MYKOLO ROMERIO UNIVERSITETAS

Available online at www.sciencedirect.com

ScienceDirect

Intellectual Economics 10 (2016) 28–37

www.elsevier.com/locate/intele

Comparative analysis of bureaux de change and official exchange rates volatility in Nigeria

Kalu O. Emenike*

Department of Banking and Finance, Rhema University, PMB 7021, Aba, Abia State, Nigeria

Received 20 January 2016; accepted 11 April 2016
Available online 13 April 2016

Abstract

Exchange rates stability is an important monetary policy target. Hence monetary authorities aim at avoiding wide divergence between the official exchange rate and parallel exchange rates in most developing economies. This paper employs GARCH (1,1) and GJR-GARCH (1,1) models to estimate and compare volatilities of official, interbank, and bureaux de change markets Naira/US$ exchange rates for the January 1995–December 2014 period. The results of the study show that the volatilities of interbank and bureaux de change exchange rates in the previous periods influence current volatility of exchange rates. The results also show evidence of volatility clustering in the interbank market and bureaux de change Naira/US$ exchange rates. Sum of the ARCH and GARCH coefficients indicates evidence of volatility persistence in the exchange rates returns series. Comparative analysis between the exchange rates volatilities shows that the magnitude of impact of volatility shocks on current volatility as well as volatility clustering are greater in bureaux de change than in other exchange rates in Nigeria. The asymmetric parameter indicates that exchange rates depreciation tends to produce higher volatility in the immediate future than appreciation of the same magnitude in both the interbank and bureaux de change markets in Nigeria.

JEL classification: G11; C32

Keywords: Volatility comparison; Exchange rates; Cureaux de change; GARCH models; Nigeria.

1. Introduction

The importance of stable exchange rate to sustainable development of developing economies is well established. Monetary authorities therefore aim at avoiding wide divergence between the official exchange rate and parallel exchange rates. Omojimite and Akpokodje (2010) observe that exchange rates have been highly volatile in Africa

* Tel.: +2348035526012.
E-mail address: emenikekaluonwukwe@yahoo.com.

http://dx.doi.org/10.1016/j.intele.2016.04.001

especially since the move to a floating exchange rate system with negative repercussions for trade, investment and growth. Nigeria for instance, practiced a fixed exchange rate before 1986, but she adopted flexible exchange rate policy thereafter. As a result, the official Naira exchange rate was allowed to float, within a pre-specified band, in relation to other currencies thereby allow changes within the band to be determined by market forces of demand and supply. Some of the policies employed to ensure exchange rate stability include among others: second-tier foreign exchange market, bureaux de change, autonomous foreign exchange market, inter-bank foreign exchange market, the enlarged foreign exchange market, and Dutch auction system (DAS), which includes the retail and wholesale DAS. The ineffectiveness of each of the policies to achieve sustainable stability in the Nigeria exchange rate led to the adoption of another.

Despite these policy efforts by the Nigeria monetary authority to maintain exchange rate stability, the Naira continues to fluctuate widely against the US dollar. The Naira, according to Opara, Emenike, and Ani (2015), appreciated against the US dollar from ₦0.71 in 1970 to ₦0.62 in 1975 and further to ₦0.55 in 1980. However, the exchange rate depreciated throughout the 1980 s. For instance, the naira depreciated from ₦0.61 in 1981 to ₦2.02 in 1986, and further to ₦8.04 in 1990. By the year 2000, the exchange rate stood at ₦106.71, and depreciated further to ₦132.86 in 2005. Thereafter, the exchange rate appreciated minimally to ₦128. 26, ₦118.21 and ₦117.74 in 2006, 2007 and 2008 respectively, before moving upward. In 2014, the official, interbank and bureaux, de change Naira/US$ exchange rates closed at ₦169.68, ₦188.33 and ₦188.45. It is therefore surprising to see that Naira/US$ exchange rate which was less than ₦1/$1 in 1980 closed at ₦197/$1 by the end of first quarter of 2015. These wide depreciation in the value of Naira exacerbates exchange rates volatility.

Exchange rate volatility makes international trade and investment decisions more difficult because volatility increases exchange rate uncertainty and risk. Hericourt and Poncet (2012) argue that there is indeed a negative impact of exchange rate volatility on firms exporting behaviour, magnified for financially vulnerable firms, and dampened by financial development. In the same vein, Aghion, Bacchetta, Ranciere, and Rogoff (2009) provide evidence of substantial negative effects of the exchange rate volatility on growth in developing countries, and emphasis that financial development tends to reduce the impact of exchange rate volatility on economic performance. Taiwo and Adesola (2013) note that a stable exchange rate is needed to improve the ability of the banking sector to channel credit to the economy. Given the uncertainty and risk associated with volatile exchange rates as well as the frequent exchange rate policy changes in many developing countries, there is need to measure exchange rate volatility across time. Hence, empirical evidence on the nature of exchange rate volatility should be provided frequently and compared across official and parallel rates in the economy, as a gauge to the efficacy of exchange rate policies.

