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Volatility, Spillover Effects among Foreign Exchange Rates, Oil Price Fluctuation and the Nigerian Stock Exchange: A Multivariate VAR-EGARCH-CC Analysis

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This paper examines the hidden dynamics prices changes and the volatility spillover among foreign exchange market (Naira/USD, Naira/GBP), stock exchange market (NSE-30) and the crude oil market (WTI). The methodology of the study is the fusion of the Constant Correlation (CC) model to the Vector Autoregressive Exponential Generalized Autoregressive Conditional Heteroskedasticity (VAR(1)-EGARCH(1,1)) model, to examine the spillover effects as well as capture the time series stylized facts. This approach is quite different from the popular Koutmos (1996) multivariate EGARCH methodology which may lead to inaccurate parameter estimate due to the imposed constraints. Our findings suggest the existence of leverage effect in the currency market (Naira/USD, Naira/GBP) and in crude oil market. Beside the high persistent of volatility in the currency market (Naira/USD, Naira/GBP) and the stock market (NSE-30), there is also dominance of shocks in the local market. This paper will be of immense benefit to practitioner, academic scholars and policies makers on the inter-relationship among these variables.

Keywords: Volatility; stock market; spillover; heteroskedasticity; VAR-EGARCH.

1. Introduction

Since the discovery of crude oil in large commercial quantity in Nigeria, oil has been the main stay of the country's economy. And a substantial fluctuation in the price of oil could have significant implication on macroeconomic variables, such as, exchange rate, external reserve and economic growth. Hence, Hamilton (1983) and Wakeford (2006), simply put oil price shock as price fluctuation resulting from the changes in either the demand or supply side of the international oil market. These changes have been traditionally traced to supply side disruption such as OPEC supply quotas, political upheaval in the rich oil nations and the activities of various militant groups (including the Niger delta region of Nigeria). Oil price increase represent inflationary period where the amount of money demand also increases. If this happens then the inflation rate of the country may rise, investment may decrease and the country's total GDP may decline. These relationships between oil prices and other economy indices on a nation's economic activities have attracted many researchers and this has also resulted to huge literature.

The stock return and foreign exchange rate (FX) also plays a crucial role in influencing the development of a country's economy. This has also drawn much attention from both the statisticians and the economists on theoretical and empirical analysis. The Nigerian Stock Exchange (NSE) was formed and known as the Lagos Stock Exchange in 1960. But in December, 1977, it was renamed the Nigeria Stock Exchange with its head office situated in Lagos. The Nigeria Stock Exchange (NSE) in 1988 recorded 5.1 billion naira in annual market capitalization and has continue to increase until 1997 when it dropped to 276.3 billion naira from 279.8 billion naira in 1996 and reduced further by 19.5 billion naira in 1998. It has since been following an upward trend that got to its peak of 10301 billion naira in 2007 and later crumbled to 3343.5 billion naira in 2008 (CBN Bulletin, 2008).

The interrelationship and spillover effects between oil prices, stock exchange and foreign exchange rate have frequently been utilized in predicting the future trends for each other.

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Maghyereh (2004), investigated the linkages between crude oil price shock and stock market return in twenty-two emerging countries and found that oil shocks have no significant impact on stock index return. Sadorsky (1999), showed that changes in oil price significantly affects stock returns using an unrestricted VAR model with Generalized Autoregressive Conditional Heteroskedasticity models on US monthly data. Adjasi and Biekpe (2005) investigated the relationship between stock market returns exchange rate movements in seven African countries. Co-integration test showed that in the long-run exchange rate depreciation leads to increase in stock market prices in some of the countries and in the short-run, exchange rate depreciation reduces stock market return. Solnik (2006), on the other hand, posits that there is a negative correlation between stock market and local currency.

The role of oil prices in explaining exchange rate movement was noted early by Golub (1983) and Krugman (1983), both concluded that a country exporting oil may face exchange rate appreciation when oil price rises, and exchange rate depreciation when oil prices falls. Ademola et al, (2011), analyzed the relationship between the naira, oil price and the U.S. dollar using regression and correlation model as the method of analysis. Unfortunately, regression models are not adequate enough to model financial data, which have heavy tail, volatility clustering effects, leverage effects etc. Hammoudeh and Choi (2006) examine the relationship between five Gulf cooperation council's shock markets and their links to the three global factors (the WTI Oil prices, the U.S. 30 months treasury bill rate and S & P 500 index). They found that there is no direct effect of oil price on the S & P 500 index.

However, it may be mention here that most previous studies on the relationship between oil price, stock market and exchange rate applied a bivariate model for variables inter-relationship, even when the series are more than two variables. The reason for this may be the researcher's inability to handle large computational analysis when all the variables are estimated for analysis. The present study would complement the emerging literature on the investigation of the behavior of return and volatility spillover among foreign exchange rate, stock exchange and the prices of crude oil with the direct inter-relationship among all variables. The rest of the paper has been structured as follows. Section 2 describes the materials and methods of the study. Section 3 explains the empirical results and discusses the findings from the study, while Section 4 contains the conclusion and finding of the study.

