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Article

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Returns Effect, Shocks and Volatility Transmission between Foreign Exchange-Stock Markets in Nigeria

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Abstract *The paper examined effect of passed return on current return, shocks spillover and volatility transmission between FX-Stock markets. Using result obtained from VAR-GARCH models, we also calculate the optimal weight and risk minimizing hedging ratio for FX-Stock markets and employed the newly developed bivariate GARCH framework Findings reveal evidence of short term predictability in both markets through time. One period lagged returns significantly impact current return in both markets, and impact was greater in FX market both VAR-GARCH and VAR-AGARCH models. There were evidence of bi-directional volatility transmission in both markets and uni-directional shocks spillover from stock to FX market in both models. VAR-AGARCH model showed evidence of leverage effect; bad news has more impact on volatility than positive news of the same magnitude. We showed that optimal polio of FX-Stock market should holds more foreign exchange to stocks in their asset polio. Our result showed evidence of effective hedging in FX-Stock markets in Nigerian. Hence, the inclusion of stocks in diversified polio of foreign exchange could improve it risks adjusted performance of hedging ratio.*

Key words Shocks and Volatility Spillover, Foreign Exchange-Shock market, Returns Impact in Nigeria

JEL Codes: C, C5, C58

1. Introduction

Nigeria economy is heavily dependent on oil industry and oil export, recent crash in oil price has profound consequences on all strata of the economy. Stocks and foreign exchange markets are not exempted from the negative impact of crash in oil price. Foreign exchange and stocks market play a complimentary role in the economy and they provide a diversification opportunity for investors in financial market. Economic slowdown reduces the value of companies stocks, causing investors (especially foreign ones) to withdraw their funds in the financial market, thereby reduces the demand for the domestic currency, and induces downward pressure on the exchange rate, and ultimately led to the fall in the price and volume of the trade in the stock markets in Nigeria. The massive sell off from foreign investors pulling out from the equities market as a result of backlash on the heel of economy meltdown has cause distortion in FX market; the subsequent unabated depreciation in domestic currency tends to spread to the equities market; daily downward movement in the all share index is the consequence of the chain reaction in the economy and a pointer to somewhat relationship between these financial variables.

The Flow oriented model, developed by Dornsburch and Fischer (1980), stress the importance of trade balance and maintains that there is causal relationship running from the exchange rate to the stock prices. While Stock oriented model, by Branson (1983) stresses the important role of the capital account, in the exchange rates determination and international capital movements in financial market. According to Adjasi and Biekpe (2007) in stock oriented model, the exchange rate equates demand and supply for assets (bonds and stocks). An expectation of relative currency movements have a significant impact on price movements of financially held assets. Hence, stock price movements may influence or be influenced by exchange rate movements.

The liberalization policy and automation of Nigeria stock exchange has increased ease and volume of stocks and foreign exchange transactions in financial market. There are two main channels of relationship between stock and foreign exchange markets; the trade balance channel and market portfolio channel; in trade balance the exchange rate affects the trade balance of the domestic and foreign goods. Promote the growth of real output by affecting a current and future cash flows of domestic firms particularly export oriented ones, hence, the positive relationship between the two financial assets. On the one hand, portfolio balance channel emphasized supply and demand of financial assets. An increased demand for stocks induces demand for domestic currency used to settle transactions for domestic assets and ultimately leads to domestic currency appreciation. If the exchange rate changes are caused by any external breaks the investors decide to buy or sell any assets, hence the direct relationship between two financial variables.

Although, there hasn't been consensus on the existence of relationship between stock prices and exchange rates and on the direction of the relationship in both theoretical and empirical works and most of the research are concentrated on advanced economies of the World. The understanding of the relationship between the currency and equities markets is important in the risk hedging and portfolio diversification decisions when investing in financial market in the country. It is imperative to empirical examines return effects, shocks spillover and volatility transmission between these two markets, this will assist investors in risk management and portfolio diversification decision making. The result of this paper could help regulators, in policy formulation to mitigate systemic risk in financial market and ensure appropriate behavior of markets participant.

