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ARE FOREIGN EXCHANGE FORECASTS RATIONAL? NEW EVIDENCE FROM SURVEY DATA

by

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ABSTRACT

Tests of rational expectations in foreign exchange markets have been inconclusive because of disagreement over the underlying asset pricing model. This paper uses a newly available set of data on foreign exchange forecasts to examine directly expectations formation in four foreign currency markets. Generally, results do not support the simple rational expectations hypothesis.

Are Foreign Exchange Forecasts Rational ?
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INTRODUCTION

For two decades, theories of expectations formation -- particularly the rational expectations hypothesis -- have been at the forefront of economic research. More recently empirical work has begun to focus on testing the operational validity of rational expectations[1]. Survey evidence on the formation of expectations has, as a result, become an important data source. This paper examines the rationality of a newly available set of survey data on foreign exchange rate forecasts provided by Money Market Services (MMS)[2].

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[1]Rationality in the Muth (1961) sense is defined as an expectation which is "own-model-consistent". This definition requires that there be a specific model which agents both know and use to formulate their expectations. Typically, however, tests of rationality are not based on a specific model but require that the prediction error be uncorrelated with "all available information".

[2]Thanks to Mark Porter and David Broder from MMS for providing me with the survey data.

The first section of the paper describes the joint hypothesis problem implicit in tests of market rationality and the consequential usefulness of direct observations of market expectations to circumvent the problem. Section II describes the rationality tests, the data and the method of estimation used in this study. Section III presents the regression results of the rationality tests using concensus forecasts. Finally, section IV provides a summary and conclusions.

I. The Joint Hypothesis Problem and a Circumvention

A. Exchange Rate Efficiency

The decision to change from the Bretton Woods fixed exchange rate system to market-determined exchange rates in 1971 dramatically changed the research focus of empirical work on exchange rates. The economic argument for changing to a floating exchange rate regime centered largely on the issue of market efficiency[3]. In an efficient market, exchange rates should fully reflect all available information, and rational economic decisions based on these relative prices should insure an efficient allocation of resources. After the change to flexible exchange rates, empirical research therefore focused on testing the efficiency hypothesis, i.e., testing whether floating exchange rates did indeed serve as efficient aggregators of information.

One approach to testing exchange rates' informational efficiency, advocated by Fama (1970), argues that efficiency requires that actual prices (or rates of return) follow a "fair game" process

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[3]Seminal papers on the topic include: Friedman (1953) and Johnson (1969).

relative to expected equilibrium prices (or rates of return). In other words, in an efficient market investors should not be able to earn excess profit using publically available information, where excess profit is defined relative to an expected equilibrium rate of return. In the context of foreign exchange markets we therefore first require a model of equilibrium exchange rates. Conditional on the equilibrium model we can then derive expectations which are model-consistent or rational. The efficiency test is consequently of a joint hypothesis, that the equilibrium model specified is correct and that expectations are rational, conditional on the equilibrium model.

The main problem confronting this approach to testing foreign exchange market efficiency lies in the first part of the joint hypothesis: specifying the equilbrium model. While a number of models have been developed to describe the determination of flexible exchange rates, none of the models have gained general acceptance by the profession[4]. Empirical tests of structural models in the literature have had little success in isolating the important explanatory variables[5]. Indeed Meese and Rogoff (1983, 1985) find that neither structural models nor univariate time series techniques improve on a random walk model of exchange rates in spite of the fact that they base their forecasts on realized values of future explanatory variables.

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[4]See Appendix A for an example of the fundamental variables typically included in equilibrium exchange rate models and the central role the expectations formation process plays in such models.

[5] See, for example, Frenkel (1976), Branson, Halttunen, and Mason (1979), Hooper and Morton (1982), Edison (1985).

B. Forward Market Efficiency

One path that researchers have taken to side-step the "lack of an equilibrium rate" problem is to examine the forward exchange rate, testing whether it is an unbiased predictor of future spot rates. Forward market studies can exploit Fama's "fair-game" approach by testing whether there exist unusual profit opportunities in the forward exchange market.

An investor can sign a forward contract at time t to purchase foreign currency at time t+i at a price, $f_{t,i} = e_t + (r_{t,i} - r^*_{t,i})$, where the variables are the forward rate (F), spot exchange rate (E) and the interest rate (R); capital letters denote the level and lower case letters the logarithm; and foreign variables are denoted with an asterisk *. At time t+i the investor can turn around and sell the foreign currency at the spot price e_{t+i}. Presumably the "rational" investor will only enter into a forward contract if he expects that:

(1) $E_t(e_{t+i}) \geq e_t + (r_{t,i} - r^*_{t,i}) = f_{t,i}$

where E_t is the expectation conditional on information available at time t. Further, if the forward market is efficient, then expected forward market profits should be zero; $E_t(e_{t+i}) - f_{t,i} = 0$. However, forward market efficiency does not preclude the existence of a risk premium, defined as the excess expected return demanded by investors for assuming the risk of future changes in exchange rates. So the relevant forward market equilibrium condition may include an additional term :

(2) $E_t(e_{t+i}) - risk_{t,i} - f_{t,i} = 0.$

Forward market tests therefore involve the joint hypothesis of a specific risk/return relationship and rationality.

Empirical tests of formal models of exchange rate risk have had little success in characterizing the nature of the risk premium.[6] Consequently, recent work has generally tested for risk neutrality and rationality, consistently rejecting this joint hypothesis[7], but it remains unclear whether this rejection shows expectations to be biased and inefficient, or whether it reflects the existence of a time-varying (and elusive) risk premium.

C. Survey Expectations

The benefits to be derived from studying direct observations of exchange market expectations should be clear. Survey data allow single-hypothesis, model-free tests of rationality in foreign currency markets. Studies which reject the joint hypothesis of spot and forward market efficiency cannot distinguish whether it was the failure of the equilibrium model or rational expectations which led to the rejection. In order to test the rationality hypothesis directly, therefore, expectations data is essential.

Although survey data have become increasingly accepted in empirical work, some economists remain wary of potential bias. The methodology and respondent sample for the Money Market Services survey

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[6] Hansen and Hodrick (1983) and Hodrick and Srivastava (1984) provide weak evidence in support of a time varying risk premium using a single beta latent variable model. Domowitz and Hakkio (1985) find little evidence for the existence of a risk premium based on the conditional variance of market forecast errors which are assumed to follow an ARCH process.

[7] See, for example, Tryon (1979), Hansen and Hodrick (1980), Hakkio (1981), Cumby and Obstfeld (1981, 1983) and Hsieh (1984).

should, however, inspire unusual confidence. The thirty respondents are professional exchange rate forecasters; most work in foreign currency trading divisions of major commercial banks. The standard arguments against surveys[8] - in particular, that they do not adequately reflect the decisive players in the market - are clearly less problematic with this sample than in most surveys. There is equal reason to have confidence in the survey's design and execution. Unlike many surveys which are administered through the mail, the MMS survey is conducted by telephone each Wednesday afternoon eastern standard time (EST). Such accurate timing minimizes the problem of different information sets across forecasters.[9]

II. Description of the Tests, the Data, and Estimation.

A. Tests of the Rational Expectations Hypothesis

The rational expectations hypothesis states that rational participants in the market have expectations which are optimal forecasts using all available information. The usual rationality tests found in the literature have been of two basic sorts: the first tests whether the forecasts are unbiased estimates of the actual series, and the second, whether forecasts incorporate available information. Commonly, unbiasedness is tested by running the OLS regression:

$$e_{t+i} = \alpha_0 + \alpha_1 E_t e_{t+i} + u_{t,i} \quad (3)$$

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[8]See Appendix B for further discussion of the usefulness of survey data.

[9]Frankel and Froot (1985) and Froot (1985) use a semi-annual mail survey published by Amex Bank Review and the Economist Financial Report to examine exchange rate expectations. Although their results are consistent with this papers findings, because the respondants were not polled simultaneously and the number of survey dates was small, the power of their tests is probably considerably lower.

where e_{t+i} is the i-period ahead spot exchange rate, E_t is the expectation at time t and $u_{t,i}$ is the forecast error. ($E_t e_{t+i}$ has typically been proxied with the time t, i-period-ahead forward rate.) Unbiasedness requires the joint hypothesis that $\alpha_0=0$ and $\alpha_1=1$.

The second type of test checks that relevant information is included in the forecast. Clearly if any information available at time t is systematically excluded from the forecast and would improve the forecast, then the forecast is not optimal, and therefore also not rational. In order to test whether forecasts do incorporate relevant information we regress forecast errors on specific data[10] that were available to the forecasters. One piece of information which a rational forecaster should consider is his most recent forecast error. This can be tested by running the regression:

$$(4) \quad (e_{t+i} - E_t e_{t+i}) = \beta_0 + \beta_1(e_t - E_{t-1}e_t) + u_{t,i}$$

If the forecast errors exhibit a significant non-zero mean and serial correlation[11] (significant β_1) then this implies that the information contained in past forecast errors was not fully utilized in forming future predictions.