2. Materials and Method

2.1 *Data description and preliminary analysis*

The data sets used in this study contains the daily foreign exchange rates of Naira/USD, Naira/GBP, the closing prices of the Nigerian Stock Exchange for the first thirty leading companies, listed on the floor of the Nigerian Stock Exchange (NSE-30) and the daily prices of the West Texas Intermediate crude oil (WTI) in U.S. dollar spot price per barrel. All data are obtained from the bloomberg information network. The full sample period under investigation ranges from 2nd April, 2012 to 26th September, 2014. The daily data are used because; more information will be captured than using the weekly or monthly data. However, missing data arising from holiday and special events are filled using Neaime (2012) recommendations which recommends that missing data arising from holiday and special events should be recorded as average of previous prices and the next price.

The historical time index series for the four variables are shown in Fig 1. The prices of the stock exchange are low during the first three months of second quarter of 2012, but rises beginning from July, 2012. The dollar had a high exchange rate of about 166 naira during the first quarter of 2014, while the naira/GBP exchange rate was above 270 naira during the second quarter of 2014.

Fig 2, displays the dynamics of all sample returns for log index. There are period of quiet volatility beginning from mid August 2012 to early June 2013. At this period, the

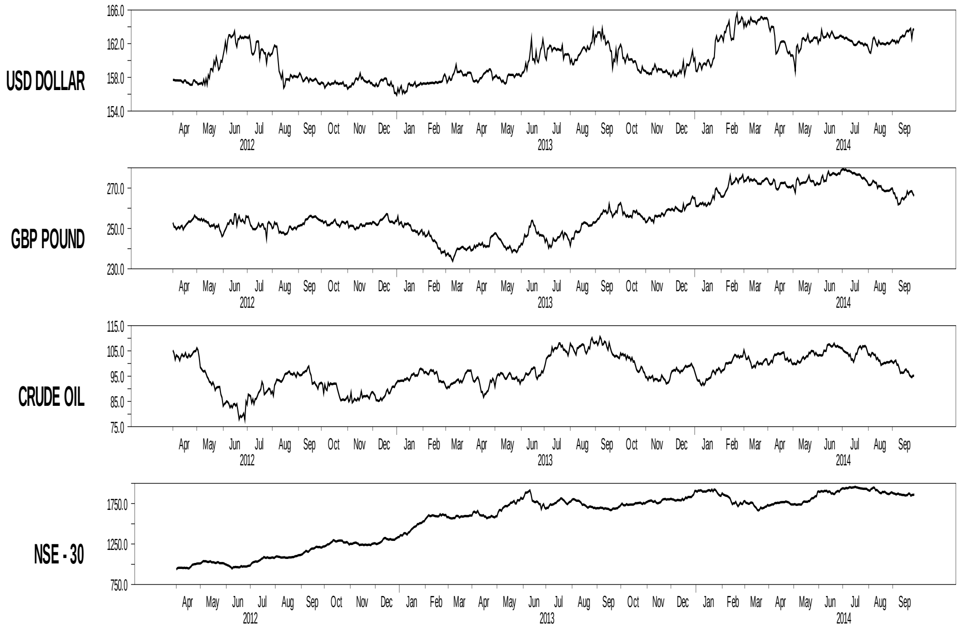

Figure 1: Daily Index Series (2nd April 2012 - 26th September 2014)

price of naira/USD exchange rate maintain stability around 158 naira per dollar, but with a turbulent periods between June to September, 2013 and between January to May, 2014. The prices of crude oil (WTI) also had a period of high volatility during the month of June and July of 2012, but maintain calmness beginning from May 2013. Statistically significant at 5% and p values are reported in brackets. This table is the author's calculation, similar to West and Cho (1995).

2.2 *Statistical properties of data*

The continuously compounded daily return expressed in logarithmic difference of the series considered in percentage was used. Where t and $t-1$ represent the current day's close total index and the previous day's close total return index respectively. The daily return series for the variables are

$$\left.\begin{aligned} \text{Ret}_{FX} &= 100 * \log\left(\text{Currency Market in day t/Currency Market in day t-1}\right) \\ \text{Ret}_{SX} &= 100 * \log\left(\text{Stock Market in day t/Stock Market in day t-1}\right) \\ \text{Ret}_{OIL} &= 100 * \log\left(\text{Oil Market in day t/Oil Market in day t-1}\right) \end{aligned}\right\} \quad (1)$$

In Table 1, there is evidence of skewness, the excess kurtosis exhibits large values and the Jarque-Bera test statistics (line 14) is highly significant for all the four variables considered, indicating that the distribution of all returns is not normal and are in the form of leptokurtosis. With the exception of the Naira/USD exchange rate, the changes in standard deviation of other variables are about 1% per day. And the price of crude oil (WTI) shows much volatility than the exchanges rate and stock exchange. The maximum and minimum changes in the sample sizes are generally three or more standard deviation away from the mean, while the inter-quarter range is much less than two.

