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Modelling Nigeria Naria Exchange Rate against Some Selected Country's Currencies Volatility: Application of GARCH Model

Ajayi Abdulhakeem[1], Samuel Olorunfemi Adams[1*] and Rafiu Olayinka Akano[1]

[1]Department of Statistics, University of Abuja, Nigeria.

Authors' contributions

This work was carried out in collaboration among all authors. Author SOA designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors AA and SOA managed the analyses of the study. Author ROA managed the literature searches. All authors read and approved the final manuscript.

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Abstract

This paper examines the exchange rate volatility with GARCH-type model of the daily exchange rate return series from January 2012 – August 2016 for Naira/Chinese Yuan, Naira/India Rupees, Naira/Spain Euro, Naira/UK Pounds and Naira/US Dollar returns. The studies compare estimates of variants of GARCH (1, 1), EGARCH (1, 1), TGARCH (1,1) and GJR-GARCH (1,1) models. The result from all models indict presence of volatility in the five currencies and equally indicate that most of the asymmetric models rejected the existence of a leverage effect except for models with volatility break. For GARCH (1, 1), GJR-GARCH (1, 1,) EGARCH (1,1) and TGARCH (1, 1), it was observed that India have the best exchange rate with the highest log-likelihood (Log L) and the lowest AIC and BIC followed by USA, China, Spain and United Kingdom respectively. The four models was later compared for the exchange rates of the five countries under consideration i.e. China, India, Spain, UK and USA to select the best fitted model for each country and it was discovered that GJR-GARCH (1,1) is the best fitted model for all the countries followed by GARCH (1,1), TGARCH (1,1) and EGARCH (1,1) in that order.

Keywords: EGARCH; exchange rate; foreign exchange; GARCH; GJR-GARCH; volatility and TGARCH.

**Corresponding author: E-mail: samuel.adams@uniabuja.edu.ng;*

1 Introduction

Exchange rate policy in Nigeria has gone through many changes spanning between two major regimes. These are fixed and flexible exchange rate systems was adopted between 1960 and 1986, while the flexible exchange rate system remains in use from 1986 till date having undergone series of modification. A number of factors have contributed to the dwindling fortunes of the naira in all the foreign exchange markets. Some of them are fundamental while others are secondary [1] The fundamental factors emanate from structural imbalances relating to: Weak production base and undiversified nature of the economy, import-dependent production structure, fragile export base and weak non-oil export earnings, fiscal imbalances and accommodating monetary policy or expansionary fiscal and monetary policies, sluggish foreign capital inflow, phenomenon of excess demand for foreign exchange in relation to supply, instability of earnings from crude oil, upon which the economy depends very heavily unguided trade liberalisation policy speculative activities and sharp practices of authorized foreign exchange dealers, for example, round tripping in the foreign exchange market.

The exchange rate and its volatility are key factors that influence economic activities in Nigeria. That is why foreign exchange (FX) market fluctuations have always attracted considerable attention in both the economics and statistics literature. The country has adopted a fixed exchange rate regime supported by exchange control regulations that engendered significant distortions in the economy since before the introduction of structural adjustment programme in Nigeria in 1986 by the Babangida regime. The fixed exchange rate period was also characterised by sharp practices perpetrated by dealers and end-users of foreign exchange [2]. The country also depends heavily on imports from various countries as most industries in Nigeria import their raw materials from foreign countries. Apart from raw materials, there were massive importation of finished goods with the adverse consequences for domestic production, balance of payments position and the nation’s external reserves level, [2]. The foreign exchange market in the fixed exchange rate period was characterized by high demand for foreign exchange which cannot be adequately met with the supply of foreign exchange by the Central Bank of Nigeria (CBN). The inadequate supply of foreign exchange by the CBN promoted the parallel market for foreign exchange and created uncertainty in foreign exchange rates. The introduction of SAP in Nigeria in September 1986 which deregulated the foreign exchange market led to the introduction of market determined exchange rate, managed floating rate regime. The CBN usually intervene in foreign exchange market through its monetary policy actions and operations in the money market to influence the exchange rate movement in the desired direction such that ensures the competitiveness of the domestic economy. This introduction of managed floating rate regime tends to increase the uncertainty in exchange rates, thus, increasing the volatility of exchange rate by the regime shifts. This made the exchange rate to be the most important asset price in the economy. The *Naira,* like other key currencies, has experienced volatility especially following the liberalization of the FX market in the mid–1980s. As a result, volatility in the FX market tends to be high when supply, demand, or exogenous forces contribute large random shocks to the currency market. Therefore, volatility in the exchange rate of a currency is a reflection of different activities revolving around that currency, either domestically or internationally [3].

