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The Term Structure of the Exchange Forward Premium

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ABSTRACT : The purpose of this paper is to analyze the term structure of the forward premium on foreign exchange markets, on the one hand, in a linear framework using the approach of cointegration and the estimation of Vector Error Correction Model (VECM), and secondly, in a nonlinear framework via a Logistic Smooth Transition Dynamic Regression (LSTR) model. The results plead in favor of the non-verification of the Forward Rate Unbiased Hypothesis (FRUH), and show that the term structure of the forward premium does not contribute to the explanation of the deviations of spot exchange rates. In addition, the estimation results confirm the existence of an asymmetric dynamic characterizing the famous Fama regression and show that the forward premium anomaly can be explained at least partially by the presence of frictions in the foreign exchange markets.

***KEYWORDS*:** cointegration, Forward premium anomaly, FRUH, LSTR, VECM.

I. INTRODUCTION

The relationship between changes in exchange rates and interest rate differentials has baffled economists for many years. It seems reasonable to expect a depreciation of currencies with high interest rates so that changes in exchange rates reduce international disparities in the total anticipated returns. This hypothesis is known as *the uncovered interest rate parity*. However, empirical research states that currencies with high interest rates tend to appreciate (Hodrick 1987, Froot and Thaler 1990, Lewis 1995 and Engel 1996). If the hypothesis of uncovered interest rate parity is combined with that of rational expectations, then expected returns in excess, often referred to the risk premiums, should be constant and eventually equal to zero. In addition, empirical studies find that risk premiums appear to be highly variable and strongly related to changes in interest rates. These empirical regularities related to changes in exchange rates and interest rate differentials are referred to *"the forward premium puzzle",* since the risk-free arbitrage requires differential interest rates to be equal to the forward premiums.+

The forward premium puzzle is a phenomenon that has been extensively studied in the literature. According the uncovered interest rate parity, the forward exchange rate could be an unbiased anticipation of the future spot exchange rate. Since the observations have shown ex post deviations from uncovered interest rate parity, in addition to the rejection of the Unbiasedness Forward Exchange Rate hypothesis, the results have often led to that the change in the future spot exchange rate is negatively related to the forward discount. A remarkable explanation for the rejection of the Forward Rate Unbiased Hypothesis is summarized in the existence of a time varying risk premium. Other explanations involve the peso problem, the irrationality of expectations and market inefficiency. In addition, Fama (1984) argues that it is the attitude of risk aversion of traders that explains the existence of a bias in the forward premium: "no forward rate could be interpreted as the sum of a premium and an expected future spot rate"However, more recent empirical research suggests that the existence of an exchange premium is unable to explain the ex post deviations from uncovered interest rate parity adequately. However, Frankel and Froot (1989) found that excess returns represent the result of systematic errors of prediction and not exchange risk premiums. These forecast errors may increase due to the existence of irrational actors. Based on the literature that has been strongly influenced by the seminal work of Meese and Rogoff (1983) giving emphasis to empirical models of exchange rates based on conventional macroeconomic fundamentals, models that exploit the information in the term structure of the forward exchange rate and the forward premiums have demonstrated intuitive results. Indeed, despite the rejection of the Forward Rate Unbiased Hypothesis, the forward exchange rates still contain valuable information for the forecasting of the future spot exchange rates.

Following these developments, we propose, in this paper, to conduct a comparative analysis of the term structure of the forward premium separately in a linear framework and a nonlinear framework. To do this, the first approach is taken using the multivariate cointegration and error correction models, in order to test the ability of the forward exchange premium to provide valuable information about future movements in the spot exchange rates. The approach taken using the multivariate cointegration is interesting in several respects. First, the presence of some stable long-run equilibrium relationship allows the use of error-correction model to specify the short-term adjustment in order to achieve the equilibrium. Econometrically, the validity of an error correction model requires the presence of a restoring force which is negative and statistically negative. Then, we try to exploit the Granger causality test (1969) to identify the uni and bi-directional potential causality relationships. Since the linear framework described above occult possible asymmetries and nonlinearities that can characterize the famous Fama regression or the regression of the Forward Rate Unbiased Hypothesis, then we proceeded to a second approach on the part of the regime-switching models. Thus, in order to analyze the term structure of the forward premium in a nonlinear framework, we used the nonlinear adjustment model LSTR with the risk-adjusted forward premium as transition variable. The present paper is organized as follows: Section 2 provides a review of the theoretical literature relating to this issue. Section 3 begins our empirical analysis of the term structure of the forward premium in a linear framework. Section 4 will be devoted to the study of the term structure of the forward premium in a nonlinear framework. Section 5 concludes with the implications of our findings.

II. REVIEW OF LITERATURE

Currency risk plays a major role in international portfolio diversification and in many aspects of economic policy. These aspects include the price estimation of the uncertainty of exports and imports, the value of international reserves and open foreign exchange positions, the domestic currency value of debt payments and compensation of workers who, in turn, can affect domestic wages, prices and output. In this regard, in the international financial markets, expectations of future exchange rates affect the decisions of agents, including their investment, their speculation and their decisions of borrowing and repayment. Therefore, it is hardly surprising that a huge economic literature has developed focusing on modeling and forecasting nominal exchange rates.This literature is strongly influenced by the seminal work of Meese and Rogoff (1983 a, b), which began first with emphasis given to empirical models of exchange rates based on conventional macroeconomic fundamentals. These models, as proposed by the theory of international macroeconomics, can not interpret a simple lack of change, or an expectation of exchange rate random walk in terms of standard measures of forecast accuracy. It was only after more than twenty years of research since the publication of the work of Meese - Rogoff, that their results remain, with a few exceptions, very robust (Mark, 1995; Neely and Sarno, 2002). However, although the macroeconomic fundamentals do not seem to be useful in predicting exchange rate, models that exploit the information in the term structure of forward exchange rates and forward premiums have generated satisfactory results. Clarida and Taylor (1997) argue , first, that although the forward exchange rate is not an optimal predictor of the future spot exchange rate, forward exchange rates still contain an important information for the prediction of future spot exchange rates.

An extensive literature in the exchange rate economics has studied the forecast performance of empirical models of exchange rates by using specific criteria for predicting conventional purpose . However, in the context of the currency risk management, interest is not centered only on the referred forecasts. It is in this context that Sarno and Valente (2005) provide a formal evaluation of recent models of exchange rates based on the term structure of forward exchange rates . The economic value of the density forecasts of exchange rates is examined in the context of a single application of risk management.In an influential article, Ding (2005) contributes to the literature related to the forward premium puzzle in several angles. First, it provides further evidence that deepens the literature on this forward premium puzzle. This investigation shows that the forward premium puzzle depends on the horizon of the forward contracts, as well as the day of the week. Thereafter, the existing standard models of the puzzle are evaluated by examining closely if they are able to explain the new results. In addition, Ding (2005) develops a framework based on a model of the term structure of interest rates in order to explain the new enigmatic phenomena from the perspective of the effect of information on foreign exchange markets. The absolute differences between the tests results using short horizon data (one day) against long horizon data (one week or a month) have a puzzling anomaly. Similarly, the difference between the tests results using Thursday data and other days of the week is another new puzzle. No standard explanation of the forward premium puzzle, the irrational anticipation , the problem of study, the measurement error , or the econometric description , seem , at first glance, offer an explanation why results should be different using essentially the same study periods for the tests.

