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Forward Rates and Spot Rates in the European Monetary System – Forward Market Efficiency

By

Alexander C. Jung and **Volker Wieland**

Contents: I. Introduction. – II. Forward Market Efficiency. – III. Cointegration of Forward and Spot Rates. – IV. The Forward Rate as a Predictor of the Spot Rate. – V. Conclusions.

I. Introduction

The purpose of this paper is to examine the forward market efficiency hypothesis for six currencies vis-à-vis the D-Mark in the period 1979–89. In a first step, we introduce the concept of forward market efficiency as discussed by Levich [1985]. In a second step, we apply the theory of cointegration as developed by Engle and Granger [1987] to investigate the joint behaviour of forward and future spot rates. In a third step, we test for forward market efficiency, following a procedure suggested by Fama [1984] and comparing three flexible exchange rates with three exchange rates of the European Monetary System.

It has been shown in the recent literature that flexible exchange rates follow a random walk,[1] which means that the best an individual could do is to take today's exchange rate as a predictor for the future spot rate. In a system of flexible exchange rates, forward rates have been found to be poor and biased predictors of the future spot rate.[2] These results might not hold for fixed but adjustable exchange rates as in the case of the European Monetary System, because the variability of the spot rate is reduced. According to de Grauwe [1989, p. 199], the forward rate should be a good predictor in the EMS, because monetary authorities provide an anchor for expectations by commit-

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[1] See Gerber [1982], Meese and Rogoff [1983], Fratianni and Hur [1987].
[2] See Froot and Frankel [1989], Fama [1984], Hansen and Hodrick [1980].

ting themselves to certain rules. However, we cannot confirm de Grauwe's findings for the EMS. Unit root tests show for all six exchange rates that forward and spot rates follow a random walk. In this case the cointegration method allows us to test for a stable linear relationship between forward and future spot rates. Such a stable linear relationship between these two time series is a necessary condition for forward market efficiency. We find the forward and the future spot rate to be cointegrated in the case of all six exchange rates.

A sufficient condition for forward market efficiency is given by the Fama-test [Fama, 1984], which requires that the forward rate correctly predicts the future spot rate and excludes on average the possibility of profits in the forward market. Applying the Fama-test it is shown that the forward market efficiency hypothesis does not hold for the EMS but does hold for the flexible exchange rates.

In Section II we present the concept of forward market efficiency. In Section III we test for cointegration of forward and spot rates. In Section IV we analyze the quality of the forward rate in predicting the future spot rate. In the final section we summarize the results.

II. Forward Market Efficiency

A forward market is efficient if there exists no strategy for market agents, which would allow on average for positive profits by speculation. In an efficient forward market, prices fully reflect all available information [Fama, 1970, p. 383]. Market agents process all available information (1) and form rational expectations on the future exchange rate (2):

$$F_{t,3} = E(\tilde{S}_{t+3} | \Phi_t), \tag{1}$$

$$E(\tilde{S}_{t+3} | \Phi_t) = S_{t+3}, \tag{2}$$

where $F_{t,3}$ denotes the 3-month forward rate, S the spot rate, a tilde denotes random variables, E expected values, Φ_t the information set that is assumed to be fully reflected in the expected spot rate at time t, which equals the forward rate [Levich, 1985, p. 1031]. If both conditions are fulfilled, deviations between forward and future spot rates should have zero mean and should not be serially correlated. The forward market efficiency hypothesis can be tested in a regression of the form:

$$S_{t+3} = \alpha + \beta F_{t,3} + \sigma X_t + u_t, \tag{3}$$

where u_t denotes an error term and X_t denotes a variable, which can represent a risk premium or transaction costs.

A necessary condition for forward market efficiency is that forward and future spot rates are cointegrated. In testing for cointegration of forward and future spot rates, we test whether the exchange rates behave as random walks and whether there exists a stable linear relationship between S_{t+3} and $F_{t,3}$. This is equivalent to the hypothesis H_0: $\alpha = 0$, $\beta > 0$, $\sigma = 0$, u_t is stationary. This hypothesis implies that market agents anticipate the direction of the exchange rate movements correctly. Cointegration does not exclude the possibility of speculative profits because it does not require the error term u_t to be white noise.

A sufficient condition for forward market efficiency is given by the hypothesis H_1: $\alpha = 0$, $\beta = 1$, $\sigma = 0$, u_t is white noise. In this case the future spot rate equals the 3-month forward rate plus a random stochastic deviation, excluding on average the possibility of speculative profits.

