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Oil Price Shocks, Stock Market Returns and Volatility in Nigeria: A Disaggregated Approach

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Abstract

This study examined empirically, the returns and volatility spillover effects between oil price and sectoral stocks returns in Nigeria using high frequency daily data on oil price and eleven sectors i.e Agriculture, Conglomerates, Construction/Real Estate, Consumer Goods, Financial Services, Health Care, ICT, Industrial Goods, Natural Resources and Oil & Gas. The main objective of which is to examine the return and volatility spillover effects between the sectors and oil price. The study is anchored on three theories; the Discounted Cash Flow Model, the Capital Assets Pricing Model and the Arbitrage Pricing Theory. The data on the variables listed above were obtained from Nigerian Exchange Group and US Energy Information Administration. The study utilized the Vector Autoregressive Moving Average-Generalized Autoregressive Conditional Heteroskedasticity (VARMA-GARCH) multivariate volatility model for estimation where findings indicate bidirectional return and volatility spillover effects, between oil market and majority of the stock sectors. Additionally, results indicate low Constant Conditional Correlations (CCC) coefficients between oil and stock prices. The study concludes that there exist both return and volatility spillover effects, and that both return and volatility in both markets are fueled by own return and volatility effects and therefore recommends among others construct hedge ratios and portfolio weights to as a guide to minimize loses, also to factor in their decision making own short and long term shocks.

Keywords

Disaggregated Approach, Oil Price, Stock Returns, Varma-Garch Model, Volatility

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INTRODUCTION

The Nigerian capital market is seen as one of the fastest growing in Africa and indeed other emerging market economies (EMEs) worldwide, making it to be only three frontier markets in Africa since 2002. Thus, this provides opportunities for investors both domestic and foreign to earn high return on their investments culminating in large capital inflows into the economy.

However, the activities of the stock market have not been without challenges, leading to decline in stock returns. For instance, daily stock prices on the flow of the NSE shows that between 2008 and 2010, prices decreased by 25%, leading to the decline in market capitalization to 9.7 trillion naira from 12.5 trillion naira in a space of 6 months, CBN (2009, 2011). The NSE All Share Index in January, 2020 decreased to about 13% and further went down to below 11% by December of the same year. Also, almost all the industrial sectors' indices drastically declined between March and July, 2020, especially oil and gas, industrial goods and banking sectors. In order to stem these dwindling fortunes, the authorities took measures such as the introduction of the Central Securities Clearing System (CSCS) to aid computerization, introduction of a single clearing house for all shares traded on the exchange, reclassification of industrial sectors into 11 sectors from 33, to conform to global best practices, opening up the market to attract foreign participation, etc.

This is due to the fact that oil, as a source of energy, play a strategic role in the performance or otherwise of global economies, as it affects the consumption and investment decision of households and business firms at various times. An important discourse in the financial economics literature of recent is the understanding of the complex dynamics that explains the volatility of oil prices over time as it is critical for the growth and development of any economy. It is pertinent to

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note that almost all issues of production had to do with oil (Malik & Rashid, 2017; Mansoor, 2020; Castro & Rodroguez, 2024). Oil is said to occupy an important place in the world economy since it is considered as an important source of energy in the world, not just as fuel and source of energy for heating, but also as raw material in the production process (Al-Quduh, 2015). Fluctuations in the prices of oil have over bearing influence on other economic activities of a nation, Ordue *et al.* (2024).

Oil price have witnessed large volumes of fluctuations beginning from the big downward turn in oil prices of 1970 (Hamilton, 1983). Empirical evidence from previous studies like Abeng (2017); Killian & Park (2009); Yua *et al.* (2023), link changes in oil prices with weak financial systems, stunted growth of the economy, over increasing inflation, high interest rates depreciating exchange rate and downward trend in unemployment situations. The price of oil was below $10 in 1986, and around $23 in the 1990s. It peaked at $145 in 2008 before declining to $76 in 2010. This decline continued till 2014 when the price rose to about $127. However, due to the outbreak of Covid-19, oil prices went down to as low as $12 around the middle of 2020 before averaging to $68 as at first quarter of 2021. As at January, 2024, oil prices averaged $98 per barrel. Since crude oil was discovered in large quantities in Nigeria in 1956, it (oil) has dominated the entire economy by accounting for more than 90% of the export's earnings, contributing 25% of the GDP and about 80% of public revenues (Kumeka *et al.,* 2017; Ajekwe *et al.,* 2024). In the early nineties, there was an increase in oil prices globally by about $1. This led to increased public revenue of over 300 billion dollars and foreign exchange earnings of over 600 million dollars. As important as oil prices are, they are prone to fluctuations; otherwise known as price shocks which according to Hamilton (1983) occurs as a result of changes in demand or supply conditions in the international oil markets. One of the areas through which oil prices exert considerable effect worldwide according to Abdalla (2014; Tule *et al.,* 2019; Omale *et al.,* 2024) has to do with stock market development.

The stock market is considered worldwide as a market where elements that feed into the development of a nation's economy is said to operate. In both developed and developing economies, stock markets, which are part of the financial system plays a pivotal role in the development process. A well-functioning economy is one which is binged on a sound financial system of which the stock market is a major player. Stock markets are often seen as a place for accessing long term securities comprising both the primary and secondary market for the issue of new securities and trading of existing share respectively. Stock markets, as posited by (Adenuga 2010; Yua *et al.,* 2025) supports resource allocation to spur growth by reducing transaction costs, affecting the average productivity of capital mobilizing savings and altering the rate of investment, promoting and improving resource allocation among others. On the other hand, stock market also has some degree of influence on the oil market. For instance, a boom in the stock market will induce an increase demand for more production which will require listed firms using more inputs from oil which may likely affect the oil prices.

Oil price shocks are considered to be among the factors that effects stock market performance in Nigeria considering its predominance both as a source of public revenue and foreign exchange earner. Because of the glaring effect of oil prices shocks on real economic activity, especially on a stock market return, several scholars have probe into the oil prices stock return nexus. Studies such as Olufisayo (2014); Abraham (2016); Ajekwe *et al.* (2024); Lawal *et al.* (2016) maintained that oil price shocks affect stock returns negatively, while another research works like Adebuji *et al.* (2009) are of a contrary conclusion. However, as Kumar (2014) discovered, emerging markets are more vulnerable or prone to negative news and events happening elsewhere like the global economic crises of 2008/2009 usually results in institutional investments flowing into or out of the market, creating an environment of high volatility and uncertainty. Against this background, therefore, this study intends to examine the impact of the return spillover from oil prices to sector specific stock returns, stock indices, stock returns to oil prices, conditional correlation between oil prices and each of the sectors in Nigeria.

LITERATURE REVIEW

Conceptual Review

Concept of Oil Price Shocks

Oil price shocks are unexpected changes in global demand and supply due to economic or geopolitical events. Demand-side shocks, such as the Iranian invasion of the U.S. embassy in 1978 and Iraq's invasion of Kuwait in 1980, disrupt oil production and lead to higher prices. Demand-side shocks, like China's economic growth and the 2007-2009 financial crises, can also cause oil price collapse. Killian (2009) identifies three types of oil price shocks: supply-side shocks, aggregate demand shocks, and precautionary demand shocks.

Concept of Stock Returns

Investors invest resources for earnings and income, often focusing on profits from shares or dividends. Stock returns, measured by changes in firm prices on the Nigerian stock exchange, are influenced by various economic risk factors and global economic events.

For this study the daily returns of the series will be calculated as

$$R_{it} = log\frac{\rho_{i\,t}}{\rho_{i\,t-1}} = log\rho_{i\,t} - log\rho_{i\,t-1}$$

Where $\rho_{i\,t}$ is the daily close price of oil, and the eleven (11) sector indices namely; Agriculture, Conglomerates, Construction/Real Estate, Consumer Goods, Financial Services, Health Care, ICT, Industrial Goods, Natural Resources and Oil & Gas on the Nigerian Exchange Group.

Concept of Stock Market

Volatility is a key concept in financial markets, indicating an asset's riskiness over time. It can be classified as conditional volatility, which changes over time, or unconditional volatility, which doesn't depend on time. Asset returns show features like serial correlation, volatility clustering, and asymmetry. Conditional volatility is negatively correlated, aligning with the LeBann effect. During economic downturns, stock price falls cause increased market volatility, leading to the 'lover age effect', increasing financial leverage and making stocks riskier.

Concept of Stock Volatility Spillover

The notion of the volatility of stock returns can be traced back to the pioneer work of Engle *et al.* (1990) Own and cross spillover are two types of volatility spillover. Own spillover refers to the volatility of an asset based on past volatility, while cross spillover focuses on the current volatility of the same asset and other assets.

THEORETICAL LITERATURE

Capital Asset Pricing Model (CAPM)

The capital asset pricing model was pioneered by notable authors including Sharpe (1964); Umer (1965); Mossin (1960). The CAPM is a single factor model, quantifies the expected rates of return of an asset with level of market systematic risk. The CAPM has variously been used among others by Chen (2003); Kim & Moser (2017a).

Nguyen & Nguyen (2017) the model assumes competitive financial markets, investors plan to invest over the same time horizon, no discretionary taxes or transaction costs, and unlimited borrowing and lending. Investors like overall portfolio reward and dislike risk.

Algebraically, the Capital Assets Model is presented as

$R_i = RFR + \beta_i\,(Rm - RFR)$ .1

Where,

Rm	=	Expected return on portfolio
RFR	=	risk free return
R_i	=	Return on asset
β_i	=	$\frac{COV\ (RI,RM)}{\delta^2 M}$ 2.2

βis called the beta of the asset i and δ_m^2 is the variance of the market portfolio. For any portfolio < = (<1----<n) of risky assets, its beta can be constructed as a weighted average of individual asset betas as follows:

$E(rd) = RFR+\beta\lambda(RM) - RFR$ 2.3

$\beta\lambda = \sum_{i=1}^{p} \propto i\beta i$ 2.4

The Beta value indicates a measure of risk for individual assets/portfolio. It measures the nondiversifiable or transferable part of risk known as systematic risk. According to this model, the expected return of an asset depends on its stand-alone risk. However, the CAPM he models assumes a perfect competitive market environment, but this is unrealistic due to factors like demand and supply, tax liabilities, and borrowing rates, which differ from individual investors.