The term structure of forward premium puzzle implies a term structure of the forward exchange rates. However, forward exchange rates appear to be mainly related to the movement of interest rates between countries. In fact, banks are assessing the forward contract based on the covered interest rate parity, which describes the relationship between the forward rate and the interest rate differential. Therefore, the term structure of the forward rates should also be related to the term structure of the interest rates.

III. ANALYSIS OF THE TERM STRUCTURE OF THE FORWARD PREMIUM IN A LINEAR FRAMEWORK

In this section, our object is, first, to present the theoretical results to the empirical test. Then, after recalling the test procedures to be implemented, we test the existence of a cointegrating relationship between the spot exchange rates and the forward exchange rates. We intend to see if the term structure of the forward premium helps to explain the deviation of the forward exchange rates compared to the spot exchange rates. We aim, through the empirical analysis, to analyze the term structure of the Euro / Dollar forward premium. Our starting point is the anomaly that characterizes the forward premium, which is mainly due to the aberrant results of the relationship of the uncovered interest rate parity. The first phase will involve the study of this commonly known as “the Forward Rate Unbiased Hypothesis (FRUH)” in a linear framework.

3-1- Data

We apply our empirical study on EUR / USD parity over the period from 04 January 1999, launch date of the Euro on the international foreign exchange markets, to 26 March 2008. The data collected are daily frequency and are obtained from the Datastream database. Our time series of the Euro / U.S. Dollar have a set of 2408 observations corresponding to the spot exchange rates and the three-month, six-month and one-year forward exchange rates and are expressed in logarithmic series.

3-2- The graphical analysis

Fig. 1. The 3-month forward exchange rate versus the spot rate

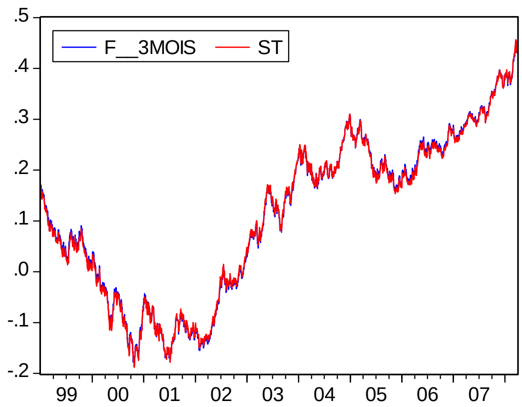


Fig. 2. The 6-month forward exchange rate versus the spot rate

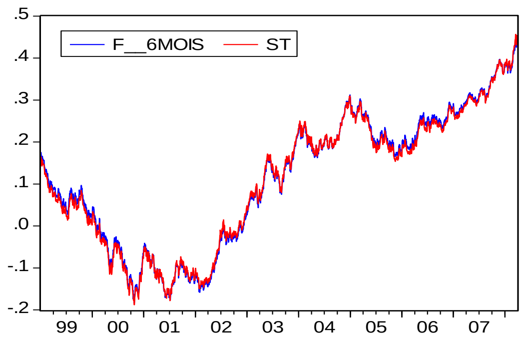
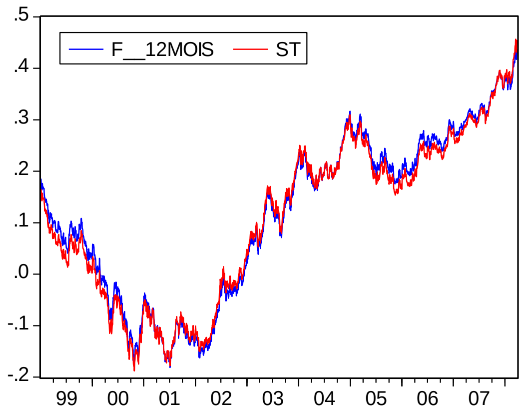


Fig. 3. The 12-month forward exchange rate versus the spot rate



Figures (1), (2) and (3) tracing the evolution of the three-month, six-month and one-year forward exchange rates versus the spot exchange rate, respectively, relate distinctly that the forward exchange rates predict perfectly the spot exchange rate especially over short horizons.Moreover, we note that more the horizon increases, the deviations of the forward rate relative to the spot rate are clear of the fact that the two curves representing their joint growths are not as stacked as they were to less low horizon, as described in the figures relating to the horizons of 6 months and 12 months.

3-3- The descriptive statistics

The descriptive statistics relating to the spot exchange rate and the 3, 6 and 12-month forward rate series are shown in Table (1.1).In light of these descriptive statistics, we find that the spot exchange rates and the forward exchange rates have the same statistical properties in terms of average, variance and kurtosis.

Table. 1.1. Descriptive statistics

	Spot rate	Forward rate (3months)	Forward rate (6months)	Forward rate (12months)
Nb.observations	2408	2408	2408	2408
Mean	0.109369	0.110828	0.112290	0.115557
Median	0.145789	0.147764	0.146935	0.145297
Standard deviation	0.157971	0.158598	0.159119	0.159779
Skewness (Sk)	-0.140248	-0.151904	-0.168012	-0.199897
Kurtosis (Ku)	1.864098	1.853654	1.841953	1.821429
Jarque-Bera (J-B)	137.3515	141.1097	145.8832	155.4027
Prob	0.0000	0.0000	0.0000	0.0000
Q(12)	27726	27765	27813	27888
Q(24)	53601	53740	53901	54157

Statistics provided by Eviews (version 5.0)

3-4- The Forward Rate Unbiased Hypothesis and the unit root tests

We propose to estimate the relationship of the uncovered interest rate parity (UIP) and to interpret the results relative to the presence of a unit root. Indeed, several studies have shown that the non-stationary series of the forward premium is the main cause of the rejection of the FRUH. In addition, they showed that these forward premium series are characterized by a stationary long memory attitude which is amplified by the presence of ruptures.

In what follows, we briefly present the equations for the Forward Rate Unbiased Hypothesis.

Level specification:

$$s_{t+k} = \alpha + \beta\, f_{t,k} + \varepsilon_{t+k}$$
(1.1)

Forward specification:

$$s_{t+k} - s_t = \alpha + \beta(f_{t,k} - s_t) + \varepsilon_{t+k} \quad (1.2)$$

Now trying to test the Forward Rate Unbiased Hypothesis which is written as follows:

$$s_{t+k} - s_t = \alpha + \beta(f_{t,k} - s_t) + \varepsilon_{t+k} \quad (1.3)$$

The relationship of the uncovered interest rate parity (UIP) will be held only if:

$$\begin{cases} \alpha = 0 \\ \beta = 1 \\ \varepsilon_{t+1} \text{ is a white noise } (\varepsilon_{t+1} \to N(\mu, \sigma^2)) \end{cases}$$

3-4-1-The rejection of the Forward Rate Unbiased Hypothesis

The estimation results of the specification level, given in Table (1.2), show good results with regard to the forecasting of the future changes in the spot exchange rates.