The contributions of the paper to literature is threefold; the paper is the first to applied the newly developed VAR-GARCH to FX-Stock market nexus in Nigeria, it analyzed both the shocks spillover and volatility transmission between markets, and, in addition, examines the effect of passed return on the current returns in both markets and last but not the least, it calculate the optimal weight for holding foreign exchange and stocks assets also hedging ratios for risk diversification across markets.

The paper is structured as follows: Section II briefed literature review, section III present econometric methodology employed, Session IV presentation of result and discussion and section V paper conclusion and policy recommendations.

2. Literature review

The advent of flow oriented model by Dornsburch and Fischer (1980) and Stock oriented model by Branson (1983), posited somewhat relationship between exchange rate and stock price. Has spurred interest in empirical research on relationship between these variables to validate or counter position of these theories. For instance, Mikhaylov (2016), Korsgaard (2009), Beer *et al.* (2008), Morales(2007), Mun's (2004), Francis *et al.* (2002) found relationship ran from exchange rate to stock market, lead credence to flow oriented theory. However, there has been numbers of studies such as; Bonga and Hoveni (2011), Choi *et al.* (2009), Richards *et al.* (2009) Jayasinghe and Tsui (2008), Ghazili and Ismali (2008), Qayyum and Kemal (2006) and Kanas (2000) found relationship ran from stock price to exchange rate, validating stock oriented theory. Other studies had found two ways relationship, for example; Grobys (2015), Panda and Deo (2014), Andreu *et al.* (2013), Kumar (2013), Andreou *et al.* (2013), Diamandis and Drakos (2010), Morales (2008), Mishra *et al.* (2007), Aloui (2007), Wu (2005), Muhammad and Rasheed (2002), Kumar *et al*. (2007), Bahmani-Oskooee and Sohrabian (1992). Worth of note, some studies could not establish any form of relationship, for instance; Rahman and Uddin (2009), Franck and Young (1972).

There are numbers of studies on Nigeria; Kalu (2014) examined volatility transmission between stock and foreign exchange markets by means of multivariate GARCH model in BEKK framework. Use Nigerian stock returns and Naira/USD exchange rate, from January 1996 to March 2013. Found bidirectional shock transmission between stock and foreign exchange markets and uni-directional volatility transmission from foreign exchange market to stock market. Umoru and Asekome (2013) examined stock prices-Naira-USD exchange rate nexus in Nigeria, use co-integration and Granger-Sim causality methods from 2000 to 2012. Found change in Naira-US$ exchange rate will bring about similar changes in stock prices and two way causal relationship exist. Subair and Zubair (2013) employed Johansen's co-integration test and Granger causality to determine causal relationship between stock market index and monetary indicators (exchange rate and M2) before crises and during global financial crisis in Nigeria, use monthly data for period 2001–2011. Found no long-run relationship before and during crisis and uni-directional causality from M2 to ASI before crisis, while during crisis there is no causal relationship. Olugbenga (2012) investigate long run and short run impact of exchange rate on stock market development from 1985:1 to 2009:4 use Johansen-Juselius cointegration and bi-variate model found positive significant stock market performance effect on exchange rate in short run and negative significant impact of stock market performance on exchange rate in long run. Exchange rate grangers cause stock market performance. Okpara and Odionye (2012) employed Granger causality test, multivariate cointegration and vector error correction model (VECM) method, examined causal and long run relationship between stock prices and exchange rate in Nigeria, use quarterly data from 1990-Q1 to 2009-Q4 by using three stock exchange indicators, the series were order one I(1), long run relationship exist between stock prices and exchange rate. There is evidence of strong one way causality from stock prices to exchange rate irrespective of stock indicators used. Exchange rate has negative impact on stock prices and speed of adjustment is high, when stock market capitalization (SMC) was used as proxy for stock prices, ASI and Valued of stock traded (VST) respectively. Salihu (2010) examined exchange rate volatility effect on Nigeria stock markets. Found exchange rate volatility has stronger negative impact on Nigeria stock markets. However could not find long run relationship among inflation, interest rate and Nigeria stock market. Adebiyi, *et al.* (2009) examined effects of oil price shocks and exchange rate on stock returns in Nigeria from 1985:1 to 2008:4, applied multivariate VAR analysis by dividing oil price shocks into sub-samples of; first subsample (1985-1999), second subsample (2000-2004) and third subsample (2005- 2008) showed significant negative effect of real stock returns on oil price shock in Nigeria. Causal relationship from oil price shocks to stock returns, from stock returns to real exchange rate. Aliyu (2009) used Engle-Granger and Johansen-Juselius co-integration approach examined long run and short run interactions between stock prices and exchange rate in Nigeria. The variables were integrated of I (1), found long run relationship and bidirectional relationship between stock price and exchange rate.