The standard errors and p-values in table 1 (rows 1 – 4, 15, 16 and rows 5 – 8, 17, 18, 19, 20) are very robust to the presence of serial correlation and conditional heteroskedasticity.

Table 1: Summary statistics

	USD	GBP	Crude Oil	NSE-30
Panel A: e_t				
1. Mean	0.006	0.008	-0.016	0.106
	(0.010)	(0.018)	(0.049)	(0.036)
2. Standard deviation	0.323	0.528	1.268	0.791
	(0.019)	(0.027)	(0.078)	(0.042)
3. Skewness	-0.284	0.235	0.323	-0.211
	(0.326)	(0.237)	(0.526)	(0.307)
4. Excess kurtosis	4.108	3.144	4.826	2.910
	(1.037)	(1.067)	(2.705)	(1.031)
5. Modified L-B(5)	18.175	5.819	7.102	14.732
	[0.003]	[0.324]	[0.213]	[0.012]
6. Modified L-B(10)	25.526	8.811	9.506	22.677
	[0.004]	[0.550]	[0.485]	[0.012]
7. Modified L-B(50)	61.566	34.967	54.787	56.185
	[0.126]	[0.947]	[0.298]	[0.254]
8. Modified L-B(90)	107.036	89.640	93.154	97.584
	[0.106]	[0.491]	[0.389]	[0.274]
9. Minimum	-1.549	-2.180	-4.761	-4.197
10. Q1	-0.123	-0.253	-0.724	-0.305
11. Median	0.000	0.024	0.040	0.031
12. Q3	0.143	0.268	0.705	0.524
13. Maximum	1.811	2.960	9.001	2.915
14. J-Bera	0.000	0.000	0.000	0.000
Panel B: e^2_t				
15. Mean	0.105	0.279	1.608	0.637
	(0.013)	(0.029)	(0.198)	(0.065)
16. Standard deviation	0.258	0.634	4.196	1.381
	(0.038)	(0.111)	(1.218)	(0.228)
17. L-B(5)	48.739	19.763	39.807	33.817
	[0.000]	[0.001]	[0.000]	[0.000]
18. L-B(10)	61.696	22.451	66.660	92.575
	[0.000]	[0.013]	[0.000]	[0.000]
19. L-B(50)	102.243	64.893	153.375	158.242
	[0.000]	[0.077]	[0.000]	[0.000]
20. L-B(90)	159.236	94.277	201.326	184.035
	[0.000]	[0.358]	[0.000]	[0.000]

All tests are statistically significant at 5%.
Source: Author's calculation

In panel A of Table 1, the means of all the variables analyzed i.e the foreign exchange rates, stock exchange and the price of crude of oil have zero unconditional means (line 1) and appears to be serially uncorrelated as shown in different modified L-B (5, 10, 50 and 90). This is in conformity with Engle and Bollerslev (1986), Baillie and Bollerslev (1989), Diebold and Nerlove (1989), West and Cho (1995), Dahiru Bala and Joseph Asemota (2013), etc.

submissions. However, Panel B of table 1, suggests in stark contrast to the levels described in panel A, reveals that the squares residual of exchange rate (naira/USD), price of crude oil (WTI) and the Nigerian Stock Exchange (NSE-30) are highly serially correlated. With this statistical characteristics described in table 1 particularly Panel B, the assumption of constant variance (Homoskedasticity) is inappropriate. This implies that these results clearly favor models that incorporate the ARCH/GARCH features.