However, rejection of these restrictions on the coefficients cannot be immediately translated into rejection of the forward market efficiency hypothesis because a risk premium may generate a wedge between forward and spot rates. Risk averse agents demand a positive premium in order to be indifferent between a certain present income and an uncertain future income. The degree of risk aversion may differ regionally and with respect to time. If the profits earned by forward speculation can be explained by a "fair" risk premium [Varian, 1985, p. 166], the forward market can still be called efficient. If market agents are assumed to be risk neutral, there still remains the possibility of transaction costs such as trading fees [Sohmen, 1966, p. 31]. In testing for forward market efficiency we assume σ to be zero.

III. Cointegration of Forward and Spot Rates

We make use of the idea of cointegrated variables to test whether there exists a stable linear relationship between the forward and the future spot rate, which is a necessary condition for forward market efficiency. Cointegration theory uses the stochastic properties of time series, especially the order of integration, to find a stable relation between non-stationary time series. All the variables in the model

[3] This makes it difficult to examine the causal orderings of the model under consideration [see also Granger, 1988, and Hansen, 1988, p. 357]. However, if two variables are cointegrated, their movements may be determined by the same causal factors and they may share a common trend.

under consideration are treated as jointly endogenous.[3] In testing for cointegration we follow a procedure suggested by Engle and Granger [1987] that consists of two steps. In a first step we check the order of integration of the variables. It is necessary that the two series are integrated of the same order and are non-stationary, which means that they behave as random walks. In a second step we estimated a cointegration regression and test if the residuals of this regression are stationary.[4]

If forward rates and spot rates are stationary and have an ARMA representation after differencing once, they are said to be integrated of order one, I(1). The order of integration can be tested with tests for unit roots as proposed by Box and Jenkins [1976]. We apply the Dickey-Fuller test (DF) and the augmented Dickey-Fuller test (ADF) for unit roots.[5] The following regression equations have to be estimated to test for stationarity of F_t and S_t:

$$\begin{aligned} \Delta F_t &= \Gamma_1 F_{t-1} + u_t, \\ \Delta S_t &= \Gamma_2 S_{t-1} + o_t. \end{aligned} \tag{4}$$

The null hypothesis is that both series have a unit root, $H_0: \Gamma_i = 0$ $(i = 1, 2)$. In this case, F_t and S_t are non-stationary and can be described by a random walk. According to the DF-test, H_0 can be rejected at a significance level of 5 per cent if the t-statistic of Γ_i is less than -2.89. Table 1 reports the results for the EMS and the non-EMS exchange rates.[6] It can be seen that forward and spot rates are non-stationary for all six exchange rates since the respective t-statistics exceed the critical value of -2.89. For the first differences of forward and spot rates the t-statistics lie significantly below the critical value. Consequently, the first differences are stationary and all forward and spot rates are integrated of order one.

To make sure that the basic DF-tests are not misspecified, we apply also the augmented DF-test [Dickey and Fuller, 1979; 1981].

[4] Granger's Representation Theorem [Engle and Granger, 1987, p. 255] shows that cointegrated series can be represented by an error correction model. For a bivariate system a typical error correction model relates the change of one variable to past equilibrium errors and to past changes of both variables. We applied this approach to forward and future spot rates. However, the results in modelling the joint behaviour of forward and spot rates could not be improved by an error correction model.

[5] The null hypothesis of cointegration includes the null hypothesis of a unit root [Diebold and Nerlove, 1988, p. 56].

[6] The data used for this and the other tables are obtained from Deutsche Bundesbank [various issues]. Forward rates are monthly and for a three-month term. The data reported are monthly averages. Spot rates are also monthly data and averages.

