AN EMPIRICAL ANALYSIS OF EX ANTE PROFITS FROM FORWARD SPECULATION IN FOREIGN EXCHANGE MARKETS

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Abstract—This paper constructs a time series band for ex ante profits from forward speculation and examines the permanent component of the median of the band for six different exchange markets. The unpredictability of ex ante profits is rejected using nonparametric tests. Deviations of ex ante profits from forward premia are attributed to deviations of nominal exchange rates from martingale processes. It is shown that movements in the terms of trade are responsible for most of the variability and serial correlation properties of ex ante profits.

I. Introduction

IT is by now widely recognized that the forward rate is not an unbiased predictor of future spot rates and that realized nominal profits from speculating in the forward market are nonnegligible and highly volatile (see, e.g., Hodrick (1987), Frankel and Meese (1987)). However, the nature of these profits is as of yet undetermined.

This paper attempts to shed light on this issue by examining the time series properties of ex ante profits from forward speculations in six foreign exchange markets. I focus on three aspects of the problem. First, I provide a measure of the range and the variability of ex ante profits, two issues with contradictory evidence in the literature (see Hodrick (1987) and Frankel (1988) for references). Second, I relate deviations from uncovered interest parity to risk and to deviations of nominal spot rates from martingale processes. Third, I link the time series properties of ex ante profits to the behavior of the real exchange rate.

Since ex ante profits are not observable, the empirical analysis requires the construction of a time series for the expected future spot rate. Frankel and Froot (1987), Ito (1988), Cumby (1988), and Diebold and Nason (1990) have all suggested ways of computing this series.[1] Here I provide an alternative method for constructing a time series for expected future spot rates and for statistically assessing the properties of ex ante profits. Expected future spot rates are measured as a 90% confidence band obtained from the simulated recursive distribution for the linear predictor of the series. I simulate the distribution of the linear predictor rather than use simple point forecasts in order to reduce the forecast error due to parameter uncertainty. An additional measure for expected future spot rates considered is a point estimate of the permanent component of the median of the band.

I use nonparametric tests to examine the relationship between ex ante profits and other series. Nonparametric tests are employed here for two reasons. First, I am interested in the entire population properties of the data. Existing results are derived by examining only the first and second moments of the data. Second, efficiency tests are generally based on linear parametric functional forms. Pagan and Ullah (1988) have pointed out problems with these tests when the conditional mean of the data is nonlinear. Nonparametric tests overcome these problems.

The results indicate that nominal (and real) rates do not follow martingale processes, that a risk premium rarely explains the behavior of the ex ante profits and that variations in expected terms of trade account for the time series properties of ex ante profits.

The rest of the paper is organized as follows: section II describes the data, the forecasting model and the construction of expected future spot rates. Section III examines the statistical features of ex ante profit. Section IV constructs a point estimate of the permanent component of ex ante profits and tests two efficiency propositions. Section V reinterprets the evidence using a real decomposition of the estimated permanent

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[1] Frankel and Froot use survey data on expectations of future spot rates. Ito constructs expectations of future spot rates as linear predictions from a VAR model. Cumby directly computes ex ante profits by projecting ex post profits on a given information set. Diebold and Nasan construct nonparametric predictions of future spot rates.

component of ex ante profits and concludes the paper.

II. The Data and the Forecasting Procedure

The data set employed spans nine years of weekly data from 1979,1 to 1987,52. For all variables weekly samplings (at Wednesday) of daily values are constructed. Spot rates are the values at the New York market for six different currencies in terms of the U.S. dollar (French franc (FF), Swiss franc (SF), German Mark (DM), English Pound (£), Canadian Dollar (CAN\$) and Japanese Yen (YEN)). Forward rates are arithmetic averages of the bid–ask spread in the New York market and refer to contracts made for delivery 13 weeks ahead. Interest rates are 13 week Eurodeposit rates computed as averages of bid–ask spread.

