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EXCHANGE RATE FORECASTING TECHNIQUES, SURVEY DATA, AND IMPLICATIONS FOR THE FOREIGN EXCHANGE MARKET

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ABSTRACT

The paper presents new empirical results that elucidate the dynamics of the foreign exchange market. The first half of the paper is an updated study of the exchange rate expectations held by market participants, as reflected in responses to surveys, and contains the following conclusions. First, the bias observed in the forward discount as a predictor of the future spot rate is not attributable to an exchange risk premium, as is conventionally believed. Second, at short horizons forecasters tend to extrapolate recent trends, while at long horizons they tend to forecast a reversal. Third, the bias in expectations is robust in the samples, based on eight years of data across five currencies.

The second half of the paper abandons the framework in which all market participants share the same forecast, to focus on the importance of heterogenous expectations. Tests suggest that dispersion of opinion, as reflected in the standard deviation across respondents in the survey, affects the volume of trading in the market, and, in turn, the degree of volatility of the exchange rate. An example of how conflicting forecasts can lead to swings in the exchange rate is the model of "chartists and fundamentalists." The market weights assigned to the two models fluctuate over time in response to recent developments, leading to fluctuations in the demand for foreign currency. The paper ends with one piece of evidence to support the model: the fraction of foreign exchange forecasting services that use "technical analysis" did indeed increase sharply during 1983-85, but declined subsequently.

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I. Introduction

Forecast data gathered in surveys of participants in the foreign exchange market, as a way of measuring expectations regarding future exchange rates, offer an alternative to the forward market or ex post changes in the spot rate. Studies using this data thus help shed light on some of the thorniest questions in international finance. But they raise some new questions of their own. In particular, they oblige one to conflict the reality that market participants do not in fact all use a common agreed-upon model for thinking about the foreign exchange market, and thus do not all share the same expectations at any point in time.

In this paper we focus on the heterogeneity of expectations. We offer some evidence that the degree of dispersion of forecasts, as measured by the standard deviation of responses across participants in the survey, is related to the volume of trading and to volatility in the market. We also know that the existence of "technical analysis" as an approach to exchange rate forecasting, alongside traditional models based on economic fundamentalists, is an important example of heterogeneity in expectations-formation and how it can lead to extra movement in the exchange rate.

II. Updated Tests of Exchange Rate Expectations Using Survey Data

The proper measurement of investors' expectations regarding exchange rates is critical to attempts to answer many of the most important questions in the field of international finance. How responsive are international investors' to expected rates of return? Does sterilized foreign exchange intervention have an effect in the market? Are expectations rational? Do speculators extrapolate past trends?

In the past, there were only two possible approaches to measuring investors' expectations, and each had serious drawbacks. The first is to use the forward exchange market. The well-known drawback here is that, if investors are risk-averse, then a time-varying exchange risk premium may cause the observed forward discount to deviate from the expected rate of depreciation that one wishes to measure. The proposition that the risk premium is constant or zero is a proposition that one would like to be able to test rather than impose a priori. The second approach is to use the rational expectations methodology, that is, to infer what investors must have expected ex ante from what actually happened ex post. The drawback here is that during episodes of large swings in the exchange rate, it appears implausible that investors could in fact have anticipated the swing, or that the risk premium could be large enough to explain the observed differences in average rates of return across countries, even when the movements appear prolonged enough to pass standard tests of

statistical significance. 1/ [The rational expectations methodology could fail either because agents do not act rationally or because distribution difficulties associated with the "peso problem" invalidate the test statistics in conventional sample sizes.] The proposition that observed patterns of movement in the exchange rate reflect investors' expectations is a proposition that one would like to be able to test rather than impose a priori.

In recent years, a number of researchers have begun to use survey data as a third alternative for measuring investors' expectations. They include Dominguez (1986), Frankel and Froot (1985, 1987, 1989), Froot and Frankel (1989), Froot and Ito (1988) and Ito (1989). A measure of expected depreciation based on survey data is exempt from the problems that plague the conventional measures, and can be used to test propositions such as the constancy of the risk premium and the validity of the rational-expectations methodology. Of course, the survey data undoubtedly have problems of their own; their measurement of market participants' expectations may be subject to error. Nevertheless, even allowing for the possibility of measurement error, there is much that one can learn from this approach.

The purpose of the first half of this paper is to update many of the results on a data sample that runs through 1988, and to review what has been learned from the survey data about the behavior of expectations in the foreign exchange market. We will be testing a number of issues: whether there is a time-varying risk premium, whether the rational expectations methodology is valid, and whether market participants tend to form their expectations by extrapolating past trends (as the popularity of "technical analysis" in the marketplace would suggest).

There exists a benchmark hypothesis that is useful for evaluating our results throughout. It is the hypothesis of static expectations: investors' expected future spot rate is equal to today's spot rate, so that expected depreciation is constant at zero. This hypothesis is not a "straw man." Ever since Meese and Rogoff (1983), a common finding has been that the exchange rate follows a random walk; that changes in the spot rate cannot be predicted (whether by the forward exchange market, the recent history of the spot rate, or economic models). The rational-expectations methodology, applied to the random-walk finding, would imply the static-expectations hypothesis: if the optimal predictor of changes in the spot rate is zero, then that must be what investors expect as well. An over-arching conclusion of this paper, however, rejects this view: the

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1/ Cutler, Poterba and Summers (1989), Engel and Hamilton (1989), Frankel and Froot (1989), and Krugman (1985). Kasdan and Pigott (1988, p.37) point out that differences in ex post rates of return across currencies (the deutsche mark, yen, and pound, each relative to the dollar) typically exceed the differences between yields on very high risk junk bonds and AAA-rated bonds.

expected depreciation variable, far from being tied down to zero, is both large and variable.