Although, numerous empirical studies have documented evidence of exchange the volatility in both developed and emerging economies (See for example, Hsieh, 1989; Abdalla, 2012; Marreh, Olubusoye, and Kihoro, 2014), most of the studies modeled the volatility of the official exchange rates without comparison with parallel rates in the economy. Analysing the volatility of both the official exchange rate, interbank exchange rate and bureaux de change exchange rate and comparing their estimates against the other would be a more informative method of gauging the volatility of exchange rates. Such analysis would highlight whether or not parallel exchange rates move closely with the official exchange rates set by the monetary authorities.

The objective of this study is to estimate and compare the volatilities of the official market, interbank market, and bureaux - de change Naira/US$ exchange rates in Nigeria using GARCH models. The findings of this study will be useful to monetary authorities, international traders, investors and scholars. Given that exchange rate stability is one of the goals of monetary policy, and the need to keep the official rates close to parallel rates, comparative analysis of exchange rates volatilities will enhance exchange rates policy-making and management in developing economies. More so, international traders want to understand volatility dynamics of Naira/US$ exchange rates as majority of foreign trades in Nigeria are transacted using the US dollar. This study will also serve as reference materials to scholars. The remainder of the paper is organised as follows: Section 2 presents the overview of foreign exchange market and empirical literature review. Section 3 provides the methodology and data. Section 4 presents the empirical results, and Section 5 provides the summary and conclusions.

2. Overview of Nigerian foreign exchange market and empirical review

2.1. Overview of Nigerian foreign exchange market

Before the Central Bank of Nigeria (CBN) came into operation in July 1959 and the enactment of the Exchange Control Act of 1962, foreign exchange was earned by the private sector and held in balances abroad by commercial banks which acted as agents for local exporters. During this period, the Nigerian pound was tied to the British pound sterling at par with easy convertibility. The establishment of the CBN and the subsequent centralisation of foreign exchange authority in the bank created the need to develop the Nigerian foreign exchange market (CBN, undated). The Nigerian foreign exchange market experienced a boom during 1970′s as result of enhanced official foreign exchange receipts from crude oil export, and the need for management of foreign exchange resources became necessary to ensure that shortage did not arise. In 1982 however, comprehensive exchange controls were applied as a result of the foreign exchange crisis that set in that year. The increasing demand for foreign exchange at a time when the supply was shrinking encouraged the development of a flourishing parallel market for foreign exchange.

In September 1986, the Second-tier Foreign Exchange market (SFEM) was introduced because of inability of the exchange control system to evolve an appropriate mechanisms for foreign exchange allocation in consonance with the goal of internal balance. Under SFEM, the determination of the Naira exchange rate and allocation of foreign exchange were based on market forces (CBN, undated). To enlarge the scope of the foreign exchange market, bureaux de change (BDC) were introduced in 1989. The major objectives include providing access to foreign exchange to small-scale end-users: serving as tools for the management of exchange rate while assisting in the fight against illegal financial activities; facilitating economic activities; and providing economic data for policy decisions (CBN, undated). As a result of volatility in exchange rates, further reforms were introduced in the foreign exchange market in 1994. These included the formal pegging of the Naira exchange rate, the centralization of foreign exchange in the CBN, the restriction of bureaux de change to buy foreign exchange as agents of the CBN, the reaffirmation of the illegality of the parallel market and the discontinuation to open accounts and bills for collection as means of payments sectors. The foreign exchange market was liberalised in 1995 with the introduction of an autonomous foreign exchange market (AFEM) for the sale of foreign exchange to end-users by the CBN through selected authorised dealers at market determined exchange rate. In addition, bureaux de change was once more accorded the status authorised buyers and sellers of foreign exchange. The foreign exchange market was further liberalised in October 1999 with the introduction of an inter-bank foreign exchange market (CBN, undated).

In 2006, the CBN introduced the Wholesale Dutch Auction (WDAS) to achieve the convergence of the official exchange rate and the interbank exchange rate. The CBN admitted BDCs into the official market through direct dollar sale, and also allowed them to act as brokers in the interbank market. To achieve the later, the CBN removed restrictions on foreign exchange purchases by widening the scope of transactions that can be funded by official foreign exchange. As BDCs had access to more foreign exchange, the number of BDCs increased from about 74 in 2004 to over 3208 in June 2014, with 1417 applications awaiting CBN approval (Chidiebere, 2014). With this huge increase in the number BDCs, effective monitoring of their activities became a Herculean task.

