Exchange Rate Volatility, Global Financial Crisis and the Day-of-the-Week Effect

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Abstract
This paper investigated the day-of-the-week effect in the Nigerian foreign exchange market using the GARCH (1, 1) and GJR-GARCH (1, 1) models in the light of banking reforms and the global financial crisis. Using data over the period, January 2, 2002 and March 13, 2009, we examined the persistence in volatility for the Nigerian foreign exchange market. Although the results failed to support the presence the day-of-the week effect in the FOREX rate returns, there was evidence of this effect on the volatility of the returns. Additionally, available evidence indicated persistence in volatility of the Nigerian foreign exchange market returns. The results further showed that the banking reform in July 2004, insurance reform and global financial crisis have no impact on exchange rate return but had impact on exchange rate volatility. Among the models considered, the GARCH (1, 1) model fitted the data best.

Key words: day-of-the-week effect, volatility, exchange rate, generalized autoregressive conditional heteroscedasticity models

INTRODUCTION

The day-of-the-week effect market anomaly, which the mean returns for each day of the week are different, has been well documented and tested for various developed stock markets (Aydogan and Booth, 2003; Cross, 1973; French, 1980; Gibbons and Hess 1981; Keim and Stambaugh, 1984; Rogalski, 1984 and Lakonishok and Levi, 1982; Yamori and Mourdoukow, 2003). However, less is known about the day of the week effect in the emerging and less developed markets (Berument,Coskun and Sahin, 2006). Most studies on the day-of-the-week effect have focused on the seasonal pattern of the mean return (see Jaffe and Westerfield 1985; Solnik and Bousquet 1990; Barone 1990). However, an investor should not only be concerned with expectations in asset returns, but also the variances of returns. Engle (1993) argues that risk-averse investors should reduce their investments in assets with higher return volatilities.

For import dependent economies like Nigeria, the foreign exchange market plays a leading role in performance of the financial market. The exchange rate is an important element in the monetary transmission process (Robinson & Robinson, 1997; Allen and Robinson, 2004) and these movements have a significant pass-through to consumer prices (Robinson, 2000a, 2000b; McFarlane, 2002). In the Nigerian market, the shift from a fixed-exchange rate regime to a managed floating exchange rate, an event preceded by the deregulation of the Nigerian FOREX market, raised the level of uncertainty and volatility. Understanding the behavior of the FOREX market, especially in Nigeria, is thus critical to monetary policy (Longmore & Robinson, 2004).

The day of the week effect in the financial market has been widely documented in the finance literature. Cross (1973) demonstrated empirically that Monday yields were lower than Friday ones for the S&P 500 Index. French (1980) reported similar results after comparing Monday, Friday and weekly average returns for the same index. He observed that Monday returns were lower than the average while Friday returns were greater than the average. Gibbons and Hess (1981) on a study of a sample of 30 stocks from the Dow Jones Industrial Index also concluded that Mondays resulted in negative returns. Different explanations were offered for the day of the week effect. Lakonishok and Levi (1982) proffered market transaction procedures to account for the seasonal behavior in the daily returns while Keim and Stambaugh (1984) associated the weekend effect in the American market to the measurement errors in stock prices. Outside United States, Jaffe and Westerfield (1985a) reportedly found evidence of the weekend effect for Canada, Australia, Japan and the United Kingdom markets. Jaffe and Westerfield (1985b) also reported finding negative Tuesday returns for the Japanese market. Condoyanni, O'Hanlon and Ward, (1987) reported similar results for the Singapore, Japan and Australia markets. Kim (1988) reported significantly negative returns on Mondays for the UK and Canadian stock markets. Athanassakos and Robinson (1994) observed negative Tuesday returns in the Canadian market that exceeded those from mondays. Agrawal and Tandon (1994) found evidence of seasonal behavior in stock markets of eighteen countries (Australia, Belgium, Brazil, Canada, Denmark, France, Germany, Hong Kong, Italy, Japan, Luxembourg, Mexico, the Netherlands, New Zealand, Singapore, Sweden, Switzerland, and the UK). They observed large, positive mean returns on Fridays and Wednesdays in most of these countries. They observe lower or negative mean returns on Mondays and Tuesdays, and higher and positive returns from Wednesday to Friday in almost all the countries. However, Dubois and Louvet (1996) did not arrive to any clear conclusions when they studied nine international markets using both parametric and non-parametric tests. They observed negative returns on Mondays and Tuesdays and positive returns on Wednesdays.

