

Impact of Macroeconomic Variables on Stock Return Volatility: Evidence from Sub-Sahara Africa

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Abstract

The main purpose of this paper was to investigate the impact of macroeconomic variables on stock market return volatility in Sub-Sahara markets. The study concentrated on three stock markets including Ghana, Nigeria and South Africa using GARCH-X (1,1) model on monthly data from January 2000 to December 2017. Preliminary analyses from descriptive statistics show that 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 the GARCH-X (1,1) model show that macroeconomic variables do not significantly impact stock market returns volatility in Nigeria, Ghana and South Africa at the 5% significance Level. We therefore recommend that stock market regulators, market participants and investors should concentrate more efforts on other macroeconomic variables aside interest rate and inflation rate, in estimating stock market return volatility in Sub-Sahara Africa

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INTRODUCTION

Understanding the impact of macroeconomic variables on stock market return and volatility is important to stock market participants, investors and regulators. This is because of the strong link between the stock market and macroeconomy. Emenike and Odili (2014) observe that stock market is a veritable source of long-term capital hence identifying the macroeconomic variables that influence stock market return volatility and the nature of influence will help in correctly pricing stocks and managing associated risks. Schwert (1989) documents amongst others, that a positive relationship exists between macroeconomic variables and stock market volatility, with causality being stronger from stock markets to macroeconomic variables. Whether this evidence holds for Sub-Sahara Africa stock markets is an empirical question. From the financial regulation perspective, the extent to which the macroeconomic variables affect stock market volatility is of great concern to regulators and financial policy-makers. It may be possible for a volatility shock in the stock market to have destabilising effects on other markets. If the nature of the impact macroeconomic variables on stock market volatility is known, stock market regulators could adopt proactive measures to protect or, at least, mitigate the impact of the volatility shock from one market on other market(s).

Granted that numerous empirical studies have examined the impact of macroeconomic variables on stock market volatility using GARCH family models, in both emerging and developed markets (Lee, 1994; Hwang and Satchell, 2005; Aliyu, 2012; Emenike and Odili, 2014; Kwadwo, 2016); but most of these studies were country-specific. Lee (1994) for example, used GARCH-X to examine how the short-run disequilibrium affects uncertainty in predicting cointegrated series. Hwang and Satchell (2005) also applied GARCHX to model aggregate stock market return volatility by including a measure of the lagged cross-sectional return variation as an explanatory variable in the GARCH conditional variance equation. However, no study in the author's knowledge, has studied the impact of macroeconomic variables on stock market volatility in Sub-Saharan Africa. The few

existing studies are country-specific. Emenike and Odili (2014) for example, examine the impact of macroeconomic variables on stock market return volatility in Nigeria using GARCH-X model. Unlike prior studies, this study will provide evidence on the impact of macroeconomic variables on stock market return volatility in three Sub-Saharan African countries. Hence, this will therefore contribute to closing this gap in empirical literature by providing comparative evidence on the impact of macroeconomic variables on stock market volatility in Sub Saharan Africa stock markets using Ghana, Nigeria, and South Africa data.

The objective of this study therefore is to investigate the impact of macroeconomic indicators on volatility of stock market returns of Nigeria, Ghana and South Africa. The study specifically provides evidence on the impact of interest rate and inflation rate on stock market return volatility in the Sub-Saharan African countries. The analysis has practical applications to portfolio investment analysts, risk managers and capital market regulators in Sub-Sahara Africa. From the findings of this study, the portfolio investment managers for instance, will identify the macroeconomic variables that impact stock market return volatility in Sub-Sahara Africa, and then design investment strategies to contain effect of changes of those variables on their portfolio. Future scholars on related field will also find this article useful as it will serve as reference material for future studies. The remaining parts of this paper are organised as follows: Section 2 reviews literature on macroeconomic variables and stock market volatility. Section 3 outlines the data and method of analysis. Section 4 discusses the results and discussions, and Section 5 concludes the study.