Arbitrage Pricing Theory (APT)

Arbitrage pricing theory, introduced by Ross and improved by Fama and French, involves selling and buying assets at lower prices due to market failure. The Arbitrage Pricing Theory (APT) is an augmented version of CAPM that incorporates macroeconomic factors, allowing researchers to generate returns without specifying factors driving expected asset returns. Diversifiable markets require security-specific risk, while multi-factor models generate returns influenced by macroeconomic factors, using betas for each factor tested against stocks. Factors can be firm-specific, macroeconomic, or any author's opinion on stock returns.

A multi-factor APT model as expressed as follows:

$$Rit = \Psi_{it}+\beta_{1i}+F_{1t}+\beta_{2i}F_{2t}+\beta_{3i}F_{3t}+\beta_{4i}F_{4t}\ldots\ldots\ldots+\ldots\ldots+\ldots\ldots\ldots+ E_{it} \quad 2.5$$

Where

R_{it} = Return on Asset i at time t.

Ψ_{it} = Risk Free Rate

β_i = Security of the factors

F = Risk Factors

Discounted Cash Flow Model (DCF)

The relationship between oil price shocks and stock market return can also be theoretically explored or viewed through the discounted cash flow model (equity pricing model) developed by Huang *et al.* (1996). The model has been adopted in several literature (Sek, 2015; Basher, 2014; Zakanya & Abdala, 2013; Abeng, 2017; Degiannakis, 2017). According to this model, macroeconomic variables including commodity prices can exert a significant effect on stock returns of firms. According, the price of equity at a given point in time is equal to the expected present value of the discounted future cash flows as follows:

$$P = \frac{E(C)}{E(r)} \quad 2.6$$

Where

P = Stock price

C = cash flow

r = Discount rate (interest rate)

E(1) = expectation operator

The realized stock returns R can be expressed approximately as

$$R = \frac{CE(C)}{E(C)} = \frac{dE(r)}{E(r)} \quad 2.7$$

Where d(.) is the difference operator.

Stock returns, R, Oil prices can impact expected cash flows and discount rates, which are determined by the systematic movements in these variables. Rising oil prices increase production costs, dampening cash flows and reducing stock prices. The discounted rate, which consists of expected inflation and expected real interest rate, can also be affected by oil price changes. Higher oil prices can negatively affect trade balances, leading to higher inflation and lower stock returns.

Review of Empirical Studies

Modeling the effect of oil price shocks on energy sector stock returns in Nigeria was examined by Ebechidi & Nduka (2017). The study analyzed oil prices and stock returns of energy firms from 2000 to 2015 using GARCH modeling. Results showed a negative 74% effect on energy sector stock returns, with an increase in oil prices leading to a margin increase in stock return.

Modeling the impact of oil price fluctuations on the stock returns in an emerging market like Saudi-Arabia, Abdala (2013) The study, analyzing aggregate stock index and oil prices from 2007 to 2011, found that crude oil price fluctuations increased stock market returns volatility.

Sek *et al.* (2015) compared, by way of analysis, the effect of oil prices across stock markets of China, India, South Korea, Singapore and Italy, using data from January 2009 to December 2013. The study found detectable spillover effects between crude oil price and stock returns for all countries using the Baba, Engle, Kroner (BEKK) multivariate volatility model. However, a panel Garch or panel ARDL methodology should have been used.

Abdala (2014) The study analyzed oil price fluctuations on Sudanese stock market performance from 2008 to 2014, finding that past oil price values significantly influenced KSE returns, with crude oil shocks positively impacting returns.

Sector responses of GCC stock market returns to international oil price changes was the topic of study conducted by Khamis & Handen (2016). A study on GCC stock markets reveals that oil price changes affect sectors differently, but fails to account for return and volatility spillover effects due to financial linkages.

A sector analysis of asymmetric nexus between oil prices and stock returns was examined by Salisu *et al.* (2017). The study on the US stock market, using monthly data from 1999-2017, found that oil price shocks significantly impact sectoral stock returns. However, the findings may not be applicable to developing countries like Nigeria or with higher frequency data.

Waheed *et al.* (2017) The study from 1998-2014 in Pakistan used industry-wise analysis to examine the impact of oil prices on stock returns of listed firms on the Karachi stock exchange, finding a significant positive effect.

The impact of oil prices on stock markets from Gulf Cooperative Council financial markets was examined by Alqattan & Alhaykay (2016). The study, using monthly data on oil prices and stock returns from GCC countries, found no evidence of cointegration, except for Oman, and the use of monthly data may affect consistency.

Analyzing the impact of oil price shocks on asset price of UK firms was the topic of the study conducted by Alaali (2017). The study analyzed UK firms' responses to oil price shocks using the Fama-French four factors asset pricing model. Results showed transportation sector returns were insensitive, while travel, tourism, airlines, and oil and gas showed asymmetric responses. The study's main drawback is its use of monthly financial series data.

Jafarian & Safari (2015) The study examined the impact of oil price fluctuations on Malaysia's stock market returns from 2000 to 2014. Results showed positive effects on consumables and energy sectors, while utilities and telecom sectors were negatively affected. However, the study's main drawback is its use of monthly data.

Volatility spillover between oil price and the stock market under structure breaks was examined by Ewing & Malik (2015). The study used the MGARCH model to analyze oil price volatility and US stock market returns from 1996 to 2014. Results showed no spillover, but strong evidence of volatility spillover when structural breaks are included.

The impact of oil price shocks on Amman Stock Exchange Real return was conducted by Al-Qudah (2015). The study examines the impact of oil prices, stocks, and interest rates on stock returns in Jordan from 2000 to 2014. Results show a significant negative effect on Amman stock exchange returns, with a unidirectional casualty between oil price shocks and short-term interest rates.

Oil price and stock markets in Europe was carried out by Arouri *et al.* (2009). The study explores the long-term relationship between oil prices and European sector stock market returns. Results show a significant response in automobiles, oil & gas, financials, and technology sectors, but the study's drawback is its over-ten-year history.

An empirical analysis of oil price and stock market performance in Nigeria was examined by Ogiri *et al.* (2013) The study uses data on oil prices, GDP, EXP, and market capitalization to explore stock price movements and their links to market performance, highlighting the importance of oil price changes.

Oil prices and stock market behavior in Nigeria was examined by Adavanola (2012). The study examined the dynamic effects of oil prices on stock markets from 1985 to 2009 using quarterly data.

Results showed a positive short-run response to oil price shocks, but a reverse long-run effect, indicating causality.

The effect of oil price shocks on stock returns of energy firms in Nigeria was investigated by Soyemi *et al.* (2017). The study, analyzing oil prices and stock market returns from 2007-2014, found a direct positive effect of oil shocks on company stock returns, with an indirect relationship through market returns. However, the study limited to energy firms and did not consider asymmetries.

METHODOLOGY

Nature and Sources of Data

This study covers the period 4th January, 2011 – 8th January, 2022 where data was retrieved on daily frequency level making a total of about 3000 observations. Stock market data was sourced from the Nigeria stock exchange, for the oil price, data was sourced from United States Energy Information Administration (EIA).

Variable Definitions and Measurements

The study made use of two (2) variables, oil price and stock returns disaggregated into 11 sectoral indices listed on the Nigerian Exchange Group. The daily return of each series is computed as;

$$R_{it} = log\frac{\rho_{i\,t}}{\rho_{i\,t-1}} = log\rho_{i\,t} - log\rho_{i\,t-1}$$

Where $\rho_{i\,t}$ is the sum of daily mean closing price of brent crude oil, and the eleven (11) sector indices on the Nigerian Stock Exchange namely Agriculture, Conglomerates, Construction/Real Estate, Consumer Goods, Financial Services, Health Care, ICT, Industrial Goods, Natural Resources and Oil & Gas.

Model Specification

The study specify the conditional mean, variance and covariance of a bivariate VARMA (1,1) – GARCH (1,1) as in Salisu & Isah (2019); Malik & Rashid (2017); Tule *et al.* (2017); Yaya *et al.* (2017); Lin *et al.* (2014) as follows:

VARMA – GARCH MODEL

In financial literature, the (APT) theory assumes that specifically the return on assets can be generated as

$$R_i = \vartheta + \beta_i\rho + \varepsilon_i$$

Where R_i is volatility of stock returns, ϑ is expected (unconditional) stock return volatility, β_i measures the coefficient of oil price shock, ρ is oil price shock and ε_i denotes error/residual effect. In line with the (APT) above, and following Yaya *et al.* (2017); Malik & Rashid (2017), Fasanya *et al.* (2019), the CC-VARMA GARCH model for the mean (return), the variance equation and the covariance equations are specified as follows:

$$\begin{matrix} R_{oil_t} = \\ R_{s_t} = \end{matrix} A\begin{pmatrix}\gamma_{oil}\\ \gamma_s\end{pmatrix} + B\begin{pmatrix}\varphi_{oil}\varphi_{oil,s}\\ \varphi_{s,oil}\ \varphi_s\end{pmatrix}\begin{pmatrix}R_{oil_{t-1}}\\ R_{s_{t-1}}\end{pmatrix} + C\begin{pmatrix}\varepsilon_{oil_t}\\ \varepsilon_{s_t}\end{pmatrix} \qquad 3.1$$

Where,
A is a matrix of coefficients of returns on each series
B is a matrix of coefficients allowing for cross sectional dependence of conditional retunes between oil and stock markets conditioned on $t - 1$
C is a matrix vector representing error terms.

These coefficients are denoted as follows:
R_{oil_t} and R_{s_t} are the daily return of sectors specific stock index and oil prices respectively, φ_s and φ_{oil} are the coefficients of own past lag effect of sector stock returns and oil price returns respectively. φ_s and φ_{oil} both measure the return spillover effect of oil on the stock returns and stock on oil returns respectively.