Table 1 – *DF-Tests and ADF-Tests for Unit Roots*

		I(0)		I(1)	
		DF	ADF	DF	ADF
EMS					
DM/FF	F_t	−1.18	−1.20	−11.53	−6.93
	S_t	−1.24	−1.12	− 8.41	−6.77
DM/lira	F_t	−1.26	−1.28	−11.49	−7.89
	S_t	−1.52	−1.36	− 8.29	−8.59
DM/guilder	F_t	−2.31	−2.19	−11.90	−7.83
	S_t	−2.31	−2.61	− 7.73	−7.51
NON-EMS					
DM/$	F_t	− .97	−1.00	−10.50	6.63
	S_t	− .96	−1.26	− 7.92	−6.40
DM/pound	F_t	− .81	− .95	− 9.74	−7.20
	S_t	− .53	−1.06	− 7.38	−6.31
DM/SFR	F_t	−2.03	−2.30	− 9.40	−8.80
	S_t	−1.63	−2.24	− 7.52	−8.84

Lagged changes of the variables are included on the right hand side of (4) to induce residual whiteness (5):

$$\begin{aligned} \Delta F_t &= \Gamma_1 F_{t-1} + \sum_{i=1}^{N} b_i \Delta F_{t-i} + u_t, \\ \Delta S_t &= \Gamma_2 S_{t-1} + \sum_{i=1}^{N} b_i \Delta S_{t-i} + o_t. \end{aligned} \tag{5}$$

The hypothesis of non-stationarity can be rejected at the 5 per cent level if the t-statistic of Γ_i $(i = 1, 2)$ is less than -3. Table 1 reports the results for the EMS and the non-EMS currencies and shows that the ADF-tests[7] confirm the results of the DF-tests.[8] It can be seen that all six spot rates and their corresponding forward rates are non-stationary and integrated of order one. Consequently, forward and spot rates can best be described by a random walk. Concerning flexible exchange rates this is a standard result which has been widely confirmed in the literature.[9] Concerning the exchange rates in the EMS this is a striking result because it indicates an unexpectedly high

[7] For all six currencies only the first lagged changes in the two equations (5) are significant and thus included in the regressions for the ADF-tests.

[8] See Garbers [1989] for a similar result for the Swiss-franc/US dollar exchange rate.

[9] See Gerber [1982], Meese and Rogoff [1983], Fratianni and Hur [1987].

exchange rate variability in the EMS. For a system of fixed but adjustable exchange rates as the EMS, one would expect the exchange rates to behave in a predictable way and not as random walks.

After having shown that the time series under consideration are non-stationary and I(1), we can test for cointegration of the forward rate, $F_{t,3}$, and the future spot rate, S_{t+3}. Cointegration means that there exists a linear combination of the two non-stationary time series, which is stationary and therefore I(0) with constant mean and finite variance. This stationary linear combination can be interpreted as a stable relationship between the two variables. Following Engle and Granger [1987], the stable relationship between $F_{t,3}$ and S_{t+3} is estimated by means of the static regression (6) in either direction:

$$S_{t+3} = \delta_1 F_{t,3} + o_t, \qquad F_{t,3} = \delta_2 S_{t+3} + u_t. \tag{6}$$

The null hypothesis that $F_{t,3}$ and S_{t+3} are not cointegrated is equivalent to the hypothesis that the residuals of the regression (6) are non-stationary. The null hypothesis can be tested by means of the DF-test, the CRDW-test[10] or the ADF-test. Engle and Granger recommend the ADF-test because the critical value of the DF-test is too sensitive to the particular parameters in the null hypothesis. The ADF-test requires an auxiliary regression of the residuals ($\hat{o}_t$, $\hat{u}_t$) of the cointegration regression (6):

$$\Delta\hat{o}_t = -\Phi\,\hat{o}_{t-1} + \sum_{i=1}^{N} b_i \Delta\hat{o}_{t-i} + \sigma_t, \qquad \Delta\hat{u}_t = -\Phi\,\hat{u}_{t-1} + \sum_{i=1}^{N} b_i \Delta\hat{u}_{t-i} + \varepsilon_t. \tag{7}$$

The null hypothesis of no cointegration can be rejected at the 5 per cent level if the t-statistic, (t_Φ), of the first coefficient in the auxiliary regression exceeds 3.17. The results for (7) are shown in Table 2. The ADF-tests indicate cointegration of the forward rate and the future spot rate for all six currencies. The data allow us to reject the null hypothesis of no cointegration at a level above 5 per cent for both regressions.

Cointegration of forward and spot rates can be interpreted as a stable linear relationship of both variables. This relationship holds

[10] CRDW: Cointegration Regression Durbin Watson test with the null hypothesis DW equal to zero and the critical value 0.386 for rejection of the null at the 5 per cent level. Because of its simplicity, the CRDW-test may be used for a quick approximate result.

