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THE NATURE OF DOMESTIC VOLATILITY TRANSMISSION BETWEEN SECTORS OF THE NIGERIAN ECONOMY

Emenike Kalu O[1], Peter Ifeanyichukwu Ali[2]
[1]Department of Banking and Finance, Rhema University Aba, Nigeria
[2]Department of Financial Management Technology, Federal University of Technology Owerri

Abstract: *Volatility transmission between sectors of a market or an economy is important to successful portfolio selection and hedging strategy within the domestic economy. This paper examines domestic volatility transmission between sectors of the Nigerian economy using Multivariate Generalised Autoregressive Conditional Heteroscedasticity (MGARCH) procedure. The central focus is to evaluate the nature and direction shock and volatility transmission between the banking sector, the consumer goods sector and the Shari'ah compliant equities sector of the Nigerian Stock Exchange (NSE). The results indicate existence of unidirectional shock and volatility transmission from the banking sector to the consumer goods sector and the Shari'ah compliant equities sector, and bidirectional shock and volatility transmission between the consumer goods and the Shari'ah compliant equities sectors of the NSE. These findings have crucial implications for domestic portfolio selection and management through the hedging opportunities available in the NSE sectors.*

Keywords: *volatility transmission, sectors of economy, BEKK-GARCH Model, Nigeria*

JEL Classification *Numbers: G11, G32, C32*

Introduction

A good understanding and accurate prediction of volatility transmission between assets, sectors or market returns are crucial to successful portfolio selection and hedging strategy. Financial assets and market returns are generally influenced by the portfolio decisions of investors who actively participate in more than one financial market. In turn, these decisions are usually influenced by a continuous flow of information that often results in market price volatility spillover within and across markets (Hurditt, 2004). Investors' major objective is to minimise the risk exposure of their portfolios while maintaining their expected returns. Along this line, Fleming, Kirby and Ostdiek (1996) assert that, as a portfolio manager considers the correlation between different market returns, he will take a position in one market in order to hedge his speculative position in another. It is, thus, extremely important to understand the volatility linkages within the domestic financial market and the interrelationships with international financial markets. To this extent, understanding the banking, consumer goods and Shari'ah equities sectors' volatility linkages will provide means to hedge against the sectoral risks emanating from shocks that persist within any of the sectors and those that may arise from the market as a whole.

Numerous empirical studies have considered volatility transmission across international financial markets (see, Hamao, Masulis and Ng, 1990; Kanas, 2000; Worthington and Higgs, 2004; Valadkhani, Harvie and Karunanayake, 2013). Other studies have also concentrated on volatility transmission across markets in the same economy (see, Turkyilmaz and Balibey, 2013; Emenike, 2014). There are also very few studies that have examined volatility transmission across sectors of the same market (see for example, Malik and Ewing, 2009; Arouri, Jouini and Nguyen, 2011). While majority of these studies were conducted mainly for developed and recently for emerging financial markets, such evidence is either not available or scant in the case of Nigeria.

The major objective of this study therefore is to augment the findings already obtained on volatility transmission in both developed and developing financial markets by providing an answer to the question: What is the nature of volatility transmission between the banking sector, consumer goods sector and Shari'ah compliant equities sector of the Nigerian Stock Exchange (NSE)? Answer to this question is important to risk management and hedging strategy. In the presence of volatility transmission, a shock in one of the sectors could have a destabilizing impact on the other sectors. If, for instance, there is comovement of volatility between these sectors, investors will look for other sources to hedge against risk. Thus, the nature of volatility transmission will improve sector risk-sharing, enhance portfolio selection and hedging as well as enrich extant literature. Immediately preceding this introduction is Section 2, which contains brief review of empirical literature. Section 3 describes methodology and data for analysis. Section 4 presents empirical results, and section 5 concludes.

Brief Review of Related Empirical Literature

While a considerable number of empirical studies have examined volatility transmission across international financial markets, few studies have explored volatility transmission across markets in the same economy, and fewer studies have investigated volatility transmission across sectors of the same economy. One of the earliest studies of volatility transmission across international markets is Hamao, Masulis and Ng (1990), which analyse the short-run interdependence of prices and price volatility across London, New York and Tokyo stock markets in the pre-October period. They show evidence of price volatility spillover from New York to London, from New York to Tokyo and from London to Tokyo but not in other directions. Similarly, Worthington and Higgs (2004) examine the transmission of equity and volatility among three Asian developed markets (Japan, Hong Kong, and Singapore) and six Asian emerging markets (Indonesia, Korea, Malaysia, Philippines, Taiwan, and Thailand), and find evidence of positive mean and volatility spillover. Their results also show that own stock market spillovers were generally higher than cross-volatility spillovers for all markets. Valadkhani, Harvie and Karunanayake (2013) examine the dynamics of cross-country GDP volatility transmission, and find that shock influences are mainly exerted by the larger economies onto the smaller economies. Other studies of volatility transmission across countries include Koutmos and Booth (1995), Kanas (2000), among others.