The result from Nigeria studies not different from those of other countries and conclusion remain mixed. The general limitation of Nigeria studies is application of OLS, Johasen-Juselius and Granger causality to study financial data with certain characteristics, these econometrics methodologies lacked power to capture adequately see [Engel, 1984 for detailed literature] and none employed Bivariate VAR-GARCH method, volatilities and shocks transmissions between FX-Stock markets and calculation of optimal weight and hedging ratios, hence, the literature gap this study intends to fill.

3. Data and preliminary analysis

Data covered observations from 31st May 2002 to 1st November 2016; exchange rate is rate at which a unit of US dollar exchange for Naira, denoted by EXR, obtained from Asset Macro data base (www.assetmacros.com) is used to represent foreign exchange market. Nigeria all share index, donated by STK, all share Index is the aggregate measure of Nigerian stock market performance, was obtained from database of Nigerian Stock Exchange (www.nse.com.ng) used to represent stock market.

The returns of these assets are computed on the continuous compounding basis as follows: $r_t = \ln(R_t/R_{t-1}) \times 100$

Figure 1 illustrates relationship between exchange rate and all share indexes, there are basically four different trends, in summary, these variables have inverse relationship. However, between 2002 to first quarter of 2004 it's appeared the variable tends to move the same direction, from first quarters 2004 to 2012 these variables revealed inverse relationship while from 2012 to first quarter of 2014 there seems to be co-movement between the variable, and henceforth inverse relationship are apparent between variable.