Ex ante profits from forward speculation, as an annualized percentage of the spot rate on a contract quoted at t for execution at $t+13$, are defined as

$$PR^e_{t,t+13} = 400 \times \left[\frac{S^e_{t+13} - F_{t,t+13}}{S_t}\right] \qquad (1)$$

where e indicates expected values, S^e_{t+13} is the expected spot rate at $t+13$ and $F_{t,t+13}$ is the forward rate quoted at t for transactions to be delivered at $t+13$.

Since $PR^e_{t,t+13}$ is not observable, the auxiliary assumption of rational expectations is usually employed to substitute realized values for expectations in (1). However, this assumption alone is not sufficient to generate a time series for ex ante profit. Direct computation of $PR^e_{t,t+13}$ under rational expectations, on the other hand, can be very demanding when the conditioning set is large (see, e.g., Diebold and Nason (1990)). Two different ways of approximating conditional expectations exist in the literature. One is to use survey data on expected future spot rates, as, e.g., in Frankel and Froot (1987). One problem with this kind of data is that survey responses may report the median or the mode of the distribution of future spot rates. If such a distribution is asymmetric, the reported measure is a biased estimate of the true conditional mean. Another way to approximate S^e_{t+13} is to use time varying linear projections as in Ito (1988) or Cumby (1988). This approximation is (asymptotically) exact if the variables in the information set of agents are (asymptotically) normal because S^e_{t+13} will be a linear function of these variables. In general, however, an approximation error will occur. In addition, since the parameters of the linear projection are estimated, sampling error is added to the approximation.

This paper follows the second approach but I introduce a modification in the forecasting scheme designed to reduce the error due to parameter uncertainty. To see how parameter uncertainty affects the quality of the approximation consider the problem of generating forecasts from the model:

$$Y_t = f(a, X_t) + u_t \qquad u \sim \left(0, \operatorname{diag}\left\{\sigma^2_{u_j}\right\}\right) \quad (2)$$

where $f: R^{np} \times R^{np} \to R^n$ is a continuous function, a is an $n \times np$ vector of parameters, $X_t = [Y_{t-1}, \ldots, Y_{t-p}]$ is an $np \times 1$ vector and each Y_{t-i} is an $n \times 1$ vector. If agents in the economy have a quadratic loss function, their optimal point forecast of $Y_{j,t+k}, \forall\, k$ is $E[Y_{j,t+k}|I_t] = g_j(a, X_t)$ where I_t is the information set and g_j is the j^{th} component of the Borel measurable function g, $j = 1, \ldots, n$. The variance of the k-period forecast error is $\sigma^2_{u_j}$. In practice, econometricians have less information than agents. They usually approximate the function g_j with a first order Taylor expansion, i.e, $g_j(a, X_t) = b_j X_t + e_{jt}$ where e_{jt} may be serially correlated with mean zero and variance σ^2_{jt} and b is a $1 \times np$ vector of parameters, and they treat b_j as unknown. Assume for simplicity that e_{jt} are serially uncorrelated. Then the variance of the k-period forecast error computed by the econometrician using t observations is

$$\sum_{i=0}^{k-1} b^{2i}_{j,t}\left(\sigma^2_{u_j} + \sigma^2_{jt}\right) + \operatorname{var}\left[\left(b^k_{j,t} - \hat{b}^k_{j,t}\right)X_t\right] \qquad (3)$$

where a caret indicates estimated values and the subscript t on b refers to the sample size. The last term in (3) is the component of the variance of the forecast error due to parameter uncertainty. If the true b are constant, its size increases with the dimensionality of the model and decreases as the sample size t increases.

For fixed t the dimensionality problem is typically solved by using univariate models or multivariate models with a small number of coefficients. Martingale models of exchange rates are popular tools to forecast out of sample (see, e.g., Meese and Rogoff (1983)). However, there is evidence that this is not the best available solution (see, e.g., Canova and Ito (1991), Canova (1990)).[2] An alternative solution to the dimensionality problem is offered by Bayesian methods. These methods are known to perform successfully in a variety of situations (see, e.g., Litterman (1986)).

