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THE FORWARD EXCHANGE PREMIUM DYNAMICS

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ABSTRACT

The purpose of this paper is to analyze the JPY/USD and the CAD/USD forward exchange premiums by adopting the ARCH/GARCH modeling, given its descriptive and predictive advantages. We estimate a symmetric linear model by taking into account the effect of the mean and the conditional variance in a univariate framework. The estimation results show that the shocks induced by the volatility are very persistent, so that forecasts of the conditional variance converge very slowly to the regular state. This shows the relevance of the heteroscedastic GARCH-in-Mean model in the estimation of the forward premium on the international foreign exchange markets. This result may have several important implications for monetary policy in most developing countries.

Keywords: Forward premium anomaly, GARCH-M, volatility persistence, heteroscedastic model.

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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 . This puzzle of the uncovered interest rate parity 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.

Furthermore, there is a large literature on the existence of time varying risk premiums on the foreign exchange market and its influence in explaining the difference between the forward exchange rate and the future spot exchange rate. In the same perspective, Bhar and Chiarella (2003) aim to model the risk premium as a mean reversion diffusion process. The approach was then allowed to use daily observations of forward exchange rates for different maturities. That is, in return, it is to characterize the risk premium over time for these maturities, and subsequently obtain a term structure of the risk premium for three different maturities of forward exchange rates. On the other hand, Frankel and Poonawala (2004) argue that the foreign exchange forward market is less biased for emerging currencies than for the case of base currencies. Indeed, several studies have replicated the result which states that the forward exchange rate is an unbiased predictor of the future spot exchange rate.

There are several other studies that have attempted to clarify the forward premium puzzle from other angles that relate to the term structure of interest rates and exchange rates. The explanations of the forward premium anomaly, which is based on arguments of the risk premium based on equilibrium models or asset valuation models including several works from Frankel and Engel (1984) , Hodrick (1987), Bekaert and Hodrick (1993), Bekaert (1996) to Verdelhan (2010), Shaliastovich Bansal (2010) and Menkhoff, Sarno, Schmeling and Schrimpf (2012). Other recent works are based on the context of treatment of incomplete information (Bacchetta and van Wincoop, 2009); the differences in developed markets versus emerging markets (Bansal and Dahlquist, 2000 and Frankel and Poonawala, 2010); and eventually on profitability and economic value of the currency speculation (Burnside, Eichenbaum, Kleshehelski and Rebelo, 2011 and Della Corte, Sarno and Tsiakas, 2009).

Nevertheless, it is still impressive to scrutinize some new insights with regard to the famous forward premium anomaly as suggested by Pippenger (2011) claiming that the paradox disappears when two additional variables are recognized in the forward specification of the forward premium. Although Baillie (2011) fully recognizes the existence of solving difficulties of all kinds of puzzles of International Finance, it believes that it is premature to claim victory at the paradox of the forward premium. The forward premium anomaly provides some important empirical evidence confirming not understanding the functioning of some international financial markets. These extreme events may be the most important in terms of production of new theories and new insights.

Following these developments, we propose, in this paper, to study the dynamics of the JPY/USD and CAD/USD forward premiums and its main features via a symmetric linear and univariate ARCH / GARCH modeling. This choice is based on the works that argue that ARCH / GARCH models provide a better forecasting of low horizon variability characterizing the foreign exchange risk premium. We estimate a GARCH -in Mean model in which the conditional variance is supposed to explain the forward exchange premium.

The remainder of the paper is set out as follows. Section 2 discusses the foreign exchange forward premium. We describe the empirical model and the estimation procedure applied to evaluate the forward exchange premium dynamics in Section 3. We present the estimation results in Section 4. Section 5 concludes.

2. THE FORWARD EXCHANGE PREMIUM ANALYSIS WITH A UNIVARIATE GARCH-CLASS MODEL

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

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

f_t^{t+1} : 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 random term with zero mean.