Literature on Macroeconomic Variables on Stock Market Volatility

Among the premiere attempts to evaluate the impact of macroeconomic variables on stock return volatility was Schwert (1989). The study documents three important empirical findings in an attempt to decipher why stock market volatility changes overtime. Firstly, the findings show a positive relationship between macroeconomic volatility and stock market volatility, with causality being

stronger from stock markets to macroeconomic variables. Secondly, the findings show that stock market uncertainty is higher during recessions than expansions. This result has been explained using an operating leverage effect, where profits would tend to fall more rapidly than revenues during recessive economic cycles when fixed costs are large. Thirdly, the findings reveal that macroeconomic volatility explains less than half of the stock returns volatility. In China, Xufang (2010) investigated the relationship between Chinese stock market returns and macroeconomic variables such as GDP, interest rate, and inflation. The study adopted two steps methodology. First step involved estimation of volatility for each variable using EGARCH. The second step involved estimating LA-VAR model for evaluation of the causal relationship between stock market returns volatility and macroeconomic indicators. The results show amongst others that there exist a bidirectional causal relationship between stock market volatility and inflation volatility. The findings also show that there is a unidirectional causality from stock market volatility to interest rate volatility.

Using developing stock markets data, Kadir, Selamat, Masuga, and Taudi (2011) examined the predictability power of exchange rates and interest rates' volatility on the volatility of stock market and return of the monthly index of Kuala Lumpur Composite Index (KLCI) returns, 3 months Malaysia Treasury bond and monthly exchange rate of Ringgit per US Dollar from 1997 January to 2009 November. The results of GARCH (1,1), model show a negative relationship between interest and exchange rates with KLCI returns. But the relation is significant for exchange rate, and insignificant for interest rate. More so, the results also show insignificant relationship between volatility of returns and the variables, though positive for exchange rate and negative for interest rate. Al-Raimony and El-Nader (2012) investigate the effect of macroeconomic indicators on Amman Stock Exchange (ASE) returns volatility using GARCH models on monthly data from 1991 to 2010. Findings from their study suggest that consumer price index growth, real money supply growth, weighted average interest on loans, and real exchange rates have adverse effects on the

returns volatility of ASE, whereas real gross domestic products has a positive effect.

In Africa study, Andrew (2011) aimed to provide answer to the question: do macroeconomic variables drive future stock market returns in South Africa? Data was collected from 1965 to 2010, and macroeconomic variables were selected based on international and local precedent of intuitive influential macroeconomic factors. Estimates from Johansen multivariate cointegration, Granger causality and innovation accounting methodologies show that the selected South African macroeconomic variables did not significantly influence future FTSE/JSE All Share Index returns. The study concludes that the selected macroeconomic variables should not be used as a future predictive tool for South African stock market returns. Aliyu (2012) assessed the effect of inflation on returns and volatility of stock market using quadratic GARCH model on monthly returns series from Ghana and Nigeria. The study shows that inflation rate and its 3-month average have significant impact on volatility of stock market in Ghana and Nigeria. Addo and Sunzuoye (2013) examined the combined impact of interest rates and Treasury bill rate on stock market returns in Ghana Stock Exchange the January 1995 to December 2011 period. Using Johansson's Multivariate Cointegration Model and Vector Error Correction Model the study establish that there is cointegration between Interest rate, Treasury bill rate and stock market returns indicating long run relationship. Additional analysis from multiple regression suggest that both Treasury bill and interest rates have insignificant negative relationship with stock market returns in Ghana. These results lend credence to the notion that money market instruments have both negative relationship and weak predictive power on stock market returns independently. The study conclude that interest rate and Treasury bill rate jointly impact on stock market returns in the long run. In a country-specific study, Emenike and Odili (2014) examine the impact of macroeconomic variables on stock market return volatility in Nigeria using GARCH-X model. Five macroeconomic variables: broad money supply, consumer price index, credit to the private sector, US dollar/ Naira exchange rate, and the net foreign assets, were included in the