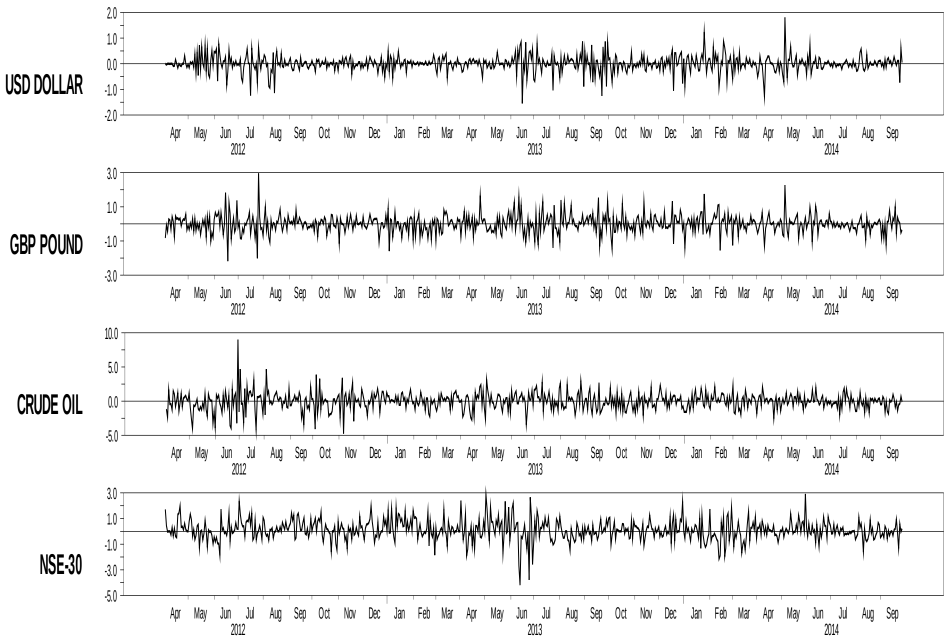

Figure 2: Daily Return for log Index (2nd April 2012 - 26th September 2014)

Information criteria are often used as a guide for selecting models (Grasa, 1989). The three major information criteria are subjected to statistical analysis and the appropriate lag order for the VAR model chosen. These information criteria include; the Akaike Information Criterion (AIC), the Bayesian/Schwarz Information Criterion (BIC) and the Hannan-Quinn information criterion (HIC). Table 2 shows the information criteria values for 10 lag selections. Lag one of Akaike Information Criterion (AIC) is use in this paper, indicating the influence of one variable on another often lasts not more than one day (Isakov and Perignon, 2000). Therefore our VAR model is of lag 1.

2.3 *Test for sign and size bias*

To determine whether an asymmetric model is necessary to test the volatility of shock, we use the sign and size bias test developed by Engle and Ng (1993). The sign test considers the sign effects of different past shock on different sign of the present volatility. Similarly, the size, investigates where past shocks of the same sign but different magnitude have a different effect on the present variance. The symmetric GARCH (1,1) model is estimated and the tests apply on the estimated standardized residual, define as $\hat{v}_t = (\hat{\epsilon}_t/\hat{\sigma}_t)$, where $\hat{\epsilon}_t$ and $\hat{\sigma}_t$ are the residual and standard deviation of the series respectively. The sign and size test given as:

$$\hat{v}_{it}^2 = \varphi_{i0} + \varphi_{i1} s_{i(t-1)}^{-1} + u_{it} \tag{2}$$

Table 2: VAR Lag Selections

Lags	AICC	Lags	SBC/BIC	Lags	HQ
0	4890.33155	0	4908.15549*	0	4897.24078
1	4855.75101*	1	4944.61774	1	4890.04423*
2	4873.75402	2	5033.25301	2	4935.02070
3	4867.50782	3	5097.22070	3	4955.32957
4	4870.88047	4	5170.38076	4	4984.83083
5	4886.29685	5	5255.14979	5	5025.94106
6	4897.71752	6	5335.47986	6	5062.61232
7	4906.03099	7	5412.25075	7	5095.72441
8	4918.46851	8	5492.68477	8	5132.49962
9	4928.51466	9	5570.25729	9	5166.41333
10	4944.27510	10	5653.06455	10	5205.56178

The statistical significance of φ_{i1} implies that positive and negative shocks to $\epsilon_{i(t-1)}$ impact differently on the conditional variance. Similarly, in equation (3), the statistical significant of φ_{i1} suggest the presence of negative size bias

$$\hat{v}_{it}^2 = \varphi_{i0} + \varphi_{i1} s_{i(t-1)}^{-1} \epsilon_{i(t-1)} + u_{it} \tag{3}$$

The Engle and NG also propose the joint test for sign and size bias. It's stated as:

$$\hat{v}_{it}^2 = \varphi_{i0} + \varphi_{i1} s_{i(t-1)}^{-} \epsilon_{i(t-1)} + \varphi_{i2} s_{i(t-1)}^{-} \epsilon_{i(t-1)} + \varphi_{i3} s_{i(t-1)}^{+} \epsilon_{i(t-1)} u_{it} \tag{4}$$

The statistical significance of φ_{i1} in equation (4) indicates the presence of sign bias. Here positive and negative shocks have different impacts on the conditional variance. Significance φ_{i2} and φ_{i3} implies that the size bias is present. Table 3 shows the test results for asymmetric effect for the variables (naira/USD, naira/GBP, Oil (WTI) and the NSE-30). Result reveals that positive and negative innovation in all markets have additional effects on own volatility more than what is predicted by the symmetric GARCH (1,1) model. There is presence of negative and positive bias in the four different markets, indicating that small and large negative shocks have different effects on the standardized residuals. Although, naira/GBP has marginal rejection of the null of no asymmetric in the joint test, however, the overall results would suggest that asymmetric effect on volatility exist. Therefore, to eliminate bias in empirical analysis and to assure consistent estimates, a multivariate VAR-EGARCH model, which allow us to examine the asymmetric effects in all four markets, is appropriate for study.