Moreover, this is not the case of the forward specification whose estimation results reported in Table (1.3) argue in favor of rejecting the Forward Rate Unbiased Hypothesis.

Table. 1.2. Estimation results of the level specification

Horizon	$\hat{\alpha}$	$\hat{\beta}$	R^2
3 months	-0.000981 (-9.144210) [0.000]	0.995680 (1796.230) [0.000]	0.999255
6 months	-0.001982 (-10.44016) [0.000]	0.991636 (1017.259) [0.000]	0.997680
12 months	-0.004447 (-12.84846) [0.000]	0.984931 (561.0760) [0.000]	0.992415

Estimates made on the software Eviews 5.0

Note: The values in parentheses are the t-Student statistics. Values in brackets are their respective probabilities.

Table. 1.3. Estimation results of the forward specification

Horizon	$\hat{\alpha}$	$\hat{\beta}$	R^2
3 months	-4.18 E^{-05} (-0.335294) [0.7374]	0.111681 (4.127314) [0.000]	0.007030
6 months	8.26E^{-05} (0.652135) [0.5144]	0.013210 (0.860666) [0.3895]	0.000308
12 months	0.000166 (1.280492) [0.2005]	-0.007236 (-0.852575) [0.3940]	0.000302

Estimates made in the Eviews software (version 5.0)

In addition, the Wald test results shown in Table (1.4) confirms the conclusions we have reached that the probabilities associated with the Fisher statistic F is less than 0.05. The test shows the rejection of the constraints imposed on the coefficients α and β at the 5% level of significance.

Therefore, the uncovered interest rate parity is unverified and we reject the Forward Rate Unbiased Hypothesis (FRUH) at the level of 5% with an overall significance of the model.

Table. 1.4. Results associated with the Wald test of the UIP

$H_0:\alpha=0$ and $\beta=1$ against $H_1:\alpha\neq 0$ and/or $\beta\neq 1$	3 months	6 months	12 months
Level Specification			
F-Statistic	168.2052 (0.0000)	214.1951 (0.0000)	280.3353 (0.0000)
Chi-Squared	336.4103 (0.0000)	428.3902 (0.0000)	560.6706 (0.0000)
Forward Specification			
F-Statistic	603.0354 (0.0000)	2345.826 (0.0000)	8351.378 (0.0000)
Chi-Squared	1206.071 (0.0000)	4691.652 (0.0000)	16702.76 (0.0000)

Estimates made in the Eviews software (version 5.0)

Note: The values in parentheses are p-values.

3-4-2-The unit root tests

It is imperative to report that the implementation of the bi and multivariate cointegration tests procedure requires first the specification of the order of integration of the different series of spot exchange rates and forward exchange rates. To do this, we use the Augmented Dickey Fuller (ADF) (1979) and Phillips and Perron (PP) (1988) tests. At this level, it should be noted that these tests are carried out under the following three assumptions:

i. Absence of a constant
ii. Presence of a constant
iii. Presence of a constant and a trend

in the autoregressive equations related to various tests.
In addition, lag orders were specified by examining the profiles of the autocorrelation function (ACF) and the partial autocorrelation function (PACF) and the Akaike's Information criterion (AIC) and the Schwarz Information criterion (SC).

3-5 - The cointegration tests

The cointegration test procedure and the estimation of the VECM is synthesized into five main steps. First, it is the test of stationarity of the series studied to determine if there is possibility of cointegration or not. In a second step, if the stationarity test shows that the series are integrated of the same order, then there is risk of cointegration and we can consider the estimation of a VECM. To do this, we first determine the number of lags p of the VAR (p) model using information criteria (Akaike and Schwarz). Thereafter, it is the implementation of the Johansen test to determine the number of cointegrating relationships which should be identified. Finally, it is possible to estimate the VECM via the maximum likelihood method and to validate the usual tests of significance of the coefficients and of the verification that the residuals are white noise (Ljung-Box test).

3-5-1 - Stationarity Tests

The stationarity of the spot exchange rates and the three-month, six-month and one-year forward exchange rates is tested through the use of unit root tests of Augmented Dickey and Fuller (ADF, 1981), of Phillips and Perron (PP, 1988) whose results are reported in Tables (1.5) and (1.6).

Table. 1.5. Results of the ADF unit root test

Series		Model [1]	Model [2]	Model [3]
Spot rate	s_t	0.872215	0.364175 (0.620897)	-2.850112 [3.715444]
EUR/USD	Δs_t	-2.845608**	-2.846055 (-0.556022)	-2.850112 [2.412793]
3-month forward rate	$f_{t,3}$	0.843341	0.337077 (0.619167)	-2.838515 [3.706478]
EUR/USD	$\Delta f_{t,3}$	-2.837198**	-2.840346 (-0.598163)	-2.838515 [2.401796]
6-month forward rate	$f_{t,6}$	0.790405	0.290726 (0.616553)	-2.843591 [3.707645]
EUR/USD	$\Delta f_{t,6}$	-2.837647**	-2.838692 (-0.617547)	-2.843591 [2.399475]
12-month forward rate EUR/USD	$f_{t,12}$	0.688850	0.200914 (0.610264)	-2.835049 [3.689686]

	$\Delta f_{t,12}$	-2.828009**	-2.828513 (-0.664307)	-2.835049 [2.374538]
Critical values 1% 5% 10%		-2.565923 -1.940955 -1.616611	-3.432873 -2.862541 -2.567348	-3.961859 -3.411676 -3.127714

Tests made on the Eviews software (version 5.0)

Note: Δ indicates the first difference of the series studied.
Exhibitors *, **, *** indicate that the corresponding statistics are significant respectively at the 10%, 5% and 1% levels of significance.
Model [1]: without constant; model [2]: with constant; model [3] : with constant and trend.
Values in parentheses are t-statistics of the constant.
Values in brackets are t-statistics of the trend.
Critical value of the constant = 2.52 (see ADF Table).
Critical value of the trend = 2.78 (see ADF Table).

