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Exploration of the Foreign Exchange Forward Premiums and the Spot Exchange Return: A Multivariate Approach

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ABSTRACT

This paper empirically examines the interdependence between the foreign exchange forward premiums and the spot exchange return through a multivariate generalized autoregressive conditional heteroskedasticity type framework. The purpose of this study is to test the correlation sensitivity to shocks and the to capture the dynamic links between the EUR/USD 1, 3, 6, 9 and 12 months forward premiums and the spot exchange return. Our empirical analysis is based on daily data from January 8, 1999 to January 8, 2016. Our daily analysis reveals the presence of high correlations between the unconditional EUR/USD forward exchange premiums at different horizons and the possible effect of asymmetric shocks on the conditional variance. The estimation results show that the dynamic conditional correlations have a relatively small and insignificant autoregressive effect, in addition to the existence of significant correlation sensitivity to shocks.

Keywords: Forward Premium Anomaly, Dynamic Conditional Correlation-multivariate Generalized Autoregressive Conditional Heteroskedasticity, Conditional Volatility, Volatility Persistence
JEL Classifications: F31, C22, C58, G15

1. INTRODUCTION

One of the most puzzling characteristics of the attitude of exchange rates, since the advent of floating exchange rates in the early seventies, is shown by the tendency of countries with high interest rates to see their currencies appreciate rather than depreciate as suggested by the uncovered interest rate parity (UIP). This puzzle of the UIP known as "the forward premium puzzle," is prone to an abundant theoretical and empirical review of literature and it was a crucial phenomenon in the field of International Finance. Many studies in this area include the works of Bilson (1981), Cumby (1988), Fama (1984), Gregory and McCurdy (1984) and Hodrick and Srivastava (1984). The most widely accepted interpretation of the exchange returns forecasting is materialized by the existence of a time varying risk premium on the foreign exchange markets. In fact, the forward premium puzzle is a phenomenon that has been extensively studied in the literature. According the UIP, the forward exchange rate could be an unbiased anticipation of the future spot exchange rate. Since the observations have shown ex post deviations from UIP, 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"[1]. However, more recent empirical research suggests that the existence of an exchange premium is unable to explain the ex post deviations from UIP adequately. However, Frankel and Froot (1989) found that excess returns represent the result of systematic errors of prediction and not exchange risk premiums. These forecasts errors may increase due to the existence of irrational actors. Henceforth, the research that considers that, in the context of balanced portfolios, the forward premium has not been successful by professionals is limited.

1 Fama (1984. p. 337).

Indeed, the net position of the majority of U.S. assets does not change sign with a sufficient frequency to explain the attitude of time varying risk premiums. Although the model of Carlson and Osler (2003) is positioned in the short term, it shares many properties with models with balanced portfolios, including the importance of net positions of international risk premiums assets. Both authors suggest that short-term assets are most appropriate for the forward premium puzzle, since the puzzle applies only to short-term forward premiums (Chinn and Meredith, 2002). 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. Since the forward premium anomaly leads to a prominent empirical result which is often enigmatic, various explanations have been presented but none of them has proved entirely satisfactory. A first line of research has affirmed the presence of a "peso problem" or even released the assumption of "rational expectations" in order to arrive at a reconciliation between the theory and the puzzle. It is only a few other studies of the forward premium puzzle that eventually were able to link the exchange risk premium to interest rates differentials (Carlson and Osler, 2003; including the work of Obstfeld and Rogoff, 1998; and Hierce Hagiwara, 1999; Mark and Wu, 1998; Meredith and Ma, 2002; Driskill and McCafferty, 1982). Moreover, Boudoukh, et al. (2005) attribute much of the forward premium anomaly to abnormal attitude of short-term interest rate, and not to the analysis of the relationship between fundamentals and exchange rates. Several recent studies suggest that the forecast horizon is an important element in understanding the forward premium puzzle. We cite, for example, Chaboud and Wright (2005) who have provided some empirical validation showing that the coefficient of the regression slope is close to unity, and for a very short horizons (at a frequency of 5 min for the spot interest rate differentials). On the other hand, Alexius (2001) and Chinn and Meredith (2004) used quarterly data for the yields of long-term government bonds. In total, these papers suggest that in extreme cases of the distribution, the role of the risk premium or other factors causing the forward premium anomaly could be less important than in the case of a median horizon. In addition, Yang and Shintani (2006) analyze the regression of the Forward Rate Unbiased Hypothesis by varying time horizons from 1 day to 1 year. Through panel data, they offer the possibility to obtain a slope coefficient that is positive for short horizons and negative at longer horizons and improving forecast performance coefficient. Thus, their approach is less prone to the problem of potential bias caused by a mixture of different sources, periods of time or frequencies. In this regard, there have been many recent important contributions, including prominent papers by Backus et al., (2001), Lustig and Verdelhan (2007), Burnside et al. (2010a; 2010b), Verdelhan (2010), Bansal and Shaliastovich (2013), Backus et al. (2010), Bacchetta and van Wincoop (2010), Pippenger (2011).