2.2. Empirical literature Review

Many empirical studies have modeled volatility of exchange rates in both developed and emerging economies. Most of the empirical studies have been motivated by the importance of exchange rate stability on sustainable economic development. Hsieh (1989) modeled heteroscedasticity in exchange rates using autoregsssive conditionally heteroscedastic (ARCH) model and generalized ARCH (GARCH) models on daily closing bid prices of five currencies, including British pound, Canadian dollar, Deutsche mark. Japanese yen, and Swiss franc, in terms of the US dollar for the 1974 to 1983 period. The major finding of the study is that the ARCH and GARCH models are capable of removing all heteroscedasticity in price changes in all five currencies. He also reported that the standardized residuals from all the ARCH and GARCH models using the standard normal density are highly leptokurtic, and the standard GARCH(1,1) are more efficient in removing conditional heteroscedasticity from daily exchange rate movements.

Olowe (2009) examined the nature of volatility of Naira/Dollar exchange rates in Nigeria using several variants of GARCH models on monthly data for the period January 1970–December 2007. Results of the study show that all the GARCH family models indicates evidence of volatility persistent Naira/Dollar exchange rates. The findings are similar for both the fixed exchange rate and managed float rate regimes.

Kamal, Haq, Ghani, and Khan (2012) analysed Pakistan Rupee/US dollar exchange rates using symmetric GARCH-M (1,1) with other two asymmetric models EGARCH (1,1) and TARCH (1,1) on daily and monthly data for the period January 2001 to December 2009. The results of the GARCH-M (1,1) model show evidence of volatility clustering. The results of asymmetric EGARCH (1,1) model show evidence of asymmetric effects, where positive and negative news have different impact on volatility progression. The TARCH (1,1) model results also provide support for the asymmetric behaviour in both the daily and monthly exchange rate returns in Pakistan.

Abdalla (2012) examined the daily returns of exchange rates series of nineteen Arab countries using two symmetric and asymmetric univariate specifications of the generalized autoregressive models, for the period ranging from January 1 2000 to November 19 2011. The currencies considered are the United Arab Emirates dirham, Bahraini Dinar, Djiboutian Franc, Algerian Dinar, Egyptian pound, Iraqi Dinar, Kuwaiti Dinar, Lebanese Pound, Libyan Dinar, Moroccan Dirham, Mauritanian Ouguiya, Omani Rial, Qatari Riyal, Saudi Arabian Riyal, Somali Shilling, Syrian Pound, Tunisian Dinar and Yemeni Rial, all against the US dollar. The results of the symmetric GARCH (1,1) model show that while volatility is an explosive process for the ten of nineteen currencies, it is quite persistent for seven currencies. The results of the asymmetric EGARCH (1,1) model show evidence of leverage effects for all currencies, except for the Jordanian Dinar, indicating that negative shocks imply a higher next period volatility than positive shocks of the same magnitude. The study concludes that the exchange rates volatility can be adequately modeled using GARCH family models.

Marreh, Olubusoye, and Kihoro (2014) modeled daily exchange rates of the Gambian Dalasi against the Euro and US dollars from May 2003 through May 2013 by applying autoregressive moving average (ARMA) and generalized conditional heteroscedasticity (GARCH 1,1). The empirical results of the study show, among others, that the sum of ARCH and GARCH parameters is very close to one. The study concludes that the volatility in the Gambian foreign exchange market is highly persistent and that the distribution of the return series is heavy-tailed.

Narsoo (2015) conducted an empirical analysis of the volatility of the exchange rate of US Dollar/Mauritian Rupee (USD/MUR) using various GARCH-type models using daily data over the period January 2004 to June 2015. Specifically, he compared the predictive ability of the symmetric GARCH model with the asymmetric EGARCH, TGARCH, PGARCH and GJR-GARCH models. The results indicate, among others, that the USD/MUR exchange rate series exhibit volatility persistence as well as the stylised features, volatility clustering and leverage effects; hence supporting the implementation of the asymmetric models. The results also show the suitability of asymmetric GARCH-type models in predicting the volatility of USD/MUR exchange rates.

3. Methodology and description of data

3.1. Methodology

To model and compare volatility of Naira/US$ official exchange rate and bureaux de change exchange rates, we apply symmetric GARCH (1,1) models in the framework of (Bollerslev, 1986) which is a generalization of the ARCH model developed by Engle (1982), and the asymmetric GJR-GARCH (1,1) introduced by Glosten, Jagannamthan, and Runkle (1993). The first step in modeling volatility is correct specification of the conditional mean. If the conditional mean is not specified adequately. Then the construction of consistent estimates of the true conditional variance would not be possible and statistical inference and empirical analysis might be wrong (Rachev, Mittinik, Fabozzi, Focardi, & Jasic, 2007: 293). The conditional mean model is pacified thus:

$$R_t = \phi + \delta R_{t-i} + \varepsilon_t \tag{1}$$

Where $R_t$is as defined in Eq. (1), $\delta$is the coefficient of AR (p) term in the mean equation that accounts for serial correlation in the exchange rate return, $\varepsilon_t$is the error term. The conditional variance equation models are specified as follows:

$$\sigma_t^2 = \omega + \alpha 1 \varepsilon_{t-1}^2 + \beta 1 \sigma_{t-1}^2 \tag{2}$$