Table. 1.6. Results of the PP unit root test

Séries		Model [1]	Model [2]	Model [3]
Spot rate EUR/USD	s_t Δs_t	0.880234 -2.856903**	0.372389 (0.613573) -2.856508 (-0.564771)	-2.853456 [3.736421] -2.853456 [2.440031]
3-month forward rate EUR/USD	$f_{t,3}$ $\Delta f_{t,3}$	0.820338 -2.883281**	0.321052 (0.612580) -2.885569 (-0.607083)	-2.875832 [3.745120] -2.875832 [2.405931]
6-month forward rate EUR/USD	$f_{t,6}$ $\Delta f_{t,6}$	0.774879 -2.881035**	0.281490 (0.613090) -2.880631 (-0.621610)	-2.879207 [3.736210] -2.879207 [2.388263]
12-month forward rate EUR/USD	$f_{t,12}$ $\Delta f_{t,12}$	0.677357 -2.868711**	0.195308 (0.605377) -2.868327 (-0.671105)	-2.869340 [3.722119] -2.869340 [2.375045]
Critical values 1% 5% 10%		-2.565923 -1.940955 -1.616611	-3.432872 -2.862540 -2.567348	-3.961857 -3.411675 -3.127714

Tests réalisés sur le logiciel Eviews (version 5.0)

Note: Δ indicates the first difference of the series studied.
Exhibitors *, **, *** indicate that the corresponding statistics are significant respectively at the 10%, 5% and 1% levels of significance.
Model [1]: without constant; model [2]: with constant; model [3] : with constant and trend.
Values in parentheses are t-statistics of the constant.
Values in brackets are t-statistics of the trend.
Critical value of the constant = 2.52 (see ADF Table).
Critical value of the trend = 2.78 (see ADF Table).

Given the results of unit root tests, we note that the spot exchange rates and the 3, 6 and 12-month forward rates series are TS processes (Trend Stationary) as the test statistics *t* are superior to all the critical values given by Eviews and the trends are significant (the t-statistic of the trend is greater than its critical value equal to 2.78). We then reject the hypothesis H_1 of stationary series of spot exchange rates and forward exchange rates whatever the level of significance of 1% to 10% and we hold the model (3) with trend and constant. So the results of these tests reinforce the current consensus on the stationarity of daily variations in exchange rates. We note that there are two classes of non-stationary processes, in the terminology of Nelson and

Plosser (1982), namely the TS processes (Trend Stationary) and DS processes (Difference Stationary) in which there is a persistence property of shocks that does not exist in the TS processes. If the time series is TS type, it should be stationary by regressing on time and the estimation residual is studied according to the Box-Jenkins methodology.

Referring to the calculated values of the ADF and PP tests, we unequivocally reject the null hypothesis of a unit root in the differentiated exchange rate series regardless of the considered model. Then, the series are integrated of order one.The different sets of exchange rates exhibit the same order of integration, it is plausible to look for possible cointegration relationships. The presence of one or more cointegrating relationships allows us to estimate an Error Correction Model to specify the short-term dynamics of variables in order to achieve stable long-term equilibrium.In what follows, we will attempt to identify all cointegrating relations in the system involving the spot and forward exchange rates. To do this, we will begin our study with the implementation of the test procedure of multivariate cointegration of Johansen (1988). The first step of this analysis is to determine the number of lags p of the autoregressive vector model (VAR (p)). Thereby, we consider a number of autoregressive processes and we retain the one that minimizes the criteria of Akaike and Schwarz. Table (1.7) reports the overall results.

Table. 1.7. Determining the number of lags p of the VAR (p)

VAR(p)	VAR(1)	VAR(2)	VAR(3)	VAR(4)	VAR(5)
AIC	-39.278	-39.556	-39.666	-39.713	-39.736
SC	-39.230	-39.470	-39.541	**-39.549**	-39.534

By examining the table (1.7) above, we see clearly that the minimum value of Schwarz information criterion corresponds to a number of delays p = 10 for the VAR model with variables in level.

Table. 1.8. Estimation of a VAR model

VAR(p)	VAR(1)	VAR(2)	VAR(3)	VAR(4)	VAR(5)
AIC	-39.307	-39.587	-39.695	-39.743	-39.763
SC	-39.259	-39.500	-39.570	**-39.580**	-39.561

From Table (1.8), we find it appropriate to hold a range of delays p = 4 delays that minimise the Schwarz criterion. Hence, we are in the presence of a VAR (4) with variables in first difference.

Estimation of the long-term relationship

We regress s_t on a constant and 3-month f_t^{t+1} and we estimate the long-term relationship by OLS:

$$s_t = c + \alpha f_t^{t+1} + \varepsilon_t$$

Then we get the residuals of this relationship and we apply the ADF test on the estimated residuals.

Table. 1.9. Engle-Granger cointegration results

	Coefficient	Standard error	T statistics	p-value
Constant	0.0005	6.84 E^{-05}	7.305396	0.0000
3-month forward rate	1.303816	0.044020	29.61903	0.0000
6-month forward rate	0.072091	0.068318	1.055238	0.2914
12-month forward rate	- 0.378389	0.025132	- 15.05587	0.0000

The examination of Table (1.9) clearly shows that there are cointegrating relationships in the system involving the EUR / USD spot exchange rate and the three-month, six-month and one-year forward exchange rates.

Table 1.10. Dickey-Fuller test on residuals

	Test statistics	Critical value (%)	p-value
	-29.40545	-4.48	0.0000

From the results shown in the table (1.10), the calculated Dickey-Fuller statistic value is (-29.40545). It is compared with the tabulated value by Engle and Yoo (1987), which is equal to (-4.48). The calculated value is less than the tabulated value, so we reject the null hypothesis of no cointegration between (f_t^{t+1}) and (s_t). There exists at least one cointegrating relationship between the two sets and then it is possible to estimate a model called the Error Correction Model (ECM) that includes the variables in difference and in level.

3-5-2- the Johansen test

This test determines the number of cointegrating relationships. With the Johansen test, if there is one (or more) cointegrating relationship, this means that there is one (or more) long term equilibrium relationships. The test results of the Trace Test and the Maximum Eigenvalue Test are presented in the table (1.11).

Table. 1.11. Test of cointegrating relationships

Rank	Eigenvalue	Trace Statistics	p-value	Maximum Eigenvalue Test	p-value
r = 0*	0.147626	558.8505 (47.85613)	0.0001	383.8301 (27.58434)	0.0001
r ≤ 1*	0.066518	175.0204 (29.79707)	0.0001	165.4064 (21.13162)	0.0001
r ≤ 2	0.003799	9.613947 (15.49471)	0.3116	9.145276 (14.26460)	0.2743
r ≤ 3	0.000195	0.468671 (3.841466)	0.4936	0.468671 (3.841466)	0.4936

Note: the values in parentheses are the critical values at the 5% level of significance.
* Denotes rejection of the hypothesis at the 5% level of significance.

Both the Trace test and the Maximum Eigenvalue test conclude that there are two cointegrating equations in the system studied at the 5% level of significance. Subsequently, we found it useful to present two clear matrices from Johansen cointegration test because their product generates a long-term cointegration matrix that can capture information on long-term relationships between the different variables studied. The results of the two matrices are given in Tables (1.12) and (1.13).

