WORLD OIL PRICES, VOLATILITY TRANSMISSION, HEDGING AND STOCK MARKETS IN ECOWAS COUNTRIES

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ABSTRACT

This paper investigates world oil prices, volatility transmission, hedging and the stock market in ECOWAS countries. The study employsConstant Conditional Correlation CCC model and VAR-GARCH model and the bivariate form of multivariate GARCH models. The study found that the return spillover from stock price to oil price estimates are not statistically significant for Ghana and WAEMU countries indicating that the returns in the stock market do not significantly influence the returns in the oil market. However, the return spillover in the case of Nigeria is statistically significant. The outcome of the optimal weights and hedging ratios of holding the two assets (stock and oil markets) revealed that investors should acquire more stocks than oil in their portfolio in all countries to curtail the risk without reducing the expected returns.

Keywords*: Multivariate GARCH, Volatility spillovers, Hedging, Conditional correlations, Crude oil prices, Stock indices.*

JEL Classifications: *C22, C32, G17, G32*

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1. INTRODUCTION

Evidence suggests that an increase in the price of oil can translate into higher transportation, production, and heating costs, which can put pressure on corporate earnings and stock market performance. Rising production cost can also stir up worries about inflation, limit consumers' discretionary outlay and lead to a decline in sales due to higher prices and lower profits.

Conversely, lower oil prices imply a reduction in costs associated with the production and distribution of goods. This will bring about a reduction in the prices of goods, an increase in sales and higher profits for a business. The increase in profit would also make stock attractive to business owner (See Musibau and Adenikinju (2012), Hammoudeh, Dibooglu, & Aleisa, (2004)), Arouri, M. E. H., Jouini, J., & Nguyen, D. K. (2011), Kling, (1985), Sadorsky, (1999), Faff and Brailsford, (1999), Papapetrou, (2001), Ibrahim and Aziz, (2003), Valadkhani and Chancharat, (2008), Eryigit, (2009) and Sadorsky, P. (1999)). These outcomes raise the question, therefore, of how oil price changes and its volatility affect the economies, stock markets and hedging approaches. Even though handful of studies has been conducted in Nigeria and other developing countries, very little attention has been paid to the issue of return and volatility spillovers. Also, to the best of our knowledge, few studies have been conducted in the context of the Economic Community of West African States (ECOWAS).

The following reasons inform the choice of ECOWAS. Firstly, Nigeria is one of the major suppliers of oil in the world markets; hence, her stock market is likely to be more exposed to changes in oil prices, economic performance in its trading partners in West Africa. Secondly, a sizable number literatures concentrated their attention on oil importing countries and ignored these issues on oil exporting countries. Thirdly, some studies explored the short-term effects of oil price shocks in stock markets but ignored the long-term dynamics. Finally, most of the studies focused on countries in Asia, the Gulf Cooperation Council (GCC) countries and Europe, thus leaving out a knowledge gap for countries in Africa and West Africa in particular. Also, the relationship between oil price shocks spillover and stock market performance has also remained unsettled in the literature. Some studies have reported a significant negative relationship between oil price shocks and stock market returns (see, for example, Wang, Wu and Yang (2013), Cunado, Perez de Gracia (2014), while others have established that there is a positive association (for example, Dagher and El Hariri (2013)).

The paper is structured as follows: Section II is the review of the literature. Section III discusses the data, methodological issues and discussion of the main empirical findings, while, section IV deals with conclusion and recommendations.

2. REVIEW OF RELATED STUDIES

The empirical research examining volatility transmission and spillover effects provide a mixed result. Some of the studies establish positive effects, while some found adverse outcomes and others found significant bidirectional volatility spillovers. For example, Kling (1985), Sadorsky (1999), Hung, et al. (1996), Jones and Kaul (1996) and Park and Ratti (2008) applied different methodologies to examine the relationship between crude oil price shock and stock market performance. Kling (1985) found that crude oil price changes affect the future stock prices in the industries which use oil as input factors. Jones and Kaul (1996) found a significant adverse effect of oil shocks on the stock market. Sadorsky (1999) found that oil price changes and volatility have a significant negative impact on real stock returns. The study also revealed that oil price movements explain a significant portion of the forecast error variance in real stock returns than interest rates. Park and Ratti (2008) found that the impacts of oil price shocks on oil-importing countries' stock market are negative, while the impact on oil-exporting countries' stock market is positive. Hung et al. (1996), however, found no negative effects between stock returns and changes in the price of oil futures.

However, some other group of studies have found a positive relationship between crude oil prices and stock markets. Al-Mudhaf and Goodwin (1993) in a firm-specific study examined the returns from 29 oil companies listed on the New York Stock Exchange. Their findings suggested a positive impact of oil price shocks on expost-returns for firms with significant assets in domestic oil production. Gjerde and Saettem (1999) found that Oil price shocks have a positive impact on the stock market. Sadorsky (2001) found that the rise of the stock market index and oil price had a positive effect on oil companies' returns. Hammoudeh and Li (2004) suggested that the oil price increases have had positive impacts on the USA, Mexico and Norway oil and transportation industries stock yields and Boyer and Filion (2007) also found out similar impact for the Canadian oil and gas stock returns. Eryigit (2009) also found that the price changes of oil or energy affect emerging economies' markets more than developed markets.

Furthermore, some other studies have shown that oil price shocks influenced various industries' stock price differently. For example, Hung's et al. (1996) found crude oil future returns had significant abilities to explain oil companies' stock returns while Sadorsky (2008) found that changes in oil prices have an asymmetric effect on stock prices.

Summarily, the outcomes of the studies seem to suggest that positive or negative relationship between oil price movement and stock markets could have well existed and the outcome of the result in some cases depends on the characteristics of the economy, the industry being considered and the firm size.

3. METHODOLOGY

a. Modelling Framework

i. Model Specification: Estimating Spillover Effects

We consider the returns of the two variables of interest, namely oil price and stock market price index, calculated here by taking the first difference of the natural logarithm of the level series.

Fundamentally, several models have been developed in the literature to deal with spillover analyses. A vital aspect of the study is to examine if volatility in oil prices is transmitted into stock price volatility (that is, to investigate whether shocks in oil prices and volatility in stock prices are transmitted to stock returns or have a spillover effect on the stock market). Accordingly, the CCC model of Bollerslev (1990) and VAR-GARCH model of Ling and McAleer (2003) is presented in this section. Constant conditional correlations were assumed in the models, and it is not affected by the "curse dimensionality" when compared with the VECH and BEKK models. McAleer et al., (2008) and Caporin and McAleer (2009) have more details on these models.