Exchange rate can either appreciate or depreciate. Appreciation in the exchange rate occurs if less unit of domestic currency exchanges for a unit of foreign currency while depreciation in exchange rate occurs if more unit of domestic currency exchanges for a unit of foreign currency.

Exchange rate can be measured in two ways: the nominal exchange rate and the real exchange rate. The nominal exchange rate is the number of unit of domestic currency that must be given up to get a unit of foreign currency, whereas real exchange rate is inflation adjusted exchange rate. Exchange rate volatility as the risk associated with the unexpected movement in the exchange rate. In other word, it is the risk associated with currency depreciation or appreciation. The role of exchange rates and its volatility on macroeconomic performance has continued to generate interest among international finance scholars. Many of the scholars argue that exchange rate stability facilitates production activities and economic growth. The importance of appropriate exchange rate policy to stability of the economy need not be overemphasised. [4] were of the opinion that Nigeria practiced a fixed exchange rate, when the Naira was pegged against the

British pound and later on the American dollar. However, with the collapse of the Bretton Wood institutions, a flexible exchange rate policy was adopted, and the Nigerian exchange rate was allowed to float, with its value relative to the US dollar determined by market forces of demand and supply. Some of the policies employed to ensure exchange rate stability included among others: Second-Tier Foreign Exchange Market (SFEM), Autonomous Foreign Exchange Market (AFEM), Inter-bank Foreign Exchange Market (IFEM), the enlarged Foreign Exchange Market (FEM), and the Dutch Auction System (DAS). It is pertinent to mention here that the inability and failure of individual policy to achieve stability in the exchange rate led to the adoption of another. Despite various efforts by government to maintain exchange rate stability in the last two decades, the Naira continued to depreciate against the American dollar. For example, the Naira appreciated against the US dollar from N0.7143 in 1970 to N0.6159 in 1975 and further to N0.5464 in 1980. However, the exchange rate depreciated throughout the 1980s. For instance, the naira depreciated from 0.6100 Naria in 1981 to 2.0206 Naria in 1986 and further to 8.0378 Naria in 1990. Although the exchange rate became relatively stable in the mid-1990s, it depreciated further to 102.1052 Naria, 120.9702 Naria, and 133.5004 Naria in 2002, 2002, 2004; respectively. Thereafter, the exchange rate appreciated to 132.147 Naria, 128.6516 Naria, 117.968 Naria, 180.00 Naria and 360.00 Naria in 2005, 2006, 2007, 2010 and 2015, respectively.

The main objective of this paper is to model the exchange rate volatility of Nigeria Naira against Chinese Yuan, India Rupees, Spain Euro, UK Pounds and US Dollar returns using GARCH, EGARCH, TGARCH and GJR-GARCH models. The review of related Literatures are discussed in section 2. Section 3 presents the material and methods of the study. Section 4 presents the results generated via a simulation study, and finally, the conclusion and recommendations are presented in section 5.

2 Literature Review of Exchange Rate Volatility

Exchange rate is a key price variable in an economy and perform dual role of maintaining international competitiveness, and serving as nominal anchor for domestic prices. It is therefore, defined as the price of one currency Vis -a-Vis another and is the number of units of currency. The debate on exchange rate management has preoccupied Statisticians and public sector managers for a very long time. This transcended the collapse of the gold standard in the 1930s to the emergence of the Bretton Wood system of adjustment peg from the 1940s, through the adoption of a flexible exchange rate regime by developing economics in the 1970s and those undergoing structural reforms in the 1980s, as well as in the aftermath of the currency crises in emerging economics in the 1990s. Besides factors such as market opportunity, political risks and the legal environment, business entities take exchange rate into consideration in making investment decisions. The focus has always been on the volatility of exchange rates in the foreign exchange market and in its impact on business outcomes [5].

