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FORWARD FOREIGN EXCHANGE RATES AND EXPECTED FUTURE SPOT RATES

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ABSTRACT

In this paper I explore whether knowledge of the time-series properties of premia in the pricing of forward foreign exchange can be usefully exploited in forecasting future spot exchange rates. I use signal-extraction techniques, based on recursive application of the Kalman filter, to identify these premia.

Predictions using premium models compare favourably with those obtained from the use of the forward rate as a predictor of the future spot rate. The results also provide an interesting description of the time-series properties of premia.

This methodology can be applied straightforwardly to other financial markets, such as futures markets and markets for government debt instruments.

JEL classification: 430

Keyword: exchange rates, premia, forecasting

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NON-TECHNICAL SUMMARY

Previous research has shown that the future spot exchange rate is better predicted by its own current value than by the current forward rate. The discrepancy between the current forward rate and the future spot rate is composed of errors in the market's expectation of the future spot rate as well as a premium. This premium can be thought to consist of two components: one is the result of risk aversion of market participants (the risk premium); the other component results from the presence of stochastic inflation. In this paper I examine the time-series properties of this discrepancy in order to distinguish between expectational errors and risk premia. Having identified these premia we can then model their behaviour; predictions of the premia allow us to forecast future spot rates.

We distinguish these components using signal-extraction techniques widely used by engineers. This approach treats a stochastic sequence as a mixture of a systematic signal and noise; the engineering analogy is a radio signal overlaid with hiss. The technique of Kalman filtering allows an optimal separation of signal from noise, and the paper contains a brief description of the Kalman filter. The two components of the apparent prediction error in the forward rate are assumed to be a true (market) prediction error and a premium. The true prediction error is assumed to be "white noise", i.e. a random variable which is uncorrelated with its own past values. This assumption would hold if market expectations are formed rationally, conditional upon the information available at a given date. This component is the noise in the signal-extraction approach. The sequence of premia is assumed to be generated by a first-order autoregressive process: each value is the sum of the last period's value and a purely random (unpredictable) part.

We apply this approach to monthly series from 1973 to 1984 for the Dollar/Pound, Dollar/Yen and Dollar/Deutschmark exchange rates. We estimate the values of the unknown parameters of the Kalman filter by means of a grid search. Each choice of parameter values generates a sequence of estimated premia which can be used to generate forecasts of the future spot rate using the forward rate. The optimal values of the parameters are chosen to minimize the root mean square of these forecasts. During the sample period the premia have not been greater than 1.5-2.0% in absolute value. The premia for the Dollar/Pound and Dollar/Mark exchange rates follow similar paths while the premium for the Dollar/Yen rate appears more volatile. On average the premia are negative in the first part of the graph and positive in the second part. If the premium reflected only pure risk, one might conclude that the Dollar was on average riskier than the other currencies until 1980 and less risky thereafter.

Examination of these data confirm that the current spot rate is a better predictor of the future spot rate than is the current forward rate, both in terms of mean absolute error and root mean square error. We find that our one-step-ahead forecast errors in forecasting the future spot rate compare favourably with forecasts based on the unadjusted forward rate. The premium models which perform best in terms of root mean square forecast error have fairly high positive first-order autocorrelation coefficients it is plausible that international risk has a tendency to persist over time. In the most successful premium models changes in the premia account for between 9% and 16% of the variance of the one-step-ahead prediction errors of the unadjusted forward rate. Useful information concerning the spot exchange rates is captured by our empirical characterization of the time-series properties of the premia.

We find, however, as have earlier investigations, that the models we develop are inferior in predictive power to the simple random walk model, although this is a very close contest. It may be possible to obtain an improved forecast by combining the forecasts from the premium and the random walk models.

This methodology can be applied in a straightforward fashion to other financial markets, such as futures markets and markets for government debt instruments.

1. INTRODUCTION

There exists a substantial literature on the presence or absence of premia (possibly time-varying) in the pricing of forward contracts for foreign exchange. Conditional on the hypothesis that the foreign exchange market is efficient or rational, the existence of time-varying premia has been documented in the literature by Fama (1984), Hansen and Hodrick (1983), Hodrick and Srivastava (1984), Hsieh (1982) and Korajczyk (1985). Frankel (1982) failed to identify such premia. Equilibrium models of international asset pricing that describe the determination of the premium are presented by Adler and Dumas (1983), Fama and Farber (1979), Hodrick (1981), Hodrick and Srivastava (1984), Solnik (1974) and Stulz (1981).

In this paper we will explore whether knowledge about the time series properties of premia can be usefully exploited in forecasting future spot exchange rates. In order to identify such premia, we take a signal-extraction approach, based on recursive application of the Kalman filter. The results that we obtain provide us with a useful description of the time series properties of premium terms.

The organisation of the paper is as follows. In Section 2 we present some evidence on the properties of current forward and spot exchange rates as predictors of future spot rates. In Section 3 we explain the methodology that is used in this paper; here the Kalman filter is described in some detail. In Section 4 we present the prediction results that we obtain on the basis of the premium models that are constructed in the previous section and we present parameter estimates that describe the time series properties of premia. Section 5 offers some conclusions.