1. The risk premium

We begin with the topic of the risk premium, so as to make clear from the beginning how misleading the traditional approach can be, and how much difference our use of the survey data makes.

The conventional rational expectations methodology tries to learn about the exchange risk premium by looking at bias in the forward exchange market. The standard regression equation is:

$$\Delta s_{t+1} = a + b\ fd_t + u_{t+1} \qquad (1)$$

The null hypothesis of unbiasedness is represented by b=1: all the variation in the forward discount would be explained as variation in expected depreciation, rather than as variation in the risk premium. (Sometimes the null hypothesis is also interpreted as implying a=0. But usually the focus is on the time-varying component of the bias, rather than on the constant term. 1/)

The standard finding is that the coefficient b is in fact significantly less than one. Often it is close to zero (or even negative). Under the rational expectations methodology, this rejection of the null hypothesis is interpreted as evidence of an exchange risk premium that varies over time with the forward discount. When results show an estimate of b that is insignificantly different than zero--an instance of the popular random-walk findings--the rational expectations methodology interprets it as evidence that there is no variation in expected depreciation, and that all the variation in the forward discount represents variation in the exchange risk premium. Fama (1984) and Hodrick and Srivastava (1986) have argued that when b is found to be significantly less than 1/2, this is evidence that the variation in expected depreciation (even if not zero) is smaller than the variation in the risk premium. 2/

1/ One reason to allow for a constant term is to allow for the possible role of the convexity term that can emerge from Jensen's inequality.

2/ Koedijk and Ott (1987) purport to weigh the two alternative interpretations of the standard forward bias regression. But, in fact, the article imposes the rational expectations methodology, thereby ruling out the alternative interpretation a priori, just as Fama and Hodrick-Srivastava do.

It is important, first, to reproduce the standard results of regression equation (1) for our sample period. Otherwise, commentators may erroneously attribute to differences in the sample the difference in results obtained when we use the survey data (in place of ex post changes in the spot rate) to measure expectations. 1/ Table 1 reports the regression of the ex post spot rate change against the forward discount, for the period June 1981 to August 1988. In each case, the three-month, six-month, and 12-month horizons, we find highly significant bias in the forward discount (we reject b = 1). In fact, the estimates of the coefficient are even less than zero, and significantly so. 2/ The question is whether the bias is evidence of a time-varying risk premium, expectational errors, or some combination of the two.

Table 2 reports an update of our test of the time-varying risk premium. It is a regression of the expected depreciation of the currency, as measured by the survey data, against the forward discount:

$$\Delta s_t^e = a_2 + b_2 \, fd_t + e_t \qquad (2)$$

For two out of the three maturities studied, the coefficients are even closer to 1 than they were in the 1981-1985 results. Expected depreciation appears to move closely with the forward discount. The results support the view that variation in expected depreciation is a large part of variation in the forward discount, and variation in the risk premium a small part, precisely the reverse of the conventional wisdom, even more strongly than did the earlier results. Three null hypotheses are relevant: $b_2 = 0$, $b_2 = 0.5$, and $b_2 = 1$. The first null hypothesis would represent the view that none of the variation in the forward discount represents variation in expected depreciation; it is easily rejected at the 99 percent level of significance. The second represents the middle-of-the-road case where the variance of expected depreciation is equal to the variance of the exchange risk premium; it is also rejected at conventional significance levels, in favor of the hypothesis that expected depreciation is more variable than the risk premium. The third hypothesis represents the view that all the variation in the forward discount represents variation in expected depreciation, and none represents variation in the risk premium; the results by a wide margin do not reject this hypothesis.

These findings do not necessarily mean that the risk premium is zero, or even that it is constant. A majority of the t-ratios, when computed for the five individual currencies, show statistically significant constant terms, part of which could be due to constant

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1/ Koedijk and Ott (1987) and Hodrick (1987) both try to attribute our results using the survey data to peculiarities of the sample period, while exempting the standard results using ex post changes from the same verdict.

2/ These results are similar to those in Froot and Frankel (1989), and many others before, but are a little stronger.

Table 1. Standard Test of Forward Rate Bias:
OLS Regression of $Ds_{t+1} = a + b\ fd_t + u_{t+1}$
(Economist survey, June 1981-August 1988)

Term (k)	3-month	6-month	12-month
b estimate	-1.916	-2.539	-2.080
Standard error	0.580	0.467	0.458
GMM s.e. (homos.)	0.907	0.875	1.065
GMM s.e. (hetero.)	0.979	1.010	0.766
t: b=0	-2.11*	-2.90*	-1.95
t: b=0.5	-2.66**	-3.47*	-2.42
t: b=1	-3.21*	-4.04*	-2.89*
F: a=0, b=1	3.14*	10.00*	x
DF	309	309	0
R^2	0.05	0.12	0.11
DW (lower bound)	1.01	0.54	0.24

* Significant at 99 percent level.

Table 2. Test for Time-Varying Risk Premium:
OLS Regression of $Ds_t^e = a_2 + b_2\, fd_t + e_t$

Term (k)	3-month	6-month	12-month
b_2 estimate	1.123	1.113	1.005
Standard error	0.143	0.096	0.099
GMM standard	0.196	0.146	0.185
Error (homos.)	0	0	0
GMM s.e. (correcting for heteros.)	0.198	0.122	0.169
t: b_2=0	5.73*	7.61*	5.44*
t: b_2=0.5	3.18*	4.20*	2.73*
t: b_2=1	0.63	0.77	0.03
F: a_2=0,b_2=1	20.9*	41.8*	x
DF	308	0	0
R^2	0.36	0.58	0.53
DW (lower bound)	1.60	1.29	0.90

Notes: GMM standard errors are calculated using the Generalized Method of Moments; although overlapping observations are not an issue because ex post spot rate changes do not enter in, pooling across currencies creates a correlation across exchange rates.