The Bollerslev (1990) CCC-MGARCH model is given below:

Conditional Mean equation: $Y_t + E\left(Y_t \middle| F_{t-1}\right) = \varepsilon_t;$ (1)

$$\varepsilon_t = D_t \eta_t$$

Conditional Variance equation: $Var\left(\varepsilon_t \middle| F_{t-1}\right) = H_t = D_t \eta_t \eta_t' D_t = D_t \Gamma D_t$ (2)

Where:

$y_t = \left(y_{1t},\ldots,y_{mt}\right)'$ is a vector of series under consideration; $i = 1, \ldots, m$ defines the individual series in the model; m is the number of series being examined; $t = 1,\ldots, n$ represents the period covered by the series; n is the total number of observations; $\eta_t = \left(\eta_{1t},\cdots,\eta_{mt}\right)'$ is a series of independently and identically distributed disturbances for the individual series; F_t denotes previous information available at time t; $D_t = diag\left(h_{1t}^{1/2},\ldots,h_{mt}^{1/2}\right)$ and the elements denote conditional standard deviations for the respective series (1,...,m). In other words, $h_{i,t}$ represents the conditional variance for series i.

The Conditional Mean equations for the two-return series are given below:

Mean equation for stock price return: $r_{s,t} = \lambda_s + \phi_s r_{s,t-1} + \theta_s r_{o,t-1} + \varepsilon_{s,t}$ (3)

Mean equation for Oil price return: $r_{o,t} = \lambda_o + \phi_o r_{o,t-1} + \theta_o r_{s,t-1} + \varepsilon_{o,t}$ (6)

The Variance Equations for VAR-CCC-MGARCH (1, 1) are written as:

The Variance Equations for stock price returns:

$$h_{1t} = c_1 + \alpha_{11}\varepsilon^2_{1t-1} + \alpha_{12}\varepsilon^2_{2t-1} + \beta_{11}h_{1t-1} + \beta_{12}h_{2t-1} \quad \text{(d)}$$

The Variance Equations for oil price returns:

$$h_{2t} = c_2 + \alpha_{21}\varepsilon^2_{1t-1} + \alpha_{22}\varepsilon^2_{2t-1} + \beta_{21}h_{1t-1} + \beta_{22}h_{2t-1} \quad (5)$$

This implies that the conditional variance of each series, $h_{i,t}$, $i = l,..., m$, indicates a univariate GARCH process, given as:

$$h_{i,t} = \omega_i + \sum_{k=1}^{p} \alpha_{ik}\, \varepsilon^2_{i,t-k} + \sum_{r=1}^{q} \beta_{ir} h^2_{i,t-r}; \quad (6)$$

Where $k = 1,..., p$; $r = 1,...,q$; $\sum_{k=1}^{p} \alpha_{ik}$ denotes the short run persistence or ARCH effect, of shocks to series *i,* and $\sum_{k=1}^{p} \alpha_{ik} + \sum_{r=1}^{q} \beta_{ir}$ denotes the long run persistence of shocks to series *i*. The conditional covariance between the stock and oil market returns can be expressed as:

$$h_{sot} = \rho_{so} \times \sqrt{h_{so}} \times \sqrt{h_{ot}} \quad (7)$$

The constant conditional correlation is represented by ρ_{so} . The fundamental underlying assumption for the implementation of the CCC-MGARCH model is that the conditional correlation is constant over time. This is a very restrictive assumption, and therefore, a formal pre-test must be carried out to verify if this assumption is valid or not. The Engle-Sheppard (2001) CCC test that is chi-square distributed is considered in this regard. This pre-test essentially tests the null hypothesis of constant correlation against the alternative of dynamic conditional correlation (DCC). If the null hypothesis of the Engle-Sheppard (2001) CCC test is not rejected; then, the CCC-MGARCH model is appropriate; otherwise, it is not. Our Engle-Sheppard tests on the ECOWAS countries indicated that the CCC-MGARCH model is appropriate. More

importantly, the CCC-MGARCH model also assumes that negative and positive shocks of equal magnitude have the same impacts on the conditional variance. To isolate the asymmetric impacts of positive and negative shocks, therefore, Hoti, Chan and McAleer (2002) proposed the asymmetric CCC-MGARCH model.

Additionally, it is also essential to carry out a pre-test on the presence of asymmetric effect after the Engle-Sheppard (2001) CCC test before modelling with CCC-AMGARCH model. In this regard, Engle and Ng (1993) recommended three pre-tests instead of modelling the asymmetry directly: the sign bias test, the negative size bias test and the positive size bias test to verify the presence of an asymmetric effect. The tests are denoted by the null hypothesis to determine if the null model is correctly specified, suggesting that there is no remaining asymmetry (Harris and Sollis, 2003). The tests for both the sign and size bias are carried out individually and jointly. We are expected not to reject the null hypothesis for both the individual and joint tests for the symmetric version to be valid; otherwise, the asymmetric version will be appropriate. Regarding the pre-test on the presence of asymmetric effect for all the ECOWAS countries included, as well for Nigeria and Ghana, in the model, asymmetric version was found to be appropriate based on the results from both the sign and size bias tests.

i. Data and Preliminary Analyses

Stock market price and crude oil data were obtained from the Bloomberg database and the Central Bank of Nigeria (CBN). In this paper, we use a set of data for Nigeria, Ghana and The WAEMU (West African Economic and Monetary Union) Countries (these include Benin, Burkina Faso, Côte d'Ivoire, Guinea Bissau, Mali, Niger, Senegal and Togo) and stock indices and oil price (Brent). All data are at the daily frequency and cover a seven year ranging from 2010 to 2017 yielding a total of 2394 observations. Some preliminary analyses, including the description of relevant statistical properties of the variables used in the study, are provided in this section. These analyses are conducted in two phases: the first Phase presents the descriptive statistics of the two variables including their returns while the second pertains to performing ARCH LM tests and serial correlation to justify the consideration of time-varying volatility models.