This paper follows a different route. To improve the reliability of the forecasts of the model, I numerically construct the densities of the recursive estimates $\hat{b}_{j,t}^{k}$ and the recursive forecasts $\hat{Y}_{j,t+k} = \hat{b}_{j,t}^{k} X_t$ obtained from an 11 variable Vector Autoregressive (VAR) model. The VAR model includes six exchange rates and five interest rates, eight lags of all variables and a linear trend. The Swiss and the French eurodeposit rates are excluded from the model because they are collinear with the German eurodeposit rate. I use eight lags because the residuals of univariate AR(8) regressions of all the variables are white noises according to Durbin's (1969) test. A linear trend is included following Sims, Stock and Watson (1990). The first set of forecasts is computed using one year of data and recursive estimates of the coefficients are then computed with the Kalman filter.

Using a bootstrap algorithm I obtain a large number of recursive estimates and forecasts for each date in the sample. The recursive densities for $\hat{b}_{j,t}^{k}$ and $\hat{Y}_{j,t+k}$ are constructed by smoothing the histogram at each t. The region of the plane where 90% of the time t forecasts of the future spot rate lie is used as a 90% confidence band estimate for S_{t+13}^{e}.

This procedure accomplishes two goals. First, it gives us an idea of the size of the forecast error variance due to parameter uncertainty. Second, it allows us to correct for small sample biases in measuring the volatility of the series. As compared with numerical estimates obtained with Monte Carlo methods and normally distributed errors, one may expect improved estimates of the band since the empirical density of exchange rates is fat tailed. In general, if a "peso problem" or rational bubbles exist, the procedure provides a better measure of the true distribution of the linear recursive forecasts, which is highly nonnormal at all horizons (see Obstfeld (1987) and Froot and Ito (1989) for this issue).

III. The Properties of Ex Ante Profits

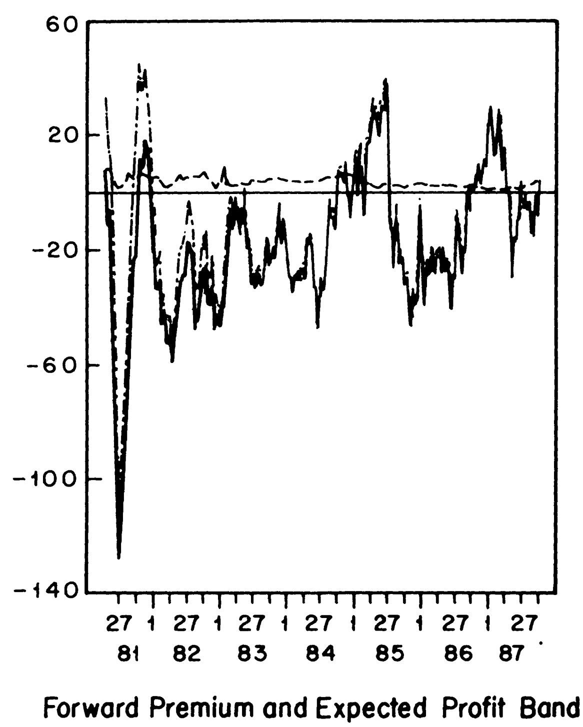
Equation (1) can be rewritten as

$$PR_{t,t+13}^{e} = 400 * \left[\frac{S_{t+13}^{e} - S_t}{S_t} - \frac{F_{t,t+13} - S_t}{S_t} \right] \tag{4}$$

where the first term is the expected change in the spot rate (ECS) and the second the forward premium (FP). Figure 1 plots the forward premium over the ex ante profit band for each market.

