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ON TESTS OF THE EXISTENCE OF TIME VARIABLE RISK PREMIA IN THE FORWARD FOREIGN EXCHANGE MARKET

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Abstract: It is shown here that the existence of a time variable risk premium cannot be tested without additional specification as to how such a premium should be related to observable variables. Recent empirical results are discussed in this context and it is argued that no conclusive evidence of a time variable risk premium has been found as yet because of the possibility of market inefficiency. A similar criticism applies to tests concerning futures markets and markets for (nominally) risk free assets.

I. INTRODUCTION

There has been substantial controversy lately about what determines the forward foreign exchange rate. The main point of debate is whether there exists a (possibly time variable) risk premium such that the forward exchange rate at time t (F(t)) cannot be considered an unbiased forecast of the subsequent (t+1) spot rate (S(t+1)). A similar debate is taking place about futures markets, the question being what determines the average deviation of the futures price from the subsequent spot price. Also, comparable issues were discussed earlier in the literature with respect to the explanatory power of interest rates as to subsequent inflation rates.

It will be argued here that tests of the existence of time variable risk premia in the forward foreign exchange rate should be based on testing the relationship between the average deviation of the forward exchange rate from the subsequent spot rate and any variables which the risk premium is postulated to depend on. This statement can be found elsewhere in the literature (Frankel, 1982), but without theoretical justification. The idea is that without adding information as to how the risk premium should be related to observable variables, it will always be possible to find a time variable risk premium (and, hence, reject the unbiasedness of the forward foreign exchange rate). Indeed, the decomposition of an observable variable into a risk premium and an expected change is tautological. Moreover, by adding such information, a distinction can be made between deviations from unbiasedness caused by (time variable) risk premia and those caused by market inefficiency. The latter possibility has somewhat been neglected in recent studies.

Indeed, recent studies (Fama, 1984; Hansen and Hodrick, 1983; Hodrick and Srivastava, 1984; Gregory and McCurdy, 1984) do not consider this possibility. More importantly, they fail to add any information to their tests as to how the risk premium should be related to observable variables. Consequently, they could always accept the existence of a time variable risk premium. Fortunately, they generally obtain results with which they can unambiguously reject unbiasedness. However, whether these results are due to a time variable risk premium or market inefficiency is not clear.

This contrasts with the results from an earlier, less powerful method (Cornell, 1977; Cornell and Dietrich, 1978; Geweke and Feige, 1979). Their test procedure is applied in this paper to a time series comparable to the ones used in more recent studies.
It is, however, subject to the same criticisms.

A closer look to foreign exchange data reveals clear evidence of some type of market inefficiency, corroborating the importance of the issue discussed here. Hence, even if one can safely reject the unbiasedness assumption, one cannot conclude that a time variable risk premium exists. Indeed, the possibility of some kind of market inefficiency has to be taken serious.

Section II discusses the theory behind unbiasedness, risk premia and market efficiency. In Section III, the main features of tests of the unbiasedness against the existence of a time variable risk premium are explained, from which the major results of this paper naturally arise. In this light, Section IV comments on the two test procedures of the aforementioned studies. Section V discusses the results of those methodologies. In Section VI, foreign exchange data are looked at more closely and evidence of market inefficiency is discussed. Finally, Section VII summarises the main points of this paper.

The results here apply also, mutatis mutandis, to the aforementioned tests concerning futures markets and interest rates. In both cases, the consideration of an unobservable variable (a risk premium or the real interest rate) complicates test procedures in the same fashion a time variable risk premium affects tests about the forward foreign exchange rate.

II. THE THEORETICAL MODEL

The theoretical structure underlying the forward foreign exchange rate will now be looked at. It is worthwhile to do so, as it will highlight the differences between unbiasedness, (time variable) risk premia and market efficiency.

Consider the following problem. How many dollars would an investor be willing to pay for a foreign riskless bond maturing next period (t+1) and worth 1 unit of the foreign currency? Obviously, the answer is S(t) dollars, where S(t) is the actual (t) spot exchange rate (or the number of dollars per unit of the foreign currency). Hence,

$$S(t) = (ER(S(t+1))(1+I^*))/(1+I)$$

where $ER(S(t+1))(1+I^*)$ is the expected risk adjusted (or certainty equivalent) value of the investment (I^* being the interest paid on the foreign bond, and $S(t+1)$ the future spot exchange rate). This expected risk adjusted value is to be discounted at the domestic risk free rate (I) to obtain the actual value ($S(t)$). Moreover, it is well known that

$$S(t) = F(t)(1+I^*)/(1+I)$$

where $F(t)$ stands for the forward foreign exchange rate. Indeed, this is the interest rate parity theorem. Hence, $ER(S(t+1)) = F(t)$. Therefore, it is reasonable to define the forward exchange rate as the market determined certainty equivalent value of the future spot rate. This suggests that $F(t)$ consists of two elements, namely the expected future spot rate and a risk premium.