Several studies have examined day of the week effect on exchange rate. Aydogan and Booth (2003), in a study of the Turkish Lira, noted the presence day of the week effect in the currency's daily depreciation over the period, 1986–1994. Berument,Coskun and Sahin (2006) in a similar study on the depreciation and volatility of the Turkish lira (TL) against the US dollar (USD), reported discovered the day-of- the-week effect in both return and volatility equations. Yamori and Mourdoukow (2003) investigated the day of the week effect for the Yen/US dollar exchange rate and reported the presence of the day of the week effect for the 1973–1989 periods. They further argued that the day of the week effect disappeared in the 1990s, an occurrence they ascribed to the financial deregulation in Japan that increased the efficiency of the financial markets. Furthermore, Yamori and Kurihara (2004) investigated the day of the week effect for 29 foreign exchange markets in the 1980s and found the presence of the day of the week effect, an effect they noted disappeared for almost all 29 countries in the 1990s.

Most of the studies above have focused on seasonal pattern in mean return. An investor should be concerned not only with variations in asset returns, but also the variances in returns. Engle (1993) argues that risk-averse investors should reduce their investments in assets with higher return volatilities. The introduction of autoregressive conditional heteroskedasticity (ARCH) model by Engle (1982) as generalized (GARCH) by Bollerslev (1986) has led to the development of various models to model financial market volatility. Some of the models include IGARCH originally proposed by Engle and Bollerslev (1986), GARCH-in-Mean (GARCH-M) model introduced by Engle, Lilien and Robins (1987),the standard deviation GARCH model introduced by Taylor (1986) and Schwert (1989), the EGARCH or Exponential GARCH model proposed by Nelson (1991), TARCH or Threshold ARCH and Threshold GARCH were introduced independently by Zakoïan (1994) and Glosten, Jaganathan, and Runkle (1993), the Power ARCH model generalised by Ding,. Zhuanxin, C. W. J. Granger, and R. F. Engle (1993) among others.

If investors can identify a certain pattern in volatility, then it would be easier to make investment decisions based on both return and risk (Kiymaz and Berument, 2003). Thus, an investigation of the day of the effect in returns should also consider the day of the week effect on stock volatility. Several studies have been done using the GARCH framework to investigate the day of the week effect. Berument and Kiymaz (2001) model the day of the week effect using GARCH model. Their findings show that the day of the week effect is present in both volatility and return equations. Berument, Coskun and Sahin (2006) assess the day of the week effect of the daily depreciation of the Turkish lira (TL) against the US dollar (USD) and its volatility. They found the day of the week present in both return and volatility equation. Some other studies on the day of the week effect using different variations of the GARCH model include Copeland and Wang (1994), Corhay and Rad (1994), Theodossiou and Lee (1995), Corredor and Santamaría (1996), Miralles and Miralles (2000), Choudhry (2000), Amigo and Rodríguez (2001), Balaban, Bayar and Kan (2001), Kiymaz and Berument (2003), Yalcin and Yucel (2006), Chandra (2004), Apolinario, Santana, Sales and Caro (2006) among others. Little or no work has been done on the day of the week effect for the Nigerian foreign exchange market using GARCH models. This paper attempts to fill this gap.

The banking reforms in Nigeria in 2004, the insurance reform of 2005 and global financial crisis of 2008 could have affected the uncertainty in the Nigeria foreign exchange market. This paper investigates the day-of-the-week effect in the Nigerian foreign exchange market using the GARCH (1,1) and GJR-GARCH (1,1) models in the light of banking reforms and the global financial crisis.

METHODOLOGY

The Data

Data used in this study included daily Naira/Dollar exchange rates from January 2, 2002 to March 13, 2009 downloaded from the Central Bank of Nigeria's website. The return on exchange rate was computed using the formula:

$$r_t = log\left(\frac{e_t}{e_{t-1}}\right) \quad (1)$$

Where e_t mean Naira/dollar exchange rate at time t and e_{t-1} represent naira exchange rate at time $t-1$.

On July 4, 2004 and September 5, 2005, the Central Bank of Nigeria introduced reforms in the banking and insurance industries that brought in new capitalization requirements. To account for the reforms, we introduced dummy variables. We further introduced a dummy variable to account for the global financial crisis critical point triggered by the United States of America's government takeover of Fannie Mae (Federal National Mortgage Association) and Freddie Mac (Federal Home Loan Mortgage Corporation), officially made public on September 7, 2008.

Data analysis

Table 1 reports the descriptive statistics for the returns on exchange rates for the study period as well as the returns for each day of the week. The average return for the entire study period is 0.0001. The standard deviation of the return is 0.0822, and skewness is -0.0257. The kurtosis is 715.254 that is much larger than three. Further, the Jarque-Berra normality test ($p < 0.001$) reveals a statistically significant deviation of the data from normality.