When the information set is restricted to a constant and the current or lagged set of forecasts, the tests examine what is commonly called the weak version of rational expectations (RE). When other, publicaly

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[10] In the strictest sense, the forecast errors should be regressed on "all available information" to test for rationality. In the interest of parameter parsimony, however, only those variables which models would predict to influence exchange rates are generally included.

[11] This, more specifically, tests only that the forecast error, $(e_{t+i} - E_t e_{t+i})$ is white noise, not that it is an innovation with respect to $(e_t, E_{t-1}e_t, \ldots)$.

available regressors are included, the tests examine the <u>semi-strong form</u> of RE. Semi-strong rationality tests take the form:

(5) $(e_{t+i} - E_t e_{t+i}) = \delta_0 + \delta_1 z_t + u_{t,i}$

where z_t is a variable which embodies available information relevant to the forecasts. The hypothesis of informational efficiency requires that the coefficient on z_t and the constant be insignificantly different than zero.

Results of these three rationality tests will be presented in the following section. The remainder of this section will describe the data and econometric technique used in the regression estimation.

B. Description of the Data

Money Market Services surveys bilateral (dollar) exchange rate forecasts of the British pound, the West German mark, the Swiss franc and the Japanese yen. From January 1983 to October 10, 1984 forecasters were asked every other week (bi-weekly) to predict spot rates two weeks and three months from the day of the survey. Since October 24,1984 forecasters have been asked weekly for their one-week-ahead forecasts and bi-weekly for their one-month-ahead forecasts. Throughout its existence, the survey has typically been taken after 12 pm EST: the forecasters thus have information on the noon New York spot rate and can calculate (but are not told) their forecast error from their two-week or one-week previous short-horizon forecast. If the forecast date falls on a holiday or weekend, the date is switched to the next business day. In contrast to the one and two week-ahead cases, forecasters will not be able to calculate their previous one- or three-month-ahead forecast error before the next survey.

Temporal alignment of exchange rate data is extremely important as the rates can vary as much within a day as across days. The actual market spot and forward rates used in the regression analyses are taken from Data Resources Inc. and the New York Federal Reserve Bank International Balance of Payments Data Base. All series are in logarithms[12] and are the average of the New York certified noon bid and ask rates. Each MMS median[13] prediction was carefully aligned with the corresponding spot rate, and, in the one- and three-month-ahead cases, the one- and three-month-ahead forward rate. The relevant institutional features of forward contract delivery timing have been taken into account as discussed in detail by both Meese and Singleton (1980) and Hsieh (1984)[14].

C. Data Stationarity - A Pre-Test

A number of rationality tests in the literature have involved the

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[12]In order to avoid Siegel's (1972) Paradox (which arises because the expectation of an inverse does not, in general, equal one over the expectation of the original variable), spot, forward and survey expectations are in logarithms, thereby ensuring that results are independent of whether exchange rates are expressed in units of home or foreign currency.

[13]The median is the appropriate value to use for RE tests with the MMS data because the thirty individual forecasts are not, in general, symmetrically distributed. If a distribution is symmetric the mean will equal the median but, if not, the median measure gives distributional outliers less influence than does the mean.

[14] Forward contracts are set for the same date; however, many months ahead, (i.e., Jan. 1 to Feb. 1 for an one-month contract) but delivery takes place two business days later (one day for Canada). However, unless the trader is holding a covered position, she must cover for the above example on Feb. 1 as her spot transaction also takes two business days. This paper assumes that forward contracts are uncovered so that spot rates are aligned two days before actual delivery of the forward contract.

level-form of actual and expected variables[15]. If, however, the stochastic processes generating the series are non-stationary, the usual asymptotic theory invoked to construct hypothesis tests is not justified. While a number of foreign exchange-market studies have constructed rationality tests using first differences of variables rather than their levels in order to avoid problems of nonstationarity, with the exception of Meese and Singleton (1982) and Meese and Rogoff (1985), none have explicitly tested for unit roots[16].

Granger (1983)[17] defines a series to be integrated of order d (expressed as I(d)), if the series must be differenced d times in order to achieve stationarity. Similarly, two nonstationary series are co-integrated of order (d,b) if there exists a linear combination of them which jointly achieves stationarity[18]. We can test whether series, in level or difference (integrated) form, are stationary by testing for unit roots.

The Sargan and Bhargava (1983) unit root test, using the Durbin-Watson statistic, tests the null hypothesis that a series is a Gaussian random walk against the alternative that roots are strictly less than

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[15]See, for example, Bilson (1978), Frankel (1979) and Frenkel (1979).

[16]Mussa (1979) was one of the first to describe the process generating the logarithm of spot exchange rates as a random walk.

[17]See also, Granger and Engle (1984) and Granger and Weiss (1984).

[18]If e_t and f_t are both I(d), there may exist a co-integrating vector α such that: $\alpha e_t + (1-\alpha)f_t \sim I(d-b)$, $b>0$.

one, a stationary process[19]. The test involves regressing the relevant series on a constant and comparing the D.W. for the residuals to the bounds provided in Sargan and Bhargava (1983).

Table 1(a) presents unit roots tests on the level of the spot (e_{t+i}), forward ($f_{t,i}$), and expectations ($E_t e_{t+i}$) series. With the exception of the one-week and three-month-ahead $/SWF spot expectation series, the tests cannot reject the hypothesis that unit roots are present in the first-order autoregressive representations of the logarithms of the spot, forward and expectations variables for all the level series. Table 1(b) presents tests using rates-of-change of the one- and two-week and one- and three-month-ahead spot rates. In contrast to the level-form results in Table 1(a), the change-form variables do appear stationary[20]. Finally, Table 1(c) presents tests of whether the forward rate and the expectations series are co-integrated with the contemporaneous spot exchange rate. Intuitively we are testing whether the actual and expectations series tend to move together over time. Unit root tests on the differences between each of the two expectations series and the spot exchange rate, termed the forward and

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[19] A number of unit root tests of the random walk hypothesis are available in the literature. The Sargan and Bhargava (1983) test results are presented here because their alternative hypothesis, (stationary process) is highly restrictive. Other unit root tests have as alternative hypotheses that roots do not equal one (potentially stationary) or that the the data generation process is not white noise.

[20] The tests for stationarity were performed on the rate-of-change of the variable between the forecast and the current period because this form is easily interpreted in regressions. However, because lags can always be re-parameterized (ie. $(e_{t+2} - e_t) = (e_{t+2} - e_{t+1}) + (e_{t+1} - e_t)$), omission of lagged variables does not vitiate the tests.

expected premia, can generally reject the null hypothesis at the .01 level. These test results suggest that foreign exchange rationality tests should be conducted using integrated (or co-integrated) transformations rather than the levels of these series.

Table 1(a) Unit Root tests on level series.

DEP.VAR.	HORIZON	SMPL	$/STLG	$/DM	$/SWF	$/YEN
e_{t+1}	1-WK	84-86	0.073	0.061	0.062	0.044
e_{t+2}	2-WK	83-84	0.071	0.084	0.069	0.281
e_{t+4}	1-MO	84-86	0.063	0.055	0.057	0.044
e_{t+12}	3-MO	83-84	0.054	0.077	0.058	0.210
$f_{t,4}$	1-MO	84-86	0.087	0.073	0.072	0.043
$f_{t,12}$	3-MO	83-84	0.083	0.086	0.066	0.259
$E_t e_{t+1}$	1-WK	84-86	0.125	0.108	1.250**	0.063
$E_t e_{t+2}$	2-WK	83-84	0.087	0.107	0.083	0.335
$E_t e_{t+4}$	1-MO	84-86	0.128	0.122	0.113	0.068
$E_t e_{t+12}$	3-MO	83-84	0.096	0.090	0.586*	0.276

Table 1(b) Unit Root tests on differenced series.

DEP.VAR.	HORIZON	SMPL	$/STLG	$/DM	$/SWF	$/YEN
$e_{t+1}-e_t$	1-WK	84-86	1.920**	1.943**	1.933**	1.712**
$e_{t+2}-e_t$	2-WK	83-84	1.833**	1.567**	1.699**	1.645**
$e_{t+4}-e_t$	1-MO	84-86	0.562*	0.511*	0.498*	0.505*
$e_{t+12}-e_t$	3-MO	83-84	0.563*	0.480	0.489	0.477

Table 1(c) Unit Root tests on linear combinations of series.