Table. 1.12. Unrestricted Adjustment Coefficients (Alpha)

D (Spot Rate)	0.000566	0.000385	-0.000298	2.83E-05
D (3 Months Forward Rate)	-0.000205	7.42E-05	-0.000326	3.22E-05
D(6 Months Forward Rate)	1.57E-05	-9.54E-05	-0.000331	3.01E-05
D(12 Months Forward Rate)	-6.11E-05	-1.45E-05	-0.000343	2.10E-05

Note: D indicates the first difference.

Table. 1.13. Unrestricted Cointegrating Coefficients Normalized (Beta)

Spot Rate	3 Months Forward Rate	6 Months Forward Rate	12 Months Forward Rate
-723.0022	1986.525	-1561.200	297.7621
-333.9213	-678.9340	1767.017	-756.8957
-25.17442	-55.27486	-15.96957	94.37691
11.49306	14.00860	-21.00522	-10.48422

3-6 - Estimation of the Vector Error Correction Model (VECM)

The use of an Error Correction Model in the case of cointegration provides more reliable forecasts that if we had used the long-term relationship because the estimation results of this relationship are distorted by the non-stationary series.The estimation results of the VECM are summarized in the table (1.14).

Table. 1.14. Estimation results of the VECM

Error Correction:	D(ST)	D(FWD3)	D(FWD6)	D(FWD12)
CointEq1	-0.538130	0.123798	0.020484	0.049034
	(0.09151)	(0.09458)	(0.09451)	(0.09410)
	[-5.88062]	[1.30895]	[0.21674]	[0.52109]
CointEq2	0.863550	-0.458558	0.096048	-0.111527
	(0.24123)	(0.24932)	(0.24913)	(0.24805)
	[3.57985]	[-1.83926]	[0.38554]	[-0.44961]
D(ST(-1))	-0.061978	0.167368	0.235726	0.212685
	(0.08705)	(0.08997)	(0.08990)	(0.08951)
	[-0.71199]	[1.86027]	[2.62204]	[2.37601]
D(ST(-2))	0.023692	0.220783	0.263080	0.243209
	(0.07990)	(0.08258)	(0.08251)	(0.08216)
	[0.29654]	[2.67371]	[3.18835]	[2.96032]
D(ST(-3))	0.011387	0.117346	0.143722	0.138476
	(0.06839)	(0.07068)	(0.07063)	(0.07033)
	[0.16649]	[1.66015]	[2.03486]	[1.96907]
D(ST(-4))	-0.022560	0.045233	0.053890	0.052198
	(0.05110)	(0.05281)	(0.05277)	(0.05255)
	[-0.44148]	[0.85644]	[1.02114]	[0.99337]
D(FWD3 (-1))	-0.313975	-0.050210	0.245313	0.381043
	(0.23411)	(0.24196)	(0.24178)	(0.24074)
	[-1.34113]	[-0.20751]	[1.01461]	[1.58282]
D(FWD3(-2))	-0.340500	-0.082043	0.129606	0.180258
	(0.21617)	(0.22342)	(0.22325)	(0.22229)
	[-1.57516]	[-0.36722]	[0.58054]	[0.81093]
D(FWD3(-3))	-0.356466	-0.112741	0.030410	0.042725
	(0.18817)	(0.19448)	(0.19433)	(0.19349)
	[-1.89441]	[-0.57971]	[0.15649]	[0.22081]
D(FWD3(-4))	-0.040589	0.085779	0.165807	0.147659
	(0.14427)	(0.14911)	(0.14899)	(0.14835)
	[-0.28134]	[0.57529]	[1.11285]	[0.99535]
D(FWD6(-1))	0.019193	-0.561005	-0.792502	-0.298207

	(0.27356)	(0.28273)	(0.28252)	(0.28130)
	[0.07016]	[-1.98422]	[-2.80514]	[-1.06011]
D(FWD6(-2))	-0.041215	-0.345898	-0.521285	-0.168656
	(0.25798)	(0.26663)	(0.26643)	(0.26528)
	[-0.15976]	[-1.29730]	[-1.95659]	[-0.63578]
D(FWD6(-3))	0.035747	-0.179878	-0.324397	-0.085247
	(0.22860)	(0.23626)	(0.23608)	(0.23507)
	[0.15638]	[-0.76134]	[-1.37407]	[-0.36265]
D(FWD6(-4))	0.150866	0.003472	-0.073841	0.048775
	(0.17856)	(0.18455)	(0.18441)	(0.18362)
	[0.84488]	[0.01881]	[-0.40041]	[0.26563]
D(FWD12(-1))	0.403847	0.473737	0.336071	-0.274642
	(0.17512)	(0.18099)	(0.18086)	(0.18008)
	[2.30611]	[2.61741]	[1.85822]	[-1.52515]
D(FWD12(-2))	0.373637	0.211735	0.128022	-0.262538
	(0.19433)	(0.20085)	(0.20069)	(0.19983)
	[1.92272]	[1.05422]	[0.63790]	[-1.31383]
D(FWD12(-3))	0.281865	0.149373	0.118076	-0.123380
	(0.18928)	(0.19563)	(0.19548)	(0.19463)
	[1.48917]	[0.76356]	[0.60404]	[-0.63391]
D(FWD12(-4))	-0.065878	-0.108043	-0.117414	-0.226258
	(0.15801)	(0.16332)	(0.16319)	(0.16249)
	[-0.41691]	[-0.66156]	[-0.71949]	[-1.39248]
C	0.000135	0.000125	0.000117	9.91E-05
	(0.00012)	(0.00012)	(0.00012)	(0.00012)
	[1.17525]	[1.05087]	[0.98035]	[0.83704]

Note: the values in parentheses represent the standard deviations.
The values in brackets represent the t-Student statistics.

Considering the results shown in the table (1.14) relating to the estimates of error correction terms in the equations of the VECM, and reported in the first two rows of the table (1.14), we find that those on forward rates are not statistically significant. Contrariwise, the error correction term on the spot exchange rate is negative and statistically different from zero in both cointegration equations. Therefore, the forward rates are considered weakly exogenous and there is no possibility of adjusting the disequilibrium to the long term equilibrium. At this level, we can deduce that the term structure of the forward premium does not contribute to the explanation of the deviations of spot exchange rates at a 5% level of significance.On the other hand, the analysis of the coefficients of variables expressed in first differences shows the existence of a short-term causal relationship between many of them. Indeed, the spot exchange rate and the 6-month forward exchange rate delayed for a period are statistically significant in the FWD3 and FWD6 equations. In addition, the spot exchange rate, delayed for a period, two periods and three periods is statistically significant in the FWD6 and FWD12 equations. Concerning the 12-month forward rate delayed for a period, the t-Student statistics showed significance in both the ST and FWD3 equations. Moreover, the constant in all equations of the VECM are not significantly different from 0.

Thereafter, we intend to consolidate the results mentioned above through the Granger causality test.