2. CURRENT SPOT AND FORWARD RATES AS PREDICTORS OF FUTURE SPOT RATES

A number of researchers have investigated the properties of forward exchange rates as predictors of future spot rates, eg. Bilson (1981), Fama (1984) Hansen and Hodrick (1980), Levich (1979) and Meese and Rogoff (1983). The general consensus is that forward rates are not very good predictors of future spot rates. In fact, both Fama and Meese and Rogoff find that the current spot rate is a better predictor of the future spot rate than current forward rate.

In Table 1 we present summary statistics on the one-month-ahead forecasting performance of the forward rate and the once lagged spot rate for three important exchange rates involving the U.S. Dollar: the Dollar/Pound, Dollar/Mark and Dollar/Yen exchange rates. Spot exchange rates and thirty-day forward rates are taken from the Harris Bank Data Base that is supported by the Center for Studies in International Finance at the University of Chicago. The rates are Friday closes sampled at four-week intervals. All rates are logs of U.S. Dollars per unit of foreign currency. There are 148 observations covering the period April 6, 1973, to July 13, 1984.

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:

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

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

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

where N is the total number of forecasts, A(t) is the actual value of the log of the spot rate at time t and F(t) is the predicted value for A(t) that is given by our model.

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.

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 predictor of the level of the spot exchange rate expressed as units of currency j per unit of currency i.

TABLE 1

SUMMARY STATISTICS ON THE FORECASTING PERFORMANCE OF CURRENT FORWARD AND SPOT EXCHANGE RATES AS PREDICTORS OF FOUR-WEEK AHEAD SPOT RATES, 4/6/1973-7/13/1984 (N=147)

Rate	ME[a]	MAE[a]	RMSE[a]	U-Stat.
		Forward Rate		
$/Pound	-0.22	1.98	2.57	1.021
$/Mark	-0.31	2.38	3.13	1.017
$/Yen	-0.15	2.13	2.94	1.034
		Spot Rate		
$/Pound	-0.43	1.92	2.52	1.000[b]
$/Mark	0.00	2.31	3.08	1.000[b]
$/Yen	0.06	1.98	2.84	1.000[b]

[a]The ME, MAE, and RMSE are approximately in percentage terms.

[b]The U-statistic of the random walk forecast is one by definition.

Consistent with the previous literature the results in Table 1 indicate that the current spot rate is a better predictor of the future spot rate than the current forward rate, both in terms of mean absolute error and root mean square error.

In Table 2 autocorrelations of the forecast error f(t,t+1)-s(t+1), the log of the thirty-day forward rate minus the log of the corresponding spot rate observed four weeks later, are presented. Significant autocorrelations are reported in a number of cases, in particular at lag one. These autocorrelation give us information about the time series properties of the underlying premia. In Section 3 we will advance a hypothesis concerning the time series properties of premium terms that is consistent with the autocorrelation patterns that are observed in Table 2.

3. MODELLING THE PREMIUM

3.1 The Model

The forward exchange rate can be conceptually divided into an expected future spot rate and a premium term:

$$(1) \qquad f(t,t+1) = E[s(t+1)|t] + P(t)$$

where f(t,t+1) is the log of the current forward rate for currency to be delivered thirty days later, E[s(t+1)|t] is the rational or efficient forecast of the log of the spot rate at time t+1, based on all information available at time t, and P(t)

TABLE 2

AUTOCORRELATIONS OF $f(t,t+1)-s(t+1)^a$, 4/6/1973-7/13/1984

Lag	$/Pound	$/Mark	$/Yen
1	0.24**	0.15*	0.19**
2	0.14*	-0.02	0.04
3	-0.02	0.04	0.08
4	-0.04	-0.11	0.03
5	0.06	-0.09	0.09
6	0.09	-0.08	-0.02
7	0.09	0.02	-0.10
8	0.03	0.12	0.04

[a] f(t,t+1) is the log of the forward exchange rate at time t for currency to be delivered at time t+1 and s(t+1) is the actual, realised value of the spot rate at time t+1.

NOTE: under the hypothesis that the true autocorrelations are zero, the standard error of the sample autocorrelations is approximately 0.08.

**=significantly different from zero at the 5% level.
*=significantly different from zero at the 10% level.

is the premium. Different asset pricing models give different expressions for the premium term. The premium is generally thought to consist of two components: one is the result of risk aversion of market participants (the "risk premium") and the other component would exist under risk neutrality; it results from the presence of stochastic inflation. Adler and Dumas (1983) refer to the latter component as the "inflation premium". Subtracting s(t+1) from both sides in equation (1), we obtain

$$f(t,t+1)-s(t+1) = E[s(t+1)|t] - s(t+1) + P(t) \tag{2}$$

and if we define $\nu(t)=E[s(t+1)|t]-s(t+1)$, we have

$$f(t,t+1)-s(t+1) = P(t) + \nu(t) \tag{3}$$

where $[\nu(t)]$ is an uncorrelated, zero mean sequence, given our assumption of rational expectations. Equation (3) states that the forecast error of the forward rate as a predictor of the future spot rate consists of a premium component and a white noise error term due to the arrival of new information concerning the spot rate between times t and t+1. If we have information about the time series properties of the premium term, this knowledge could potentially be usefully combined with the forward rate in generating forecasts of future spot exchange rates.