conditional variance model of the Nigerian Stock Exchange (NSE) All-share Index from January 1996 to March 2013. Results of the GARCH-X model suggest that the NSE return volatility is positively influenced by changes US dollar/ Naira exchange rates and credit to private sector but negatively influenced by changes broad money supply and inflation. On the other hand, changes in net foreign assets shows negative but not significant influence on changes in stock market return volatility. They recommended that investors should adjust their portfolio to changes in these macroeconomic variables. In a related study Kwadwo (2016) sought to establish the impact of selected macroeconomic variables on volatility of stock prices in Ghana Stock Exchange using annual time series data over the period ranging from 1990-2014. The macroeconomic variables analysed in the study are real gross domestic product growth rate, inflation rate, and interest rate. Granger causality test was applied to determine whether any causal link exist between volatility of stock prices and macroeconomic variables in Ghana. Evidence from Granger causality test shows that real domestic product rate granger causes stock price but stock price does not Granger-cause real domestic product rate, at 10% significance level. The results also show that inflation rate and interest rate do not significantly Granger-cause stock prices volatility. Recently, Joseph, Paul and Terzungwe (2017) analysed impact of inflation on volatility of stock market returns in the Nigerian stock market using GARCH and E-GARCH volatility models on monthly series of stock market returns and consumer price index as a proxy for inflation rate. The results suggest that inflation rate does not have explanatory power stock market return volatility in Nigeria. Specifically, results from the E-GARCH model did not show any evidence of asymmetry in the stock return volatility. Thus imply that is good news and bad news have equal impact on stock returns in Nigeria. Results from the GARCH model indicate high volatility persistence in the stock returns series. Many other studies provide substantial evidence in support of the impact of macroeconomic variables on stock market volatility.

METHODS

The data for this study were generated from secondary sources. The data consisted of Monthly All-Share Index (ASI), Monthly interest rates (IR), and Monthly inflation rate (IFR). The Nigerian series were collected from the Central Bank of Nigeria (CBN) statistic database. The Ghana series were collected from Bank of Ghana Monetary Time Series Database, and the South African time series were collected from the South African Reserve Bank Statistics database. This study analysed 216 monthly observations for stock market returns series, interest rates and inflation rates series during the period ranging 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 (ATS), which enhanced the informational efficiency of the Sub-Saharan African stock market. In addition, the period captures both the boom period in Sub-Saharan African stock market and Global Financial Crisis period. These series were transformed into the first difference of natural logarithm of prices or indices thus:

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

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.

$$\text{IF}_t = \text{Ln} (\text{IFR}_t - \text{IFR}_{t-1}) \quad (2)$$

Where:

IF_t = monthly inflation rates returns in Nigeria, Ghana, and South Africa,

IFR_t = monthly inflation rates in Nigeria, Ghana, and South Africa at time t ,

IFR_{t-1} = previous month inflation rates in Nigeria, Ghana, and South Africa, and

Ln = natural logarithm.

$$\text{IN}_t = \text{Ln} (\text{INT}_t - \text{INT}_{t-1}) \quad (3)$$

Where:

$INTR_t$ = monthly interest rates returns in Nigeria, Ghana, and South Africa,

INT_t = monthly interest rates in Nigeria, Ghana, and South Africa at time t ,

INT_{t-1} = previous month interest rates in Nigeria, Ghana, and South Africa, and

Ln = natural logarithm.

To evaluate the influence of inflation rate and interest rate on stock market return volatility in Nigeria, Ghana, and South Africa stock markets, the GARCH-X (1,1) model was employed. This is in agreement with earlier studies of volatility clustering (see for example, Lee, 1994; Hwang & Satchell, 2005; Emenike & Odili, 2014). In accordance with earlier studies the GARCH-X (1,1) model was specified as follows:

$$R_t = \theta + \mu_t \quad (4)$$

$$\mu_t \sim (0, \sigma_t^2)$$

$$\sigma_t^2 = \alpha_0 + \alpha_1 \mu_{t-1}^2 + \beta_1 \sigma_{t-1}^2 + \lambda (\text{Macroeconomic variables})_{t-1} \quad (5)$$