A number of interesting features emerge from the figure. In the four panels corresponding to European currencies ex ante profits exhibit a

FIGURE 1.—THE FORECASTS OF THE MODEL: EX-ANTE PROFIT BAND (—) AND FORWARD PREMIUM (--)



[2] Canova and Ito showed that longer lags and a larger information set significantly help in explaining movements in the yen/dollar risk premium series. Canova demonstrates that there are large multivariate models which can improve the out-of sample performance of univariate martingale models of exchange rates.

common pattern of swings throughout the sample. The size of the bands is wider at the beginning of the sample because of parameter uncertainty and is reduced after 1982. Although the size of all the 90% bands shrink over time, their volatilities do not decrease. Throughout the sample it is common to see changes in profits of the order of 20% over the course of a year. Large spikes appear in ex ante profits in the \$/SF and \$/£ markets. Since the forecasts for future spot rates constructed take into account interdependences across markets while the *FP* series does not, the abnormal size of these profits is probably the result of the large differential existing in the Swiss and U.K. eurodeposit rates relative to the interest rates of other countries (but not the U.S.).

The bands are, in general, entirely negative from 1982 to 1984, sharply positive in 1985 and include zero afterward. The 1982–84 pattern implies that, although the forward rate indicated depreciation, the dollar was expected to appreciate. In 1985, on the other hand, the dollar was expected to depreciate faster that the forward rate predicted.

This evidence is consistent with three explanations. If expected profits represent a risk premium, then the dollar was less risky than other currencies up to 1984 and a sharp change of market conditions appears in 1985. Alternatively, profits may be the result of a "peso problem" (see Lewis (1988), Kaminsky (1989)). Between 1982 and 1984, the forward rate appeared to be biased because agents assigned a positive probability to an event that occurred only at the end of 1985. Finally, profits may have been the result of irrational bubbles (see Krugman (1988), Branson (1988)).

In all markets the time series behavior of ex ante profit bands differs from that of the forward premium. The *FP* is outside the 90% band for most of the sample and is contained in it only when the band includes zero. Differences in the time path of the bands and the *FP*'s, however, do not necessarily indicate that the population properties of the two series differ. To determine whether the population properties also differ and whether any difference is simply due to the way ex ante profits were constructed, table 1 presents the first four moments and a few autocorrelations of the upper and lower bound of the band, of *FP* and of ex post profits (*EPP*).[3]

Table 1 confirms that the ex ante band and *EPP* have fairly similar population properties. Both, however, differ from *FP*. The mean of *FP* does not lie between the means for the upper and lower limits of the 90% band in four out of six cases, its variability is no more that 1/6 of the variability of both ex ante profits and *EPP*, and its autocorrelation function is different from those of the upper and lower limits of the band and of *EPP* (for the \$/DM profits *FP* and *EPP* have similar autocorrelations). Finally, all series are skewed and leptokurtic.

These results imply that most of the volatility and the serial correlation properties in ex ante profits come from expected changes in the spot rate. For those who believe that nominal exchange rates follow martingale processes this outcome is puzzling. It can be argued that the profit band contains a large amount of transitory variability that should be eliminated before a comparison with *FP* is made. In other words, the population properties of *FP* should match only the population properties of the permanent component of ex ante profits. The next section computes a permanent component of ex ante profits and compares it with *FP*.

IV. An Estimate of the Permanent Component of Ex Ante Profits

Several procedures are available to construct the permanent component of a series. For the purpose of this paper I experimented with three approaches: the one of Hodrick and Prescott (1980), the one of Watson (1986), and a frequency domain masking. Because of space limitations, results are presented only for the frequency domain masking approach. To minimize the bias in the estimate of the permanent component due to the availability of only 9 years of weekly data, I adopt the conservative procedure of masking cycles with periods less than or equal to one year from the median of the 90% bands. Table 1 contains the first four moments and some autocorrelations for the permanent (*PC*) and transi-

[3] For the sake of robustness, statistics for three subsamples 80, 14–82, 40; 82, 41–85, 40 and 85, 41–87, 40 were also computed and are available on request from the author.