There seems to be evidence of significant variation in the trend of both the stock market and oil price shown by the significant differences between their respective minimum and maximum values. Figures 1, 2 and 3 are the graphical representation of the developments in the price of both all share index (ASI) in Nigeria, Ghana GGSECI Index and WAEMU ICXCOMP Index for the period 2010 and 2017. The graphs largely display similar trends in terms of the movements among the countries. Figures 4, 5,6 and 7 illustrates the relationship between the oil prices and the stock indices for Nigeria, Ghana and some WAEMU countries in the ECOWAS region. It is worthy to

mention that the stock exchange of WAEMU is known as the BRVM (the index is the BRVM Composite Index for West Africa Stock Exchange). The movements in the graphs suggest a positive relationship between oil price and the stock market in all the countries.

Figure 1: Trends in Daily Nigeria and BRVM Comp Stock Prices, 2010 2017(ASI/ICXCOMP)

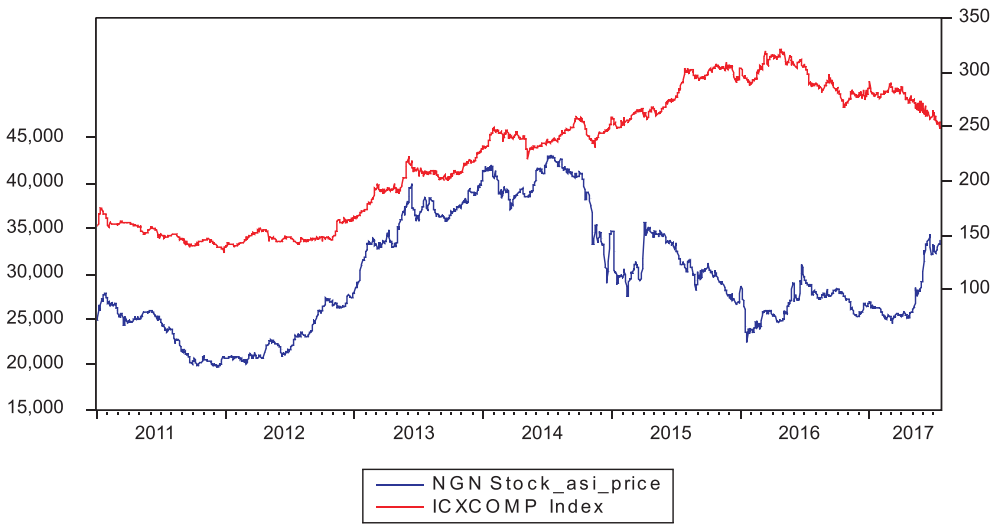


Figure 2: Trends in Daily Nigeria and Ghana Stock Prices, 2010-2017(ASI/GGSECI)

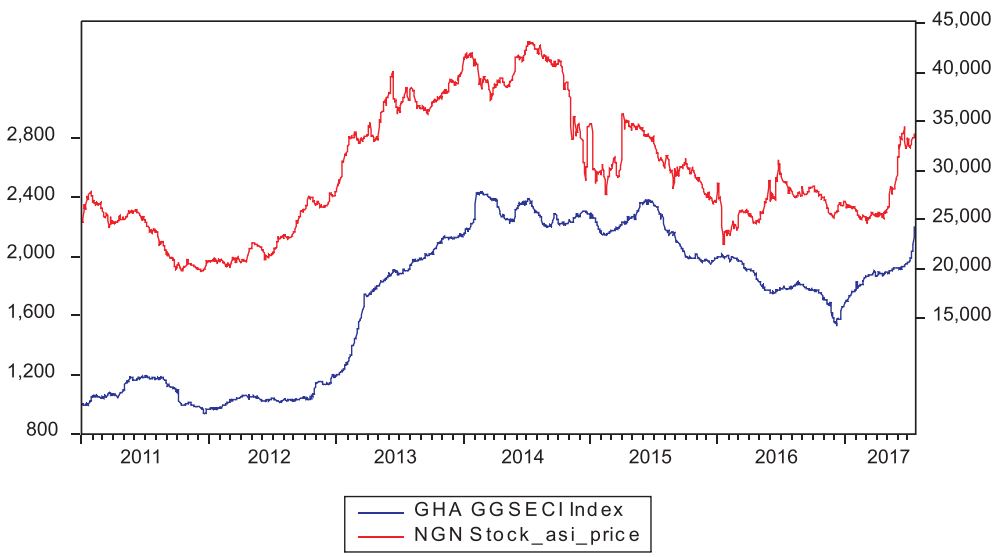


Figure 3: Trends in Daily Ghana and BRVM Comp Stock Prices, 2010-2017(GGSECI/ICXCOMP)