From equation (3) it follows that the autocorrelations that were presented in Table 2 in the previous section are also the autocorrelations of the combined time series process $[P(t)+\nu(t)]$.

It it convenient to refer to the premium component P(t) as the signal that we would like to characterise and to $\nu(t)$ as noise that is added to the signal. The problem that we face can thus be characterised as extracting a signal from a noisy environment.

In this section we take a Kalman-filtering approach to signal-extraction. In order to apply the Kalman filter, some assumptions about the time series properties of the premium must be made. On the basis of the autocorrelation patterns that we reported in Table 2, we conjecture that the premium process [P(t)] may be adequately described by an autoregressive time series process of order one:

$$(4) \quad P(t) = \alpha P(t-1) + \xi(t)$$

where α is a constant autocorrelation coefficient and $[\xi(t)]$ is an uncorrelated, zero mean sequence. It can be shown that, under this assumption together with the assumption that $|\alpha|<1$, the combined process $[P(t)+\nu(t)]$ has autocorrelations ρ_j for $j=1,2,3,\ldots$, where ρ_j is defined as:

$$(5) \qquad \rho_j = \alpha^j - \alpha^j/[(\sigma_\xi^2/\sigma_\nu^2)/(1-\alpha^2)+1].$$

Here σ_ξ^2 and σ_ν^2 denote the variances of $\xi(t)$ and $\nu(t)$, respectively. For instance, if $\alpha=0.9$ and $\sigma_\xi^2/\sigma_\nu^2=0.05$, then we obtain $\rho_1=0.188$, $\rho_2=0.169$, $\rho_3=0.152$, etc. Thus, we expect to find fairly small positive autocorrelations that decay exponentially from the starting value ρ_1. Given the fact that autocorrelations of such small magnitude are hard to detect in finite samples, we argue that the results in Table 2 are roughly consistent with our hypothesis concerning the time series properties of P(t).

In the forecasting experiment that we undertake in the next section we consider the two-equation model given by equations (3) and (4). In addition, the following properties are assumed:

(a) $E[\nu(t)]=0$, $var[\nu(t)]=\sigma_{\nu}^{2}$

(b) $E[\xi(t)]=0$, $var[\xi(t)]=\sigma_{\xi}^{2}$

(c) $[\nu(t)]$ is an independent sequence

(d) $[\xi(t)]$ is an independent sequence

(e) $\nu(t)$ and $\xi(r)$ are independently distributed for all r,t

(f) $[\nu(t), \xi(t)]$ and P(r) are independent for all $r \leq t$.

With these assumptions, the system (3)-(4) is easily recognised as a state-space model, which can be recursively estimated by means of the Kalman filter (see e.g. Anderson and Moore (1979)). Equation (3) is the observation equation and (4) is the state-transition equation.

3.2 The Kalman Filter

We assume that the error terms $\nu(t)$ and $\xi(t)$ are normally distributed and that the premium P(t) has a prior distribution with mean $P(0|0)$ and variance $\Sigma(0|0)$. At every point in time t after the history of the process $R(t)=[f(r,r+1)-s(r+1);\ r=1,\ldots,t]$ has been observed, we want to revise our prior distribution of the unknown state variable P(t). The Kalman filter allows us, given knowledge of $P(0|0)$, $\Sigma(0|0)$ and the ratio $\sigma_\xi^2/\sigma_\nu^2$, to recursively compute the mean and variance of P for each subsequent period.

Denote the conditional distribution of P(t) given R(t) by $p[P(t)|R(t)]$. Given our normality assumptions, $p[P(t)|R(t)]$ and $p[P(t+1)|R(t+1)]$ are also normal and completely characterised by their first two moments. If we denote the mean and variance of $p[P(t)|R(t)]$ by $P(t|t)$ and $\Sigma(t|t)$ respectively, and those of $P[P(t+1)|R(t)]$ by $P(t+1|t)$ and $\Sigma(t+1|t)$, then the Kalman filter recursions for t=0,1,2,... , are given by equations (6)-(10):

$$(6) \qquad P(t+1|t) = \alpha P(t|t)$$

$$(7) \qquad \Sigma(t+1|t) = \alpha^2 \Sigma(t|t) + \sigma_\xi^2$$

$$(8) \qquad P(t+1|t+1) = P(t+1|t) + k(t+1)[f(t+1,t+2)-s(t+2)-P(t+1|t)]$$

$$(9) \qquad \Sigma(t+1|t+1) = \Sigma(t+1|t) - k(t+1)\Sigma(t+1|t)$$

where

$$(10) \qquad k(t+1) = [\Sigma(t+1|t) + \sigma_\nu^2]^{-1} \ \Sigma(t+1|t)$$

Without the normality assumptions, the above results hold for best linear unbiased prediction rather than conditional expectations.

