

Volatility Spillover in African Stock Markets: Evidence from Nigeria, Ghana and South Africa

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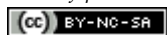
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Abstract

The purpose of this paper was to analyze stock market return volatility spillover between in Sub-Sahara markets using Nigeria, Ghana and South Africa monthly data from January 2000 to December 2017. Preliminary analyses from descriptive statistics show that show mean monthly returns are positive for all the stock markets. Skewness coefficients show that the stock returns and interest rates distribution of all Sub-Sahara Africa stock markets are negatively skewed but inflation rate is positively skewed for Nigeria and South Africa, and flat for Ghana. Excess kurtoses are positive for all the stock markets and macroeconomic indicators, and Jarque-Bera statistics indicate the stock markets' series and macroeconomic indicators are not normally distributed. The Unit roots tests results indicate that all the stock markets and macroeconomic indicators are first difference stationary. The results of multivariate BEKK-GARCH (1,1) model show evidence of volatility spillover in Sub-Sahara Africa stock markets. We therefore recommend amongst others that stock market authorities should formulate and implement policies that would mitigate any negative effect of stock return volatility on the wealth of retail investors so as to sustain investors' confidence in the African stock markets. This will eliminate the destabilising impact on the investors' confidence on the markets.

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1. Introduction

A number of studies have analysed the nature of volatility spillover among financial markets in both developing and developed markets (Emenike, 2016; Emenike, 2018; Varghese, 2018; Panda et al., 2019; and Senga & Cassimon, 2019). However, majority of these studies are either country-specific studies that examine stock market volatility in specific countries or cross-country studies that concentrated on other segments of the financial market. Emenike (2016) for example examines volatility spillover between money and stock markets in a developing economy using Nigeria data. The results of the bivariate BEKK-GARCH (1,1) model show amongst others, evidence unidirectional shock transmission from the

stock market to the money but not otherwise. Senga & Cassimon (2019) showed evidence of significant volatility spillover among the sub-Saharan Africa bonds. Emenike (2018) considered exchange rate volatility spillover among West African countries. However, these studies are country-specific studies that examine stock market volatility in specific countries. The need for a study on stock market return volatility spillover is clear.

The direction and nature of stock return volatility spillover is very important in investment decision making and financial market regulation (Kumar, 2013; Yarovaya et al., 2016; Umar et al., 2021; and Corbet et al., 2021). In addition, Sub-Saharan African stock markets are increasingly becoming more liberalized as a result of advancements in ICT. Information may easily

transmit from one market to another as a result of the speed of information transmission through ICT. Improved ICT, especially internet technology increase the speed of dissemination of news across the globe as well as give investors access to the most recent news and information on their investments (Nnachi, 2008). In Nigeria, for example, the over-the-counter (OTC) trading platform provided by the National Association of Securities Dealers (NASD) Plc and the Financial Markets Dealers Quotation (FMDQ) OTC Plc has broaden tradable and investible financial instruments across the money, foreign exchange, debt and capital markets, and provide a point of convergence for financial markets dealers, investors and other participants through ICT (Emenike, 2016). Also computerized trading and settlement systems have facilitated the process whereby an investor can transact in financial assets from any part of the world through the internet (Friedman & Shachmurove, 2005). Given the advancements in the stock market trading infrastructure in across the globe due developments in ICT, it may be possible for shocks and/or volatility from one African stock market to impact significantly on other stock markets in the continent. It thus imperative to empirically investigate the nature of volatility spillover between Nigeria, Ghana and South Africa stock markets.

