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EXCHANGE RATES, INNOVATIONS AND FORECASTING

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ABSTRACT

In this paper an ex-post forecasting experiment is performed on the basis of a version of the "news" model of exchange rate determination. A general finding is that the "news" formulation of monetary exchange rate models leads to relatively accurate ex-post exchange rate forecasts. Often the results compare favourably with those obtained from the naive random walk forecasting rule. Thus, the evidence presented in this paper supports the argument that the 1983 finding by Meese and Rogoff (that structural models do not even outperform the random walk in an ex-post forecasting experiment) may be due to the fact that the models were not properly tested in a "news" framework.

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Keyword: exchange rates, forecasting, news

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NON-TECHNICAL SUMMARY

It has often been claimed that the best predictor of the next period's spot exchange rate is the current spot rate, i.e. that spot rates follow a random walk. Evidence suggests that this simple random walk model outperforms the forward rate as a predictor of the future spot rate. It has also been found that the random walk model outperforms a variety of "structural" models of the exchange rate (i.e. models in which the exchange rate is explained by other variables). This is so even when the structural forecasts are performed ex-post, using actual (rather than expected) future values of the explanatory variables. Only models with time-varying parameters have been found to forecast better than the random walk rule, and then not by much.

In recent years more emphasis has been given to the distinction between anticipated and unanticipated movements in economic variables. The "asset market theory" of Frenkel and Mussa, for example, views the exchange rate as a highly sensitive asset price which is immediately affected by the receipt of new information. This approach suggests that structural exchange rate models should focus on the relationship between innovations in exchange rates and innovation in the explanatory variables.

In this paper we construct a structural model of exchange rates that reflects this approach. We begin with a structural model in which the spot exchange rate depends on a set of explanatory variables which reflect market fundamentals and the expected change in the exchange rate. The explanatory variables include foreign and domestic money supplies, real income, interest rates, inflation rates, and the relative prices of traded versus non-traded goods. The expected change in the exchange rate is included in the model because it motivates domestic and foreign residents to move into or out of the foreign currency, depending on whether its relative price is expected to rise or fall. This model can be rewritten so that the innovation in the spot rate depends on the innovation in the relevant explanatory variables.

Since these innovations are unobservable, we must first estimate them. The innovations in the explanatory variables are constructed by estimating a system of vector autoregressions (VARS) for these explanatory variables. Each explanatory variable is regressed on 12 lagged values of itself and the other explanatory variables. The innovations, or "news", are the residuals from these regressions. We must also construct an innovation series for the expected change in the exchange rate. This requires an accurate proxy for the market's expectations of the future spot rate; for this purpose we use the current spot rate. Using the current spot rate as a proxy for the market's conditional expectation of the future spot rate in effect assumes that changes in the spot rate are entirely unpredictable, but this is borne out by the empirical experience of floating rates.

The "news" model is then estimated by regressing the spot exchange rate on its lagged value and the innovations in the explanatory variables. We use monthly data from 1973-84 to estimate this equation recursively, using the Kalman filter technique. The equation is first estimated over the period 1974-7 and forecasts are generated at horizons of 1, 3, 6, 12 and 24 months. Then an additional month's data is added to the sample, the parameters are re-estimated and new forecasts are generated based on the updated parameters. We find that, for the $/Yen and $/£ exchange rates, the structural "news" model compares favourably with a random walk model for forecast horizons of up to 6 ($/Yen) or 12 ($/£) months. In all cases the structural model performs less well compared to the random walk as the forecast horizon recedes.

These empirical results are, however, potentially sensitive to the method used for constructing innovations in the explanatory variables. In particular, we have experimented in other papers with a broader set of useful "news" variables. Since much of the real appreciation of the US Dollar towards the end of the sample period was not predicted by the models, it would appear useful to pay particular attention to variables that may capture "news" concerning the strength of the US economy. We have added the Index of Leading Indicators (as constructed by the US Department of Commerce) and Standard & Poor's index of stock prices (500 common stocks) to the set of explanatory variables, but this did not lead to improved forecasting results.