Table. 1.15. Granger Causality Test

Null Hypothesis	**F-Statistic**	**Probability**
FWD3 does not Granger Cause ST	29.6610	4.1E-24
ST does not Granger Cause FWD3	9.87913	6.3E-08
FWD6 does not Granger Cause ST	26.0459	3.6E-21
ST does not Granger Cause FWD6	10.1353	3.9E-08
FWD12 does not Granger Cause ST	28.3038	5.2E-23
ST does not Granger Cause FWD12	8.22407	1.4E-06
FWD6 does not Granger Cause FWD3	0.79724***	0.52684
FWD3 does not Granger Cause FWD6	4.85971	0.00067
FWD12 does not Granger Cause FWD3	3.09824	0.01483
FWD3 does not Granger Cause FWD12	2.39341	0.04856
FWD12 does not Granger Cause FWD6	5.17661	0.00038
FWD6 does not Granger Cause FWD12	0.66986***	0.61289

Note: D refers to the studied variable expressed in first difference.
*** Denotes that the null hypothesis is accepted at the 10% level of significance.
The selected number of delays equals 4.

From Table (1.15) summarizing the results of Granger causality test between the spot exchange rates and the forward exchange rates relating to the EUR / USD parity exhibits values consistent with the conclusions which resulted from the VECM. Indeed, we note the presence of a bi-directional short-run causal relationship between most of the variables, especially between the spot rate and all forward rates whatever the horizon. Only the three-month forward rate and the one-year forward rate are not caused by the six-month forward rate. These results remind us of a framework for "feedback effect" of the fact that the variables cause between them at the 5% level of significance. At this stage, we are required to verify the validation of the VECM representation. So, we need to study some characteristics for the residuals through tests on the residuals of each equation of the VECM.

Table. 1.16. Tests on residuals

Test	*p-value*			
	Equation 1	Equation 2	Equation 3	Equation 4
Q (20)	0.992	0.968	0.967	0.913
R^2	0.069065	0.021241	0.026155	0.017992
J-B	0.0000	0.0000	0.0000	0.0000
ADF	0.0000	0.0000	0.0000	0.0000
LM test	0.2362			

Note: *p-value* is the probability on each test used.
Q (20) is the Q statistic of Ljung-Box. It is distributed as a chi-square law with 20 degrees of freedom.
The orthogonal method used to test the normality is the method of Lutkepohl (1993).
LM test is the Lagrange multiplier (we chose six delays).

Inspection of Table (1.16) reveals, on the one hand, the absence of residual autocorrelation since the probability relating to the statistic of Ljung-Box Q is greater than the 5% level of significance, so the null hypothesis of white noise is accepted. On the other hand, we notice the low level of significance of the model due to the very low values of the coefficient of determination R^2, which refers to the difficulty of forecasting exchange rates. It is also worth checking the normality of errors through the normality test of Jarque and Bera. However, the zero probabilities assigned to the system residuals confirm that they are not normal distributions. In addition, the ADF unit root test applied to the residuals strongly rejects the null hypothesis of unit root. Therefore, we are in the presence of stationary and convergent series of residuals. The Lagrange multiplier test for autocorrelation of the residuals whose results are presented in the table reveals the absence of autocorrelation of residuals. Indeed, the critical probability associated with the test statistic is greater than the statistical threshold of 5% (p-value of the 6th delay is greater than 0.05). In addition, White test results relate the presence of heteroscedasticity in the residuals of the VECM equations since the critical probability of the test is less than the 5% statistical threshold.

Furthermore, it is appropriate to proceed with the BDS test of independence to detect an independent white noise in the residuals.

Table. 1.17. BDS test of independence

Dimension	Equation 1	Equation 2	Equation 3	Equation 4
2	0.1970	0.6218	0.5729	0.6249
3	0.6061	0.8867	0.8636	0.9412
4	0.4020	0.1190	0.2091	0.1738

Note : epsilon is equal to 0.7.

The results shown in Table (1.17) are consistent with those resulting from the above table to the extent that the probabilities for the test statistic are all above the level of 5%. Thus, the residuals of the studied system are independent and identically distributed. In total, from all tests on residuals, we can deduce that the system studied showed some stability, while taking into consideration the fact that the series of residuals are heteroscedastic and are not normally distributed.

IV. ANALYSIS OF THE TERM STRUCTURE OF THE FORWARD PREMIUM IN A NONLINEAR FRAMEWORK

We intend to see if a regime switching model is appropriate to model the relationship of the uncovered interest rate parity and to provide answers to the causes of the forward premium anomaly. It is to study the long-term adjustment dynamics in the relationship of Fama regression by using recent developments of the nonlinear econometrics. For that purpose, we estimate a Logistic Transition Regression (LSTR) model incorporating the Risk Adjusted Forward Premium as transition variable. The exchange rates can be characterized by a nonlinear attitude. It is then necessary to analyze the forward premium anomaly in the context of a nonlinear structure and test nonlinearities and asymmetries that can characterize the forward premium. We begin first by modeling the three-month, six-month and one-year forward exchange rates using regime switching models.

4-1 - Presentation of the LSTR Model

Under study of the term structure of the forward premium anomaly, it seems appropriate to address this issue in a nonlinear framework. We propose to estimate the Fama regression via a Logistic Smooth Transition Dynamic Regression (LSTR) model within the framework of LSTAR models introduced by Granger and Terasvirta (1993) and Terasvirta (1994). The adjustment process in the LSTR model is done in each period with a speed of adjustment which is managed by the set of values of the transition variable.

The LSTR model on the regression of the forward premium anomaly is as follows:

$$\Delta s_{t+k} = [\alpha_1 + \beta_1(f_{t,k} - s_t)] + [\alpha_2 + \beta_2(f_{t,k} - s_t)]\, F(z_t, \gamma, c) + u_{t+1}$$
(1.4)

Where $F(z_t, \gamma, c) = [1 + \exp(-\gamma(z_t - c)/z_t)]^{-1}$

and u_{t+1} is a stationary disturbance term with zero mean.
F (.) is the logistic transition function

4-2- Descriptive statistics

The Descriptive statistics relating to daily EUR/USD 3, 6 and 12-month forward premiums are shown in table (1.18).

Table 1.18. Descriptive statistics of forward premium series

	Forward premium (3 months)	Forward premium (6 months)	Forward premium (12 months)
Nb.observations	2407	2407	2407
Mean	-4.13^{e-06}	-8.26^{e-06}	-1.59^{e-05}
Median	0.0000	1.51^{e-06}	0.0000
Std.Dev	0.003086	0.003074	0.003067
Skewness (Sk)	0.042575	0.029015	0.052139

Kurtosis (Ku)	8.622270	7.569343	7.637303
Jarque-Bera (JB)	3170.938	2094.317	2157.821
Prob	0.0000	0.0000	0.0000
Q(12)	560.44	543.97	520.37
Q(24)	564.46	550.87	526.10

Statistics provided by Eviews 5.0

Inspection of Table (1.18) shows that the distributions of EUR/USD forward premiums (whatever the 3, 6 and 12-month horizon) are asymmetric showing *skewness* coefficients which are positive, then inducing thicker right series. We also note that there are indeed extreme values for all premiums eventually studied, since the *skewness* and their respective averages have opposite signs. This shows in particular that the Euro met phases of sudden depreciation and appreciation respectively. About the *kurtosis* coefficient of 3, 6 and 12-month forward premium series, it is higher than the reference value of the normal distribution equal to 3. We then deduce that the distribution of the forward premium of the euro against the dollar is leptokurtic, then having a thicker tail than that of the normal distribution.