The interrelationship between changes in stock market return volatility is useful for investors to make necessary investment decisions and for policy-makers to regulate financial markets more effectively (Emenike, 2016). The objective of this paper therefore is to analyze the stock market return volatility spillover between Nigeria, Ghana and South Africa. The analysis has many important use in portfolio investment analysts, risk managers and capital market regulators in Sub-Saharan Africa. From the findings of this study, the portfolio investment managers for instance, will identify the flow and direction of volatility shocks, and then make investment policy to minimize negative impact of the shock on their portfolio. Future scholars on related field will also find this article useful as it will serve as reference material for future studies,

2. Literatur Review

Many empirical studies have investigated stock market return volatility across the globe. Emenike (2010) for example used monthly NSE All Share Index (ASI) between January 1985 to

December 2008 as an empirical sample to investigate the behaviour of stock return volatility in the Nigerian stock exchange market. He employed GARCH (1,1) to capture the stock return volatility clustering and GJR-GARCH model to capture the presence of leverage effect in the ASI series. The overall results indicate evidence of volatility clustering, fat-tailed distribution and the existence of leverage effect in the Nigerian stock exchange market return series. Rhoda (2014) adapted autoregressive moving average (ARMA) GARCH models to investigate volatility and financial market risk of stocks in the Johannesburg Stock Exchange (JSE) assuming skewed Student-t distribution. They used daily data for the period starting from 2002 to 2010. They estimated several types of GARCH models namely threshold GARCH, GARCH-in mean and exponential GARCH. Their findings show that JSE daily returns can be modelled using an ARMA (0, 1) process. This implies that shocks to conditional mean disappear after one period. The results further show that ARMA (0,1)-GARCH(1, 1) model achieves the most accurate volatility forecast. They therefore conclude that their findings are important to financial managers and scholars in both emerging and developed economies. Akuffo, Ampaw and Lartey (2014) applied the GARCH model to explore the volatility of Ghana monthly interest rates from 2003:01 to 2013:12. The findings suggest that the best GARCH model to adequately capture interest rate volatility in Ghana is GARCH (1, 2). The estimated GARCH model was used to predict interest rate for a year in Ghana, and the findings indicate that interest rate is forecasted not to grow above 30% at the end of 2014. Botha and King (2014) also reported that conventional GARCH effects are important for capturing heteroscedasticity.

Many studies have also considered stock return volatility spillover in both developed and developing financial markets. Shafiq (2000) for example, used trivariate GARCH models to investigate price and volatility transmission between money market and foreign exchange market. Three variants of the models were estimated with data on USD/Canadian dollar, USD/Deutsche Mark, and USD/Japanese yen daily exchange rate returns series with 90-day Eurodollar, Euro Canada, Euromark, and Euroyen deposits returns series. The fact that exchange rate shocks can cause persistent increases in the volatility of short-term interest rates suggests that the Bank of Canada might wish to take policy actions following a

large exchange rate shock should it want to mitigate the higher money market volatility. Bhargava et al. (2012) examined whether interest rate swap market volatility in the US dollar spill-over to the Indian swap rates market using GARCH family models. Their findings indicate that volatility transmits from the USA dollar interest rate swap markets to the Indian swap markets. There is however no evidence of spillover from the Indian swap markets to the US swap markets. In addition, there is also evidence that the spillover from the USA dollar interest rate swap markets to the Indian swap market is asymmetric. The study therefore concludes that the results are valid to emerging markets' policy-makers because of integration of emerging economies into the global economy. Ramona et al (2014) investigated long-term volatility of Romania, Poland, Greece and USA (R.P.G.U) stock markets using asymmetric GARCH class models. The results of the analysis suggest that volatility does not diverge to infinity and seems to react significantly different considering the case of high positive or high negative stock returns. The researchers concluded that their work provide a better understanding of the relationship between the R.P.G.U stock markets in order to facilitate global diversification investing perspective for international investors. A later study by Varghese (2018) analysed spillover effects of return volatility between stock market index returns, foreign exchange market returns and West Texas Intermediate (WTI) crude oil market across five emerging nations namely Brazil, Indonesia, Malaysia, Pakistan and South Korea. Using a trivariate diagonal BEKK-GARCH model, the study documents evidence of significant volatility clustering in WTI returns, stock returns and foreign exchange returns. The results also show that volatility in WTI returns spillover to the stock market volatilities. The study concludes amongst others that as a result of globalization and liberalization of capital markets, the investors are anticipated to diversify their portfolios across international currencies and national stock markets.