Olowe R. O. [6] investigated the volatility of Naira/Dollar exchange rates in Nigeria using GARCH (1,1), GJR-GARCH(1,1), EGARCH(1,1), APARCH(1,1), IGARCH(1,1) and TS-GARCH(1,1) models. The result is the same for the fixed exchange rate period and managed float rate regime. The results from all the asymmetry models rejected the hypothesis of leverage effect. The APARCH model and GJR-GARCH model for the managed floating rate regime show the existence of statistically significant asymmetry effect. The TSGARCH and APARCH models are found to be the best models. [7], compared the effect of exchange rate volatility on the exports of the panel of Communaute Financiere Africaine (CFA) countries with that of the non-CFA counterparts during the period 1986-2006. Exchange rate volatility was found to negatively impinge on the exports of both panels of countries. However, exchange rate volatility has a larger effect on the panel of the non-CFA countries than on the CFA. They conclude on the need to take appropriate monetary and fiscal policy actions to stem the rising exchange rate volatility. [8] investigates the effect of exchange rate movements on real output growth in Nigeria. The estimation results suggest that there is no evidence of a strong direct relationship between changes in exchange rate and output growth. [9] proposed GARCH (Generalized Auto-Regressive Conditional Heteroskedasticity) model to analyze the volatility of stock price. The results show that the volatility of web news events and public attitudes are suitable to GARCH model by some adjusting and test of parameters. [10] describes methods for choosing and assessing volatility forecasts using open, high, low and close prices. Results for DM/Dollar futures prices at the IMM in Chicago from 1977 to 1983 show high and low prices are valuable when seeking accurate volatility forecasts. The best forecasts are a weighted average of present and past high, low and close prices, with adjustments for weekend and holiday effects. [11], examines the relation between dollar-real exchange rate volatility implied in option prices and subsequent realized volatility using GMM estimation consistent with telescoping observations evidence suggests that implied volatilities give superior forecasts of realized volatility if compared to GARCH (p,q), and Moving Average predictors, and that econometric models forecasts do not provide significant incremental information to that contained in implied volatilities.

Meese and Rogoff [12] compares the out of sample forecasting accuracy of various structural and time series exchange rate models of twelve month horizons for dollar/mark, dollar/yen and trade weighted dollar exchange rate. The structural models performed poorly despite the fact that the forecast was based on actual realized values of future explanatory variables. [13], applies univariate nonlinear time series analysis to the daily (TZS/USD) exchange rate data spanning from January 4, 2009 to July 27, 2015 to examine the behavior of exchange rate in Tanzania, it also employs exponential GARCH (EGARCH) model to capture the asymmetry in volatility clustering and the leverage effect in exchange rate. The paper reveals that exchange rate series exhibits the empirical regularities such as clustering volatility, nonstationarity, non-normality and serial correlation that justify the application of the ARCH methodology. [14], studied the performance of GARCH model and its modifications, using the rate of returns from the daily stock market indices of the Kuala Lumpur Stock Exchange (KLSE) including Composite Index, Tins Index, Plantations Index, Properties Index, and Finance Index. The models are stationary GARCH, unconstrained GARCH, non-negative GARCH, GARCH-M, exponential GARCH and integrated GARCH. It was observed that, among the models, even though exponential GARCH is not the best model in the goodness-of-fit statistics, it performs best in describing the often-observed skewness in stock market indices and in out-of-sample (one-step-ahead) forecasting.

3 Materials and Methods

3.1 Source of data

The time series data used in this study consists of the daily exchange rate return from January 2012 – August 2016 for Naira/Chinese Yuan, Naira/India Rupees, Naira/Spain Euro, Naira/UK Pounds and Naira/US Dollar returns obtained Central Bank of Nigeria Statistical Bulletin 2017. The methodology employed in this study include; GARCH (1, 1), EGARCH (1, 1), TGARCH (1,1) and GJR-GARCH (1,1) models which proved to be very successful in predicting volatility changes, financial and economic.

3.2 Autoregressive conditional heteroskedasticity model (ARCH)

Return of an asset. Engle created the first heteroskedastic model in 1982 to capture the movements of the Inflation rate in UK [15]. Because of the characteristics of the volatility for any financial time series the ARCH model is built on two assumptions. The first assumption is that high volatility appears in clusters and therefore the movement of the assets return is dependent on the previous values but for the whole time series it's uncorrelated. The second assumption is that the distribution of the asset returns ($a!$) can because of its dependence with the previous values be explained by a quadratic function of the former lagged values. The model is built on the information set that exists at time *t-1*. The conditional variance depends on the previous n lagged innovations:

The ARCH (n) model becomes:

$$\sigma_t^2 \ = \ \omega + \alpha(L)\varepsilon_t^2 \ + \ \beta(L)\sigma_t^2 \tag{1}$$

Where; $\alpha(L) \ = \alpha_1(L) + \alpha_2(L) + \ldots + \alpha_q L^q, \beta(L) \ = \beta_1(L) + \beta_2(L) + \ldots + \beta_q L^q$

In the equation it can be seen that large values of the innovation of asset returns has a bigger impact on the conditional variance because they are squared, which means that a large shock have tendency to follow the other large shock and that is the same behaviour as the clusters of the volatility.