At this point, it should be noted that a transformation of the variables S and F is necessary, as $E(S) \neq E(1/S)$. If we want the results of any theoretical analysis to be independent of the reference currency (remember, the dollar is being used as the reference currency), then it is necessary to work in a logarithmic structure, as $E(\ln S) = -E(\ln(1/S))$. Denoting $\ln S$ and $\ln F$ by s and f respectively, we obtain:

$$f(t) = ER(s(t+1))$$

Decomposing f into its two elements gives:

$$f(t) = E(s(t)|\Phi(t)) - p(t) \qquad (1)$$

where $p(t)$ represents the risk premium, and $\Phi(t)$ denotes the information available at t. (1) need not be additive, but most theoretical analyses (for instance the ones where time is considered to be a continuous variable) lead to this additive expression[1]. From (1):

$$f(t)-s(t) = E(s(t+1)-s(t)|\Phi(t)) - p(t) \qquad (2)$$

Assume that foreign exchange markets are efficient in that the forecasts of s(t+1), conditional on the available information $\Phi(t)$, are equal to the unconditional forecasts and that the forecast errors are not related over time:

$$s(t+1)-s(t) = E(s(t+1)-s(t)) + e(t) \qquad (3a)$$

Assume also that the forecast errors are normally distributed:

$$e(t) \sim N(0,\sigma^2),\ E(e(t).e(t+k))=0 \quad (k=\ldots,-2,-1,1,2,\ldots) \qquad (3b)$$

This gives enough structure to discuss three possible hypotheses: unbiasedness, a (possibly time variable) risk premium and market (in)efficiency. It is clear that market efficiency underlies both the unbiasedness and the risk premium hypotheses. Indeed, market efficiency and unbaisedness, or market efficiency and the existence of a risk premium are so-called joint hypotheses.

First, unbiasedness obtains if p(t) in (2) is zero for all t. Hence, given (3a) and (3b), f(t)-s(t) (the forward premium or discount) is an unbiased forecast of the subsequent change in the spot exchange rate (s(t+1)-s(t)). Forecast errors are normally and independently distributed. Indeed, from (2), (3a) and (3b):

$$s(t+1)-s(t) = f(t)-s(t) + e(t) \qquad (4a)$$

where

$$e(t) \sim N(0,\sigma^2),\ E(e(t).e(t+k))=0 \ (k=\ldots,-2,-1,1,2,\ldots) \qquad (4b)$$

Second, a risk premium is said to exist if p(t) in (2) is nonzero for some t. In that case, (2), (3a) and (3b) cannot be merged to get anything simple like (4a) and (4b). Notice that p, the risk premium, may depend on time (it is then called a time variable risk premium). Also, it is clear that p(t) is not observable: all we know is f(t)-s(t), s(t+1)-s(t) and f(t)-s(t+1). Finally, it is not easy to determine exactly in which cases the risk premium must be zero. Risk neutrality is neither sufficient nor necessary[2]. The reason is that in international asset pricing models, investors may have state dependent utilities, the states being defined by the purchasing power of the investors' budgets.

Third, the market is said to be (weakly) inefficient if (3a) and (3b) do not hold. Clearly, if both the unbiasedness assumption and the existence of a risk premium are rejected in an empirical test, the foreign exchange market must be inefficient. But if one only tests, say, the unbiasedness assumption, and one finds that the data contradict this hypothesis, it is impossible to determine whether a risk premium or market inefficiency caused the rejection.

III. TESTING UNBIASEDNESS AGAINST RISK PREMIA

How would one test the unbiasedness assumption against the existence of a (time variable) risk premium ? The unbiasedness assumption is represented by equation (4a), repeated here for convenience.

$$s(t+1)-s(t) = f(t)-s(t) + e(t) \qquad (4a)$$

On the other hand, if a (time variable) risk premium exists, the following is true (see Section II):

$$s(t+1)-s(t) = E(s(t+1)-s(t)) + e(t) \qquad (3a)$$

$$f(t)-s(t) = E(s(t+1)-s(t)) - p(t) \qquad (5)$$

(where the latter equation is a restatement of (2), taking into account market efficiency). It is clear that one can step from the last two equations (representing the hypothesis of a risk premium) to (4a) (representing unbiasedness) by assuming that the variance of p(t) is zero. (We therefore disregard the possibility of a constant risk premium). Hence, the unbiasedness assumption can be investigated against the alternative that a time variable risk premium exists, by testing:

H : var(p(t))=0

H : var(p(t))=0

However, p(t) is _unobservable_ (as is E(s(t+1)-s(t))), hence, var(p(t)) is completely arbitrary. By taking var(p(t)) large enough, one is leaded to reject the Null Hypothesis always, in favor of a time variable risk premium. Indeed, without additional information, (3a) together with (5) are tautological[3]. Hence, one _must_ add information in order to test the existence of a time variable risk premium. Such information may include a model as to how the risk premium is related to observable variables, which is the usual approach in econometrics when dealing with unobservable variables.