2.4 *Model specification for return and volatility*

The VAR model allows us to analyze and capture the dynamics and interdependency of return spillover across the four different variables (price of crude oil, foreign exchange, and stock exchange) considered in this paper. The exponential GARCH models (EGARCH(1,1))

Table 3: Volatility Specification Test

Variables	Naira/USD	Naira/GBP	Oil(WTI)	NSE-30
Sign Bias	1.0208	-0.1547	0.1304	-0.3471
	(0.0349)	(0.0279)	(0.0196)	(0.0623)
Positive Sign Bias	-0.3653	0.6091	-0.2347	0.0864
	(0.0002)	(0.3041)	(0.0041)	(0.0175)
Negative Sign Bias	0.5833	-0.2178	2.0014	-0.0848
	(0.0009)	(0.0443)	(0.1531)	(0.0000)
Joint Test	6.6256	13.1146	9.3325	19.226
	(0.0367)	(0.0512)	(0.0291)	(0.0623)

All test are statistically significant at 5%

with asymmetric effects described by Nelson, 1991 is fused the restricted multivariate Constant Correlation (CC) model of Bollerslev (1990), which assumes that the covariance are generated with a constant correlation. The VAR model was made popular by Sims (1980) and applied to financial data by Hamilton (1994). Series 1,2,3,4 is assigned to the naira/USD, naira/GBP, price of crude oil (WTI) and the Nigerian Stock Exchange (NSE-30) respectively. The return for these four variables has the following VAR equations:

$$ret_{it} = c_0 + \sum_{i=1}^{4} m_i r_{i(t-1)} + \epsilon_t,\ i = 1, 2, 3, 4. \tag{5}$$

$$\left.\begin{aligned}
ret_{1t} &= c_{10} + m_{11}r_{1(t-1)} + m_{12}r_{2(t-1)} + m_{13}r_{3(t-1)} + m_{14}r_{4(t-1)} + \epsilon_{1t}\\
ret_{2t} &= c_{20} + m_{22}r_{2(t-1)} + m_{21}r_{1(t-1)} + m_{23}r_{3(t-1)} + m_{24}r_{4(t-1)} + \epsilon_{2t}\\
ret_{3t} &= c_{30} + m_{33}r_{3(t-1)} + m_{31}r_{1(t-1)} + m_{32}r_{2(t-1)} + m_{34}r_{4(t-1)} + \epsilon_{3t}\\
ret_{4t} &= c_{40} + m_{44}r_{4(t-1)} + m_{41}r_{1(t-1)} + m_{42}r_{2(t-1)} + m_{43}r_{4(t-1)} + \epsilon_{4t}
\end{aligned}\right\} \tag{6}$$

$$\epsilon_t = \sigma_{jt} z_{it} \tag{7}$$

$$z_{it}\,|\Omega_{t-1} \sim \psi(x, v) \tag{8}$$

$$\log H_t = c_i + B_i \log H_{t-1} + A_i \left\{ \frac{|u_{t-1}|}{\sqrt{H_{t-1}}} - \frac{E\,|u_{t-1}|}{\sqrt{H_{t-1}}} \right\} + D_i \frac{u_{t-1}}{\sqrt{H_{t-1}}} \tag{9}$$

Denoting the ijth element $(i, j = 1, 2, 3, \cdots)$ in H_t by h_{ijt}, the conditional correlation (CC) coefficient are given by,

$$\rho_{ijt} = \frac{h_{ijt}}{\sqrt{h_{iit}h_{jjt}}}.$$

Tse and Tsui (2002) assume that the time-varying conditional correlation $\Gamma_t = \{\rho_{ijt}\}$ is generated by the following recursion

$$\Gamma_t = (1 - \pi_1 - \pi_2)\Gamma + \pi_1\Gamma_{t-1} + \pi_2\psi_{t-1} \tag{10}$$

where $\Gamma_i = \{\rho_{ij}\}$ is a time-invariant $k \times k$ positive-definite correlation matrix π_1 and π_2 are assumed to be non-negative and sum up to less than 1 and ψ_t is a function of the standardized residual $z_{i,t}$. $\psi_t = \{\psi_{ijt}\}$ and the element of ψ_{t-1} are specified as

$$\psi_{ij,t-1} = \frac{\sum_{a=1}^{M} z_{i,t-a}z_{j,t-a}}{\sqrt{\left(\sum_{a=1}^{M} z_{i,t-a}^2\right)\left(\sum_{a=1}^{M} z_{j,t-a}^2\right)}}, \; 1 < i < j \leq k \tag{11}$$

where M is set equal to k. The conditional variance-covariance matrix H_t can be defined as

$$H_t = \{h_{ijt}\} = D_t\Gamma_tD_t, \; D = diag\left\{\sqrt{h_{iit}}\right\}, \text{ and } \Gamma_t = \{\rho_{ijt}\}$$

And the log likelihood function written as

$$l_t = -\frac{1}{2}\log|D_t\Gamma_tD_t| - \frac{1}{2}(z_{1t}, z_{2t}, z_{3t}, \cdots, z_{kt})D_t^{-1}\Gamma_t^{-1}D_t^{-1}(z_{1t}, z_{2t}, z_{3t}, \cdots, z_{kt}) \tag{12}$$

where Γ_t is defined by the recursion in (10).