3.3 Generalized autoregressive conditional heteroskedasticity (GARCH) model

Bollerslev T [15] recommend a transformation of the ARCH model, to a generalized ARCH model (GARCH), this is in the ARCH model there is several restrictions that has to be fulfilled so that the model can sufficiently estimate the volatility, which can be a problem. The GARCH model is give as;

$$\sigma_t^2 = \omega + \alpha(L)\varepsilon_t^2 + \beta(L)\sigma_t^2$$

$$\sigma_t^2 = \left(1 - \sum_{i=1}^{p} \beta_i L_i\right)^{-1} \left[\omega + \sum_{j=1}^{q} \alpha j \varepsilon_{t-j}^2\right]$$

$$\sigma_t^2 = \omega^* + \textstyle\sum_{k=0}^{\infty} \emptyset_k \varepsilon_{t-k-1}^2 \tag{2}$$

Where; $\sigma_t^2 \geq 0, if\ \omega^* \geq 0$ and $\emptyset_k \geq 0$. The non-negative of $\omega^*$and $\emptyset_k$is also a necessary condition for the non-negativity of σ_t^2, for $\omega^*\ e\ \{\emptyset_k\}_{k=2}^{\infty}$ to be well defined.

3.4 Exponential GARCH model (EGARCH)

Nelson D. B. [16], the exponential GARCH model (EGARCH) (Nelson, 1991). The change he proposed was that there should be a weighed invention to the model that should allow for the unequal changes of the volatility in the return of the asset.

Letting a_t be the innovation of the asset return at time t, and then the EGARCH (m, s) model can be written as:

$$In\left(\sigma_t^2\right) = \omega + \sum_{t=1}^{s} \alpha_i \frac{\left|a_{t-i}\right| + \theta_i a_{t-i}}{\sigma_{t-i}} + \sum_{j=1}^{n} \beta_j In\left(\sigma_{t-1}^2\right) \tag{3}$$

In which, EGARCH (1, 1) is written as

$$\begin{gathered} a_t = \sigma_t \in_t, \\ In\left(\sigma_t^2\right) = \omega + \alpha\left(\left[\left|a_{t-1}\right| - E\left(\left|a_{t-1}\right|\right)\right]\right) + \theta a_{t-1} + \beta In\left(\sigma_{t-1}^2\right) \end{gathered} \tag{4}$$

where $\in_t$ and $\left|a_{t-1}\right| - E\left(\left|a_{t-1}\right|\right)$ are iid and have mean zero.

3.5 Threshold GARCH model (TGARCH)

Threshold GARCH (TGARCH) model was created by [17] and [18] said the idea behind TGARCH is that it captured better the movements of the negative shocks, due to the fact that they have a bigger effect on the volatility than the positive shocks have [19]. The model is given as;

$$\sigma_t^2 = \omega + n\sum_{i=1}^{m}\left(\alpha_1 + \gamma_{\mathrm{i}} N_{t-1}\right)\sigma_{t-1}^2 + \sum_{j=1}^{s}\beta_j \sigma_{t-1}^2 \tag{5}$$

Where; α_i , γ_i and β_j are positive parameters which has the same properties as the GARCH models parameters.

TGARCH (1, 1) is written as;

$$\sigma_t^2 = \omega + (\alpha + \gamma N_{t-1})\sigma_{t-1}^2 + \beta_j \sigma_{t-1}^2 \quad (6)$$

Where; $\beta_j \neq 0, j = 1, \ldots, q$

4 Results and Discussion

The volatility test on exchange rate of the five countries under consideration.

Table 1. Descriptive statistics measure

Descriptive measure	China	India	Spain	UK	USA
Min	23.53	2.43	187.37	230.87	154.25
Max	52.37	5.18	367.43	426.94	324.50
Range	28.84	2.75	367.43	426.94	170.25
Sum	31784.39	3391.63	244972.80	307646.76	199422.34
Median	25.36	2.91	208.75	254.72	155.30
Mean	27.66	2.95	213.21	267.75	173.56
Var	21.076	0.153	680.35	1154.90	1002.45
Std. Dev.	4.591	0.3914	26.08	33.98	31.66

The result obtained shows that the mean of the series are 240.23, 2.95, 213.21, 267.75and 173.56 for China, India, Spain, UK and USA respectively, with the median values of 25.36, 2.91,208.75, 254.72 and 155.30 in that order and the standard deviation of China which is 7205.12, India is 39.14 , Spain with 26.08, UK with 33.98 and USA is 6.959.