Notice that the same phenomenon appeared earlier in the literature following Fama's 1975 article on the forecast power of interest rates as to subsequent inflation rates. Fama assumed that the real interest rate was constant over time. He then tested whether interest rates varied significantly with subsequent inflation rates (and they did). The comments on his article (Carlson, 1977; Joines, 1977; Nelson and Schwert, 1977) all used a tautological relationship similar to the one above to criticise Fama's results. It is clear that with such a relationship, one can always find a stochastic process for the real interest rate dismissing Fama's hypothesis. However, some comments did make an attempt to overcome the tautological nature of the decomposition of the interest rate into a real rate and an inflation forecast by adding exogenous information to their test, such as survey data (Carlson, 1977).

In short, tests of the existence of a risk premium are meaningless if no additional information is provided as to how the risk premium should vary over time, because the risk premium itself is not observable.

Moreover, by specifying a model as to how risk premia and observable variables are related, one obtains a method of determining whether in a statistical test the unbiasedness assumption is rejected due to the existence of a (time variable) risk premium or due to market inefficiency. Indeed, the risk premium model can itself be tested, so that, if it is rejected as well, the data clearly seem to favor the inefficiency hypothesis.

Let us now turn to some recent tests of the forward foreign exchange market and see how these phenomena reappear there.

IV. SOME RECENT TESTS

Two methodologies will be discussed here: the one that appeared in articles by Fama (1984), Hansen and Hodrick (1983), Hodrick and

and Srivastava (1984) and Gregory and McCurdy (1984), and the one used by Cornell (1977), Cornell and Dietrich (1978) and Geweke and Feige (1979).

Central in the first methodology are the following regression equations:

$$s(t+1)-s(t) = a + b(f(t)-s(t)) + u(t) \tag{6}$$

$$f(t)-s(t+1) = c + d(f(t)-s(t)) + v(t) \tag{7}$$

From (2), these equations appear to be complementary (i.e., a+c=0, b+d=1, u+v=0). They put a linear restriction on the decomposition of the forward premium (f(t)-s(t)) into a subsequent spot rate change (s(t+1)-s(t)) and a risk premium (f(t)-s(t+1)). Using these and similar regression equations, the above mentioned researchers test the unbiasedness assumption against the existence of a time variable risk premium. This is translated into statistical terms as follows:

H_o: b=1 or d=0 (unbiasedness)

H_1: b≠1 or d≠0 (risk premium)

Common to all such regression equations is that no other information is used apart from the forward premium, the change in the spot rate and the realised risk premium. Hence, the conclusion of the previous Section should apply here. Indeed, it is obvious that the Null Hypothesis can be true even if a time variable risk premium exists. In other words, it is always possible to specify nonzero p(t) such that the Null Hypothesis holds. This is easy to see when decomposing the probability limit of the Ordinary Least Squares estimator of b ($\hat{b}$):

$$\text{plim}\hat{b} = \frac{\text{var}(E(s(t+1)-s(t))) - \text{cov}(p(t),E(s(t+1)-s(t)))}{\text{var}(E(s(t+1)-s(t))) + \text{var}(p(t)) - 2\text{cov}(p(t),E(s(t+1)-s(t)))} \quad (8)$$

(see Fama, 1984). Let:

$$\text{var}(E(s(t+1)-s(t))) = 2.\text{cov}(p(t),E(s(t+1)-s(t)))$$

$$\text{var}(p(t)) = \text{cov}(p(t),E(s(t+1)-s(t)))$$

In this case, $\text{plim}\hat{b} = 1$, hence, in large samples, H_o would never be rejected. Nevertheless, p(t) varies over time, contradicting the unbiasedness assumption !

What if one can reject the Null Hypothesis (i.e., $b \neq 1$) ? It does not necessarily imply that a time variable risk premium exists, as explained in the previous Section. Indeed, an inefficient market may have generated the data. But inefficiency is not considered as a possible explanation of what happens with the forward foreign exchange rate in these papers, contrary to earlier work by Cornell (1977), Cornell and Dietrich (1978), Geweke and Feige (1979).