$$\sigma_t^2 = \omega + \alpha 1 \varepsilon_{t-1}^2 + \beta 1 \sigma_{t-1}^2 + \gamma \mu_{t-1}^2 \mathrm{I}\mu < \mathrm{o}(\mu t - 1) \quad (3)$$

where ω is the constant variance that correspond to the long run average, $\alpha 1$ is the first order ARCH term which transits news about volatility from the previous period, and $\beta 1$ the first order GARCH term, is the new information that was not available when the previous forecast was made (Engle, 2003), γ is the GJR-GARCH asymmetric coefficient that signifies asymmetric effects of shocks on the Naira/US$ exchange rates volatility. The parameters were estimated using the BHHH maximum like hold algorithm (recommended in Berndt, Hall, Hall, & Hausman, 1974) with correction for heteroscedasticity and misspecification. The non-negatively restrictions of the symmetric GARCH (1,1) are $\omega > 0$, $\alpha_1 > 0$ and $\beta_1 \geq 0$.

Statistical significance of the conditional variance parameters are tested using *p*-value and *t*-statistics. Under the null hypothesis of no volatility clustering in the Naira/US$ exchange rates, the *p*-value of parameters should be greater than the chosen 5% significance level and computed *t*-statistics will be lesser than theoretical t ($\pm$1.96). The sum of α_1 and β_1 indicate persistence in volatility clustering and varies from *0* to *1*. The closer $(\alpha_1 + \beta_1)$ to *1*, the more persistent is volatility clustering (Emenike & Aleke, 2012). The presence of asymmetric effects, using GJR-GARCH (1,1) model of Eq. (3), were examined using sign and significance of the γ coefficient. A zero γ coefficient would imply that positive and negative shocks of the same magnitude have the same effect on volatility of Naira/US$ exchange rates. The effect of a shock is asymmetric if $\gamma \neq 0$. if the γ coefficient were positive, then negative shocks tend to produce higher volatility in the immediate future than positive shocks. The opposite would be true if the γ coefficient were negative.

3.2. Description of data

The data consist of monthly official, interbank market and bureaux de change Naira/US$ exchange rates. The data are obtained from Central Bank of Nigeria (CBN) statistics database. The period under consideration for the exchange rate series ranges from January 1995 to 2014. This study period was selected to avoid the effects of market was liberalised in 1995 with the introduction of an Autonomous Foreign Exchange Market (AFEM) for the sale of foreign exchange to end-users by the CBN through selected authorized dealers at market determined exchange rate. The study period therefore concentrates on the deregulated era of the Nigerian foreign exchange market.

The official, interbank and bureaux de change Naira/US$ exchange rates series were transformed to returns series by taking their first log difference thus:

$$R_t = Ln(P_t - P_{t-1}) \times 100 \quad (4)$$

where R_t is the vector of monthly exchange rate returns specified in Eq. (1), P_t is the current Month exchange rate, P_{t-1} is the previous Month exchange rate, and *Ln* is natural logarithm.

4. Empirical results

4.1. Graphic presentation and descriptive statistics

Fig. 1 presents a time series plot of the log-level and return series of the official, interbank and bureaux de change Naira/US$ exchange rates in Nigeria. Clearly Fig. 1 reveals that the official Naira/US$ exchange rate maintained a value (₦22/$1) from beginning of the study period to December 1998 before moving to ₦86/$1 in January 1999. It also reveals steady upward swing in all the exchange rates except for the last quarter of 2008, which is the period of the global financial crisis. The return series of the official Naira/US$ exchange rates show that the rate of change is within 200 basis points except for January 1999, whereas the bureaux de change market hovers around 1000 basis points. These suggest that wide divergence exist between the official exchange rate and the bureaux de change exchange rates. Again, notice that all the exchange rates are returns above their average rates. Another major feature of the return series graphs is that the exchange rates of the interbank market and bureaux de change market appear to be mean reverting.

Table 1 shows the descriptive statistics, results of the normality, serial correlation and ARCH-LM tests for the monthly returns of the Naira/US$ official, interbank market and bureaux de change rates. Under assumptions

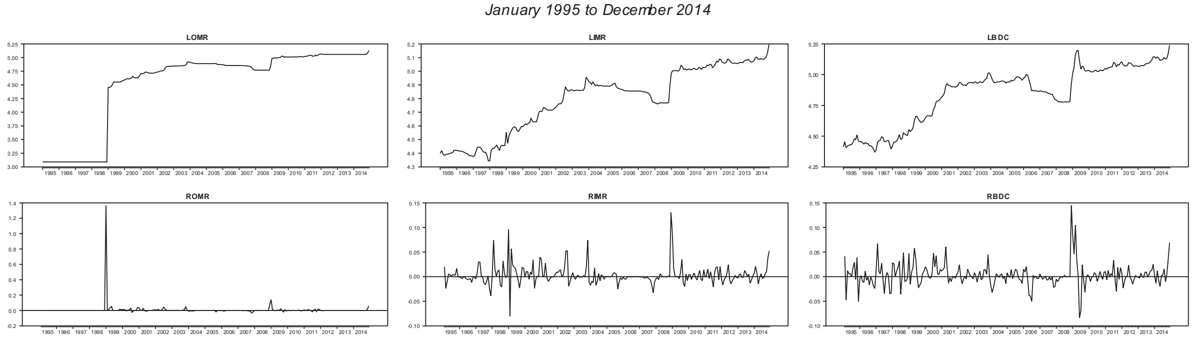

Fig. 1. Time series plot of log-levels and Naira/US$ exchange rates in Nigeria.