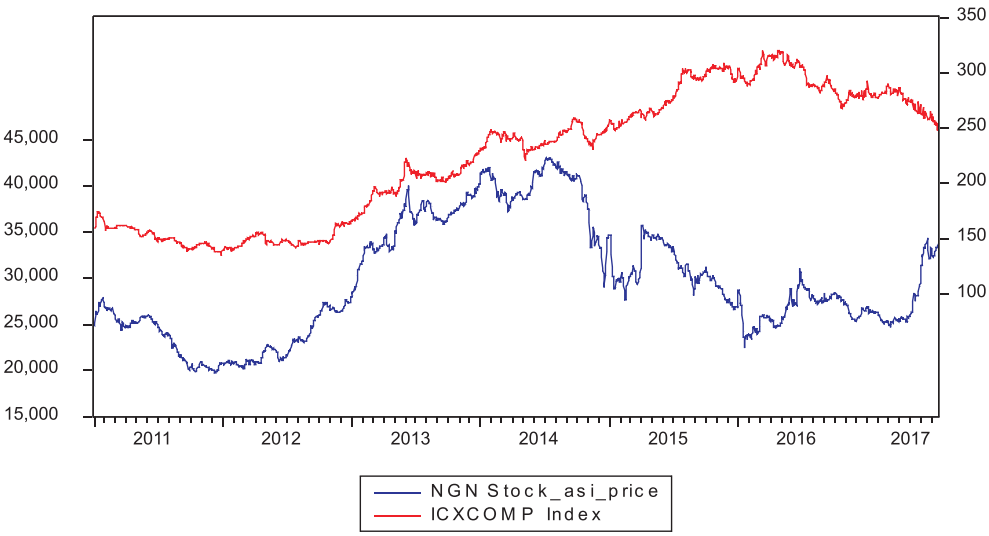


Figure 4: Trends in Daily Oil Prices, 2010-2017

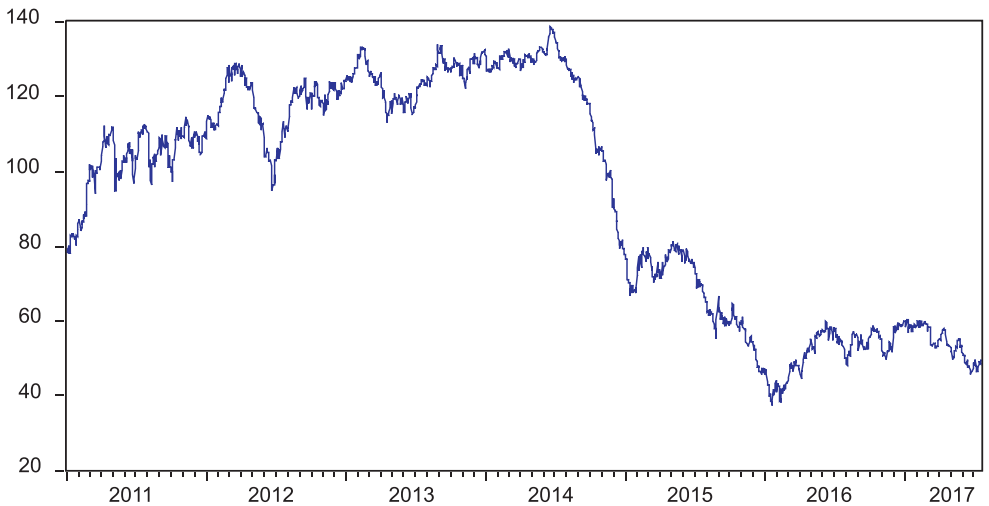


Figure 5:Trends in Daily Oil Price and Nigerian Stock Prices, 2010-2017

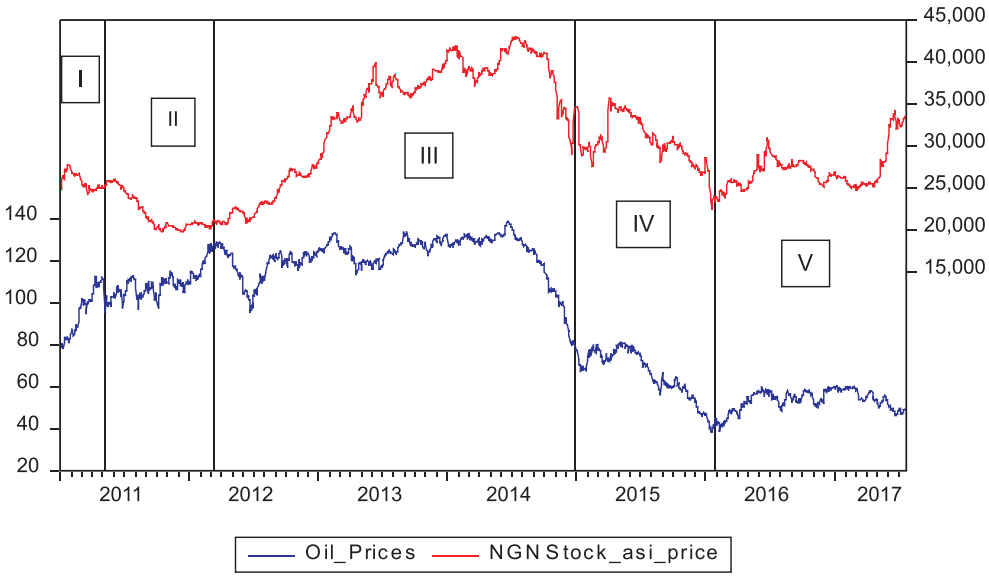
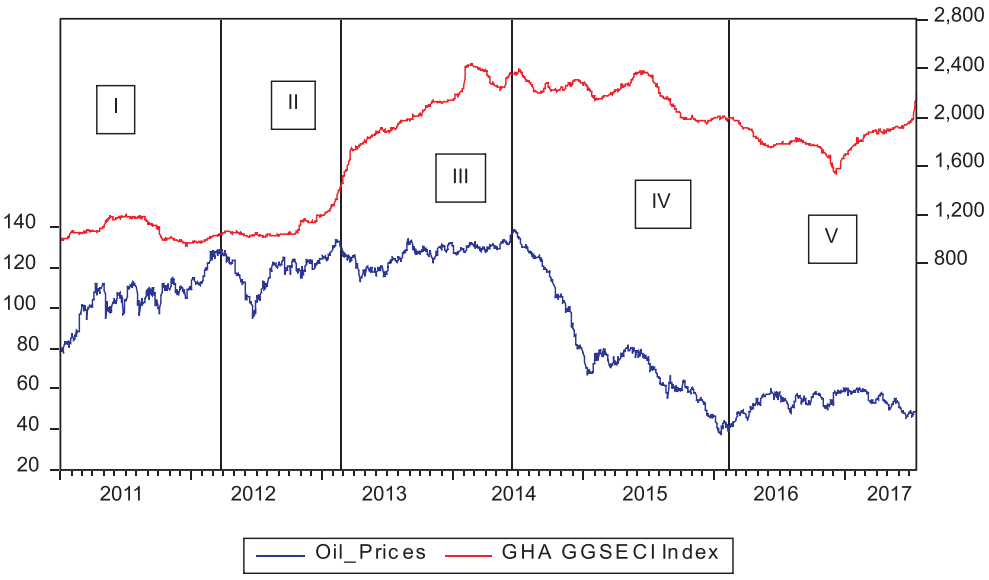


Figure 7:Trends in Daily Oil Price and Ghana Stock Prices, 2010-2017



Furthermore, figure 8 and 9 also illustrate the level of volatility on the returns in the stock market in the presence of oil price shocks. The higher the volatility clustering displayed in all various markets reflects, the higher the standard deviation obtained for the oil price series.

We further consider relevant descriptive statistics and formal pre-tests to evaluate the statistical properties of the series included in the study. Table 1 provides all the relevant preliminary analyses for the return series. The descriptive statistics for the returns cover the mean, standard deviation as well as the distribution properties based on skewness and kurtosis. The mean values reported in the summary statistics indicate positive average returns in the stock market for the period under consideration for all the stock market of the various countries. The oil price, however, was negative for the sample period under consideration, which is not surprising considering the downward trends in the price of oil in the past few years.

