Using Survey Data to Test Standard Propositions Regarding Exchange Rate Expectations

By 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 modeled 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.

*Department of Economics, University of California, Berkeley, CA 94720, and Sloan School of Management, MIT, Cambridge, MA 02139, respectively. This is an extensively revised version of NBER Working Paper No. 1672. We 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 UC-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.

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) 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 fourteen 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 biweekly 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 have 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, and 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 their 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

[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 turned 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

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, that is, that expected depreciation is zero:

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

For example, William Branson, Hannu Halttunen, and Paul Masson did so, giving as a reason that "we have very little empirical evidence on alternative, more complicated expectations mechanisms" (1977, 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.

several times as many observations for the *Economist* data and have added the MMS sample to the analysis.

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 sug-

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 are the average of four currencies (the pound, mark, Swiss franc, and yen) and do 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 are the average of four currencies (the pound, mark, Swiss franc, and yen) and do not include the French franc.

gests 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 1970's clearly failed to find any unconditional bias.[5] But in the 1980's, 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 yet it was not until 1985 that the great, long-anticipated dollar depreciation began to materialize. Indeed, George Evans (1986)

[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).

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		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		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 $s^e(t+1)-s(t+1)$			Forward Discount Error $f(t)-s(t+1)$		
Forecast Horizon	Survey Source	Dates	*N*	Mean	*SD* of Mean	*t*-Statistic	Mean	*SD* of Mean	*t*-Statistic
1 Week									
Total	MMS	10/84–2/86	247	−19.17	8.17	−2.35			
UK			62	−27.79	19.87	−1.40			
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			
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.

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 are available through 1985, the first year of dollar decline. The bias is not quite statistically significant at the three- 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 1980's 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 nonnormality 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.

[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 lognormally distributed this convexity term is bounded above by the unconditional variance of the spot rate and is therefore small. For a lognormally 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

$$f(x) = (1/2\pi)\exp\left[-(x-\mu)^2/2\sigma^2\right].$$

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 1980's, $\sigma^2 = 0.02$ 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 1970's and early 1980's in Table 3.

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, that is, 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 states

> [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. [1944, p. 118]

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 in 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

[9] See, for example, the discussion in Michael Dooley and Jeffrey Shafer (1983, pp. 47–48).

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

Seemingly Unrelated Regressions[a] of Survey Expected Depreciation:
$s^e(t+1)-s(t)=a+g(s(t-1)-s(t))$

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

Notes: Asymptotic standard errors are shown in parentheses.
[a]Amex 6 and 12 Month regressions use *OLS* due to the small number of degrees of freedom.
[b]The *D-W* 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 our papers (1986).
[d]Significant at the 10 percent level.
[e]Significant at the 5 percent level.
[f]Significant at the 1 percent level.

equivalent representation would be

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

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 Tables 4–11, 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 (SUR)[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

[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.

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 1 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 (D-W) 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 D-W 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 seemingly unrelated 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:

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

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:

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

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 D-W 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

[11] We take the definition of extrapolative expectations from Jacob 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 Rudiger 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-Frankel, Table 3), we suspect that this bias is small.

TABLE 5—ADAPTIVE EXPECTATIONS
(Independent variable: $s^e(t) - s(t)$)

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

Data Set	Dates	γ_1[c]	D-W[b]	DF	t: $\gamma_1 = 0$	R^2
Economist 3-Month	6/81–12/85	0.0798 (0.0203)	2.01	169	3.93[f]	0.63
with AR(1) Correction		0.0716 (0.0180)		164	3.97[f]	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[f]	0.53
with AR(1) Correction		0.0783 (0.0223)		154	3.52[f]	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[f]	0.81
Amex 12-Month	1/76–8/85	0.0946 (0.0212)	0.55	31	4.47[f]	0.69

Notes and footnotes: See Table 4.