A word of warning is in order. The forecasting results that are obtained from estimation of the "news" model depend critically on the validity of empirical measures of "news" that are employed. In this respect it is important that all relevant innovations are appropriately dated. One problem with datasets such as the one that we use is that information subsequently available to the econometrician may not have been contemporaneously observable to economic agents. Announcement effects and the like, on the other hand, could lead to situations in which variables in our dataset that are dated at time t were actually in agents' information sets at time t-1 or t-2. Another problem indicated by Frenkel is that different frequencies of data collection for different time series may have systematic effects on the time series characteristics of the innovations series. Although it is not obvious how to tackle them in a systematic way, these problems clearly deserve more attention in future work.

Nevertheless, the evidence presented in this paper supports the argument that structural models of exchange rate determination have not outperformed the random walk in ex-post forecasting experiments in the past because these models were not properly tested in a "news" framework.

The forecasting performance of structural exchange rate models has recently received considerable attention. Meese and Rogoff (1983a,b) have studied the forecasting performance of several important structural exchange rate models. While in-sample studies of these models usually show quite satisfactory fits, Meese and Rogoff's out-of-sample results were not very encouraging: the structural models failed to improve upon the simple random walk forecasting rule, even though the models' forecasts were based on actual, realised values of future explanatory variables (i.e. they performed an ex-post forecasting experiment). Wolff (1987) applied varying-parameter estimation techniques to improve the models' predictive performance. He finds that allowing estimated parameters to vary over time enhances the models' forecasting performance for the Dollar/Pound, Dollar/Mark and Dollar/Yen exchange rates. Contrary to Meese and Rogoff's results, ex-post forecasts for the Dollar/Mark rate compare favourably with those obtained from the naive random walk forecasting rule. His overall results, however, may be interpreted as a confirmation of Meese and Rogoff's dim assessment of the models, since the performance of the models, remains quite unimpressive, despite the fact that parameters are allowed to vary over time.

In recent years the distinction between anticipated and unanticipated movements in the exchange rate and its driving variables has been emphasised in the literature [see, e.g., Frenkel and Mussa (1980), Frenkel (1981) and Mussa (1984)]. The essence of this line of thinking is embodied in the 'asset market theory' of the exchange rate that is presented in Frenkel and Mussa (1980). The framework that was developed by Frenkel and Mussa views the exchange rate as a highly sensitive asset price which is immediately affected by an influx of new information. This approach is generally taken to imply that empirical research on the determinants of exchange rates should relate innovations in exchange rates to innovations in a relevant vector of explanatory variables. The idea was first implemented empirically by Frenkel (1981). Isard (1983) and Saidi (1983) have argued that the finding that the structural models do not even outperform the random walk in an ex-post forecasting experiment may be due to the fact that the structural models have not been properly tested in a "news" or innovations framework. In this paper we will address this claim. We will derive a version of the "news" model which will form the basis for a forecasting experiment. The model's ex-post forecasts will be studied and compared with the random walk forecasting rule.

The paper is organised as follows. In section I we present a derivation of the "news" model. In section II various ways of measuring innovations in the exchange rate and its driving variables are discussed. Then, in section III, the forecasting results are presented. Section IV offers some concluding comments.

I. A Derivation of the "News" Model

Consider the following simple model of exchange rate determination:

$$s(t) = \beta' z(t) + aE[s(t+1)-s(t)|t] \quad (1)$$

$$H[L]z(t) = F[L]v(t) \quad (2)$$

Equation (1) is due to Frenkel and Mussa (1980) and states that the logarithm of the equilibrium spot exchange rate, $s(t)$, is determined not only by a set of current market fundamentals, but also by the expected rate of change of the exchange rate, $E[s(t+1)-s(t)|t]$, which motivates domestic and foreign residents to move into or out of foreign exchange depending on whether the relative price of foreign exchange is expected to rise or fall. The vector β is a vector of parameters, a $(a>0)$ is a scalar parameter and

$E[.|t]$ denotes an expected value conditional on information available at time t. Equation (1) represents a general relationship which can be derived from a variety of models of exchange rate determination that generally differ in their interpretations of the elements of the vector z(t). In equation (2) it is assumed that z(t) follows a general vector ARMA time series process. $H[L]$ and $F[L]$ are square matrices, assumed of full rank, whose elements are finite polynomials in the lag operator L. The vector z(t) is assumed to be m-dimensional and thus $F[L]$ and $H[L]$ are mxm matrices. Further, we assume that the mx1 vector of innovations v(t) has a zero mean, an identity covariance matrix and no serial correlation, that is,