Our empirical study is in the same line of this work. We will identify any correlation between the forward premium series and the spot exchange return expressing the forward premium anomaly via a multivariate generalized autoregressive conditional heteroskedasticity (MVGARCH) modeling. Apart from the obvious advantage to confront the specifics of the latter, our study has the merit of wear on the parity of the Euro against the U.S. Dollar.

The present paper is organized as follows: Section 2 presents the methodology adopted in this study. Section 3 begins our empirical analysis of volatilities and correlations of the forward premiums and the spot exchange return. Section 4 discusses the empirical findings. Section 5 concludes with the implications of our findings.

2. METHODOLOGY

Starting from the relationship of the UIP such developed by Fama (1984), we briefly present the equations for the Forward Rate Unbiased Hypothesis.

Level specification:

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

Forward specification:

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

The Forward Rate Unbiased Hypothesis is written as follows:

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

The relationship of the UIP will be held only if:

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

The purpose of this regression is to show whether the current forward-spot differential, $f_{t,k}-s_t$, has a prediction power to explain the movement in the spot rate, $s_{t+k}-s_t$.

To analyze the foreign exchange forward premium, we specify the difference between the forward exchange rate and the spot exchange rate $(f_t^{t+1}-s_t)$ as the forward premium, we denote by:

s_t: Represents the natural logarithm of the spot exchange rate at time t

f_t^{t+1}: Represents the natural logarithm of the forward exchange rate at time t

E_t (.): The expectations operator conditional on the information available at that date

ε_t: A white noise error term.

In this section, we propose to submit the question of the forward premium anomaly on the foreign exchange market to empirical test using a MVGARCH. The use of MVARCH models proves intuitive since such models can capture the dynamic links between the forward premium series and the spot exchange return.

The proposed empirical application is then based on the dynamic conditional correlation (DCC) methodology in the family of MVARCH models, the choice is based on its superiority over other specifications. Indeed, the DCC model is very flexible, has the advantage of being limited to a reasonable number of parameters to be estimated taking into account the time variation of the correlations between variables and the possible effect of asymmetric shocks the conditional variance.

Thereby, we propose to continue the work of Engel (2002) by exploring the conditional covariance that may exist in the relationship characterizing the forward premium anomaly. Through DCC-MVGARCH modeling, we intend to model both variances and conditional correlations of forward premiums and the spot exchange return jointly.

In this context, the DCC model proposed by Engel (2002) is best suited for this purpose. The choice of this model is mainly based on comparative advantage demonstrated by the DCC specification compared to other MVGARCH models such as BEKK, constant conditional correlation (CCC) and VEC. Indeed, such a model reduces the number of parameters to be estimated.