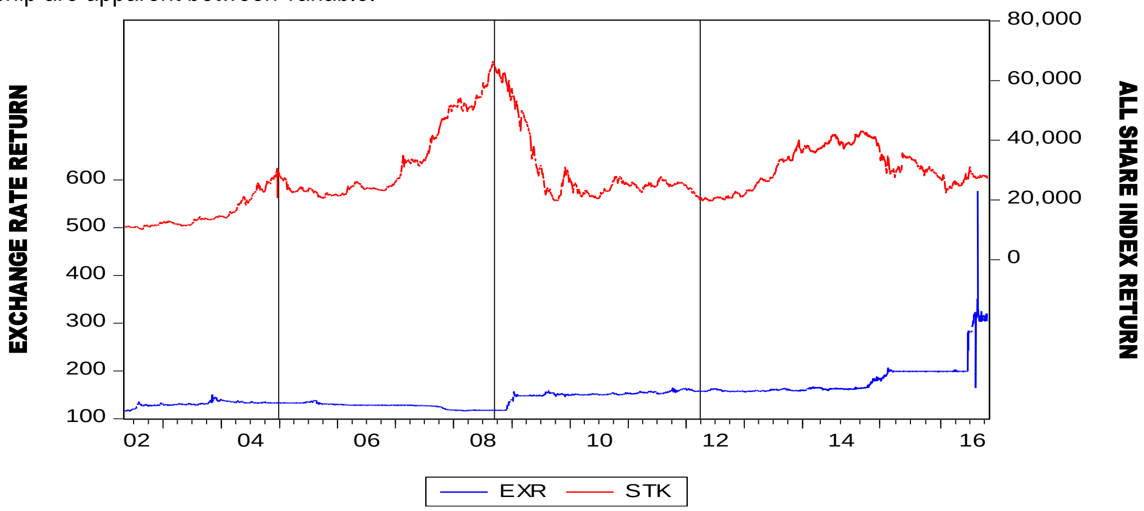

Figure 1. Exchange rate and all share indexes from 1/5/2002 to 1/11/2016

Table 1 showed descriptive statistic for exchange rate and it return series (EXRR), as well as stock market index and it return series (STKR). Result showed mean return of exchange rate is -0.025 and that of all share index is -0.023, it means on average there was losses in both markets and returns behave in similar fashion. Exchange rate was more volatile as could be seen in standard deviation of 2.12 for exchange compared to 1.32 for all share index. We can deduce this from difference between maximum and minimum of each return, while exchange rate has highest return and lowest return within this time period. Moving to the stochastic nature of the returns, represented by the skewness and kurtosis, exchange rate return is negatively skewed; this is case of extreme left tail or thin tail (this could also means there was extreme losses in the FX market) while all share index is positively skewed; this is case of extreme right tail usually refers to as fat tail (this could also means the gain in stock market were extreme). The returns were leptokurtic with kurtosis far greater than 3 cut off for normal distribution and further confirmed by Jacque-Bera statistic with probability (0.000) the null hypothesis of normal distributions is rejected. The ARCH tests were significant at 1, 5 and 10 lags, implying the rejection of null of no ARCH effect in the series, unconditional correlation test showed insignificant inverse level relationship between the series. Both ADF and PP test are significant suggesting the rejection of unit root in the returns series. Having found these results, we turn our attention to bivariate VAR-GARCH models for the returns, shocks spillover and volatility transmission between FX-stock markets.

4. Methodology and empirical analysis

GARCH type models are most appropriate in modeling high frequency financial and macroeconomics data, however, over the years it application was concentrated on univariate modeling and forecasting. Until the development of multi-variate model such as; the DCC-MGARCH model of Engle (2002), Engle and Kroner (1995) BEKK-MGARCH model, Bollerslev (1990) CCC-MGARCH model became attractive in estimating volatility interdependence and transmission of volatility across different time series, despite this advantage these models are dope with limitation such as excess parameters, difficulties in achieving convergence during estimation procedure, especially when additional exogenous variables are added to the conditional mean and variance equations. Due to drawback mentioned above, and our objective of joint determination of evolution of conditional returns, shocks, volatility transmission and also correlation between exchange rate and stock markets in the system. We employed the newly developed VAR-GARCH model by Ling and McAleer (2003), this VAR-GARCH model, includes the multivariate CCC-GARCH model of Bollerslev (1990) a special case in which correlations between system shocks are assumed to be constant to ease the estimation and inference procedure.

Table 1. Descriptive statistics

Statistics	Exchange rate ($/N)		Stock Index (ASI)	
	EXR	EXRR	STK	STKR
Mean	152.11	-0.025	28462.53	-0.023
Maximum	577.04	64.99	66374.10	39.56
Minimum	116.11	-66.40	10173.95	-38.18
Std. Dev.	33.72	2.12	11544.10	1.34
Skewness	2.97	-0.54	0.98	0.66
Kurtosis	18.20	703.81	3.87	362.71
Jarque-Bera	43129.13	7944	753.86	2092
Probability	0.000	0.000	0.000	0.000
Observation	3882	3881	3882	3881
ARCH (1)	122.89**		2338.45**	
ARCH (5)	445.72**		3772.09**	
ARCH (10)	170.09**		3774.23**	
Correlation Coef.	-0.0127			
ADF	-5.275**		-39.431**	
PP	-7.421**		-61. 552**	

***Note**:* ***, **, * denoted rejection of associated null hypothesis at 1%, 5% and 10% respectively, ADF and PP carried out with regression equation with constant but no trend.

This paper adopts the bivariate form of Bollerslev (1990) model, to estimate the interdependency of FX and stock markets in Nigeria. The bivariate VAR (1)-GARCH(1,1) is given as follows:
The conditional mean equation is given by;

$$R_t = \zeta + \Pi R_t + \varepsilon_t \quad (1)$$
$$\varepsilon_t = H^{1/2}\eta_t \quad (2)$$