Apart from exploring volatility transmission in financial markets across different countries, researchers have also studied the volatility linkages between domestic markets and, even sectors of an economy. Some examples of studies that examine volatility transmission across different markets of the same economy include, Turkyilmaz and Balibey, (2013), which examine the relationship between interest rate, exchange rate and stock price using BEKK-MGARCH

approach. They conclude that there is significant transmission of shocks and volatility among the three variables. Emenike (2014) examines volatility transmission between stock and foreign exchange markets in Nigeria. His results show evidence of bidirectional shock transmission between the stock and foreign exchange markets, and a unidirectional volatility transmission from the foreign exchange market to the stock market. Other studies include Ebrahim (2000), Kim (2013), and so on.

The few literature on volatility transmission among sectors of market include Ewing (2002), which analyses the interrelationship between five major sectors (i.e., capital goods, financials, industrials, transport and utilities) of the S&P stock indexes, and find that unanticipated shocks in one sector has significant impacts on other sectors. Hassan and Malik (2007) examine the mean and conditional volatility interactions among different United States sector indexes using multivariate GARCH model. They find evidence of shock and volatility transmission among different sectors. Malik and Ewing (2009), employs bivariate GARCH models to simultaneously estimate the conditional variance between five US sectors and oil prices using weekly returns and find evidence of significant transmission of shocks and volatility between oil prices and some of the examined sectors. Similarly, Arouri, Jouini and Nguyen (2011) investigate volatility transmission between oil price and equity returns in Europe and the United States at the sector-level, and find significant evidence of return and volatility spillovers. Their results however show that the spillover is usually unidirectional from oil markets to stock markets in Europe, but bidirectional in the United States.

Methodology and Data

Methodology

The BEKK representation of multivariate GARCH model outlined in Engle and Kroner (1995) is adopted to investigate volatility transmission between stock and foreign exchange markets in Nigeria. The BEKK model presents a natural way to estimate the interaction within conditional mean and conditional variance of two or more series because of its capability to detect volatility transmission among the series, as well as persistence of volatility within each series.

The first step in the multivariate GARCH methodology is to specify the mean equation. Thus, the mean equation for return series is specified as follows:

$$R_t = \mu_i + \theta R_{i,t-i} + \varepsilon_t$$
$$\varepsilon_t = \mathrm{H}_t^{1/2}\eta_t \qquad (1)$$

Where $R_t = \left(\mathrm{R}_t^{\mathrm{B}}, \mathrm{R}_t^{CG}, \mathrm{R}_t^{LII}\right)$` is a vector of returns of the banking, consumer goods, and lotus Islamic sectors respectively, $\theta$ refers to a 3x3 matrix of coefficients, $\varepsilon_t = \left(\varepsilon_t^{\mathrm{B}}, \varepsilon_t^{CG}, \varepsilon_t^{LII}\right)$` is the vector of error terms of conditional mean equation for banking, consumer goods, and lotus Islamic sectors respectively. $\eta_t = \left(\eta_t^{\mathrm{B}}, \eta_t^{CG}, \eta_t^{LII}\right)$ is a sequence of independently and identically

distributed (i.i.d) random errors; $H_t = \begin{pmatrix} h_t^{B} & h_t^{BCG} & h_t^{BLII} \\ h_t^{CG} & h_t^{CGB} & h_t^{CGLII} \\ h_t^{LIIB} & h_t^{LIIB} & h_t^{LIICG} \end{pmatrix}$ is conditional variance-covariance of the banking, consumer goods and Shari'ah equities sectors' returns.