Fig. 1 shows the trend of the exchange rate of China where a shock was notice before the first 200 days and parallel constant movement from the very first day of 3rd of January 2012 to the 1149 end date of 31st august 2016 shows that the trend is totally stationary. Fig. 2 shows India exchange rate where there is gradual constant movement from the very first day to over 400 days , with a little rise around day 825 to 850 and later a suddenly rise after 1000 days, and later fall which shows that the trend is not stationary. Fig. 3 shows the trend of Spain exchange rate where there is fluctuation from the very first day and a break occurs around day 800 and continued with the fluctuation to over 1000 days with a suddenly rise around 1130 day, which indicate that the trend is not stationary. Fig. 4 shows the trend of United Kingdom (UK) exchange rate starting with a constant fluctuation where a break occurs around day 800 with a slight increase, with another break around day 1135. It also shows that Spain exchanges rate is not fully stationary. Fig. 5 shows the trend of USA exchange rate where it was notice that there is gradual constant from very first day to over 700 days, later with a little rise around day 725. Two breaks occurs around one before day 800 and the other after day 1100 after which a slight increase occurred which shows that the trend is not stationary.

Table 2 presents the unit root tests results of the exchange rates in of Nigeria against China, India, Spain, United Kingdom and United States of America. ADF (Augmented Dickey-Fuller) tests the null hypothesis of unit roots is rejected in the exchange rates of China, India, and USA but accepted for both Spain and UK. ERST (Elliot-Rothenberg-Stock) tests shows that the null hypothesis of unit roots is rejected in the exchange rates of all the countries under consideration. KPSS tests, indicts that the null hypothesis of unit roots was accepted in the exchange rate of china but rejected in India, Spain, UK and USA. Phillips-Perron (PP) tests indicated that the null hypothesis of unit roots is rejected in the exchange rates of Spain and India and was accepted for China, UK and USA.

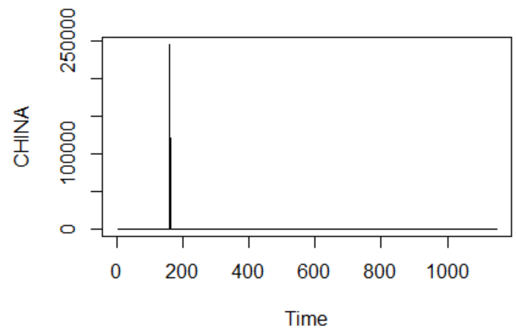

Fig. 1. Trend of china exchange rate

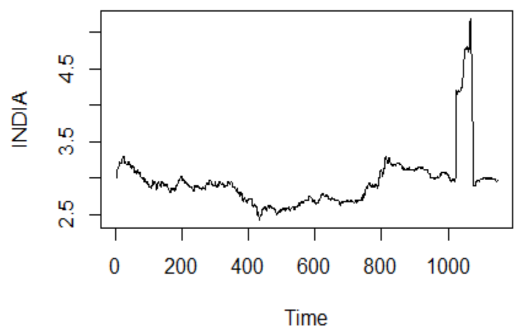

Fig. 2. Trend of India exchange rate

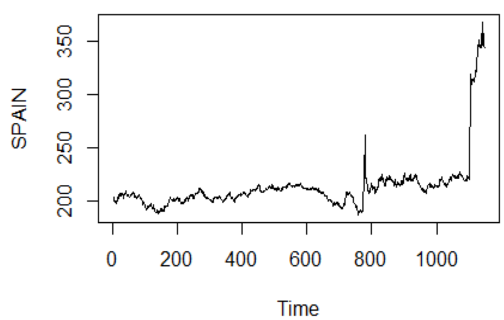

Fig. 3. Trend of Spain exchange rate

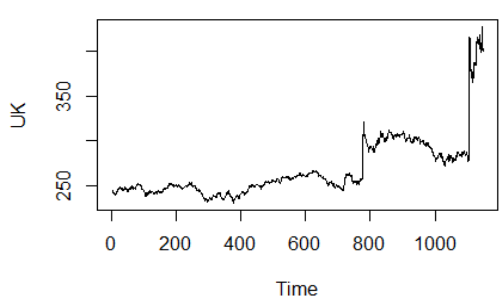

Fig. 4. Trend of UK exchange rate

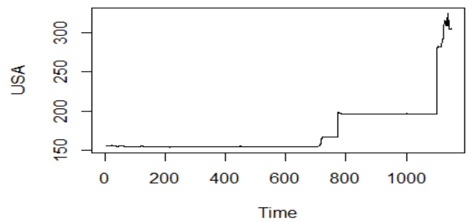

Fig. 5. Trend of USA exchange rate

Table 2. Unit root tests on exchange rate

Country	ADF	ERST	KPSS	PP
China	-23.913	-15.0964	0.2123	-1146.311
India	-0.4108	-3.2389	2.9035	-19.9987
Spain	1.2901	1.237	4.1081	3.0242
UK	-0.4108	0.614	8.5533	-1.2316
USA	1.7887	2.2039	8.1108	-1.1925