DEP.VAR.	HORIZON	SMPL	$/STLG	$/DM	$/SWF	$/YEN
$f_{t,4}-e_t$	1-MO	84-86	2.173**	2.181**	2.122**	2.024**
$f_{t,12}-e_t$	3-MO	83-84	0.509*	0.490	0.463	0.480
$E_t e_{t+1}-e_t$	1-WK	84-86	2.141**	2.201**	2.022**	1.845**
$E_t e_{t+2}-e_t$	2-WK	83-84	1.455**	1.498**	1.193**	1.188**
$E_t e_{t+4}-e_t$	1-MO	84-86	0.849**	1.667**	1.515**	1.363**
$E_t e_{t+12}-e_t$	3-MO	83-84	0.743**	1.656**	1.859**	0.991**

* denotes rejection at the .05 level and ** denotes rejection at the .01 level of the simple random walk hypothesis. Confidence limits are presented in Sargan and Bhargava (1983) pp.157.

D. The Estimation Method

In the following section, all models using one- and two-week-ahead forecasts were estimated over the four currencies using seemingly unrelated regressions (SUR). Currency arbitrage implies that error terms across currencies are likely to be comtemporaneously correlated. Zellner's (1962) joint estimation technique resulted in an efficiency gain because individual equation disturbances were contemporaneously correlated. If the error terms had not been correlated, SUR would be identical to four stacked OLS regressions.

While the one- and two-week-ahead forecasts are nonoverlapping, the one- and three-month-ahead forecasts are surveyed bi-weekly and therefore do overlap. If the sample size were not already small, constructing a nonoverlapping data set would be preferable. Hansen and Hodrick (1980,1983) and Hayashi and Sims (1983) discuss the econometric problem which arises when the sampling interval is finer than the interval over which forecasts are made. In our case, because the actual spot rate corresponding to the preceeding period one- and three-month-ahead forecast is not available for another two or six periods respectively, the disturbances are no longer guaranteed to be serially uncorrelated. The OLS estimate of α_1 in a regression of the form $e_{t+i} = \alpha_0 + \alpha_1 E_t e_{t+i} + u_{t,i}$ should remain consistent as long as $u_{t,i}$ and $E_t e_{t+i}$ are not correlated, but the standard errors will be biased when any lagged values of $u_{t,i}$ are not in the information set (ie. $E[u_{t,i}|u_{t-k,i}]$ is non-zero for all i>1 and k<i, where i=forecast horizon and k=sampling interval).

In order to correct for bias, all the one- and three-month-ahead equations in the following section are estimated with the Hansen (1982) heteroscedasticity consistent asymptotic covariance matrix, assuming a moving average process of order one for the bi-weekly one-month disturbances, and of order five for the bi-weekly three-month disturbances[21].

III. The Test Results

A. Tests of Unbiasedness

Tables 2 and 3 present regressions of actual spot depreciation $(e_{t+i} - e_t)$ on forecasted depreciation $(E_t e_{t+i} - e_t)$. Rationality requires that the coefficient on forecasted depreciation be one, the constant be zero, and the disturbances be innovations with respect to the complete set of information available at time t. In addition to the finding that the variables in change-form appear stationary, Tryon (1979) shows that using the change in the spot rate, rather than the level, constitutes a more stringent test of rational expectations. The change-form test of unbiasedness is to estimate the regression coefficents in :

(6a) $(e_{t+i} - e_t) = a_0 + a_1(E_t e_{t+i} - e_t) + u_{t,i}$

Adding the current spot, e_t, to both sides and rearranging terms we obtain:

(6b) $e_{t+i} = a_0 + a_1 E_t e_{t+i} + (1-a_1)e_t + u_{t,i}$

The change-form regression, by explicitly including the current spot rate in the regression, allows us to distinguish whether it is the current spot rate or the forecast that actually has predictive power.

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[21]See Appendix C for a more detailed discussion of the method of estimation.

TABLE 2 $(e_{t+i} - e_t) = a_0 + a_1(E_t e_{t+i} - e_t) + u_{t,i}$ i=1,2 (WK)

CURRENCY	HORIZON	SMPL	a_0	a_1	D.W.	R^2	$Chi^2(2)$
$/STLG	2-WK	83-84	-.005	.034	1.99	.003	96.2**
			(.003)*	(.119)**			
	1-WK	84-86	.001	-.171	1.85	.05	44.3**
			(.003)	(.181)**			
$/DM	2-WK	83-84	-.004	.122	1.79	.03	155.3**
			(.002)*	(.095)**			
	1-WK	84-86	.002	.049	1.85	.01	48.8**
			(.003)	(.137)**			
$/SWF	2-WK	83-84	-.004	.101	1.80	.01	84.0**
			(.002)*	(.091)**			
	1-WK	84-86	.002	.064	1.88	.01	62.3**
			(.003)	(.118)**			
$/YEN	2-WK	83-84	-.001	.166	2.05	.02	69.3**
			(.002)	(.100)**			
	1-WK	84-86	.003	.502	1.59	.07	12.8**
			(.002)	(.146)**			

TABLE 3 $(e_{t+i} - e_t) = a_0 + a_1(E_t e_{t+i} - e_t) + u_{t,i}$ i=4,12 (WK)

CURRENCY	HORIZON	SMPL	a_0	a_1	MA	R^2	$Chi^2(2)$
$/STLG	3-MO	83-84	-.029	-.450	5	.01	39.23**
			(.015)*	(.395)**			
	1-MO	84-86	-.001	-.505	1	.05	21.44**
			(.006)	(.329)**			
$/DM	3-MO	83-84	-.043	.412	5	.01	23.26**
			(.016)**	(.529)			
	1-MO	84-86	.014	-.248	1	.01	15.07**
			(.007)	(.392)**			
$/SWF	3-MO	83-84	-.033	.054	5	.001	135.38**
			(.009)**	(.099)**			
	1-MO	84-86	.012	-.374	1	.02	11.52**
			(.008)	(.425)**			
$/YEN	3-MO	83-84	.003	-.457	5	.02	9.38**
			(.016)	(.626)**			
	1-MO	84-86	.015	.341	1	.01	4.98
			(.008)	(.359)			

The numbers in parentheses are the estimated standard errors of the coefficients, * denotes rejection at the .05 level and ** at the .01 level for the hypotheses that $a_0=0$ and $a_1=1$. MA is the moving average assumption for the disturbances. The chi-square statistic pertains to the joint hypothesis that $a_0=0$ and $a_1=1$.

These tables show unbiasedness rejected at the .01 level for all equations but the one-month-ahead $/Yen regression, which almost rejects at the .05 level. The a_1 coefficients are particularly striking. In the short-horizon equations a_1 is generally positive and close to zero for all but the one-week-ahead $/Yen equation. In the longer-horizon equations a_1 is generally negative and close to -.5, implying that forecasters both over-predicted the size of spot depreciation and also got the direction of the exchange rate movements wrong. Further, across both short- and long-horizon equations a_1 is insignificantly different from zero for all but the one-week-ahead $/Yen equation, suggesting that the forecasts do no better than the contemporaneous spot in predicting future spot rate changes.

Figures 1 through 8 in Appendix D present graphs of MMS predicted and actual spot depreciation for the currencies over the four forecast horizons. A number of empirical regularities are notable:

(1) In all cases the variance of ex-post depreciation (appreciation) was markedly greater than predicted changes.

(2) The short-horizon forecasts generally predicted very small changes relative to the longer-horizon forecasts[22]. Both the one-week and two-week-ahead forecast error variances were found to be smaller than the one-month and three-month-ahead forecast error variances[23].

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[22] Discussions with MMS indicate that the survey changed from two-week and three-month-ahead forecasts to one-week and one-month-ahead forecasts specifically because the forecasters felt more comfortable reporting shorter-horizon forecasts.

[23] In contrast, Engle and Kraft (1983) show in another context that forecast error variances estimated from ARCH models for several periods ahead can be less than one period inflation forecast error variances.

(3) The three-month-ahead forecasts from 1/83 through 10/84 consistently predict depreciation of between one and two percent for the four currencies while, throughout the sample period, the actual spot rate appreciated by as much as six percent in some three-month periods.

(4) The one-month-ahead forecasts consistently predicted appreciation from 10/84 until 8/85, while actual spot depreciation began in 3/85 for the four currencies. Since 10/85 the one-month-ahead forecasts have been much closer aligned to actual spot movements.

