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TIME SERIES MODELING OF NIGERIAN STOCK EXCHANGE INDEX (NSEI) AND USD/NGN EXCHANGE RATES

Amala Isabella S; Davies Iyai & E. H. Etuk
Department of Mathematics
Rivers State University, Port Harcourt, Nigeria

ABSTRACT
This study performed time series modeling of NSEI and USD/NGN Exchange rates. Monthly data spanning from January 2007 to December 2018 was used. Data was sourced from the Central Bank of Nigeria statistical bulletin. The models employed were ARMA model, GARCH (1,1) model and Granger Causality test. Both series were stationary at first difference. The All Share Index of the Nigerian Stock Exchange suggests ARIMA (0,1,0), a white noise process, and at such, GARCH (1,1) model was adopted, while USD/NGN exchange rate suggested ARMA (4,1,0) model, but residual were conditionally heteroskedastic, hence GARCH (1,1) model was also adopted and estimated and they Granger Cause each other.
Keywords: Exchange rate, Stock Price, ARMA Model, GARCH (1, 1) Model, Granger Causality Test.

INTRODUCTION
There is need to understand the behavior of exchange rate and stock market in terms of their relationship when they fluctuate, reason being that these financial markets play major roles in influencing the development of a country's economy. This issue has received considerable attention of economists, policy makers and investment community for a long time. Changes in exchange rate pose foreign exchange risk because it is one of the main determinants of business profitability and equity process. Changes in exchange rate affect the prices of goods in the international markets and this in turn affects the profit margin of exporters and importers. Through stock exchange, savings are mobilized and efficiently allocated to achieve economic growth (*Alile*, 1984). The Nigerian stock market performed fairly well as there was steady increase in the market capitalization (the total value of listed shares). It recorded the highest value of N13.2294 trillion in 2007 but collapsed to N9.564 trillion in 2008 due to the global financial meltdown and it has continued declining. Reports showed that the index suffered mightily in 2015 and 2016 as low oil prices, militant attacks, currency depreciation, Ebola and elections attacked investor's sentiments. But in 2017, the Nigerian Stock Exchange (NSE) revived as it recorded a lot of success and growth.

For the first time in three years, the NSE closed the year in the positive note as the All Share Index returned 42.30% year-on-year. It was ranked the third best capital market in the world (according to S & P Dow Jones Indices). Market capitalization grew positively to close at N13.61 trillion as opposed to N9.25 trillion recorded in 2016. From 2009, the Nigerian currency against the US dollar has been oscillating downward, though slightly appreciated by 0.12% in 2013, but continued trending downward as it recorded $N158.55, N192.44, N253.39$ *and* $N305$, for 2014, 2015, 2016 and 2017 respectively. Changes in exchange rates and stock market prices have been a source of concern in many economies including Nigeria.

Researchers have divergent views on the issue of exchange rate and stock price relationship. Reports from studies like Doong *et al* (2005), Rjoub (2012) and Umoru and Asekone (2013) revealed bi-directional linkage between the variables, while Maku and Alanda (2009) and Olugbenga (2012) reported a uni-directional relationship. Still others like Ong and Izan (1999) confirmed a weak relationship and Ozar (2006), no causal linkage and co-integration between stock prices and exchange rates. Indeed there is no fixed pattern regarding the relationship of these variables. This research work seeks to model the relationship between $NSEI$ and USD/NGN exchange rates. Also no study has been conducted within the time frame used by this research work. This paper is structured as follows; Section two (2); reviewed literature, Section three (3); reported data and methodology, Section four (4); discussion and Section five (5); conclusion.