Table 1
Descriptive statistics.

	Mean	Std. Dev	Skewness	Kurtosis	J-B Stat.	L-BQ_{12}	ARCH-LM_{12}
ROMR	0.0085	0.0891	14.8886	226.842	521,262.31	0.286 (0.990)	0.004 (0.999)
RIMR	0.0033	0.0196	2.2226	12.2091	1681.20	5.627 (0.059)	9.987 (0.000)
RBDC	0.0034	0.0231	1.3479	8.4637	785.739	28.946 (0.000)	15.643 (0.000)

Note: J-B Stat is the Jarque–Bera statistics. Std. dev is standard deviation. ROMR, RIMR, and RBDC are the logarithmic first difference of official market exchange rate, interbank market exchange rate, and bureaux de change exchange rate in Nigeria respectively. L-BQ, is the Ljung-Box Q statistics for test of the null hypothesis of no autocorrelation. ARCH-LM is the Engle (1982) Lagrange multiplier test for heteroscedasticity in squared residuals. (.)/parenthesis value is the *p*-value.

of normality, skewness and kurtosis have asymptotic distribution of N(0) and N(3) respectively (Gujarati, 2003). Empirical distribution of the monthly exchange rates returns differ significantly from the normal distribution. The descriptive statistics show positive skewness in official (14.888), interbank market (2.222), and bureaux de change (1.347), which indicate that depreciation in the Naira/US$ exchange rate occurs more often than it appreciates. The monthly returns series being positively skewed, suggest that the exchange rates returns distribution may not be symmetric. The excess kurtosis are positive, having a very high value for the return series of the official rates (226.84), interbank market rates (12.2091) and bureaux de change rates (8.46), thus points out that the returns distribution are leptokurtic. Furthermore, results of normality test conducted using the procedure proposed in Jarque and Bera (1987), indicate that the null hypothesis of normal distribution in all the exchange rates series is not true.

The results of serial correlation tests conducted using Ljung-Box Q statistic up to 12 lags (L-BO_{12}) indicate that the official exchange rate series are not serially correlated. The interbank market and bureaux de change exchange rates series, on the other hand, exhibit evidence of serial correlation. The existence of serial correlation in the exchange rates series of interbank market and bureaux de change provide impetus for estimation of autoregressive (AR) mean model.

The results of heteroscedasticity test conducted examine the presence of ARCH effect in the squared residuals of the mean equation of the official, interbank market and bureaux de change exchange rates are presented in Table 1. Notice from Table 1 that there is heteroscedasticity (i.e., ARCH effect) in interbank market and bureaux de change exchange rates, but no such evidence for the official exchange rate. The presence of heteroscedasticity in the series is a justification for the estimation of GARCH models. But absence of ARCH effect in the official exchange rate will exclude if from subsequent analysis using GARCH models

4.2. Stationarity test

Table 2 present the results of unit root tests performed on log-levels and returns series of the Naira/US$ official, interbank market and bureaux de change exchange rates using Augmented Dickey–Fuller (ADF) and Kwiatkowski, Phillips, Schmidt, and Shin (1992) (KPSS) tests. Notice that the ADF test statistic reject the null hypothesis of the

Table 2
Stationarity test results.

	Log-level Series				Return Series			
	ADF		KPSS		ADF		KPSS	
	c.val	t-stat	c.val.	t-stat.	c.val.	t-stat.	c.val.	t-stat.
OMR	–3.429	–1.601	0.146	0.856**	–3.429	–15.367**	0.146	0.053
IMR	–3.429	–2.202	0.146	0.575**	–3.429	–12.981**	0.146	0.061
BDC	–3.429	–2.327	0.146	0.618**	–3.429	–10.572**	0.146	0.055

Note: c.value id the 5% critical value of the ADF and KPSS, whereas the t-stat, is the computed value of the tests. OMR, IMR and BDC are the official market exchange rate, interbank exchange rate, and bureaux de change exchange rate in Nigeria, respectively.
** Denotes significant at the 1% level.

Table 3
Akaike Information Criterion (AIC) lag selection for the series.