$$E[v(t)] = 0, \quad E[v(t)v'(r)] = \delta_{rt}I, \tag{3),(4}$$

where I is an mxm unit matrix and δ_{rt} is the Kronecker delta. Since we assume initially that the process is stationary and invertible (stationarity will be relaxed below), all roots of $\|H[L]\| = 0$ and, $\|F[L]\| = 0$ lie outside the unit circle ($\|.\|$ indicates the determinant of a matrix). Since $H[L]$ is assumed to have full rank, (2) can be solved for z(t):

$$z(t) = (H^*[L]/\|H[L]\|)F[L]v(t), \tag{5}$$

where $H^*[L]$ is the adjoint matrix (the transpose of the matrix of cofactors) associated with $H[L]$. Equation (5) expresses z(t) as an infinite, invertible vector moving average process. For simplicity of notation, we define

$$B[L] \equiv (H^*[L]/\|H[L]\|)F[L]. \tag{6}$$

The matrix B[L] can be written as

$$B[L] = B_0 + B_1L + B_2L^2 + B_3L^3 + \ldots. \tag{7}$$

Wolff (1986) shows that under rational expectations the model (1)-(2) and some auxiliary assumptions together imply the following relationship:

$$D^u[s(t)] = [1/(1+a)]\beta'Cv(t+1). \tag{8}$$

Here $D^u[.]$ is the unexpected change operator, $D^u[s(t)] \equiv s(t+1)-E[s(t+1)|t]$, and the matrix C is defined as

$$C \equiv \lim_{n\rightarrow\infty} \sum_{j=0}^{n} [a/(1+a)]^j B_j. \tag{9}$$

Under the assumption of a stationary and invertible vector ARMA process in equation (2), the infinite series on the right hand side of (9) always converges to a finite matrix. Convergence is also obtained for all non-stationary processes that satisfy

$$\lim_{n\rightarrow\infty} \sum_{j=0}^{n} [a/(1+a)]^j |b_j^{kl}| < \infty \tag{10}$$

for all k, l, where b_j^{kl}, is the k,l th element of the matrix B_j and |.| denotes an absolute value. Equation (8) is a linear relationship between the innovation in the spot exchange rate between t and t+1 and innovations in the elements of the z-vector in the corresponding period. Given appropriate measures of innovations in the exchange rate and its driving variables, the validity of (8) can be examined empirically. It should be noted that estimated coefficients in regression equations that are in innovations form do not have the same interpretations as those estimated from standard structural models. That is, when estimating an equation based on (8) one does not recover the parameter vector β, but a complicated vector of coefficients that involves the elements of the vector β, the elements of the matrix C and scalar a. Equation (8) forms the basis for the forecasting experiments that are performed in this paper.

Since innovations are inherently unobservable, any empirical study on the basis of (8) involves a joint examination of the model and the method that is used to construct innovations. We will therefore discuss the construction of innovations at some length in the next section.

II Constructing Empirical Measures of Innovations

In this section we will take an autoregressive approach to the contruction of innovations. In order to construct innovations we will be fitting vector autoregressive systems (VARs) to vectors of relevant z-variables. We study the same set of exchange rates as Meese and Rogoff (1983a,b) and Wolff (1987): the U.S. Dollar-German Mark, U.S. Dollar-Japanese Yen and U.S. Dollar-British Pound spot exchange rates. The monthly dataset covers the period from March 1973, the beginning of the floating exchange rate period, through April 1984. The data are drawn from I.M.F. and O.E.C.D. publications and are described in detail in the Data Appendix.

The z-vectors that we employ are closely related to the monetary models of Bilson (1978), Dornbusch (1976a), Frankel (1979), Frenkel (1976) and Frenkel and Clements (1980):