Correcting for possible heteroskedasticity makes little difference; the reported test statistics assume homoskedasticity. Separate constant terms were estimated for each currency, but are not reported, to save space. The five currencies are the pound, mark, Swiss franc, yen and French franc.

x: F stat not reported, because GMM covariance matrix not positive definite.

* Significant at 95 percent level.

risk premiums (as opposed to the convexity term). 1/ Indeed, a recent examination of the effects of sterilized intervention in the foreign exchange market finds that the risk premium, as measured with survey data, varies systematically with daily intervention and with the spot rate variance (Dominguez and Frankel, 1989). However, the present finding does strongly suggest that variation in the forward discount does not reflect variation in the exchange risk premium as conventionally thought.

2. Are expectations biased?

If the bias in the forward discount as a predictor of the future spot rate does not represent a risk premium, does it instead represent a statistically significant bias in the expectations of market participants? This question can be answered directly using the survey data. Earlier papers found that the answer was "yes." 2/ The bias was still not necessarily attributed to a failure of investors to be rational, however; an alternative possible explanation, as in the conventional literature on the bias in the forward rate, was a set of problems associated with the distribution of the forecast error: structural change in the true model, learning by investors and the "peso problem". To try to mitigate such problems, a larger sample size, particularly one that includes both upswings and downswings of the dollar, is important.

The null hypothesis to be tested is that the errors that respondents make in predicting the future change in the spot rate are independent of information that is contemporaneously available. We have found [both in past studies and in the present data sample] that the most powerful test of this hypothesis is a test for "over-excitability." 3/ This is a regression of the prediction error against the forward discount.

$$\Delta s_{t+1} - \Delta \hat{s}^{e}_{t} = a_1 + c\ fd_t + v_{t+1} \qquad (3)$$

The unbiasedness hypothesis is represented by $c = 0$. The alternative is $c < 0$: speculators could reduce their errors by moving their predictions in the direction of betting against the forward discount. To see why the alternative has been described as the hypothesis that speculators are

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1/ Kasdan and Pigott (1988, p. 37) use our survey data to compute average foreign exchange risk premia for the dollar against the mark, yen and pound, and find them in the range of 2.86 to 7.75 percent. Such risk premia would be smaller and more plausible than the differences in ex post rates of return across currencies. It is also quite possible that part of the variation in the regression error term could be attributed to a (time-varying) risk premium, though the interpretation preferred in Froot and Frankel (1989) is that the regression error represents (random) measurement error in the survey data.

2/ Dominguez (1987), Frankel and Froot (1987,1988) and Froot and Frankel (1989).

3/ Or "excessive speculation." The expressions are due to Bilson (1981).

overly excitable, recall the conclusion from the preceding section that variation in the forward discount reflects variation in investors' expectations. Thus a negative estimate of the coefficient c would suggest that one could expect to make excess profits by adjusting one's forecasts for change in the direction away from the forecasts of the marketplace. 1/ The case where $c = -1$, combined with the finding of the preceding section that $b_2 = 1$, would imply that an optimal strategy for speculators would be to ignore all information that they currently use (as reflected either in the forward discount or the survey data), and instead to forecast the spot rate as a random walk (possibly with drift).

Estimates of equation (3) are reported in Table 3. In each case, except the MMS 4-week forecast, the coefficient is significantly less than zero at the 99 percent confidence level, suggesting that speculators could indeed expect to make excess profits by betting against the forward discount. The estimates are qualitatively the same as in Froot and Frankel (1989), but the significance levels are much higher. 2/ If the bias is due to a peso problem, eight years of fluctuations across five exchange rates has not been enough to eliminate it.

3. Do speculators extrapolate?

We have established that the market's expectations as to future changes in the exchange rate are not constant, though they would be more accurate if they were. How do market participants determine these expectations?

In earlier work, we found that at the shorter-term horizons (1-week and 4-week) captured in the surveys by Money Market Services, Inc., market participants tended to extrapolate the trends of the recent past, while at the longer-term horizons (3-, 6-, and 12-month) captured in the surveys by the Financial Report the respondents, to the contrary, tended to forecast a return to a long-run equilibrium such as Purchasing Power Parity. 3/

1/ In Froot and Frankel (1989) we also try the test using the survey data to measure expected depreciation on the right-hand side of the equation. But the argument for using the forward discount on the right-hand side is so that any measurement error in the survey data will not bias the estimate. [Measurement error in the left-hand side variable, in this test or any of the others in the paper, will not bias the results, provided the measurement error is random.]

2/ In the case of the MMS 4-week equation, the estimates reported in the 1989 paper (the middle row of the nine rows in Table VI) are suspect, due to some erroneous observations in the 4-week survey data set. (No correct 4-week survey data is in fact available from MMS before October 1984.) For the MMS 4-week horizon, the results reported in this paper supersede those in the earlier paper. The other results reported earlier were correct.

3/ Frankel and Froot (1989) and, for the case of the yen, Frankel and Froot (1988).

Table 3. Test for Biased Expectations ("overexcitability"): OLS Regression of $Ds_{t+1} - D\hat{s}_t^e = a_1 + c\ fd_t + v_{t+1}$

	MMS survey Oct.1984-Jan.1988		Economist survey June 1981-Aug.1988	
Term (k)	4-week	3-month	6-month	12-month
Estimate of under-excitability parameter c	-0.006	-2.992	-3.586	-3.129
Standard Error	0.615	0.609	0.505	0.479
GMM s.e.(homos.)	0.863	0.930	0.926	1.040
GMM s.e. (hetero)	0.809	1.053	1.083	0.820
t: c=0	-1.17	-3.22*	-3.875*	-3.007*
F: a_1=c=0	3.24*	2.33	4.36*	182.64*
DF	(5,659)	(6,308)	(6,308)	(6,308)
DW (lower bound)	1.04	0.89	0.48	0.29
R^2	0.001	0.08	0.15	0.14

* Significant at 99 percent level.