Lags	0	1	2	3	4	5
ROMR	-4.831*	-4.822	-4.814	-4.806	-4.799	-4.790
RIMR	-7.851	-7.865*	-7.859	-7.850	-7.842	-7.839
RBDC	-7.526	-7.634*	-7.628	-7.622	-7.615	-7.614

Note: ROMR, RIMR, and RBDC are as defined on Table 1 above.
* Indicates the lag length chosen by Akaike Information Criterion (AIC).

existence of unit root in the returns series at 1% level of significance. This is evident in the absolute values of the ADF statistics for official (–15.367), interbank market (–12.981), and bureaux de change (–10.572) exceeding the 5% critical value of 3.429. Similarly, the results of the (KPSS) tests show that the level series are nonstationary, whereas their returns are stationary.

4.3. Lag analyses for the Naira/US$ exchange rates returns

Table 3 reports the Akaike information criterion (AIC) lag analysis for the Naira/US$ exchange rates return series. Rachev et al (2007:293) state that if the conditional mean is not specified adequately, then the construction of consistent estimates of the true conditional variance would not be possible and statistical inference and empirical analysis might be wrong. For this purpose, lags 0–5 of the AIC were estimated to select the appropriate autoregressive lag length. Notice from Table 3 that the return series of the official exchange rate, according to the AIC, do not require any lag, whereas the interbank market and bureaux de change exchange rates require autoregressive lag one (AR_I) model.

4.4. Results of GARCH models for the Naira/US$ exchange rates returns

Preliminary analyses of lag selection using AIC indicate that the Naira/US$ interbank market and bureaux de change exchange rates returns can be reasonably modeled with an AR(1) component for the mean equation, and GARCH (1,1) as well as GJR-GARCH(1,1) were selected for the variance equation. The results presented in Table 4 show that the coefficients for long-run average volatility are all significant at 1% for the interbank market and bureaux de change Naira /US$ exchange rates in Nigeria. The coefficients of ARCH parameters are also significant, at the 5% level, for the two exchange rates, suggesting that the volatility of exchange rates in the previous periods influence current volatility of exchange rates. Notice, however, that the magnitude of the ARCH coefficient for bureaux de change (0.197) is greater than that of the interbank market (0.163). This suggests that volatility of bureaux de change Naira/US$ exchange rates in the previous periods have more influence on current volatility of exchange rates than those of the interbank market.

Similarly, the GARCH coefficients are significant at the 5% level for both the interbank market and bureaux de change Naira/US$ exchange rates in Nigeria. Notice also that the magnitude of the GARCH coefficient for bureaux de change (0.649) is higher than that of the interbank market (0.335). This indicates evidence of more

Table 4
Results of AR(I)-GJR-GARCH(1.1) exchange rates model.

Coefficients	RIMR	RBDC
	Panel A: Conditional mean equation	
ϕ	0.0026	0.0028
	(1.7164)	(1.7374)
	[0.0860]	[0.00.823]
δ	0.4244	0.2558
	(5.1755)	(3.7224)
	[0.0000]	[0.0001]
	Panel B: Conditional Variance equation	
ω	0.0002	0.0001
	(4.8340)	(2.5661)
	[0.0000]	[0.0102]
$\alpha 1$	0.1637	0.1974
	(2.5736)	(1.9633)
	[0.0100]	[0.0496]
$\beta 1$	0.3359	0.6497
	(4.2684)	(4.7276)
	[0.00.001]	[0.0000]
γ	-0.8845	-0.2182
	(-2.1525)	(-1.9879)
	[0.0313]	[0.0468]
	Panel C: Standardized residuals diagnostics	
ARCH-LM (8)	0.057 [0.9940]	0.084 (0.9871)
Ljung-Box Q (24)	23.377 [0.4976]	27.144 (0.2977)
Ljung-Box Q^2 (24)	1.990 [0.9994]	2.708 (0.9827)
McLoed-Li(30)	2.8664 (1.000)	4.277 (1.000)

Note: LM is ARCH-LM test at lag 8:LB is Ljung-Box Q-statistic with lag 24 and Mcleod-Li test at 30 lags chosen by AIC. *P*-values are displayed as (.)/parenthesis and *t*-statistics are displayed as [.]/square. The LM tests are conducted under null hypothesis of no ARCH effect in the standardized residuals. Whereas the Ljung-Box Q and McL tests are conducted under the null hypotheses of no serial correlation in the standardized residual and squared standardized residual respectively. All the tests are conducted at 5% significant level.

volatility clustering in the bureaux de change Naira/US$ exchange rates than the interbank market. Evidence of volatility clustering in exchange rates has also been documented in earlier studies (See, Olowe, 2009; Abdalla, 2012; Marreh et al., 2014; Narsoo, 2015). The sum of $\alpha 1 + \beta 1$ shows the degree of persistence of volatility clustering, and ranges from 0 to 1 for weakly stationary volatility process. The closer the sum of $\alpha 1 + \beta 1$ to 1, the higher the persistence of volatility clustering. As shown in *Panel B* of Table 4, bureaux de change Naira/US$ exchange rates exhibit higher volatility persistence (0.85) than the interbank market (0.50).