Figure 8: Daily Returns on Nigeria, Ghana and BRVM Comp Stock Prices, 2010-2017

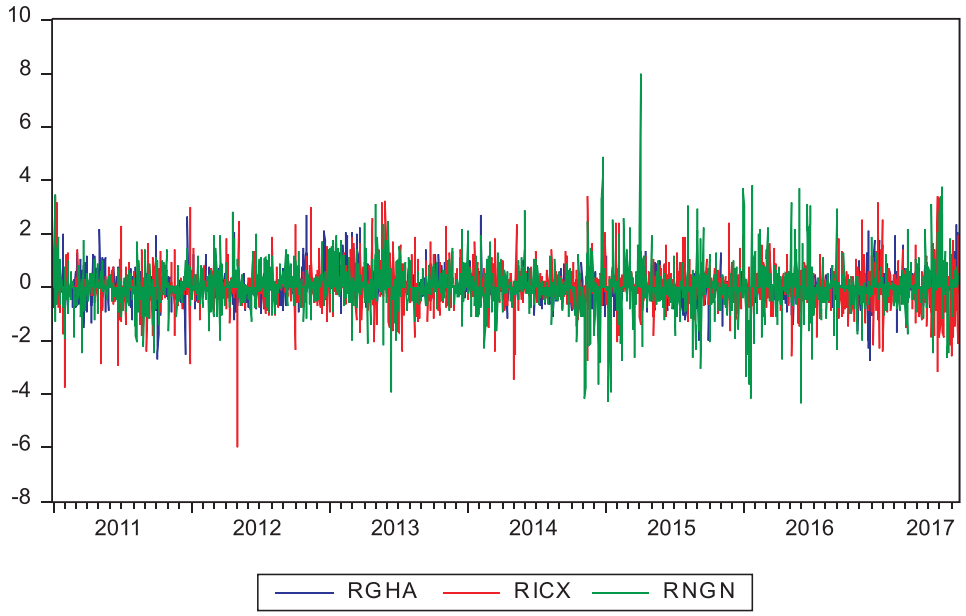
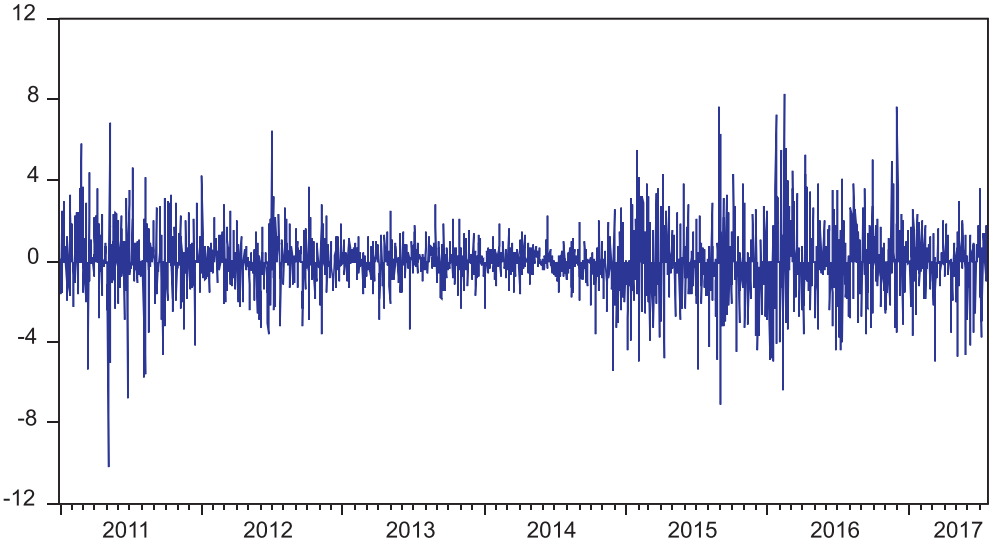


Figure 9: Daily Oil Price Returns, 2010-2017



The stock market in Nigeria recorded the worst performance (0.012 per cent) among all the countries considered. The descriptive statistic tests presented in Table 2 suggest that the oil price is more volatile than the stock market, i.e. the standard deviation of oil price is significantly larger than the stock market. The Jarque-bera values indicate that the variables are not normally distributed (not shown here). The skewness is positive in the Nigeria and Ghana stock markets, but negative in the stock markets of the WAEMU countries and in the oil markets. It means that likely positive and negative returns are to be realised in the stock markets and oil markets, respectively.

A common feature of volatility and volatility clustering were displayed by both series, although volatility clustering in the oil price series appears to be higher in magnitude. The mean returns seem to be more in all the capital markets, but the volatility of the oil price return is higher than that for the return on the capital market price.

The nature of the distribution of the return series as shown in the descriptive summary table indicate that each of the mean equations will need to be tested for the presence of conditional heteroskedasticity. We also found that the null hypothesis of no ARCH effects was rejected at all levels for all the series. Hence, confirming the fact, the GARCH model was the appropriate approach for capturing the return and volatility transmission between world oil prices and stock markets in ECOWAS countries. The results from the computation of the unconditional correlations between the stock returns of ECOWAS countries and oil price changes revealed the presence of low cross-market correlations. This implies that the combination of both assets in a

portfolio will lead to greater diversification gains. The result also shows a positive correlation between the stock market and oil prices for Nigeria, but negative for other countries.