The upper half of Table 4 reports updated estimates of the degree to which respondents extrapolate past expectations. As in earlier results, the 1-week and 4-week horizons show "bandwagon" tendencies. 1/ In a week in which the dollar has appreciated by 1 percent, the market expects the dollar to rise another 0.13 percent over the subsequent week. Also as before, the longer-term horizons show the reverse. When the dollar has appreciated by 1 percent, the market expects it to depreciate by 0.08 percent over the subsequent three months, 0.17 percent over the subsequent six months, and 0.33 percent over the coming 12 months. These estimated parameters are higher than in the earlier study (though only in the case of the 3-month horizon has the significance level increased).

Another way to specify expectations is the regressive model, as in Dornbusch overshooting, reported in the lower half of Table 3. The parameter again rises in magnitude over time, reaching 0.14 at the 12-month horizon. But these magnitudes and significance levels are somewhat lower than in the earlier study.

In the preceding section we found that, whatever information it is that speculators look at to form their forecasts, they would do better--at least at longer-term horizons of 3, 6, and 12 months--if they stopped. In this section, we have found that speculators form their forecasts--at longer-term horizons--by predicting a partial reversal of the most recent trend. Would they do better if they stopped their habit of predicting a reversal, perhaps even switched to extrapolating in the way they do at shorter horizons? Table 5 reports the results of a regression of the respondents' forecasting errors against the lagged change in the exchange rate. At shorter horizons, their tendency to extrapolate the recent trend appears to be about right. But at the longer horizons, where Table 4 told us that they tend to forecast a reversal of the recent trend, they would do better to move in the direction of setting their forecasted future rate closer to the contemporaneous spot rate. In the case of the 6-month and 12-month horizons, the bias in respondents' forecasts is statistically significant.

III. Chartists, Fundamentalists and Trading in the Foreign Exchange Market

The overshooting theory of exchange rates seems ideally designed to explain some important aspects of the movement of the dollar in recent years. Over the period 1981-1984, for example, when real interest rates in the United States rose above those among trading partners (presumably due to shifts in the monetary/fiscal policy mix), the dollar appreciated strongly. It was the higher rates of return that made U.S. assets more attractive to international investors and caused the dollar to appreciate.

1/ The estimated degrees of extrapolation are similar to the earlier ones, but the significance levels are lower, despite the fact that the length of the sample period for 1-week and 4-week MMS data has more than doubled.

Table 4. Extrapolative and Regressive Expectations:
OLS regression of $D\hat{s}_t^e = a + g\, Ds_t + e_t$

Survey Data Source	MMS International		Economist		
Sample period	Oct.1984-Jan.1988		June 1981-Aug.1988		
Term of forecast	1-week	4-week	3-month	6-month	12-month
Estimate of extrapolative parameter	0.13	0.08	-0.08	-0.17	-0.33
Standard Error	0.02	0.03	0.01	0.02	0.03
GMM s.e.(homos.)	0.03	0.05	0.03	0.03	0.06
GMM s.e. (hetero.)	0.04	0.07	0.03	0.03	0.05
t-statistic	4.32*	1.60	-2.98*	-4.98*	-
F: a = g = 0	20.70*	31.45*	35.31*	94.69*	x
DF	(5,663)	(5,659)	(6,308)	(6,308)	
DW (lower bound)	1.74	1.59	1.52	1.07	0.74
R^2	0.11	0.09	0.30	0.53	0.58
OLS regression of $D\hat{s}_t^e = a + h\,(s_t - \bar{s}) + e_t$					
Estimate of parameter (-h)			-0.10	-0.048	-
Standard Error			0.006	0.007	0.10
GMM s.e. (homos.)			0.014	0.018	0.030
GMM s.e. (hetero)					
t-statistic			-0.726	-2.73*	-
F: a = h = 0			46.96*	88.44*	836.06*
DF			(6,308)	(6,308)	(6,309)
DW (lower bound)			1.42	1.02	0.93
R^2			0.23	0.47	0.61

* Significant at 99 percent confidence level.
x Cov matrix not positive definite.

Table 5. Test for Biased Expectations ("insufficient extrapolation")
OLS Regression of $Ds_{t+1} - D\hat{s}_t^e = a + d\ Ds_t + v_{t+1}$

	MMS survey Oct. 1984 - Jan. 1988		Economist survey June 1981 - Aug. 1988		
Term (k)	1-week	4-week	3-month	6-month	12-month
Estimate of under-extrapolation parameter	-0.025	-0.101	0.165	0.433	0.841
Standard Error	0.042	0.095	0.060	0.433	0.841
GMM s.e. (homos.)	0.069	0.149	0.130	0.209	0.375
GMM s.e. (hetero.)	0.087	0.187	0.128	0.211	0.295
t:d=0	-0.362	-0.681	1.264	2.068*	2.243*
F: a=d=0	2.14	3.24**	x	2.20*	4.63**
DF	(5,663)	(5,654)		(6,308)	(6,308)
DW (lower bound)	1.84	1.02	0.87	0.53	0.36
R^2	.005	.003	0.03	0.08	0.12

* Significant at 95 percent level.
** Significant at 99 percent level.
x Cov matrix not positive definite.

The overshooting theory would say that, as of 1984 for example, the value of the dollar was so far above its long-run equilibrium that expectations of future depreciation [formed in the manner of the equation for regressive expectations that is estimated in the bottom half of Table 3] were sufficient to offset the higher nominal interest rate in the minds of international investors. (Figure 1 shows the correlation of the real interest differential with the real value of the dollar, since exchange rates began to float in 1973.