Table 3. Parameter estimates of GARCH models for Naira/Yuan exchange rate

Parameter	GARCH (1,1)	EGARCH (1,1)	TGARCH(1,1)	GJR-GARCH (1,1)
ω	0.0005	0.0196 (0.0002)	0.0192 (0.0055)*	0.0005
α	0.7696		0.5860 (0.0784)*	0.7380 (0.0323)*
γ			-0.0431 (0.0300)	-0.0268 (0.0268)
β	0.3052 (0.0251)*		0.3962 (0.0850)*	0.3133 (0.0230)*
σ		0.9909 (0.0003)		
δ		0.4575 (0.0004)		
ν		-0.6478 (0.0003)		
Log L likelihood	-1494.418	-5365.825	-1462.908	-1427.938
Persistence	0.9000		0.8800	0.9010
AIC	2.4933		2.5551	2.4942
BIC	2.5109	9.3768	2.5771	2.5162
SIC	2.4933		2.5551	2.4942
HQIC	2.5000		2.5634	2.5025
N	1149	1149	1149	1149

*Notes: Standard errors are in parentheses. * indicates significant at the 5% level. Log L, AIC, SIC, HQIC, and N are the maximum log-likelihood, Alkaike Information Criterion, Schwarz information Criterion, Hannan-Quinn information criterion and Number of observations respectively*

For Naria/Yuan; β parameter is significant, γ coefficient is asymmetry and leverage effects are negative and statistically significant at 5% level in TGARCH (1, 1), and GJR-GARCH (1, 1) model. GJR-GARCH and TGARCH models show the existence of statistically significant asymmetry effect. This shows that the impact of change on the Naira/Yuan depends on the choice of the model, this implies that EGARCH (1, 1) model coefficient is highly significant.

Table 4. Parameter estimates of GARCH models for Naira/Rupees exchange rate

Parameter	GARCH (1,1)	EGARCH (1,1)	TGARCH	GJR-GARCH
ω	0.0003	0.0475	0.0098	0.0003
	(0.00002)*	(0.0009)	(0.0012)*	(0.0000)*
α	0.9990		0.9990	0.9990
	(0.0434)*		(0.0276)*	(0.0436)*
γ			-0.0567	-0.0451
			(0.0237)*	(0.0219)*
β	0.0000		0.0000	0.0000
	(0.0013)		(0.0053)	(0.0013)
σ		0.8869		
		(0.0012)		
δ		0.5520		
		(0.0019)		
ν		-0.8400		
		(0.0006)		
Log L	671.8774	-2858.4602	660.2263	673.9925
Persistence	0.9	0.880	0.880	0.901
AIC	-1.1625	-	-1.1405	-1.1645
BIC	-1.1450	5.0124	-1.1186	-1.1425
SIC	-1.1626	-	-1.1406	-1.1645
HQIC	-1.1559	-	-1.1322	-1.1562
N	1149	1149	1149	1149

*Notes: Standard errors are in parentheses. * indicates significant at the 5% level. Log L, AIC, SIC, HQIC, and N are the maximum log-likelihood, Alkaike Information Criterion, Schwarz information Criterion, Hannan-Quinn information criterion and Number of observations respectively*

For Naria/Rupees; the δ and α parameter are significant while β is not significant. For TGARCH (1, 1) and GJR-GARCH (1, 1), all the parameter estimated are significant except beta which is not significant. GARCH (1, 1), TGARCH (1, 1) and GJR-GARCH (1, 1) show some level persistence in the 0.9, 0.880 and 0.901 respectively. The EGARCH (1, 1) model is covariance stationary since σ is 0.8869 and ($\sigma < 1$) implies stability, ω of 0.0475 is the unconditional or long-term log volatility, δ of 0.5520 indicate the ARCH parameter and ν is -0.8400 is the leverage or volatility-asymmetry parameter of the Naira/Rupees returns rate, this implies that the EGARCH (1, 1) model coefficient is highly significant.

For Naria/Dollars; α is significant while the δ and β are not significant. For TGARCH (1, 1), all parameters are significant except for δ. In GJR-GARCH (1, 1), only α and γ are significant. GARCH (1, 1), TGARCH (1, 1) and GJR-GARCH show some level of persistence in the 0.9, 0.8798 and 0.901 respectively. The EGARCH (1, 1) model is covariance stationary since σ is 0.9999 ($\sigma < 1$), implies stability, ω of 0.0213 is the unconditional or long-term log volatility, δ of 0.1709 indicate the ARCH parameter and ν which is -0.5818 is the leverage or volatility-asymmetry parameter of Naira/Dollars returns rate, EGARCH (1, 1) model coefficient is highly significant.