Table 2: Some preliminary analyses for Stock and Oil Market Returns

1a: Descriptive Statistics				
Statistics	**Stock and Oil Market Returns in Nigeria and Other ECOWAS Countries**			
	r_s	r_s	r_s	r_o
	Nigeria	**BRVM Comp Shares**	**Ghana**	**Oil**
Mean (%)	0.012859	0.019433	0.032979	-0.019947
Maximum(%)	7.972911	3.438337	2.721203	8.240247
Minimum (%)	-4.353162	-5.959836	-2.758154	-10.20763
Std. Dev.	0.814813	0.652484	0.440265	1.426507
Skewness	0.419463	-0.077721	0.575180	-0.003368
Kurtosis	12.96325	11.60404	11.82155	8.292474
Corr with Br Oil Prices	0.020	-0.022	-0.024	
2b: Conditional Heteroscedasticity and Autocorrelation Tests				
ARCH LM (5)	24.4496(0.00)	7.6965(0.00)	23.849(0.00)	21.028(0.00)
ARCH LM (10)	17.9627(0.00)	7.0028(0.00)	18.144(0.00)	15.899(0.00)
LB(5)	6.9899 (0.22)	15.598(0.01)	37.039(0.00)	0.729(0.981)
LB(10)	10.471 (0.40)	53.638(0.00)	114.79(0.00)	6.413(0.779)
LB2(5)	136.92 (0.00)	43.683(0.00)	156.56(0.00)	128.07(0.00)
LB2(10)	248.20 (0.00)	75.720(0.00)	247.91(0.00)	233.69(0.00)
2c: Asymmetry test and CCC test				
	Stock Price Nigeria	**Stock Price BRVM Comp Shares**	**Stock Price Ghana**	**Oil_Price Oil**
Sign bias test	0.247(0.80)	1.755(0.079)	2.054(0.04)	1.577(0.149)
Negative size bias test	2.947(0.00)	0.305(0.760)	0.548(0.58)	3.572(0.000)
Positive size bias test	2.876(0.00)	0.756(0.450)	0.665(0.51)	2.640(0.008)
Joint bias test	17.03(0.00)	3.826(0.281)	6.968(0.07)	23.169(0.00)
Engle-Sheppard CCC test* χ^2_2	2.316(0.31)	0.664(0.718)	1.526(0.47)	
Observations	2394	2394	2394	2394

Note: The ARCH LM tests are related to the Engle (1982) test for conditional heteroscedasticity. The LB and LB2, other, other hand, denote the Ljung-Box tests for

autocorrelations comprising the standardized residuals in levels and squared standardized residuals respectively. The null hypothesis for the ARCH-LM test is stated as no ARCH effects in the series (that is, it is not volatile) while the null hypothesis for LB test is stated as "there is no serial correlation on the series" or the series are not serially corrected. The figures in parentheses represent the actual probability values. * Number of series and degree of freedom

Table 2. presents some statistics on the autocorrelation function of the two series. We presented both the Ljung–Box Q-statistic and Q2-statistic which tests for the null hypothesis that there is no autocorrelation at lags 5 and 10. For both the stock price and oil price return series, the null of no autocorrelation was rejected at the 1% level as indicated in the Ljung–Box Q2-statistic. There seems, therefore, to be evidence of autocorrelation in the two stock market series (see table 2b).

Also, the ARCH-LM test, as stated earlier, indicates that all the series exhibit non-constant variance. In other words, both oil price and stock market returns exhibit conditional heteroscedasticity, which has to be captured when modelling the returns. Furthermore, the superior Ljung-Box2 tests indicate the presence of serial correlation between the current and past values of oil price and stock prices, further confirming the need for the use of an AR model which is best handled by the VAR-GARCH models.

3.3 Asymmetry & CCC Test

The result of the asymmetric tests presented in table 2c, suggests that the sign, positive and negative size bias and joint bias for oil price and stock prices are not statistically significant and thus the estimation model should be a symmetric GARCH model, but not in the case of Nigeria. Also, the probability value of 0.718, 0.47 and 0.31 of the Engle Sheppard CCC test suggests that the null hypothesis of conditional constant correlation should not be rejected.

To determine the integration property of the data series, we conducted the ADF test. The ADF test was applied to determine if the null hypothesis for the presence of a unit root could be rejected or not. Weare able to reject the unit root null hypothesis for both the series for all the ECOWAS countries. In addition, the inclusion or not of a time trend did change the results. Hence, we conclude that both series are stationary.

Table 3: Unit Root Test

Augmented Dickey-Fuller (ADF)			KPSS STATIONARITY TEST		
VARIABLE	LEVEL	FIRST DIFFERENCE	LEVEL	FIRST DIFFERENCE	I(d)
Nigeria - r_s	-35.898[a***]	-	0.1434[b***]	-	I(0)
r_o	-51.190[a***]	-	0.4393[b**]	-	I(0)
BRVM Comp	-16.901[a***]	-	0.2909[b***]	-	I(0)
Shares r_s					
Ghana- r_s	-11.412[a***]	-	0.3534[b**]	-	I(0)

NB: ***, ** and *, denote significance at 1%, 5% and 10%, respectively. [a] indicates regression without constant and trend; [b] indicates regression with only constant, and[c] indicates regression with constant and trend.

3. 4. Estimation and Discussion of Results

First, we will start with the discussion of the estimated results of our findings using the bivariate form of multivariate GARCH models to determine the return links and volatility transmission between oil and stock markets in ECOWAS countries that include Nigerian, Ghana and WAEMU stock markets. Specifically, the empirical framework was designed within the VAR (1)–GARCH (1,1) model. Also, the estimated results relating to the optimal weights and hedge ratios for the choice of holding oil -stock in a portfolio will then form the later part of our discussion in this session.

The estimated results from the VAR (1) – GARCH(1,1) are presented in table 4. First, we observed from the diagnostics that there are no remaining ARCH effects in the return series of stock for WAEMU and Ghana stock markets, but not for Nigeria after the estimation of the VAR(1)–GARCH(1,1). We also found the presence of ARCH effects remaining in the return series for the oil market for all the countries. The McLeod-Li test at different lag orders is used to test for the presence of ARCH effects. In the case of Ljung-Box tests, there is no evidence of serial correlation at different lags for the return series of stock for WAEMU countries and Nigeria stock markets included in the study, but with the exception of the Ghana stock market. Also, we observed significant explanatory power in the stock market returns for Nigeria and Ghana stock market more than in the WAEMU countries stock market at their current values.

Return spillover among the three markets in all countries is assumed symmetric; that is, positive and negative returns are assumed to have identical impacts. The parameters of interest here are θ_s [return spillover from oil price to stock price] and θ_o [return spillover from stock price to oil prices]. Nonetheless, we include ownlagged returns [θ_s and θ_o] in the conditional mean equations to ensure that spillover effects are not confounded with serial dependence. As observed in table 4, the return spillover from stock price to oil price estimates are not statistically significant for Ghana (0.028) and WAEMU countries indicating that the returns in the stock market do not significantly influence the returns in the oil market. However, the return spillover in the case of Nigeria is statistically significant indicating that the returns in stock significantly influence the returns in the oil market. However, the outcomes from oil price to stock price are statistically significant for Nigeria, but not for Ghana and the WAEMU countries indicating that the returns in oil market influence the returns in the stock market. This development in the Nigeria stock and oil market is not unconnected with the fact that the country is an oil producing country when compared with other countries. However, investors in stock market seem to take into account the immediate past returns of changes in the stock market when making investment decisions.