The Ljung-Box test Q statistics as reported in Table 2 confirmed the presence of autocorrelation in the exchange rate returns. The Ljung-Box test for heteroscedasticity, Q^2 statistic, was significant ($p < 0.001$) for all reported lags, which confirmed the presence of heteroscedasticity in the exchange rate returns.

Table 1
Summary Statistics of the Exchange Rate Return (January 2, 2002 – March 13, 2009)

	Monday	Tuesday	Wednesday	Thursday	Friday	All Days
Mean	0.0019	0.0052	-0.0049	0.0000	-0.0015	0.0001
Median	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Maximum	0.5633	2.3090	0.5128	0.0141	0.0211	2.3090
Minimum	-0.0310	-0.5134	-2.3102	-0.0234	-0.5633	-2.3102
Std. Dev.	0.0306	0.1263	0.1255	0.0015	0.0301	0.0822
Skewness	18.1006	17.1524	-17.2481	-7.5392	-18.5332	-0.0257
Kurtosis	332.6105	317.6619	321.8162	170.4914	346.0088	715.1254
Jarque-Bera	1571420	1465263	1529653	414784	1740799	37062205
Probability	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Observations	343	351	357	352	351	1754

Table 2
Autocorrelation and Homoscedasticity tests for the Exchange rate Returns

	Lags			
	1	6	12	20
Ljung-Box Q Statistics	438.07	438.07	438.08	438.09
p-value	0.000	0.000	0.000	0.000
Ljung-Box Q^2 Statistics	438.02	438.04	438.06	438.09
p-value	0.000	0.000	0.000	0.000

Table 3 shows the results of unit root test for the exchange rate return series. The Augmented Dickey-Fuller test and Phillips-Perron test statistics for the stock returns return series are less than their critical values at the 1%, 5% and 10% level. This shows that the stock returns return series has no unit root. Thus, there is no need to difference the data.

Table 3
Unit Root Test of the Exchange rate Returns

	Statistic	**Critical Values**		
		1% level	5% level	10% level
Augmented Dickey-Fuller test	-21.0783	-2.5663	-1.9410	-1.6166
Philips-Perron test	-379.3510	-2.5663	-1.9410	-1.6166

In summary, the analysis of the exchange rate return indicates that the empirical distribution of returns in the exchange rate returns is non-normal, with very thick tails. The leptokurtosis reflects the fact that the foreign exchange market is characterized by very frequent medium or large changes. These changes occur with greater frequency than what is predicted by the normal distribution. The empirical distribution confirms the presence of a non-constant variance or volatility clustering.

Modeling the Data

This study investigates the day-of-the-week effect in the Nigerian foreign exchange market by modeling the volatility of the daily exchange rate return series using the GARCH (1,1) and GJR-GARCH (1,1) models taking into account the banking and insurance reforms, and the global financial crisis, events that took place within the study period. The choice of the models was based on the Akaike information Criterion. The mean and variance equations of the GARCH (1,1) model are given as :

$$R_t = b_0+\sum_{i=1}^{4} e_i R_{t-i} +b_1\delta_{1t}+b_2\delta_{2t}+b_4\delta_{4t}\ b_5\delta_{5t} +g_1BR+g_2ISR+g_3GFC+\varepsilon_t \quad (2)$$

Where $\varepsilon_t / \phi_{t-1} \sim N(0,\sigma_t^2, v_t)$ and

$$\sigma_t^2 = h_0 + \alpha\varepsilon_{t-1}^2 + \beta\sigma_{t-1}^2 + \Theta_1BR+\Theta_2ISR+\Theta_3GFC+h_1\delta_{1t}+h_2\delta_{2t} +h_4\delta_{4t} +h_5\delta_5 \quad (3)$$

Where v_t is the degree of freedom. δ_{jt} is a dummy variables which takes on the value 1 if day is j and 0 otherwise (j = 1, 2, 4, 5). Wednesday dummy variable is excluded to avoid the dummy variable trap. BR = banking reform dummy variable (= 1, prior to July 4, 2004, zero otherwise), ISR = Insurance sector dummy reform variable (= 1, prior to September 5, 2005, zero otherwise) and GFC = global financial crisis dummy variable ((= 1, prior to September 7, 2008, zero otherwise).