Hereafter, we propose to estimate the GARCH-M model (p, q) defined as follows:

$$f_t^{t+1} - s_t = \beta h_t + \varepsilon_t \quad (1.1)$$

$$h_t = a_0 + a_1 h_{t-1} + b_1 \varepsilon_{t-1}^2 + \eta_t \quad (1.2)$$

$(\varepsilon_t/t) \sim N(0, h_t)$ (1.3)

Equation (1.1) is the equation of the conditional mean.

Equation (1.2) is the equation of the conditional variance.

Equation (1.3) is the assumption of conditional normality of errors.

h_t : is the conditional variance of forward premium series which is assumed to follow a GARCH (1,1) process.

h_{t-1} : represents the forecasting of the variance at the last period and the coefficient a_1 associated therewith represents the GARCH parameter.

ε^2_{t-1} : represents the squared delayed residuals informing us about the volatility or the instantaneous variability, and the coefficient b_1 associated therewith is referred to the ARCH parameter.

We note that equation (1.1) is the pivotal equation of GARCH-M model in which the forward exchange premium is a function of its conditional variance. In this specification in mean, the conditional variance is introduced into the mean equation and the choice of such a model depends on its ability to capture stylized facts of forward exchange premiums (at low or high frequency).

3. DATA SOURCE AND PRELIMINARY ANALYSIS

Before estimating the GARCH -in -Mean specification on the forward premium series, we specify the model and its hypothesis. Sub-section 3.1 presents the data and some descriptive statistics while the GARCH -in -Mean specification is displayed and discussed in sub-section 3.2.

3.1. Data

Our study focuses on the parity of the Canadian Dollar and the Japanese Yen against the U.S. Dollar. We examine monthly observations, end of period, which are the spot and the three-month forward exchange rates. We have 288 observations covering the period from January 1980 to December 2004. All time series are obtained from the DataStream database and are expressed in logarithmic form to avoid the Siegel's paradox (Baillie and McMahon, 1989).

We are based in our empirical investigation on stationary series.

The Descriptive statistics relating to monthly JPY/USD and CAD/USD 3 month forward premiums are shown in table (1.1).

Table 1. Descriptive statistics of forward premium series

	Forward premium JPY/USD	Forward premium CAD/USD
Nb.observations	288	288
Mean	0.005432	- 0.000425
Std.Dev	0.035781	0.023956
Skewness (Sk)	-0.260123	0.357927
Kurtosis (Ku)	3.562341	4.834756
Jarque-Bera (JB)	7.311596	48.32309
Prob	0.000	0.000
Q(20)	47.963	498.22

Statistics provided by Eviews 5.0

Inspection of Table (1) shows that the distribution of 3-month CAD/USD forward premium is asymmetric showing skewness coefficient which is positive, then inducing thicker right series. However, the distribution of 3-month JPY / USD forward premium is not asymmetric demonstrating a non-significant skewness coefficient. We also note that there are indeed extreme values for all forward premiums eventually studied, since the skewness and their respective averages have opposite signs. This shows in particular that both the Japanese yen as the Canadian dollar met phases of sudden depreciation and appreciation respectively.

About the kurtosis coefficient of 3-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 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 JPY/USD and CAD/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, that series of forward premiums are 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.

At this stage, it is important to note that the existence of non-linearity can be explained either by the presence of ARCH effect, or by the existence of a long memory.

3.2. The GARCH-in-Mean Model

In order to apply the GARCH -in -Mean specification for the JPY/USD and the CAD/USD three-month forward premium series, we should firstly check certain conditions that will allow us to confirm the use of such a heteroscedastic model in which there is inevitably a volatility effect. Indeed, the ARCH-type models can model chronics that have an instantaneous volatility depending on the past, and it will then be possible to develop a dynamic forecasting of the exchange risk premium in terms of mean and variance.

After the descriptive statistics of the forward exchange premiums, we note that it is possible to estimate these series via the GARCH -M model since they are neither normal distributions nor white noise processes, as required by the heteroscedastic ARCH specification.