Why did the three-month-ahead forecasts consistently predict depreciation in 83-84, while the actual spot rate continued to appreciate? Why did one-month-ahead forecasts not begin predicting depreciation until late summer 1985? A few explanations are possible. First, the MMS forecasts may be consistent with a "rational" bayesian learning process model. After four years of appreciation, one-month-ahead forecasts of appreciation in early 1985 may have reflected a skepticism that the exchange rate would reverse itself so quickly. The new "depreciation regime" may not have been fully legitimized until the September 1985 G-5 meeting where a policy of dollar weakening was officially sanctioned. Further, if the forecasters perceived shifts in the exchange process over the estimation sample, the underlying covariance matrix estimator assumption - that changes in the exchange rate are egodic (every sequence is equally representative of the whole process) may not be justified, in which case the standard errors presented in Table 3 may be suspect. This explanation, however, is less convincing for the earlier sample three-month-ahead forecasts which consistently predicted depreciation after two years of consistent, albeit volatile, spot appreciation.

A second explanation for the biased forecasts, which has been widely discussed in the literature, is the peso problem: the existence of a small probability of a large depreciation which did not occur over the sample period used (Krasker 1980). The forecasters may actually have rationally incorporated the true probability of depreciation in their predictions, but because the three-month-ahead forecast sample ended before the spot rate began to depreciate, the test statistics are able to reject unbiasedness.

Dornbusch (1985) states that if we think of the dollar appreciation as a single rational speculative bubble (where the small probability event is the bursting of the bubble[24]) this probability should have been fully incorporated in the interest differential paid on dollar assets. While the interest differential did rise sharply after 1980 (when the dollar began its appreciation), both long and short-term interest differentials declined after mid-1984 yet the actual and forecasted dollar continued to appreciate through February 1985. Frankel (1985) shows that the short-term interest differential was insufficient to sustain a rational dollar bubble between 1/85 and 3/85. He finds that the cumulative probability of noncollapse over this period would have been only three percent.

A final explanation for the survey expectations may well be that

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[24]The probability of depreciation could be based on the fact that fundamentals (see Appendix A for examples) were stacked against the dollar by mid-1984 or in response to record U.S. budget deficits over the sample three years.

the forecasts are biased, that forecasters over-weighted the small probability of depreciation in their three-month-ahead forecasts and under-weighted the probability of depreciation in their one-month forecasts.

B. Tests of Weak- and Strong-Form RE

The second type of RE test examines whether expectations incorporated available information. As a preliminary check for weak-form RE, the Durbin-Watson statistic on the previously presented non-overlapping short-horizon unbiasedness tests do not suggest the presence of serial correlation in the regression forecast errors for all but the one-week-ahead $/Yen equation. A direct check for serial correlation involves regressing the current period forecast error on the previous period error (equation (4) presented earlier). Table 4 presents the forecast error regression results, a significant slope coefficient would indicate that forecasters did not incorporate past errors in their current forecast.

TABLE 4 $(e_{t+i} - E_t e_{t+i}) = b_0 + b_1(e_t - E_{t-1}e_t) + u_{t,i}$ i=1,2 (WK)

CURRENCY	HORIZON	SMPL	b_0	b_1	D.H.	R^2	$Chi^2(2)$
$/STLG	2-WK	83-84	.004	-.050	.093	.002	3.43
			(.003)*	(.122)			
	1-WK	84-86	-.005	-.033	.181	.001	1.85
			(.004)	(.053)			
$/DM	2-WK	83-84	.007	.008	-.174	.001	6.31*
			(.003)**	(.086)			
	1-WK	84-86	-.002	-.025	.303	.001	1.07
			(.003)	(.034)			
$/SWF	2-WK	83-84	.008	-.003	.132	.001	10.09**
			(.002)**	(.012)			
	1-WK	84-86	-.001	-.003	.225	.001	0.29
			(.003)	(.008)			
$/YEN	2-WK	83-84	.003	.124	-.739	.014	4.85
			(.002)	(.090)			
	1-WK	84-86	-.002	.129	.705	.001	3.64
			(.002)	(.082)			

* denotes rejection at the .05 level and ** at the .01 level for the hypotheses that $b_0=0$ and $b_1=0$. The chi-square statistic pertains to the joint hypothesis that $b_0=b_1=0$.

While three of the two-week-horizon equations show significant constant terms, all equations show insignificant serial correlation. This indicates that although the short-horizon forecasts were generally biased, they did efficiently incorporate information from past errors. For the one-month and three-month-ahead cases, since the previous forecast errors are not available before the next forecast, an analogous test is not feasible.

The one- and three-month-ahead forward rates provide strong-form tests of rationality. Since the MMS survey is taken after 12pm EST; the noon N.Y. forward rate is available to forecasters. Table 5 presents the estimated regression results of the MMS forecast error on the appropriately aligned one- and three-month-ahead forward premium $(f_{t,i} - e_t)$.

TABLE 5 $(e_{t+i} - e_t)-(E_t e_{t+i} - e_t) = c_0 + c_1(f_{t,i} - e_t) + u_{t,i}$ i=4,12

CURRENCY	HORIZON	SMPL	c_0	c_1	MA	R^2	$Chi^2(2)$
$/STLG	3-MO	83-84	-.039	-7.89	5	.37	128.8**
			(.006)**	(1.03)**			
	1-MO	84-86	.012	-1.26	1	.03	5.9
			(.017)	(1.56)			
$/DM	3-MO	83-84	.003	-4.96	5	.08	36.9**
			(.053)	(4.33)			
	1-MO	84-86	.019	-1.14	1	.03	6.4*
			(.008)**	(1.18)			
$/SWF	3-MO	83-84	.065	-7.89	5	.26	69.4**
			(.049)	(3.19)**			
	1-MO	84-86	.015	-1.15	1	.05	3.5
			(.009)	(1.11)			
$/YEN	3-MO	83-84	.003	-3.26	5	.06	6.9*
			(.035)	(3.59)			
	1-MO	84-86	.015	-.357	1	.01	3.1
			(.008)	(.783)			

* denotes rejection at the .05 level and ** at the .01 level for the hypotheses that $c_0=0$ and $c_1=0$. The value of the chi-square statistic pertains to the test of the joint hypothesis that $c_0=c_1=0$.

These regression results indicate that the forward premium contains additional information for the three-month-ahead forecasts. While the $/DM one-month-ahead forecast also rejected the efficiency hypothesis, it is the constant term, not the forward premium which lead to the rejection. The three-month-ahead forward rates over the early sample period generally (wrongly) predicted spot depreciation as did the survey predictions but by a smaller percentage. The one-month-ahead forward rates predicted spot depreciation throughout the later sample period. The MMS appreciation forecasts were therefore more correct for the first five months of the sample. The forward rate then "beat" the MMS forecasts through August 1985 as the survey continued to predict appreciation incorrectly. After September 1985 the survey correctly predicted larger depreciation than did the one-month forward rate.

IV. Summary and Conclusions

This paper tested the rational expectations hypothesis in foreign exchange markets using a newly available set of survey data collected by Money Market Services. Tests examined whether these expectations series are unbiased and whether they incorporate information available from past forecast errors and the forward rate.

The estimation procedure employed on regressions with overlapping data allowed both for conditional heteroscedasticity and serially correlated forecast errors. Seemingly unrelated regressions were used in tests of the short-horizon non-overlapping data. The test results found that the MMS forecasts fail consistently at predicting future changes in the spot rate. Indeed, the MMS forecasts do no better than the current spot rate in forecasting the future spot rate. In change form, all forecasts are biased, and the three-month-ahead MMS forecasts were found to violate strong-form RE.

A number of possibilies were proposed to explain the behavior of the survey forecasts. It is possible that, although the tests presented reject unbiasedness, the early sample period was not long enough to bear out the forecasters' "rational" expectation of depreciation. However, rationality arguments, whether they are in the context of a bayesian or bubble process, do not seem convincing given the direction and magnitude of forecast errors over the two sample periods. Certainly, however, a direct test of the bayesian and bubble hypotheses is warranted in future research.

Finally, it seems that there is a great deal to be learned from subjecting survey data on expectations to rigorous tests. This seems particularly so for high-quality data covering the expectations of expert participants in asset markets. Further work with the MMS and similar data, therefore, should generate additional useful perspectives on exchange rate behavior.

Appendix A. The Monetary Approach to Exchange Rate Determination

The standard monetary approach to exchange rate determination is illustrative both of the fundamental variables typically included in equilibrium models and of the central role of the hypothesized expectations formation process.

In the monetary approach the exchange rate is viewed as the relative price of one country's money in terms of another. The money demand equations conventionally used for both the domestic and foreign countries depend on income and interest rates and, for simplicity, many models assume that the elasticities with respect to income and interest rates are identical for both countries:

(A1) $m = p + \alpha y - \beta r$

(A2) $m^* = p^* + \alpha y^* - \beta r^*$

where, the variables are money (M), prices (P), income (Y), the interest rate (R), and the exchange rate (E); capital letters denote the level and lower case letters the logarithm; and foreign variables are denoted with an asterisk *. Goods prices in the two countries are assumed to be perfectly flexible and substitutable so that purchasing power parity holds instantaneously.