Table 4: VAR-GARCH Results

	Nigeria	Ghana	BRVM Comp Shares		Nigeria	Ghana	BRVM Comp Shares
Variables	Stock	Stock	Stock	Variables	Oil	Oil	Oil
Mean Equation Constant (λ_s)	-0.0070	-0.0165**	-0.0354***	λ_0	0.0122	0.0022	0.0204
ϕ_s	0.2063***	0.1267***	-0.0475**	ϕ_o	-0.0471***	-0.0519***	-0.0294
θ_s	0.0311***	0.0064	-0.0011	θ_o	0.0915***	0.0287	0.0535*
Variance Equation Constant (c_i)	0.0119***	0.0190***	0.0562***	c_2	0.0043***	0.0027***	0.0059***
α_{11}	0.0715***	0.0798***	0.1291***	α_{21}	0.0075	0.0265***	-0.0296***
α_{12}	-0.0016	-0.0020	-0.0256***	α_{22}	-0.0054***	-0.0128***	0.0359***
β_{11}	0.8863***	0.8130***	0.7398***	β_{21}	26.161***	132.928***	-15.604
β_{12}	25.625***	152.03***	-101.043	β_{22}	0.9857***	0.9850***	0.9619***
γ_1	0.0079	0.0355***	-	γ_1	0.0499***	0.5923***	-
ρ_{so}	-0.0004***	-0.0000***	-0.0000***	ρ_{so}	-same-	same-	-same-
Model Selection Criteria							
AIC	5.395	4.286	5.188				
SBC	5.441	4.332	5.229				
Hannan-Quinn	5.412	4.286	5.203				

Post Estimation Diagnostics						
Ljung-Box Q(2)	0.127(0.938)	13.251(0.00)	2.482(0.289)	0.486(0.78)	0.861(0.65)	2.631(0.268)
Ljung-Box Q(5)	2.612 (0.760)	17.255 (0.00)	4.746(0.448)	0.977(096)	1.360(0.93)	2.902 (0.715)
McLeod-Li(2)	27.153(0.000)	0.5862(0.74)	1.564(0.457)	20.159(0.0)	20.580(0.0)	11.233(0.004)
McLeod-Li(5)	35.328(0.000)	3.1448(0.68)	9.416(0.093)	34.938(0.0)	34.077(0.0)	26.834(0.000)

The optimal lag order for the VAR model is selected using the AIC and SIC information criteria; Note: ***, ** and *denote statistical significance at 1%, 5% and 10% levels. Figures in parentheses represent p-values.

The estimates of one-period lagged own stock returns are positive for all the countries included are statistically significant except for WAEMU countries. This result also indicates the interdependence of returns in mean equations. The positive and statistically significant stock market returns obtained after one-period lag for the stock market prices in Nigeria and Ghana, but not for WAEMU countries. This result supports the facts that oil price shocks have a positive effect on the stock market. A much higher elasticity of the stock market's reactions to oil price change was obtained in this regard at an estimated coefficient of 0.21 in Nigeria. The presence of negative shock spillover from oil to stock in WAEMU countries is not unconnected with less reliance on the stock market on oil companies but on agricultural and service-oriented companies. These features are likely to undermine market operations on investment and speculations. Generally, shock transmission through previous oil price changes tend to have a positive and significant effect on stock markets in Nigeria and Ghana, but a negative and significant effect in the case of the WAEMU countries stock market. The level of impact tends, therefore, to be more in the Nigeria stock market when compared with the Ghana stock market. It is expected that these results will assist investors to understand the dynamics in both markets in these countries better and be able to forecast future returns on stocks.

Regarding the conditional volatility equations, the volatilities of stock and oil returns are sensitive to both own past shocks as well as past own conditional variance. The estimated results show that both ARCH and GARCH coefficients are significant in most cases. The magnitude of the reactions or interactions of GARCH-term past own conditional volatility seems to be quite significant in all countries included in the study. In this regard, we observed that the coefficients of the ARCH-terms which measure the effect of past shocks on conditional volatility is preferably very small and entirely reflected in a slow change in the general conditional volatility. Also, the relatively sizable GARCH-term estimates, which measure the impact of past volatility on current volatility, are quite significant in both countries and display a steady variation of conditional volatility over time.

Regarding volatility spillovers from oil to stock markets in all countries, the estimated coefficients are much smaller, and thus, the impacts of past shocks and past volatility of oil returns on the volatility of stock markets are quite minimal.

In clear terms, volatilities in these two markets may be accentuated by their shocks. These findings have profound implications. Firstly, unexpected events in the stock market in the current period, for example, have the capability of fueling high volatility in the market in the immediate succeeding period. Secondly, the volatility of the market in one period is capable of driving higher volatility in the immediate later period. Thirdly and technically speaking, the own past innovation and past own conditional variance of the two returns can be employed to forecast their future volatility. Lastly, the constant conditional correlation coefficient is statistically significant; thus, validating the assumption of constant correlations between the various markets. The sign is negative ($\rho_{so} = 0.0004$) indicating an inverse relationship between the two prices. As a result, the negative results from the estimate of constant conditional correlations between oil and stock markets in the countries, suggests some possible inverse relationship between oil and stock market and potential gains for investors in investing in either stock or oil markets in the presence of oil price shock. However, the Nigerian stock market may offer higher gains than Ghana and WAEMU countries stock market given the magnitudes of the conditional correlations.