LITERATURE REVIEW

Several researchers, both theoretical and empirical have revealed evidences regarding the relationship between the changes in exchange rates and how it affects stock prices. From related theories, the purchasing power parity (PPP) originally developed as a theory for exchange rate determination, holds that currencies are valued for what they will buy. The relative external value of two currencies, i.e. the exchange rates between them is determined by their relative internal purchasing power as measured by the ratio of the general price level in the two countries concerned. It follows that changes in the relative national price levels determine changes in the exchange rate ratio. In particular, the theory predicts that the percentage ratio of change in exchange rate will tend to equal the differential between the rates of price inflation at home and abroad. According to Madura (2009), price rates vary among countries, which cause international trade patterns and exchange rates to adjust accordingly. Madura argued that when a country's inflation rise, the demand for its currency as well as its export decline due to their high prices, therefore consumers and firms in their country tend to increase their imports. The theory bases its prediction of exchange rate movement on changing patterns of trade due to different inflation rates between countries. Purchasing power parity suggests that prices of the same basket of product in two different countries should be equal when measured in a common currency because consumers will shift their demand to wherever prices are lower without international trade barriers and transport costs.

Another theory is the Arbitrage Pricing Theory(*APT*). *APT* is an equilibrium model which determines equilibrium rates of return on the capital market. Rashid and Karachi (2007) held that according to Arbitrage theory, a rise in real interest rate reduces the present value of a firm's future cash flows and causes stock prices to fall. But at the same time, a higher interest rate stimulates the capital inflow and therefore, exchange rate falls. In this regard, the model assumes that macroeconomic variable such as exchange rate can have effect on the stock market. Stock Oriented Model or the Portfolio Approach postulates that changes in stock prices affects movement in exchange rates through portfolio adjustments (inflow/outflow of foreign capital). This approach believes that an inflow in foreign capital rises as upward trend in stock prices is recorded. However, a reduction in stock prices would induce a reduction in domestic investor's wealth, which will result to a fall in the demand for money and money authorities will reduce the interest rates causing capital outflow from the country and consequently currency depreciation. It also points out that from the country where there is a fall in local currency, exporting goods become attractive which increases foreign demand and hence revenue for the firm and its value appreciates, thus stock prices appreciates. Conversely, when local currency improves, exporting firm's profit reduces, thereby affecting its value of stock prices negatively, Jorion (1991).

Flow Oriented Model or the Traditional approach is another theoretical argument about relationship between stock prices and exchange rates. This theory assumes that changes in exchange rates affects firm's value through competitiveness of the firm's exports, which in turn results in changes in the value of firms assets and liabilities, culminating in higher profits and reflecting its stock prices. Several empirical studies regarding the relationship between stock prices and exchange rates have been carried out for different countries. Abdalla and Murinda (1979) looked at the long-run relationship between stock prices and exchange rates as they investigated for India, Korea, Pakistan and Philippines with *VECM* (Vector Error Correction Model) framework for the period of 1985:01 – 1994:07. A unidirectional relationship was reported for Pakistan and Korea, exchange rate Granger caused the stock price index in India, while no causal relationship was evident in the case of Philippines.

Morales (2007) employed the Johansen co-integration technique, Vector Error Correction Modelling (*VECM*) and Granger Causality test to investigate the long-run and short-run association between exchange rate and stock prices in four eastern European markets; Czech Republic, Hungary, Poland and Slovakia. The result of the study showed no association between these variables in the long-run and short-run. However, in Slovakia, co-integration relationship was evident. Muhammad and Rasheed (2011) examined the long-run and short-run relationship between stock prices and exchange rates for four south Asian countries; Pakistan, India, Bangladesh and Sri-Lanka. The study employed co-integration, *VECM*, and standard Granger causality test. The results showed no short-run relationship between the two financial variables for all the four countries, no long-run association between the variables for India and Pakistan, and there was evident of a bi-directional causality between the variables for Sri-Lanka and Bangladesh. Other studies that revealed bi-directional linkage between stock prices and exchange rates include; Doong *et al* (2005), Erbaykao and Okuyan (2009), R.joub (2012), Mok (1993), Umoru and Asekome (2013). Etc.