TABLE I.—SAMPLE STATISTICS 1980, 40–1987, 40

Market	Variable	Mean	S.E.	Skewdness Significance Level	Kurtosis Significance Level	Autocorrelations 1	4	13
$/DM	*Upper*	33.64	187.86	.00	.00	.94	.78	.34
	Ex post	−3.71	27.14	.00	.00	.94	.76	.33
	Lower	−17.02	25.87	.00	.01	.93	.70	.06
	FP	3.95	1.75	.00	.00	.92	.77	.33
	PC	−11.44	18.78	.00	.12	.99	.94	.58
	TC	0.002	19.22	.00	.00	.93	.60	−.52
	ERRD	0.29	0.35	.78	.23	.91	.75	.38
$/SF	*Upper*	70.08	264.95	.00	.00	.94	.76	.30
	Ex post	−3.66	29.96	.00	.00	.93	.76	.29
	Lower	−12.87	74.60	.00	.00	.93	.70	.06
	FP	5.50	2.65	.00	.59	.97	.91	.63
	PC	7.27	40.68	.00	.63	.99	.93	.49
	TC	0.86	34.48	.00	.00	.95	.66	−.58
	ERRD	0.05	0.50	.18	.00	.94	.85	.58
$/FF	*Upper*	30.44	185.55	.00	.00	.96	.77	.33
	Ex post	−1.57	26.70	.23	.00	.94	.78	.37
	Lower	−21.41	28.85	.05	.02	.96	.79	.12
	FP	−3.04	4.35	.00	.00	.87	.64	.40
	PC	−1.74	22.73	.42	.00	.99	.97	.83
	TC	0.31	17.44	.00	.00	.89	.60	−.55
	ERRD	−0.17	0.30	.00	.68	.86	.50	−.05
$/£	*Upper*	18.63	89.94	.00	.00	.94	.76	.31
	Ex post	−2.63	27.03	.00	.98	.94	.80	.29
	Lower	−13.24	49.39	.00	.00	.91	.65	.10
	FP	−0.83	2.99	.02	.01	.97	.89	.67
	PC	−12.59	26.57	.00	.99	.99	.93	.57
	TC	0.57	19.16	.00	.00	.93	.60	−.51
	ERRD	−0.07	0.36	.35	.11	.85	.52	.10
Yen/$	*Upper*	12.45	74.20	.00	.00	.88	.55	.42
	Ex post	−1.74	26.91	.37	.01	.95	.76	.26
	Lower	−60.21	23.52	.00	.00	.94	.78	.34
	FP	−4.04	3.04	.00	.97	.97	.91	.71
	PC	−5.41	23.93	.04	.43	.99	.94	.66
	TC	−1.83	12.40	.31	.79	.89	.51	−.23
	ERRD	0.36	0.37	.00	.00	.82	.55	.19
$/Can$	*Upper*	12.13	60.75	.00	.00	.94	.88	.82
	Ex post	−0.74	8.42	.00	.17	.91	.66	−.05
	Lower	−3.99	7.78	.00	.00	.86	.73	−.08
	FP	−0.95	1.36	.00	.00	.95	.81	.41
	PC	−1.64	6.49	.00	.00	.99	.92	.44
	TC	0.14	3.74	.00	.00	.78	.29	−.15
	ERRD	−0.06	0.16	.00	.00	.76	.39	−.19

Notes: *Upper* and *Lower* refer to the upper and lower values of the 90% confidence band. *FP* is the Forward Premium. *Ex post* refers to ex post profits. *PC* and *TC* refer to the permanent and transitory component of ex ante profits. *ERRD* is the expected real interest rate differential.

TABLE 2.—KOLMOGOROV-SMIRNOV STATISTICS

Market	White *TC*	Strong *PC-FP*	Weak *PC-FP*	White *ERRD*	Weak *PC-ERRD*
$/DM	6.15	8.85	9.75	0.75	10.05
$/SF	5.85	7.50	7.43	3.82	7.20
$/FF	6.45	4.27	6.22	6.53	5.40
$/£	6.37	8.25	9.68	1.20	9.30
Yen/$	6.98	7.50	7.95	0.37	7.28
$/Can$	6.45	7.88	10.05	2.92	9.15

Note: The null hypotheses are rejected at the 5% (1%) confidence level if the statistics exceed 1.36 (1.63).

tory (TC) components of ex ante profits for each market.