The latter papers use a different methodology. Their aim, however, is to test unbiasedness against market inefficiency without consideration of a time variable risk premium. Their test procedure goes as follows. Remember that equation (4a) represents the unbiasedness assumption. Adding f(t)-s(t) to both sides in this equation gives:

$$f(t)-s(t+1) = e(t) \quad (9)$$

This means that if the forward foreign exchange rate is an unbiased forecast of the subsequent spot rate, f(t)-s(t+1) should be mean zero white noise. In other words, the sample mean of f(t)-s(t+1) should be statistically 'close enough' to zero, and s should have autocorrelation and partial autocorrelation functions corresponding to white noise.

Obviously, the same criticisms apply to this methodology: acceptance of (9) does not necessarily mean that the forward foreign exchange rate is an unbiased forecast of the subsequent spot rate. Similarly, rejection of (9) does not necessarily mean that the market is inefficient (the results may be due to a time variable risk premium).

In the next Section, the results appearing in the literature using either methodology will be discussed with the comments of Section IV in mind.

V. RESULTS

The results from the first methodology (Fama, 1984; Hansen and Hodrick, 1983; Hodrick and Srivastava, 1984; Gregory and McCurdy, 1984) are shown in table 1, for the Belgian Frank (B), the Swiss Frank (CH), the Canadian Dollar (CND), the Deutsche Mark (D), the French franc (F), the British Pound (GB), the Italian Lira (I), the Japanese Yen (JPN) and the Dutch Guilder (NL). Estimates for c and d in equation (7) are given. These results are not directly comparable, however, for the following reasons:

(1) The estimation methods are different: Fama's results are based on (Zellner's) seemingly unrelated regressions, Hansen and Hodrick's results on OLS adapted for overlapping observation periods. Hodrick and Srivastava, and Gregory and McCurdy used

OLS.

(2) The period covered differs. Fama used August 31 1973 to December 12 1982; Hansen and Hodrisk used May 2 1976 to December 29 1980; Hodrick and Srivastava look at the period February 1976 to September 1982; Gregory and McCurdy used data covering 1973 to 1981.

(3) Hodrick and Srivastava, and Gregory and McCurdy do not use logarithms. Instead, they normalize each variable by dividing by S(t);

(4) Hansen and Hodrick, Hodrick and Srivastava, and Gregory and McCurdy added other explanatory variables to equation (5). Contemporaneous values of f(t)-s(t) and the forecast error for other countries were added in Hansen and Hodrick, while Hodrick and Srivastava included contemporaneous values of f(t)-s(t) for other countries. Finally, Gregory and McCurdy included a one-period lagged value of f(t)-s(t+1).

Looking at Table 1, one can in general reject the Null Hypothesis that d equals zero. As explained before, this does not necessarily imply that a time variable risk premium exists (as was concluded in these papers): market in efficiency can also explain the outcomes.

Results for the second methodology are shown in Tables 2 and 3, for a period comparable to the ones investigated under the first procedure. The test is done using spot exchange rates and 30 day forward rates for nine currencies (U.S. Dollar per foreign currency unit) . The data are from the Harris Bank Data Base, and are Friday closing rates sampled at four week intervals, covering the period August 31st 1973 until December 10th 1982.

Table 2 shows means, standard deviations and t-statistics to test the Null Hypothesis (equation 9). Probability values for the statistics under the Null Hypothesis are given as well. The tests are not valid, however, if the time series f(t)-s(t+1) is not a random sample, which is checked in Table 3, where the sample autocorrelation and partial autocorrelation functions are shown for the nine currencies with their respective standard errors.

In general, it is not possible to reject the Null Hypothesis. However, the time series of three currencies (the Canadian Dollar, the British Pound and the Japanese Yen) are not white noise (see Table 3). This not only rejects the Null Hypothesis for these currencies, but it also invalidates the tests in Table 2, which should be based on random samples.

But, as pointed out in the previous Section, such outcomes are not inconsistent with the existence of a time variable risk premium. They also contrast with the results of the first methodology, which raises questions about the power of either procedure. Obviously, the newer methodology is more powerful because it not only examines whether f(t)-s(t+1) can be considered a white noise time series (as is done in the second methodology) but it relates f(t)-s(t+1) to any information that is available at time t. Evidence of such a relationship leads generally to a rejection of the unbiasedness assumption.

VI. MARKET INEFFICIENCY

The rejection of unbiasedness does not necessarily imply that a time variable risk premium exists. Indeed, evidence will now be discussed which indicates that the possibility of market inefficiency should be paid serious attention to.