$$z' = [m-m^*,\ y-y^*,\ i-i^*,\ \pi-\pi^*,\ q] \qquad (11)$$

where

$$q = \ln[P_t/P_n)/(P_t^*/P_n^*)]. \qquad (12)$$

Here m and m* are the logs of the domestic and foreign money supplies, respectively, y and y* are the logs of domestic and foreign real income levels, i and i* domestic and foreign nominal interest rates, π and π^* are domestic and foreign long-run expected inflation rates, P_t and P_t^* are domestic and foreign price levels of internationally tradable goods and P_n and P_n^* are domestic and foreign price levels of nontradable goods.[1] The variables $m-m^*$, $y-y^*$, $i-i^*$ and $\pi-\pi^*$ are those that enter the monetary models presented in Frankel (1979) and Frenkel (1976). The variable q is an indicator variable for the equilibrium real exchange rate that is based on Balassa's (1964) approach to relative prices in a world with internationally traded and nontraded goods. This approach was subsequently introduced into modern exchange rate models by Dornbusch (1976b) and implemented empirically (in-sample) by Clements and Frenkel (1980) in a study of the Dollar-Pound exchange rate in the 1920's. The approach assumes the existence of two categories of goods: those that are internationally traded and those that are not. The general price level in a country is assumed to be a linear homogeneous Cobb-Douglas function of the prices of traded and nontraded goods. Given these assumptions q, as defined in equation (12), is a relevant variable that enters into the equations of the monetary models. For exact derivations, see Clements and Frenkel (1980) and Wolff (1985). In Wolff (1987) it is shown that inclusion of q into the monetary models increases the models' forecasting accuracy in the case of the Dollar/Yen exchange rate. Because we will engage in ex-post forecasting experiments, we explicitly do not include the exchange rate itself in the VAR systems. If the exchange rate itself would be included, current innovations in the z's would be calculated on the basis of future spot exchange rates, which are not assumed to be known in the current period.

Given the specification in equation (11), we have to choose the laglength p for each VAR model. Given the size of our samples, we will restrict our attention to VAR systems of orders up to twelve. As the results of the forecasting experiments are potentially sensitive to this choice of p, we employ three different laglength selection criteria: (i) Akaike's (1974) Information Criterion (AIC), (ii) Parzen's (1975) CAT criterion and (iii) Likelihood Ratio (LR) tests. The three criteria are described in Appendix A. All three criteria have large sample justifications. Their relative performance in finite samples remains largely unexplored.

The VAR models are estimated using data over the period from March 1973 through April 1984. A constant and eleven seasonal dummy variables are included in the estimated equations. We have experimented with two methods to reduce the systems to stationarity: first-differencing and including a time trend in the VARs. (As the results are very similar, we only report the prediction results for the latter case in the next section.) Our three laglength selection criteria unanimously prescribe employing the full twelfth order systems. Thus the choice of laglengths for the VAR's is in part determined by data availability. If more data were available, it would probably be desirable to employ larger systems. A separate method is needed to construct innovations in the (log of the) spot exchange rate[1] at time t, s(t). That is, we have to find an accurate empirical proxy for the market's expectations E[s(t+n|t] concerning future spot rates at various horizons n, on the basis of information available at time t, in order to generate the innovations s(t+n)-E[s(t+n)|t]. An obvious choice for E[s(t+n|t] would be the forward exchange rate at time t for currency to be delivered at time t+n, f(t,t+n). Genberg (1984) studies exchange rate innovations that are calculated along these lines. For a number of reasons, however, we will use the current spot rate as a proxy for E[s(t+n)|t] when constructing exchange rate innovations. These reasons are the following:

(a) In a number of studies [e.g. Hansen and Hodrick (1980) and Hsieh (1982)] forecast errors resulting from the use of the forward exchange rate as a predictor of the future spot rate have been shown to be correlated with variables that are assumed to be in traders' information sets at the time when the forward rates were quoted, such as past values of spot and forward rates. This finding indicates that forward rates are not optimal predictors of future spot rates.

(b) The results in Meese and Rogoff (1983a) and Wolff (1987) show that current spot rates have been more accurate predictors of future spot rates than current forward rates.

(c) For the longer forecasting horizons that we study forward rates do not exist. They could be constructed from the covered interest arbitrage relationship, but such a procedure would introduce unnecessary measurement error.

Using the current spot rate to proxy for the market's conditional expectation of the future spot rate amounts to assuming that changes in the spot rate are almost entirely unpredictable. This assumption is in accord with the empirical evidence over the recent floating exchange rate period [see Frenkel (1981)], Meese and Rogoff (1983a), Mussa (1979, 1984) and Wolff (1985, 1987)]. Mussa (1984) argues: "...changes in spot prices are largely unanticipated and correspond fairly closely to changes in the market's expectation of future spot prices".

In this section we have described the construction of innovations in the variables that we will use in the forecasting experiment that is performed in section III. In that section we will also investigate how robust the prediction results are with respect to different ways of calculating innovations in the z-vectors.