To allow for possible asymmetric and leverage effects, the impact of the day-of-the-week effect in the Nigerian foreign exchange market was investigated using the GJR-GARCH (1,1) model. The mean equation was the same as in Equation (2) while the variance equation was:

$$\sigma_t^2 = \omega + \alpha\varepsilon_{t-1}^2 + \beta\sigma_{t-1}^2 + \gamma\varepsilon_{t-1}^2 I_{t-1}^{-} +\Theta_1BR+\Theta_2ISR+\Theta_3GFC+h_1\delta_{1t}+h_2\delta_{2t}+h_4\delta_{4t}+h_5\delta_5 \quad (4)$$

The volatility parameters estimated include ω, α, β and γ.

THE RESULTS

The results of estimating the augmented GARCH (1,1) and the augmented GJR-GARCH (1,1) models are presented in Table 4. In the mean equation, e_1, e_2, e_3 and e_4 (coefficient of lag of exchange rate returns) are significant in the two models confirming the correctness of adding the variable to correct for autocorrelation in the exchange rate return series. The coefficient b_5, b_6 and b_7 representing coefficients of the banking reform, insurance reform and global financial crisis respectively, are all statistically insignificant at the 5% level as reported in the significant in the two augmented models. This implies that the new bank capital requirement announced in 2004, insurance reform and global financial crisis have no impact on exchange rate returns. The coefficients b_1, b_2, b_4 and b_5 representing Monday effect, Tuesday effect, Thursday effect and Friday effect are statistically insignificant at the 5% level in the two models. This implies the absence of the day of the week effect in the exchange rate return series in Nigeria.

The variance equation in Table 4 shows that the α coefficients are positive and statistically insignificant at the 5% level for both models. However, α coefficient is significant at the 10% level in the augmented GARCH (1,1) model. This appears to confirm that the ARCH effects are not well pronounced in both models at the 5% significance level. However, the presence of the ARCH effect appears to be inconclusive for the augmented GARCH (1,1) model.

Table 4 shows that the β coefficients (the GARCH parameter) are statistically significant in the two augmented models. The sum of the α and β coefficients in the augmented GARCH (1,1) model is 0.5872. This appears to show that there is persistence in volatility as the sum of α and β is close to 1. In the augmented GJR-GARCH model, the sum of α, β and γ/2 is 0.5788. This also confirms the existence of volatility persistence.

The variance equation of the two models indicates that Θ_1, Θ_2 and Θ_3 representing coefficients of the banking reform, insurance reform and global financial crisis respectively are all statistically significant at the 5% level. This implies that the new bank capital requirement announced in 2004, insurance reform and global financial crisis have impact on volatility equation. This appears to indicate that the global financial crisis accounted for the sudden change in variance.

Table 4
Parameter Estimates of the GARCH Models

		AUGMENTED GARCH (1,1)		**AUGMENTED GJR-GARCH (1,1)**	
		Coefficient	Prob.	Coefficient	Prob.
Mean equation					
b_0		-0.0024	(0.9354)	-0.0005	0.9867)
e_1		-0.7583	0.000***	-0.7590	0.000***
e_2		-0.5679	0.000***	-0.5683	0.000***
e_3		-0.3717	0.000***	-0.3717	0.000***
e_4		-0.1812	0.000***	-0.1818	0.000***
g_1		-0.0016	0.9738	-0.0019	0.9607
g_2		-0.0006	0.9879	-0.0014	0.9662
g_3		0.0025	0.8602	0.0034	0.7721
b_1		0.0028	0.8697	0.0018	0.9235
b_2		0.0044	0.8069	0.0106	0.5612
b_4		0.0030	0.8752	0.0005	0.9778
b_5		0.0100	0.5723	0.0078	0.6785
Variance equation					
ω		0.0035	0.000***	0.0035	0.000***
α		0.0936	0.0677	0.0919	0.1004
β		0.4936	0.000***	0.4973	0.000***
γ				-0.0208	0.8707
Θ_1		-0.0006	0.023*	-0.0006	0.0525
Θ_2		-0.0005	0.0133*	-0.0005	0.034*
Θ_3		-0.0006	0.000***	-0.0006	0.000***
h_1		-0.0020	0.000***	-0.0020	0.000***
h_2		-0.0018	0.000***	-0.0015	0.000***
h_4		-0.0022	0.000***	-0.0022	0.000***
h_5		-0.0016	0.000***	-0.0016	0.000***
ν		19.8379	0.000***	19.8296	0.000***
Persistence		0.5872		0.5788	
LL		3595		3545	
AIC		-4.0825		-4.0241	
SC		-4.0106		-3.9491	
HQC		-4.0559		-3.9964	
N		1754		1754	
Wald test					
Mean Equation	F	0.1488	0.9305	0.3009	0.8248
	χ^2	0.4464	0.9305	0.9026	0.8248
Variance Equation	F	2.6408	0.0480*	3.4371	0.0163*
	χ^2	7.9225	0.0476*	10.3113	0.0161*