The $\mathrm{DCC_E}$ model proposed by Engel (2002) is written as follows:

$$\begin{cases} \mathrm{H}_t = \mathrm{D}_t\ \mathrm{R}_t\ \mathrm{D}_t \\ \mathrm{D}_t = \mathrm{diag}\ (\sqrt{\mathrm{h}_{11t}}, \sqrt{\mathrm{h}_{22t}}, \ldots, \sqrt{\mathrm{h}_{NNt}}) \\ \mathrm{R}_t = (\mathrm{diag}\ \mathrm{Q}_t)^{½}\ \mathrm{Q}_t\ (\mathrm{diag}\ \mathrm{Q}_t)^{-½} \end{cases}$$

Where Q_t is a matrix of size ($N \times N$), symmetric and positive. It is given by:

$$Q_t = (1-\theta_1-\theta_2)\overline{Q} + \theta_1 u_{(t-1)} u'_{(t-1)} + \theta_2 Q_{(t-1)}$$

The term $\overline{Q_t}$ is the unconditional variance-covariance matrix of dimension ($N \times N$), symmetric and positive definite while $u_{t=}(u_{1t}, u_{2t}, \ldots u_{Nt})$ is a column vector of standardized residuals of N assets portfolio at time t:

$u_{it} = \varepsilon_{it} / \sqrt{h_{iit}}$ for i = 1,…,N. The coefficients θ_1 and θ_2 are parameters to be estimated. The sum of these coefficients must be <1 to satisfy the positivity of the matrix Q. If $\theta_1 = \theta_2 = 0$ and $\overline{q_{ii}} = 1$, then we get the CCC model.

Before estimating the coefficients of the model presented above, we should firstly proceed to a preliminary analysis of series studied via the descriptive statistics (the test of the normality hypothesis of the series), the unit root tests.

3. DATA AND PRELIMINARY RESULTS

We apply our empirical study on EUR/USD parity over the period from 08 January 1999, with the introduction of the Euro on the international foreign exchange markets, to 08 January 2016. The data collected are daily frequency and are obtained from Datastream. Our time series of the Euro/U.S. Dollar have a set of 4436 observations corresponding to the spot exchange rates and the 1 month, 3 months, 3 months, 9 months and 1 year forward exchange rates and are expressed in logarithmic form to avoid the Siegel's paradox (Baillie and McMahon, 1989).

The estimation of the DCC-MVGARCH model requires preliminarily to check the non-normal distribution of forward premiums and of spot exchange return and conclude the presence of a potential heteroskedasticity which is represented by a leptokurtic distribution with fatter tails compared to the normal distribution.

3.1. Descriptive Statistics

The descriptive statistics relating to daily EUR/USD 1, 3, 6, 9 and 12 months forward premiums and the spot exchange return are shown in Table 1.

Inspection of Table 1 shows that the distributions of EUR/USD forward premiums (whatever the 1, 3, 6 and 9 months 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. Henceforth, this is not the case for the 12 months forward premium and the spot exchange return.

About the kurtosis coefficient of 1, 3, 6, 9 and 12 months 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 series 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 and the spot exchange return. 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 it is indeed volatile variables.

Regarding the Q statistic, it is distributed asymptotically as a Chideux (at 12 and 24° of freedom). We note clearly, from Table 1, all Q Ljung-box statistics of forward premiums are above χ^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. The existence of non-linearity can be largely explained by the presence of ARCH effect.

3.2. The Unit Root Tests

In order to test the stationarity of the Euro/U.S. Dollar 1 month, 3 months, 6 months, 9 months, 1 year forward premiums and the spot exchange return, we have used the unit root tests of Dickey and Fuller test (noted ADF) (1979, 1981), Elliot, Rothenberg and Stock (denoted ADF-GLS) (1996) and Kwiatkwski and et 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 2.

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 1 month, 3 months, 6 months, 9 months and 1 year horizons are not stationary at the 1% level significance; then we reject the hypothesis H_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.