1. Bubble episodes

At times, however, the path of the dollar has departed from what would be expected on the basis of macroeconomic fundamentals. The most dramatic episode is the period from June 1984 to February 1985. The dollar appreciated another 20 percent over this interval, even though the real interest differential had already begun to fall. The other observable factors that are suggested in standard macroeconomic models--money growth rates, real growth rates, the trade deficit--at this time were also moving in the wrong direction to explain the dollar rise.

It is now widely accepted that standard observable macroeconomic variables are not capable of explaining, much less predicting ex ante, the majority of short-term changes in the exchange rate. But economists divide into two camps on what this means. One view is that the unexplained short-term changes must be rational revisions in the market's perception of the equilibrium exchange rate due to shifts in "tastes and technologies," even if the shifts are not observable to macroeconomists in the form of standard measurable fundamentals. Campbell and Clarida (1987) have used the identity that the current exchange rate must equal the long-run equilibrium exchange rate plus the cumulation of the expected future change in the exchange rate as reflected in the long-term interest differential, to argue that changes in the long-run equilibrium rate must explain the majority of changes in the observed exchange rate since changes in the real interest differential cannot do so.

A major difficulty with this interpretation is that it is difficult to believe that there could have been an increase in the world demand for U.S. goods (or in U.S. productivity) sufficient to increase the equilibrium real exchange rate by more than 20 percent over a 9-month period, and that such a shift would then be reversed over the subsequent nine months.

This brings us to the second view, which is that the appreciation may have been an example of a speculative bubble: that it was not determined by fundamentals, but rather was the outcome of self-confirming market expectations. The dollar "overshot the overshooting equilibrium." Some have suggested that the appreciation of 1988-89, on a smaller scale, may also have been of this nature.

There exists elegant theories of "rational speculative bubbles," in which all participants know the correct model. But these theories have

the disadvantage of having nothing to say about what causes such bubbles to get started. Some observers have suggested that 1984-85 may best be described as a bubble that was not characterized by rational expectations. 1/ We have suggested that such episodes may best be described by models of bubbles in which market participants do not agree on the model for forecasting the exchange rate. 2/

While the conventional approach in the literature, theoretical as well as empirical, is to assume that there is such a thing as "the" market expectation of the future exchange rate, there is evidence that investors have heterogeneous expectations. For one thing, the expectations surveys examined in the first half of this paper show wide dispersion at any point in time. The magnitude of the dispersion of course increases with the horizon of the forecast. The data in the survey conducted by MMS International show a dispersion of opinion (as measured by the standard deviation [of the log] across respondents) that averaged 1.0 percent at the 1-week horizon and 2.2 percent at the 1-month horizon for the yen/dollar rate. The dispersion was slightly higher for the deutsche mark, pound and Swiss franc rates: 1.2, 1.2, and 1.3 percent, respectively, at the 1-week horizon, and 2.6, 2.7, 2.7 percent at the 1-month horizon. (The sample period is October 1984 to December 1987; further results using these data are reported in the next section.) The survey conducted by the Financial Report (affiliated with the Economist) reports a high-low range of 6-month forecasts that averages 15.2 percent. A recent survey by Currency Forecasters' Digest reports a high-low spread of 45 percent at the 5-year horizon (for the yen/dollar rate, September 1989).

2. Trading in the foreign exchange market

The tremendous volume of foreign exchange trading is another piece of evidence that reinforces the idea of heterogeneous expectations, since it takes differences among market participants to explain why they trade. The Federal Reserve Bank of New York (1989) has released its three-yearly count of transactions in the U.S. foreign exchange market. It showed that in April 1989, foreign exchange trading (adjusted for double-counting) totaled $110.5 billion a day among banks, an increase of 121 percent from March 1986. The total including trading among nonbank financial institutions was $129 billion. Simultaneous counts in London and Tokyo reported

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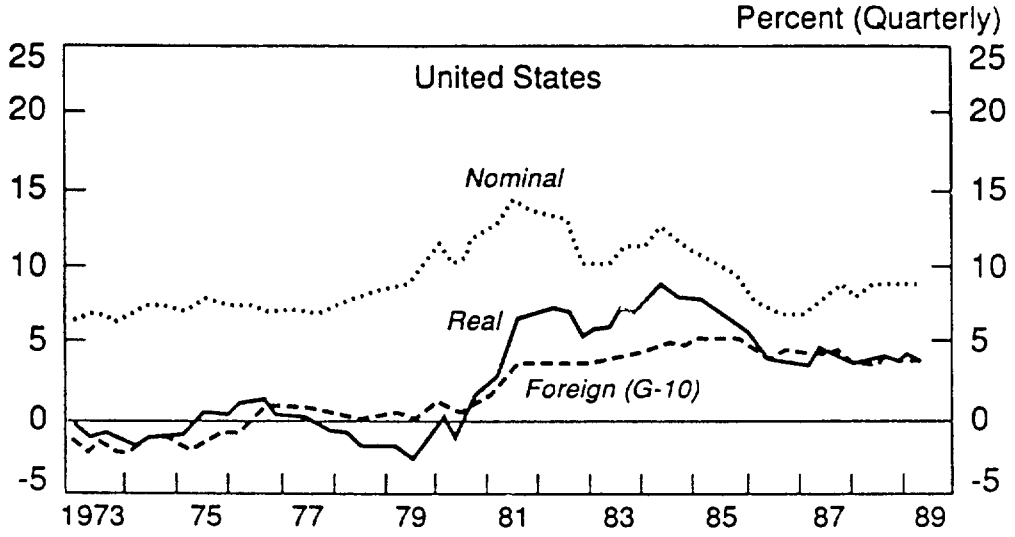
1/ Paul Krugman (1985) was one of the first to suggest that the market did not appear to realize the extent to which the appreciation of the dollar was not sustainable. Charles Engel and James Hamilton (1989) find that long-term swings are a general characteristic of exchange rates, and that they are not adequately reflected in the forward market. Such findings of predictable excess returns are standardly interpreted as risk premiums. But the evidence from survey data reported in the first section of this paper suggests that the prediction errors of the forward market are not due to risk premiums.