III. The Ex-post Prediction Results

In this section we report the prediction results on the basis of the "news" model. The statistical forecasting equation that we use is based on equation (8) and the methods for constructing innovations that were described in section II:

$$s(t) = s(t-1) + \varepsilon'(t)\,\gamma + \eta(t) \tag{13}$$

where s(t) is the log of the spot exchange rate, $\varepsilon(t)$ is the vector of innovations in the z-variables that results from the estimated VAR models, γ is a vector of parameters to be estimated and $\eta(t)$ is a disturbance term. Initially, forecasts will be generated using the ordinary Least Squares (OLS) estimation technique. A variety of other techniques are also implemented below.

After innovations have been calculated on the basis of the entire sample, we estimate equation (13) over the period March 1974 through November 1977 (45 observations). [The first twelve observations are lost because we estimated the VARs conditional on these observations.] Forecasts are generated at horizons of 1,3,6,12 and 24 months. Then December 1977 data are added to the sample, the parameters are updated and new forecasts are generated. This recursive process continues until forecasts are generated using April 1984 data (the end of our sample period). For computational efficiency these rolling regressions are calculated using the Kalman filter algorithm. This procedure provides us with time series of spot rate forecasts at various prediction horizons.

Forecasting accuracy is measured by four summary statistics that are based on standard symmetric loss functions: the mean error (ME), the mean absolute error (MAE), the root mean square error (RMSE) and the U-statistic. The ME, MAE and RMSE are defined as follows:

$$ME = \sum_{j=0}^{N-1} [A(t+j+k)-F(t+j+k)]/N$$

$$MAE = \sum_{j=0}^{N-1} |A(t+j+k)-F(t+j+k)|/N$$

$$RMSE = [\sum_{j=0}^{N-1} [A(t+j+k)-F(t+j+k)]^2/N]^{0.5}$$

where k=1,3,6,12,24 denotes the forecast step, N the total number of forecasts in the projection for which the actual value of the exchange rate, A(t), is known, and F(t) the forecast value. Theil's U-statistic is the ratio of the RMSE to the RMSE of the naive random walk forecast. Because we are looking at the logarithm of the exchange rate, the ME, MAE and RMSE are unit-free (they are approximately in percentage terms) and comparable across currencies. The values of the summary statistics are presented in Table I.

INSERT TABLE I

It is interesting to look at the U-statistics that are reported in Table 1. U-statistics are easily interpreted: if U<1 the model performs better than the simple random walk forecasting rule and if U>1 the random walk outperforms the model. The U-statistics are smaller than one in a number of cases for the Dollar/Yen and Dollar/Pound exchange rates, indicating that the "news" model outperforms the random walk in those cases. The performance of the "news" model, relative to the random walk, is weaker as the forecasting horizon is extended.

Table 1. Summary Statistics on the Forecasting Performance of the "News" model. November 1977 - April 1984.

horizon (months)	ME	MAE	RMSE	U-stat.	no. obs
$/Mark					
1	-0.06	2.77	3.63	1.02	77
3	-0.17	4.97	6.04	1.04	75
6	-3.95	7.23	9.13	1.12	72
12	-9.02	12.11	15.33	1.26	66
24	-22.18	25.78	29.33	1.47	54
$/Yen					
1	-0.02	2.91	3.73	0.97	77
3	-0.07	4.87	6.51	0.96	75
6	-1.43	8.17	9.92	0.97	72
12	-4.86	10.63	13.08	1.07	66
24	-13.74	14.21	16.68	1.68	54
$/Pound					
1	-0.01	2.55	3.27	0.99	77
3	-0.04	4.57	5.63	0.99	75
6	-0.08	6.60	8.27	0.98	72
12	-1.97	11.92	13.47	0.97	66
24	-6.05	23.63	25.41	1.06	54

NOTE: Innovations in explanatory variables are constructed on the basis of 12th order VAR systems. In the estimation of the forecasting equations intercepts have been included.

The mean errors are consistently negative and for the longer forecasting horizons they are often not much smaller in absolute value than the mean absolute errors. This means that our version of the "news" model on average missed out on "news" that led to appreciation of the Dollar. Since the forecasts for the (log of the) spot exchange rate at horizons beyond one month are generated using the chain rule of forcasting, these systematic forecast errors are compounded for the longer horizons, as is evident from the larger mean errors.

Since all three exchange rates that we study involve the U.S. Dollar, it is likely that the covariance matrix of errors terms [the η's in equation (13)] across currencies is not diagonal. In Table 2 we present an estimate of this covariance matrix over the period March 1974 - April 1984. The table shows that off-diagonal elements are indeed of non-negligible size.