4. PREDICTION RESULTS ON THE BASIS OF PREMIUM MODELS

In this section we will employ the Kalman filter for recursive signal-extraction and spot rate prediction. Predicted values for the spot exchange rate at time t+1, given the information that is available at time t, can be generated as

$$(11) \qquad E[S(t+1)|t| = f(t,t+1)-E[P(t)|t| = f(t,t+1)- \alpha E[P(t-1)|t|$$

Thus, the forward rate as a predictor of the future spot rate is essentially "corrected" for a premium term.

In order to be able to apply the Kalman filter, two parameters need to be specified:[1] the state transition parameter and the variance ratio $\sigma_\xi^2/\sigma_\nu^2$.

[1]From equations (3) and (4) it can be shown that:

$$(12) \qquad [f(t,t+1)-s(t+1)]-\alpha[f(t-1,t)-s(t)] = \upsilon(t)-\tau\upsilon(t-1),$$

where $\upsilon(t)-\tau\upsilon(t-1) \equiv \nu(t)-\alpha\nu(t-1)+\xi(t-1)$ and $\upsilon(t)$ is white noise. Thus, [f(t,t+1)-s(t+1)] follows an ARMA (1,1) process and α and $\sigma_\xi^2/\sigma_\nu^2$ could in principle be estimated by application of maximum likelihood techniques to (12) (note that $\sigma_\xi^2/\sigma_\nu^2 = (\alpha/\tau)(1+\tau^2)-1-\alpha^2$). Partial autocorrelations (not shown) are consistent with an ARMA (1,1) process. It turns out, however, that direct application of maximum likelihood techniques results in extremely imprecise estimates of α and $\sigma_\xi^2/\sigma_\nu^2$. Sometimes a negative variance ratio $\sigma_\xi^2/\sigma_\nu^2$ is implied by the point estimates for α and τ. Pagan (1980) presents some results concerning parameter identification for the class of models to which (3)-(4) belong.

Since information about the magnitudes of α and $\sigma_\xi^2/\sigma_\nu^2$ is difficult to obtain, we implement a search procedure: we search over a plane of values for the parameters α and $\log_{10}(\sigma_\xi^2/\sigma_\nu^2)$. Given a combination of values for α and $\log_{10}(\sigma_\xi^2/\sigma_\nu^2)$, predictions for future spot rates can be generated from equations (3) and (4) on a period by period basis and summary statistics on the model's forecasting performance can be calculated. Values of α in the range 0.00-1.10 (grid size 0.01) and values of $\log_{10}(\sigma_\xi^2/\sigma_\nu^2)$ in the range -10.0-0.0 (grid size 0.1) are tried.

To be able to start off the Kalman filter we also need to specify the starting values $P(0|0)$ and $\Sigma(0|0)$. In order to obtain "reasonable" values for $P(0|0)$ and $\Sigma(0|0)$, we estimated equation (13) by ordinary least squares (OLS):

(13) $$f(t,t+1)-s(t+1)= \text{constant} + \text{error term}$$

using the first 25 observations of our sample. The estimated intercept and its estimated variance were then used as prior mean and variance for the state variable P(t). The Kalman filter was then started of for the 26th observation and run for 20 periods before forecasts were generated.

The model's ability to predict one-month-ahead spot exchange rates is judged mainly on the basis of the root mean square forecast eror (RMSE). In both the α and $\sigma_\xi^2/\sigma_\nu^2$ dimensions distinct global minima are found in terms of the RMSE criterion, for all three exchange rates.

In Figures 1-3 the model's forecasting performance for different values of the autocorrelation coefficient α is shown