2.5 *Distribution assumption of the model*

The distributional assumption for the standardized residual of the VAR-EGARCH(1,1)-CC model, is the Generalized Error Distribution (GED) proposed by Nelson. The conditional density function $f_x(x; v)$ of the GED with unit variance and degree of freedom v written as

$$f_x(x; v) = \frac{v\exp\left(-\frac{1}{2}|z/\lambda|^v\right)}{\lambda 2^{1+1/v}\Gamma\left(\frac{1}{v}\right)\sqrt{v/(v-2)}}, \; -\infty < x < \infty, 0 < v \leq \infty \tag{13}$$

where

$$\lambda \equiv \left(2^(- 2/v)\Gamma(1/v)/\Gamma(3/v)\right)^{1/2}, \; E\left[X = x\right] = \frac{\lambda 2^{\frac{1}{2}}\Gamma(2/v)}{\Gamma(1/v)},$$

$\Gamma(\bullet)$ is the gamma function, v is the tail thickness parameter, when $v = 2$, x has a standard normal distribution. For $v < 2$ the distribution of x has thicker tails than the normal. For $v > 2$ the distribution of x has thinner tails than the normal.

3. Results and Discussion

The parameter estimates of the MVAR(1)-EGARCH(1,1)-CC model by the BFGS (Broyden, Fletcher, Goldfarb, Shanno) method of non-linear estimation are reported in Table 5, of Appendix 1. The model parameters estimation which converged in 117 iterations with log likelihood of -1231.5003, considers both returns and asymmetric volatility spillover. The diagonal elements of matrix A captures the ARCH effects, while the elements in matrix B captures the GARCH effects and parameter D_i measures the asymmetric effects. As shown in Table 5, the estimated diagonal parameters of A_{ij} and B_i are statistically significant at 5%, indicating a strong GARCH effects. In other words, own past shock and volatility affects the conditional variance of all variable considered.

Our model analysis reveals the following in summary. (1) The return of other variables (naira/GBP, Oil, and NSE-30) strongly impact the naira/USD exchange rates. (2) Nigeria's NSE-30 stock exchange and the prices of crude oil do not influence the exchange rates of naira/GBP but the naira/USD does. (3) There is no return spillover of the NSE-30 on the price of crude oil. However, there is weak influence of naira/USD and naira/GBP on crude oil prices. (4) There is weak impact of naira/USD, naira/GBP and crude oil price on the NSE-30.

Transmission of shock exists as seen in of Table 5 and the matrices are statistically not different from zero. This means that there is spillover effects of shock among the four variables analyzed and the spillovers are reciprocal. However, there is weak influence of shock from naira/USD exchange rates on crude oil prices. Our model results also shows that shocks naira/USD, crude oil prices and the NSE-30 have strong influence on the exchange rate of naira/GBP. The existence of asymmetric effect of shocks in the naira/USD exchange rates, the naira/GBP exchange rates and the prices of crude oil is another finding from our model. This indicates that bad news in these markets have greater impacts on the volatility of its index.