The results indicate that the permanent component differs from FP. The means of the transitory components are all insignificantly different from zero. However, serial correlation is still apparent in all series, a result which is consistent with Canova's (1989) finding of seasonalities in ex ante profits. To test for the whiteness of the transitory component, I employ the Kolmogorov-Smirnov (KS) test (see Hollander and Wolfe, 1973, p. 219).[4] Table 2, column 1, reports the values of the KS statistic for this test. The null hypothesis of white noise is rejected in all currencies.[5] Therefore, there is information in the transitory component which is useful in predicting short-run movements of ex ante profits.

Next, I use (4) to test two hypotheses concerning the permanent component. First, I test for a strong form of predictability of PC. We say that a market displays strong predictability if the populations from which PC and FP are drawn are identical. Therefore, if a market is strongly predictable, the expected change in the spot rate should have a degenerate distribution. Second, I test for a weak form of predictability of PC. We say that a market displays weak predictability if FP contains all the information needed to forecast PC. Hence, if a market is weakly predictable, the expected change in the spot rate should be a white noise. Table 2, columns 2–3, reports the values of the KS statistics for the two propositions. Both hypotheses are rejected for all currencies.

This evidence is therefore consistent with the idea that ex ante profits are predictable using their own past, that FP does not contain all the information necessary to forecast the stable (permanent) component of ex ante profits and that nominal exchange rates *deviate* from martingale processes.

[4] The test is nonparametric, compares the populations (instead of moments) and it is almost assumption free since it only requires continuous and invariant population for the processes under consideration.

[5] Results obtained with the other two methods, when different cycles are included in the two components and when the sample is split in various ways, are available on request from the author. None of the conclusion presented here is, however, altered.

V. Some Explanations

The biasedness of the forward rate is often taken as evidence of the existence of a risk premium. However, if this were the case, FP, which includes a risk premium, should explain the features of ex ante profits. Frankel (1988) argues that fluctuations in realized profits are too large to be explained by a risk premium and suggests the possibility of irrational market behavior. The results so far obtained support his observation, but not the conclusion that agents act irrationally. This is because the risk premium is not the only source of profits. To see this we can use the log version of covered interest parity

$$F_{t,13} - S_t = \left[i^f_{t,13} - i^h_{t,13}\right] \quad (5)$$

where i^f and i^h are the log of the foreign and dollar denominated eurodeposit rates, and the definition of the log real exchange rate:

$$d_t = p^f_t - p^h_t + S_t \quad (6)$$

where p^f_t and p^h_t are the logs of the foreign and domestic price levels, to rewrite (4) as

$$\ln PR^e_{t,13} - \ln 400 = \left(d^e_{t+13} - d_t\right) - \left(r^f_{t,13} - r^h_{t,13}\right) \quad (7)$$

where $r^f_{t,13}$ and $r^h_{t,13}$ are the logs of the foreign and domestic real eurodeposit rates, $r^j_{t,13} \equiv i^j_{t,13} - \pi^{e,j}_{t,13}$, $j = f$, d and $\pi^{e,j}_{t,13}$ is the 13-week expected inflation on currency j.

In (7) expected profits depend on the expected changes in the terms of trade ($ECTT$) and the expected real interest rate differential ($ERRD$). Most of the empirical literature (a notable exception is Levine (1989)) has restricted attention to the case where expected purchasing power parity ($EPPP$) holds (i.e., to the case where nominal exchange rates are martingales), in which case profits from forward speculation should compensate investors only for a nominal risk premium. In general, profits should compensate investors for both predictable movements in the terms of trade and in the real interest rate differential (real risk premium). Next, I argue that there is no theoretical reason to expect $EPPP$ to hold, that the real risk premium is small and show that $ECTT$ is likely to explain both the range and the variability of ex ante profits.