3. 4.1 Portfolio Management Implications

The estimated results from the previous section revealed the possible potential gains to investors through the diversification of their assets by investing in either in the oil or stock markets in all the countries. Also, there are potential risk spillovers from the oil market to the stock market due to the significant influence of oil price volstity returns on stock returns. Thus, asset managers will need to devise measures that will minimise the risk without reducing expected returns. We attempt, therefore, to illustrate how an asset or portfolio managers can adequately quantify the optimal weights and hedging ratios of holding the two assets (stock and oil markets) using the methodology introduced by Kroner and Ng (1998) and adopted by Arouri et al. (2011). According to Kroner and Ng (1998), the optimal weight of holding both assets can be specified as:

$$\boldsymbol{w_{so,t} = \frac{h^{s}_{t} - h^{os}_{t}}{h^{o}_{t} - 2h^{os}_{t} + h^{s}_{t}}} \qquad (11)$$

and

$$\boldsymbol{w_{os,t} = \begin{cases} 0, & if\ w_{os,t} < 0 \\ w_{os,t}, & if\ 0 \le w_{os,t} \le 1 \\ 1, & if\ w_{os,t} > 1 \end{cases}} \qquad (12)$$

Where $w_{so,t}$ represents the weight of oil in a one dollar consisting of two assets within a portfolio at time t: and $\boldsymbol{h^{os}_{t}}$ refers to the conditional covariance between oil and stock market returns at time t. This means that the optimal weight of the stock market index within the portfolio under consideration is $1 - w_{so,t}$.

Table 5 reports the values of (optimal weights) for the all countries. They vary from 24.37 per cent for Nigeria to 3.0 and 27.29 per cent for Ghana and French speaking countries, respectively. This implies that the optimal weight of holding of oil in a one-dollar oil-stock market portfolio would be 24.37 per cent in the case of Nigeria and the remaining budget of 75.63 per cent should be invested in the stock market. In the case of Ghana and the French speaking countries, optimal holding of oil is as low as 3.0 and as high 27.29 per cent for Ghana and French speaking countries, respectively, while the rest of 97 and 72.71 per cent, respectively, are invested in stock market. This overall result suggests that investors should acquire more stocks than oil in their portfolio in all countries to curtail the risk without reducing the expected returns is not surprising. The stock markets in Ghana and French speaking countries depend less on oil companies, but more on agricultural and service oriented companies.

Regarding the hedge ratios, we also applied the methodology introduced by Kroner and Sultan (1993) and adopted by Arouri et al. (2011) to examine a portfolio of two assets that include oil and stock market index. Evidently, the likely risk of this portfolio will be negligible if a short position of one dollar in the oil market can be hedged by a long position of dollars in the stock market index, and it is specified as:

$$\rho_{os,t} = \frac{h_t^{os}}{h_t^{s}}$$

Table 5: Optimal Portfolio weights and Hedge ratios

Table 5 presents the values of the hedge ratios computed for all countries using equation (11).

Nigeria	Ghana	BRVM Comp Countries

We observed that the hedging ratios are higher in Nigeria and Ghana when compared to that of WAEMU countries. The ratios range from -0.07, -0.02 and +0.002 per cent in Nigeria, Ghana and WAEMU countries, respectively. The observed higher values obtained for the hedge ratios in both countries suggest that hedging effectiveness relating to both stock and oil markets in both countries will not deliver the desired outcome to investors.

The results obtained above implies that of one dollar short position in the oil market should be longed by - 0.07, -0.02 and 0.002 per cent in Nigeria, Ghana and WAEMU countries.

Table 6: Robustness Check (With WTI oil prices)

$\omega_{so,t}$	0.24372	0.03017	0.27282
$\rho_{so,t}$	-0.00079	-0.00023	0.000022

Optimal Portfolio weights and Hedge ratios

3.4.2 Evaluation for Robustness

	Nigeria	Ghana	BRVM Comp Countries
$\omega_{so,t}$	0.11882	0.03999	0.26121
$\rho_{so,t}$	-0.00634	-0.08093	0.02057

To further evaluate the robustness of the regression results obtained in the case of the optimal weights and hedging ratios for all countries, we replaced the Brent oil price with WTI oil price. As you will recall, the oil price was measured using brent oil price as oil price proxy. In this regard, we re-estimated all the equations using WTI oil price as oil price proxy. The results, as shown in table 6 indicate that our analyses are robust to different oil price proxies. This implies that using different oil price proxies to determine an optimal portfolio and hedging ratios for both countries will produce similar inferences for both short and long-run relationships.

4.0 Conclusion

This paper investigates the returns and volatility spillovers in the ECOWAS. The study adopted the CCC model of Bollerslev (1990) and VAR-GARCH model of Ling and McAleer (2003). In addition, the estimated results relating to the optimal weights and hedge ratios for the choice of holding oil -stock in a portfolio was also discussed. The study found from the diagnostics results that there were no remaining ARCH effects in the return series of stock for the WAEMU countries and Ghana stock markets, but not for Nigeria after the estimation of the VAR(1)–GARCH(1,1). We also found the presence of ARCH effects remaining in the return series for the oil market for all the countries. Regarding the Ljung-Box tests, we found no evidence of serial correlation at different lags for the return series of stock for WAEMUcountries and Nigeria stock markets included in the study, but with the exception of the Ghana stock market. Also, we observed significant explanatory power in the stock market returns for Nigeria and Ghana stock market more than in the WAEMU countries stock market from the estimated results. As observed

the return spillover from stock price to oil price estimates are not statistically significant for Ghana and WAEMU countries indicating that the returns in the stock market do not significantly influence the returns in the oil market. However, the return spillover in the case of Nigeria is statistically significant, indicating that the returns in stock significantly influence the returns in oil market. The presence of negative shock spillover from oil to stock in WAEMU countries is not unconnected with less reliance on the stock market on oil companies but on agricultural and service-oriented companies.

These features are likely to undermine market operations on investment and speculations. Generally, shock transmission through previous oil price changes tend to have a positive and significant effect on stock markets in Nigeria and Ghana, but a negative and significant effect in the case of the WAEMU countries stock market. The level of impact tends, therefore, to be more in the Nigeria stock market when compared with the Ghana stock market. It is expected that these results will assist investors to better understand the dynamics in both markets in these countries and be able to forecast future returns on stocks.

Also, the estimated results revealed the possible potential gains to investors through the diversification of their assets by investing in either the oil or stock markets in all the countries. In addition, there are potential risk spillovers from the oil market to the stock market due to the significant influence of oil returns on stock returns. Thus, asset managers will need to devise measures that will minimise the risk without reducing expected returns. The outcome of the optimal weights and hedging ratios of holding the two assets (stock and oil) revealed that investors should acquire more stocks than oil in their portfolio in all countries to curtail the risk without reducing the expected returns.

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