The conditional variance equation for the oil stock series for objective three and four is specified as follows:

$$\begin{pmatrix}\delta^2{}_{oil,t}\\ \delta^2{}_{s,t}\end{pmatrix} = D\begin{pmatrix}\omega_{oil}\\ \omega_s\end{pmatrix} + E\begin{pmatrix}\lambda_{oil}\lambda_{oil,e}\\ \lambda_{s,oil}\lambda_s\end{pmatrix}\begin{pmatrix}\varepsilon^2{}_{oil\,t-1}\\ \varepsilon^2{}_{s\,t-1}\end{pmatrix} + F\begin{pmatrix}\beta_{oil}\beta_{oil,s}\\ \beta_{s,oil}\beta_s\end{pmatrix}\begin{pmatrix}\delta^2{}_{oil,t-1}\\ \delta^2{}_{s,t-1}\end{pmatrix} \qquad \mathbf{3.2}$$

Where,
D is matrix of coefficients of constants
E is matrix of coefficients of short-run shock or ARCH effects conditioned on past innovations.
F is matrix of coefficients of long-run volatility or GARCH effects conditioned on past innovations.

The coefficients are denoted as follows:
$\delta^2{}_{oil}$ and $\delta^2{}_s$ are the variance of the two series. ω_{oil} and ω_s are the non-negative constants of the model, λ_{oil} and λ_s measures the short run persistence or ARCH effects of the past shocks of both oil and sector stock return respectively at time $t-1$ on the present conditional variance series capturing the impact of direct transmitted shocks. $\varepsilon^2{}_{oil\,t-1}$ and $\varepsilon^2{}_{s\,t-1}$

β_{oil} and β_s measure long run persistence or GARCH effects of past shocks of oil and stock return at $t-1$ respectively, on the transmitted conditional volatility series capturing the direct impact of the effects of the transmitted conditional volatility series $\delta^2{}_{oil,t-1}$ and $\delta^2{}_{s,t-1}$.

$\lambda_{oil,s}$ and $\lambda_{s,oil}$ measures the cross value of the error terms $\varepsilon^2{}_{s\,t-1}$ and $\varepsilon^2{}_{oil\,t-1}$ on current conditional variance series for oil and sector stock respectively. Thus, these parameters and shock spillover or volatility spillovers coefficients that measure the effects of volatility shocks between oil and stock markets such that $\lambda_{oil,s}$ measure the impact of sector stock shocks (volatility) on oil market, whereas $\lambda_{s,oil}$ measure the impact of oil market volatility shocks on sector stock volatility. In the same vein, volatility spillover between oil prices and sector stock returns are measured by $\beta_{oil,s}$ and $\beta_{s,oil}$, i.e $\beta_{oil,s}$ measures the impact of volatility spillover from stock to oil market while $\beta_{s,oil}$ measures the impact of volatility spillover from oil to sector stock market returns.

To accommodate the asymmetries in the model, McAleer *et al.* (2009) introduced the VARMA-AGARCH version. The authors adopted the GJR style of asymmetry to uncover the asymmetry impact of unconditional shocks on the conditional variances. In line with their works and following Yaya *et al.* (2017); Yaya *et al.* (2021): Ogbonna (2017) the VARMA-AGACH model is specified as follows:

$$\begin{pmatrix}\delta^2{}_{oil,t}\\ \delta^2{}_{s,t}\end{pmatrix} = D\begin{pmatrix}\omega_{oil}\\ \omega_s\end{pmatrix} + E\begin{pmatrix}\lambda_{oil}\lambda_{oil,e}\\ \lambda_{s,oil}\lambda_s\end{pmatrix}\begin{pmatrix}\varepsilon^2{}_{oil\,t-1}\\ \varepsilon^2{}_{s\,t-1}\end{pmatrix} + F\begin{pmatrix}\beta_{oil}\beta_{oil,s}\\ \beta_{s,oil}\beta_s\end{pmatrix}\begin{pmatrix}\delta^2{}_{oil,t-1}\\ \delta^2{}_{s,t-1}\end{pmatrix} + G\begin{pmatrix}\phi_{oil}I(\varepsilon_{oil,t})\varepsilon^2_{oil\,t-1}\\ \phi_s I(\varepsilon_{st})\varepsilon^2{}_{s\,t-1}\end{pmatrix} \quad \textbf{3.3}$$

Where
D is matrix of coefficients of constants
E is matrix of coefficients of short-run shock or ARCH effects conditioned on past innovations.
F is matrix of coefficients of long-run volatility or GARCH effects conditioned on past innovations.
G is matrix of coefficients of asymmetric (leverage) effects

Note that the only difference between the VARMA – GARCH and the VARMA – AGARCH model is the inclusion of the leverage effect parenthesis ϕ_{oil} and ϕ_s which measure the asymetic impact of volatility of oil and stock markets respectively using the indicator variable $I(\varepsilon_{oil,t})$ and $I(\varepsilon_{st})$ conditioned such that $I(\varepsilon_{oil,t}) = 1$ for $I(\varepsilon_{st}) \leq 0$ and is otherwise, same as $I(\varepsilon_{s,t}) = 1$ when $I(\varepsilon_{s,t}) \leq 01$.

The Covariance Equation which can either be dynamic conditional correlation (DCC) or constant conditional correlations (CCC) is specified as follows:

First, The CCC model is specified as

$$\rho_{s,o,t} = \rho^{so}\sqrt{h_{st}},\sqrt{h_{ot}} \quad \textbf{3.4}$$

Where
ρ^{so} is constant conditional correlation between stock and oil price returns.
Secondly the Direct Conditional Coloration (DCC) between the stock and oil market returns is specified as:

$$Q = (1 - л_1 - л_2)Q_O + л_1 n_{t-1}n^1_{t-1} + л_2 Q_{t-1} \quad \textbf{3.5}$$

Where,

$$n_{t-1} = \left[\varepsilon_{oil\,t-1}/\sqrt{h_{oil\,t-1}}\,\varepsilon_{st-1}/\sqrt{h_{st-1}}\right]$$

The $л_1$ and $л_2$ are the effects of previous shocks and previous conditional correlation on the current conditional correction respectively.

Pre-Estimation/Preliminary Analysis
Before estimating the model parameters, the following pre-estimation analysis were conducted and the results reported in chapter four.

Summary (Descriptive) statistics was carried out to uncover the historical properties of the twelve variables of the study. Such statistics include mean, median, skewness and kertosis, Jarque-Bera, etc.

The unit root properties of the variables were examined. This is because, most economic and financial series exhibit episodes of non-stationarity. The study tests for the order of integration of the variables using the Augmented-Dickey Fuller test. The test regression for variable say y is specified as follows:

$$\blacktriangle y_t = {}_{\beta 0} + {}^{\varphi}y_{t-1} + \sum_{i=1}^{P} \dot{\omega} \blacktriangle yt - 1 + ul. \qquad \textbf{3.6}$$

The null hypothesis is

H_o $\varphi = 0$

While the alternative hypothesis is

H_1 $\varphi < 0$

The series y_t is stationary if the null hypothesis is rejected, otherwise the series has a unit root.

The twelve (12) variables were subjected to virtual (graphical) analysis in order to have firsthand information on the series in question.

The ARCH-LM test for the existence or otherwise of ARCH effects in the residuals was also carried out, to test the null hypothesis that there are no ARCH effects up to lag order q in the residual. The test regression is specified as;

$$\varepsilon_t^2 = \varphi_t + \left(\sum_{j=1}^{n} \varphi_{t-j}^2\right) + vt \qquad \textbf{3.7}$$

$\varphi_{t-j}$are the residuals from the ARCH model φ_0 is the intercept while φ_j are the coefficients.

Sign and size biased tests

It is important and necessary to uncover the presence or otherwise of asymmetric effects before deciding to adopt either VAR-GARCH or its asymmetric version the VAR-AGARCH model. The Engle and Ng (1993) sign and size bias test was carried out to verify the presence or otherwise of asymmetric effects.

These tests determine the significance of volatility changes when a negative or positive return shock occurs by regressing the squared residual term on a dummy variable reflecting the sign of the residual term.

Using $\varepsilon_{it,\ i}$= stock and oil return to indicate the residual of asset *i* at time t, the following tests will be estimated.

Sign biased test

$$\varepsilon_{it}^2 = a + bS_{i,t-1}^- + ui, t \qquad \textbf{3.8}$$

Negative Size biased test

$$\varepsilon_{it}^2 = a + bS_{i,t-1}^- \varepsilon_{i,t-1} + ui, t \qquad \textbf{3.9}$$

Positive size biased test

$$\varepsilon_{it}^2 = a + bS_{i,t-1}^+ \varepsilon_{i,t-1} + ui, t \qquad \textbf{3.10}$$

The sign bias test is the t statistic for testing $H_o b = 0$, in equation 3.11 and the negative size bias test is the t statistic of testing $H_o b = 0$, in equation 3.12 these tests can be jointly carried out using the joint bias test.

Joint Biased Test $\varepsilon_{it}^2 = a + b_1 S_{i,t-1}^- + b_2 S_{i,t-1}^- \varepsilon_{i,t-1} + b_3 S_{i,t-1}^+ \varepsilon_{i,t-1} + uit$ **3.11**

$S_{i,t-1}^-$ and $S_{i,t-1}^+$ are dummy variables that take a value of **1** for negative and **0** for positive residuals of ***i*** respectively. The LM test statistic for the null hypothesis is $H_o: b1 = b2 = b3 = 0$ which has a Chi squared distribution. Rejecting the null hypothesis imply using the VARMA-AGARCH model and vice versa. However, Engle and Ng (1993 cited by Salisu 2009 advises that the joint test be considered to determine asymmetric effects where there is a conflict among the individual tests.

The Engle-Sheppard CCC x^2 Test

Though VARMA-GARCH class of models assume constant conditional correlations, it is still necessary to conduct a formal test. For this, the Engle-Sheppard (2001) CCC test was conducted to enable us choose between the CCC or DCC GARCH variant to use. The null hypothesis of CCC is tested against the alternative of DCC both earlier outlined in equations 3.5 and 3.6

Thus, the rejection of the null implies adopting the DCC model while the non-rejection of the null favours the CCC model and its variant such as the VARMA-GARCH model.