INSERT TABLE 2

Thus we employed Zellner's (1962) seemingly unrelated regression method (SURM) in an attempt to obtain more efficient estimates of the parameter values. The forecasting experiment was repeated using updated SURM parameter estimates on a period-by-period basis. The forecasts on the basis of SURM or iterated SURM, however, turned out not to lead to any improvement in the models' performance and are note presented. Along the lines of Wolff (1987) we have also experimented with estimation methods that allow for random walk parameter variation. In the context of the "news" model, however, the introduction of parameter variation does not lead to an improved forecasting performance.

The empirical results in Table 1 are potentially sensitive to the method used for isolating innovations in the z-vector. In Wolff (1985) we

Table 2. An Estimate of the Covariance Matrix of Error Terms Across Currencies from Regression Equations of the Form

$$s(t) = \text{constant} + s(t-1) + \epsilon'(t)\,\gamma + \eta(t)$$

Period : March 1974 - April 1984

	$/Mark	$/Yen	$/Pounds
$/Mark	0.997[b]		
$/Yen	0.454	0.927	
$/Pound	0.477	0.328	0.817

[a]This estimate was obtained from an iterated SURM procedure. SURM was iterated until the log determinant of the estimated covariance matrix changed by less than 0.001.

[b]All entries are scaled by 10^3.

have considered a range of alternative methods to calculate innovations:[2]

a) Shorter laglengths for the VAR systems were tried and the forecasting experiment was repeated on the basis of innovations that were thus calculated.

b) Bayesian prior distributions of the class proposed by Litterman (1980) have been implemented in the estimation of the VARs. Litterman suggests that in the context of regressions with a large number of parameters and a high degree of collinearity, such as a VAR, suitable restrictions on the parameters may lead to substantial reduction in the sample variance of parameter estimates. We have implemented a large number of variants of Litterman's class of prior distributions in order to calculate innovations for the forecasting experiment.

c) It is quite possible that the estimated VAR systems suffer from parameter instability, as the result or changes in the underlying international economic structure. In an attempt to cope with this potential problem, we have estimated variants of the VARs in which the are allowed to vary over time. [Only generic vector random walk parameter variation was allowed for.[

d) We have tried to broaden the set of useful "news" variables. Since much of the real appreciation of the U.S. Dollar towards the end of the sample period was not predicted by the models, it would appear useful to pay particular attention to variables that may capture "news" concerning the strength of the U.S. economy. We have experimented with the Index of Leading Indicators (as constructed by the U.S. Department of Commerce) and with Standard & Poor's index of stock prices (500 common stocks) as additional elements of the vector z.

None of the variants described under a)-d), however, led to forecasting results that were better than those presented in Table 1 (or even very different). Thus, the results are robust in the sense that different innovations constructs within the vector autoregressive approach do not lead to very different ex-post forecasting results. It should be noted, however, that there are in principle many other ways to construct measures of "news".

A caveat is in order. The forecasting results that are obtained from estimation of the "news" model depend critically on the validity of empirical measures of "news" that are employed. In this respect it is important that all relevant innovations are appropriately dated. One problem with datasets such as the one that we use is that information that is subsequently available to the econometrician may not have been contemporaneously observable to economic agents. Announcement effects and the like, on the other hand, could lead to situations in which variables in our dataset that are dated at time t were actually in agents' information sets at time t-1 or t-2. Another problem is indicated by Frenkel (1984). He suggests that different frequencies of data collection for different time series may have systematic effects on the time series characteristics of the innovations series. Although it is not obvious how to tackle them in a systematic way, these problems clearly deserve more attention in future work.

IV Conclusions

In this paper we performed an ex-post forecasting experiment on the basis a version of the "news" model of exchange rate determination. A general finding is that the "news" formulation of monetary exchange rate models leads to relatively accurate ex-post exchange rate forecasts. Oftentimes the results compare favourably with those obtained from the naive random walk forecasting rule. The performance of the "news" model relative to the random walk is weaker as the forecasting horizon is extended.

Thus, the evidence presented in this paper supports Isard's (1983) and Saidi's (1983) suggestion that the Meese and Rogoff (1983a,b) finding that structural models of exchange rate determination do not outperform the random walk in an ex-post forecasting experiment, may be due to the fact that the models were not properly tested in a "news" framework.