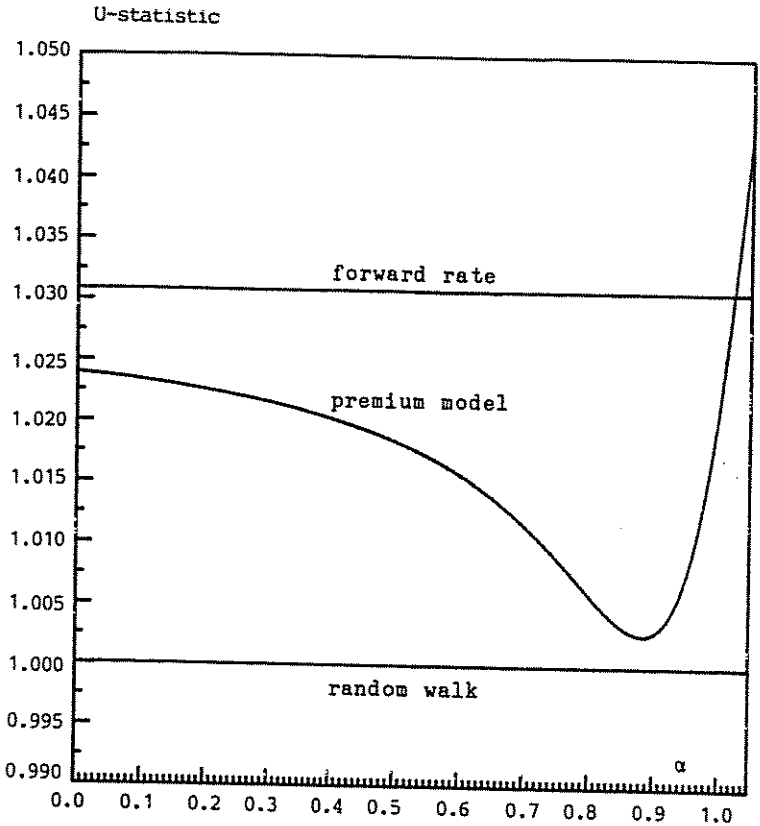

Fig. 1 . U-statistics on the forecasting performance of the premium model for the Dollar/Pound exchange rate for different values of the state transition parameter α. ($\log_{10}(\sigma_\xi^2/\sigma_\nu^2) = -1.42$)

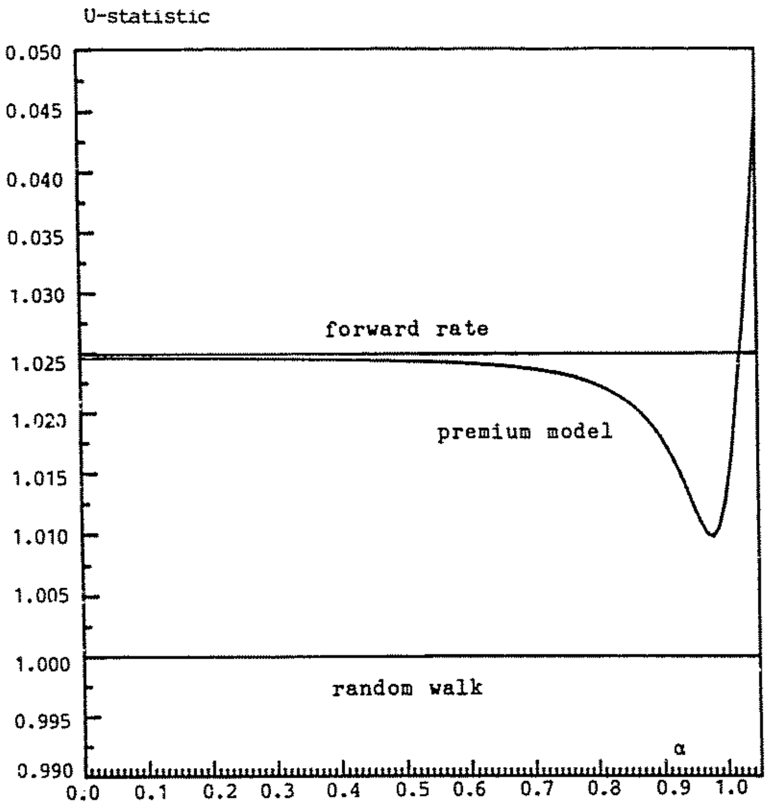

Fig.2 . U-statistics on the forecasting performance of the premium model for the Dollar/ Mark exchange rate for different values of the state transition parameter α. ($\log_{10}(\sigma_\xi^2/\sigma_\nu^2)=-2.38$)

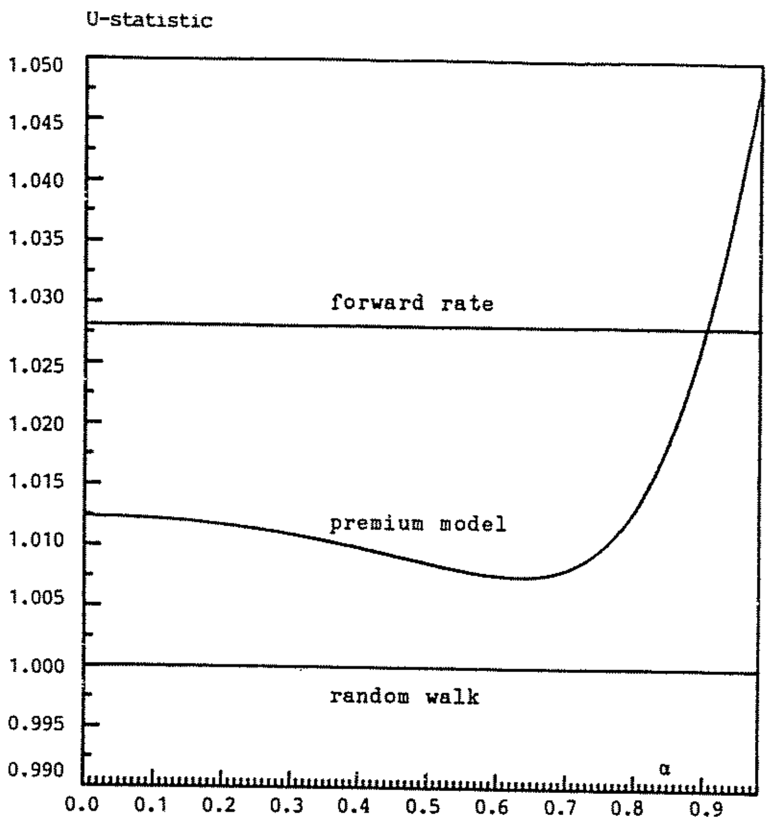

Fig. 3 . U-statistics on the forecasting performance of the premium model for the Dollar/Yen exchange rate for different values of the state transition parameter α. ($\log_{10}(\sigma_\xi^2/\sigma_\nu^2) = -0.94$)

