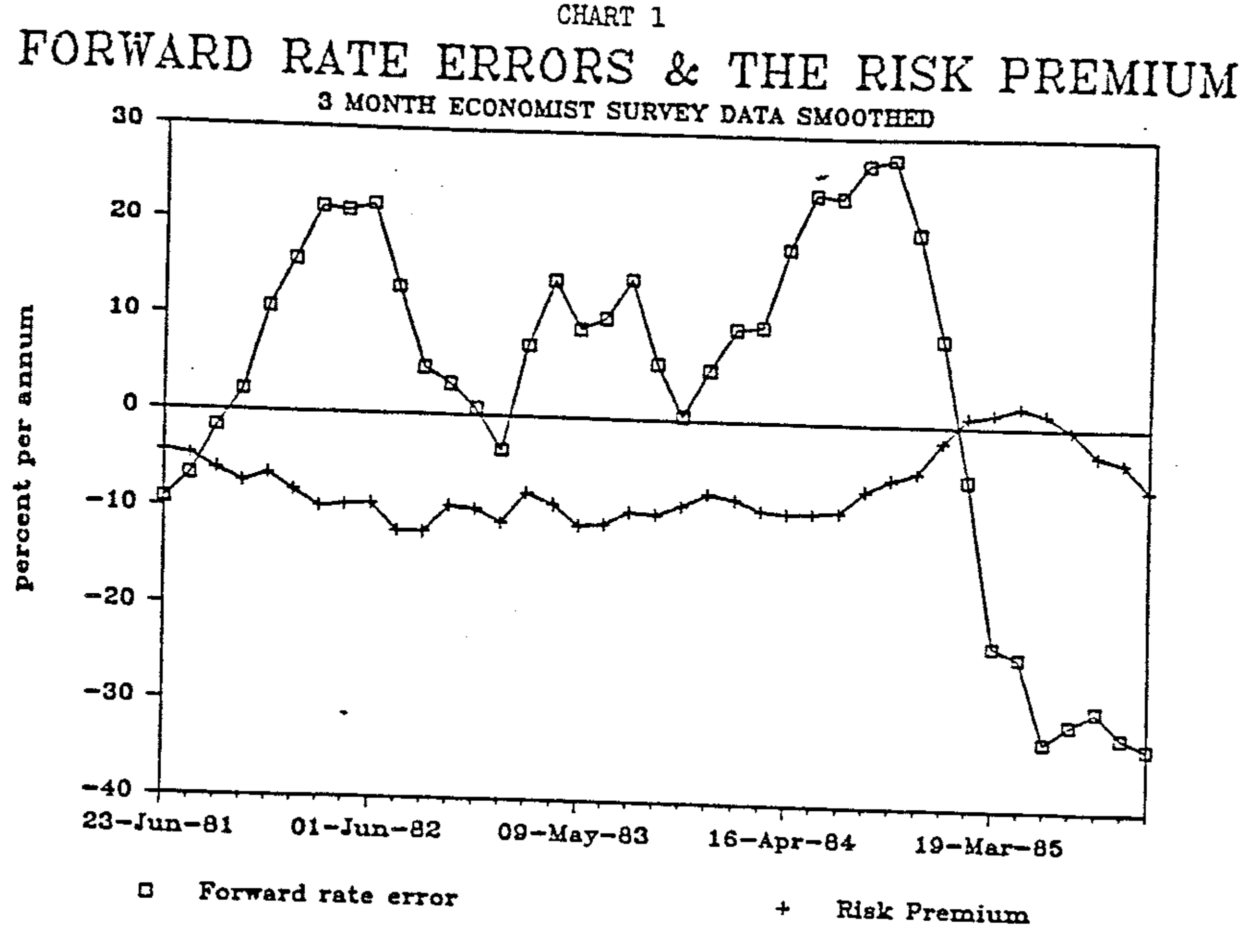

CHART 3

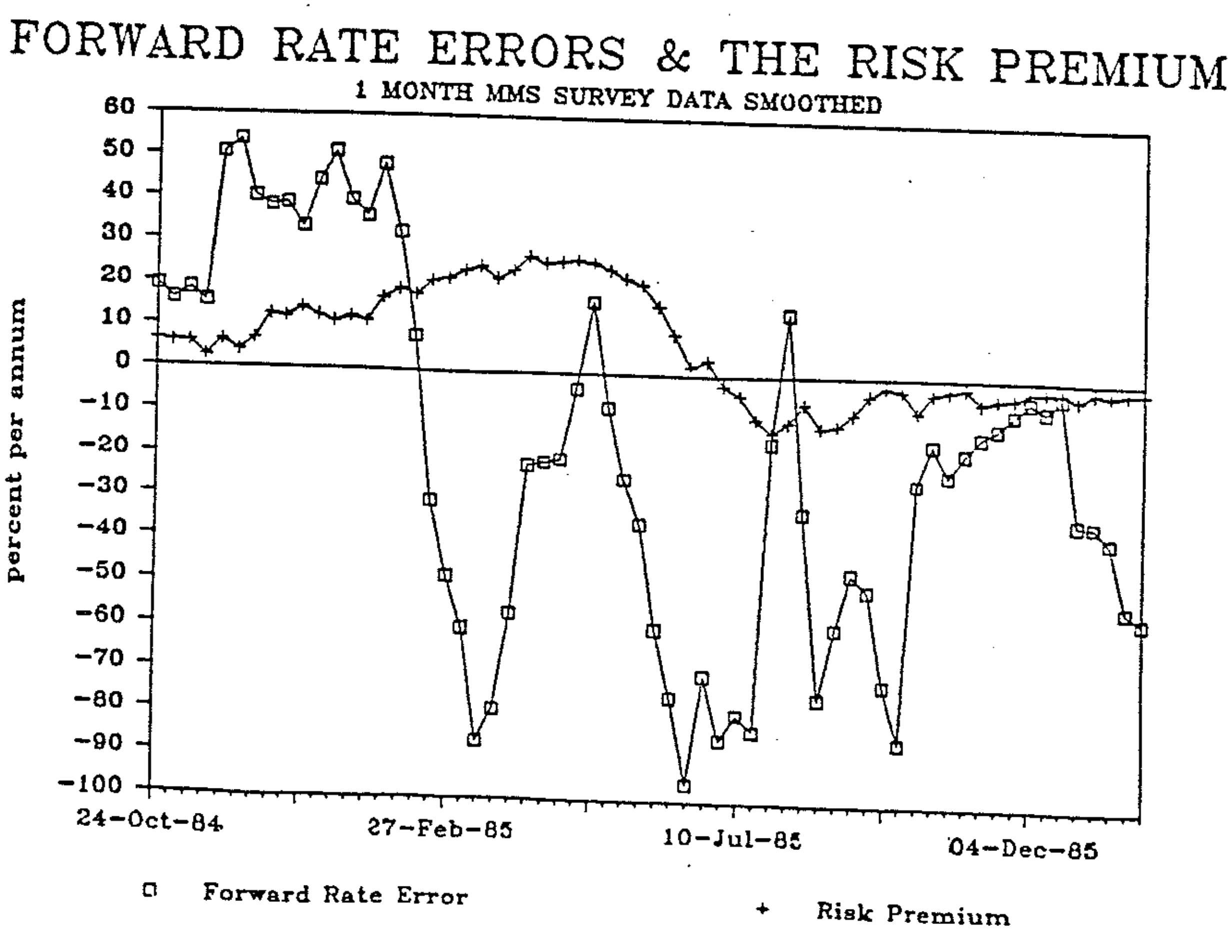

CHART 2