It is generally accepted that in order for a market to be (informationally) efficient, prices should obey a random walk model (Samuelson, 1965). This is tested for the foreign exchange market using the data from Table 2 (see Section V). Under the Null Hypothesis (the random walk model), the first differences of s(t) should be a white noise time series. Table 4 displays some of the statistical properties of s(t) after taking first differences. There is evidence that the random walk model can be rejected for three out of nine currencies: the Canadian Dollar, the British Pound and the Japanese Yen[4]. These results may be due, however, to direct central bank intervention in the foreign exchange market for instance, and as such do not necessarily support the idea of an inefficient market (see also Levich, 1979). But the forward foreign exchange market should take any autocorrelation into account for it to be (informationally) efficient. Apparently, it does not do so. Autocorrelation turns up in the statistical tests reported in Section V in the case of the same three currencies. Indeed, the hypothesis of white noise for the forecast error (f(t)-s(t+1)) is rejected for these currencies (see Table 3 and the discussion in Section V), and the error in the regression of f(t)-s(t+1) on f(t)-s(t) is autocorrelated also for these currencies, as shown in Table 5, where the error of Fama's regression (see Table 1) is analysed[5 6]. This is clear evidence against market efficiency, and consequently, the possibility of market inefficiency as an alternative to the unbiasedness assumption should be seriously considered, in addition to the existence of a time variable risk premium, corroborating the importance of the main issue of this paper.

In order to illustrate this in a different way, an additional regression was carried out, again using Fama's data. The future spot rate (s(t+1)) was regressed on the forward exchange rate (f(t)), and it was tested whether the coefficient of f(t) was significantly different from one. This is an alternative test of the unbiasedness assumption (see Levich, 1979), but, again, less powerful than the one used in recent studies[7]. The results are reported in Table 6 and they indicate that in general the unbiasedness assumption cannot be rejected, but that for three currencies, namely the Canadian Dollar, the British Pound and the Japanese Yen, the error appears to be correlated over time, exactly like in the other tests.

VII. CONCLUSION

It is shown in this paper that the existence of a (time variable) risk premium in the forward foreign exchange market cannot be tested without additional specification as to how the risk premium is related to observable variables. Otherwise, all one can get is a tautological relationship.

This has already been pointed out earlier, although without justification. Indeed, Frankel comments: 'Only a systematic relationship between ... deviations [of exchange rate changes from the forward discount], on the one hand, and variables on which the risk premium is theoretically supposed to depend ... on the other hand, would constitute evidence of a risk premium' (Frankel, 1982, p.203).

A discussion of statistical tests reveals that serious attention should also be paid to the possibility of market inefficiency as an alternative to the unbiasedness assumption, in addition to the possibility of a time variable risk premium. Tests that include a specification of how the risk premium should vary over time as a function of observable variables allow one to distinguish between the existence of time variable risk premia and market inefficiency.

Frankel (1982) relates the risk premium to the supply of government bonds and does not find evidence of such a premium. In another paper (Bossaerts, 1985), it is argued that the risk premium should depend on the distribution of wealth across nations through the spot foreign exchange rate. Results favor the existence of a risk premium in the case of some continental European currencies.

It has already been emphasised that the phenomena under study here are not specific to the foreign exchange market. In futures markets, risk premia emerge as deviations of the futures price from the subsequent spot price. Also, the forward interest rate can be split in a way similar to the forward foreign exchange rate decomposition. Finally, interest rates of any maturity can be written as the sum of expected inflation and a real rate.

In each case, the relationship is tautological, such that information should be added in order for the decomposition to be empirically verifiable.

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NOTES

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(1) For a survey of continuous-time international asset pricing models, see Adler and Dumas (1983).

(2) Hence, p(t) cannot literally be taken as a risk premium (for a discussion, see Adler and Dumas (1983)).

(3) Why not decompose the forward premium into an expected change of the spot exchange rate, a market risk premium and risk premia corresponding to state variables in a Merton CAPM fashion (see Merton, 1971) ? This would be another tautological decomposition, as none of its components is observable.

(4) It is interesting to investigate the statistical properties of first differences of the raw series S(t) (i.e., before taking logarithms). In most cases, the random walk model is rejected in favor of a first order autoregressive model. These results are not reported here, but they empirically justify our taking logarithms, because the ensuing statistical analysis is somewhat more in line with the random walk hypothesis.

(5) Ordinary Least Squares was used to obtain the errors, contrary to the Zellner seemingly unrelated regression method that was used for generating the results of Table 1.

(6) Notice that this evidence of autocorrelation also invalidates the statistical test reported in Table 1 and discussed in Section V.

(7) Both the dependent and the independent variable are nonstationary time series, which may cause spurious correlation. However, adjustment for nonstationarity need not be carried out here, because we are not interested in testing whether there is any covariance at all, but whether the coefficient in the regression is close to one. Moreover, spurious correlation will emerge after taking first differences of both series.