Furthermore, the GJR-GARCH model estimates in *Panel B* of Table 4 also indicate that volatility of Naira/US$ exchange rates in both the bureaux de change market and the interbank market are asymmetric. These can be seen in the *p*-values coefficients of (0.046) and (0.031) for the bureaux de change market and the interbank market respectively, which are less than the significance level (0.05). The *t*-statistics of the asymmetric coefficients are equally greater than theoretical *t*-statistics. As highlighted in Section 3.1, positive (negative) coefficient indicate that negative (positive) shock tends to produce higher volatility in the immediate future than positive (negative) shocks. According to results presented in Table 4, the asymmetric coefficients are negative, indicating that increase in the Naira/US$ exchange rate tends to produce higher volatility in the immediate future than negative shock of the same magnitude. In other word, a appreciation in the Naira/US$ does not stimulate exchange rate volatility equal to a depreciation in the exchange rates. This finding, which implies that conditional volatility is more related to depreciating Naira/US$ exchange rates than otherwise, may explain why many Nigerian wants hold US dollar whenever there is a sustained depreciation in Naira/US$ exchange rates. CBN (2014) highlights the gradual dollarisation of the Nigerian economy with attendant adverse consequences on the conduct of monetary policy and subtle subversion of cashless policy initiative, as one of deficiencies of bureaux de change in Nigeria.

The findings of volatility clustering and volatility asymmetry are not surprising as similar evidence abound in literature. The findings of more volatility shock, clustering and persistence occurring in the bureaux de change than the interbank market exchange rate may not be far from the deficiencies in the operational effectiveness of bureaux de change in Nigeria (CBN, 2014). Before the introduction wholesale Dutch Auction System (WDAS) in 2006, there were about 74 bureaux de change in Nigeria. With the introduction WDAS and the subsequent admission of bureaux de change into the official market through direct dollar sale as well as allowing them to act as brokers in the interbank market, the number of bureaux de change exploded to about 3208 in June 2014, with 1417 applications awaiting CBN approval (Chidiebere, 2014). It is not difficult therefore to see that majority of the bureaux de change are not interested in achieving the objectives CBN has set but to widen margins and make huge profits from the foreign exchange market. Regardless of prevailing official and interbank rates. This may explain the higher volatility shock and clustering in the returns of bureaux de change Naira/US$ exchange rate in Nigeria.

One way to assess the adequacy of a GARCH model is to see how well it fits the data. This is measured using non-negativity constraints and weakly stationary condition of the symmetric GARCH process. In addition to providing good fit, the estimated standardized residuals should be serially uncorrelated and should not display heteroscedasticity (Emenike & Opara, 2014). From Table 4, notice that the estimates of the GARCH (1,1) parameters overcome the non-negativity constraints with as well as satisfy the weakly stationarity condition. Similarly, the results of the diagnostic tests displayed in *Panel C* of Table 4 show that null hypothesis of no heteroscedasticity in the standardized residuals of the interbank market and bureaux de change exchange rates volatility models cannot be rejected at the 5% significance level. The results of Ljung-Box Q and Ljung-Box Q^2 tests as well as the McLeod-Li test accept the null hypotheses of no serial correlations in the standardized residual and squared standardized residual of both the mean and variance models at the 5% significance level. There is therefore no serial correlation in the residuals and squared residuals of the estimated models. Consequently, GARCH (1,1) and GJR-GARCH (1,1) models are adequate to explain volatility of Naira/US$ exchange rates.

5. Summary and conclusions

The importance of stable exchange rate to sustainable development of an economy need not be overemphasised. Among the major roles of monetary authorities is to prevent divergence between the official exchange rates and parallel exchange rates in the economy. This paper modeled and compared the volatilities of Naira/US$ official market, interbank market and bureaux de change market exchange rates using GARCH (1,1) and GJR-GARCH (1,1) models for the period ranging from January 1995 to December 2014.

Univariate statistics show that exchange rates return series for all the markets are positively skewed with heavy tails. The Jarque-Bera statistics provide support for non-normality of the Naira/US$ exchange rates return series. Stationarity tests results show that all the exchange rates returns series are integrated of order one. Estimates from the ARCH parameter show that the exchange rates volatilities of interbank and bureaux de change markets in the previous periods influence current volatility of exchange rates but that the magnitude of influence is greater in the bureaux de change exchange rates. The coefficient of GARCH parameters indicate evidence of volatility clustering in the interbank market and bureaux de change Naira/US$ exchange rates in Nigeria but there is more volatility clustering in bureaux de change returns. Sum of the ARCH and GARCH coefficients indicates evidence of volatility persistence in the exchange rates return series. The asymmetric parameters indicate that exchange rates depreciation tends to produce higher volatility in the immediate future than appreciation of the same magnitude in the interbank market and bureaux de change Naira/US$ exchange rates in Nigeria.