FORWARD RATE ERRORS & THE RISK PREMIUM

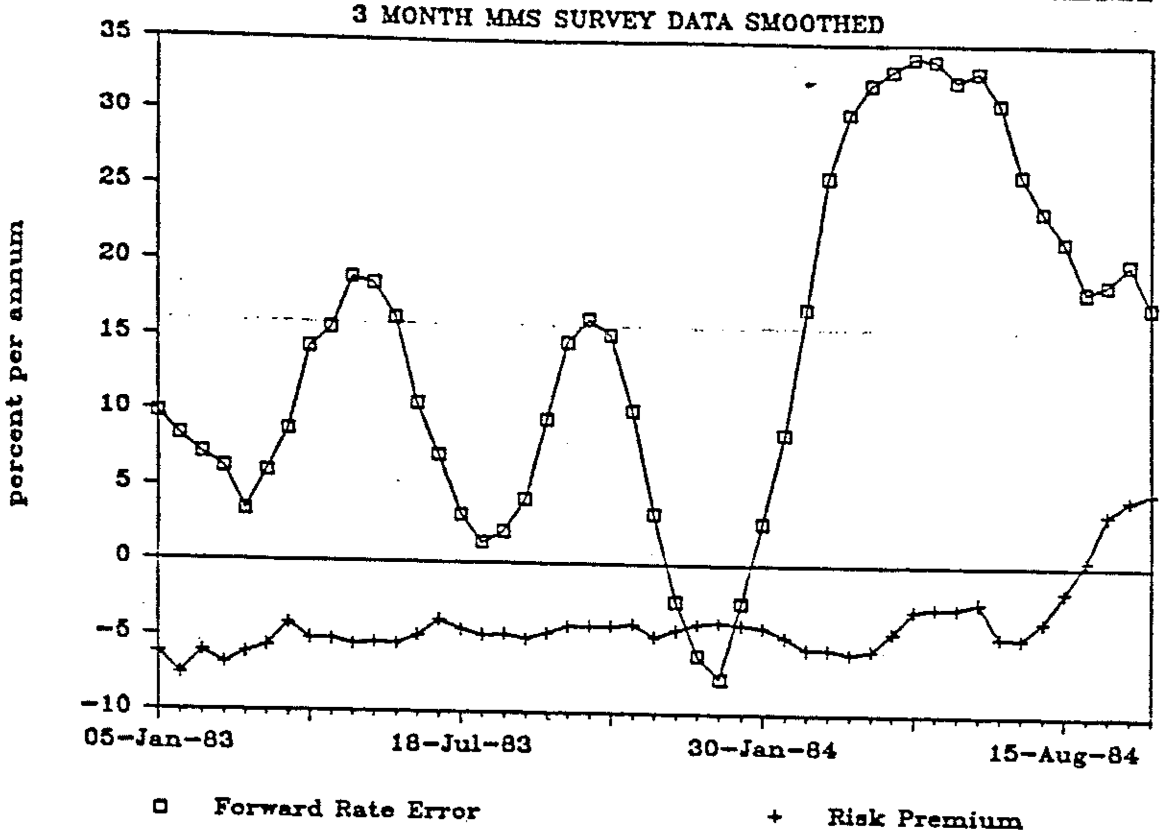

CHART 4.

FORWARD RATE ERRORS & THE RISK PREMIUM