for the three exchange rates. U-statistics are reported in the figures, i.e. RMSEs are scaled by the RMSEs of corresponding random walk forecasts. The U-statistics in Figures 1-3 are calculated for the values of $\sigma_\xi^2/\sigma_\nu^2$ for which overall minimum RMSEs are attained. For comparison, levels of the U-statistics that result from the use of the forward rate and the lagged spot rate as predictors of the four-week-ahead spot exchange rate are indicated in the graphs.

Similarly, in Figures 4-6 the model's forecasting performance is shown for different values of $\sigma_\xi^2/\sigma_\nu^2$ (for the values of for which overall minimum RMSEs are attained).

Several comments are in order with regard to these figures. First, the premium models do better than the forward rate over wide ranges of parameter values. Useful information concerning the future values of spot exchange rates is being picked up by our empirical characterisation of the time series properties of the premia. Second, the premium models never do better than the random walk forecast: U-statistics smaller than one are not attained. Third, the graphs all show distinct global minima in terms of the RMSE criterion. The locations of these minima provide us with information about the premium processes in the sense that the best empirical description of the premia can be expected to give the best empirical description of the premia can be expected to give the best forecasting results.

Thus, these graphs give an impression of the magnitudes of the α's and the $\sigma_\xi^2/\sigma_\nu^2$'s. Direct in-sample maximum likelihood estimation proved not very useful in this respect (recall footnote 1). The estimation approach we take here is essentially

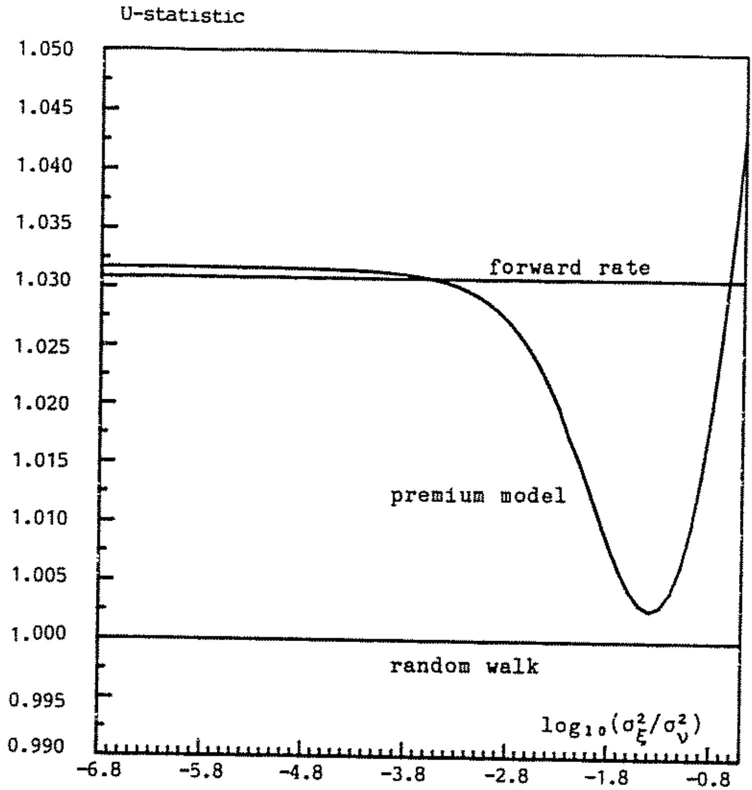

Fig. 4 . U-statistics on the forecasting performance of the premium model for the Dollar/ Pound exchange rates for different values of $\log_{10}(\sigma_\xi^2/\sigma_\nu^2)$. ($\alpha$=0.88)