The next step is to specify the conditional variance-covariance equation. Thus, the BEKK representation of multivariate GARCH (1,1) model is given by:

$$H_t = CC` + A\varepsilon_{t-1}\varepsilon`_{t-1}A` + BH_{t-1}B` \qquad (2)$$

Where, *Ht* is the conditional variance matrix. *C, A,* and *B* are parameter matrices. C is a 3x3 lower triangular matrix, *A* is 3x3 square matrix that shows how conditional variances correlate with past squared errors, and *B* is 3x3 square matrix that measures the effect of past conditional variances on the current conditional variances and the degree of persistence in the volatility of the markets. The parameter matrices can be represented as follows:

$$\begin{bmatrix} h_{b,t} & .h_{b,cg,t} & .h_{b,lii,t} \\ h_{cg,b,t} & h_{cg,t} & .h_{cg,lii,t} \\ h_{lii,b,t} & h_{lii,cg,t} & h_{lii,t} \end{bmatrix} = \begin{bmatrix} c_{b,b} & . & . \\ c_{cg,b} & c_{cg,cg} & . \\ c_{3lii,b} & c_{lii,cg} & c_{lii,lii} \end{bmatrix} + \begin{bmatrix} a_{b,b} & a_{b,cg} & a_{b,lii} \\ a_{cg,b} & a_{cg,cg} & a_{cg,lii} \\ a_{lii,b} & a_{lii,cg} & a_{lii,lii} \end{bmatrix} + \begin{bmatrix} b_{b,b} & b_{b,cg} & b_{b,lii} \\ b_{cg,b} & b_{cg,cg} & b_{cg,lii} \\ b_{lii,b} & b_{lii,cg} & b_{lii,lii} \end{bmatrix} + \begin{bmatrix} \varepsilon_{b} & \varepsilon_{b,cg} & \varepsilon_{b,lii} \\ \varepsilon_{cg,b} & \varepsilon_{cg} & \varepsilon_{cg,lii} \\ \varepsilon_{lii,b} & \varepsilon_{lii,cg} & \varepsilon_{lii} \end{bmatrix} \qquad (3)$$

Where $h_{b,b,t}$, $h_{cg,cg,t}$ and $h_{lii,lii,t}$ denote the conditional variance of the banking sector, consumer goods sector, and Shari'ah equities sector respectively; $h_{b,cg,t}$ and $h_{b,lii,t}$ the covariance of banking and consumer goods sectors, as well as banking and Shari'ah equities sectors; $h_{cg,b,t}$ and $h_{cg,lii,t}$ are the covariance of consumer goods and banking sectors, and consumer goods and Shari'ah equities sectors; $h_{lii,b,t}$ and $h_{lii,cg,t}$ are the covariance of Shari'ah compliant equities and banking sectors, and Shari'ah equities and consumer goods sectors of the NSE. The significance of the diagonal coefficients $a_{bb,t}$ ($a_{cg,cg,t}$) [$a_{lii,lii,t}$] suggests that the current conditional variance of $h_{bb,t}$ ($h_{cg,cg,t}$) [$h_{lii,lii,t}$] is correlated with its own past squared errors, while the significance of the lagged variance $b_{11,t}$ ($b_{cg,cg,t}$) [$b_{lii,lii,t}$] indicates that the current conditional variance of $h_{bb,t}$ ($h_{cg,cg,t}$) [$h_{lii,lii,t}$] is affected by its own past conditional variance. Similarly, the significance of the off-diagonal coefficients $a_{b,cg,t}$ & $b_{b,cg,t}$, and $a_{b,lii,t}$ & $b_{b,lii,t}$ indicate evidence of shock and volatility transmission from the banking sector to the consumer goods and Shari'ah equities sectors; whereas the significance of the off-diagonal coefficients $a_{cg,b,t}$ & $b_{cg,b,t}$, and $a_{cg,lii,t}$ & $b_{cg,lii,t}$ show evidence of shock and volatility transmission effects from the consumer goods sector to the banking sector and the Shari'ah equities sector. Similarly, the significance of the off-diagonal coefficients $a_{lii,b,t}$ & $b_{lii,b,t}$, and $a_{lii,cg,t}$ & $b_{lii,cg2,t}$ show evidence of shock and volatility transmission effects from the Shari'ah equities sector to the consumer goods sector and the banking sector. The parameter matrices are estimated using the expanded BEKK-MGARCH (1,1) equation:

$$h_{11,t+1} = c_{11}^2 + c_{11}^2 + a_{11}^2\varepsilon_{1,t}^2 + 2a_{11}a_{12}\varepsilon_{1,t}\varepsilon_{2,t} + 2a_{11}a_{31}\varepsilon_{1,t}\varepsilon_{3,t} + a_{21}^2\varepsilon_{2,t}^2 + 2a_{21}a_{31}\varepsilon_{2,t}\varepsilon_{3,t} + a_{31}^2\varepsilon_{3,t}^2 + b_{11}^2h_{11,t}^2 + 2b_{11}b_{12}h_{12,t} + 2b_{11}b_{31}h_{13,t} + b_{21}^2h_{22,t} + 2b_{21}b_{31}h_{23,t} + b_{31}^2h_{33,t} \quad (4)$$

$$h_{22,t+1} = c_{12}^2 + c_{22}^2 + a_{12}^2\varepsilon_{1,t}^2 + 2a_{12}a_{22}\varepsilon_{1,t}\varepsilon_{2,t} + 2a_{12}a_{32}\varepsilon_{1,t}\varepsilon_{3,t} + a_{22}^2\varepsilon_{2,t}^2 + 2a_{22}a_{32}\varepsilon_{2,t}\varepsilon_{3,t} + a_{32}^2\varepsilon_{3,t}^2 + b_{12}^2h_{11,t}^2 + 2b_{12}b_{22}h_{12,t} + 2b_{12}b_{32}h_{13,t} + b_{22}^2h_{22,t} + 2b_{22}b_{32}h_{23,t} + b_{32}^2h_{33,t} \quad (5)$$

$$h_{33,t+1} = c_{13}^2 + c_{33}^2 + a_{13}^2\varepsilon_{1,t}^2 + 2a_{13}a_{23}\varepsilon_{1,t}\varepsilon_{2,t} + 2a_{13}a_{33}\varepsilon_{1,t}\varepsilon_{2,t} + a_{23}^2\varepsilon_{2,t}^2 + 2a_{23}a_{33}\varepsilon_{1,t}\varepsilon_{3,t} + a_{33}^2\varepsilon_{3,t}^2 + b_{13}^2h_{11,t}^2 + 2b_{13}b_{23}h_{12,t} + 2b_{13}b_{33}h_{13,t} + b_{23}^2h_{22,t} + 2b_{23}b_{33}h_{23,t} + b_{33}^2h_{33,t} \quad (6)$$

Equations (4), (5) and (6) show how shocks and volatility are transmitted between the three sectors of the NSE. Statistical significance of the off-diagonal parameters is evidence in support of shock and volatility transmission between the three sectors of the Nigerian economy. The parameters are estimated using the maximum likelihood estimation method optimized with the Broyden, Fletcher, Goldfarb, and Shanno (BFGS) algorithm. The conditional likelihood function $L(\theta)$ is expressed thus:

$$L(\theta) = -T\ln(2\pi) - \frac{1}{2}\sum_{t=1}^{T}(\ln|H_t| + \varepsilon_t' H_t^{-1}\varepsilon_t) \quad (4)$$

Where, T is the number of observations and θ is the parameter vector to be estimated.

The robustness of the multivariate GARCH models can be evaluated using a number of diagnostics tests. The Ljung-Box (1978) Q test statistics are used to examine the null hypothesis of no autocorrelation in the estimated residuals and squared standardized residuals up to a specific lag. Also, Engle's (1982) LM statistic is used to test the null hypothesis of no remaining ARCH effects up to a specific order. In fact, if the multivariate GARCH model is specified correctly, then the estimated standardized residuals should behave like white noise, i.e., they should not display serial correlation, ARCH effect, or any other type of nonlinear dependence (Emenike, 2014).

Data

The data used in this study comprises the daily NSE banking index to capture the banking sector, the daily NSE consumer goods index to capture the consumer goods sector, and the NSE Lotus Islamic Index to capture Shari'ah compliant equities in the NSE. The NSE Banking Index is designed to provide an investable benchmark to capture the performance of the banking sector, this index comprises the most capitalized and liquid companies in banking sector of the Nigerian economy. The NSE Consumer Index provides an investable benchmark to capture the performance of the consumer goods sectors, this index comprises the most capitalized and liquid companies in food, beverage and tobacco. The NSE-Lotus Islamic Index (NSE LII) tracks the performance of 15 Shari'ah compliant equities which have met the eligibility requirements of a renowned Shari'ah Advisory Board. The component stocks are rigorously screened and reviewed bi-annually to ensure their continuous compliance for inclusion. The indexes are based on the market capitalization methodology.