(A3) $e = p - p^*$

We can solve equations (A1) and (A2) for prices and then substitute in equation (A3) to yield the exchange rate as a function of relative money supplies, income and interest rates.

(A4) $e = (m - m^*) + \alpha(y^* - y) + \beta(r - r^*)$

We can further refine equation (A4) by including time subscripts and substituting the covered interest parity condition for the interest differential

(A5) $r_{t,i} - r^{*}_{t,i} = f_{t,i} - e_t$

where $f_{t,i}$ is the i-period-ahead forward rate. Foreign and domestic bonds are assumed to be perfect substitutes and international arbitrage ensures that speculative efficiency holds, i.e., that the i-period ahead forward rate equal the i-period ahead expectation of the spot rate

(A6) $f_{t,i} = E_t(e_{t+i})$

where E_t represents the mathematical expectation at t. If we combine (A5) and (A6), substitute this in (A4), and let $z=(m - m^{*}) + \alpha(y^{*} - y)$, we arrive at an expression for the exchange rate in terms of relative monies, income and the future exchange rate.

(A7) $e_t = z_t + \beta(E_t(e_{t+i}) - e_t)$

We can now rearrange terms and solve for the reduced form of the exchange rate by process of forward iteration.

(A8) $e_t = 1/(1+\beta)\sum_{j=0}^{\infty}[\beta/(1+\beta)]^j E_t(z_{t+j})$

In the monetarist model, the current spot rate depends on current expectations of all important driving variables (the z's) from now into the indefinite future. The model, while not successful empirically[25], exemplifies the view that exchange rates are fundamentally dependent on beliefs concerning the future course of monetary policy.

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[25]Meese and Rogoff (1983, 1985) find that out-of-sample exchange rate forecasts using the monetary model do no better than a random walk model.

APPENDIX B. On the Usefulness of Survey Data

Although many readers will not require justification for using survey data, such data have often been dismissed by economists claiming that surveys are not representative of the agents who drive the market. The usual example given, is a market with a few rational agents whose actions ensure rationality at the margin despite the irrationality of the majority (Miskin 1981).

The rationality on the margin argument may bear relevance. However, no one has been able to provide convincing theoretical evidence which shows how such a marginal condition might apply. Indeed, newer work[26] concludes that only under a very restricted set of conditions is rationality of some but not all agents sufficient to ensure rationality in the market result overall.

There is little debate that use of massive surveys along the lines of the Livingston series[27] is likely to bias the tests of rationality improperly towards rejection (in the sense of examining the rationality of macroeconomically irrelevant expectations). However, one way around the problem is to use surveys of professional forecasters. Since the success and indeed livelihood of a professional forecaster is presumably a function of accuracy, the use of professional forecasters as representative agents will ensure that those examined are those most

[26] See, for example, Akerlof and Yellen (1985), Haltiwagner and Waldman (1985).

[27] Numerous papers have examined this bi-annual data set on inflation forecasts compiled by Joseph Livingston of the Philadelphia Inquirer. See, for example, Carlson (1977) for tests of unbiasedness and efficiency. Struth (1984) finds that a simple Kalman filter using only past price information can out-perform the Livingston Forecasts.

likely to have the most rational expectations. The performance of professional forecasters therefore may be taken to define an upper bound on the expectational accuracy of agents in the economy as a whole (Nordhaus and Durlauf 1984).

Appendix C. Estimation with Overlapping Data

With the MMS data, at time t when MMS respondents are bi-weekly forecasting the month ahead forecasts, $E_t e_{t+4}$, they will not know what their previous periods forecast error was because e_{t+2} is still a forecast period (two weeks) away. Therefore, it is likely that $E[u_{t,4}|u_{t-2,4}]$ is non-zero. Hansen and Hodrick's (1980) method (generalized latter in Hansen 1982) is first to obtain consistent estimators of $E(e_t e_{t+k}')$ and $E(u_{t,i}u_{t+k,i}')$ for k=-i+1,...,0,..,i-1. They show that if e_t is stationary and ergodic and k>0,

(C1) $$1/T\sum_{t=k+1}^{T} e_t e_{t-k}' \rightarrow E(e_t e_{t+k}') \text{ (almost surely) and}$$

(C2) $$1/T\sum_{t=k+1}^{T} \hat{u}_{t,k}\hat{u}_{t-k,i}' \rightarrow E(u_{t,i}u_{t+k,i}') \text{ (almost surely)}$$

where $\hat{u}_{t,i}$ is the OLS residual for observation t with a sample size T. Using these relationships they can then obtain a consistent estimate of the asymptotic covariance matrix :

(C3) $$T(E_T'E_T)^{-1}E_T'\hat{\Omega}_T E_T(E_T'E_T)^{-1}$$

where $1/T(E_T'\hat{\Omega}_T E_T)=\sum_{k=-i+1}^{i-1}\ \sum_{t=k+1}^{T}\hat{u}_t e_t' e_{t-k}\hat{u}_{t-k}$ and E_T is the matrix of T stacked observations on e_t.

However, this asymptotic covariance matrix is not justified in our case, unless the conditional covariances of forecast errors with respect to lagged forecasts are constants. Cumby and Obstfeld (1983) provide a formal test for conditional homoscedasticity. Under the assumption that the survey forecasts are unbiased predictors of future spot rates, the expectation of the square of the forecast error from the OLS unbiasedness regression:

(C4) $$e_{t+i} - e_t = a_0 + a_1(E_t e_{t+i} - e_t) + v_{t+i}$$

with respect to all instruments available at time t, z_t, should be constant.

(C5) $$E(\hat{v}^2_{t+i} \mid z_t) = \sigma$$

This can be tested by estimating an equation of the form:

(C6) $$\hat{v}^2_{t+i} = d_0 + d_1(E_t e_{t+i} - e_t) + d_2(E_t e_{t+i} - e_t)^2 + u_{t+i}$$

and testing the hypothesis that $d_1=d_2=0$. Table 6 provides results of the conditional homoscedasticity tests of one- and three-month-ahead survey forecast errors. The instrumental variables used were the time t expected depreciation $(E_t e_{t+i} - e_t)$ and the same variable squared for the four countries.

Table 6 $\hat{v}^2_{t+i} = d_0 + d_1(E_t e_{t+i} - e_t) + d_2(E_t e_{t+i} - e_t)^2 + u_{t+i}$ $i=4,12$

CURRENCY	HORIZON	SMPL	$Chi^2(2)$
$/STLG	3-month	83-84	1.58
	1-month	84-86	5.71*
$/DM	3-month	83-84	1.31
	1-month	84-86	1.10
$/SWF	3-month	83-84	1.56
	1-month	84-86	1.82
$/YEN	3-month	83-84	0.77
	1-month	84-86	6.40*

The chi-square statistic pertains to the joint hypothesis that $d_1=d_2=0$; * denotes rejection of the joint hypothesis at the .05 level.

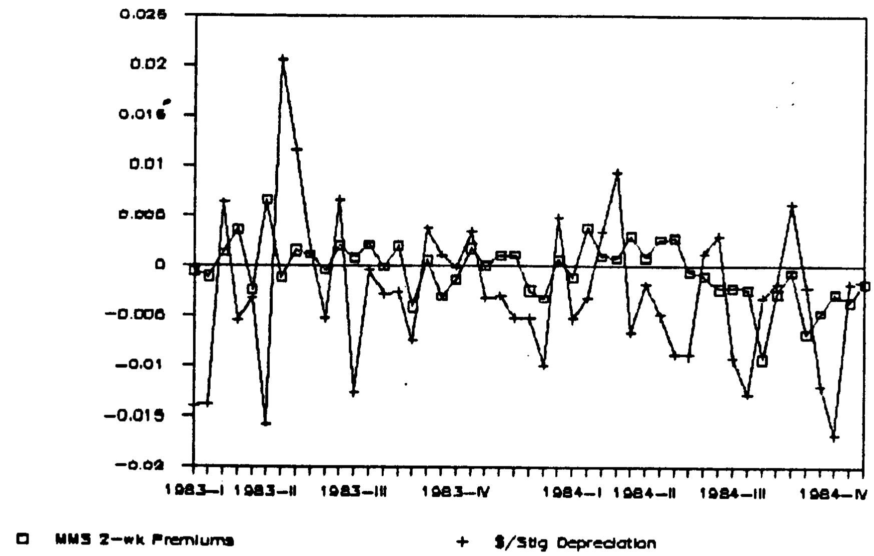
In two of the eight cases, the null hypothesis of conditional homoscedasticity is rejected. These results suggest that Hansen and Hodrick's (1980) asymptotic covariance matrix may not always be justified in conducting hypothesis tests on the coefficients of unbiasedness tests with the survey data. Further, Hsieh's (1984) results with non-overlapping data suggest that tests assuming conditional homoscedasticity when the assumption is not justified often underestimate the standard errors of the OLS coefficients, biasing toward rejection.