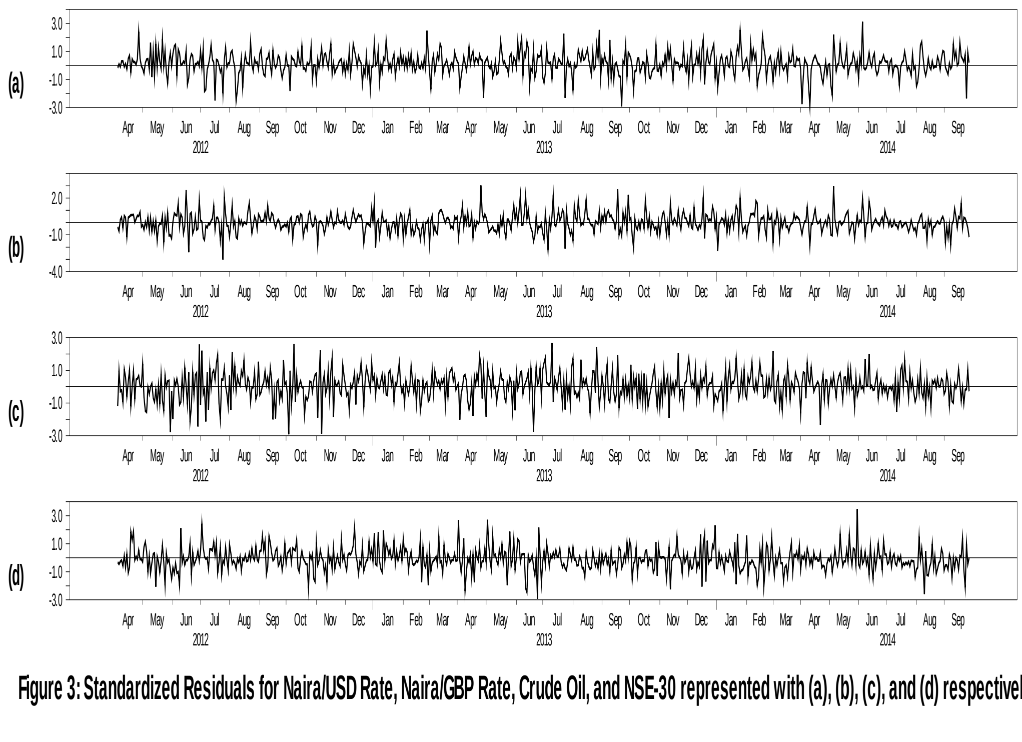

Figure 3: Standardized Residuals for Naira/USD Rate, Naira/GBP Rate, Crude Oil, and NSE-30 represented with (a), (b), (c), and (d) respectively

Table 4, shows the various diagnostics tests and analysis (both univariate and multivari-

Table 4: Diagnostics Analysis

The Univariate Lung-Box(Q) and ARCH Test

Variables	Q	Signif	ARCH	Signif
USD DOLLAR	17.9135	0.0564	9.1792	0.3274
GBP POUND	5.7137	0.8387	5.6281	0.6888
CRUDE OIL	19.9841	0.0294	15.7990	0.0453
NSE-30	22.0144	0.0150	4.3310	0.8261

Independence Tests for Series

Naira/USD			Naira/GBP		
Test	Statistic	P-Value	Test	Statistic	P-Value
Ljung-Box Q(80)	69.267215	0.7985	Ljung-Box Q(80)	76.048669	0.6044
McLeod-Li(80)	88.705810	0.2367	McLeod-Li(80)	78.028781	0.5415
Turning Points	-2.208102	0.0272	Turning Points	0.311000	0.7558
Difference Sign	0.883856	0.3768	Difference Sign	-0.203967	0.8384
Rank Test	-0.385481	0.6999	Rank Test	-0.456692	0.6479

WTI(Oil)			NSE-30		
Test	Statistic	P-Value	Test	Statistic	P-Value
Ljung-Box Q(80)	102.82630	0.0438	Ljung-Box Q(80)	90.708441	0.1939
McLeod-Li(80)	158.48720	0.0000	McLeod-Li(80)	74.891018	0.6405
Turning Points	0.21770	0.8277	Turning Points	1.710501	0.0872
Difference Sign	1.83570	0.0664	Difference Sign	0.203967	0.8384
Rank Test	-0.35169	0.7251	Rank Test	-2.393545	0.0167

Multivariate Diagnostics Analysis

Test for Multivariate Ljung-Box Q	Test for Multivariate ARCH		
	Statistics	Degrees	Signif
Multivariate L-B Q(40) = 618.17956	850.40	36	0.1827
Sig Level as Chi-Sq (640) = 0.72517			

Author's calculation. All tests are statistically significant at 5%

ate) confirming the robustness of the MVAR(1)-EGARCH(1,1)-CC model, which is also graph in Figure 3 in the form of standardized residuals. Both the univariate and multivariate Lung-Box and Arch test of the squares of standardized residuals are analyzed at 5% level of significance. The residuals analysis revealed lack of serial correlation and Arch effects in the model. As shown from Table 4, high lag order of 40 and 80 in the multivariate

Lung-Box and Mcleodi tests also corroborated the appropriateness of the model of no serial dependence in the square residuals. The McLeodi test is a very powerful statistical test specifically aimed at looking for serial dependence in the squares. The runs and rank tests which formally test residuals independence also confirmed the adequacy of the model.

4. Conclusion

This paper investigates the return dynamics and volatility transmission among naira/USD exchange rates, naira/GBP exchange rates, the prices of crude oil (WTI) and the Nigerian Stock Exchange (NSE-30) using the MVAR(1)-EGARCH(1,1)-CC model.

The results and analyses show that the return of naira/GBP exchange rates, the price of crude oil (WTI) and the Nigerian Stock Exchange (NSE-30) influences the exchange rate of naira/USD. There is no reciprocal return stimuli spillover between NSE-30 and the crude oil price. Thus, the Nigeria stock exchange for the thirty leading listed stocks does not determine the prices of the West Intermediate crude oil. In addition, the naira/USD, naira/GBP and WTI passes weak return stimuli to the NSE-30.

The asymmetric effects of naira/USD exchange rates, naira/GBP exchange rates and the WTI are statistically not different from zero. Intuitively, this implies that bad news from both the currency market (naira/USD and naira/GBP) and the crude oil market increases volatility in these markets than the good news of equal magnitude and from same source. There is dominance of own stocks in naira/USD exchange rates, indicating that changes in the naira/USD exchange rates are more importance than from other market. Volatility of naira/USD exchange rates, naira/GBP exchange rates and NSE-30 are persistent which takes a long time to change.