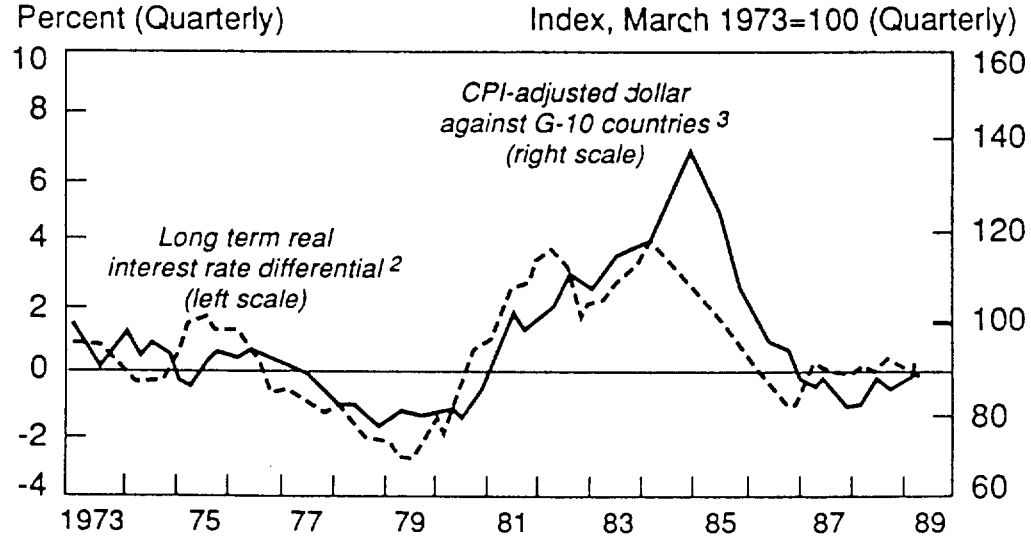
2/ Frankel and Froot (1988).

FIGURE 1

NOMINAL AND REAL LONG TERM INTEREST RATES [1]



THE DOLLAR AND REAL INTEREST RATES



Source: Federal Reserve Board macro data base. P. Hooper and C. Mann.

[1] Long-term government or public authority bond rates adjusted for expected inflation estimated by a 36-month centered calculation of actual inflation. Foreign index uses the same trade weight as described in note 3.

[2] Long-term real U.S. interest rate minus weighted average of long-term real foreign-country interest rates.

[3] The CPI adjusted dollar is a weighted average index of the exchange value of the dollar against the currencies of the foreign Group-of-Ten countries plus Switzerland, where nominal exchange rates are multiplied by relative levels of consumer price indexes. Weights are proportional to each foreign country's share in world exports plus imports during 1978-83.

$187 billion and $115 billion a day, respectively. The worldwide total is probably well over $500 billion of foreign exchange trading a day. 1/

Perhaps this growing volume of foreign exchange trading is simply servicing the growing volume of international trade and investment, rather than "speculation"? This seems unlikely; the volume is over 100 times as large as trade flows. Interestingly, the banks in the 1989 census by the New York Federal Reserve Bank reported that only 4.9 percent of their trading was with a nonfinancial firm, and the nonbanks only 4.4 percent; in other words, 95 percent of the trading takes place among the banks and other financial firms, rather than with customers such as importers and exporters. If the 1986 data are a guide, similar proportions apply in London (still the world's largest foreign exchange market).

Clearly, trading among themselves is a major economic activity for banks. Stephan Schulmeister (1987, p. 24) reported that in 1985, 12 large U.S. banks earned a foreign exchange trading income of $1.165 billion. Every single bank reported a profit from its foreign exchange business in every year that he examined. Charles Goodhart (1988, p. 25 and Appendix D) has surveyed banks that specialize in the London foreign exchange market: "Traders, so it is claimed, consistently make profits from their position-taking (and those who do not get fired), over and above their return from straight dealing, owing to the bid/ask spread" (p. 59).

What is the importance of trading volume (beyond motivating the importance of heterogeneous expectations)? There are three possible hypotheses, with regard to implications for movements in the market price: (1) the higher the liquidity or "depth" of the markets, the more efficiently is news regarding economic fundamentals processed and the smaller is "unnecessary volatility" in the exchange rate; (2) the foreign exchange market is already perfectly efficient, so that trading volume is irrelevant to price movements and therefore uninteresting (except to those who make their living by brokering the trades); (3) much trading is based on "noise" rather than "news," and leads to excessive volatility.

Choosing convincingly among these three hypotheses may be too large a task to accomplish here. But there is evidence that trading volume, exchange rate volatility, and the dispersion of expectations among forecasters are all positively related. We have recently developed a weekly data set for four currencies (British pound, German mark, Japanese yen, and Swiss franc), covering the period October 1984 to February 1988. Trading volume is measured by the weekly number of futures contracts (nearest-term) traded on the IMM of the Chicago Mercantile Exchange, volatility is measured by the squared percentage change each 15 minutes in the futures price, averaged over the week, and dispersion is measured by the percentage standard deviation of forecasts across respondents

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1/ On September 8, 1989, Singapore reported $60 billion of daily trading for the first five months of the year, which would make it the fourth largest foreign exchange market.

in the survey of market participants that is conducted weekly by MMS International.

Granger-causality tests on pre-whitened data, reported in Table 6, show that the degree of dispersion has strong effects on the market. Dispersion Granger-causes volume at the 90 percent level in three currencies out of four, whether dispersion is measured in 1-week or 1-month forecasts. Dispersion also Granger-causes volatility, in four out of four currencies at the 1-week horizon, and three out of four at the 1-month horizon. We also find that the contemporaneous correlation between volume and volatility is high: 0.515 for the pound, 0.316 for the deutsche mark, 0.412 for the Swiss franc, and 0.417 for the yen.