Studies of volatility spillover are also growing in the African financial markets. Chinzara, (2010) investigated how systematic risk evolving from the macroeconomic spillovers into stock market volatility using augmented autoregressive GARCH and Vector Autoregression models for the 1997 to 1998 Asian crises, and the 2007 to 2008 sub-prime global financial crises. Estimates from

the AR-GARCH model show that macroeconomic uncertainty significantly influences stock market volatility. The results further show that financial crises increase stock market volatility as well as in many macroeconomic indicators. These in turn strengthen the effects of changes in macroeconomic variables on the stock market. Emenike, (2016) examines volatility transmission between money and stock markets in a developing economy using Nigeria data. The results of the bivariate BEKK-GARCH (1,1) model show amongst others, evidence unidirectional shock transmission from the stock market to the money but not otherwise. A related study by Emenike (2018).

Emenike (2018) evaluated the nature of exchange rate volatility spillover between the West Africa CFA Franc, Gambian Dalasi, and Nigerian Naira, in relation to the USD for the period ranging from 01 August, 2007 to 31 December, 2015 using multivariate GARCH (1.1)-BEKK model. The results show that there is bidirectional shock spillover between Nigerian Naira and West Africa CFA Franc/USD exchange rates, and unidirectional shock spillover from Gambian Dalasi to West Africa CFA Franc/USD exchange rate. However, there exist no evidence of exchange rate shock spillover between Nigerian Naira and Gambian Dalasi. The results further show evidence of bidirectional volatility spillover between the Nigerian Naira and West African CFA Franc/USD exchange rate, but could not find any evidence of exchange rate volatility spillover between the Nigerian Naira and Gambian Dalasi, and between the West African CFA Franc and Gambian Dalasi. Senga & Cassimon, (2019); and Ali (2019) showed evidence of significant volatility spillover among the sub-Saharan Africa bonds.

Panda *et al.*(2019) reported evidence of volatility spillover in the stock markets of Africa and Middle East region. In a more recent study, Emenike (2020) examined dynamic interdependence between crude oil and foreign exchange markets using BEKK-GARCH model and reported evidence of unidirectional shock and volatility transmission from crude oil market to foreign exchange market in Nigeria.

3. Data and Methods

The data for this study were generated from secondary sources. The data consisted of Monthly All-Share Index (ASI) of the Nigerian Stock Exchange (NSE), the Ghanaian Stock Ex-

change (GSE) and the Johannesburg Stock Exchange (JSE). The study period ranges from January 2000 to December 2017. This period is chosen to capture the effect of the NSE transition from the Open Outcry System to the Automated Trading System, which enhanced the informational efficiency of the Nigerian stock market. In addition, the period captures both the boom period in Nigeria stock market and Global Financial Crisis period. These series were transformed into the first difference of natural logarithm of prices or indices thus:

$$R_t = \text{Ln} (P_t - P_{t-1})$$

Where, R_t = monthly returns of the African stock market returns, P_t = closing monthly stock indices at time t , P_{t-1} = previous month closing stock indices, and Ln = natural logarithm.

The multivariate GARCH-BEKK model was employed to evaluate volatility spillover between Nigeria, Ghana, and South Africa stock market returns, and to achieve objective seven. This method was applied by Emenike (2018) to evaluate volatility spillover between exchange rates among West African Countries. A general specification of the GARCH- BEKK model can be specified as follows:

$$H_t = CC + A_{st-1st-1}A + BH_{t-1}B$$

where H_t is the conditional variance matrix. C , A , and B are parameter matrices. C is a 3x3 lower triangular matrix with three parameters, 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. According to Emenike (2018) as follows:

$$H_t = \begin{bmatrix} h_{1,t} & h_{1,2,t} & h_{1,3,t} \\ h_{2,1,t} & h_{2,t} & h_{2,3,t} \\ h_{3,1,t} & h_{3,2,t} & h_{3,t} \end{bmatrix} = \begin{bmatrix} c_{11} & \cdot & \cdot \\ c_{21} & c_{22} & \cdot \\ c_{31} & c_{32} & c_{33} \end{bmatrix} + \begin{bmatrix} a_{11} & a_{1,2} & a_{1,3} \\ a_{21} & a_{2,2} & a_{2,3} \\ a_{31} & a_{3,2} & a_{3,3} \end{bmatrix} + \begin{bmatrix} b_{11} & b_{1,2} & b_{1,3} \\ b_{21} & b_{2,2} & b_{2,3} \\ b_{31} & b_{3,2} & b_{3,3} \end{bmatrix} + \begin{bmatrix} \varepsilon_1 & \varepsilon_{1,2} & \varepsilon_{1,3} \\ \varepsilon_{2,1} & \varepsilon_2 & \varepsilon_{2,3} \\ \varepsilon_{3,1} & \varepsilon_{3,2} & \varepsilon_3 \end{bmatrix}$$

where $h_{1,t}$ denotes the volatility of the Nigeria stock market, $h_{2,t}$ denotes the volatility of the Ghana stock market, and $h_{3,t}$ denotes the volatility of the South Africa stock market. $h_{1,2,t}$ is the covariance of Nigeria and Ghana markets, and $h_{1,3,t}$ the covariance of Nigeria and South Africa stock market. Statistical significance of the off-diagonal coefficients $a_{1,2,t}$, $a_{1,3,t}$ and $a_{2,3,t}$ would indicate evidence of shock spillover effect between stock markets in Sub-Sahara Africa, whereas the statistical significance of the off-diagonal coefficients $b_{1,2,t}$, $b_{1,3,t}$ and $b_{2,3,t}$ would show evidence of volatility spillover effects between stock markets in Sub-Sahara Africa.

To ascertain adequacy of the BEKK-GARCH model, the estimated standardized residuals should be serially uncorrelated and should not display any remaining conditional volatility. The adequacy of the multivariate GARCH models were, therefore examined using autocorrelation function (ACF) and Ljung & Box (1978) Q test statistic. The ACF and L-B Q test statistics tested the null hypothesis of no autocorrelation in the estimated residuals and squared standardized residuals up to a specific lag.

4. Result

Descriptive Analysis

Table 1 shows the descriptive statistics of the level and return series of the monthly All-share index, inflation rates, and interest rates in Sub-Sahara Africa. As shown in Table 1, the average monthly All-share index for Nigeria is 26625, Ghana is 3481 and South Africa is 28218. The average monthly return for Nigeria, Ghana and South Africa are 0.008, 0.005 and 0.009 respectively, for the study period. These results indicate that the South Africa stock market generates more returns than Nigeria and Ghana; and Nigeria stock market generates more returns than the Ghana stock market within the study period. The corresponding monthly standard deviations are 0.069, 0.144, and 0.047. These indicate that Ghana stock market has the highest rate of variability from the mean return, whereas the South Africa stock market has the least variability from its mean. The null hypothesis of normal distribution of Jarque-Bera statistics is 0 (Okpara & Odionye, 2012; and Civcir & Akkoç, 2021). The empirical Jarque-Bera statistics for all the variables deviate from normal distribution at the 5% significance level. Similarly, skewness and kurtosis represent the nature of departure from normality. In a normally distributed series, skewness is 0 and kurtosis is 3. Positive or negative skewness indicate asymmetry in the time series under study and kurtosis coefficient greater than or less than 3 suggest peakedness or flatness of the data (DeCarlo, 1997; Onwumere, 2005; Emenike, 2016). The skewness coefficient for Nigeria, Ghana and South Africa Stock markets are -0.577, -11.318, and -0.278, respectively. These indicate that the Sub-Saharan African stock markets returns are negatively skewed; thus implying that there are more negative changes in the Sub-Saharan African stock markets returns than predicted by normal distribution. The kurtosis coefficients for all

the Sub-Saharan African stock markets returns series show evidence of peaked distribution. The implication of peaked is that, for a large part of the time, extreme observations are much more

likely to occur. Leptokurtic stock returns, for example, implies that investors can make very high returns and as well lose large amount of their investments (Emenike, 2020).