Estimation Technique

The estimation of the parameters in 3.2 was carried out using numerical maximizations of the joint likelihood function under the distributional assumptions of the models. For a sample of N observation, as outlined in Yaya et al 2017, the log-likelihood function to the maximized with respect to the parameters set ϴ is

$$\left((\Theta) \sum_{t=1}^{N} l_t(\Theta) = -N I_n 2\pi - {}^{1}/_{2} \sum_{t=1}^{N} I_n / H_t(\Theta) - {}^{1}/_{2} \sum_{t=1}^{N} \varepsilon_t^{/}(\Theta) H_t^{-1} \varepsilon_t^{/}(\Theta)\right) \quad \textbf{3.12}$$

Where N is the size of the return series, and ϴ is the parameter set of the model estimated. The Quasi-maximum likelihood estimation function is therefore optimized and implemented using RATS 10.2 and Oxmetrics 8.0 software's.

Post Estimation/Diagnostics

Post estimation and diagnostics tests was also conducted to determine the adequacy or otherwise of the models. Two prominent tests were conducted as follows:

Serial Correlations

For this, Ljung Box test for serial correlation was carried out to determine if the estimated model is free for serial correlation.

ARCH Effects

To determine the existence of remaining ARCH effects in the model, the study conducted ARCH LM serial correlation test and the McLeod – Li test.

PRESENTATION AND DISCUSSION OF RESULTS

Stationarity Tests

Though the study uses return series, which are already stationary nonetheless, stationarity tests are conducted on the price data just for confirmatory reasons. The result is reported as follows:

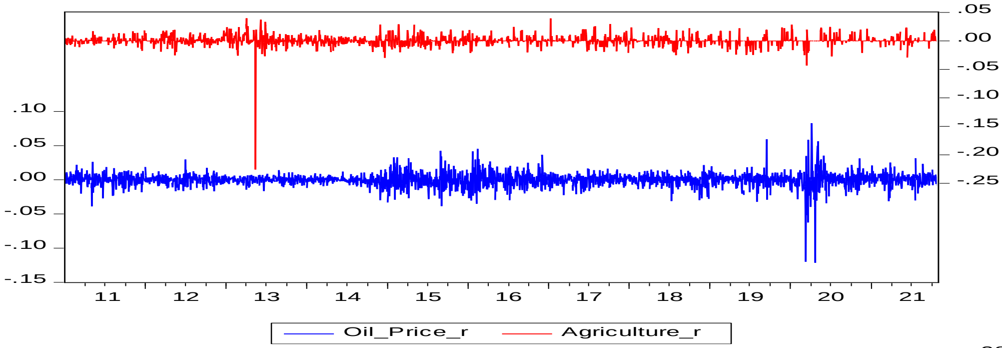
Table 1. *Unit Root Tests Results*

Variable	ADF Stat	PV	Decision	PP stat.	PV	Decision
Oil Price	63.59203	0.0001	1(1)	61.2311	0.0000	1(1)
Agriculture	47.24475	0.0001	1(1)	28.1000	0.0001	1(1)
Conglomerates	46.85522	0.0001	1(1)	36.1007	0.0000	1(1)
Consumer goods	47.14081	0.0001	1(1)	50.0611	0.0000	1(1)
Construction/Real Estate	50.17499	0.0001	1(1)	51.3171	0.0000	1(1)
ICT	39.03502	0.0000	1(1)	-36.0179	0.0001	1(1)
Industrial Goods	-50.27804	0.0001	1(1)	-39.1311	0.0001	1(1)
Health care	-32.60718	0.0000	1(1)	-48.2910	0.0000	1(1)
Natural Resources	-33.31252	0.0000	1(1)	-46.0017	0.0000	1(1)
Oil and Gas	-48.36656	0.0001	1(1)	-39.1874	0.0001	1(1)
Financial Services	-45.98963	0.0001	1(1)	-34.1217	0.0000	1(1)
Services	-49.47295	0.0001	1(1)	58.8181	0.0000	1(1)

As we can see from the ADF and Philip Peron (PP) stationarity test above, all the series are stationary after been differenced once. Consequently, the series are adequate for analysis using appropriate volatility models.

Time Plots for Return Series

The time plots of the return series are presented on figure 1.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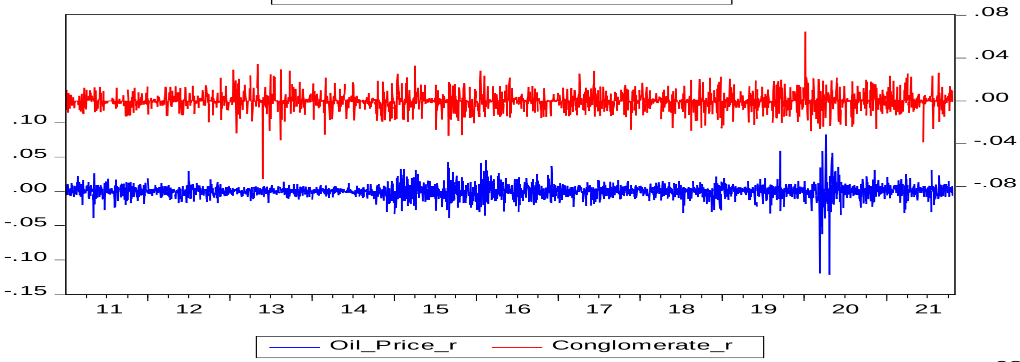
Oil_Price_r
Agriculture_r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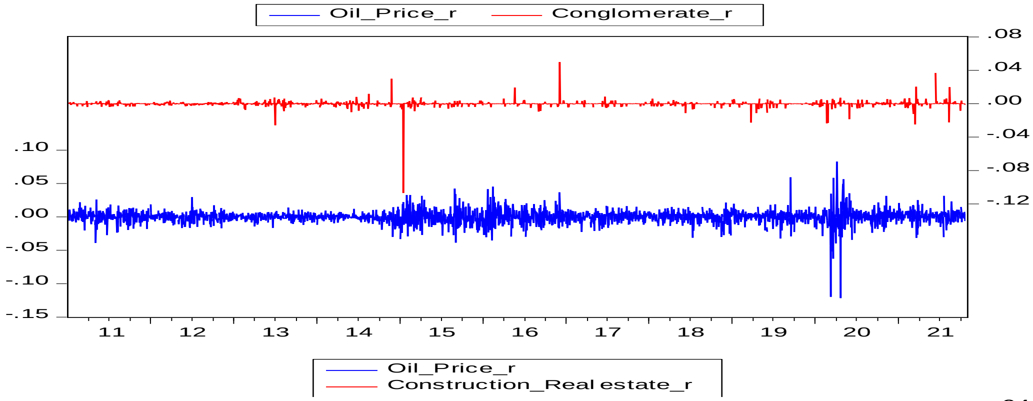
Conglomerate_r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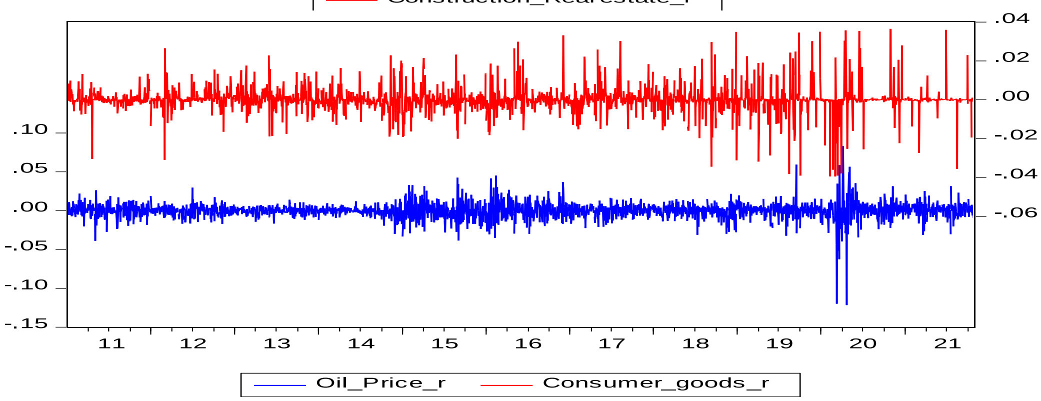
Oil_Price_r
Construction_Real estate_r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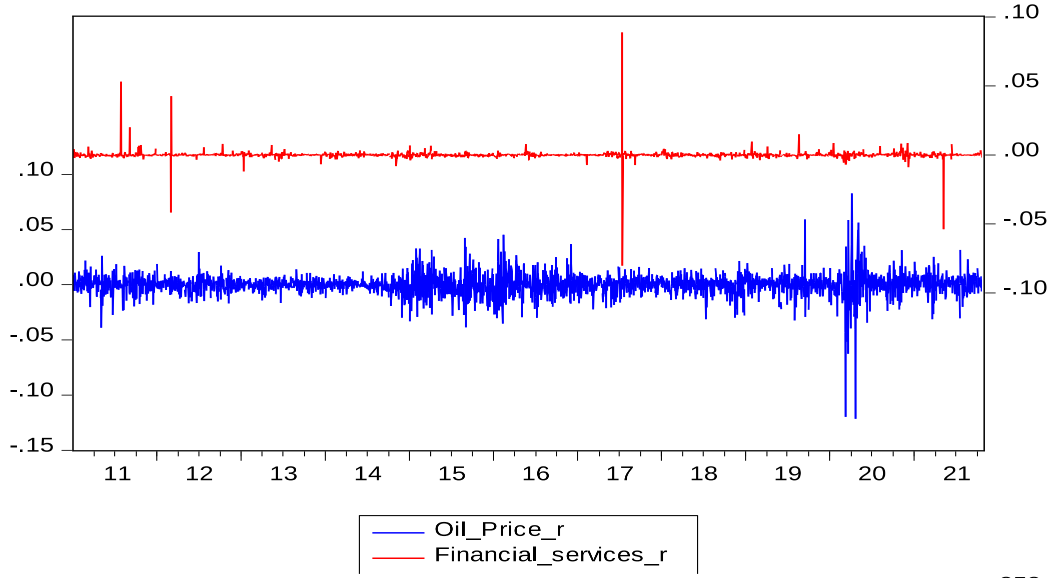
Oil_Price_r
Consumer_goods_r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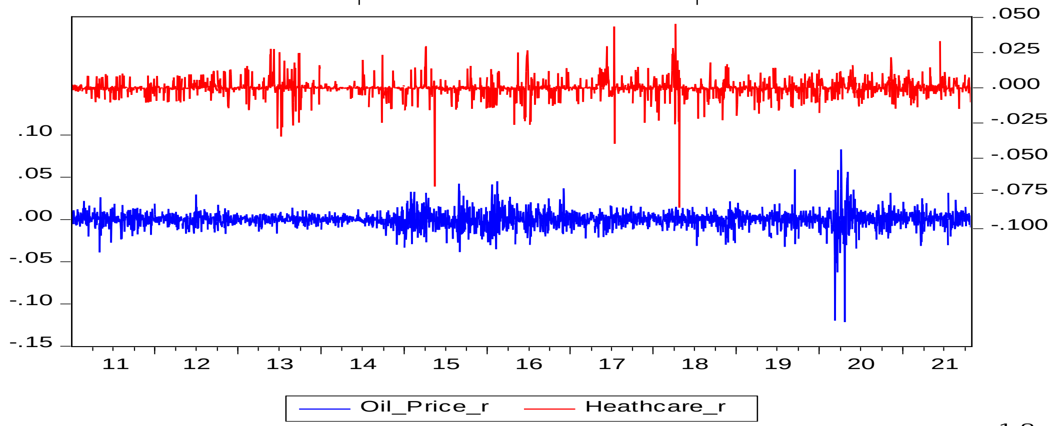
Oil_Price_r
Financial_services_r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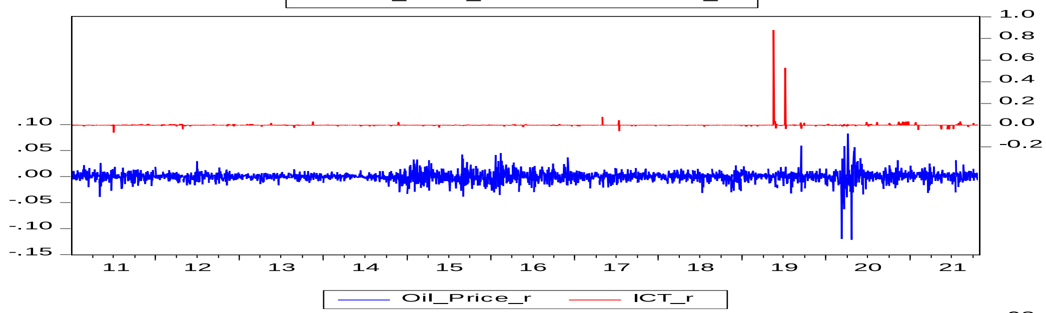
Oil_Price_r
Heathcare_r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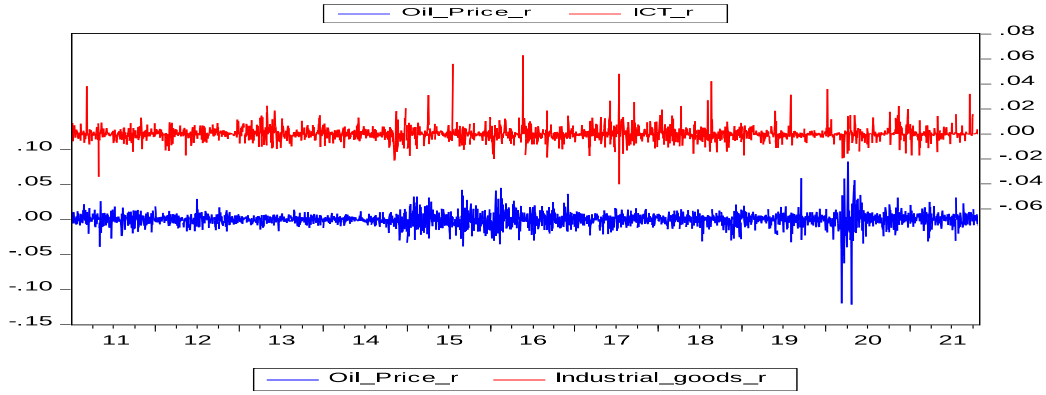
Oil_Price_r
ICT_r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Oil_Price_r
Industrial_goods_r