Where
$R_t = (EXRR_t, STKR_t)'$ is vector of returns of exchange rate and stock market index at time t respectively; ζ is a (2 x 1) vector of constant of the form $\zeta = \begin{pmatrix} \zeta^{EXRR} \\ \zeta^{stkrR} \end{pmatrix}$; Π is a (2 x 2) matrix of coefficient of the form $\begin{pmatrix} \pi_{11}\ \pi_{12} \\ \pi_{11}\ \pi_{22} \end{pmatrix}$; ε_t = $(\varepsilon_t^{EXRR}, \varepsilon_t^{EXRR})'$ is vector of error term for mean equation for FX and stock market index respectively; $\eta_t = \left(\eta_t^{EXRR}, \eta_t^{STKR}\right)$ is vector of independently and identical distributed (iid) random error; $H^{1/2} = diag\left(\sqrt{h_t^{EXRR}}, \sqrt{h_t^{STKR}}\right) = \begin{pmatrix} h_t^{EXRR} & h_t^{EXRRSTKR} \\ h_t^{EXRRSTKR} & h_t^{STKR} \end{pmatrix}$ is matrix of conditional variance for exchange rate and stock index respectively, and h_t^{EXRR} and h_t^{STKR} are conditional variance of exchange rate and stock index. Equation (1) is used to measure return independent in each market.
The shocks spillover and volatility transmission across markets is given as follows:

$$h_t^{EXRR} = \varpi_0^{EXRR} + \beta_1^{EXRR} h_{t-1}^{EXRR} + \alpha_1^{EXRR}(\varepsilon_{t-1}^{EXRR})^2 + \beta_2^{EXRR}(h_{t-1}^{STKR}) + \alpha_2^{EXRR}(\varepsilon_{t-1}^{STKR})^2 \quad (3)$$

$$h_t^{STKR} = \varpi_0^{STKR} + \beta_1^{STKR} h_{t-1}^{STKR} + \alpha_1^{STKR}(\varepsilon_{t-1}^{STKR})^2 + \beta_2^{STKR}(h_{t-1}^{EXRR}) + \alpha_2^{STKR}(\varepsilon_{t-1}^{EXRR})^2 \quad (4)$$

Equations (3) and (4) show explicitly how volatility is transmitted over time and across markets under consideration. The volatility transmission across FX and stock markets is measure by cross value of the error terms, $(\varepsilon_{t-1}^{STKR})^2$ and $(\varepsilon_{t-1}^{EXRR})^2$, which captures effect of direct impact of shock transmission, and those of lagged conditional volatilities, h_{t-1}^{EXRR} and h_{t-1}^{STKR}, which directly account for risk transfers across markets. The null hypothesis is that; the alpha one and beta one coefficient in Eq. (2) and (3) are equal to zeros; hence, there is no spillover of volatility in either direction, exchange rate to stock and stock to exchange rate. To guaranteed stationary, the root of the equation $|I_2 - AL - BL| = 0$ must be outside the unit root cycle, where L is the lag polynomial, I_2 is a (2 x 2) identity matrix, and

$$A = \begin{pmatrix} \alpha_1^{EXRR} & \alpha_2^{EXRR} \\ \alpha_1^{STKR} & \alpha_2^{STKR} \end{pmatrix} \text{ and } B = \begin{pmatrix} \beta_1^{EXRR} & \beta_2^{EXRR} \\ \beta_1^{STKR} & \beta_2^{STKR} \end{pmatrix}$$

Given that, ρ is the conditional constant correlation, we can also denote the conditional covariance $h_t^{EXRRSTKR}$ between the exchange rate and stock return as follows:

$$h_t^{EXRRSTKR} = \rho\sqrt{h_t^{EXRR}}\sqrt{h_t^{STKR}} \quad (5)$$

For the structural and statistical properties of the model, as well as properties for necessary and sufficient conditions for stationary, ergodicity, sufficient conditions for the existence of moments of ε_t and sufficient conditions for consistency and asymptotic normality for the Quasi-Maximum Likelihood estimator in the absence of normality of η_t. See [Ling and McAleer (2003) as cited in Salisu and Mobolaji (2013) for detail literature]. Equation (1) through Equation (4), provides us with relevant information to make judgment on the probable lagged return effect, shock and volatility spillover between FX and stock markets.

5. Results

We begin analysis of estimated result of bivariate VAR(1)-GARCH(1,1) model of FX-stock market in Nigeria as depict in table 2, the mean equation, measure effect of past return denote by AR(1) on current return of each markets. One period lagged return significantly impact on current return in both markets, judging from magnitude of past return for FX market, passed returns has more influence on it current return compared to current stock market return. This findings, lead credence to short term predictability in both market (FX and stock prices) through time and consistent with findings of Inci and Lee (2014) and Qayyum and Kemal (2006).