Table 1 Descriptive Statistics for Sub-Saharan African Stock Markets Indices.

Variable	Mean	Std. Dev.	Skewness	Kurtosis	J-B Stat.
Level Series					
NSI	26625.466	12291.142	0.664	0.552	18.649
GSI	3481.267	2678.746	0.999	0.088	36.006
SASI	28218.295	16029.133	0.308	-1.204	16.469
Return Series					
NSI	0.008	0.069	-0.577 (0.000)	5.520 (0.00)	284.926 (0.000)
GSI	0.005	0.144	-11.318 (0.000)	151.422 (0.00)	209993.181 (0.000)
SASI	0.009	0.047	-0.278 (0.098)	0.655 (0.05)	6.623 (0.036)

Note: *P*-values are displayed as (.). All the tests are conducted at 5% significant level

Table 2 Results of Multivariate GARCH-BEKK Model for Volatility Spillover

Parameters	Coefficient	<i>t</i> -statistic	<i>p</i> -value
C _(1,1)	0.010	1.713	0.086
C _(2,1)	0.002	0.528	0.596
C _(2,2)	0.000	1.004	0.577
C _(3,1)	0.034	5.646	0.000
C _(3,2)	0.000	0.296	0.497
C _(3,3)	0.000	3.061	0.417
A _(1,1)	0.264	4.295	0.000
A _(1,2)	-0.180	-2.890	0.003
A _(1,3)	-0.253	-3.332	0.000
A _(2,1)	0.001	0.124	0.900
A _(2,2)	0.005	0.245	0.806
A _(2,3)	0.005	0.193	0.846
A _(3,1)	0.282	3.076	0.002
A _(3,2)	-0.125	-1.340	0.179
A _(3,3)	0.461	4.615	0.000
B _(1,1)	0.545	7.958	0.000
B _(1,2)	0.159	7.772	0.000
B _(1,3)	0.015	0.126	0.899
B _(2,1)	-0.053	-4.375	0.000
B _(2,2)	0.563	8.005	0.000
B _(2,3)	-0.042	-1.495	0.134
B _(3,1)	0.417	1.778	0.075
B _(3,2)	0.064	0.301	0.762
B _(3,3)	0.462	2.218	0.026
Panel B: Diagnostic Tests			
	Statistic	<i>p</i> -value	<i>p</i> -value (χ^2)
MV Q (12)	5.729	0.929	
MV ARCH-LM (12)	8.267		0.323

Note: *P*-values are displayed as (.). All the tests are conducted at 5% significant level

Table 2 presents the results of the multivariate GARCH-BEKK model estimated to evaluate volatility spillover between Nigeria, Ghana, and South Africa stock market. In Table 2, Nigeria, Ghana and South Africa represent 1, 2 and 3, re-

spectively. The estimates of multivariate GARCH-BEKK model suggest that there is evidence of volatility spillover in Sub-Sahara Africa stock markets. This can be seen in the statistical significance of the *t*-statistics for the coefficient of the off-diagonal elements of matrices *A* and *B* which

capture shock and volatility spillover among markets (Emenike, 2018). From the off-diagonal elements of matrix A , notice evidence of unidirectional negative shock spillover from the Nigeria stock market to Ghana stock market ($A_{(1,2)}$) at 5% significance level, and bidirectional negative shock spillover between Nigeria and South Africa stock markets ($A_{(1,3)}$ and $A_{(3,1)}$). With 95% confidence, this result suggests that negative shock from the Nigeria stock market spillover into negative Ghana stock market shock, and negative shock spillover between the Nigeria and South Africa stock markets.