The study period ranges from 04 January 2010 to 30 April 2014, totaling 1071 observations for each index. This time period was chosen because of the availability of data. The NSE started the compilation of other sector indices in January 2009, but the Lotus Islamic Index in January

2010. In addition, the study period corresponds with post global financial crises era. All the indexes were obtained from the NSE and converted into daily returns as follows:

$$Rt = Ln\,(P_t / P_{t-1}) * 100 \qquad (5)$$

Where, R_t is daily returns of the sector indexes, P_t is a vector of closing indexes at time t, P_{t-1} is the previous day closing indexes, and Ln is natural logarithm.

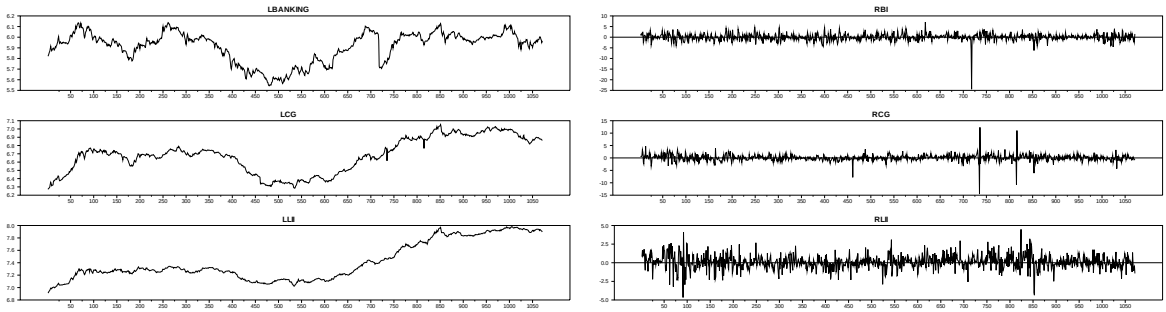
Empirical Results and Discussions

Descriptive Statistics

Figure 1, shows time series plots of level series and daily return series of the NSE banking, consumer goods, and Shari'ah equities sectors indexes for the period ranging from 04 January 2010 to April 30 2014. The level series of all the three indexes show trending behaviour, whereas the return series show mean reversion tendency. Notice, also from *Figure 1*, the downward movement in the level series from November 2011, although with minor fluctuations, the northward movement from beginning of first quarter of 2012. Another visible feature of *Figure 1* is the negative spike in the banking sector and negative and positive spikes in consumer goods and Shari'ah equities sectors return series. In all, while trending series suggest that the underlying series are non-stationary; mean reverting series may indicate that the underlying series are stationarity.

FIGURE 1: Time Plot of Level Series and Returns of the NSE Banking, Consumer Goods, Islamic Indexes

4 January 2010 to 30 April 2014



Descriptive statistics and ARCH-LM estimates are presented in *Table 1* below. As this table shows, annualized mean returns are 3.36%, 13.70% and 22.88% for the NSE banking, consumer goods, and Shari'ah equities indexes respectively. The annualized volatility of the returns are 20.01%, 17.98%, and 15.33% for the NSE banking index, consumer goods index, and Shari'ah equities index respectively. These suggest that the banking sector has the lowest return and standard deviation, whereas the Shari'ah compliant equities sector has the highest return and lowest standard deviation for the study period. The skewness of a normal distribution is zero (0). But the return series of all the three sectors are negatively skewed, with the banking sector exhibiting most negative skewness (-3.20). The negative skewness suggests that there are more negative observations in the three sectors than in standard normal distribution. The excess

kurtosis of a normal distribution is zero (0). But the excess kurtosis for the three sectors indicates that they are all more peaked than the normal distribution. In addition, the Jarque-Bera test coefficients for the three sectors are significant at conventional levels, showing that all the series are not normally distributed. Notice also from *Table 1* that ARCH-LM results reject the null hypotheses of no ARCH effect in all the series at the 1% significance level. Thus provides support for ARCH/GARCH model.

Table 1: Descriptive Statistics and Test for ARCH Effect

	Mean	S.D	Skew.	E.Kurt	JB Stat	LM (20)
Banking	0.013	1.608	-3.201 (0.00)	49.929 (0.00)	112972.4 (0.00)	132.42 (0.00)
CG	0.055	1.298	-0.687 (0.00)	32.387 (0.00)	46850 (0.00)	282.55 (0.00)
LII	0.091	0.943	-0.081 (0.27)	2.523 (0.00)	285.09 (0.00)	139.57 (0.00)

Note: *P*-values are displayed as (.). The ARCH LM tests are conducted under null hypothesis of no ARCH effect and at 95% confidence level using squared returns.