For Naria/Euros; all the parameter estimated for GARCH (1, 1) and GJR-GARCH are significant except β which is not significant, all the parameter estimated for TGARCH (1, 1) were significant, GARCH (1, 1), TGARCH (1, 1) and GJR-GARCH (1, 1) show some level persistence in the order 0.9, 0.901 and 0.8798 respectively, EGARCH (1, 1) model is covariance stationary since σ of 0.9706 and ($\sigma < 1$), implies stability, ω is -0.0018 which is the unconditional or long-term log volatility, δ of -0.1300 indicate the ARCH parameter and ν is -0.3655 implies the leverage or volatility-asymmetry parameter of the Naira/Euro returns rate, this implies that the EGARCH (1, 1) model coefficient is highly significant.

Table 5. Parameter estimates of GARCH models for Naira/Dollars exchange rate

Parameter	GARCH (1,1)	EGARCH (1,1)	TGARCH	GJR-GARCH
ω	0.0020	0.0213	0.0101	0.0022
	(0.0364)	(0.0004)		
α	1.0000		0.2673	0.2661
	(0.0596)*		(0.0111)*	(0.0237)*
γ			0.0516	-0.9999
			(0.0054)*	(0.0933)*
β	0.0000		0.6833	0.0000
			(0.0138)*	(0.0024)
σ		0.9999		
		(0.0006)		
δ		0.1709		
ν		(0.0009)		
		-0.5818		
Log L	-1340.658	-7202.517	-1459.913	-1331.466
Persistence	0.9		0.8798	0.901
AIC	2.3406		2.5499	2.3263
BIC	2.3581	12.5738	2.5719	2.3483
SIC	2.3405		2.5499	2.3263
HQIC	2.3472		2.5582	2.3346
N	1149	1149	1149	1149

*Notes: Standard errors are in parentheses. * indicates significant at the 5% level. Log L, AIC, SIC, HQIC, and N are the maximum log-likelihood, Alkaike information Criterion, Schwarz information Criterion, Hannan-Quinn information criterion and Number of observations respectively*

Table 6. Parameter estimates of GARCH models for Naira/Euro exchange rate

Parameter	GARCH (1,1)	EGARCH (1,1)	TGARCH	GJR-GARCH
ω	0.9693	-0.0018	0.2437	1.0187
	(0.0728)*	(0.0006)	(0.0592)*	(0.0592)*
α	0.9999		0.7389	0.9999
	(0.0972)*		(0.0646)*	(0.0646)*
γ			-0.0745	-0.0283
			(0.0233)*	(0.0233)*
β	0.0634		0.2952	0.0512
	(0.0752)		(0.0634)*	(0.0634)
σ		0.9706		
		(0.0007)		
δ		-0.1300		
		(0.0008)		
ν		-0.3655		
		(0.0025)		
logL	-3819.468	-7138.3022	-3821.062	3818.746
Persistence	0.9		0.8798	0.901
AIC	6.6553		6.6598	6.6598
BIC	6.6729	12.4620	6.6818	6.6818
SIC	6.6553		6.6598	6.6598
HQIC	6.6619		6.6681	6.6681
N	1149	1149	1149	1149

*Notes: Standard errors are in parentheses. * indicates significant at the 5% level. Log L, AIC, SIC, HQIC, and N are the maximum log-likelihood, Alkaike information Criterion, Schwarz information Criterion, Hannan-Quinn information criterion and Number of observations respectively*

Table 7. Parameter estimates of GARCH models for Naira/Pounds exchange rate

	GARCH (1,1)	EGARCH (1,1)	TGARCH (1,1)	GJR-GARCH (1,1)
ω	0.7542	0.0271	0.5372 (0.0769)*	0.7596
α	1.0000 (0.0481)*	-	0.9644 (0.0688)*	1.0000 (0.0335)*
γ	-	-	-0.0424 (0.0256)	-0.0311 (0.0143)*
β	0.0045 (0.0390)	-	0.0000 (0.0663)	0.0000 (0.0199)
σ	-	0.9956 (0.0004)	-	-
δ	-	0.6488 (0.0001)	-	-
ν	-	0.6957 (0.0004)	-	-
Log L	-4375.55	-8058.57	-4379.61	-4374.55
Persistence	0.9	-	0.8798	0.901
AIC	-7.6232	-	7.6320	7.6232
BIC	-7.6408	14.0639	7.6540	7.6452
SIC	-7.6232	-	7.6320	7.6232
HQIC	-7.6299	-	7.6403	7.6315
N	1149	1149	1149	1149

*Notes: Standard errors are in parentheses. * indicates significant at the 5% level. Log L, AIC, SIC, HQIC, and N are the maximum log-likelihood, Alkaike information Criterion, Schwarz information Criterion, Hannan-Quinn information criterion and Number of observations respectively*