However, it should be checked prior to the adequacy of the GARCH -M model (p, q) for different orders. For this, we use the statistical criteria of Akaike (AIC) and Schwarz (SC) to determine the optimal pair (p,q) that minimizes both of these two functions :

Table 2. GARCH (p,q)

	JPY / USD			CAD / USD		
(p,q)	(1,1)	(2,1)	(1,2)	(1,1)	(2,1)	(1,2)
AIC	-3.805770	-3.799987	-3.804411	-4.913293	-4.916620	-4.909099
SC	-3.756265	-3.738106	-3.752530	-4.863788	-4.854740	-4.847219

Extracted from the software Eviews 5.0

With regard to the table (2), we find that the adequate order of the GARCH-M model that minimizes both the criteria of Akaike and Schwarz is relative to the pair (1,1).

It is imperative to stress that the main objective of this study is to study the dynamics and the evolution of the forward exchange premium. Therefore, we test in a first step, a GARCH-M (1,1) specification of JPY / USD and CAD / USD forward premiums along the period from January 1980 to December 2004.

Thereafter, we adopt the same approach, except that the period initially considered will be subdivided into two periods i.e. [1986: 10 to 1995: 09] and [1995: 10 to 2004: 12], for the case of JPY / USD forward premium.

The interest of this subdivision is to relate the explanation given to the Japanese economic crisis based on the currency risk (Goyal 2001, Goyal and McKinnon 2003, according to which, the negative interest rate differential between Japan and the United States, since the mid-nineties, is caused by the negative risk premium on assets nominated in terms of Japanese yen.

Eventually, we note that the late of the nineties period has been dominated by a certain persistence of the US Dollar appreciation.

4. ESTIMATION RESULTS

The estimation of GARCH-M (1,1) model respectively for the JPY/USD and the CAD/US three-month forward premiums is equivalent to estimating both the mean equation and the conditional variance equation for these series.

4.1. The global period studied:

The estimation results of the GARCH-M (1,1) model for the first period studied which runs from January 1980 to December 2004 are shown in Table (3).

Table 3. Estimation of GARCH-M (1,1) model

$f_t^{t+1} - s_t = \beta h_t + \varepsilon_t$ $h_t = a_0 + a_1 h_{t-1} + b_1 \varepsilon_{t-1}^2 + \eta_t$ $(\varepsilon_t / t) \sim N(0, h_t)$		
	Forward premium JPY/USD	Forward premium CAD/USD
β	3.877834* (1.642482)	-1.009112 (2.460524)
a_0(constant)	0.000236 (0.000416)	4.61E-05* (1.73E-05)
b_1(*ARCH*)	0.044097 (0.056773)	0.261431* (0.081307)
a_1(*GARCH*)	0.769571* (0.360918)	0.660891* (0.081527)
Q (20) Q^2 (20)	$48.780_{[0.000]}$ $15.856_{[0.001]}$	$171.17_{[0.000]}$ $8.3773_{[0.007]}$
Jarque-Bera	8.350738	18.85389

Estimates made on EVIEWS software (version 5.0)

Note: Values in parentheses are standard deviations and values in brackets are the *p value* of the null hypothesis of no autocorrelation of errors (Q) and their squares (Q^2). Jarque-Bera is the Jarque-Bera statistic of standardized residuals series. The superscript * indicates that the coefficient is statistically significant.

In the light of the table (4), the GARCH –M (1,1) estimation results of the JPY/USD forward premium show that the coefficient β of the mean equation is positive and statistically significant for the JPY/USD forward premium, whereas it is negative and not significant for the CAD/USD forward premium. This clearly shows that the JPY/USD forward premium is positive and largely explained by its conditional variance, i.e by its volatilities with the GARCH term, also proves significant; whereas the ARCH term and the constant of the variance equation are not.

Nevertheless, the CAD/USD forward premium is negative and weakly explained by its volatility and relates the significance of their ARCH and GARCH terms.