Unit Root Test Results

Table 2 shows the results of the augmented Dickey-Fuller (ADF) unit root test. The null hypothesis of the ADF test is that a time series contains a unit root. As shown in *Table* 2, the calculated values of the ADF test statistics indicate that the level series contain unit root at the 1% significance level, implying that the level series of three sector indexes under study are non-stationary. However, in the case of the return series, the ADF statistics reject the null hypotheses of unit root at the 1% significance level, implying that the returns series of the NSE banking index, consumer goods index, and Shari'ah equities index are stationary at first difference.

Table 2: Augmented Dickey-Fuller Unit Root Test Results

	Level		First Difference	
Variables:	**5% critical value**	**computed**	**5% critical value**	**computed**
Banking	-3.4164	-2.1269	-3.4164	-19.2759**
CG	-3.4163	-1.5093	-3.4164	-22.2581**
LII	-3.4163	-0.9794	-3.4164	-27.6896**

Note: ADF lag length is selected using Akaike information criterion (AIC). ** indicates significant at 99% confidence level.

Multivariate GARCH (1,1)-BEKK Model Results

Table 3 presents the results of the multivariate GARCH(1.1)-BEKK model adopted to examine the nature of volatility transmission between the banking sector, consumer goods sector, and Shari'ah equities sector of the Nigerian economy. Notice from *Table 3* that the coefficients of the diagonal parameters, $A_{b,b}$, $A_{cg,cg}$, $A_{lii,lii}$, $B_{b,b}$, $B_{cg,cg}$, and $B_{lii,lii}$ are all statistically significant at 99% confidence level. These indicate that the null hypotheses of no ARCH and no GARCH effects in the banking, consumer goods, and Shari'ah equities sectors are not true. They also suggests that strong ARCH and GARCH (1.1) process drive the shocks and conditional variances of the sectors' returns. In other words, own past shock and volatility affect the current shock and volatility of the banking, consumer goods, and Shari'ah compliant equities sectors in Nigeria. This finding agrees with Worthington and Higgs (2004) who show evidence of own stock market spillovers being generally higher than cross-volatility spillovers for all markets they examined.

The off-diagonal elements of matrices *A* and *B* capture cross-sector shock and volatility transmission between the banking sector, consumer goods sector, and Shari'ah equities sector. From the off-diagonal elements of matrix *A*, notice that shock from the banking sector spillover to the consumer goods sector and Shari'ah equities sector at 1% significance level, but there no shock transmission from consumer goods and Shari'ah compliant equities sector to the banking sector. This suggests that information flow from the banking sector impact the consumer goods and Shari'ah compliant equities sectors but not the other way round. Notice also that while shocks from the consumer goods sector transmits to the Shari'ah compliant equities sector at 10% significance level, shocks from the Shari'ah compliant equities sector transmits to the consumer goods sector at 1% significance. This implies bidirectional shock transmission between consumer goods and Shari'ah compliant equities sectors within the conventional confidence band. This result agrees with Ewing (2002) finding that shocks in one sector has significant impacts on other sectors using the S&P stock indexes. Evidence of unidirectional shock transmission between banking to consumer goods sector and Shari'ah compliant equities sector is not unexpected given the position of the banking sector in the NSE. SEC (2010), in Emenike and Ani (2014), reports that of the twenty most actively traded equities, banks are the first five. Similarly, of the twenty most capitalised companies on the NSE, eleven are banks. In the same vein, Alawiye (2013), in Emenike and Ani (2014), reports that the banking sector accounted for 57.98 per cent of total trades in the NSE in February 2013. It thus appear that the banking sector lead the information flow in the NSE.

The results of the off-diagonal elements of matrix *B* show evidence of volatility transmission from the banking sector to the consumer goods sector and Shari'ah compliant equities sector, with negative and statistically significant coefficients at 99% confidence level, but not the other way round. This finding suggests that the volatility of the banking sector negatively affects other sector of the NSE. Notice also, from *Table 3*, that while volatility transmits positively from the consumer goods sector transmits to the Shari'ah equities sector, it transmits negatively from the Shari'ah equities sector to the consumer goods sector, all at 1% significance level. These results suggest that there exist evidence of unidirectional shock and volatility transmission from the banking sector to the consumer goods and the Shari'ah equities sectors, whereas bidirectional shock and volatility transmission exist between the consumer goods and the Shari'ah equities sectors at conventional confidence levels. Bidirectional shock and volatility transmission is in agreement with Hassan and Malik (2007), who show evidence of significant shock and volatility transmission among different United States sector indexes.