Hansen (1982) and Hansen and Hodrick (1983) provide a heteroscedasticity consistent covariance matrix estimator which does not require knowledge of the nature of the heteroscedasticity. This alternative estimate of Ω, can be obtained by calculating a consistent estimate of the spectral density matrix at frequency zero of the vector stochastic process $[e_t'\hat{v}_t]$ (where $\hat{v}_t$ are, again, the OLS residuals of the unbiasedness regression).

The one- and three-month-ahead equations in the paper were estimated with Hansen's (1982) case(v) heteroscedasticity consistent covariance matrix; assuming a first-order moving average process for the bi-weekly one-month-ahead disturbances and a fifth-order moving average process for the bi-weekly three-month-ahead disturbances.

Appendix D. Graphs of Expected and Actual Depreciation

Figure 1
Two-Week $/Sterling
Expected and Actual Depreciation



Three-Month $/Sterling
Expected and Actual Depreciation

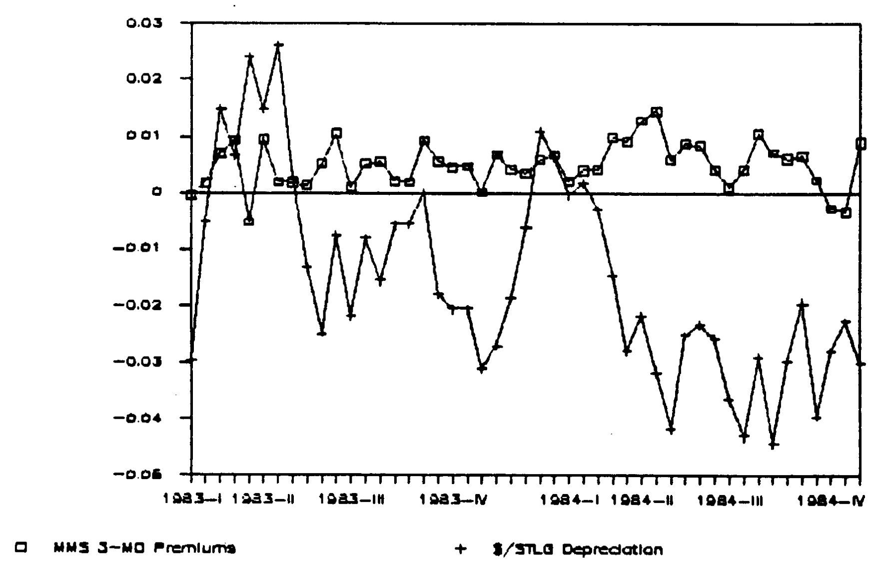
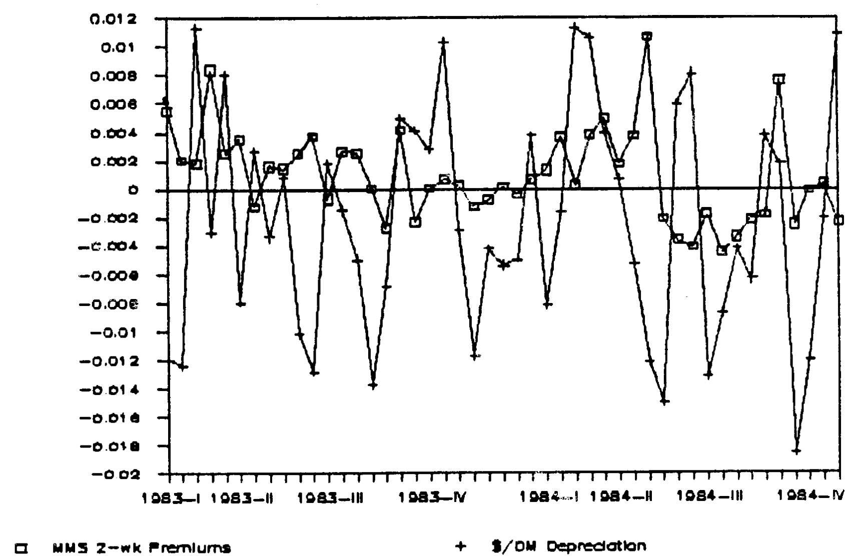


Figure 2
Two-Week $/DM
Expected and Actual Depreciation



Three-Week $/DM
Expected and Actual Depreciation

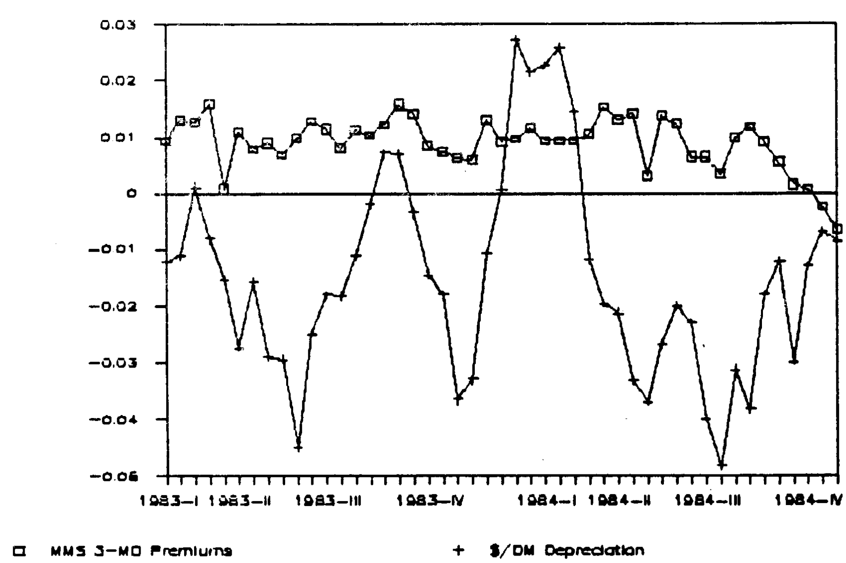
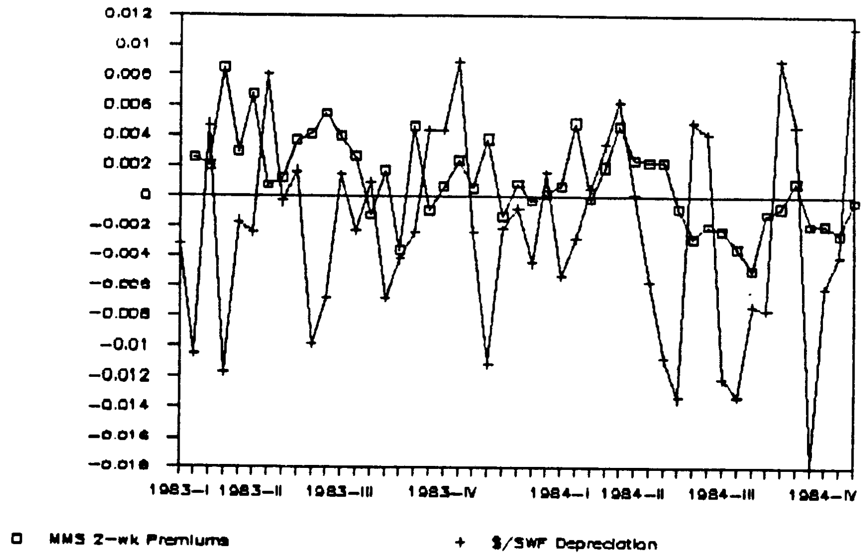