The equation 3.16 is an extension of standard GARCH (1,1) model to estimate the impact of change in Sub-Saharan African interest rates and inflation rates on Sub-Saharan African stock returns volatility. The estimate of λ measures the extent to which these Macroeconomic variables forces influence stock return volatility in the Sub-Saharan African stock markets. Positive and statistically significant lambda coefficient, for example, would indicate that Macroeconomic variables forces have positive impact on Sub-Saharan African stock markets returns volatility. Statistically insignificant lambda coefficient would indicate absence of any impact. The adequacy of the GARCH-X (1,1) model was examined using the Ljung-Box Q

statistic and ARCH-LM test (Enders, 2004: 136; Engle & Paton, 2001). Well specified mean model has uncorrelated standardized residuals. Likewise, a good variance model has uncorrelated squared standardized residuals.

RESULTS AND DISCUSSIONS

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-Saharan 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. 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 (Emenike, 2014).

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

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 (0.000)	284.926 (0.000)
GSI	0.005	0.144	-11.318 (0.000)	151.422 (0.000)	209993.181 (0.000)
SASI	0.009	0.047	-0.278 (0.098)	0.655 (0.053)	6.623 (0.036)

Note: *p*-values are reported brackets.

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 (Emenike, 2017). 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, 2019).

Descriptive Statistics of Interest Rates in Sub-Saharan Africa

Table 2 shows the descriptive statistics of the level and return series of the monthly interest rates in Sub-Saharan Africa. Notice that the monthly mean interest rates for Nigeria, Ghana and South Africa 12.6%, 19.4%, and 8.1% respectively. These results show that the Ghana interest rate is higher than the other countries under study, and South Africa interest is the least within the study period. The monthly mean interest rate returns for Nigeria, Ghana and South Africa are zero; with corresponding monthly standard deviations are 0.052, 0.032, and 0.035. These indicate that Nigeria has the highest rate of interest rate variability among the countries studied. Notice also from Table 2 that the interest rate returns are negatively skewed, peaked and non-normal distributions.

Table 2. Descriptive Statistics for Sub-Saharan African Interest Rates

Variable	Mean	Std. Dev	Skewness	Kurtosis	J-B Stat.
Level Series					
NINR	12.686	3.598	0.037	-0.211	0.454
GINR	19.405	5.093	0.275 (1.000)	-1.392 (0.001)	20.176 (0.000)
SAINR	8.128	2.582	0.622	-0.961	22.255
Return Series					
NINR	-0.001	0.052	-1.878 (0.000)	16.709 (0.000)	2627.511 (0.000)
GINR	-0.000	0.032	-0.563 (0.001)	6.006 (0.000)	334.612 (0.000)
SAINR	-0.002	0.035	-1.309 (0.000)	5.703 (0.000)	352.908 (0.000)

Note: *p*-values are reported brackets.

Descriptive Statistics of Inflation Rates in Sub-Saharan Africa

Table 3 shows the descriptive statistics of the level and return series of the monthly Sub-Saharan African inflation rates. As shown in Table 3, the average monthly inflation rates for Nigeria, Ghana and South Africa 12.15%, 17.62%, and 5.73% respectively. These results show that the Ghana inflation rate is highest among the Sub-Saharan African countries under study, and South Africa interest is the least within the study period. The monthly mean inflation rate returns for Nigeria,

Ghana and South Africa are zero but Ghana is negative. The corresponding monthly standard deviations are 0.19, 0.12, and 0.21. These indicate that South Africa has the highest rate of inflation rate variability among the countries studied. Notice also from Table 3 that the South African and Nigerian inflation rates returns are not skewed but Ghana inflation return is positively skewed. More so, the Nigeria, Ghana and South Africa inflation rate returns are peaked and non-normally distributed.