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Appendix

Table 5: Estimation of the VAR(1)–EGARCH(1,1)-CC Model

Variable	Coeff	Std Error	T-Stat	Signif
1. XSUSD{1}	-0.183599790	0.008387378	-21.89001	0.00000000
2. XSGBP{1}	-0.148529940	0.014343588	-10.35515	0.00000000
3. XSWTI{1}	-0.000880575	0.000257406	-3.42096	0.00062401
4. XSNSE{1}	-0.030205357	0.004815818	-6.27211	0.00000000
5. Constant	-0.037951437	0.003611683	-10.50796	0.00000000
6. XSUSD{1}	0.352817567	0.048154520	7.32678	0.00000000
7. XSGBP{1}	-0.247419343	0.025222281	-9.80955	0.00000000
8. XSWTI{1}	0.000538084	0.011415745	0.04714	0.96240544
9. XSNSE{1}	-0.016652293	0.018308349	-0.90955	0.36306176
10. Constant	0.003773285	0.014272490	0.26437	0.79149124
11. XSUSD{1}	0.552090735	0.122347237	4.51249	0.00000641
12. XSGBP{1}	0.143168818	0.068083809	2.10283	0.03548045
13. XSWTI{1}	0.122897303	0.030431344	4.03851	0.00005379
14. XSNSE{1}	0.045503981	0.050061348	0.90896	0.36336894
15. Constant	-0.114083945	0.036743294	-3.10489	0.00190349
16. XSUSD{1}	-0.026230428	0.011937691	-2.19728	0.02800058
17. XSGBP{1}	-0.167410701	0.013786352	-12.14322	0.00000000
18. XSWTI{1}	-0.023581152	0.001577489	-14.94853	0.00000000
19. XSNSE{1}	0.204812230	0.003512223	58.31414	0.00000000
20. Constant	0.174317579	0.003159656	55.16979	0.00000000

Variable	Coeff	Std Error	T-Stat	Signif
21. C(1)	-0.665106147	0.056562054	-11.75888	0.00000000
22. C(2)	-0.573016229	0.136583514	-4.19535	0.00002724
23. C(3)	0.026345152	0.069733412	0.37780	0.70558057
24. C(4)	-0.075338438	0.016032989	-4.69896	0.00000261
25. A(1,1)	0.701600798	0.051437626	13.63984	0.00000000
26. A(1,2)	0.446119287	0.072115195	6.18620	0.00000000
27. A(1,3)	0.697117940	0.053837333	12.94860	0.00000000
28. A(1,4)	0.125636320	0.026875140	4.67482	0.00000294
29. A(2,1)	-0.004935609	0.000000000	0.00000	0.00000000
30. A(2,2)	0.229428531	0.000000000	0.00000	0.00000000
31. A(2,3)	-0.008238923	0.000000000	0.00000	0.00000000
32. A(2,4)	-0.009580931	0.000000000	0.00000	0.00000000
33. A(3,1)	0.007119028	0.000000000	0.00000	0.00000000
34. A(3,2)	-0.004713013	0.000000000	0.00000	0.00000000
35. A(3,3)	0.234187028	0.000000000	0.00000	0.00000000
36. A(3,4)	-0.011552234	0.000000000	0.00000	0.00000000
37. A(4,1)	-0.004793988	0.000000000	0.00000	0.00000000
38. A(4,2)	-0.002560979	0.000000000	0.00000	0.00000000
39. A(4,3)	0.013841420	0.000000000	0.00000	0.00000000
40. A(4,4)	0.230588058	0.000000000	0.00000	0.00000000
41. B(1)	0.881016582	0.016597744	53.08050	0.00000000
42. B(2)	0.608647352	0.131452194	4.63018	0.00000365
43. B(3)	0.282484107	0.104864160	2.69381	0.00706405
44. B(4)	0.993041106	0.006339547	156.64228	0.00000000
45. D(1)	-0.067801341	0.028062420	-2.41609	0.01568817
46. D(2)	-0.073325175	0.020597687	-3.55987	0.00037103
47. D(3)	-0.295939705	0.039930982	-7.41128	0.00000000
48. D(4)	0.035560636	0.015379347	2.31223	0.02076484
49. R(2,1)	0.420642262	0.022819272	18.43364	0.00000000
50. R(3,1)	-0.018947930	0.027843469	-0.68052	0.49617771
51. R(3,2)	0.220594386	0.025539288	8.63745	0.00000000
52. R(4,1)	-0.009306720	0.027684870	-0.33617	0.73674546
53. R(4,2)	-0.062163459	0.028790194	-2.15919	0.03083554
54. R(4,3)	0.024247268	0.031769601	0.76322	0.44533083
55. Shape	0.294427185	0.010146365	29.01800	0.00000000

Statistically significant at 5%