The series considered are non-stationary, then they should be stationnarised (remove the deterministic component) by the method of ordinary least squares and we will be based in our empirical investigation on stationary series. Figures 1-5 illustrate

Table 1: Descriptive statistics

Statistics	Forward premium					Spot exchange return
	1 month	3 months	6 months	9 months	12 months	
Nb. observations	4435	4435	4435	4435	4435	4436
Mean	-1.64^{e-07}	-4.82^{e-07}	-8.80^{e-07}	-1.23^{e-06}	-1.50^{e-06}	-3.25^{e-05}
Median	-8.30^{e-07}	8.45^{e-08}	8.98^{e-07}	0.0000	0.0000	0.0000
SD	0.000221	0.000247	0.000297	0.000369	0.000453	0.006396
Skewness	0.293815	0.564399	0.573509	0.375257	−0.005395	−0.389769
Kurtosis	754.7206	496.8674	249.7942	118.9065	61.01538	12.60641
JB	1.04^{e+08}	45071853	11255420	2482653	621968.9	17169.30
P	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Q(12)	775.78	506.15	140.18	57.859	45.925	14.270
Q(24)	784.69	510.16	155.64	82.947	67.146	15.894

Statistics provided by Eviews 5.0. SD: Standard deviation, JB: Jarque-Bera

Figure 1: Graph of the differentiated EUR/USD 1 month forward premium

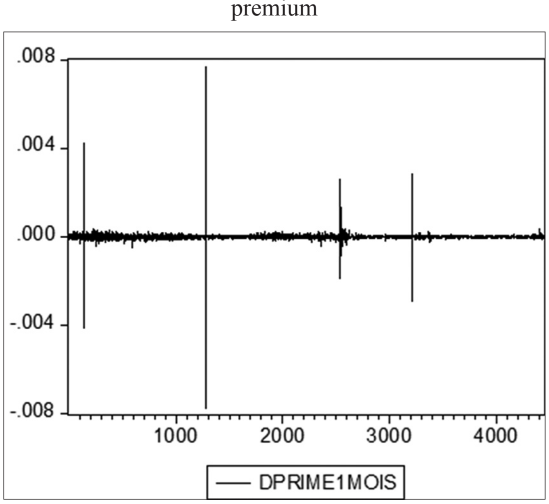
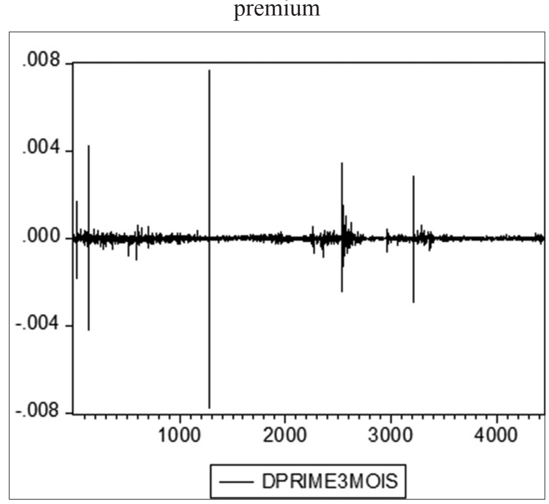


Figure 2: Graph of the differentiated EUR/USD 3 months forward premium



the evolution of the differentiated EUR/USD 1, 3, 6, 9 and 12-month forward premiums.