Table 3. Descriptive Statistics for Sub-Saharan African Inflation Rates

Variable	Mean	Std. Dev.	Skewness	Kurtosis	J-B Stat.
Level Series					
NIFR	12.150	5.054	0.232	0.618	5.387
GIFR	17.626	11.523	2.405	5.844	515.704
SAIFR	5.731	2.369	0.455	1.024	16.905
Return Series					
NIFR	0.009	0.192	0.332 (0.050)	9.052 (0.000)	724.338 (0.000)
GIFR	-0.000	0.120	0.988 (0.000)	10.190 (0.000)	965.192 (0.000)
SAIFR	0.002	0.210	0.107 (0.522)	17.776 (0.000)	2831.303 (0.000)

Note: *p*-values are reported brackets.

Unit Roots Tests for Stock Market Indexes in Sub-Saharan Africa

This sub-section presents the Unit Roots Tests conducted to examine the stock market indexes for stationarity. Tables 4 presents the result of Unit Roots tests for the log-levels and first difference series of the stock market indices for Nigeria, Ghana and South Africa. The Unit Roots tests were computed using augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests. The ADF and PP tests were computed at the 5% level of significance in order not to accept a false null hypothesis.

Notice from Table 4 that the Nigeria, Ghana and South Africa stock markets level series are not

stationary. This is because the absolute computed ADF values for Nigeria (-2.54), Ghana (-1.82) and South Africa (-0.67) are less than the 5% ADF critical tau value (-2.87). The PP tests show similar results for all the stock markets studied.

In their first differences, however, the absolute values of the computed ADF coefficients exceed the critical values at 5% significance level. Table 4 shows that the computed ADF coefficient -12.29, -13.68, and -15.28 for the Nigeria, Ghana and South Africa stock markets returns are greater than the theoretical value (-2.87) at 5% significance level.

Table 4. Unit Root Tests Results for Sub-Saharan African Stock Markets Indexes ADF Unit Root Test Results

Variables	Log-level series		Return series	
	critical value 5%	computed value	critical value 5%	computed value
NSI	-2.875	-2.540	-2.875	-12.299**
GSI	-2.874	-1.820	-2.875	-13.682**
SASI	-2.874	-0.678	-2.875	-15.287**
Phillips-Perron Unit Root Test Results				
Variables	critical value 5%	computed value	critical value 5%	computed value
NSI	-2.874	-2.571	-2.875	-12.524**
GSI	-2.874	-1.919	-2.875	-13.786**
SASI	-2.874	-0.694	-2.875	-15.337**

Unit Roots Tests for Interest Rates in Sub-Sahara Africa

Sub-section 4.2.2 presents the Unit Roots tests computed to evaluate Sub-Saharan Africa interest rates for stationarity. Table 5 presents the results of Unit Roots tests for the log-levels and first difference series of the interest rates for Nigeria, Ghana and South Africa. The Unit Roots tests were computed using augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests. The ADF and PP tests were computed at the 5% level of significance in order not to accept a false null hypothesis.

Notice from Table 5 that the Nigeria, Ghana and South Africa interest rates level series are not

stationary. This is because the absolute computed ADF values for Nigeria (-1.51), Ghana (-1.60) and South Africa (-1.95) are less than the 5% ADF critical tau value (-2.87). The PP tests show similar results for all the Sub-Saharan Africa interest rates under study.

In their first differences, however, the absolute values of the computed ADF coefficients exceed the critical values at 5% significance level. Table 5 shows that the computed ADF coefficient -14.27, -7.83, and -5.61 for the Nigeria, Ghana and South Africa interest rates returns are greater than the theoretical value (-2.87) at 5% significance level.

Table 5. Unit Root Tests Results for Sub-Saharan African Interest Rates

Variables	Log-level series		Return series	
	critical value 5%	computed value	critical value 5%	computed value
NINR	-2.874	-1.518	-2.875	-14.277**
GINR	-2.875	-1.601	-2.875	-7.834**
SAINR	-2.875	-1.955	-2.875	-5.613**
Phillips-Perron Unit Root Test Results				
Variables	critical value 5%	computed value	critical value 5%	computed value
NINR	-2.874	-1.642	-2.875	-14.426**
GINR	-2.874	-1.534	-2.875	-14.721**
SAINR	-2.874	-1.557	-2.875	-12.393**

Unit Roots Tests for Inflation Rates in Sub-Saharan Africa

This sub-section presents the Unit Roots tests conducted to examine Sub-Saharan Africa inflation rates for stationarity. Table 6 presents the results of Unit Roots tests for the log-levels and first difference series of the inflation rates for Nigeria, Ghana and South Africa. The Unit Roots tests were computed using augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests. The ADF and PP tests were computed at the 5% level of significance in order not to accept a false null hypothesis.