Table 2 – *Tests of the Cointegration Regression*

		Cointegration regression			Unit root tests on the residuals	
		CONST	d	R^2	CRDW	ADF
EMS						
DM/FF	S_{t+3}, F_t	.070	.982	.99	.80	−5.64
	F_t, S_{t+3}	−.042	1.010	.99	.80	−5.64
DM/lira	S_{t+3}, F_t	.016	.998	.99	.84	−7.50
	F_t, S_{t+3}	−.011	.992	.99	.85	−7.50
DM/guilder	S_{t+3}, F_t	.902	.800	.71	.58	−5.56
	F_t, S_{t+3}	.484	.892	.71	.63	−5.49
NON-EMS						
DM/$	S_{t+3}, F_t	.045	.969	.92	.58	−5.61
	F_t, S_{t+3}	.022	.956	.92	.58	−5.58
DM/pound	S_{t+3}, F_t	.099	.932	.90	.52	−5.93
	F_t, S_{t+3}	.040	.962	.90	.53	−5.91
DM/SFR	S_{t+3}, F_t	.599	.874	.73	.64	−7.00
	F_t, S_{t+3}	.796	.834	.73	.67	−7.00

except for a stationary finite variance disturbance even though the series themselves are non-stationary and have infinite variance. Thus, a necessary condition for forward market efficiency is fulfilled for all six exchange rates.[11] It implies that there exists an anchor for the forward and the future spot rates which holds them closely together although each of them follows a random walk. This finding shows that market agents anticipate the direction of exchange rate changes correctly. However, it does not exclude the possibility of speculative profits because neither δ_1 is restricted to be equal to one nor the residuals to be white noise.

IV. The Forward Rate as a Predictor of the Spot Rate

To investigate the quality of the forward rate as a predictor of the future spot rate we follow a procedure suggested by Fama [1984], which gives a sufficient condition for forward market efficiency. The

[11] König and Möller [1989] obtain similar results for the case of the Swiss franc/US dollar and DM/US dollar exchange rates.

forward rate can be divided into the expected future spot rate and a premium π_t:

$$F_{t,3} = E(S_{t+3}) + \pi_t . \tag{8}$$

Equation (8) allows to decompose the forward discount into the expected exchange-rate change and a risk premium [Froot and Frankel, 1989]. By subtracting the actual spot rates on both sides of (8) including the expected values one obtains

$$F_{t,3} - S_t = E(S_{t+3} - S_t) + \pi_t , \tag{9}$$

where the difference on the left side, $F_{t,3} - S_t$, denotes the forward discount. By (10) we test whether the current forward discount is a good predictor of the future change of the spot rate. By (11) we test whether the forecast error, $F_{t,3} - S_{t+3}$, which is equivalent to the expected rate of return to speculation, is random with mean zero or shows systematic movements.

$$S_{t+3} - S_t = \alpha_1 + \beta_1 (F_{t,3} - S_t) + v_{1,t+3} , \tag{10}$$

$$F_{t,3} - S_{t+3} = \alpha_2 + \beta_2 (F_{t,3} - S_t) + v_{2,t+3} , \tag{11}$$

$$\text{with } \alpha_2 = -\alpha_1 , \beta_2 = 1 - \beta_1 .$$

The null hypothesis for (10) is H_0^1: $\alpha_1 = 0$, $\beta_1 = 1$,[12] which means that the exchange-rate change is equal to the forward discount plus some random error, $v_{1,t+3}$. In addition, the deviation of the future spot rate from the forward rate should be purely random: H_0^2: $\alpha_2 = 0$, $\beta_2 = 0$. If none of the hypotheses can be rejected, the forward markets are efficient.[13]

In the case of flexible exchange rates, most of the tests found in the literature[14] estimate a negative coefficient, β_1, thus clearly demonstrating a bias of the forward premium in predicting the future exchange-rate change. Two explanations for the bias are presented in the literature [Frankel and Froot, 1987; Froot and Frankel, 1989]. One is a positive risk premium, which would mean that the equations of the Fama-test are misspecified since they omit the risk premium as an explanatory variable. According to this view the bias could be avoided by adding a positive risk term, π_t, on the right-hand side of (10) and

[12] If $\beta_1 = 1$, equation (10) is identical to equation (3) with $\sigma = 0$.

[13] If the hypotheses can be rejected, forward markets may still be efficient under the assumption that market agents are risk-averse.