Figure 3: Graph of the differentiated EUR/USD 6 months forward premium

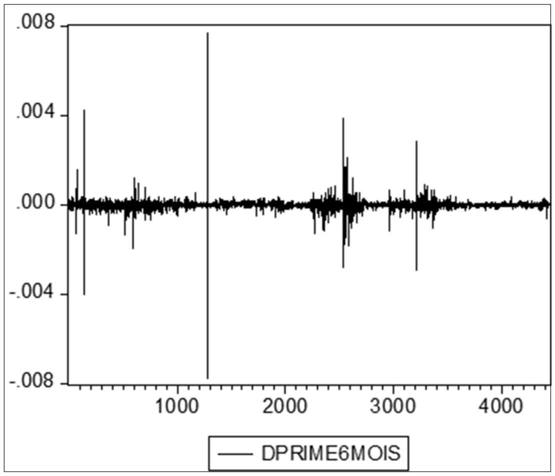


Figure 4: Graph of the differentiated EUR/USD 9 months forward premium

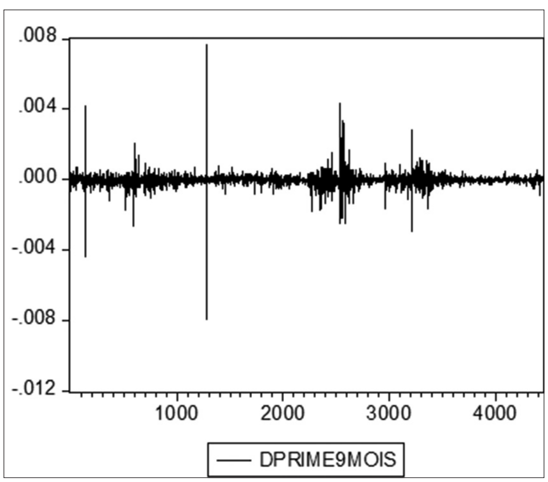
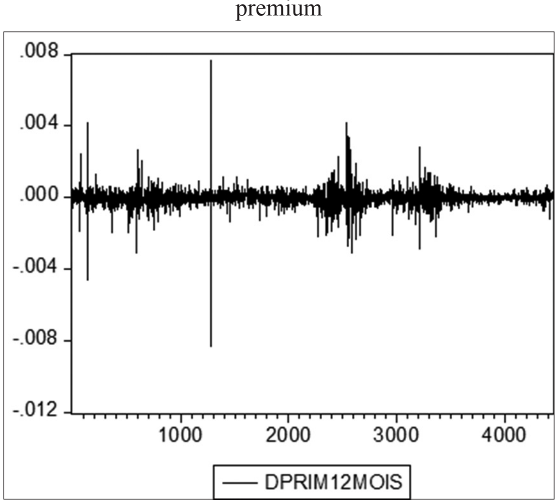


Figure 5: Graph of the differentiated EUR/USD 12 months forward premium



4. EMPIRICAL RESULTS

We focus our analysis on forward premiums at 1 month, 3 months, 6 months, 9 months and 1 year horizons and on the spot exchange return or changes in the exchange rate.

First, we present the unconditional correlation matrix and the variance-covariance matrix of the DCC model whose results are reported in Tables 3 and 4.

Table 3 exhibits remarkable unconditional correlation coefficients between the forward premiums for different horizons. Indeed, the 1 month, 3 months, 6 months, 9 months and 1 year forward premiums exhibit strong unconditional correlations highlighted by the coefficients of the order of 93%, 91% and 86%. In contrast, reading this Table 3 clearly shows that the EUR/USD forward premiums are weakly correlated with the spot exchange return with levels almost close. In fact, the highest correlation between premiums is attributed to the pair (9 months, 12 months), followed by the pair on the horizon (6 months, 9 months), and the lower pair (1 months, 12 months). On the other side, the correlations of these premiums with the spot exchange return does not exceed 2.11% for an horizon of 1 month.

The majority of conditional correlation coefficients between forward premium series and the spot exchange return are high, which leads us to infer the correlation of forward premiums for the EUR/USD parity between them. Relating to the correlation between forward premiums and the spot exchange return, it is weak.

We note that DCC-MVGARCH modeling seems to be appropriate to capture the dynamic evolution of the unconditional correlation matrix. In addition, it seems to incorporate more flexibility in the specification of the variance-covariance matrix. Graphic illustrations of these results are shown in Figures 6 and 7.

Through the estimation of DCC-MVGARCH model, we try to examine the correlation between the variable conditional correlation between the forward premiums and the spot exchange return. The estimation results are presented in Table 5.

Considering the results shown in Table 5 relative to DCC-MVGARCH model estimations, we find that these tests conclude that the DCC have a relatively small and insignificant autoregressive effect. On the other side, the coefficient α is positive and significant, it demonstrates the existence of a significant correlation sensitivity to shocks. In addition, in the bivariate estimation DCC (1, 1), the sum of the parameters α and β being less than unity, shows that the process described by the model is a process of mean reversion. This finding implies that, following the occurrence of a shock, the correlations converge to the unconditional long-term level.

However, the amount of ARCH and GARCH parameters for each univariate GARCH estimation is very close to unity only for the case of the spot exchange return. Such a result confirms the strong persistence in conditional variances, and therefore indicates the effect of regime change that contain the series.