One interpretation of these results is that the existence of conflicting forecasts leads to noise-trading--the causation runs from dispersion to the volume of trading, and then from trading to volatility--though there probably exist other interpretations as well. The Granger test does not show statistically-significant causation running directly from volume to volatility. But one would expect any such causality to be purely contemporaneous, and it is important to keep in mind that the Granger test cannot detect this type of causality.

It should be noted that the tests in Table 6 also show that volatility Granger-causes dispersion: Volatility Granger-causes 1-week dispersion for all four currencies, and 1-month dispersion for three out of four. We think that this apparent effect may be partly spurious: the MMS survey catches different respondents at different times of the day, so their forecasts of the expected future level of the exchange rate will differ more if the level of the spot rate on that day moves around more. On the other hand, it is easy to see how higher lagged volatility could cause higher dispersion of expectations because forecasters use different models to interpret the data. [If forecasters have extrapolative expectations, as in Table 4, but disagree on the extrapolative parameter, then the dispersion of forecasts will be simply proportionate to the absolute magnitude of the lagged rate of change of the exchange rate.] Cragg and Malkiel (1982) argue, for the case of stock market expectations, that dispersion of forecasts is closely related to volatility.

Other results in Table 6 are that volume Granger-causes both 1-week and 1-month dispersion in only one of four currencies. Lastly, volume and volatility do not appear to be Granger-related in either direction [contrary to the finding of Rutledge (1986) for the case of 15 commodity prices.]

3. The rising importance of chartists

It has long been remarked that if there exist traders who tend to forecast by extrapolating recent trends, i.e., who have "bandwagon expectations," that their actions can exacerbate swings in the exchange

Table 6. Volume (Vol) and One-Week Dispersion of Opinion (Disp): Cross-Correlation Tests for Causality

	Q1: Disp causal to Vol	Q2: Vol causal to Disp	Q3: Disp and Vol are causally related
British pound	8.9824**	6.1753**	15.2343**
Deutsche mark	5.1219**	0.0736	9.3893**
Swiss franc	2.5873	0.2451	9.5726**
Japanese yen	9.3782**	0.2815	17.0853**

Volume (Vol) and One-Month Dispersion of Opinion (Disp): Cross-Correlation Tests for Causality

	Q1: Disp causal to Vol	Q2: Vol causal to Disp	Q3: Disp and Vol are causally related
British pound	7.6687**	0.1304	56.3448**
Deutsche mark	0.5934	0.6339	2.2189
Swiss franc	3.7731*	3.1839*	7.5340**
Japanese yen	3.3784*	0.2170	6.6081**

Q1 and Q2 are Chi-square with 1 degree of freedom.
Q3 is Chi-square with 3 degrees of freedom.
** Denotes significance at the 5 percent level.
* Denotes significance at the 10 percent level.

Table 6 (Continued). Volume (Vol) and Price Volatility (Var): Cross-Correlation Tests for Causality

	Q1: Var causal to Vol	Q2: Vol causal to Var	Q3: Var and Vol are causally related
British pound	0.0183	4.6030**	59.7655**
Deutsche mark	0.0045	0.0972	20.8328**
Swiss franc	0.8481	2.3921	38.5250**
Japanese yen	0.1159	1.1872	37.4416**

Price Volatility (Var) and One-Week Dispersion of Opinion (Disp): Cross-Correlation Tests for Causality

	Q1: Disp causal to Var	Q2: Var causal to Disp	Q3: Disp and Var are causally related
British pound	4.9982**	4.1458**	14.5069**
Deutsche mark	7.1153**	4.4469**	17.5255**
Swiss franc	4.8134**	2.9838*	12.1650**
Japanese yen	3.5491*	5.8905**	27.4114**

Q1 and Q2 are Chi-square with 1 degree of freedom.
Q3 is Chi-square with 3 degrees of freedom.
** Denotes significance at the 5 percent level.
* Denotes significance at the 10 percent level.

Table 6 (Concluded). Price Volatility (Var) and One-Month Dispersion of Opinion (Disp): Cross-Correlation Tests for Causality

	Q1: Disp causal to Var	Q2: Var causal to Disp	Q3: Disp and Var are causally related
British pound	6.7898**	1.5047	10.6410**
Deutsche mark	3.4790*	5.0540**	15.6198**
Swiss franc	5.9060**	3.4279*	18.0211**
Japanese yen	2.2187	4.3179**	10.2997**

Q1 and Q2 are Chi-square with 1 degree of freedom.
Q3 is Chi-square with 3 degrees of freedom.
** Denotes significance at the 5 percent level.
* Denotes significance at the 10 percent level.

rate. Many so-called "chartist" forecasters, or technical analysts, are thought to use rules that are extrapolative (such as, "Buy when the 1-week moving average crosses above the 12-week moving average.")

How do speculators form expectations? We reported in the first half of this paper evidence from the survey data that, at short horizons, respondents tend to forecast by extrapolating recent trends, while at long horizons they tend to forecast a return to a long-run equilibrium such as PPP. Recall that the coefficients reported at the top of Table 4 are to be interpreted as answers to the question, "for every 1 percent that the dollar appreciates in a given week, what percentage change does the median respondent forecast for the dollar thereafter?" The answer at the 1-week horizon is another 0.13 percent in the same direction. One year out, however, respondents expect the dollar to be 0.33 percent lower, for every one percent that the dollar has appreciated this week.

This leads to the question: which kind of forecasters dominate the market, those who think short-term, and appear to have bandwagon expectations, or those who think long-term and have regressive expectations? Why don't banks or other financial institutions take sufficient long-term positions in under-valued currencies to stabilize the market?