We also note that the sum of the ARCH and GARCH parameters amounts to (0.813668; 0.922322), respectively for the JPY/USD and the CAD/USD forward premiums. Such values , close to unity, are certainly indicative that the shocks induced by the volatility are very persistent, so that forecasts of the conditional variance converge very slowly to the regular state. This shows that the GARCH model constitutes a good estimate of both forward exchange premiums.

With regard to the "Ljung-Box" test as applied to simple standardized residual series, Q (20) statistics are significant because the probabilities associated with each of the autocorrelations are below 0.05, which confirms the rejection of the assumption of normality for residual series, in addition to the fact that they are unrepresentative series of white noise. Thus, there is a residual ARCH effect not captured by the model.

In addition, the examination of the Ljung-Box statistic Q applied to the squared standardized residuals series shows that it is not significant; and this shows that the squared residual series do not exhibit ARCH effects which are not taken into account in the model, and therefore the variance equation is correctly specified. This is especially confirmed by the Lagrange multiplier test (ARCH LM test) applied to the squared standardized residuals series to test if they exhibit an additional ARCH effect.

However, it remains to verify the normality of the distribution of standardized residuals. To do this, we examine the Jarque-Bera statistic and we see it clearly exceeds the critical value of χ^2 (2) at the level of significance of 5%. Therefore, standardized residuals are highly leptokurtic and there is rejection of the hypothesis of a normal residual distribution.

4.2. The first sub-periods studied: Pre and post January 1990

Given the persistent appreciation of the US Dollar during the eighties, it would be useful to consider it in our estimates by dividing the study period into two sub-periods pre and post the nineties.

The estimation results of the GARCH-M (1,1) model for the JPY/USD and the CAD/USD forward premiums during these two sub-periods are shown in Table (4).

Table 4. Estimation of GARCH-M (1,1) model

$$f_t^{t+1} - s_t = \beta h_t + \varepsilon_t$$

$$h_t = a_0 + a_1 h_{t-1} + b_1 \varepsilon_{t-1}^2 + \eta_t$$

$$(\varepsilon_t / t) \sim N(0, h_t)$$

	1980 :01 1989 :12		1990 :01 1999 :12	
Forward premium	**JPY/USD**	**CAD/USD**	**JPY/USD**	**CAD/USD**
β	3.530264 (2.476501)	-14.36714* (6.510117)	3.507150 (2.685182)	-1.231112 (2.768553)
a_0(constant)	0.000182 (0.000340)	7.38^E-05 (0.000538)	0.001106 (0.001766)	8.87^E-05 (5.74^E-05)
b_1*(ARCH)*	0.078230 (0.131555)	-0.017315 (0.078579)	0.079656 (0.125158)	0.365676 (0.187751)
a_1*(GARCH)*	0.789998* (0.340832)	0.639745 (2.682484)	0.082278 (1.411262)	0.567687* (0.146251)
Q (20) Q^2 (20)	25.629 12.578	24.080 10.602	35.179 10.565	148.99 8.2459
Jarque-Bera	3.387719	4.273910	17.70010	13.89081

Estimates made on EVIEWS software (version 5.0)

Note: Values in parentheses are standard deviations and values in brackets are the *p value* of the null hypothesis of no autocorrelation of errors (Q) and their squares (Q^2). Jarque-Bera is the Jarque-Bera statistic of standardized residuals series. The exponent * indicates that the coefficient is statistically significant.

Based on the estimation results of the JPY/USD forward premium, we can affirm that the volatility of the Yen – Dollar forward premium, being significant, is not affected by the event during the two sub-periods since the β coefficient has barely fluctuated.

However, we find that the sum of both ARCH and GARCH terms is close to unity for the sub-period pre 1990, in addition to the significance of the Garch term, which indicates the persistence of volatility in the model; while this is not the case for the period that follows.