Figure 3
Two-Week $/Swiss-Franc
Expected and Actual Depreciation



Three-Month $/Swiss-Franc
Expected and Actual Depreciation

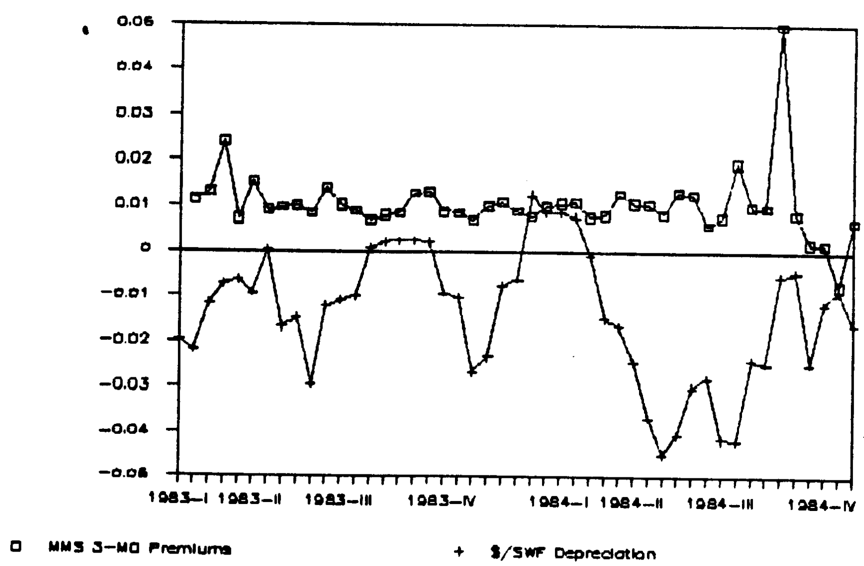
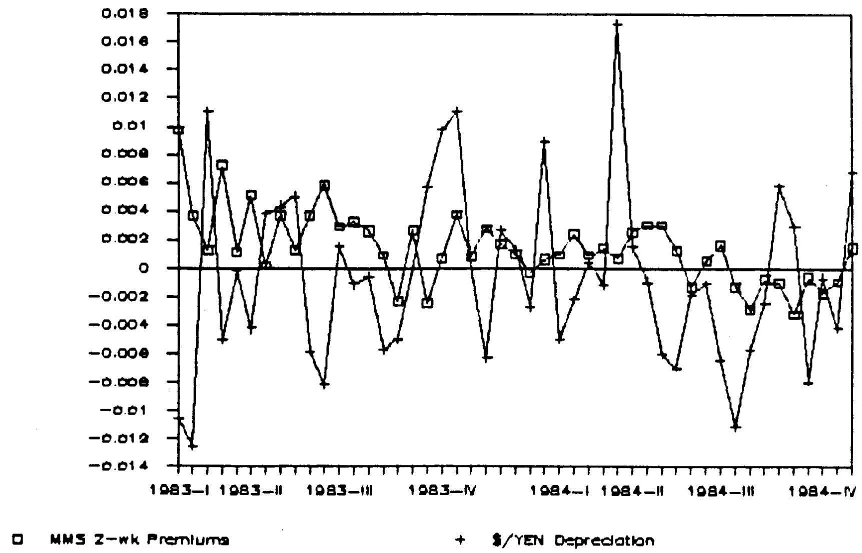


Figure 4
Two-Week $/Yen
Expected and Actual Depreciation



Three-Month $/Yen
Expected and Actual Depreciation

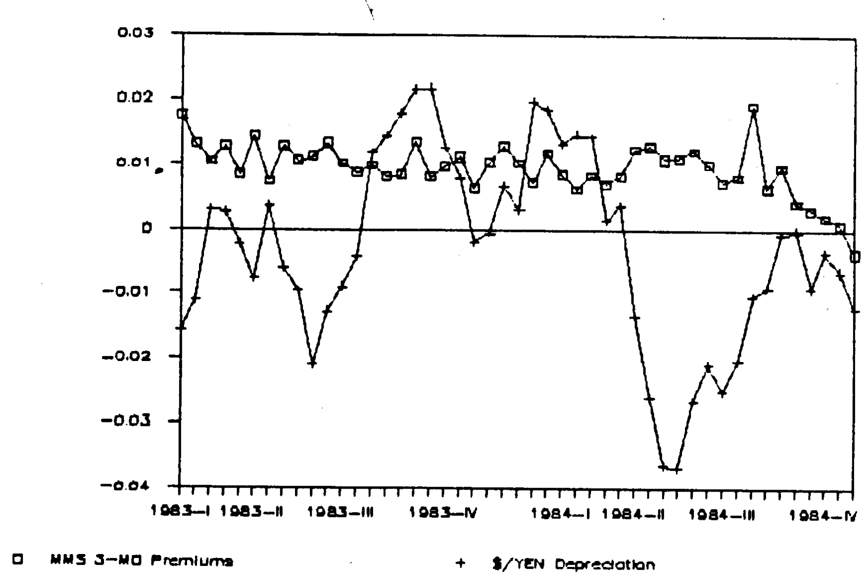
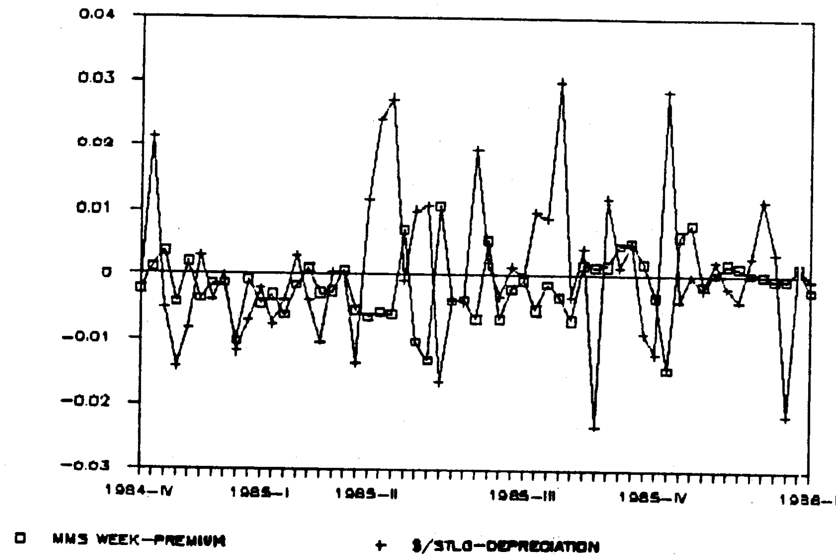


Figure 5
One-Week $/Sterling
Expected and Actual Depreciation



One-Month $/Sterling
Expected and Actual Depreciation

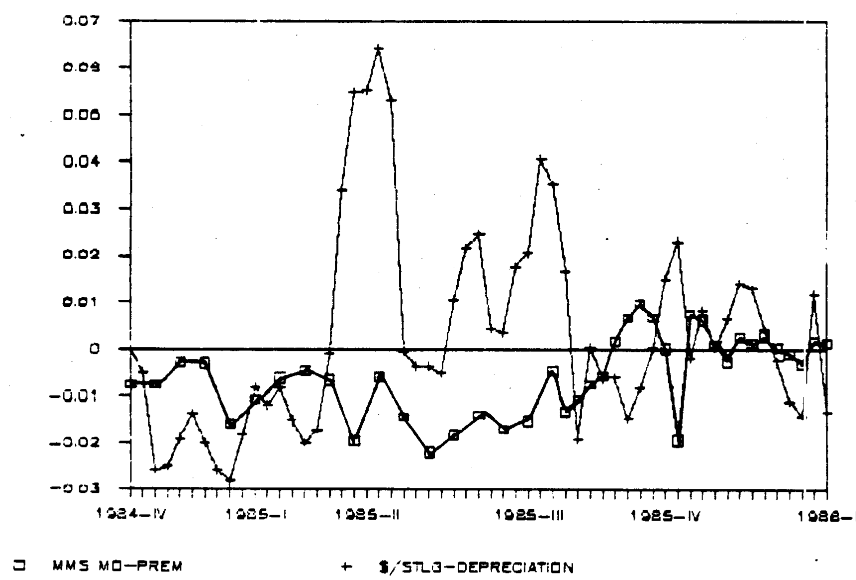
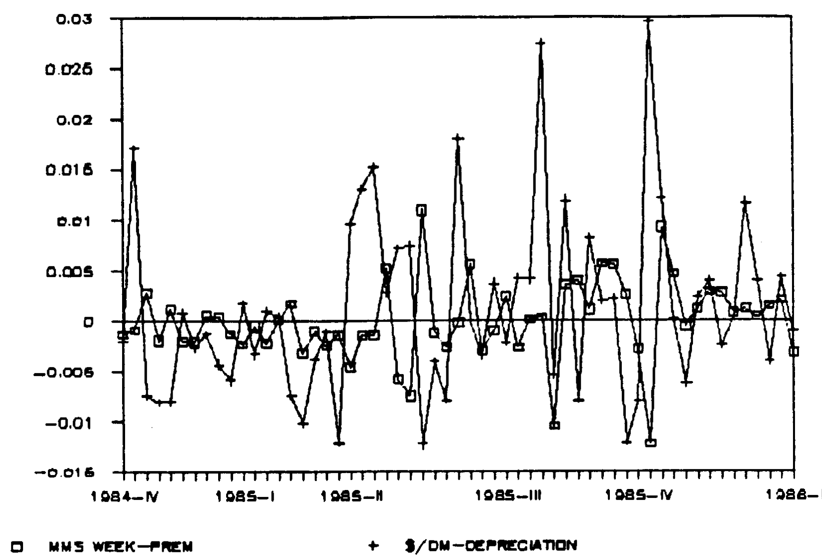