For $EPPP$ to hold, the real exchange rate must be a martingale process and the expected inflation differential must be serially uncorrelated. Consumption based models of exchange rate determination (see Lucas (1982)) rarely imply a random walk behavior for the real exchange rate. In these models, *ECTT* is given by

$$(d^{e}_{t+13} - d_t) = E_t U_{1t+13} - U_{1t} - (E_t U_{2t+13} - U_{2t}) \qquad (8)$$

where U_j is the marginal utility of consumption good j, $j = 1, 2$. In equilibrium, these models imply that $c_{jt} = f(y_{jt}, G_{1jt}, G_{2jt})$ where G_{ijt} is the purchase by government i of good j, y_{jt} is the output of good j and f is a linear function. Therefore, d_t will be a martingale only if $G_{ijt} = 0$, $\forall\ i, j, t$, if y_{jt} is a martingale process and if the utility function is linear and separable in the consumption of the two goods. Violation of any of these conditions (i.e., if agents are risk averse or if government purchases are different than zero) will induce a non-martingale behavior in d_t.

Moreover, the expected inflation rate differential is unlikely to be serially uncorrelated. Differences in the serial correlation properties of domestic and foreign money supplies or outputs may induced serially dependent movements in the expected inflation rate differential.

Since (7) provides better information than (4) on the sources of nominal profits, next I address the question of which of the two components is more closely related to observed ex ante nominal profits. Several studies (see, e.g., Campbell and Clarida (1987)) have argued that *ERRD* is small and approximately constant over time. In this case variations in the terms of trade should account for variations in ex ante profits.

To operationally examine how ex ante profits relate to *ECTT*, it is necessary to calculate expected inflation. Since price data exist only at a monthly frequency, the calculation of the weekly expected inflation involves several approximations. The results are therefore only indicative of a possible pattern existing in the markets.

The procedure I employ to construct expected inflation rates is the following. The realized monthly inflation rate, computed from CPI indices,[6] is attributed to each week of the month starting from the week when CPI data are published (usually the third week of the month). Then I project these realized values on stock market prices and nominal interest rates 13 periods in the past to generate an expected inflation series for each market.[7]

The properties of the resulting *ERRD* series are presented in table 1 for each currency. From the table, it is clear that in each market the mean is small, the variance is negligible when compared with the variance of ex ante profits and the autocovariance function differs from that of ex ante profits.

To statistically show the difference between *ERRD* and ex ante profits, I next test whether ex ante profits are weakly predictable using *ERRD* (i.e., whether d_t is a martingale) and whether *ERRD* is a white noise (i.e., whether all properties of *PR* are due to *ECTT*). Columns 4–5 of table 2 report the value of the *KS* statistic for these two propositions. While the martingale hypothesis of the real exchange rate is rejected in all markets, the white noise assumption for *ERRD* is not rejected at a 1% level in three markets.

This evidence suggests that the serial correlation properties of *ECTT* are responsible for deviations from Uncovered Interest Parity. *ECTT* explain the biasedness of the forward rate, the deviations of nominal spot rates from martingale processes and account for most of the movements of ex ante profits. The results also show that *ECTT* are not matched by opposite movements in *ERRD*, a conclusion which agrees with Campbell and Clarida (1987) and Huizinga (1987) but contrasts with Meese and Rogoff (1988).

Three caveats should be mentioned before any conclusions about the functioning of foreign exchange markets are drawn from the results. First, the sample used contains only nine years of data and this may be insufficient to correctly assess the long-run behavior of profits. Second, foreign exchange markets were extremely turbulent for at least six of the nine years of the sample. In a more normal environment, some conclusions could be reversed. Finally, the Kolmogorov-Smirnov test may have low power (see, e.g., Meyer and Rasche (1989)).

[6] CPI data are not necessarily the best choice of price index since the basket includes nontraded goods.

[7] I also sampled the data at a monthly frequency and constructed bootstrap estimates of expected inflation from a 20 variables VAR model including CPIs, nominal interest rates and spot rates. None of the qualitative features reported was altered using this alternative procedure.

If none of the above caveats applies, the results indicate an alternative explanation for the biasedness of the forward rate. If the terms of trade are mean-reverting, the forward rate must be biased for efficiency to occur.

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