In variance equation, estimated ARCH and GARCH coefficients measure shocks interdependency between FX and stock market and volatility persistency in conditional variance equation, revealed statistical significant relationship of current volatility with lagged shock and lagged volatility in both markets. The relative small size of ARCH coefficients in both markets, suggest conditional volatility change more rapidly as a result of change in past volatility rather than changes in past shock or news, and impact is stronger in FX market and has covariance stationary or means reverting process as the sum of ARCH and GARCH terms less than unity in both equations.

Now, we focus our attention on direction of volatility and shocks spillover between FX and Stock markets, result obtained from VAR (1)-GARCH (1,1) showed bi-directional volatility transmission in both market, as depicted by significant of (h_{t-1}^{EXRR}) and (h_{t-1}^{STKR}) in both equations, uni-bidirectional shock transmission from stock to FX market depicted by statistical significant of $(\varepsilon_{t-1}^{STKR})^2$ in conditional FX equation. While the $(\varepsilon_{t-1}^{EXRR})^2$ is insignificant in the conditional equation for stock, for instance, 1% change in exchange rate (FX) market volatility, stock volatility will change 0.001 percent and 1% change in stock market volatility, FX market will move in opposite direction of 0.003 percent the next day. Though both markets, transmits volatility to each other. However, FX market response stronger to volatility transmission. The constant conditional correlation shows a very weak negative correlation between markets. This represent diversification opportunity for polio manager's investing in both markets. Having found bi-directional volatility transmission between these market, we will go ahead to construct the optimal weight and hedging ratio for polio managers in these markets.

The forgone analysis, we assumed past positive and negative shock has the same effect on current volatility in financial market (FX and stock). However, this assumption might be inaccurate and could hide vital information; we incorporate leverage effect in our model to capture system response to positive and negative shock.

Table 2. Bivariate VAR(1)-GARCH(1,1) Model estimate

Variables	Exchange rate	Stock market
Mean Equation		
Constant	0.000	-0.084
AR(-1)	-0.284**	0.076**
Variance		
Constant	3.053**	1.643**
$(\varepsilon_{t-1}^{EXRR})^2$	0.306**	-0.089
$(\varepsilon_{t-1}^{STKR})^2$	-0.320**	0.170**
(h_{t-1}^{EXRR})	0.536**	-0.001**
(h_{t-1}^{STKR})	-0.003**	0.544**
CCC		
Exchange	1.000	-0.003
Stock	-0.003	1.000
Log likelihood	-7655.36	-6828.27
LB(5)	0.085**	0.000
$LB^2(5)$	0.995**	0.509**
LM(5)	0.9953**	0.519**
No. Obs.	3883	3883

Note: ***, *** and * indicate significance at 1%, 5% and 10% respectively. LB(5) and $LB^2(5)$ represent the Ljung–Box Q-statistics of order 5 for the standardized residuals and squared standardized residuals respectively and LM(5) represent order 5 Autoregressive conditional heteroscedasticity (ARCH) test.

Table 3, showed estimate of bivariate VAR(1)-AGARCH(1,1) model for FX-stock market. Result depict similar outcome for mean equation, past return denote by AR(1) on current return in both markets. There is short term predictability in both markets through time, significant of ARCH and GARCH terms in variance equation. Negative significant constant conditional correlation of FX with stock market returns.

However, the size of ARCH coefficient in FX market has increase considerably and exceeds GARCH term that is conditional volatility change more rapidly as result of change in pass shock or news rather than changes in past volatility. Conditional volatility in stock market changes more rapidly as a result of past volatility rather than change in past shocks/ news and volatility effect is stronger in FX market. Direction of volatility and shocks spillover between FX and Stock markets in VAR(1)-AGARCH(1,1) model revealed bi-directional volatility transmission in both markets as donated by significant of (h_{t-1}^{EXRR}) and (h_{t-1}^{STKR}) in both equation though FX market volatility significant but value too small. Uni-directional shock spillover from stock to FX market as shown by statistical significant of $(\varepsilon_{t-1}^{STKR})^2$ in conditional exchange rate equation while $(\varepsilon_{t-1}^{EXRR})^2$ is insignificant in the conditional equation for stock. Negative significant relationship between negative return and volatility showed leverage effect exist; bad news has more impact on current volatility than positive news of the same magnitude hence we reject symmetry effect assumption in VAR-GARCH model.