Figure 6
One-Week $/DM
Expected and Actual Depreciation



One-Month $/DM
Expected and Actual Depreciation

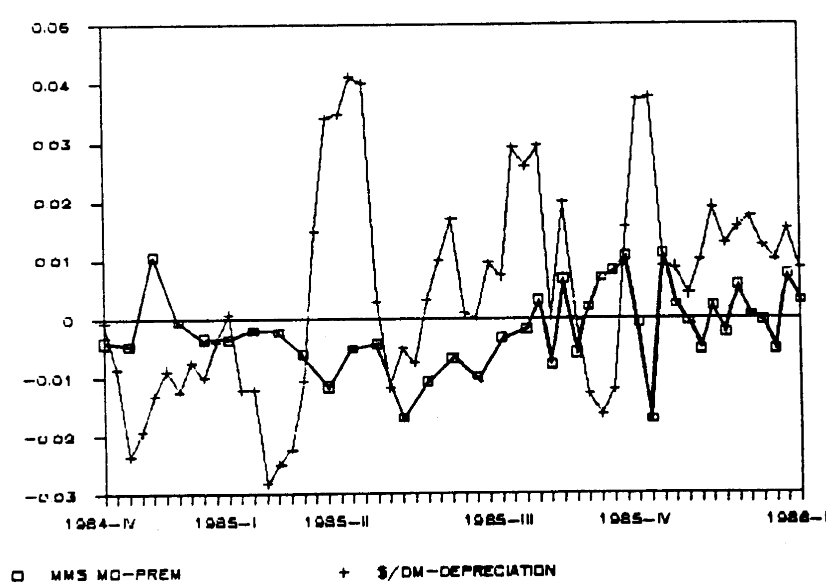
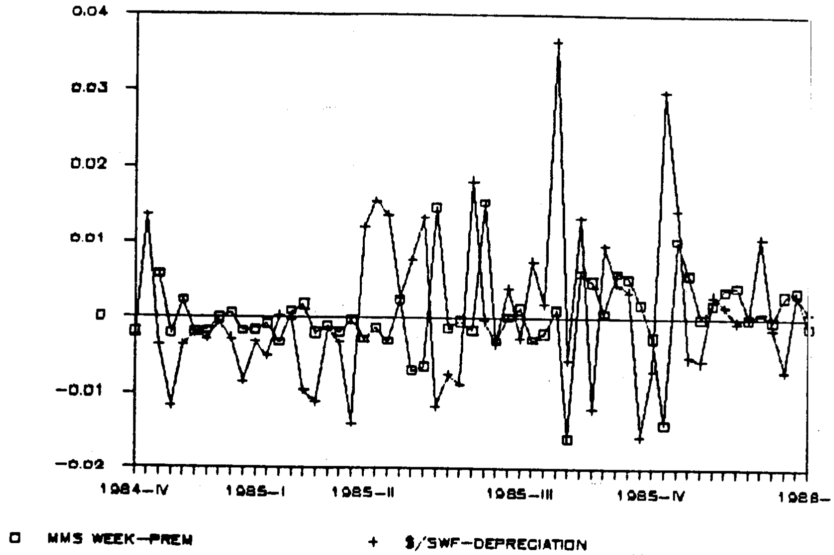


Figure 7
One-Week $/Swiss-Franc
Expected and Actual Depreciation



One-Month $/Swiss-Franc
Expected and Actual Depreciation

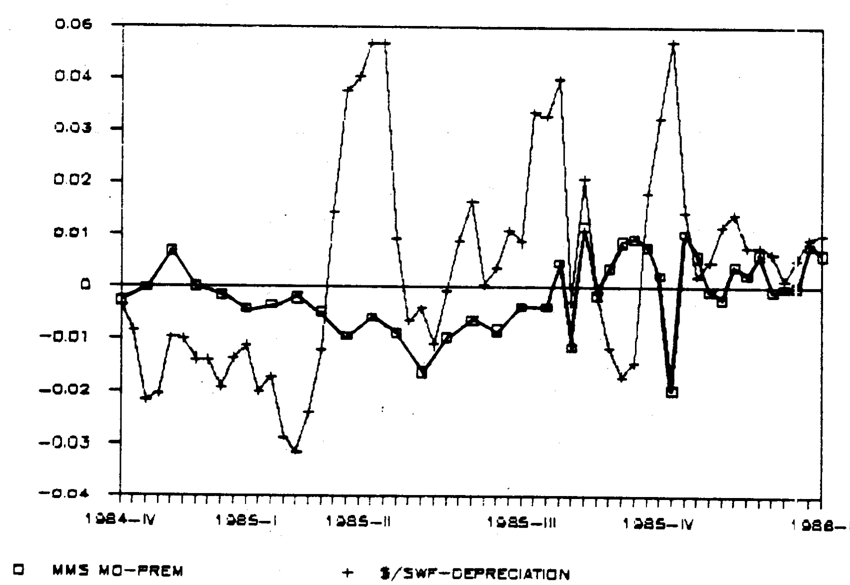
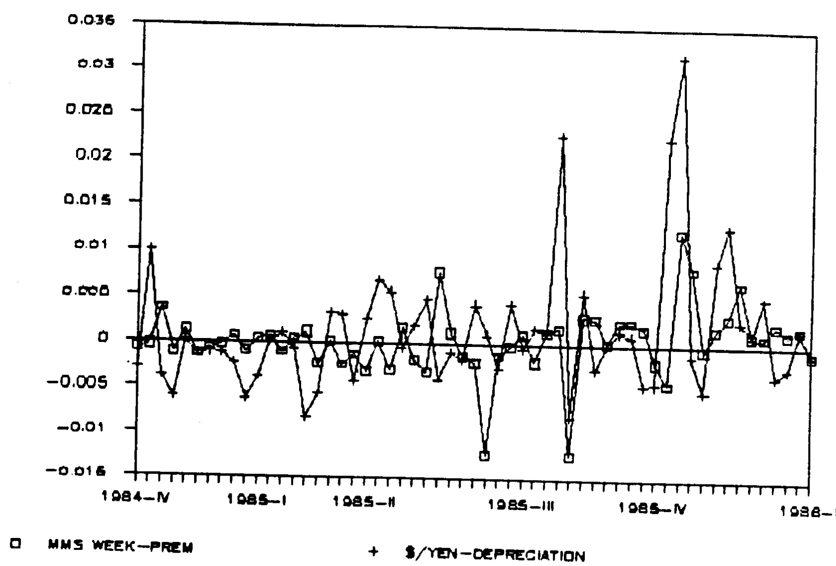
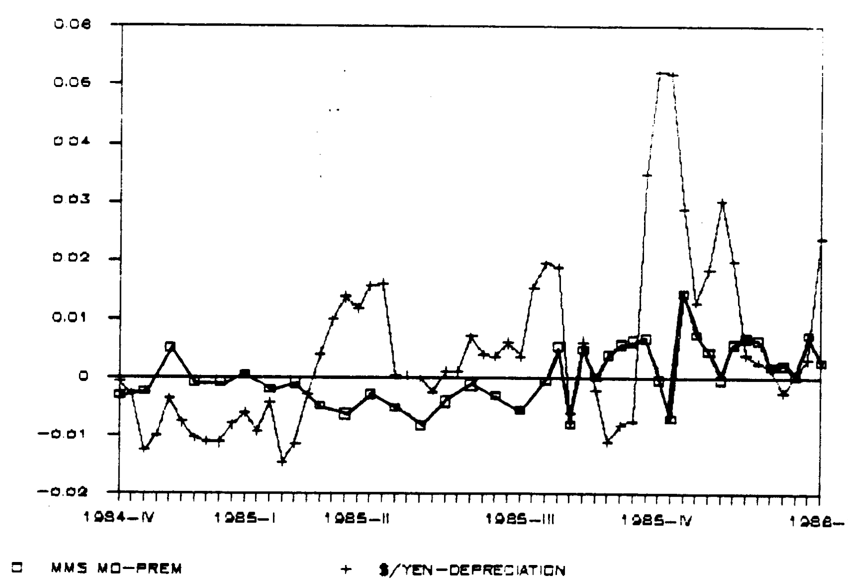


Figure 8
One-Week $/Yen
Expected and Actual Depreciation



One-Month $/Yen
Expected and Actual Depreciation



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