Footnotes

1. Natural logarithms of variables are used because we will study the models' ability to predict the log of the spot exchange rate. by comparing predictors on the basis of their ability to predict the logarithm of the spot exchange rate, we circumvent any problems arising from Jensen's inequality. Because of Jensen's inequality the best predictor of the level of the spot exchange rate expressed as unit of currency i per unit of currency j may not be the best predictory of the level of the spot exchange rate expressed as units of currency j per unit of currency i.

2. We have not experimented with instrumental variables estimation techniques. While it is clearly desirable to use these methods in order to mitigate potential simultaneous equations bias, it appears very difficult, even at the conceptual level, to identify valid instruments in the case of an equation formulated in innovations form.

Appendix A

Laglength Selection Criteria

(i) Akaike's (1974) Information Criterion (AIC)

The AIC is based on information theoretic concepts. When a model involving r independently adjusted parameters is fitted to data, the AIC prescribes minimising the function

$$AIC(r) = -2 \ln(\text{maximised likelihood}) + 2r \qquad (A1)$$

by choice of r. In the case of k-variate AR(p) model, (A1) specialises to [see Priestley (1981)]:

$$AIC(p) = N \ln|\Omega^p| + 2k^2p \qquad (A2)$$

where N is the number of observations and $|\Omega^p|$ is the determinant of the conditional maximum likelihood estimate of the covariance matrix of the innovations vector v(t), based on a fitted AR(p) model. Introduction of a deterministic component in the VAR does not affect the validity of the AIC, since this only requires the addition of a constant (in dependent of p) to the AIC values computed from (A2).

(ii) Parzen's (1975) CAT criterion.

The CAT criterion for a k-variate AR(p) process prescribes minimisation (by choice of p) of the function

$$CAT(p) = \text{trace}\,([(k/N)\sum_{j=1}^{p} (\hat{\Omega}^j)^{-1}] - (\hat{\Omega}^j)^{-1}) \qquad (A3)$$

where

$$\hat{\Omega}^j = [N/(N-kj)]\,\Omega^j \qquad (A4)$$

(iii) Likelihood Ratio tests.

Standard likelihood ratio tests can also be used for testing the laglength specification of a VAR system. If we want to test a k-variate AR(p_1) model as a restriction of a k-variate AR(p_2) model, we can calculate the following test statistic, which is asymptotically distributed as χ^2 with $k^2 x(p_2-p_1)$ degrees of freedom.

$$N(\ln|\Omega_1|-\ln|\Omega_2|) \sim \chi^2_{k^2 x(p_2-p_1)} \tag{A5}$$

where Ω_1 and Ω_2 are the estimated covariance matrices for the AR(p_1) and AR(p_2) models, respectively.

Appendix B

Data Sources

In this appendix we describe the sources for the data that are used in this study.

Exchange Rates

Spot exchange rates are taken from the International Financial Statistics (I.F.S.) (line ae), published by the International Monetary Fund.

Money Supplies

Seasonally unadjusted M1 figures are used for all countries. United States: Main Economic Indicators (M.E.I.), published by the Organisation for Economic Cooperation and Development. Germany, Japan and United Kingdom: I.F.S. (line 34).

Real Income Levels

For all countries seasonally unadjusted figures for industrial production were taken from the M.E.I.

Interest Rates

United Kingdom and United States: treasury bill rates as reported in the M.E.I.. Germany and Japan: call money rates, I.F.S. (line 60b).

Price Levels and Inflation Rates

Traded and nontraded goods prices are proxied by wholesale price indices (WPI's) and consumer price indices (CPI's) respectively. Wholesale price indices generally pertain to baskets of goods that contain large shares of traded goods relative to baskets of consumer goods, which contain large shares of nontraded consumer services.

Consumer Price Indices: I.F.S. (line 64).
Wholesale Price Indices: I.F.S. (line 63).
Expected long-run inflation rates are proxied by CPI inflation rates over the preceeding twelve-month period.

Index of Leading Indicators (U.S.)

A composite index of 12 leading indicators is taken from the 1984 Handbook of Cyclical Indicators (series 910), U.S. Department of Commerce.

Stock Price Index (U.S.)

Index of stock prices (Standard and Poor's 500 common stocks) as reported in the 1984 Handbook of Cyclical Indicators (series 19), U.S. Department of Commerce.

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