Table 3. Bivariate VAR (1)-AGARCH(1,1) Model estimate

Variables	Exchange rate	Stock market
Mean Equation		
Constant	-0.055	-0.106**
AR(-1)	0.812**	0.102**
Variance		
Constant	3.152**	1.665**
$(\varepsilon_{t-1}^{EXRR})^2$	0.703**	-0.121
$B[(\varepsilon_{t-1}^{EXRR})X((\varepsilon_{t-1}^{EXRR})<0)]$	-1.133**	
$(\varepsilon_{t-1}^{STKR})^2$	0.475**	0.178**
$B[(\varepsilon_{t-1}^{STKR})X((\varepsilon_{t-1}^{STKR})<0)]$	-0.249**	
(h_{t-1}^{EXRR})	0.373**	-0.000**
(h_{t-1}^{STKR})	-0.002**	0.545**
CCC		

Variables	Exchange rate	Stock market
Exchange	1.000	-0.014
Stock	-0.014	1.000
Log likelihood	-6898.30	-6730.39
LB(5)	0.000	0.397**
$LB^2(5)$	0.823***	0.378**
LM(5)	0.828	0.389**
Norm.	0.000	0.000
No. Obs.	3883	3883

Note: ***, *** and * indicate significance at 1%, 5% and 10% respectively. LB(5) and $LB^2(5)$ represent the Ljung–Box Q-statistics of order 5 for the standardized residuals and squared standardized residuals respectively, LM(5) represent order 5 Autoregressive conditional heteroscedasticity (ARCH) test and Normal is the normality test.

5. Portfolio management with exchange rate risk hedging strategies

The Results discussed in two models showed returns has experienced substantial fluctuation and volatility transmission between FX and stock markets. Our goal is to show how to hedge against FX risk effectively.

Consider an investor who holds a set of stocks and wishes to hedge this stock position against unfavorable effect resulting from change in exchange rate movements. The investor is face with risk minimization of exchange rate-stock portfolio without reducing its expected returns. Kroner and Ng (1998), the optimal holding weight of exchange rate in a one dollar portfolio of exchange rate/stock market at time t is given under conditions that;

$$w_t^{STKREXRR} = \frac{h_t^{STKR} - h_t^{STKR_{EXRR}}}{h_t^{STKR} - 2h_t^{STKR_{EXRR}} + h_t^{STKR}} \tag{6}$$

Given that:

$$w_t^{SE} = \begin{cases} 0, if - w_t^{SE} < 0 \\ w_t^{SE}, if\ 0 \le w_t^{SE} \le 1 \\ 1, if - w_t^{SE} > 0 \end{cases} \tag{7}$$

Where w_t^{SE} represent exchange rate weight in a one dollar exchange rate/stock portfolio at time t for two asset and optimal weight of exchange rate is evaluated 1- w_t^{SE} and h_t^{EXRR} and h_t^{STKR} are conditional variances of exchange rate market and stock market index respectively, and $h_t^{STKR_{EXRR}}$ refers to conditional covariance between exchange rate and stock market returns at time t. We illustrate how an investor would determine optimal hedge ratio for his portfolio can be made. Following Kroner and Sultan (1993), regarding risk minimizing hedge ratios of two asset portfolio; exchange rate and stock markets. The risk is minimal if long position (buy) of one dollar in foreign exchange market can be hedged by a short (sell) position of β_t dollar in the stock market index. The hedge ratio is given by:

$$\beta_t^{SE} = \frac{h_t^{SKTR_{EXRR}}}{h_t^{SKTR}} \tag{8}$$

Where β_t^{SE} is risk minimizing hedge index for both markets and h_t^{EXRR} and h_t^{STKR} are as defined earlier on in equation (6). Table 4 report average value of realized optimal weight w_t^{SE} and hedge ratio β_t^{SE}. Optimal weights for exchange rate asset in hedge polio is to a large extent similar in between models, optimal weight for VAR-GARCH is 51.2% while VAR-AGARCH is 53.4%, imply optimal allocation for FX in one Dollar FX-Stock polio should be 51.2 cent, 53.4 cent respectively, while balance of 48.8 cent and 46.6 cent invested into stock market. In spite of similarity, VAR-AGARCH model has higher FX holding weight, its means risk is slightly higher under VAR-GARCH model, and change in exchange rate might lead to unfavorable effect on performance of hedged polio. However, since VAR-AGARCH model is preferred this result is inconsequential. These findings imply, investor holding financial asset in Nigeria financial market should have more FX in their polio to stocks, in order to minimize the risk while ensuring that the expected return remain unchanged.

Table 4 reports computed average optimal hedging ratio for holding financial assets in Nigeria, given hedging ratio β_t^{SE} quite low it suggests FX risk can be hedged by taken short position in stock market. Implied one Dollar long position of FX should be shorted by 2.2% in VAR-GARCH and 0.9% VAR-AGARCH of Stocks market. VAR-AGARCH model provide a better hedging ratio and lower risk. Looking at diagnostic test from models as computed by Ljung-Box test for autocorrelation on standardized error and squared standardized error term, LM test for autoregressive conditional heteroscedasticity (ARCH) showed VAR-AGARCH was the only model that really captures stylized fact inherent in financial data.

Table 4. Optimal polio weight and hedge ratio from exchange rate and stock market

Model	w_t^{SE}		β_t^{SE}
VAR-GARCH	0.512		0.022
VAR-AGARCH	0.534		0.009

Note: The table reports average optimal weight of oil and hedge ratios for an FX-stock market portfolio.

6. Conclusions

The paper examines effect of passed return on current return of FX and stock markets, it also analysis the shock spillover and volatility transmission between markets. The paper provides new insight on FX-Stock market effect in the literature and applied new methodology on Nigeria data. The data covered period of 1/5/2002 to 1/11/2016. The result was in turn used to calculate the effectiveness of risk minimizing hedging ratio between markets and optimal polio weight for each markets. The analysis is based on the bivariate Vector autoregressive-Generalized autoregressive conditional heteroscedasticity for symmetry and asymmetry type models.

The VAR-GARCH model revealed, one period lagged returns significantly impact on current return of both markets. However, past return of FX market has more influence on it current return compared to stock market return, there is evidence of short term predictability in both markets (FX and stock prices) through time. Conditional volatility change more rapidly as result of changes in past volatility rather than change past shock/news. Effect was stronger in FX market and covariance stationary or means reverting process. There is evidence of bi-directional volatility transmission in both markets and uni-directional shock spillover from stock to FX market and FX market responds more to volatility transmission than stock market.

The VAR-AGARCH model basically provide similar result, however, the size of the ARCH coefficient in the FX market has increase considerably and even exceeds the GARCH term. The conditional volatility changes more rapidly as a result of pass shock or news, rather than changes in past volatility. While the conditional volatility in stock market, changes more rapidly as a result of past volatility, and volatility effect is strong in FX market. There is bi-directional volatility transmission in both markets, and uni-directional shock transmission from stock to FX market. There is evidence of leverage effect, that is, bad news has more effect on volatility than positive news of the same magnitude.

The weights and hedging ratios showed optimal polio in Nigeria financial market should hold more foreign exchange in their asset polio to stocks and foreign exchange investment risk can be hedged effectively with relative lower hedging cost by taking a short position in stock market, we also shows, there is a better hedging and lower risk in VAR-AGARCH model. The diagnostic test computed by the Ljung-Box test for autocorrelation on standardized error and squared standardized error term, LM test for autoregressive conditional heteroscedasticity, showed VAR-AGARCH was the only model that really captures dynamics in the FX and stock markets. Finally, our results showed evidence of effective hedging between FX and stock markets in Nigeria financial market. Hence, the inclusion of stocks in diversified polio of foreign exchange may improve it risks adjusted performance of the hedging ratio.

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