(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:

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

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,

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

The long-run equilibrium $\bar{s}_t$ can itself change. It is often 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 (*PPP*). In this case, $\bar{s}_t$ moves with relative inflation differentials instead of remaining constant:

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

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 U.S. and foreign CPIs, respectively, and P_0 and P_0^* are the average levels of the U.S. 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

TABLE 6—REGRESSIVE EXPECTATIONS I
(Independent variable: $s(t)$; Long-run equilibrium constant)

Seemingly Unrelated Regressions[a] of Survey Expected Depreciation:

$$s^e(t+1)-s(t)=a-\theta s(t)$$

Data Set	Dates	θ^c	$D\text{-}W^b$	DF	t: $\theta=0$	R^2
Economist 3-Month	6/81–12/85	0.0359 (0.0101)	1.56	184	3.55[f]	0.58
with AR(1) Correction		0.0226 (0.0109)		179	2.07[e]	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[f]	0.80
with AR(1) Correction		0.0807 (0.0170)		179	4.73[f]	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[f]	0.93
with AR(1) Correction		0.1905 (0.0182)		179	10.48[f]	0.92
Amex 12-Month	1/76–8/85	0.0791 (0.0346)	0.48	45	2.29[e]	0.37

Notes and footnotes: See Table 4.

TABLE 7—REGRESSIVE EXPECTATIONS II
(Independent variable: $\bar{s}(t)-s(t)$; Long-run equilibrium *PPP*)

Seemingly Unrelated Regressions[a] of Survey Expected Depreciation:

$$s^e(t+1)-s(t)=a+\theta(\bar{s}(t)-s(t))$$

Data Set	Dates	θ^c	$D\text{-}W^b$	DF	t: $\theta=0$	R^2
Economist 3-Month	6/81–12/85	0.0223 (0.0126)	1.66	184	1.78[d]	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[f]	0.61
with AR(1) Correction		0.0782 (0.0221)		179	3.54[f]	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[f]	0.88
with AR(1) Correction		0.2449 (0.0274)		179	8.93[f]	0.90
Amex 12-Month	1/76–8/85	0.1236 (0.0276)	0.60	45	4.48[f]	0.69

Notes and footnotes: See Table 4.

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 1980's. 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-, six-, and twelve-month horizons show that deviations from *PPP* are expected to decay at annual rates of $(1-0.9881^4) \approx 5$ percent, $(1-0.9218^2) \approx 15$ 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, that is, 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 II, Part B), 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 ex-

[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.

pectational 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

$$(9) \quad \hat{\Theta} = (\mathbf{X}'_{\mathbf{NT}}\mathbf{X}_{\mathbf{NT}})^{-1}\mathbf{X}'_{\mathbf{NT}}\hat{\Omega}\mathbf{X}_{\mathbf{NT}} \times (\mathbf{X}'_{\mathbf{NT}}\mathbf{X}_{\mathbf{NT}})^{-1},$$

where $\mathbf{X}_{\mathbf{NT}}$ 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

$$(10) \quad \hat{\omega}(i,j) = \frac{1}{NT-k}\sum_{l=0}^{N-1}\sum_{t=k+1}^{T}\hat{u}_{t+lT}\hat{u}_{t-k+lT}$$

$$\text{for } mT-n \le k \le mT+n; \quad m=0,\dots,N-1$$

$$= 0 \text{ otherwise,}$$

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:

$$(11) \quad \tilde{\omega}(t+lT, t-k+pT) = \frac{1}{N-1}\sum_{l=0}^{N}\hat{\omega}(t+lT, t-k+pT) \quad \text{if } l = p \text{ and } -n \le k \le n$$

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

$$= 0 \text{ otherwise.}$$

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

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

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

OLS Regressions of Survey Prediction Errors: $s^e(t+1)-s(t+1)=a+g(d(t-1)-s(t))$						
Data Set	Dates	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[c]
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[c]	0.48	3.32[c]
Economist 12-Month	6/81–12/85	−0.6516 (0.2564)	149	−2.54[b]	0.42	8.09[c]
Amex 12-Month	1/76–8/85	2.0001 (0.3667)	40	5.45[c]	0.77	5.28[c]

Notes: All equations are estimated allowing each currency its own constant term. To conserve space, estimates of the constants are omitted here, but are reported in our paper (1986). Methods of Moments standard errors are shown in parentheses.

[a]Significant at the 10 percent level.
[b]Significant at the 5 percent level.
[c]Significant at the 1 percent level.