Observe from Table 6 that the Nigeria and South Africa inflation rates are stationary. This is because the absolute computed ADF values for Nigeria (-4.75) and South Africa (-3.30) are greater than the 5% ADF critical tau value (-2.87). The PP tests show similar results for all the stock markets studied. The absolute computed ADF values for Ghana (-2.722) is less than the 5% ADF critical tau value (-2.87). In their first differences, however, the absolute values of the computed ADF coefficients exceed the critical values at 5% significance level for Nigeria, Ghana and South Africa.

Table 6. Unit Root Tests Results for Sub-Saharan African Inflation Rates

ADF Unit Root Test Results				
Variables	Log-level series		Return series	
	critical value 5%	computed value	critical value 5%	computed value
NIFR	-2.875	-4.753**	-2.875	-14.480**
GIFR	-2.875	-2.722	-2.875	-9.662**
SAIFR	-2.875	-3.309**	-2.875	-11.625**

Phillips-Perron Unit Root Test Results				
Variables	critical value 5%	computed value	critical value 5%	computed value
	NIFR	-2.875	-5.046**	-2.875
GIFR	-2.874	-2.584	-2.875	-9.717**
SAIFR	-2.874	-3.022*	-2.875	-11.596**

Note: ** refers to 5% statistical significance levels.

GARCH-X (1,1) Results for Macroeconomic Variables and Nigeria Stock Market Returns Volatility

This section presents the results of GARCH-X (1,1) model estimated to evaluate the impact of macroeconomic variables on volatility of Nigeria stock market. From the estimates of GARCH-X (1,1) model displayed in Table 7, macroeconomic variables do not significantly impact stock market returns volatility in Nigeria. This is evident in the statistical insignificance of the t-statistics for the coefficient of inflation rates (-1.55) and the coefficient of interest rates (-1.45) at the 5% significance Level.

The diagnostic tests results presented in the *Panel B* of Table 7 were calculated to examine the adequacy of the GARCH-X (1,1) model. Notice that the Ljung-box Q-statistic for residuals of the stock market return are not significant (0.06), indicating that there is no serial correlation in the

standardized residuals up to lags 12 at the 5% significance level. The ARCH-LM results (0.32) indicate that the null hypothesis of no ARCH effect in squared residuals is accepted with 95% confidence level. The GARCH-X model is therefore adequate for policy-making as there appear to be no specification error.

The finding of no significant effect of interest rates and inflation rates on stock market returns volatility in Nigeria has support in the extant literature (see, Kadir et al, 2011; Mushtaq, et al, 2012; Joseph et al, 2017). Kadir et al (2011) for example, examined the predictability power of exchange rates and interest rates' volatility on the volatility of stock market and return of the monthly index of Kuala Lumpur Composite Index (KLCI) returns, 3 months Malaysia Treasury bond and monthly exchange rate of Ringgit per US Dollar from 1997 January to 2009 November. The GARCH (1,1), model 1 and GARCH model 2

without interest and exchange rates. Similar to the findings of our study, their results show a negative relationship between interest and exchange rates with KLCI returns. But the relation is significant for exchange rate, and insignificant for interest rate. A similar study by Joseph, Paul and Terzungwe (2017) analysed impact of inflation on volatility of stock market returns in the Nigerian stock market using GARCH and E-GARCH volatility models on monthly series of stock market returns and consumer price index as a proxy for inflation rate. The results suggest that inflation rate does not have explanatory power stock market return volatility in Nigeria.