Bonga – Bonga and Hoveni (2011) investigated the volatility spillover between equity market and the foreign exchange market in South Africa, a multi-step family of *GARCH* was applied. The result showed a uni-directional relationship in terms of volatility spillover from the equity market to the foreign exchange market. Other studies that revealed same include; Alanda and Maku (2009) which revealed exchange rate negative effect on stock market performance in Nigeria. Sekmen (2011), carried an investigation on the *US* for the period 1980 to 2008, the squared residuals from the autoregressive moving average (*ARMA*) model on stock returns for the US was used. The result concluded that exchange rate volatility negatively affects *US* stock returns. Sichoongwe (2016) employed *GARCH* model to evaluate the impact of exchange rate volatility on the stock returns of Zambian stock market and it was revealed that stock market returns are negatively related to changes in exchange rates. Some research works found negligible impact of exchange rate on stock price. Researches like He and Ng (1998), also Ong and Izan (1999) who reported a weak relationship between exchange rates and stock prices in Australia and the group of seven countries.

Still others found no relationship. Ozair (2008) investigated *US* data, the result established no causal linkage and co-integration between stock prices and exchange rates. Desislava (2005) investigated for *UK* and *US* for the period of 1990-2004 and reported absence of causality between these variables. Ma and Kao (1990), in their study, attributes the difference in results to the nature of the countries, i.e. whether countries are import or export dominant, while Morley and Pentecost (2000) argued that the reason for the lack of strong relationship may be due to the exchange controls that were in effect in the 1980s. Previous studies carried out by various researchers revealed no fixed pattern regarding stock market and exchange rate variability. This research intends to test this issue in the light of our local experience using the *ARMA* model, *GARCH* model and Granger Causality Test.

DATA AND METHODOLOGY

This study is based on the monthly data of stock index of the Nigerian stock price and foreign exchange rate on *USD* of the Nigerian Naira. Data was sourced from the Central Bank of Nigeria (*BCN*) statistical bulletin, spanning from January 2007 to December 2018. A total of 118 data points were generated.

METHODOLOGY

In modeling the *NSEI* and *USD*/*NGN* exchange rates in order to ascertain their behavior in terms of relationship during the period of this study, the study applied Autoregressive Moving Average (*ARMA*) model, Generalized Autoregressive Conditionally Heteroskedastic (*GARCH*) model, Pearson's Correlation test and Granger Causality test. The variables captured in this analysis were the Nigerian Stock Exchange Index (*NSEI*) and the *USD*/*NGN* exchange rates.

Prior to the model estimation, visual plots were conducted on each variable and the unit root test for stationary was conducted using the Augmented Dickey fuller (1979) technique because estimates gotten from non-stationary series are not reliable. The null hypothesis of the ADF test is that a time series contains a unit root for all the unit root test. If non-stationary, that is; $H_o: \phi = 1$ is not rejected, the variable is difference and the unit root tests are carried out again until stationary is attained.

ARMA models generally represented as Autoregressive Moving Average model;

$$Y_t = \phi_1 Y_{t-1} + \ldots + \phi_p Y_{t-p} + \varepsilon_t + \theta_1 \varepsilon_{t-1} + \ldots + \theta_q \varepsilon_{t-q} \quad \ldots \ldots \ldots \ldots \ldots \ldots eq(1)$$

is a combination of the $AR_{(p)}$ and the $MA_{(Q)}$ terms were by the series Y_t depends on both its previous value and current and previous white noise error terms(ε_t). Wold (1938) showed that it can be used to model all stationary time series as long as the order of$P$, the number of AR terms and q, the number of MA terms was appropriately specified. The Box-Jenkins (1976) methodology which has the following terms; identification, estimation and diagnostic checking, proposed that differencing of data appropriately could render a non-stationary series stationary before identifying the model. In the $ARIMA\ (p, d, q)$ model, the term 'p' denotes the number of AR term, 'q' the number of MA terms and 'd', the order of integration (ie. the number of times the original series must be differenced to achieve stationarity. The model in equation 1 can be written as shown below.

$$\phi(B)(1 - B)^d Y_t = \theta(B)\varepsilon_t \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots . (2)$$

For a series that exhibits trend, the differencing factor $(1 - B)^d$ will reduce the trend to stationary components, ie. when $d = 0$, equation 2 reduces to a stationary $ARMA(pq)$ process defined as;

$$\phi_p(B)y_t = \theta_q(B)\varepsilon_t \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots (3)$$

Where p and q are as defined above.