According to Goodhart, banks consider the taking of long-term positions based on fundamentals as too "speculative" and risky. Bankers recall the Franklin National crisis and other bank failures caused by open foreign positions that were held too long. 1/ But the banks are willing to trust their spot exchange traders to take large open positions, provided they close most of them out by the end of the day, because these operations are profitable in the aggregate. 2/ The question then becomes: Why don't banks perceive that the succession of many short-term gambles is just as risky as one long-term gamble?

Consider the decision problem facing a bank executive who has responsibility for two divisions: a foreign exchange trading room, staffed by people who specialize in short-term trading, and an international securities portfolio investment fund, where the people specialize in longer-term investment. The question is how much of the banks' resources the executive should assign to long-term investing versus shorter-term trading. Given the high hourly volatility in the spot market, for a bank's trading room to meet the foreign exchange needs of customers necessarily entails placing risky bets on which way the exchange rate will move in the time it takes to unload an open position. The high

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1/ Fieleke (1981) reports data from the late 1970s showing that banks and other firms are unwilling to hold large net positions in foreign currency.

2/ In the description of Goodhart, and others as well, a typical spot trader does not buy and sell on the basis of any fundamentals model, but rather trades on the basis of knowledge as to which other traders are offering what deals at a given time, and a feel for what their behavior is likely to be later in the day.

volatility can follow from a model in which insufficient weight is given to the stabilizing investors. The question is why that weight is not close to 1.

Assume that, within each profession, some people are better-than-average at their job and others worse-than-average. The requisite skills in the case of portfolio investing would include the ability to evaluate, based on economic fundamentals, the longer-term determinants of the exchange rate (as well as the determinants of prices of various countries' government bonds, private corporate bonds, and equities). The requisite skills in the case of spot trading would include the quick reflexes to act on new developments faster than others, the stamina to work long hours without breaks (and, in a world of 24-hour trading, to check positions regularly during the night), and the instinct to know what other traders are going to do.

The only way the directors of the two bank divisions can assess and reward the abilities of their employees is by means of their track records. In the case of the foreign exchange trading room, the series of daily bets placed over the preceding year constitutes a statistically significant sample on which to evaluate whether a given trader has the requisite skills, in which case she should be rewarded and perhaps allowed increased discretion in her activities, or whether he lacks them and should be let go.

In the case of portfolio investment, a year may not be long enough to judge whether a given analyst is good or bad at picking currencies or securities that are over- or under-valued. Given high short-term volatility, many years of data may be necessary to discern statistically a slowly-disappearing mis-valuation in the marketplace. Thus it may be perfectly rational for the bank executive to restrict the size of the investment portfolio on the grounds of risk-aversion, and yet at the same time allow the spot traders to take a sequence of large open positions.

Since Milton Friedman (1953), the standard argument against the importance of destabilizing speculators is that they will on average lose money, and be driven out of the market in the long run. A number of special counter-examples to the Friedman argument have been constructed over the years, most involving heterogeneous actors (e.g., "suckers" who lose money and "sharpies" who win). 1/ The simplest counter-example would be based on the theory of rational speculative bubbles, where each market participant loses money if he doesn't go along with the herd. The problem with this theory, which identifies speculative bubbles with the unstable paths in a rational-expectations saddle-path problem, is that it has nothing to say about what causes a bubble to start. (Similarly, it has nothing to say about which unstable path is chosen, or what causes a bubble to end.) What, for example, generated a speculative bubble in the

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1/ In DeLong, Shleifer, Summers, and Waldmann (1987), noise-traders can survive and prosper, even though they trade on irrelevant information.

period leading up to February 1985, if that is what the dollar surge evident in Figure 1 was?

The model of speculative bubbles developed in Frankel and Froot (1988) says that over the period 1981-85, the market shifted weight away from the fundamentalists, and toward the technical analysts or "chartists." This shift was a natural Bayesian response to the inferior forecasting record of the former group, as their forecasts of dollar depreciation continued to be proven wrong month after month. The change in the weighted-average forecast of future changes in the value of the dollar in turn changed the demand for dollars and therefore its price in the foreign exchange market.

Is there any sort of evidence for such a theory? Euromoney magazine runs a yearly August review of between 10 and 27 foreign exchange forecasting services. Summary statistics are reported in Table 7. The trend is very clear. In 1978, 18 forecasting firms described themselves as relying exclusively on economic fundamentals, and only 2 on technical analysis. By 1985, the positions had been reversed: only 1 firm reported relying exclusively on fundamentals, and 12 on technical analysis. 1/

In short, it may indeed be the case that shifts over time in the weight that is given to different forecasting techniques are a source of changes in the demand for dollars, and that large exchange rate movements may take place with little basis in macroeconomic fundamentals.

1/ A number of firms combine the two approaches, or else offer a separate service of each kind; in this case, usually technical analysis is used for short-term forecasting and fundamentals for long-term forecasting. This pattern matches up well with the regression results from surveys of market participants regarding exchange rate expectations, reported above. It is also interesting that between 1978 and 1985, the horizon of the forecasts offered by the services grows shorter, for those services in the Euromoney review that report horizons. The pattern is also confirmed in Allen and Taylor (1989, p. 4), who report that at short horizons approximately 90 percent of respondents use some chartist input in forming their expectations, and 60 percent judge charts to be as important as fundamentals, while at the horizon of one year and longer, nearly 30 percent rely purely on fundamentals, and 85 percent judge fundamentals to be more important than charts.

Table 7. Techniques Used by Forecasting Services

Year	# of Services Surveyed	# Using Technical Models	# Using Fundamentals	# Using Both Models
1978	23	3	19	0
1981	13	1	11	0
1983	11	8	1	1
1984	13	9	0	2
1985	24	15	5	3
1986	34	20	8	4
1987	31	16	6	5
1988	31	18	7	6

Source: Euromoney, August issues.

When a forecasting firm offers more than one service, each is counted separately. Some services did not indicate the nature of their technique.

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