There are however other studies that provide contrary evidence. For example, Xufang (2010) also document evidence of show that that there is a unidirectional causality from stock market volatility to interest rate volatility. Okoli (2012) evaluated the relationship between stock market and macroeconomic variables and their volatilities using GARCH and VAR methodologies. The study finds, amongst others, that the macroeconomic variables are significant in explaining movements in the stock prices and its volatility. A later study by Emenike and Odili (2014) document evidence of show that inflation rate has a negative influence on stock return volatility in Nigeria.

Table 7. Results of GARCH-X (1,1) Model for Impact of Macroeconomic Variables on Nigeria Stock Market Returns

Parameters	Coefficient	T. Statistics	Significance
Mean	0.013	2.827	0.004
RNSI{1}	0.161	2.070	0.038
Constant (α_0)	0.000	2.244	0.024
ARCH (α_1)	0.202	2.934	0.003
GARCH (β_1)	0.668	8.307	0.000
($\alpha_1 + \beta_1$)	0.870		
Interest rates	-0.007	-1.453	0.146
Inflation rates	-0.002	-1.552	0.120
Panel B: Diagnostic Tests			
	Statistic	p-value	p-value (χ^2)
Ljung-Box Q (2)	2.395	0.302	
Ljung-Box Q (12)	20.579	0.056	
ARCH-LM	6.958		0.324

GARCH-X (1,1) Results for Macroeconomic Variables and Volatility of Ghana Stock Market Returns

Table 8 presents the results of GARCH-X (1,1) model estimated to evaluate the impact of macroeconomic variables on volatility of Ghana stock market returns, and to achieve objective four of this study. The estimates of GARCH-X model suggest that macroeconomic variables do not significantly impact stock market returns volatility in Ghana. This is evident in the statistical insignificance of the t-statistics for the coefficient of inflation rates (-1.70) and the coefficient of interest rates (-1.48) at the 5% significance Level. However, if we expand our significance level to 10%, inflation rate would become significant.

The diagnostic tests results presented in the *Panel B* of *Table 8* were calculated to evaluate the adequacy of the GARCH-X (1,1) model. Notice that the Ljung-box Q-statistic for residuals of the Ghana stock market return are not significant (0.96), indicating that there is no serial correlation in the standardized residuals up to lags 12 at all conventional significance levels. The ARCH-LM results (0.83) indicate that the null hypothesis of no ARCH effect in squared residuals is accepted at the 5% significance level. The GARCH-X model is therefore adequate for policy-making as there appear to be no specification error.

The findings of insignificant effect of interest rate and inflation rate on stock market returns volatility in Ghana have been documented in the extant literature. For example, Kwadwo (2016)

examined the impact of real gross domestic product growth rate, inflation rate, and interest rate on volatility of stock prices in Ghana stock exchange using annual data over the period ranging from 1990-2014. Similar to our findings, the results show amongst other that inflation rate and interest rate do not significantly affect stock prices volatility in Ghana.

However, Kuwornu and Owusu-Nantwi (2011) analysed the linkage between stock market

returns and macroeconomic variables using monthly data spanning from January 1992 to December 2008. Empirical findings from ordinary least square estimation show that there is a significant relationship between stock market returns and consumer price index. But crude oil prices, exchange rate and Treasury bill rate do not have any significant effect on stock returns.

Table 8. Results of GARCH-X (1,1) Model for Impact of Macroeconomic Variables on Volatility of Ghana Stock Market Returns

Parameters	Coefficient	T. Statistics	Significance
Mean	0.0003	6.549	0.000
Constant (α_0)	0.046	2.209	0.000
ARCH (α_1)	0.319	6.646	0.000
GARCH (β_1)	0.494	4.253	0.000
($\alpha_1 + \beta_1$)	0.813		
Interest rates	-0.146	-1.489	0.136
Inflation rates	-0.032	-1.707	0.084
Panel B: Diagnostic Tests			
	Statistic	<i>p</i> -value	<i>p</i> -value (χ^2)
Ljung-Box Q (2)	1.012	0.602	
Ljung-Box Q (12)	4.683	0.967	
ARCH-LM	2.825		0.830

GARCH-X (1,1) Results for Macroeconomic Variables and South Africa Stock Market Returns

Table 9 presents the results of GARCH (1,1) model estimated to evaluate the impact of macroeconomic variables on volatility of South Africa stock market, and to achieve objective six of this study. The estimates of GARCH-X model suggest that macroeconomic variables do not significantly impact stock market returns volatility in South Africa. This can be seen in the statistical insignificance of the t-statistics for the coefficient of inflation rates (-0.51) and the coefficient of interest rates (-0.57) at the 5% significance Level.