Moreover, in light of the table (4), the estimation results of the GARCH-M (1,1) model for the CAD/USD forward premium during the sub-periods pre and post 1990 indicate that the Canadian Dollar has been directly affected and concerned by the persistent appreciation of the US Dollar during this time. Indeed, the fluctuation of the β coefficient is remarkable both in terms of value and significance. Moreover, the persistence of shocks to volatility in this framework is consistent until the early nineties. This result is confirmed for the series of standardized residuals, which according to the JB statistic does not depict white noise or a normal distribution, thereby exhibiting a residual ARCH effect.

4.3. The Second sub-period studied: Pre and post September 1995

We thought interesting to divide the total sample period, from January 1980 to December 2004, in two sub-periods namely [1986: 10 to 1995: 09] and [1995: 10 to 2004: 12], for reasons already cited.

The estimation results of the GARCH-M (1,1) model for the JPY/USD forward premium during these two sub-periods are shown in Table (5).

Table 5. Estimation of GARCH-M (1,1) model

	1986 :10 1995 :09			**1995 :10 2004 :12**		
	Coefficient	z-Statistic	Probabilité	Coefficient	z-Statistic	Probabilité
β	0.135012 (3.160375)	0.042720	0.9659	8.798595 (2.901510)	3.032419	0.0024
a_0 (constante)	0.000184 (0.000525)	0.350168	0.7262	0.001088 (0.002082)	0.522720	0.6012
b_1(terme ARCH)	0.050546 (0.079020)	0.639667	0.5224	0.040884 (0.087005)	0.469908	0.6384
a_1(terme GARCH)	0.801655 (0.468893)	1.709675	0.0873	0.015629 (1.847935)	0.008458	0.9933
Log Likelihood	210.6530			216.1199		
Q (20)	37.017			26.157		
Q^2 (20)	11.858			8.4247		
JB	4.141893			33.67929		

Estimates made on EVIEWS software (version 5.0)

By examining the estimation results shown in table (5), we clearly notice that the value of the β coefficient differs remarkably from one period to another; and more specifically, it increases after the Japanese economic crisis in 1995, while being statistically significant for both sub periods. This result goes in the same direction as that of Wu (2004), since the volatility of the Yen – Dollar forward premium is growing more and more after the crisis. This also explains the effect of the forward premium volatility on the negative Japanese interest rates since the mid-nineties. In addition, the Portmanteau test applied to residuals reveals that the Q statistic is only meaningful before the Japanese economic crisis, and therefore there is a residual ARCH effect during this period. We also note, following the JB statistic, that the series of standardized residuals is no longer a normal distribution after the crisis; which is quite plausible.

6. CONCLUSION

In this paper, we have analyzed the dynamics of the JPY/USD and the CAD/USD forward premiums and its main features on the foreign exchange markets via a symmetric linear and univariate ARCH/GARCH modeling given its noticeable persistence among the puzzles which characterized the foreign exchange markets. This specification is very intuitive and powerful for modeling variable sources of risk.

Indeed, it has allowed us to describe the dynamics of the conditional mean and volatility in foreign exchange markets, and capturing the common dynamic that exists in the forward premium of the Japanese Yen and Canadian dollar expressed in terms of American dollar, knowing that this forward premium is proportional to its volatility measured by its conditional variance.

Furthermore, the estimation results indicate the existence of some residual ARCH effects. The subdivision of the study period in several sub-periods also allowed us to take account of significant events related to these basic currencies.

It is hardly worth remembering that contemporary models of exchange rates time series make the use of GARCH widespread. Indeed, these models seem to not only capture the "volatility clustering", but also accommodate some leptokurtic characteristics (fat tails) usually found in the time series of the exchange rates and therefore in the forward exchange premiums. In addition, using the framework of ARCH models can account for heteroscedasticity that characterizes exchange rates and explain the forward premium by the volatility of profitability on the foreign exchange market.

Finally, we conclude that the GARCH-M specification is a good specification for the JPY/USD and the CAD/USD forward exchange premiums.

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