Table 2: 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
EUR/USD 1 month forward premium						
Test statistic	−2.3778***	−71.6177	−2.2251***	−35.6221	0.5389**	0.1148
	(5)	(1)	(2)	(1)	[2]	[2]
	[1]	[1]	[2]	[2]		
Critical value	−2.565484	−2.565484	−2.565484	−2.565484	0.4630	0.4630
EUR/USD 3 months forward premium						
Test statistic	−2.0477***	−61.9299	−1.1440***	−54.5515	0.5593**	0.1681
	(1)	(1)	(1)	(1)	[2]	[2]
	[1]	[1]	[2]	[2]		
Critical value	−2.565485	−2.565484	−2.565484	−2.565484	0.4630	0.4630
EUR/USD 6 months forward premium						
Test statistic	−1.6494***	−52.5279	−0.8114***	−49.7681	0.5932**	0.2533
	(1)	(1)	(1)	(1)	[2]	[2]
	[1]	[1]	[2]	[2]		
Critical value	−2.565484	−2.565484	−2.565484	−2.565484	0.4630	0.4630
EUR/USD 9 months forward premium						
Test statistic	−1.5769***	−49.3086	−0.7314***	−45.0577	0.6320**	0.3274
	(1)	(1)	(1)	(1)	[2]	[2]
	[1]	[1]	[2]	[2]		
Critical value	−2.565484	−2.565484	−2.565484	−2.565484	0.4630	0.4630
EUR/USD 12 months forward premium						
Test statistic	−1.5849***	−47.4612	−0.7186***	−28.2960	0.6744**	0.3327
	(1)	(1)	(1)	(1)	[2]	[2]
	[1]	[1]	[2]	[2]		
Critical value	−2.565484	−2.565484	−2.565484	−2.565484	0.4630	0.4630
EUR/USD spot exchange return						
Test statistic	−46.436	−79.4498	−42.4320	−64.7133	0.2521	0.2803
	(1)	(1)	(1)	(1)	[2]	[2]
	[1]	[1]	[2]	[2]		
Critical value	−2.565484	−2.565484	−2.565484	−2.565484	0.7390	0.7390

Values in parentheses denote the number of lags used. **Significant at 5% significance level. ***Significant at 1% significance level. ADF: Augmented Dickey Fuller, KPSS: Kwiatkowski, Phillips, Schmidt, and Shin

Table 3: Unconditional correlation matrix

	Premium 1 month	Premium 3 months	Premium 6 months	Premium 9 months	Premium 12 months	Spot exchange return
Premium 1 month	1.0000	0.917716	0.805561	0.684812	0.569695	0.021159
Premium 3 months	0.917716	1.0000	0.905826	0.801772	0.697772	0.014940
Premium 6 months	0.805561	0.905826	1.0000	0.930094	0.869332	0.001273
Premium 9 months	0.684812	0.801772	0.930094	1.0000	0.936481	−0.004372
Premium 12 months	0.569695	0.697772	0.869332	0.936481	1.0000	−0.003033
Spot exchange return	0.021159	0.014940	0.001273	−0.004372	−0.003033	1.0000

Extracted from the software Eviews 5.0

Furthermore, considering the average values of conditional correlation coefficients generated from the estimates of the DCC-MVGARCH (1.1) model, we derive high values and relatively low values. The highest mean values of Table 6.

Correspond to the conditional correlation of forward premium pairs (Fw9, Fw12), (FW6, Fw9), (Fw3, Fw6), (Fw1, Fw3), (Fw6, Fw12), reflecting the strong unconditional correlation between forward premiums for different horizons. However, this is not the case of the unconditional correlation between forward premium series and the spot exchange returns, which is rather low or even negative.