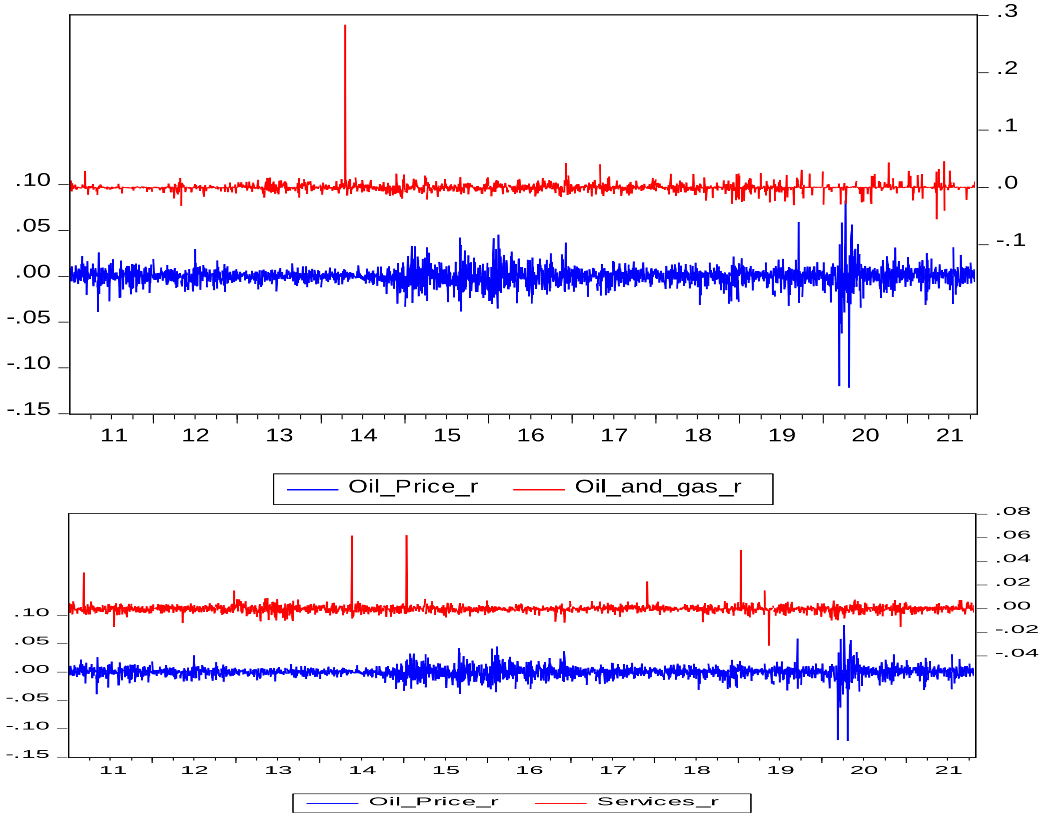

Figure 1: *Time plot for return series*

The time plots of oil and the eleven sectoral indices are as presented above. For the agriculture sector we observe spikes in oil return around late 2012, while return on agriculture sector was stable from 2011 to 2014. However, as observed by 2020, there was a sharp spike in returns perhaps due to the COVID 19 Pandemic. We can also observe that all the return series exhibit volatility clustering given rise to excess kurtosis with very high values as evidence in the table 1 on descriptive statistics. Volatility clustering indicates that large positive changes in volatility are likely to be followed by negative changes in volatility. Thus, scenario suggests the positivity of return and volatility spillover effects between the series which makes GARCH based models ideal for estimation. Fracq & Zakoian (2010), cited by Abdala (2014).

ARCH and Serial Correlation Tests

Evidence from the stationarity tests, Jarque-Bera and Kurtasis support the adoption of GARCH model however, the ARCH test serial correlation test were conducted. The Engle (1982) ARCH tests were conducted where results reveal existence of ARCH effects and serial correlation in the series. This is reported on table 2 and attached as appendix III.

Table 2. *ARCH Test Result*

Variable	ARCH LM
Oil Price	6.7606
Agriculture	3.646
Conglomerates	4.3863
Consumer goods	2.8613
Construction/Real Estate	32.5634
ICT	590.3996
Industrial Goods	19.6183

Health care	2.7309
Natural Resources	28.559
Oil and Gas	3.9690
Financial Services	6.0223
Services	2.4601

Asymmetry Sign and Size Biased/Engle-Sheppard CCC X^2 Tests

The results of the sign biased and the Engle-Sheppard CCC X^2 tests are presented on table 3 and attached as appendix IV & V respectively.