GARCH MODEL

General Autoregressive Conditional Heteroskedisticity ($GARCH$) model is used to estimate time series data that are volatile. These models have become wide spread tools for dealing with time series heteroskedasticity. The goal of this model is to provide a volatility measure that can be used in

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financing decisions concerning risk analysis, portfolio select etc. $GARCH$ model also known as $GARCH$ (1,1) has two equations, the mean and the variance equation (residuals derived from the mean equation).

$$Y_t = \chi_t^1 b + \mu_t \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots (4)$$

$$\mu_t \sim iid(0, h_t)$$

$$h_t = \delta_0 + \delta_1 h_{t-1} + \delta_2 \mu_{t-1}^2 \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots .. (5)$$

Equation 4 is the mean equation when the residuals or error terms in equation 4 are conditionally heteroskedastic, then $ARCH$ and $GARCH$ model is necessary. $GARCH$ (1,1) means one $ARCH$ term and one $GARCH$ term.

Equation 5 is the variance equation. Residuals derived from mean equation are used in making variance equation. h_t is today's volatility, U_{t-1}^2 is the previous period squared residual derived from equation 4. It is also known as previous day's information about volatility. It is the $ARCH$ term. h_{t-1} is the previous day's residual variance (volatility). It is also known as the $GARCH$ term.

GRANGER CAUSALITY

The ability of one variable to predict another variable is discussed in terms of the concept of Granger Causality. It uses empirical data sets to find patterns of correlation. The equation below was employed to estimate the Granger-Causation.

$$Y_t = C_0 + \sum_{j=1}^{P} C_j \chi_{t-1} + \sum_{j=1}^{P} d_j y_{t+1} + \mu_{yt} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (6)$$

$$\chi_t = \alpha_0 + \sum_{j=1}^{P} \alpha_j \chi_{t-1} + \sum_{j=1}^{P} b_j y_{t-1} + \mu_{xt} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (7)$$

χ Does not granger cause y if $C_j = 0, \; \forall \, j = 1 \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots ... p,$

And y does not granger cause χ if $b_j = 0, \; \forall \, j = 1, \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots .\, p$

EMPIRICAL RESULTS

The unit root test of $NSEI$ and USD/NGN has been carried out through Augmented Dicky- Fuller (1979) test. In tables 1 and 2, the null hypothesis (H_o) that the time series of $NSEI$ and USD/NGN exchange rate has a unit root is rejected after the first difference. This is due to the fact that the test statistic value of -9.933500 is less than -2.886074, for NSEI and -8.130429 is less than -2.886074 for USD/NGN exchange rate, both at the critical value at 5%.

Table 1: Test for stationary of the Index differences

Null Hypothesis: DNSEI has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-9.933500	0.0000
Test critical values:	1% level	-3.486551	
	5% level	-2.886074	
	10% level	-2.579931	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(DNSEI)
Method: Least Squares
Date: 06/04/19 Time: 01:37
Sample (adjusted): 2009M03 2018M12
Included observations: 118 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DNSEI(-1)	-0.917119	0.092326	-9.933500	0.0000
C	61.88530	182.0811	0.339878	0.7346

R-squared	0.459647	Mean dependent var	-8.533898
Adjusted R-squared	0.454989	S.D. dependent var	2677.156
S.E. of regression	1976.407	Akaike info criterion	18.03275
Sum squared resid	4.53E+08	Schwarz criterion	18.07971
Log likelihood	-1061.932	Hannan-Quinn criter.	18.05182
F-statistic	98.67442	Durbin-Watson stat	1.941178
Prob(F-statistic)	0.000000		