Table 1: Estimation Results: f(t)-s(t+1)=c+d(f(t)-s(t))+u(t).*

		B	CH	CND	D	F	GB	I	JPN	NL
Fama	c	0.36	-0.81	0.26	-0.23	0.48	0.52	1.08	-0.12	-0.10
		(0.28)	(0.42)	(0.11)	(0.29)	(0.28)	(0.26)	(0.32)	(0.28)	(0.27)
	d	1.72	2.15	2.04	1.89	1.21	1.69	1.44	1.28	1.78
		(0.24)	(0.50)	(0.59)	(0.32)	(0.30)	(0.51)	(0.24)	(0.35)	(0.25)
Han+	c		-2.38		-1.07	-0.13	-0.54		-2.25	
			(1.68)		(1.35)	(1.31)	(1.47)		(1.63)	
Hodr	d		4.50		4.59	2.00	1.78		2.56	
			(3.54)		(4.31)	(1.23)	(1.58)		(2.29)	
Hodr+	c		-27.57		-4.86	8.44	2.30		-29.01	
			(17.40)		(18.01)	(19.88)	(11.39)		(13.24)	
Sriv	d		13.02		-5.40	1.12	2.79		6.13	
			(3.68)		(6.11)	(2.09)	(1.24)		(1.59)	
Greg+	c			0.00						
				(0.00)						
McCur	d			2.14						
				(0.64)						

* In Fama, the variables are multiplied by 100.
Numbers in parentheses are standard errors.

Table 2: Time Series Features: f(t)-s(t+1) (multiplied by 100).

	B	CH	CND	D	F	GB	I	JPN	NL
mean	0.09	0.23	0.08	0.33	0.17	0.13	-0.07	0.10	0.21
s.dev.	3.22	3.82	1.16	3.12	3.10	2.65	2.95	3.15	3.08
t	0.30	0.66	0.79	1.16	0.62	0.55	-0.26	0.35	0.75
Pr>|t|	0.77	0.51	0.43	0.25	0.54	0.58	0.80	0.72	0.46

Table 3: Time Series Features: f(t)-s(t+1) (multiplied by 100).

AUTOCORRELATIONS (B)

1- 12	.11	.10	.08	-.02	.02	-.05	-.03	.04	.11	-.08	.19	0.0
ST.E.	.09	.09	.09	.09	.09	.09	.09	.09	.09	.09	.10	.10
13- 24	.04	-.02	-.06	.04	.15	.04	-.17	.10	-.02	.15	.07	.01
ST.E.	.10	.10	.10	.10	.10	.10	.10	.10	.10	.10	.11	.11

PARTIAL AUTOCORRELATIONS (B)

1- 12	.11	.09	.06	-.04	.01	-.06	-.01	.05	.12	-.11	.19	-.04
ST.E.	.09	.09	.09	.09	.09	.09	.09	.09	.09	.09	.09	.09
13- 24	.03	-.07	-.02	.03	.19	0.0	-.21	.07	.04	.14	.06	-.03
ST.E.	.09	.09	.09	.09	.09	.09	.09	.09	.09	.09	.09	.09

AUTOCORRELATIONS (CND)

1- 12	.17	-.21	.07	.04	.01	-.01	-.16	.04	.06	-.13	.15	.01
ST.E.	.09	.09	.10	.10	.10	.10	.10	.10	.10	.10	.10	.10
13- 24	-.22	-.12	.03	-.01	.10	-.16	-.17	.17	.06	-.19	-.05	.04
ST.E.	.10	.11	.11	.11	.11	.11	.11	.11	.12	.12	.12	.12

PARTIAL AUTOCORRELATIONS (CND)

1- 12	.17	-.25	.17	-.07	.08	-.06	-.15	.12	-.07	-.06	.22	-.18
ST.E.	.09	.09	.09	.09	.09	.09	.09	.09	.09	.09	.09	.09
13- 24	-.07	-.16	.06	-.05	.14	-.22	-.04	.07	.01	-.19	.05	-.01
ST.E.	.09	.09	.09	.09	.09	.09	.09	.09	.09	.09	.09	.09

AUTOCORRELATIONS (CH)

1- 12	.05	.10	.06	-.09	.09	.01	-.04	-.08	.01	-.02	.08	.01
ST.E.	.09	.09	.09	.09	.09	.09	.09	.09	.09	.09	.09	.09
13- 24	.05	-.06	.05	0.0	.14	.09	-.11	-.02	-.10	.06	.13	.04
ST.E.	.09	.09	.10	.10	.10	.10	.10	.10	.10	.10	.10	.10

PARTIAL AUTOCORRELATIONS (CH)