[14] See Fama [1984], Froot and Frankel [1989], Hansen and Hodrick [1980], and Goodhart [1988].

(11). Some authors doubt the existence of a positive risk premium [Bilson, 1981]. Froot and Frankel [1989] find by using survey data to model risk premia and exchange-rate expectations that the risk premium has little importance to explain the bias of the forward discount.

A second explanation attributes part of the bias to errors in expectations, thereby criticizing the assumption of rational expectations. In a test on market efficiency of five exchange rates against the US dollar, Frankel and Froot find no evidence for random-walk expectations, which would be rational for flexible exchange rates. Instead, they find evidence of excessive speculation, which means that investors would do better to reduce the absolute magnitude of their expected exchange-rate changes, and they find some evidence that investors form their expectations adaptively.

Our tests for three flexible exchange rates against the D-Mark do not detect a strong bias of the forward rate as a predictor of the spot rate comparable to the above findings. Table 3 shows the empirical results of standard OLS estimations for three EMS exchange rates and three flexible exchange rates against the D-Mark. The estimates of (10) and (11) give very low values of the adjusted R^2 for all six exchange rates. This demonstrates that the forward premium explains only very little of the future exchange-rate change. The estimate of β_1 is positive for all six exchange rates. This indicates that the forward rate predicts the sign of the future exchange-rate change correctly in the case of the EMS and in the case of flexible exchange rates.

F-tests on the forward market efficiency hypothesis, H_0^1: $\alpha_1 = 0$, $\beta_1 = 1$ or H_0^2: $\alpha_2 = 0$, $\beta_2 = 0$, reject forward market efficiency for the lira, the guilder, the French franc and the US dollar at the 5 per cent level and for the pound and the Swiss franc at the 10 per cent level. The single hypothesis, $\beta_1 = 1$, can only be rejected for the lira and the guilder at a significance level of 5 per cent.

A problem arises since the sampling interval (one month) is finer than the forward contract interval (three months). The overlapping observations induce serial correlation in the error terms which is partly detected by the low values in the DW-statistics (Table 3). The ordinary least-squares estimators are consistent, but they are inefficient due to the fact that they do not pick up the systematic part of the errors. This results in an incorrect computation of the standard errors of the OLS estimates. Consequently, the tests of hypotheses (F-tests, t-tests) are biased towards rejecting the null hypothesis.

By means of a Lagrange Multiplier test we find for all six currencies higher order serial correlation for any tested lag length. Thus, the

Table 3 – *Tests of Forward Premium Unbiasedness with Monthly Data (1979–89): OLS Regressions of* $(S_{t+3}-S_t)$ and (F_t-S_{t+3}) on (F_t-S_t)

	a_1	b_1	R_1^2	a_2	b_2	R_2^2	DW
EMS							
DM/FF	.007***	.984***	.403	−.007***	.016	.0001	.78
	(3.19)	(9.10)		(−3.19)	(.15)		
DM/lira	.002	.517***	.109	−.002	.483***	.095	.72
	(.58)	(3.97)		(−.58)	(3.70)		
DM/guilder	−.001	.017	.00006	.001	.983***	.165	.47
	(−1.33)	(.09)		(1.33)	(5.00)		
NON-EMS							
DM/$	.016***	1.273***	.171	−.016***	−.274	.002	.72
	(2.70)	(5.10)		(−2.70)	(−1.10)		
DM/pound	.007	.772***	.053	−.007	.228*	.006	.48
	(1.16)	(2.78)		(−1.16)	(1.82)		
DM/SFR	−.002	.550*	.022	.002	.450	.012	.59
	(−.69)	(1.92)		(.69)	(1.57)		

Note: The values in parentheses represent the t-statistics; * and *** represent significance at the 10 and 1 per cent levels.

	t-test $b_1=1$	F-test $a_1=0, b_1=1$ $a_2=0, b_2=0$	F probability
DM/FF	−0.15	18.70	$.85 \cdot 10^{-7}$
DM/lira	−3.71	65.20	$.11 \cdot 10^{-15}$
DM/guilder	−5.20	14.71	$.193 \cdot 10^{-5}$
DM/$	1.09	3.70	.0275
DM/pound	−0.82	2.92	.058
DM/SFR	−1.57	2.76	.0675

serial correlation is not a simple first order autocorrelated error process which could be dealt with by using the Generalized Least Squares technique [Hansen and Hodrick, 1980]. To get efficient estimators, we estimate (10) and (11) on the basis of quarterly data, thus adjusting the sample interval to the forecast interval.[15]