(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 are available, then more extrapolative expectations would have been correct, because the dollar had a long run of declines followed by a long run of

TABLE 9—RATIONALITY OF ADAPTIVE EXPECTATIONS
(Independent variable: $s^e(t)-s(t)$)

OLS Regressions of Survey Prediction Errors: $s^e(t+1)-s(t+1)=a+\gamma(s^e(t)-s(t))$

Data Set	Dates	γ	*DF*	t: $\gamma=0$	R^2	*F* test $a=0,\gamma=0$
Economist 3-Month	6/81–12/85	0.4296 (0.1395)	169	3.08[c]	0.51	3.39[c]
MMS 3-Month	1/83–10/84	−0.2289 (0.2207)	158	−1.04	0.11	6.35[c]
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[c]	0.66	10.27[c]
Amex 12-Month	1/76–8/85	0.5972 (0.1007)	25	5.93[c]	0.80	8.05[c]

Notes and footnotes: See Table 8.

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:

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

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,

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

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

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

[19] See, for example, Dooley-Shafer and Hansen-Hodrick.

TABLE 10—RATIONALITY OF REGRESSIVE EXPECTATIONS I
(Independent variable: $s(t)$; Long-run equilibrium constant)

OLS Regressions of Survey Prediction Errors: $s^e(t+1)-s(t+1)=a-\theta s(t)$

Data Set	Dates	θ	*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[a]	0.27	1.20
MMS 3-Month	1/83–10/84	−0.0288 (0.1431)	182	−0.20	0.00	6.02[c]
Economist 6-Month	6/81–12/85	−0.3582 (0.1936)	174	−1.85[a]	0.28	1.40
Amex 6-Month	1/76–8/85	−0.0427 (0.1647)	45	−0.26	0.01	2.07[a]
Economist 12-Month	6/81–12/85	−0.4167 (0.1895)	149	−2.20[c]	0.35	6.54[c]
Amex 12-Month	1/76–8/85	0.1904 (0.2919)	40	0.65	0.05	0.36

Notes and footnotes: See Table 8.

TABLE 11—RATIONALITY OF REGRESSIVE EXPECTATIONS II
(Independent variable: $\bar{s}(t)-\bar{s}(t)$; Long-run equilibrium *PPP*)

OLS Regressions of Survey Prediction Errors: $s^e(t+1)-s(t+1)=a+\theta(\bar{s}(t)-\bar{s}(t))$

Data Set	Dates	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[a]	0.28	1.24
MMS 3-Month	1/83–10/84	−0.0335 (0.1387)	182	−0.24	0.01	6.01[c]
Economist 6-Month	6/81–12/85	−0.4344 (0.2252)	174	−1.93[a]	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[b]	0.37	6.48[c]
Amex 12-Month	1/76–8/85	0.4278 (0.2412)	40	1.77[a]	0.26	0.85

Notes and footnotes: See Table 8.

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 percent 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 un-

[20]Stephen Marris (1985, pp. 120–22) 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.

derestimated 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 1980's, and systematically underpredicted its depreciation in the late 1970's. 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 1980's 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 nonzero, 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*

[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 our paper (1986b).

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.

DATA APPENDIX

Here we 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-, six-, 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- 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 our paper (1986a).

REFERENCES

Bilson, John, "The Speculative Efficiency Hypothesis," *Journal of Business*, July 1981, *54*, 431–51.

______, "Macroeconomic Stability and Flexible Exchange Rates," *American Economic Review Proceedings*, May 1985, *75*, 62–67.

Branson, William, Halttunen, Hannu and Masson,

Paul, "Exchange Rates in the Short Run: The Dollar-Deutschemark Rate," *European Economic Review*, December 1977, *10*, 303–24.

Cornell, Bradford, "Spot Rates, Forward Rates, and Exchange Market Efficiency," *Journal of Financial Economics*, August 1977, *5*, 55–85.

Dominguez, Kathryn, "Are Foreign Exchange Forecasts Rational: New Evidence from Survey Data," International Finance Discussion Paper Series, No. 241, May 1986, forthcoming *Economic Letters*.

Dooley, Michael and Shafer, Jeffrey, "Analysis of Short-Run Exchange Rate Behavior: March 1973 to November 1981," in D. Bigman and T. Taya, eds., *Exchange Rate and Trade Instability: Causes, Consequences, and Remedies*, Washington: International Monetary Fund, 1983.

Dornbusch, Rudiger, (1976a) "The Theory of Flexible Exchange Rate Regimes and Macroeconomic Policy," *Scandinavian Journal of Economics*, May 1976, *78*, 255–79.