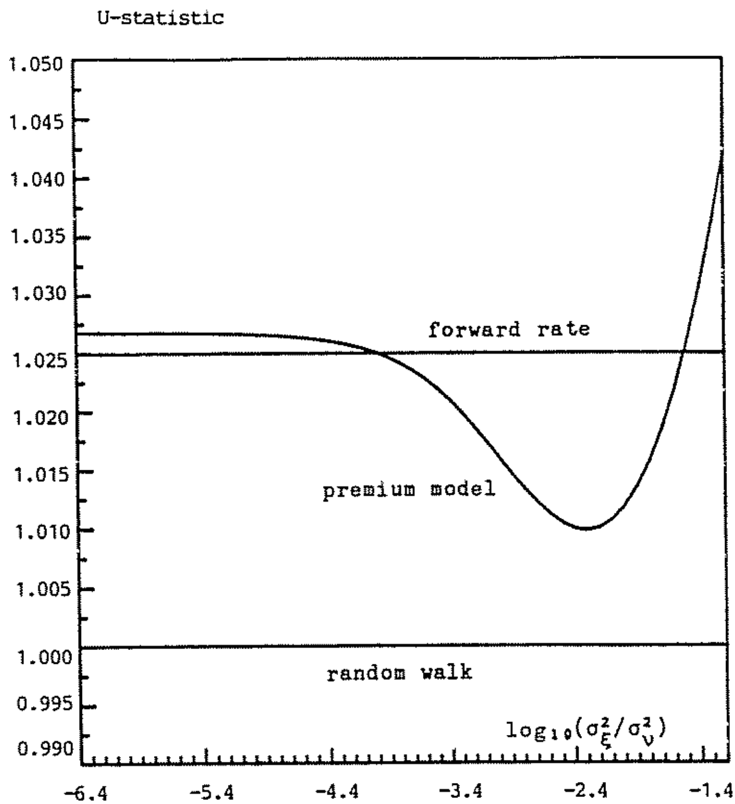

Fig. 5 . U-statistics on the forecasting performance of the premium model for the Dollar/Mark exchange rate for different values of $\log_{10}(\sigma_\xi^2/\sigma_\nu^2)$. ($\alpha$=0.98)

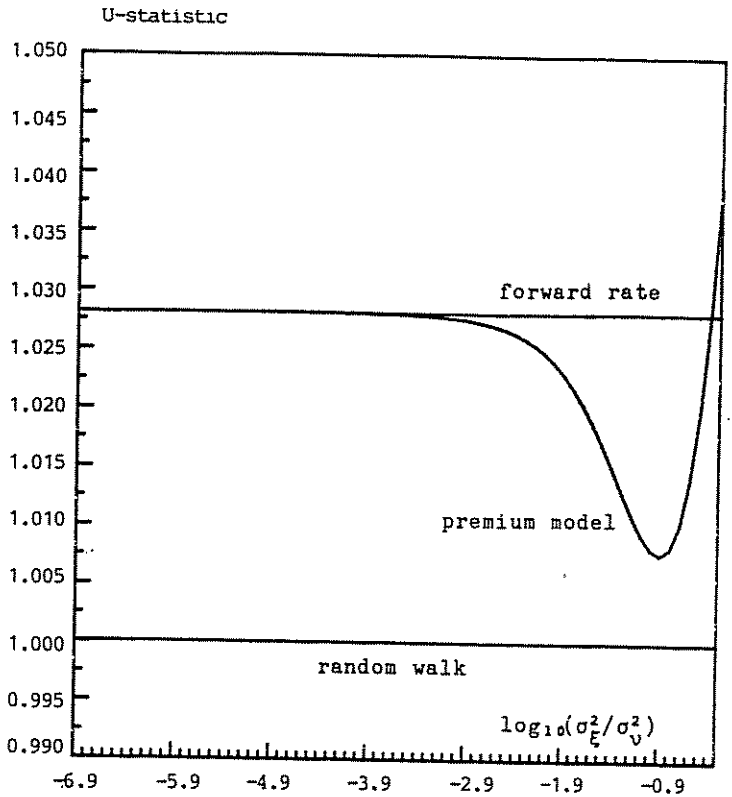

Fig. 6 . U-statistics on the forecasting performance of the premium model for the Dollar/Yen exchange rate for different values of $\log_{10}(\sigma_\xi^2/\sigma_\nu^2)$. ($\alpha$=0.63)

minimisation of the sum of squared one-step-ahead forecast errors. An obvious disadvantage of this forecasting approach is the absence of standard errors on point estimates of the parameters.

In Table 3 the parameter values of the premium models that lead to minimum RMSE one-step-ahead forecasts are presented for the three currencies. In the third row of the table we report a signal-to-noise ratio (SNR): the ratio of the variance of the premium P(t) to the variance of the noise term $\nu(t)$ that is implied by the reported values of α and $\sigma_{\xi}^2/\sigma_{\nu}^2$. In the case at hand the SNR is defined as $(1/1-\alpha^2)\sigma_{\xi}^2/\sigma_{\nu}^2$. In the lower part of the table detailed summary statistics on the forecasting performance of the minimum RMSE premium models are presented.

Again, several comments are in order. First, the premium models that perform best in terms of RMSE of four-week-ahead spot rate forecasts have fairly high, positive first-order autocorrelation coefficients (α's). This is what we would expect to find a priori: it is likely that an existing structure of international risk has a tendency to persist over time. The premium model for the Dollar-Mark rate is close to a random walk. Second, the signal-to-noise ratios are in the range 0.10-0.19. They imply that roughly 9 to 16 percent of the variance in the forecast errors f(t,t+1,t)-s(t+1) is due to variation in the premium term P(t). Third, the U-statistics indicate that, although the premium models do not outperform the random walk forecasting rule, it is a very close contest indeed. Perhaps the forecasts from the premium models and the random walk model can be usefully combined along the lines indicated by Granger and

TABLE 3

PARAMETER VALUES OF THE PREMIUM MODELS THAT LEAD TO MINIMUM RMSE ONE-STEP-AHEAD FORECASTS. THE LOWER PART OF THE TABLE PROVIDES SUMMARY STATISTICS ON THESE MODELS' FORECASTING PERFORMANCE

	\$/Pound	\$/Mark	\$/Yen
α	0.88	0.98	0.63
$\sigma_\xi^2/\sigma_\nu^2$	0.0381	0.0041	0.1154
SNR[a]	0.1687	0.1026	0.1914
ME[b]	-0.10	-0.24	-0.17
MAE[b]	2.02	2.22	2.39
RMSE[b]	2.68	3.03	3.20
U-stat.	1.0027	1.0098	1.0076
#obs.	102	102	102

[a]SNR is signal-to-noise ratio.