The existence of unidirectional shock and volatility transmission from the banking sector to the other sectors may not be far from the dominance of the banking sector in the NSE, whereas the bidirectional shock and volatility transmission between the consumer goods and the Shari'ah compliant equities sectors may partly result from advancement in information and communication technology (ICT) which has made it easier for information to flow between the sectors. In addition, the banking sector is under stringent regulatory purview of the Central Bank of Nigeria given its importance to the stability of the Nigerian economy, whereas consumer goods and the Shari'ah equities sectors have more relaxed regulation and governance.

The panel *B* of *Table 3* presents the results of diagnostic tests conducted to ascertain robustness of the estimated model. Notice from panel *B*, that the Ljung-Box Q-statistic for both the residuals and squared residuals of banking, consumer goods and Shari'ah compliant equities sectors are not significant, suggesting that there is no correlation in their residuals. Similarly, the multivariate ARCH-LM and Ljung-Box results show evidence in support of the null hypotheses of no ARCH effect and no serial correlation at 99% confidence level. As a result, there seem to be no specification error in the model.

Table 3: Results of the GARCH-BEKK Model

Parameters	Coefficient	*t*-statistic	*P*-value
$C_{(b,b)}$	0.9463	14.5895	0.0000
$C_{(cg,b)}$	0.2560	5.0335	0.0000
$C_{(cg,cg)}$	0.2193	4.4973	0.0000
$C_{(lii,b)}$	0.1750	3.4698	0.0005
$C_{(lii,cg)}$	0.1879	4.8214	0.0000
$C_{(lii,lii)}$	0.0000	8.82854e	0.9999
$A_{(b,b)}$	0.5521	15.668	0.0000
$A_{(b,cg)}$	0.0614	3.1934	0.0014
$A_{(b,lii)}$	0.0391	2.6380	0.0083
$A_{(cg,b)}$	0.0219	0.7987	0.4244
$A_{(cg,cg)}$	0.2646	8.0418	0.0000
$A_{(cg,lii)}$	-0.0262	-1.6864	0.0917
$A_{(lii,b)}$	-0.0333	-0.6245	0.5322
$A_{(lii,cg)}$	0.1148	2.6095	0.0090
$A_{(lii,lii)}$	0.3169	11.0862	0.0000
$B_{(b,b)}$	0.5112	7.6578	0.0000
$B_{(b,cg)}$	-0.1549	-4.7319	0.0000
$B_{(b,lii)}$	-0.1497	-6.6572	0.0000

Parameters	Coefficient	*t*-statistic	*P*-value
$B_{(cg,b)}$	0.0126	0.3080	0.7580
$B_{(cg,cg)}$	0.9960	44.255	0.0000
$B_{(cg,lii)}$	0.0863	5.1628	0.0000
$B_{(lii,b)}$	0.0732	1.2307	0.2184
$B_{(lii,cg)}$	-0.1792	-6.8425	0.0000
$B_{(lii,lii)}$	0.8843	43.6448	0.0000

Panel B: Diagnostic Tests

	Statistic	**Signif. Lvl.**
Q_b (65)	77.284	0.1414
Q_b^2 (65)	72.580	0.2424
Q_{cg} (65)	72.967	0.2326
Q_{cg}^2(65)	24.673	0.9999
Q_{lii} (65)	92.071	0.0152
Q_{lii}^2 (65)	69.342	0.3332
MV LM (65)	1.01	1.0000
MV Q (65)	71.23	0.2782

Note: Q_b, Qcg and Q_{lii} are the Ljung-Box Q-statistic for the banking, consumer good, and Shari'ah equities sectors respectively. MV LM and Q are multivariate ARCH-LM and Ljung-Box Q-statistic for null hypotheses of no ARCH effect and no autocorrelation in multivariate GARCH model. Lag length is displayed as (.). All the tests are conducted at 1% significant levels.