The diagnostic tests results presented in the *Panel B* of *Table 9* were calculated to evaluate the adequacy of the GARCH-X (1,1) model. Observe that the Ljung-box Q-statistic for residuals of the South Africa stock market return are not significant (0.74), indicating that there is no serial correlation in the standardized residuals up to lags 12 at all conventional significance levels. The ARCH-LM results (0.44) indicate that the null hypothesis of no

ARCH effect in squared residuals is accepted at the 5% significance level. The GARCH-X model is therefore adequate for policy-making as there appear to be no specification error.

The finding of no significant effect of interest rate and inflation rate on stock market return volatility in South Africa agrees with some of the existing evidence. A study using South African data by Andrew (2011) aimed to provide answer to the question: do macroeconomic variables drive future stock market returns in South Africa? Results from macroeconomic variables data collected from 1965 to 2010, show that the selected South African macroeconomic variables did not significantly influence future FTSE/JSE All Share Index returns. The study concludes that the selected macroeconomic variables should not be used as a future predictive tool for South African stock market returns.

However, another study by Hsing (2011) examined the effects of selected macroeconomic variables on the stock market index in South Africa,

and finds that South Africa's stock market index is positively influenced by the growth rate of real GDP, the ratio of the money supply to GDP and the U.S. stock market index, but It is negatively affected by the ratio of the government deficit to GDP, the domestic real interest rate, the nominal

effective exchange rate, the domestic inflation rate, and the U.S. government bond yield. These findings are related with our study which documents evidence negative but insignificant effect of interest rate on stock market volatility in South Africa.

Table 9. Results of GARCH-X (1,1) Model for Impact of Macroeconomic Variables on South Africa Stock Market Returns Volatility

Parameters	Coefficient	T. Statistics	Significance
Mean	0.004	0.443	0.657
RSASI{1}	0.004	0.018	0.984
Constant (α_0)	0.001	2.497	0.013
ARCH (α_1)	0.154	4.573	0.005
GARCH (β_1)	0.565	8.284	0.003
($\alpha_1 + \beta_1$)	0.719		
Interest rates	0.002	-0.570	0.568
Inflation rates	0.0003	-0.501	0.616
Panel B: Diagnostic Tests			
	Statistic	<i>p</i> -value	<i>p</i> -value (χ^2)
Ljung-Box Q (2)	0.230	0.891	
Ljung-Box Q (12)	8.522	0.741	
ARCH-LM	5.788		0.447

CONCLUSIONS

This study majorly analysed the impact of macroeconomic variables on volatility of stock market return in Sub-Sahara Africa with specific reference to Nigeria, Ghana and South Africa using GARCH-X (1,1) model. Descriptive statistics show that 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. The results also show that the Ghana interest rate (19.4%) and inflation rate (17.62%) are higher than the other countries under study, and South Africa interest rate (8.1%) and inflation rate (5.7%) are the least within the study period. 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 the GARCH-X (1,1) model employed to investigate the impact of macroeconomic variables on volatility of Nigeria stock market returns show that macroeconomic variables do not significantly impact stock market returns volatility in Nigeria, Ghana and South Africa at the 5% significance Level.

Based on the findings of this study, we conclude that macroeconomic variables do not significantly impact stock market return volatility in the Sub-Sahara Africa. On the basis of this conclusion, we recommend that stock market regulators, market participants and investors should concentrate more efforts on other macroeconomic variables aside interest rate and inflation rate, in explaining stock market return volatility in Sub-Sahara Africa.

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