[b]Approximately in percentage terms.

Newbold (1977) or Thisted and Wecker (1981).

The premium models that are described in Table 3 imply time paths for the actual premia. These time paths are pictured in Figure 7 for the three exchange rates that we study. When interpreting this figure, it should be kept in mind that we are at this stage unable to present confidence intervals for the premia.

The premia for the Dollar-Pound and Dollar-Mark exchange rates follow fairly similar paths, while the premium for the Dollar-Yen case appears more volatile. On average the premia are negative in the first part of the graph and positive in the second part. If the premium were a pure risk premium (without an "inflation premium" component), we would say that the Dollar was on average riskier than the other currencies up through 1980 and less risky after 1980. From Figure 7 it can also be inferred that, in the period that we consider, premia have not been greater than 1.5 to 2.0 percent in absolute value.

5. CONCLUSIONS

In this paper we investigate whether knowledge about premia in forward exchange rates can be usefully exploited in order to forecast future spot rates. On the basis of signal-extraction models in which premia are assumed to follow AR(1) processes, we

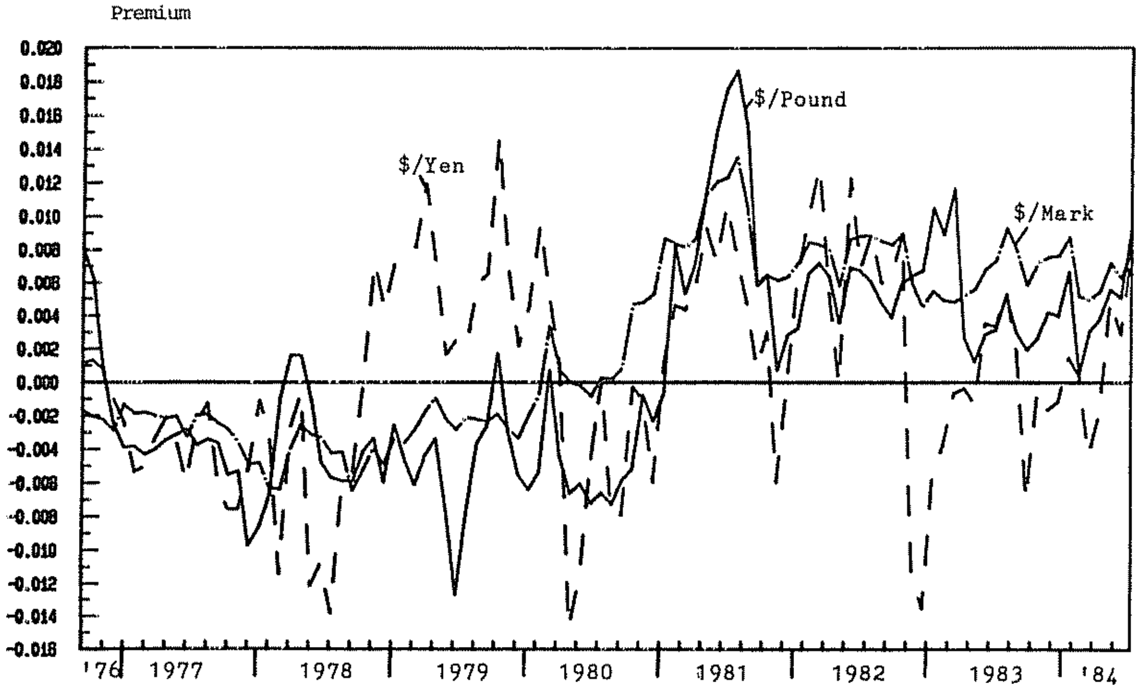

Fig. 7 . Time paths of premia implied by the premium models that are described in the top part of Table 3 .

find for a wide range of parameter values that "correcting" the forward rate for a premium term leads to one-step-ahead forecast errors that compare favourably with those obtained from the forward rate without correction. The premium models that are most successful in predicting future spot rates imply that 9 to 16 percent of the variance in the forecast errors f(t,t+1)-s(t+1) is due to variation in the premia.

However, in keeping with earlier literature on the forecasting performance of exchange rate models (Meese and Rogoff (1983), Wolff (1985)), the models that we develop are unable to outperform the simple random walk forecasting rule in a prediction experiment.

Finally, the methodology that we employ in this chapter is fairly general in the sense that it can be straightforwardly applied to other financial markets, such as futures markets and markets for government debt instruments.

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