Significance: ***p < 0.001, **p < 0.01, *p < 0.05

Table 4 shows that the coefficients of γ, the asymmetry and leverage effects, are negative and statistically insignificant at the 5% level in the augmented GJR-GARCH (1,1) model. This shows that the asymmetry and leverage effects are rejected in the augmented GJR-GARCH (1,1) model for the Nigerian foreign exchange market. The coefficients h_1, h_2, h_4 and h_5 representing Monday effect, Tuesday effect, Thursday effect and Friday effect are statistically significant at the 5% level in both the augmented GARCH (1,1) and the augmented GJR-GARCH (1,1) models in the volatility equation. This implies that the day of the week effect has impact on exchange rate volatility in Nigeria. The estimated coefficients of the degree of freedom, v are significant at the 5-percent level in GARCH model and the augmented model implying the appropriateness of student t distribution. The Wald test for the mean equation shows that F-statistic and Chi-square are statistically insignificant in the mean equation in the two augmented models. However, the Wald test for the variance equation in the two augmented model shows that F-statistic and Chi-square are statistically significant in the variance equation. This appears to imply that the day-of-the-week effect has no impact on exchange rate return but on volatility.

Table 5
Autocorrelation of Standardized Residuals, Squared Standardized Residuals and ARCH LM test of Order 4

	AUGMENTED GARCH (1,1)	**AUGMENTED GJR-GARCH (1,1)**
Ljung-Box Q Statistics		
Q(1)	0.0198	0.1058
p-value	0.8880	0.7450
Q(6)	8.6558	10.4200
p-value	0.1940	0.1080
Q(12)	8.7693	10.5450
p-value	0.7230	0.5680
Q(20)	8.9480	10.8220
p-value	0.9840	0.9510
Ljung-Box Q^2 Statistics		
$Q^2(1)$	0.0003	0.0002
p-value	0.9870	0.9890
$Q^2(6)$	0.0041	0.0069
p-value	1.0000	1.0000
$Q^2(12)$	0.0127	0.0157
p-value	1.0000	1.0000
$Q^2(20)$	0.0244	0.0274
p-value	1.0000	1.0000
ARCH-LM TEST		
ARCH-LM (5)	0.0005	0.0011
	1.0000	1.0000
ARCH-LM (10)	0.0010	0.0013
	1.0000	1.0000
ARCH-LM (20)	0.0012	0.0013
	1.0000	1.0000
Jarque-Berra	87124603	85454278

	0.000***	0.000***

Significance: ***p < 0.001, **p < 0.01, *p < 0.05

Table 5 shows the results of the diagnostic checks on the estimated GARCH (1,1) and GJR-GARCH (1,1) models. The table shows that the Ljung-Box Q-test statistics of the standardized residuals for the remaining serial correlation in the mean equation shows that autocorrelation of standardized residuals are statistically insignificant at the 5% level for the two augmented models confirming the absence of serial correlation in the standardized residuals. This shows that the mean equations are well specified. The Ljung-Box Q^2-statistics of the squared standardized residuals in Table 5 are all insignificant at the 5% level for the two augmented models. The ARCH-LM test statistics in Table 5 for the two augmented models further showed that the standardized residuals did not exhibit additional ARCH effect. This shows that the variance equations are well specified in the two augmented models. The Jarque-Bera statistics still shows that the standardized residuals are not normally distributed. In sum, all the models are adequate for forecasting purposes.

A comparison of the augmented GARCH (1,1) model and the augmented GJR-GARCH (1,1) model shows that GARCH (1,1) ranked better in terms of the of maximum log-likelihood, lowest Akaike information, Schwarz and Hannan-Quinn criteria. Thus, the GARCH (1,1) model is a preferable model for the daily exchange rate return series.

CONCLUSION

This study investigated the day-of-the-week effect in the Nigerian foreign exchange market using the GARCH (1,1) and GJR-GARCH (1,1) models taking into the banking and insurance reforms, introduced within the study period, and the global financial crisis. Volatility persistence and asymmetric properties were investigated for the Nigerian foreign exchange market. The result also revealed absence of the day-of-the-week effect in the exchange rate return equation but not in the volatility equation. There were indications of persistence in volatility in the Nigerian foreign exchange market. The results from the asymmetry model rejected the hypothesis of leverage effect. The GARCH model was found to be the best model. The result suggested that the new capital requirements, reforms in the insurance industry and the global financial crisis had no impact on exchange rate returns. The absence of the day-of-the-week effect on exchange rate returns had some suggestions about the efficiency of the Nigerian foreign exchange market.

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