These findings call for reconsideration of direct selling of foreign exchange to bureaux de change by the CBN. This will not be in tune with global practice where bureaux de change source foreign exchange from private sources but will reduce the avalanche of rent seeking bureaux de change operators who are interested in widening margins and profits from the foreign exchange market, regardless of prevailing official and interbank rates.

References

Abdalla, S. Z. S. (2012). Modelling exchange rate volatility using GARCH models: Empirical evidence from Arab countries. *International Journal of Economics and Finance, 4*(3), 216–229.

Aghion, P., Bacchetta, P., Ranciere, R., & Rogoff, K. (2009). Exchange rate volatility and productivity growth: The role of financial development. *Journal of Monetary Economics, 56*(4), 494–513.

Berndt, E. K., Hall, B. H., Hall, R. E., & Hausman, J. A. (1974). Estimation and inference in nonlinear structural models. *Annals of Economic and Social Measurement, 3&4*, 653–665.

Bollerslev, T. (1986). A generalized autoregressive conditional heteroscedasticity. *Journal of Econometrics, 31*, 307–327.

Central Bank of Nigeria. (2014). *New requirements for the operation of bureau de change in nigeria*. Abuja: Central Bank of Nigeria Publishers.

CBN. *Further liberalization & development of the foreign exchange market*. Retrieved from. http://www.cenbank.org/IntOps/.

CBN. *Exchange rate policy*. Retrieved from. http://www.cenbank.org/IntOps/ExchRatePolicy.asp.

Chidiebere, N.. *BDCs' recapitalization: CBN's masterstroke* Retrieved from http://sunnewsonline.com/new/bdcs-recapitalization-cbns-masterstroke/.

Emenike, K. O., & Aleke, S. F. (2012). Modeling asymmetric volatility in the Nigerian stock exchange. *European Journal of Business and Management, 4*(12), 52–60.

Engle, R. F. (1982). Autoregressive conditional heteroscedasticity with estimates of the variance of the United Kingdom inflation. *Econometrica, 50*, 987–1008.

Engle, R. F. (2003). Risk and volatility: Econometric models and financial practice. *Noble Lecture*.

Glosten, L., Jagannathan, R., & Runkle, D. (1993). On the relation between expected return on stocks. *Journal of Finance, 48*, 1779–1801.

Gujarati, D. N. (2003). *Basic econometrics* (4th ed). Delhi: McGraw Hill Inc.

Hericourt, J. & Poncet, S. (2012). Exchange rate volatility, financial constraints, and trade: Empirical evidence from Chinese firms. CEPII Working Paper No. 35. Retrieved from www.cepii.fr/PDF_PUB/wp/2012/wp2012-35.pdf.

Hsieh, D. A. (1989). Modeling heteroscedasticity in daily foreign exchange rates. *Journal of Business & Economic Statistics, 7*(3), 307–317.

Jarque, C. M., & Bera, A. K. (1987). A test for normality of observations and regression residuals. *International Statistical Review, 55*, 163–172.

Kamal, Y., Haq, H. U., Ghani, U., & Khan, M. M. (2012). Modeling the exchange rate volatility, using generalized autoregressive conditionally heteroscedastic (GARCH) type models: Evidence from Pakistan. *African Journal of Business Management, 6*(8), 2830–2838.

Kwiatkowski, D., Phillips, P. C. B., Schmidt, P., & Shin, Y. (1992). Testing the null hypothesis of stationarity against the alternative of a unit root: How sure are we that economic time series have a unit root? *Journal of Econometrics, 54*, 159–178.

Marreh, S., Olubusoye, O. E., & Kihoro, J. M. (2014). Modeling volatility in the Gambian exchange rates: An ARMA-GARCH approach. *International Journal of Economics & Finance, 6*(9), 118–128.

Narsoo, J. (2015). Forecasting USD/MUR exchange rate dynamics: An application of asymmetric volatility models. *International Journal of Statistics and Applications, 5*(5), 247–256.

Omojimite, B. U., & Akpokodje, G. (2010). A comparative analysis of the effect of exchange rate volatility on exports in the CFA and non-CFA countries of Africa. *Journal of Social Sciences, 24*(1), 23–31.

Olowe, A. R. (2009). Modeling naira/dollar exchange rate volatility: Application of GARCH and asymmetric models. *International Review of Business Research Papers, 5*(3), 377–398.

Opara, C. C., Emenike, K. O., & Ani, W. U. (2015). Behaviour of Nigeria financial market indicators: Evidence from descriptive analysis. *American Journal of Economics, Finance and Management, 1*(5), 421–429.

Rachev, S. T., Mittnik, S., Fabozzi, F. J., Focardi, S. M., & Jasic, T. (2007). *Financial Econometrics: from basics to advanced modeling techniques*. New Jersey: John Wiley & sons Inc.

Taiwo, O., & Adesola, O. A. (2013). Exchange rate volatility and bank performance in Nigeria. *Asian Economic and Financial Review, 3*(2), 178–185.