The statistical significance of the parameter α at the 5% level significance partially explains the advantage of using a multivariate

Table 4: Variance-covariance matrix of the DCC model

	Forward premium 1 month	Forward premium 3 months	Forward premium 6 months	Forward premium 9 months	Forward premium 12 months	Spot exchange return
Forward premium 1 month	1.299107	0.90445	0.81054	0.68539	0.54032	0.04352
Forward premium 3 months	1.173954	1.296845	0.90459	0.78500	0.66221	0.03101
Forward premium 6 months	1.027840	1.146103	1.237817	0.91187	0.83082	0.02100
Forward premium 9 months	0.828333	0.947901	1.075740	1.124329247	0.92827	0.01181
Forward premium 12 months	0.635416	0.778091	0.953727	1.015563119	1.064574	0.00887
Spot exchange return	0.048114	0.034244	0.022663	0.012140698	0.008871	0.940665

Extracted from the software RATS 7.0. DCC: Dynamic conditional correlation

Table 5: Estimation results of DCC model MVGARCH

	Forward premium					Spot exchange return
	1 month	3 months	6 months	9 months	12 months	
Constant (M)	8.5849^{e-06}	1.1772^{e-05}	1.5529^{e-05}	1.4491^{e-05}	1.7421^{e-05}	2.4957^{e-06}
	(4.0995)	(5.6502)	(6.3215)	(5.0145)	(4.8401)	(0.0331)
Constant (V)	3.2127^{e-09}	2.6793^{e-09}	2.4365^{e-09}	1.8827^{e-09}	2.0305^{e-09}	3.8982^{e-08}
	(58.4175)	(43.5032)	(36.1978)	(22.1574)	(17.5853)	(2.2215)
ARCH	0.09292	0.1399	0.13005	0.08837	0.07157	0.03223
	(72.9413)	(60.2719)	(62.5983)	(38.5967)	(50.1204)	(10.8148)
GARCH	0.81733	0.84276	0.86679	0.90637	0.92262	0.97080
	(323.8223)	(255.6126)	(401.9127)	(410.3310)	(604.9726)	(399.8753)
α_{DCC}	0.06819					
	(71.0852)					
β_{DCC}	0.89689					
	(788.2698)					

The values in parentheses are t-student statistics. dynamic conditional correlation, multivariate generalized autoregressive conditional heteroskedasticity. DCC: Dynamic conditional correlation, ARCH: Autoregressive conditional heteroskedasticity, GARCH: Generalized autoregressive conditional heteroskedasticity

Table 6: Conditional correlation test

COR (i, j)	Mean	Standard error
(Fw1, Fw3)	0.86534**	0.06299
(Fw1, Fw6)	0.73100**	0.08222
(Fw3, Fw6)	0.87026**	0.05794
(Fw1, Fw9)	0.60367**	0.08891
(Fw3, Fw9)	0.75280**	0.06940
(Fw6, Fw9)	0.91165**	0.04288
(Fw1, Return)	0.01487**	0.07220
(Fw3, Fw12)	0.64777**	0.08642
(Fw3, Return)	0.0067**	0.08466
(Fw6, Fw12)	0.84896**	0.04749
(Fw6, Return)	−0.00354**	0.09738
(Fw9, Fw12)	0.92846**	0.04615
(Fw9, Return)	−0.00624**	0.10481
(Fw12, Return)	−0.00279**	0.11552

Fw1, Fw3, Fw6, Fw9 and Fw12 are respectively the 1, 3, 6, 9 and 12 months forward premiums. Return is the spot exchange return. $COR_{i,j}$ is the conditional correlation between the studied series (i) and (j) of the pair (i, j). The values in parentheses are standard deviations. The exponent (**) indicates that the coefficient is significantly different from zero at the 5% level significance

modeling DCC relative to the CCC specification essentially based on the constancy of the correlation.

In summary, we can conclude that this MVGARCH modeling avoids overestimating the persistence and ensures a better measure of the transmission of volatility shocks. It also leads to a more adequate understanding of the co-movement of the markets as measured by the conditional correlation.