Table 2: Stationary test for the differences of the USD/NGN exchange rates

Null Hypothesis: DUDNN has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-8.130429	0.0000
Test critical values:	1% level	-3.486551	
	5% level	-2.886074	
	10% level	-2.579931	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(DUDNN)
Method: Least Squares
Date: 06/12/19 Time: 00:30
Sample (adjusted): 2009M03 2018M12
Included observations: 118 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DUDNN(-1)	-0.725362	0.089216	-8.130429	0.0000
C	1.254649	1.193216	1.051485	0.2952

R-squared	0.363001	Mean dependent var	-0.054322
Adjusted R-squared	0.357510	S.D. dependent var	16.02275
S.E. of regression	12.84312	Akaike info criterion	7.960297
Sum squared resid	19133.70	Schwarz criterion	8.007258
Log likelihood	-467.6575	Hannan-Quinn criter.	7.979365
F-statistic	66.10388	Durbin-Watson stat	1.940594
Prob(F-statistic)	0.000000		

To identify an $ARIMA\,(p,d,q)$ process for the $NSEI$ and USD/NGN exchange rate data, we examine the ACF and $PACF$ plots as shown in figures 1 and 2 respectively.

Figure 1: Correlogram of the differences of the Index series.

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.083	0.083	0.8377	0.360
		2	-0.011	-0.018	0.8515	0.653
		3	0.092	0.095	1.8926	0.595
		4	-0.077	-0.094	2.6315	0.621
		5	-0.039	-0.020	2.8192	0.728
		6	0.116	0.112	4.5445	0.603
		7	-0.021	-0.029	4.6034	0.708
		8	-0.039	-0.033	4.8009	0.779
		9	0.046	0.027	5.0758	0.828
		10	0.006	0.021	5.0807	0.886
		11	-0.062	-0.056	5.5906	0.899
		12	0.092	0.080	6.7329	0.875
		13	-0.023	-0.036	6.8064	0.912
		14	-0.049	-0.021	7.1350	0.929
		15	0.001	-0.026	7.1353	0.954
		16	-0.087	-0.077	8.2021	0.943
		17	-0.060	-0.022	8.7036	0.949
		18	-0.136	-0.166	11.333	0.880
		19	-0.050	-0.008	11.698	0.898
		20	-0.051	-0.046	12.072	0.914
		21	0.000	0.017	12.072	0.938
		22	-0.087	-0.112	13.204	0.927
		23	-0.051	-0.025	13.597	0.938
		24	-0.040	-0.035	13.837	0.950
		25	0.011	0.033	13.857	0.964
		26	-0.044	-0.057	14.159	0.971
		27	-0.061	-0.073	14.739	0.973
		28	-0.039	-0.009	14.983	0.979
		29	-0.067	-0.079	15.703	0.979
		30	-0.162	-0.147	19.936	0.918
		31	0.063	0.060	20.578	0.923
		32	-0.077	-0.110	21.564	0.919
		33	-0.056	-0.051	22.082	0.926
		34	0.018	-0.052	22.137	0.942
		35	0.013	0.013	22.166	0.955