Table 8. Comparing the GARCH (1, 1), EGARCH (1, 1), TGARCH (1, 1) AND GJR-GARCH (1, 1) models for the exchange rate

Model	Selection Criterion	China	India	Spain	UK	USA
GARCH(1,1)	Log-likelihood	-1427.94	671.8774	-3819.47	-4375.55	-1340.69
	AIC	2.4933	-1.1625	6.6553	7.6232	2.3406
	BIC	2.5109	-1.1450	6.6779	7.6408	2.3581
EGARCH(1,1)	Log-likelihood	-5365.83	-2858.46	-7138.30	-8058.57	-7202.52
	AIC	-	-	-	-	-
	BIC	9.3768	5.0124	12.4620	14.0639	12.5738
GJR-GARCH(1,1)	Log-likelihood	-1427.93	673.9925	-3818.746	-4374.55	-1331.47
	AIC	2.4942	-1.1645	6.6558	7.6232	2.3263
	BIC	2.5162	-1.1425	6.6777	7.6452	2.3483
TGARCH(1,1)	Log-likelihood	-1462.91	660.2263	-3821.062	-4379.61	-1459.91
	AIC	2.5551	-1.1405	6.6598	7.6320	2.5499
	BIC	2.5771	-1.1186	6.6817	7.6540	2.5719

For Naria/Pounds; all the parameter estimated for GARCH (1, 1) were insignificant except only α. For TGARCH (1, 1), omega and α is significant and for GJR-GARCH (1, 1), alpha and gamma parameters are significant. This shows that the impact of change on the Naira/Pounds also depends on the choice of the model. The GARCH (1, 1), TGARCH (1, 1) and GJR-GARCH (1, 1) show some level of persistence in the order 0.9, 0.8798 and 0.901 respectively. The EGARCH (1, 1) model is covariance stationary since σ of 0.9956 which is the GARCH parameter ($\sigma < 1$, implies stability), ω of 0.0271 the unconditional or long-term log volatility, δ of 0.6488 indicate the ARCH parameter and ν which is -0.6957 is the leverage or volatility-asymmetry parameter of Naira the Naira/Pounds returns rate, this implies that EGARCH (1, 1) model coefficient is highly significant.

5 Conclusion and Recommendations

This study modelled the exchange rate volatility of Nigeria Naira against Chinese Yuan, India Rupees, Spain Euro, UK Pounds and US Dollar returns over the period, January 2012 – August 2016 using GARCH (1,1), EGARCH (1,1), TGARCH (1,1) and GJR-GARCH (1,1) models. Volatility persistence and asymmetric properties are investigated for the five countries' exchange rates i.e. Naria/Yuan, Naria/Rupees, Naria Euro, Naria/Pounds and Naria/USA. The results from all the models show that volatility is persistent in all the exchange rates.

In conclusion, India has the highest Log L (671.8774) and the lowest BIC (-1.145), followed by USA with Log L (1340.69) and BIC (2.3581), China with Log L (-1427.94) and BIC (2.5109), Spain with Log L (-3819.47) and BIC (6.6779) and United Kingdom with the least Log L (-4375.55) and BIC (7.6408), this implies that; the exchange rate of Nigeria's Naria and India's Rupee have the best exchange rate with the highest log-likelihood (Log L) and the lowest BIC followed by USA, China, Spain and United Kingdom respectively. GRJ-GARCH (1, 1) is found to be the best selected model for all the currencies; Naira/Yuan with the highest Log L (-1427.948) and lowest BIC of (2.5109), Naira/Rupees with the highest Log L (673.9925) and lowest BIC of (-1.1425), Naira/Euros with the highest Log L (-3818.746) and lowest BIC of 6.6777), Naira/Pounds with the highest Log L -4374.55) and lowest BIC of (7.6452) and for Naira/Dollar with the highest Log L (-1331.466) and lowest BIC of (2.3483), followed by GARCH (1, 1), TGARCH (1, 1) and EGARCH (1, 1).

Base on the findings in this study it is recommended that concerted effort be made by policy makers to increase the level of output in Nigeria by improving productivity and supply in order to reduce over dependent on foreign goods and services, so as to boost the growth of the economy, the growth of money supply should continually be kept in check given its long-run potential and magnitude of exerting pressure of exchange rate on the economy. Appropriate steps that will moderate the expansion of the money supply should be devised, so as to ensure stable non-accelerating price level in the economy. Government should adopt effective financial policy that will reduce interest rate on lending due to the resultant effect of investment crowd-out on price level in the economy and the nation.

Competing Interests

Authors have declared that no competing interests exist.

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