Table 3. *Asymmetry Sign and Size Biased/Engle-Sheppard CCC X^2 Tests*

Variable	Sign Bias Test	-ve size bias test	+ve size bias test	Joint bias test	Eagle-Sheppard CCC X^2 test
Agriculture	1.1869 (0.235368)	2.1448 (0.032060)	0.3301 (0.74133)	13.9861 (0.002924)	1.530652 (0.465182)
Conglomerates	0.08428 (0.9328)	0.58831 (0.5564)	1.36576 (0.1721)	3.52104 (0.3188)	1.453491 (0.48348)
Construction and Real Estate	1.699 (0.0596)	1.489 (0.36682)	2.659 (0.00688)	15.603 (0.00136)	2.293520 (0.029352)
Consumer Goods	1.70426 (0.08833)	0.76213 (0.44598)	1.25435 (0.20972)	7.58415 (0.07544)	0.87052 (0.64709)
Fin. Services	0.78937 (0.42989)	0.07919 (0.93668)	0.20487 (0.93608)	0.77341 (0.85582)	5.993539 (0.05990)
Health care	0.83198 (0.4055)	0.02822 (0.9775)	0.08515 (0.9321)	0.73317 (0.8654)	1.650715 (0.438078)
ICT	1.1863 (0.23568)	0.3833 (0.70152)	2.0564 (0.03984)	8.4404 (0.03773)	0.029403 (0.998648)
Industrial goods	0.835213 (0.4037)	0.003808 (0.9976)	0.087349 (0.9304)	0.758233 (0.8594)	0.037844 (0.981255)
Natural resources	0.4332 (6.649e-1)	2.3155 (2.066e-02)	4.5577 (5.405e-06)	26.4730 (7.592e-06)	0.22862 (0.891979)
Oil and Gas	0.69921 (0.4845)	0.07271 (0.9420)	0.19427 (0.8460)	0.57841 (0.9014)	0.088905 (0.956520)
Services	0.66369 (0.5069)	0.06218 (0.9504)	1.12457 (0.2609)	2.30726 (0.5111)	8.369742 (0.0582417)
Oil	1.1265 (0.2600)	0.4485 (0.6538)	0.3311 (0.7406)	1.3004 (6.7290)	

From the results of Asymetric and sign bias tests we observe that the null hypothesis of constant conditional correlation (CCC) cannot be rejected as all the series show probability values greater than 0.05 as evidence in Yaya *et al.* (2016); Uzonwanne (2021); Tule *et al.* (2018). Turning to the bias tests, we observe that the null hypothesis of symmetry was not rejected for the series except, for agriculture, construction/real estate, ICT. This means that negative news (unexpected price increases), has the ability to increase volatility in these sectors than positive news.

CCC VARMA (A) GARCH Results

Overall, forty-four MGARCH models were estimated for oil and the eleven sectors, including CC-VARMA-GARCH, Asymmetric CCC-VARMA-GARCH, DCC-VARMA-GARCH and the Asymmetric DCC-VARMA-GARCH i.e., 4 × 1 pairs (oil with each of the eleven stock sectors totaling 44 models).

Based on the result of the Engle-Sheppard χ^2 and the sign and size biased tests, the CCC- VARMA-A-GARCH model is chosen as the best among the estimated models for oil-agriculture, oil-Construction and Real estate, and Oil-ICT Nexus, while the symmetric version, the CCC-VARMA-GARCH is estimated for the remaining pairs of oil-conglomerates, oil-consumer goods, oil-financial services, oil-health care, oil-industrial goods, oil-natural resources, oil-oiland gas and oil-services. The result is presented on table 4.

Table 4. *CCC-VARMA–(A) GARCH MODEL RESULTS*

Mean Equation												
Parameters→ Variables↓	**Oil-Agriculture Coef.**	**PV**	**Oil Conglomerates Coef.**	**PV**	**OilConstruction and Real Estate Coef.**	**PV**	**Oil-Consumer Goods Coef.**	**PV**	**Oil-Financial Services Coef.**	**PV**	**Oil-Health care Coef.**	**PV**
φ_{oil}	**0.043**	0.000	**0.289**	0.000	**0.057**	0.000	**0.027**	0.000	-0.021	0.110	0.029	0.080
φ_{s}	**0.091**	0.000	**0.008**	0.000	**-0.017**	0.000	**0.022**	0.000	**0.317**	0.000	**-0.020**	0.000
φ_{oil^s}	**0.029**	0.000	**0.002**	0.000	**-0.011**	0.000	**0.034**	0.000	**0.013**	0.000	**-0.009**	0.000
$\varphi_{s^{oil}}$	**0.113**	0.000	**0.065**	0.000	**0.148**	0.000	**0.150**	0.000	**0.272**	0.000	**0.049**	0.000
Variance Equation												
ω_{oil}	0.000	0.099	0.000	0.091	0.000	0.066	0.000	0.089	0.000	0.811	8.056	0.176
ω_{s}	0.000	0.100	0.000	0.100	0.000	0.075	0.000	0.116	0.000	0.916	1.644	0.086
λ_{oil}	**0.033**	0.000	**0.100**	0.000	**0.014**	0.000	**0.110**	0.000	**0.108**	0.000	**0.107**	0.000
λ_{s}	**0.911**	0.000	**0.135**	0.000	**0.217**	0.000	**0.116**	0.000	**0.126**	0.000	**0.081**	0.000
λ_{oil^s}	**0.029**	0.000	**0.033**	0.000	**0.021**	0.000	-0.007	0.175	**-0.003**	0.000	-6.995	0.071
$\lambda_{s^{oil}}$	**0.290**	0.000	**0.045**	0.000	**0.108**	0.000	**0.002**	0.000	**0.010**	0.000	**0.020**	0.000
β_{oil}	**0.893**	0.000	**0.846**	0.000	**0.898**	0.000	**0.686**	0.000	**0.885**	0.000	**0.879**	0.000
β_{s}	**0.045**	0.000	**0.365**	0.000	**0.406**	0.000	**0.221**	0.000	**-0.049**	0.000	**0.859**	0.000
β_{oil^s}	**0.064**	0.000	**5.794**	0.000	**0.700**	0.000	**23.429**	0.000	-0.098	0.099	**0.453**	0.000
$\beta_{s^{oil}}$	**0.017**	0.000	**5.165**	0.000	**1.356**	0.000	**17.587**	0.000	0.019	0.076	**0.256**	0.000
Leverage Effects												
$\emptyset_{oil}$	0.456	0.000	x		0.127	0.000	x		x		x	
$\emptyset_{s}$	0.073	0.000	x		0.849	0.000	x		x		x	
CCC												
ρ^{so}	-0.000		0.015		0.060		0.015		-0.002		0.040	
Residual Diagnostics												
Ljung-Box (PV)	0.4068		0.5142		0.1890		0.6281		0.6034		0.4464	
Mcleoid–Li (PV)	0.2713		0.1287		0.2143		0.4887		0.1272		0.0908	
Vol Persistence (oil)	0.92		0.94		0.91		0.80		0.99		0.93	
VolPersistence (stock)	1.33		0.50		0.62		0.33		0.08		0.94	

Table 5. *CCC-VARMA–(A) GARCH MODEL RESULTS*

Mean Equation										
Parameters→ Variables↓	**Oil-ICT Coef.**	**PV**	**Oil-Industrial Goods Coef.**	**PV**	**Oil Natural resources Coef.**	**PV**	**Oil- Oil and Gas Coef.**	**PV**	**Oil-Services Coef.**	**PV**
φ_{oil}	**0.035**	0.000	-0.03		**-528**	0.000	0.032		**-0.014**	0.000
φ_{s}	**-0.005**	0.000	**0.044**	0.000	**0.046**	0.000	-0.004		**0.050**	0.000

$\boldsymbol{\varphi_{oil^s}}$	**-0.005**	0.000	**0.007**	0.000	**0.012**	0.000	**0.038**	0.000	**0.028**	0.000
$\boldsymbol{\varphi_{s^{oil}}}$	**-0.004**	0.000	**0.040**	0.000	-0.074		**0.043**	0.000	**0.070**	0.000
Variance Equation										
$\boldsymbol{\omega_{oil}}$	1.119	0.060	-0.000	0.081	1.059	0.065	0.000	0.150	0.000	0.100
$\boldsymbol{\omega_s}$	2.378	0.070	0.000	0.910	1.975	0.095	0.000	0.151	0.118	0.651
$\boldsymbol{\lambda_{oil}}$	**0.034**	0.000	**0.109**	0.000	**0.110**	0.000	**0.108**	0.000	**0.003**	0.000
$\boldsymbol{\lambda_s}$	**1.686**	0.000	**0.297**	0.000	**0.041**	0.000	**1.329**	0.000	**0.003**	0.000
$\boldsymbol{\lambda_{oil^s}}$	**1.412**	0.000	**-0.031**	0.000	**-4.914**	0.000	**-0.015**	0.000	**-0.080**	0.000
$\boldsymbol{\lambda_{s^{oil}}}$	**-0.050**	0.000	**0.055**	0.000	**-0.127**	0.000	-0.001	0.000	**-0.011**	0.000
$\boldsymbol{\beta_{oil}}$	**0.899**	0.000	**0.842**	0.000	**0.885**	0.000	**0.879**	0.000	**0.869**	0.000
$\boldsymbol{\beta_s}$	**0.423**	0.000	**0.179**	0.000	**0.074**	0.000	**0.008**	0.000	**0.816**	0.000
$\boldsymbol{\beta_{oil^s}}$	0.038	0.100	**14.080**	0.000	**-0.010**	0.000	**0.127**	0.000	**1.361**	0.000
$\boldsymbol{\beta_{s^{oil}}}$	**0.012**	0.000	**18.372**	0.000	**-0.052**	0.000	0.000	0.100	**0.036**	0.000
Leverage Effects										
$\emptyset_{oil}$	0.106	0.000	x		x		x		x	
$\emptyset_s$	-0.088	0.000	x		x		x		x	
CCC										
$\boldsymbol{\rho^{so}}$	9.020		0.007		0.037		0.019		0.006	
Residual Diagnostics										
Ljung-Box (PV)	0.5382		0.2689		0.8051		0.4507		0.7351	
Mcleoid–Li (PV)	0.2469		0.9397		0.1438		0.1268		0.0549	
Vol Persistence (oil)	0.93		0.95				0.98		0.99	
Vol Persistence (stock)	0.42		0.48				1.33		0.81	

Source: *Author's Computation based on Oxmetrics and RATS Output*

Conditional Return (mean equation)
Evidence from the mean (return) equation from table 5 show that lagged returns are included in the conditional mean equation, the purpose and reason for which is to remove serial correlation and to ensure that spillover effects are not mistaken for serial dependence. This is in line with Tule *et al.* (2018, 2017); Uzonwanne (2021); Yousuf (2020) among others. It is observed that own lagged returns are statistically significance and positive for most of the sector stocks except few. For instance, the lagged return for the pair of agricultures, conglomerates, consumer goods, health care, natural resources and services were positive, but not significant while that of Construction and real Estate, financial services ICT, Industrial goods, Oil and Gas were all statistically significant indicating evidence of short-term predictability in prices for these sectors. Own lagged returns for oil in the oil-stock pain was statistically significant for the sectors except oil-conglomerates, oil consumer goods and oil Health care.