Figure 2: Correlogram of the differences of the USD/NGN exchange rates

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.275	0.275	9.2025	0.002
		2	-0.020	-0.103	9.2509	0.010
		3	-0.017	0.019	9.2867	0.026
		4	0.249	0.270	17.076	0.002
		5	0.054	-0.115	17.443	0.004
		6	-0.107	-0.080	18.905	0.004
		7	0.097	0.217	20.126	0.005
		8	0.045	-0.160	20.391	0.009
		9	-0.142	-0.152	23.018	0.006
		10	-0.081	0.154	23.879	0.008
		11	0.114	0.006	25.603	0.007
		12	0.138	0.044	28.175	0.005
		13	-0.055	0.044	28.593	0.007
		14	-0.147	-0.198	31.538	0.005
		15	-0.033	-0.009	31.690	0.007
		16	-0.181	-0.212	36.261	0.003
		17	-0.063	0.071	36.815	0.004
		18	-0.026	0.046	36.910	0.005
		19	0.143	0.102	39.866	0.003
		20	-0.032	0.004	40.019	0.005
		21	-0.067	0.019	40.674	0.006
		22	-0.004	-0.068	40.676	0.009
		23	0.022	-0.056	40.751	0.013
		24	-0.018	-0.039	40.801	0.018
		25	-0.061	-0.042	41.368	0.021
		26	-0.034	-0.003	41.549	0.027
		27	-0.096	-0.052	42.994	0.026
		28	-0.085	0.055	44.128	0.027
		29	-0.051	-0.060	44.549	0.033
		30	-0.022	-0.117	44.627	0.042
		31	-0.017	0.050	44.673	0.053
		32	-0.026	-0.089	44.782	0.066
		33	0.003	0.072	44.783	0.083
		34	0.002	0.050	44.784	0.102
		35	-0.011	0.021	44.803	0.124

It is evident that the correlogram of the differences for the *NSEI* showed a white noise process as there is no significant autocorrelation, so an *ARMA* model is not justified, this calls for the *GARCH* type, while that of the differenced series of USD/NGN exchange rate revealed an $ARIMA$ (4,1,0) fitted as, $X_t = 0.2303X_{t-1} - 0.4975X_{t-4} + \varepsilon_t$ as shown in table 3, but residuals are conditionally heteroskedastic, hence $GARCH$ (1,1) model was adopted.

Table 3: Estimation of the ARIMA $(4,1,0)$ model for differences of the USD/NGN exchange rates

Dependent Variable: DUDNN
Method: ARMA Maximum Likelihood (OPG - BHHH)
Date: 06/12/19 Time: 00:36
Sample: 2009M02 2018M12
Included observations: 119
Failure to improve objective (non-zero gradients) after 62 iterations
Coefficient covariance computed using outer product of gradients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
AR(1)	0.230341	0.051847	4.442672	0.0000
AR(4)	-0.497476	0.042479	-11.71116	0.0000
MA(1)	-0.010539	0.019921	-0.529023	0.5978
MA(4)	0.992562	13.50787	0.073480	0.9416
SIGMASQ	129.2508	35.00875	3.691957	0.0003
R-squared	0.257847	Mean dependent var		1.794790
Adjusted R-squared	0.231807	S.D. dependent var		13.25264
S.E. of regression	11.61549	Akaike info criterion		7.859199
Sum squared resid	15380.85	Schwarz criterion		7.975969
Log likelihood	-462.6223	Hannan-Quinn criter.		7.906616
Durbin-Watson stat	1.835155			
Inverted AR Roots	.66-.59i	.66+.59i	-.54+.59i	-.54-.59i
Inverted MA Roots	.71-.71i	.71+.71i	-.70+.71i	-.70-.71i

Table 4: Estimation of a Garch$(1,1)$ model for the differences of NSEI series

Dependent Variable: DNSEI
Method: ML ARCH - Normal distribution (BFGS / Marquardt steps)
Date: 06/04/19 Time: 03:36
Sample (adjusted): 2009M02 2018M12
Included observations: 119 after adjustments
Convergence achieved after 17 iterations
Coefficient covariance computed using outer product of gradients
Presample variance: backcast (parameter = 0.7)
GARCH = C(1) + C(2)*RESID(-1)^2 + C(3)*GARCH(-1)

Variable	Coefficient	Std. Error	z-Statistic	Prob.
	Variance Equation			
C	660885.9	287486.4	2.298843	0.0215
RESID(-1)^2	-0.036349	0.044341	-0.819769	0.4123
GARCH(-1)	0.838721	0.082179	10.20603	0.0000
R-squared	-0.001695	Mean dependent var		80.81261
Adjusted R-squared	0.006723	S.D. dependent var		1971.152
S.E. of regression	1964.515	Akaike info criterion		17.98492
Sum squared resid	4.59E+08	Schwarz criterion		18.05499
Log likelihood	-1067.103	Hannan-Quinn criter.		18.01337
Durbin-Watson stat	1.825913			