5. CONCLUSION

In this paper, we aimed to analyze the forward exchange premium anomaly given its remarkable persistence among the puzzles which characterized the foreign exchange markets. We adopt a multivariate approach, which made empirically proven to avoid the overestimation of persistence and guarantees a better measurement of the transmission of the shocks of volatility. It also allows a more adequate apprehension of the co-movement of the markets measured by the conditional correlation. With this intention, we applied a rather intuitive methodology by using the DCC-MVGARCH model in order to capture the dynamic links between the EUR/USD 1, 3, 6, 9 and 12 months forward premiums and the spot exchange return of the same parity. The empirical application is based on the DCC methodology proposed by Engle (2002) due to its superiority over other specifications. Indeed, the DCC model is very flexible and has the advantage of being limited to a reasonable number of parameters to be estimated taking into account the time variation of the correlations between variables and the possible effect of asymmetric shocks on the conditional

Figure 6: (a-m) The conditional correlations of the dynamic conditional correlation model

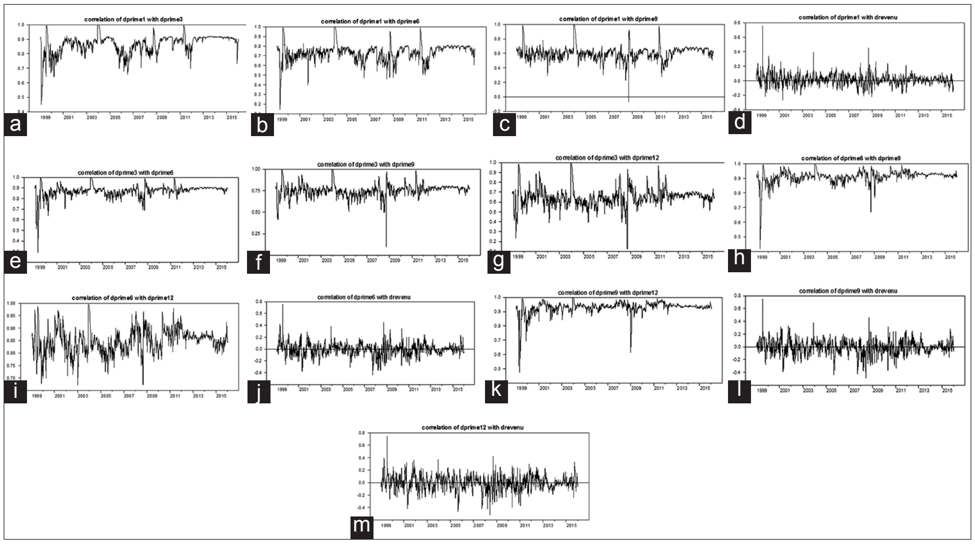
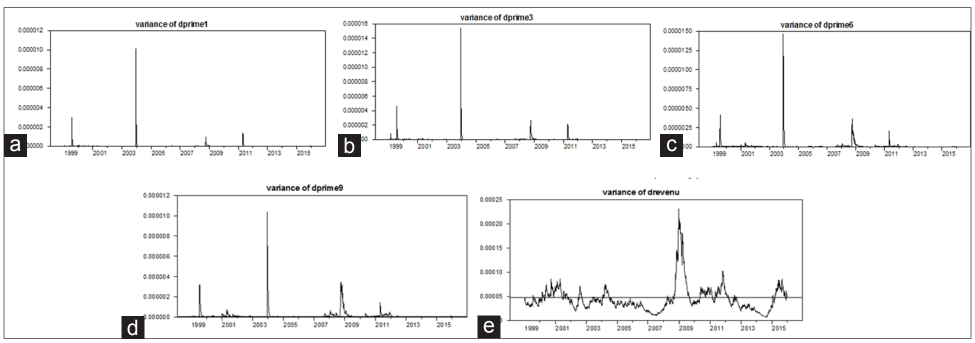


Figure 7: (a-e) The conditional variances of the dynamic conditional correlation model



variance. In addition, this specification takes into account any changes in the conditional correlation over time.

The analysis of the unconditional correlation matrix and the variance-covariance matrix of the estimated model confirms, on the one hand, the presence of high correlations between the unconditional EUR/USD forward exchange premiums at 3, 6, 9 and 12 months horizons, and on the other hand, a low correlation between them and the spot exchange return. The estimation results show that the DCC have a relatively small and insignificant autoregressive effect, in addition to the existence of significant correlation sensitivity to shocks.

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