Conclusions

Volatility transmission between the banking sector, consumer goods sector and Shari'ah compliant equities sector of the Nigerian Stock Exchange are of particular interest to academics, investors (institutional and individual), and financial market regulators due to the importance of the sectors to orderly price discovery, adoption of optimal hedging strategy and portfolio risk management. As a result, this study evaluates the nature of volatility transmission between banking sector, consumer goods sector and Shari'ah equities sector of the NSE for the period ranging from 04 January 2010 to 30 April 2014 using multivariate GARCH (1.1)-BEKK model.

The results of the multivariate GARCH (1.1)-BEKK model indicate that own past shock and volatility affect the current shock and volatility of the banking, consumer goods, and Shari'ah compliant equities sectors in Nigeria. The results also show that shock from the banking sector transmits to the consumer goods sector and Shari'ah equities sector but not from consumer goods and Shari'ah equities sector to the banking sector. However, there is bidirectional shock transmission between the consumer goods and the Shari'ah compliant equities sector within the

band of conventional significance levels. The results further show evidence of volatility transmission from the banking sector to the consumer goods sector and Shari'ah equities sector, with negative and statistically significant coefficients but not the other way round. On the other hand, volatility transmits positively from the consumer goods sector transmits to the Shari'ah compliant equities sector, whereas it transmits negatively from the Shari'ah equities sector to the consumer goods sector. In summary, the results indicate existence of unidirectional shock and volatility transmission from the banking sector to the consumer goods and the Shari'ah equities sectors, and bidirectional shock and volatility transmission between the consumer goods and the Shari'ah equities sectors of the NSE. The implication is for domestic portfolio management through hedging and risk management opportunities inherent in the NSE sectors, as well as common information sharing between regulators of different industries that comprise the NSE sectors.

References

Arouri, M. E. H., Jouini, J., & Nguyen, D. K. (2011). Volatility spillovers between oil prices and stock sector returns: Implications for portfolio management. *Journal of International Money and Finance, 30*(7), 1387-1405.

Baba, Y., Engle, R. F., Kraft, D. F. & Kroner, K. F. (1990), Multivariate simultaneous generalized ARCH, *Mimeo University of California at San Diego*.

Ebrahim, S. K. (2000). Volatility transmission between foreign exchange and money markets. *Bank of Canada Working Paper 2000-16*

Emenike, K. O. (2014). Volatility transmission between stock and foreign exchange markets: Evidence from Nigeria. *Journal of Banking and Financial Economics*, 1 (1), 59-72.

Emenike, K. O. & Ani, W. U. (2014). Volatility of the banking sector stock returns in Nigeria. *Ruhuna Journal of Management and Finance*, 1 (1), 73-82.

Engle, R.F. (1982). Autoregressive Conditional Heteroscedasticity with Estimates of the Variance of the United Kingdom Inflation. *Econometrica*, 50, 987-1008.

Engle, R. F. & Kroner, K. F. (1995). Multivariate Simultaneous Generalized ARCH. *Econometric Theory*, 11, 122-150.

Ewing, B. T. (2002). The transmission of shocks among S&P indexes. *Applied Financial Economics,12*, 285-290.

Fleming, J.; Kirby, C. & Ostdiek, B. (1998). Information and volatility linkages in the stock, bond and money markets. *Journal of Financial Economics*, 49, 111-137.

Hurditt, P. (2004). An assessment of volatility transmission in the Jamaican financial system. *Journal of Business, Finance and Economics in Emerging Economies*, *1*(1), 1-28.

Kanas, A. (2000). Volatility spillover between stock returns and exchange rate changes: International evidence. *Journal of Business Finance & Accounting*, *27*(3&4), 447–467.

Kim, H. (2013). The volatility spillover effects in Islam financial market. *International Review of Business Research Papers, 9*(5), 12-27.

Malik, F. and Ewing, B. T. (2009). Volatility transmission between oil prices and equity sector returns. *International Review of Financial Analysis*, *18*, 95-100.

Turkyilmaz, S. & Balibey, M. (2013). The relationship among interest rate, exchange rate and stock prices: A BEKK-MGARCH approach, *International Journal of Economics, Finance and Management Sciences*, *1*(3), 166-174.

Valadkhani, A., Harvie, C. & Karunanayake, I. (2013). Global output growth and volatility spillovers. *Applied Economics*, *45*(5), 637-649.

Worthington, A. & Higgs, H. (2004). Transmission of equity returns and volatility in Asian developed and emerging markets: A multivariate GARCH analysis. *International Journal of Finance & Economics*, *9*(1), 71-80.