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Table 5: Estimation of the GARCH(1, 1) model of the differences of the USD/NGN exchange rates

Dependent Variable: DUDNN
Method: ML ARCH - Normal distribution (BFGS / Marquardt steps)
Date: 06/12/19 Time: 00:42
Sample (adjusted): 2009M02 2018M12
Included observations: 119 after adjustments
Convergence achieved after 27 iterations
Coefficient covariance computed using outer product of gradients
Presample variance: backcast (parameter = 0.7)
GARCH = C(1) + C(2)*RESID(-1)^2 + C(3)*GARCH(-1)

Variable	Coefficient	Std. Error	z-Statistic	Prob.
		Variance Equation		
C	1.273008	0.344073	3.699816	0.0002
RESID(-1)^2	0.753586	0.226221	3.331185	0.0009
GARCH(-1)	0.389094	0.080397	4.839661	0.0000

R-squared	-0.018496	Mean dependent var	1.794790
Adjusted R-squared	-0.009938	S.D. dependent var	13.25264
S.E. of regression	13.31833	Akaike info criterion	6.041095
Sum squared resid	21107.96	Schwarz criterion	6.111157
Log likelihood	-356.4452	Hannan-Quinn criter.	6.069545
Durbin-Watson stat	1.423046		

$GARCH$ (1,1) model has been used to estimate the $NSEI$ and USD/NGN exchange rate. Tables 4 and 5 reveal that the sum of the coefficients of h_{t-1} *and* U_{t-1}^2 of stock index and that of exchange rate are 0.801372 *and* 1.1427 respectively. This implies that there is high degree of volatility of the variables during the period of this study. And lastly, Granger Causality test in table 10 conducted on the variables to ascertain the cause-effect proves to be statistically significant with an F – statistic of 1.81621 and a P – value of 0.1835 from NSEI to Exchange Rate and an f – statistics of 2.27487 and a p – value of 0.1237 from exchange rate to $NSEI$. This reveals a bi-directional causality between the variable's performances. Hence, exchange rate granger cause stock market performance and vice – versa. This result also confirms positive relationship but statistically insignificant according to Pearson's correlation test in table 9.

Table 9: Correlation between NSEI and UDNN

	NSEI	UDNN
NSEI	1.000000	0.222528
UDNN	0.222528	1.000000

Table 10: Granger Causality Relationship between NSEI and UDNN

Pairwise Granger Causality Tests
Date: 10/17/19 Time: 10:56
Sample: 2016M07 2018M12
Lags: 2

Null Hypothesis:	Obs	F-Statistic	Prob.
UDNN does not Granger Cause NSEI	30	2.27487	0.1237
NSEI does not Granger Cause UDNN		1.81621	0.1835

CONCLUSION

The time series of NSEI and USD/NGN exchange rate has been modeled from the period of January 2017 to December 2018 using ARMA model, GARCH (1, 1) model and Granger causality test. The time series data of NSEI showed a white noise process with the ARIMA model and GARCH (1,1) model fitted as,

$$DNSEI = 660885.9 - 0.036349RESID(-1)^2 + 0.838721GARCH(-1)$$

while the time series data of USD/NGN exchange rates produced ARIMA (4,1,0), fitted as,

$$X_t = 0.2303X_{t-1} - 0.4975X_{t-4} + \varepsilon_t$$

And GARCH (1,1) model fitted as.

$$GARCH = 1.2730 + 0.7536RESID(-1)^2 + 0.3891GARCH(-1)$$

The series were subjected to Granger Causality test and reported a bi-directional causality with negligent but statistically positively significant in terms of their relationship.

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