1- 12	.05	.10	.05	-.10	.09	.02	-.05	-.10	.05	-.01	.08	0.0
ST.E.	.09	.09	.09	.09	.09	.09	.09	.09	.09	.09	.09	.09
13- 24	.06	-.09	.06	-.02	.16	.05	-.11	-.06	-.04	.06	.13	.04
ST.E.	.09	.09	.09	.09	.09	.09	.09	.09	.09	.09	.09	.09

AUTOCORRELATIONS (D)

1- 12	.03	.09	.03	-.11	0.0	-.04	.02	.05	.07	-.04	.18	.02
ST.E.	.09	.09	.09	.09	.09	.09	.09	.09	.09	.09	.09	.10
13- 24	.01	-.05	.02	.04	.07	.07	-.19	.03	-.05	.12	.10	.05
ST.E.	.10	.10	.10	.10	.10	.10	.10	.10	.10	.10	.10	.10

PARTIAL AUTOCORRELATIONS (D)

1- 12	.03	.09	.02	-.13	.01	-.02	.03	.04	.06	-.06	.18	.02
ST.E.	.09	.09	.09	.09	.09	.09	.09	.09	.09	.09	.09	.09
13- 24	0.0	-.08	.08	.04	.09	.03	-.23	.01	.04	.14	.04	0.0
ST.E.	.09	.09	.09	.09	.09	.09	.09	.09	.09	.09	.09	.09

AUTOCORRELATIONS (F)

1- 12	.01	.09	.16	-.01	.14	.04	0.0	-.02	.06	-.10	.12	-.01
ST.E.	.09	.09	.09	.09	.09	.10	.10	.10	.10	.10	.10	.10
13- 24	-.02	-.03	0.0	.05	.10	.03	-.19	.06	-.02	.04	.01	-.01
ST.E.	.10	.10	.10	.10	.10	.10	.10	.10	.10	.10	.10	.10

PARTIAL AUTOCORRELATIONS (F)

1- 12	.01	.09	.16	-.02	.11	.02	-.02	-.07	.06	-.12	.13	-.02
ST.E.	.09	.09	.09	.09	.09	.09	.09	.09	.09	.09	.09	.09
13- 24	.01	-.09	.05	.03	.13	-.01	-.19	0.0	.03	.06	-.01	.03
ST.E.	.09	.09	.09	.09	.09	.09	.09	.09	.09	.09	.09	.09

AUTOCORRELATIONS (G B)

1- 12	.19	.08	.11	-.06	.09	.03	.15	.01	.01	.05	.07	.13
ST.E.	.09	.09	.09	.10	.10	.10	.10	.10	.10	.10	.10	.10
13- 24	.02	-.02	-.11	-.01	.10	-.03	.11	.13	-.06	-.06	.02	-.02
ST.E.	.10	.10	.10	.10	.10	.10	.10	.10	.10	.11	.11	.11

PARTIAL AUTOCORRELATIONS (G B)

1- 12	.19	.05	.10	-.11	.11	-.01	.17	-.10	.03	0.0	.11	.06
ST.E.	.09	.09	.09	.09	.09	.09	.09	.09	.09	.09	.09	.09
13- 24	-.02	-.08	.11	.05	.10	-.07	.08	.12	-.08	-.08	.03	-.04
ST.E.	.09	.09	.09	.09	.09	.09	.09	.09	.09	.09	.09	.09

AUTOCORRELATIONS (I)

1- 12	.08	.17	-.02	-.11	.07	-.03	.07	.03	.10	-.17	.07	-.03
ST.E.	.09	.09	.09	.09	.09	.10	.10	.10	.10	.10	.10	.10
13- 24	-.02	-.05	-.01	0.0	.09	.09	-.11	0.0	.02	.03	-.01	-.04
ST.E.	.10	.10	.10	.10	.10	.10	.10	.10	.10	.10	.10	.10

PARTIAL AUTOCORRELATIONS (I)

1- 12	.08	.16	-.05	-.13	.10	0.0	.04	.01	.11	-.21	.10	.03
ST.E.	.09	.09	.09	.09	.09	.09	.09	.09	.09	.09	.09	.09
13- 24	-.05	-.12	.10	-.02	.10	.05	-.12	-.08	.18	.02	-.11	.06
ST.E.	.09	.09	.09	.09	.09	.09	.09	.09	.09	.09	.09	.09

AUTOCORRELATIONS (JPN)

1- 12	.21	-.05	.07	.13	.14	-.09	-.05	.05	.05	-.07	-.08	.12
ST.E.	.09	.09	.09	.10	.10	.10	.10	.10	.10	.10	.10	.10
13- 24	.13	-.15	-.13	.06	.05	-.15	-.12	-.01	-.02	-.12	-.18	.02
ST.E.	.10	.10	.10	.11	.11	.11	.11	.11	.11	.11	.11	.11