[15] A second procedure would be to use the one-month forward rate, thus adjusting the forecast interval to the sample interval. Unfortunately these data were not available. A third procedure, which is computationally more burdensome, is suggested by Hansen and Hodrick [1980]. They estimate the coefficients consistently with the OLS technique

Table 4 – *Tests of Forward Premium Unbiasedness with Quarterly Data (1979–89): OLS Regressions of* $(S_{t+1}-S_t)$ and (F_t-S_t) on (F_t-S_t)

	a_1	b_1	R_1^2	a_2	b_2	R_2^2	DW
EMS							
DM/FF	.011***	1.317***	.448	−.011***	−.318	.023	1.90
	(2.73)	(5.78)		(−2.73)	−(1.39)		
DM/lira	.005	.650**	.120	−.005	.350	.0001	2.45
	(.71)	(2.53)		(−.71)	(1.36)		
DM/guilder	−.002	−.517	.020	.002	1.52***	.27	1.94
	(−1.54)	(−1.35)		(1.54)	(3.95)		
NON-EMS							
DM/$	.013	1.33***	.22	−.01	−.33	.01	2.05
	(1.43)	(3.53)		(−1.43)	(−.88)		
DM/pound	.0007	.345	.014	−.0007	.655*	.031	1.86
	(.07)	(.73)		(−.07)	(1.39)		
DM/SFR	−.002	.614	.015	.002	.386	.02	2.11
	(−.45)	(1.27)		(.45)	(.801)		

Note: The values in parentheses represent the t-statistics; *, ** and *** represent significance at the 10, 5 and 1 per cent levels.

	t-test $b_1=1$	F-test $a_1=0, b_1=1$ $a_2=0, b_2=0$	F probability
DM/FF	1.39	5.83	.006
DM/lira	−1.36	18.25	$.25 \cdot 10^{-5}$
DM/guilder	−3.96	8.08	$.12 \cdot 10^{-2}$
DM/$	0.88	1.08	.349
DM/pound	−1.39	.77	.471
DM/SFR	−0.80	1.60	.215

The estimated coefficients with quarterly data in Table 4 lie in the same range as the coefficients estimated with overlapping monthly data. Again the low values of the adjusted R^2 reveal the poor quality of the forward rate as a predictor of the future spot rate. A closer view on the data in Table 4 shows that β_1 has the expected positive sign for

using overlapping data and make modifications in the estimation of the asymptotic covariance matrix. However, they concede that their estimation procedure is not fully efficient. Further, a necessary condition for their procedure is the stationarity of the time series which are involved in the estimation. As we have shown in Section III, this condition is not fulfilled for forward and spot rates.

Table 5 – *Structural Stability Tests*

	Quarterly data		Monthly data	
	F-test	probability	F-test	probability
EMS				
DM/FF	4.75	.015	11.46	.000028
DM/lira	.31	.734	.53	.590
DM/guilder	2.44	.101	.716	.491
NON-EMS				
DM/$	1.18	.317	3.56	.315
DM/pound	1.20	.312	3.15	.464
DM/SFR	1.03	.366	.34	.714

Note: The null hypothesis is parameter stability. To compute the test statistics, the samples (1979,1–1989,5) have been split in the two subsamples (1979,1–1982,7) and (1982,8–1989,5).

all currencies except the guilder. The economic meaning is that market agents predict the direction of the exchange-rate movements correctly for five currencies but fail to do so for the guilder. A reason for the peculiar behaviour of the guilder may be the small size of the guilder/D-Mark forward market. Arbitrage in such a small market may not ensure the adjustment of forward rates and future exchange rates to eliminate speculative profits.

Applying F-tests and t-tests, we find that the single hypothesis, $\beta_1 = 1$, is rather robust for all currencies except the guilder. We can still reject the joint hypothesis, $\alpha_1 = 0$, $\beta_1 = 1$, for the exchange rates in the EMS at a 5 per cent level but not for the flexible exchange rates of the non-EMS currencies. Thus a sufficient condition for forward market efficiency is given in the case of the flexible exchange rates, whereas the forward market efficiency hypothesis has to be rejected in the case of the EMS.[16] An explanation may be that, on the one hand, unanticipated government interventions in the EMS such as the numerous intramarginal interventions introduce inefficiencies in the forward markets. On the other hand, anticipated realignments within the EMS can cause speculative attacks[17] which produce additional volatility of exchange rates and worsen the quality of the forward rate as a predictor of the future spot rate. The poor result of the forward rate as a predictor of the future exchange rate in the EMS can be interpreted as an unexploited potential for speculative profits.