Given the analysis above - mentioned, it is not surprising that the null hypothesis of normality is strongly rejected by the asymptotic *Jarque-Bera* (1980) test for the EUR/USD forward premiums. Indeed, the JB statistic is much higher than the critical value given by the *Chideux* table with two degrees of freedom equal to 5.99 at the 5% level significance. Eventually, these normality tests have helped us to prove some heteroscedasticity materialized by leptokurtic distributions, and thereby confirming that it is of volatile variables.Regarding the Q statistic, it is distributed asymptotically as a *Chideux* (at 12 and 24 degrees of freedom). We note clearly, from this table, all Q Ljung-Box statistics are above $\chi^2(20)$ read in the table at 5% level significance and with a value of 31.41. Also, they clearly indicate, by their critical zero probabilities, series of forward premiums unrepresentative of white noise. They also indicate that these series demonstrate significantly from a phenomenon widely known as the volatility clustering, which is ultimately linked to the notion of heteroscedasticity.

4-3- The unit root tests

In order to test the stationarity of the Euro / U.S. Dollar three-month, six-month and one-year forward premiums, we have used the unit root tests of Dickey and Fuller test (noted *ADF*) (1979, 1981), Elliot, Rothenberg and Stock (noted *ADF-GLS*) (1996) and Kwiatkwski and al. test (denoted *KPSS*)(1992). The choice depended on testing *ADF* and *ADF-GLS* tests is based on the fact that they can test the validity of the null hypothesis of a unit root against the alternative hypothesis of no unit root. At this level, the disadvantage is that they show through due to the acceptance of the null hypothesis of unit root. As for the *KPSS* test procedure, it helps to overcome this problem by imposing the condition of stationarity under the null hypothesis. In addition, the combined use of such tests can draw conclusions about the nature of the processes they are short memory and long memory. We note that the *ADF* and *ADF-GLS* tests were conducted in the presence of levels of delay from 1 to 40 in the first differences of the series of the variables studied. Concerning the *KPSS* test, it was conducted in the window Newey-West (respectively that of Bartlett). In addition, the assumption about the presence or absence of a constant and a trend was also taken into consideration.
The results of the stationarity tests are reported in Table (1.19).

Table. 1.19. The unit root tests

	ADF Test H_0 : unit root		ADF-GLS Test H_0 : unit root		KPSS Test H_0 : stationarity	
	In level	In 1st difference	In level	In 1st difference	In level	In 1st difference
Forward premium (3 months) EUR/USD						
Test statistic	-2.4461*** (10) [1]	-61.5077 (1) [1]	-2.3980*** (6) [1]	-19.3664 (1) [1]	1.1146*** [2]	0.1161 [2]
Critical value(1%)	-2.565927	-2.565927	-2.565926	-2.565926	0.216	0.216
Forward premium (6 months) EUR/USD						
Test statistic	-2.2368*** (5) [1]	-60.4702 (1) [1]	-2.0598*** (3) [1]	-20.0416 (1) [1]	1.0813*** [2]	0.1419 [2]

Critical value(1%)	-2.565925	-2.565924	-2.565924	-2.565924	0.216	0.216
Forward premium (12 months) EUR/USD						
Test statistic	-2.0528*** (2) [1]	-60.4044 (1) [1]	-1.9832*** (1) [1]	-21.0929 (1) [1]	1.021*** [2]	0.1498 [2]
Critical value(1%)	-2.565924	-2.565924	-2.565923	-2.565924	0.216	0.216
Spot exchange return						
Test statistic	-34.3060 (1) [1]	-58.8128 (1) [1]	-18.1373 (1) [1]	-53.5199 (1) [1]	0.1365 [2]	0.0393 [2]
Critical value(1%)	-2.565924	-2.565924	-2.565924	-2.565924	0.216	0.216

Note: Values in parentheses denote the number of lags used.
*, **, *** indicate that corresponding statistics are significant respectively at 10%, 5% and 1% levels.
Values in brackets indicate the type of model used for knowing the ADF test: The model (1): without constant. The model (2): with constant. The model (3): Constant and trend.

We note, in light of the results of unit root tests, that the EUR/USD forward premium series at 3 months, 6 months and 12 months horizons are not stationary at the 1% level significance; then we reject the hypothesis $\square_1$ of stationarity of series. Moreover, referring to the calculated values of ADF, ADF-GLS and KPSS tests, we reject unambiguously the null hypothesis of a unit root in differentiated forward premium series whatever the model considered. The stationary nature of differentiated once series allows us to conclude an integration order equal to one. However, the spot exchange return series show a stationarity which is maintained for different levels of delays of up to 20, in particular for the ADF test.

$$(\square_{\square,3} - \square_{\square}) \rightarrow \square(1), (\square_{\square,6} - \square_{\square}) \rightarrow \square(1), (\square_{\square,12} - \square_{\square}) \rightarrow \square(1)$$
$$\square(\square_{\square,3} - \square_{\square}) \rightarrow \square(0), \square(\square_{\square,6} - \square_{\square}) \rightarrow \square(0), \square(\square_{\square,12} - \square_{\square}) \rightarrow \square(0)$$

The series considered are non-stationary, and then they should be stationnarised (remove the deterministic component) by the method of Ordinary Least Squares (OLS).
We will be based in our empirical investigation on stationary series.

4-4- Estimation of the LSTR model of Fama:

In our study, we used the Risk Adjusted Forward Premium as transition variable $\square_{\square}$ which is expressed as follows: $(\square_{\square} - \square_{\square})/\square_{\square_{\square}}$; based on the fact that all transition variables are usually standardized dividing by their estimated standard deviations ($\hat{\square}_{\square_{\square}}$).The estimation of our model for horizons of 3 months, 6 months and 12 months was made through the method of Non Linear Least Squares (NLLS) after a tedious search of starting values of the parameters c and γ providing efficient and asymptotically normal estimators.The specification of the logistic function is fairly intuitive as much as it allows some asymmetries in the adjustment process.The estimation results of the nonlinear adjustment model LSTR for horizons of 3 months, 6 months and 12 months with the Risk Adjusted Forward Premium as transition variable are shown in Table (1.20). We find that the coefficients α_1, β_1 and α_2 are statistically significant, contrariwise the parameter β_2 associated with the nonlinear part is negative and not significant.The 12-month forward premium, in turn, is characterized by a transition speed higher than 3-month and 6-month forward premiums and not significant. The constant $\square_1$ of the linear part in the equation representing the LSTR model, is close to zero for all forward premiums studied.The estimation of the parameters of the transition function (γ and c) reveals the existence of nonlinearities since the values of these parameters are consistent both for the 3-month forward premium and for the 6-month forward premium as transition variables. Indeed, the parameters of the transition speed are significant. Henceforth, the transition is faster for the 3-month horizon than for the 6 months , which leads to more brutal changes. For the 6-month forward premium, only the parameter of the transition speed is significant. For the 12-month forward premium, the parameters $\square_1$ and $\square_2$ are significant. This suggests that the choice of 12-month forward premium as a transition variable is discussed. It would then reformulate the logistic transition function $\square(\square_{\square}, \square, \square)$ by choosing another transition variable.