PARTIAL AUTOCORRELATIONS (JPN)

1- 12	.21	-.10	.11	.09	.11	-.14	.01	.01	.03	-.08	-.01	.13
ST.E.	.09	.09	.09	.09	.09	.09	.09	.09	.09	.09	.09	.09
13- 24	.06	-.18	-.03	.06	-.03	-.15	.03	-.01	-.08	-.09	-.05	.06
ST.E.	.09	.09	.09	.09	.09	.09	.09	.09	.09	.09	.09	.09

AUTOCORRELATIONS (NL)

1- 12	.07	.08	.07	-.11	.01	0.0	0.0	.04	.04	-.05	.19	.01
ST.E.	.09	.09	.09	.09	.09	.09	.09	.09	.09	.09	.09	.10
13- 24	0.0	-.02	-.02	0.0	.12	.04	-.14	.07	-.03	.12	.07	.03
ST.E.	.10	.10	.10	.10	.10	.10	.10	.10	.10	.10	.10	.10

PARTIAL AUTOCORRELATIONS (NL)

1- 12	.07	.08	.06	-.13	.01	.01	.01	.02	.03	-.06	.19	-.01
ST.E.	.09	.09	.09	.09	.09	.09	.09	.09	.09	.09	.09	.09
13- 24	-.02	-.06	.03	0.0	.14	0.0	-.19	.07	.04	.12	.01	.01
ST.E.	.09	.09	.09	.09	.09	.09	.09	.09	.09	.09	.09	.09

Table 4: Time Series features: s(t+1)-s(t).*

	B	CH	CND	D	F	GB	I	JPN	NL
r(1)	0.07	0.00	0.13	0.02	-0.03	0.14	0.00	0.16	0.04
r(2)	0.08	0.07	-0.24	0.08	0.06	0.05	0.15	-0.11	0.06
r(3)	0.03	0.01	0.08	-0.02	0.11	0.10	-0.01	0.03	0.01
$X^2(6)$	0.94	0.83	0.12	0.79	0.63	0.46	0.44	0.09	0.75
$X^2(12)$	0.40	0.96	0.05	0.68	0.61	0.31	0.25	0.18	0.71

* r(1), r(2) and r(3) are the first, second and third order autocorrelation coefficients respectively. The standard error is 0.09. $X^2(6)$ and $X^2(12)$ are the probability values of the X^2-statistic for lag 6 and 12 respectively.

Table 5: Time Series Features of the Error in the Regression: $f(t)-s(t+1) = c + d(f(t)-s(t)) + u(t)$.*

	B	CH	CDN	D	F	GB	I	JPN	NL
DW	1.95	1.99	1.76	1.98	2.10	1.74	1.96	1.61	2.03
r(1)	0.01	-0.02	0.12	-0.01	-0.07	0.13	-0.00	0.15	-0.03

* DW = Durbin Watson Statistic.
  r(1) = first order autocorrelation coefficient (the standard error is 0.09).

Table 6: Regression Results: s(t+1) = a + bf(t) + e(t).*

	B	CH	CND	D	F	GB	I	JPN	NL
$\hat{a}$	-0.06	-0.03	-0.00	-0.03	-0.02	0.01	-0.00	-0.26	-0.03
	(0.08)	(0.01)	(0.00)	(0.02)	(0.03)	(0.01)	(0.08)	(0.10)	(0.02)
$\hat{b}$	0.98	0.97	1.00	0.97	0.99	0.98	1.00	0.95	0.96
	(0.02)	(0.02)	(0.01)	(0.02)	(0.02)	(0.02)	(0.01)	(0.02)	(0.02)
r(1)	0.12	0.04	0.17	0.04	0.02	0.20	0.08	0.21	0.09
r(2)	0.11	0.10	-0.21	0.10	0.10	0.09	0.17	-0.05	0.10
r(3)	0.09	0.04	0.07	0.04	0.17	0.12	-0.02	0.06	0.09
$X^2(6)$	0.46	0.60	0.08	0.65	0.17	0.09	0.25	0.03	0.50
$X^2(12)$	0.32	0.87	0.05	0.58	0.37	0.14	0.27	0.12	0.54
$X^2(18)$	0.42	0.87	0.01	0.82	0.63	0.30	0.52	0.03	0.76
$X^2(24)$	0.27	0.79	0.00	0.57	0.63	0.35	0.74	0.02	0.70

* Numbers in parentheses are standard errors.
r(1), r(2) and r(3) are the first, second and third order autocorrelation coefficients respectively (the standard error is 0.09).
$X^2(6)$, $X^2(12)$, $X^2(18)$ and $X^2(24)$ are the probability values of the X^2-statistic at lag 6, 12, 18 and 24 respectively.