[16] To check whether the estimated coefficients are stable, we applied Chow-tests on the monthly and quarterly data samples. With the exception of the French franc, the null hyphothesis of constant coefficients could not be rejected as can be seen in Table 5. A possible explanation for the anomalous behaviour of the French franc could be the drastic shift in economic policy in 1983 during the first term of the socialist President Mitterand.

[17] See also Salant and Henderson [1978] and Meese [1986].

V. Conclusions

Our empirical investigation of forward and spot rates in the European Monetary System in comparison to flexible exchange-rate regimes provides the following results.

Unit root tests reveal that forward rates and spot rates are best described by random walks for all six exchange rates under consideration. This indicates that even in the EMS, exchange rates behave in an unpredictable way and exchange-rate variability is relatively high. Applying cointegration theory to the forward rate and the future spot rate, we find that these two time series are cointegrated in the EMS and in flexible exchange-rate systems. There exists a stable linear relationship between the forward rate and the future spot rate which implies that a necessary condition for forward market efficiency is fulfilled.

We find the forward rate to be a poor predictor of the future exchange rate. It predicts the sign of the future exchange-rate change correctly except for the guilder, but explains only a small fraction of the change. Concerning forward market efficiency, the single hypothesis, $H_0: \beta_1 = 1$, for EMS and non-EMS exchange rates was found to be rather robust. The joint hypothesis for forward market efficiency, $H_0: \alpha_1 = 0$, $\beta_1 = 1$, could be rejected for the EMS exchange rates but not for the flexible exchange rates. Thus, a sufficient condition for forward market efficiency is violated in the case of the EMS while it holds for the flexible exchange rates.

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Zusammenfassung: Terminkurse und Kassakurse im Europäischen Währungssystem. Zur Effizienz der Terminmärkte. – Die Verfasser untersuchen für die Periode 1979–89 das Verhalten der Termin- und Kassakurse im EWS im Vergleich zum System flexibler Wechselkurse. Die „random-walk"-Hypothese für Termin- und Kassakurse kann weder für floatende noch für EWS-Wechselkurse verworfen werden. Kointegrationstests ergeben eine stabile Beziehung zwischen Termin- und Kassakursen, was eine notwendige Bedingung für die Effizienz der Terminmärkte ist. Eine hinreichende Bedingung für effiziente Terminmärkte, die sich aus einem von Fama vorgeschlagenen Verfahren ergibt, ist zwar für flexible Wechselkurse erfüllt, nicht aber für das EWS.

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Résumé: Les cours du change à terme et les cours au comptant dans le système monétaire européen (SME): L'efficience du marché à terme. – Cette étude analyse pour la période 1979–89 le comportement des cours du change à terme et des cours au comptant dans le SME en comparaison des cours du change flexibles. L'hypothèse de «random-walk» pour les cours du change à terme et les cours au comptant ne peut pas être rejetée, ni pour les cours flottants ni pour les cours dans le SME. Les tests de cointégration relèvent une relation stable entre les cours du change à terme et ceux au comptant ce qui est une condition nécessaire pour l'efficience du marché à terme. Une condition suffisante, donnée par une procédure proposée par Fama, est satisfaite pour les cours du change flexibles, mais pas pour le SME.

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Resumen: Tasas a término y spot en el sistema monetario europeo. La eficiencia del mercado a término. – En este trabajo se investiga el comportamiento de las tasas a término y spot en el sistema monetario europeo (EMS) en comparación con los regimenes de cambios flexibles de 1979 a 1989. La hipótesis del "random walk" para tasas a término y spot no puede ser rechazada, ni para tasas de cambio flexibles ni para tasas de cambio del EMS. Tests de cointegración revelan una relación estable entre las tasas a término y spot, la cual es una condición necesaria para la eficiencia del mercado a término. Una condición suficiente para la eficiencia del mercado a término, dada por el procedimiento sugerido por Fama, es satisfecha para las tasas de cambio flexibles, mas no para las del EMS.