The Ljung-Box test on residuals shows that the residuals are white noise. Therefore, we conclude that the LSTR model is appropriate.

Table. 1.20. Estimation results of the LSTR model

$$\Delta s_{t+k} = [\alpha_1 + \beta_1(f_{t,k} - s_t)] + [\alpha_2 + \beta_2(f_{t,k} - s_t)]\, G(z_t, \gamma, c) + \varepsilon_{t+k}$$
$$\Delta s_{t+k} = [\alpha_1 + \beta_1(f_{t,k} - s_t)] + [\alpha_2 + \beta_2(f_{t,k} - s_t)]\, G(z_t, \gamma, c) + \varepsilon_{t+k}$$
$$\Delta s_{t+k} = [\alpha_1 + \beta_1(f_{t,k} - s_t)] + [\alpha_2 + \beta_2(f_{t,k} - s_t)]\, G(z_t, \gamma, c) + \varepsilon_{t+k}$$
$$G(z_t, \gamma, c) = [1 + \exp(-\gamma(z_t - c)/\sigma_z)]^{-1}$$

k	EUR/USD 3 months	EUR/USD 6 months	EUR/USD 12 months
α_1	0.001925* (2.194905)	0.004215 (1.121476)	0.000731* (2.581472)
β_1	0.547655* (3.370355)	0.492039 (1.635092)	0.053327 (1.752277)
α_2	-0.004887* (-2.794584)	-0.011399 (-1.328198)	-0.001131* (-1.977363)
β_2	-0.014387 (-0.078448)	0.016240 (0.061102)	-0.035413 (-0.890597)
γ	0.015147* (2.327430)	0.014725* (2.072659)	1.361921 (0.214096)
c	0.295937 (1.757884)	0.433301 (1.274479)	0.369428* (5.419045)
AIC	-7.47298	-7 .463574	-7.454578
SC	-7.45857	-7.449156	-7.440154
R^2 adjusted	0.01881	0.009530	0.000971
Q(20)	$18.357_{[0.564]}$	$12.482_{[0.898]}$	$9.3350_{[0.979]}$
$Q^2(20)$	$112.80_{[0.000]}$	$115.01_{[0.000]}$	$105.31_{[0.000]}$

Note: The transition variable z_t is the risk adjusted forward premium.
Values in parentheses denote the t-Student statistics.
The superscript * indicates that the parameter is statistically significant.
AIC and SC are Akaike Information Criterion and Schwarz Criterion respectively.

Therefore, we conclude that the LSTR modeling relating to the three-month forward premium is appropriate to reproduce the existence of nonlinear dynamics in the relationship of Fama regression of the uncovered interest rate parity. Overall, the estimation results of the LSTR model of Fama regression confirm the idea that the presence of barriers to speculation and transaction costs on foreign exchange markets, could explain, at least partially, the forward premium anomaly.

V. CONCLUSION

In this paper, we tried to analyze the famous forward premium anomaly for the parity of the Euro against the U.S. Dollar and to examine the ability of the term structure of the forward premium to explain the deviations of the spot exchange rates. Methodologically, we have adopted two different approaches for the analysis of the term structure of the forward premium in two separate frameworks. Initially, we conducted a multivariate cointegration and VECM approaches. The use of such models is certainly advantageous as much as they allow the determination of some stable long-run equilibrium relationship. This latter allows the use of the error correction model to specify the short term adjustment dynamic to reach equilibrium. It also avoids the problem of dummy regressions due to the nonstationarity of the exchange rates. The starting point is to test the Forward Rate Unbiased Hypothesis , the results are consistent with most studies on the EUR / USD parity on the foreign exchange market which often attested to the rejection of the FRUH. Among the reasons for non - verification of the FRUH, we can retain transaction costs involving a degree of neutrality towards the arbitrage or deviations from the interest rate parity that are likely to generate profit opportunities and the cost of collecting information. In addition, it is changes in the economic policies and expectations irrationality given the specifics of the risk premium in the foreign exchange market.

This directed us to model the short-term dynamics through an error correction model. The idea is to identify short-term dynamics of spot exchange rates and forward exchange rates. Similarly, the causality tests clearly confirm the presence of bidirectional causality between the spot exchange rate and the 3-month forward rate; this also reflects the strong relationship between them. In addition, we have identified two cointegrating relationships. Estimates of error correction models allowed us to specify the short-term dynamics. The specification of the short-term dynamics is financially attractive since it allows identifying the arbitrage opportunities on foreign exchange markets. Causality tests clearly confirm these findings and reveal the presence of uni and bi-directional causality. In addition, it appears that the term structure of the forward premium does not contribute to the explanation of the deviations of spot exchange rates. Overall, the results argue in favor of rejecting the Forward Rate Unbiased Hypothesis. In addition, in the short term, the term structure of the forward premium contains important and useful information content to explain the deviations of spot exchange rates. However, in the long term, there is no causality between variables and therefore there is no adjustment of the imbalances to the equilibrium.

However, this first approach is among a linear framework ignoring the asymmetries and nonlinearities that can characterize the forward premium anomaly. This directed us to the adoption of a nonlinear framework and the use of regime switching models. In a second step, we used the framework of regime switching models in order to test the presence of any nonlinear and asymmetric adjustments that may help explain the forward premium anomaly. More particularly, we estimate a LSTR model for the famous Fama regression also described as the FRUH. Under this nonlinear framework, the estimation results confirm the existence of an asymmetric dynamic characterizing the Fama regression and explicit the forward specification of the FRUH. Therefore, the use of LSTR model is appropriate to describe the nonlinear dynamics that exist in the Fama regression for horizons of 3 and 6 months of the fact that the parameters of the transition speed are significant with more brutal changes in favor of the 3-month horizon. The analysis of these results confirm the idea that the forward premium anomaly can be explained at least partially by the presence of market frictions such as currency speculation barriers and transaction costs. The results that we have reached corroborate previous studies confirming the existence of nonlinearities in the relationship of the uncovered interest rate parity. In summary, comparative study in the empirical validation of this paper helped to highlight the contribution of each of the linear and nonlinear frameworks in the treatment of the forward premium anomaly. Ultimately, we conclude that the forward exchange premium remains to this day, enigmatic and the forward premium anomaly continues to persist and to arouse the interest of professionals and academics with regard to the various components involved about its explanation.

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