Turning to the return cross effects, we observe positive and significant return spillover from some stock sectors to oil. For example, the return spillover from agriculture sector to oil is significant at 0.0000; Construction and real estate significant at 0.0000, Consumer goods (0.0000) Financial services (0.0000) ICT (0.0000) Natural Resources (0.0000) oil and gas (0.0000) and services at 0.0000.

Results from the return (mean)equation also reveal high return spillovers from the oil to stock sectors except conglomerates whose return is positive, though not significant. For instance, the return spillover from oil market to agriculture sector -0.1135, Construction and real estate at

0.148099. We can infer from the result that the highest return spillover is from the oil market of 0.272896 is to financial services sector, while the lease (lowest) return spillover from oil of 4.146E-03 is to information and communication technology; ICT sector.

Conditional Variance Equation

Estimated results of the conditional variance equation is as reported on table 5 a and b above. Results show that the coefficients of Autoregressive conditional heteroeadoshaty (ARCH) and the generalized autoregressive conditional heterecasdesticity (GARCH) are all significant for the eleven sectors. Similar to the work of Umm & Zatang (2020), evidence further indicates current volatility of sectorial returns depends on their past shocks and past conditional volatility. For instance, the conditional volatility of agriculture sector depends strongly on its own past unexpected shock (λ_s) and own past volatility (β_s) all at significant levels.

The volatility of all the stock sectors depends on their own lag shocks (ARCH) and lag volatility (GARCH) going by their significant coefficient values. For instance, the own ARCH effect of natural resources is 0.2419, while its response to own volatility is about 0.7431. For financial services, its own short term shock effect is 0.1265 while its own volatility is low at -0.0492, though significant indicating it's non-sensitivity to own volatility. Overall, it can be observed that the highest own shock (ARCH) is absorbed by the oil and gas sector followed by the agriculture sector, with the ICT sector absorbing the least indicating that volatility of the ICT is not driven by its own shocks. For the GARCH effects we observe that the services sector volatility is heavily driven by its own volatility at 0.01604 with low ARCH effects; the conglomerates, construction, and natural resources and ICT sectors are all driven by their own volatility or GARCH effects going by the magnitudes.

Turning to the volatility of brent oil, we observe that it's estimated coefficient values of ARCH coefficients are very though significant, while the long term volatility or GARCH coefficients are very high and significant in all the oil – stock pairs. This indicates that unexpected stocks in the oil market have little effect on the volatility is driven more by its own volatility. Volatility in the oil returns ranges from 0.68% to about 0.9% in different pairs of oil – stocks sectors with the highest been that of ICT sector at 0.9% and the lowest 0.68% for the oil consumer goods sector. Turning to the cross effects, we observe cross spillover among oil stock pairs. For instance, the shock spillover from stock sectors to oil ($\lambda_{oil,s}$) is significant for agriculture and oil and gas sectors only, while for the remaining nine sector, it's not significant.

For instance, the shock spillover from agriculture to oil is about 0.29% while for oil and gas rector, its negligible at less than one percent. The shock spillover from oil to each of the rectors is however significant for all oil-stock pairs as expected. The highest shock spillover from oil of 0.29% goes to the agriculture rector while the services sector has the least. For the long term (volatility spillover effects, we observe volatility spillover from stock sectors to oil market, though surprisingly. The volatility spillover from conglomerates as consumer goods to oil show high values while the least is from natural resources. Conversely, the volatility spillover from oil to each of the sector show significant values in all sectors. High values are observed from oil to conglomerates, constructions and real estate, industrial goods and health care result indicates bidirectional volatility spillovers between oil-stock repairs. Concerning the asymmetric effects, we observe that the coefficient of leverage (asymmetry) is significant for crude oil returns among the three oil-stock parts. In a similar view, asymmetric coefficient is significant and positive for agriculture and construction sectors and negative for the ICT sect

Conditional Co-variance Equation

Results reveal that the CCC estimate for all the oil-shock, thereby validating an assumption of constant correction among and between the oil-stock pairs. The highest CCC is between construction/real estate this impact is due to the fact this sector is sensitive to oil price changes. Low conditional correction is an indication of the existence of potential gains by investors from investing in both oil and stock markets. These findings can therefore be used to construct portfolio weight and hedge ratios to guide investor and investment decision. The diagnostic tests on table 5 are for remaining ARCH effects and serial correction. Results of the Mcleod-Li test is used to test for the presence of ARCH effect we observe that going by the p values, there are no remaining ARCH effects of our Ljung-Box test show that is no more evidence of serial correction the returns series.

Discussions of Findings

Following is the discussion of findings from the results. From the return (mean) equation results, the parameters of interest are φoil^{s}, and φ_s^{oil} the return spillover effects between oil market and the sector returns, nonetheless, as is conventional with financial times series of high frequency dimension, we include own lagged returns φoil, and $\varphi_s$in the conditional return (mean) equations to make sure that spillover effects are not mistaken or confused for serial dependence. Salisu (2019); Yaya *et al.* (2016), Tule *et al.* (2018). Results from table 5 shows that own lagged oil returns for the oil stock pairs are statistically significant for oil-agric, oil-construction, oil-financial services, oil-ict, oil-natural resources, and oil-services pairs. This indicates that investors take into consideration the immediate past information of individual market returns in their investment decision making process. However, the own lagged oil returns do not have any significantly effect on the remaining oil-stock pairs for oil-conglomerates, oil-consumer goods, oil-healthcare, oil-industrial goods and oil-oil/gas pairs which means that immediate past returns have no effect on investment behaviour at present.

Turning to the industrial sectors, we observe significant effect of own lagged returns on current returns in construction/real estate, financial services, ICT, industrial goods, and oil and gas sectors indicating that the present returns on these sectors can be predicted based on their past returns. This is in line with Abdalla (2014); Abeng (2017). This also means that returns are predicted from past realizations and thus are not informationally efficient according to the weak-form efficient market hypothesis as evidenced in the works of Elder & Serlites (2008); Arouri *et al.* (2011) However, the own past returns on the remaining sectors are not statistically significant, going by their probability values. The results of the main equation also indicate evidence of short term price predictability in sector price changes which is consistent with existing literature; Arouri & Nguyen (2010); Arourietal (2012); Malik & Rashid (2017). This means that returns in these sectors can be predicted using the immediate previous returns Regarding to return spillover effects, we observe significant returns spillover from each of the sector indices to oil market for agriculture, construction, consumer goods, financial services, ICT, natural resources, oil and gas and the services sector. This means that the returns in the oil market are influenced by the returns in these sectors, though magnitudes of the estimated parameters are very low suggesting very weak spillovers. The return spillover from conglomerates Health care, Industrial goods however, does not have any significant effect on oil market returns going by the respective probability values. These findings suggest that a boom in the Nigerian stock market may lead to increase in return in the oil market. This also gives a signal to investors, to plan their investment decisions ahead.

In the same vein, the return spillover from oil market to the sector stock indices indicates significant results. This means that the return on investment on the oil market significantly affect the returns on the sector on the Nigerian stock market. Very significant values are for specific sectors such as agriculture, consumer goods, financial services and construction and real estate. For instance, a one unit change in returns in the oil market will cause the financial service sector return to rise by about .03%, while that of the consumer goods is 0.2%. This result is not however surprising due to the reliance of these stocks on oil. Also, sector stock returns can be predicted by looking at the returns in the oil market going by the results we have seen. We now turn to the results of the variance equation. From the table 5, we observe that the estimated values of the ARCH and GACH coefficients (short and long term distortions) are all significant for the brent oil in all the oil-stock pairs. This indicates that volatility of the oil market is driven by its own stock and volatility. Volatility persistence is very high for the oil market compared to the stock market. This suggests that future volatility in the oil market can be predicted from its past volatility up to about 0.98%. This is in line with Kalu (2015); Malik & Rashid (2017); Unm & Zhang (2020). For the volatility of the stock sectors are fueled by their own stocks (ARCH) in all sectors with the highest been agriculture 0.91%, oil and gas over 1% industrial goods 0.29% etc. Also, the sectors respond significantly to own volatility or (GARCH) effects, though with low GARCH estimates. This means that sudden fall and rise in prices (price fluctuations) responds to the immediate past fluctuations in the previous period. Conversely, it can be seen that volatility of the stock market as represented by their sectors is influenced more by their own price distortions than their long term volatility because the ARCH (short term) effects are far larger than the GARCH (long term) effects, This further suggests that investors, fund managers, portfolio advisors take into account, long term effects of price movements when making investment decisions rather than short term effects.

Turning to interdependence of shocks, we observe significant short term shock spillover from agriculture, oil and gas sector to oil market. This indicates that a shock (unexpected short term price movements) originating from these two sectors have the ability to affect a shock in the oil market. However, the coefficients are very low at 0.2% for agriculture and less than 0.01% for oil and gas. The shock spillover from the other sectors to the oil market is however not significant. It means therefore that in the short run, the oil market has in place strategies to withstand any shock from the Nigerian stock market. Conversely, the short term spillover from oil to the sectors is significant for 8 out of the 11 sectors of agriculture, construction/real estates, financial services, healthcare, ICT, natural resources, and services. A shock originating from oil market has the potential to cause a shock in these sectors. This means that an unexpected price movement in the oil market will elicit a corresponding sudden price change in these sectors. This conforms to Arouri *et al.* (2011); Lin *et al.* (2014). For example, a shock in oil price will cause the agriculture sector to move by about 0.29%.