The results of the off-diagonal elements of matrix B indicate evidence of bidirectional volatility spillover between Nigeria and Ghana stock markets ($B_{(1,2)}$ and $B_{(2,1)}$). This is evident in the significance of the off-diagonal parameters ($B_{(1,2)}$ and $B_{(2,1)}$) at the 95% confidence level. The results suggest evidence of volatility spillover between Nigeria and Ghana stock markets.

The diagnostic tests results presented in the *Panel B* of *Table 4.14* were computed to evaluate the adequacy of the multivariate GARCH-BEKK model. Notice that the multivariate Ljung-Box Q-statistic for residuals of the stock market returns (0.92) are not significant, indicating that there is no serial correlation in the standardized residuals of the multivariate GARCH-BEKK model. Similarly, the multivariate ARCH-LM result (0.32) indicates that the null hypotheses of no ARCH effect in squared residuals of the multivariate GARCH-BEKK model are accepted at the 5% significance level. The multivariate GARCH-BEKK model is therefore adequate for policy-making as there appear to be no specification error.

5. Discussion

The finding of significant volatility spillover between of stock markets in Nigeria, Ghana and South Africa is not a surprise. A related study by (Emenike, 2016) examines volatility spillover between money and stock markets in a developing economy using Nigeria data. The results of the bivariate BEKK-GARCH (1,1) model show amongst others, evidence unidirectional shock transmission from the stock market to the money but not otherwise. A recent study using GARCH-BEKK by Varghese (2018) analyses spillover effects of return volatility between stock market index returns, foreign exchange market returns and West Texas Intermediate (WTI) crude oil market across five emerging nations namely Bra-

zil, Indonesia, Malaysia, Pakistan and South Korea. Using a trivariate diagonal BEKK-GARCH model, the study documents evidence of significant volatility clustering in WTI returns, stock returns and foreign exchange returns. The results also show that volatility in WTI returns spillover to the stock market volatilities. The study concludes amongst others that as a result of globalization and liberalization of capital markets, the investors are anticipated to diversify their portfolios across international currencies and national stock markets.

6. Conclusion and Sugestions

Conclusion

This study analysed volatility spillover between Sub-Sahara Africa stock markets with specific reference to Nigeria, Ghana and South Africa. The methodology applied in this study include descriptive statistics and multivariate GARCH models. Descriptive statistics calculated to evaluate the mean; symmetry and distribution of the stock markets returns provide insightful information. The mean monthly returns are positive for all the stock markets but the South Africa stock market generates more returns than Nigeria and Ghana within the study period. Skewness coefficients show that the stock returns distribution of all Sub-Sahara Africa stock markets are negatively skewed. Excess kurtoses are positive for all the stock markets. These show that all the markets returns are peaked. The Jarque-Bera statistics indicate the stock markets' series are not normally distributed.

The results of multivariate BEKK-GARCH (1,1) model indicate that there is evidence of volatility spillover in Sub-Sahara Africa stock markets. From the off-diagonal elements of matrix A , notice evidence of unidirectional negative shock spillover from the Nigeria stock market to Ghana stock market at 5% significance level, and bidirectional negative shock spillover between Nigeria and South Africa stock markets. The results of the off-diagonal elements of matrix B indicate evidence of bidirectional volatility spillover between Nigeria and Ghana stock markets. Given the evidence of volatility spillover in Sub-Sahara Africa stock markets, investors and portfolio managers should carefully select the securities that comprise their portfolio. This is to ensure adequate diversification of their portfolios and to explore common information sharing benefits associated with integrated markets.

Suggestions

Capital market authorities should provide proactive stock market regulation by formulating and implementing policies that would mitigate any negative effect of stock return volatility on the wealth of retail investors so as to sustain investors' confidence in the African stock markets. This will eliminate the destabilising impact on the investors' confidence on the markets.

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