______, (1976b) "Expectations and Exchange Rate Dynamics," *Journal of Political Economy*, December 1976, *84*, 1161–76.

Engel, Charles M., "Testing for the Absence of Expected Real Profits from Forward Market Speculation," *Journal of International Economics*, November 1984, *17*, 299–308.

Evans, George W., "A Test for Speculative Bubbles and the Sterling-Dollar Exchange Rate: 1981–84," *American Economic Review*, September 1986, *76*, 621–36.

Frankel, Jeffrey, "Tests of Rational Expectations in the Forward Exchange Market," *Southern Economic Journal*, April 1980, *46*, 1083–101.

______, "The Dazzling Dollar," *Brookings Papers on Economic Activity*, 1:1985, 199–217.

______ **and Froot, Kenneth A.,** (1986a) "Using Survey Data to Test Some Standard Propositions Regarding Exchange Rate Expectations," Research Papers in Economics No. 86-11, Institute of Business and Economic Research, University of California-Berkeley, April 1986.

______ **and** ______, (1986b) "The Dollar as a Speculative Bubble: A Tale of Chartists and Fundamentalists," NBER Working Paper, No. 1854, March 1986.

Friedman, Milton, "The Case for Flexible Exchange Rates," in his *Essays in Positive Economics*, Chicago: University of Chicago Press, 1953, 157–203.

Froot, Kenneth A. and Frankel, Jeffrey A., "Interpreting Tests of Forward Discount Unbiasedness Using Survey Data on Exchange Rate Expectations," NBER Working Paper No. 1963, July 1986.

Frydman, Roman and Phelps, Edmund S., *Individual Forecasting and Aggregate Outcomes: "Rational Expectations" Examined*, New York: Cambridge University Press, 1983.

Hansen, Lars and Hodrick, Robert, "Forward Rates as Optimal Predictors of Future Spot Rates: An Econometric Analysis," *Journal of Political Economy*, October 1980, *88*, 829–53.

Huang, Roger, "Some Alternative Tests of Forward Exchange Rates as Predictors of Future Spot Rates," *Journal of International Money and Finance*, August 1984, *3*, 157–67.

Kouri, Pentti J. K., "The Exchange Rate and the Balance of Payments in the Short Run and the Long Run: A Monetary Approach," *Scandinavian Journal of Economics*, No. 2, 1976, *10*, 280–304.

Levich, Richard, "Analyzing the Accuracy of Foreign Exchange Advisory Services: Theory and Evidence," in R. Levich and C. Wihlborg, eds., *Exchange Risk and Exposure*, Lexington: D. C. Heath, 1979.

Lovell, Michael C., "Tests of the Rational Expectations Hypothesis," *American Economic Review*, March 1986, *76*, 110–24.

Marris, Stephen, *Deficits and the Dollar: The World Economy at Risk*, Washington: Institute for International Economics, December 1985.

Meese, Richard and Rogoff, Kenneth, "Empirical Exchange Rate Models of the Seventies: Do They Fit Out of Sample?," *Journal of International Economics*, February 1983, *14*, 3–24.

Mincer, Jacob, "Models of Adaptive Forecasting," in his *Economic Forecasts and Expectations*, New York: Columbia University Press, 1969.

Newey, Whitney and West, Kenneth, "A Simple, Positive Definite, Heteroskedasticity and Autocorrelation Consistent Covariance Matrix," Woodrow Wilson School Discussion Paper No. 92, May 1985.

Nurkse, Ragner, *International Currency Experience*, Geneva: League of Nations, 1944.

Parks, R. W., "Efficient Estimation of a System of Regression Equations when Disturbances are Both Serially and Contemporaneously Correlated," *Journal of the American Statistical Association*, 1967, *62*, 500–09.

Rubinstein, Mark, "An Aggregation Theorem for Securities Markets," *Journal of Financial Economics*, September 1974, *1*, 225–44.

Stockman, Alan C., "Risk, Information and Forward Exchange Rates," in J. A. Frenkel and H. G. Johnson, eds., *The Economics of Exchange Rates*, Reading: Addison Wesley, 1978.

American Express International Banking Corporation, *Amex Bank Review*, London, various issues, 1976–85.

The Economist Newspaper, Ltd., *Financial Report*, London, various issues, 1981–86.

Money Market Services, Inc., *Currency Market Services*, various issues, 1983–86.