However, we observe that the short term shock spillover from the oil market to the conglomerates, consumer goods, industrial goods and the oil and gas sectors is not statically significant. In other words, these four sectors in the short term are not responding to shocks originating from the oil market. We therefore observe bidirectional shock spillovers between oil and agriculture sector, no shock spillover between oil and conglomerates sector, unidirectional spillover from oil to construction and real estate sector, no shock spillover between oil and consumer goods sector, uni-directional spillover from oil to financial services sector, oil and health care sector, oil and ICT sector, oil and natural resources sector, oil and services, unidirectional shock spillover from oil to oil and gas and no shock spillover between oil and industrial goods. Turning our focus to long term spillovers, among the oil-stock nexus, we observe bi-directional spillover between oil and agriculture, oil and conglomerates, oil and construction, oil and consumer goods, oil and healthcare, oil and industrial goods, oil and natural resources and oil and gas and oil and services. This indicates that unexpected sudden long term price movements from the oil market affect those of the stock sectors and vice versa. This is in line with Arouri *et al.* (2011). Unidirectional volatility spillover is observed from oil to ICT, while there is a volatility spillover between oil and financial services.

The long term volatility spillover from conglomerates, consumer goods, industrial goods and services to oil indicates high significant values. This indicates that volatility in the oil market is fueled by the volatility originating from the stock market in those sectors. For instance, a 1% volatility in the stock market (conglomerates) cause the oil market to move by about 0.57%. This can be explained by the fact that a boom in the stock market will elicit demand for output, which will lead to increase demand for input (oil) will ultimately, put pressure on the demand for crude oil, thereby causing a shock in the market. Also considering the fact that Nigeria is one of the leads of oil producers in the world; this result is not surprising. Overall, the vol. spillover from the stock sector appears significantly across sectors.

Apart from the financial services sector the long term, volatility spillover from the oil market to the ten (10) sectors show significantly estimates with the most significant being conglomerates 5.1%, construction/real estate 1.35%, health care 0.25%, industrial goods 1.83% and services 0.36%. A 1% volatility in the oil market will cause the conglomerates sector to move in the same direction by 5.1%, construction sector by 1.35%, healthcare 0.28%, and industrial goods 18.3%. This is the suggestive of the fact that these sectors reliance on oil is high. This agrees with results from Lin *et al.* (2014); Arouri *et al.* (2012).

These high figures are evidence of the fact that that as indicated in Arouri *et al.* (2012). Rising financial stock priceis often indicative of high oil consumption occasioned by increased productive activities. These results are therefore indicative of the fact that individual investors, portfolios managers and investment analyst take into their account volatility spillovers in their decision-making process as to mitigate risk and uncertainty involved in investing in financial assets. The coefficient of asymmetry or the leverage effect is as reported on table 5. The parameters of oil are all statistically significant for the three oil-stock pairs for agriculture, construction and real estate and the ICT sectors. This shows that increases in oil prices tend to increase its volatility up to about 0.13% for agriculture, construction and the ICT sectors. In a similar vein for the stock sectors, asymmetric coefficients are significant for three sectors. For instance, the leverage effect is very high for construction of real estate at 0.85% which indicates that negative unexpected shock (increases in oil prices) has the ability to increase volatility of this sector by 0.85% as compares to a positive shock. This aligns with Malik & Rashid (2017).

The result of constant conditional correlation (CCC) as reported on table 5 indicates low positive coefficients upholding the use of the CCC model. Low CCC values indicate that investors can invest in oil and stock markets at the same time. This contrasts the findings of Kalu (2015) but it's in line with Rashid & Malik (2017). Nest is the analysis of long run shock persistence. Result of the long run persistence of shock to the oil and stock market indicate that shock to the stock market in sector such as financial service, conglomerate of consumer goods seems to dissipate after a short while. The persistence estimates for the remaining sectors are however, high. As a whole volatility tends to revert to it mean in the sectors except agriculture and oil and gas where the persistence estimate is above 1 in which case policy action must be taken to correct this. For the oil market, volatility persistence is high though less than 1 implying slow reversion to mean.

Tests of Hypotheses

The hypotheses of this study are tested based on the probability values of coefficients. The decision rule is that p probability value of less than 0.05 indicates that the coefficient is significant while those above 0.05 indicates insignificant values. The result of the CCC –VARMA-GARCH model is used for this purpose.

Hypothesis One

The return spillover from oil to sector specific indices on the Nigerian exchange limited is not significant: From the result on table 5, we observe that the return spillover effects from oil to the eleven industrial sectors are all significant except the conglomerates sector whose probability value is above the threshold of 0.05. We therefore, reject the hypothesis and conclude emphatically that the return spillover from oil to industrial sectors on the Ngx are significant except the conglomerates rector in which case, the hypothesis is accepted.

Hypothesis Two

There is no significant return spillover from sector specific stocks on the ngx to oil prices. From the results reported on table 5, we notice that the return spillover from the stock sectors, agriculture, construction, consumer goods, financial services ICT, natural resources, oil &gas as services to oil are significant going by their probability values, while the return spillover from conglomerates, health care and industrial goods to oil is not significant. The hypothesis is accepted for conglomerates, health care and industrial goods, and rejected for the rest.

Hypothesis Three

The volatility spillover effects from oil to sector specific stock returns on the ngx is not significant. Based on our bench mark results, we can observe that all the prob. Values from the estimated results are significant, we can therefore reject the hypothesis and conclude that the volatility spillover from oil to each of the eleven industries sectors is significant.

Hypothesis Four

The volatility spillover for sector specific returns on the ngx to oil is not significant. Also, from the results of the estimated coefficient, we observe that the probability values for the industrial sectors are significant except for financial services and the ICT sectors. We therefore, reject the hypothesis and conclude that the volatility spillover from sector specific returns to oil is significant, except for financial services and the ICT sector in which case, the hypothesis is accepted.

Hypothesis Five

There is no conditional correlation between oil market and each of the sectors on the ngx from the result of the Constant Conditional Correlation (CCC) estimates, we observe that the correlation between oil market and the each of the industrial sectors is significant for all the sectors except the agriculture sector. We therefore, reject the hypothesis and conclude that conditional correction between oil market and each of the sectors on the ngx are significant except for agriculture where the hypothesis is accepted.

SUMMARY, CONCLUSION AND RECOMMENDATIONS

Summary

The study investigates the impact of oil prices on sector-specific stock returns indices on the Nigeria Exchange Group (NGX) using a disaggregated approach. It aims to assess the effects of return spillover from oil prices to sector-specific stocks, volatility spillover from oil prices to sector-specific stocks, and the conditional correlation between oil prices and each stock sector on the NGX. Data from 2011 to 2022 was sourced on Brent oil price and eleven stock sectors.

The study conducted descriptive statistics on twelve variables, revealing non-normality and high volatility, particularly in oil prices. Return series showed kurtosis above the normal threshold, indicating leptokurtic behavior. Time plots were used to confirm historical properties and confirm descriptive statistics. Results showed that oil and stocks tend to move in the same direction, indicating non-stationary behavior in most sectors.

The study found that the return series plots on variables showed volatility, confirming ARCH effects and indicating volatility clustering. Despite using only return series for estimation, the study also conducted a stationarity test to uncover the unit root properties of the variables, indicating series stationarity at first difference.

The study used the Engle ARCH/LM test and Ljung-Box test to analyze ARCH effects and serial correlations. Results showed the CCC variant of GARCH was preferred over the DCC, and the Asymmetric GARCH was preferred in agriculture, construction, real estate, and ICT sectors, while the remaining sectors were symmetric.

The study used the asymmetric CCC VARMA GARCH for estimating parameters in agric, construction, and ICT sectors, and the symmetric version for remaining sectors. The return equation showed significant and positive own lagged returns in most sectors.

Short-term predictability was observed in sectors like ICT, oil, and gas, with significant returns spillover from oil to stock sectors and vice versa. The variance equation results showed significant ARCH and GARCH effects for eleven stock sectors, with oil and gas absorbing the highest shocks. Brent oil estimated ARCH and GARCH effects are low and high, respectively.

The study found significant stock spillover from stock to oil for agriculture and oil/gas, while shock spillover from oil to sector is significant for all sectors. Volatility spillover was significant for conglomerates and consumer goods, but not for oil to sectors. CCC estimates showed low values for oil-stock pairs, suggesting potential gains for investors. ARCH/LM and Mcleoid-Li tests showed no remaining ARCH effect or serial correlation.

Conclusion

This study examined effect of return and volatility spillover effects between oil prices and stock return at the disaggregated level in Nigeria using high frequency data. Vector Autoregressive moving average generalized autoregressive conditional heteroscedacity (VARMA-GARCH) was used to estimate the parameters of the model. Based on the results obtained, the various analyses carried out, this study makes here these conclusions as follow:

- That investors' decision to invest their resources in the stock market, represented by different sectors is significantly based or influenced by the benefits they obtain previously.
- Investors look at the signs from the oil market based on the returns, there to expect what will likely happen to their investment.
- Most of the investors who invest in the oil market do not necessarily worry themselves on what happens in the stock market.
- Short term instability in oil market will affect investors in the capital market very significantly. However, if short term instability in stock market will not cause any worry to those investing in oil market.
- Instability in the oil market that lasts longer than necessary will affect investors who invest in the capital market as this will affect their returns or profits, they intend to earn.

Recommendations

This study examined the effects of return and volatility spillover between oil prices and sector stock returns in Nigeria. Based on the results, findings and the conclusion, the study recommends as follows:

- Investors, fund managers, portfolio managers should build accurate asset pricing and forecasts of the return from both oil and stock.
- Investors should regulate their actions to avoid risk in the events of market shocks.
- Investors, policy makers should continually monitor return in both markets in order to predict and forecast prices in the short term as to minimize shocks.
- Investors, portfolio managers also should factor into their decision making own short term (ARCH) and long term (GARCH) effects to minimize risks associated with their investment.
- Because of the high level of volatility persistence, investors should construct portfolio weights and hedge ratios to minimize risks without affecting gains.
- Investors should invest simultaneously in both oil and stock sectors with the aim of getting higher returns because of the low conditional correlations.
- Policy makers should adopt policies for very high oil dependent firms to source for alternative source of inputs in their production activities.

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