Oil Price, Exchange Rate and Stock Market Performance in Nigeria

Adenekan, A. T., Hilili, M. J. and Okereke, A. N.*

Abstract
This study examined the nexus among oil price, exchange rate and stock market performance, using the VAR based technique. The Johansen cointegration test revealed the absence of long-run relationship among the variables. The Granger causality tests showed a unidirectional relationship running from crude oil price to shares and bidirectional relationship between crude oil price and exchange rate. Shocks to crude oil market had a positive impact on shares in the first two periods, but very minimal beyond these periods. However, a one standard deviation innovation to exchange rate had negative impact on shares, implying that exchange rate instability may bring about uncertainty in the stock market. In most cases, each variable's own shocks are the major drivers of whatever movements observed in the respective trends in the variable. Findings from the estimations using the volatility series also mimic the results from the return series. The findings imply that there are inherent structural or institutional rigidity in the transmission mechanism of oil price and exchange rate developments to the stock market.

Keywords: Oil Price, Exchange Rate, Stock Performance, Volatilities
JEL Classification: F31, G15, Q43

I. Introduction

This study investigated whether and to what extent the developments in the crude oil and foreign exchange markets influence the stock market performance in Nigeria. This is premised on the notion that any development in the international crude oil market, with its attendant effect on the naira exchange rate, has implications for financial variables, including the stock market. Understanding the interaction among these variables in Nigeria is particularly important because of the role of the stock market in accelerating economic growth. The stock market serves as a transmission channel where savings are effectively channeled to various economic sectors in the economy. It provides investors with the needed access to a variety of investment opportunities and the necessary support and platform that facilitate the effective allocation of capital for long-term productive investments, thus enhancing the prospects of long-term economic growth.

Nigeria relies heavily on oil export as a major source of foreign exchange earnings required to defend the domestic currency, hence, any adverse development in the international crude oil market and its attendant effect on

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exchange rate portends adverse implication for the stock market. As noted in Jones, Leiby and Paik (2004), the effect of oil price shocks on the stock market is a meaningful and useful measure of their economic impact, given that stock values ideally reflect the market's best estimate of the future profitability of firms. Moreover, since asset prices are the present discounted value of the future net earnings of firms, both the current and the expected future impacts of an oil price shock should be absorbed fairly quickly into stock prices and returns, without having to wait for those impacts to actually occur.

The effect of oil price volatility on the economy is still unsettled, just as the type and direction of the relationship between the movements in the financial variable and oil prices is yet to attain a consensus in the literature. By the same token, the impact of oil price volatility on stock market performance is also unclear. Thus, the link among these variables continues to be of interest to researchers, market actors and policy makers.

The broad objective of this paper, therefore, is to examine the short- and long-run relationships among the returns as well as volatilities of these variables. The focus on the volatilities is particularly motivated by the understanding that the return series, for example, a depreciation or appreciation of a currency, or of a stock, by itself may not necessarily matter much, given that it could be easily factored in investment decisions. However, it is the unpredictability (uncertainties) associated with the movements in these variables that may adversely impact investment decisions.

The study is structured into five sections, including this introduction. Section two contains the review of related literature, while section three discusses the summary statistics and trend analysis of the series under study. In section four, the model specification, estimations, results and interpretations are presented, while section five contains the concluding remarks.

II. Literature Review

II.1 Theoretical Review

Oil price changes affects numerous economic variables such as interest rates, investment decisions, economic growth, investors' confidence etc. these variables have been documented to affect both the stock market and exchange rate market (Hamilton, 1983; Amano & Van Norden, 1995). Again, oil prices are expressed in US dollars in the international market; hence, the dollar exchange rate may affect the price perceived by oil producing nations

(Roubaud & Arouri, 2018).

This study reviews the connection between these variables (Oil price, exchange rate and stock market) using a bivariate and multivariate approach. To some economists, there is a positive correlation between crude oil price and stock market performance (Cong, Weiy, Jiao & Fan, 2008; Boyer & Filion, 2007; Sadorsky, 2001; El-sharif, Brown, Burton, Nixon, & Russel, 2005). For example, when aggregate supply of oil is greater than the demand, price drops. The decline in oil price causes a weigh down in the stock prices. The assertion is such that a typical price of crude is exogenously determined; hence, the movement in stock price follows that of crude prices. As price drops, economic agents are concerned about deflation, which is, actually, an unusual phenomenon, since what is usually observed in an economy is inflation. Stock markets perceive a sustained drop in oil price as a measure of deflation, which could cause general downward trend in the prices of consumer and capital goods, and ultimately causing the stock market to go down. Thus, low price of crude oil and the crash in the domestic market give concern to investors and vice versa.

Another school of thought suggests that low oil price is indeed good for the economy, including the capital market, and by this same token, rising crude oil price can have adverse impact on the stock market. This is so because rising oil price have inflationary effect that would be worrisome to the investors given that this would reflect in the corporate earnings. Such development could rattle stock market, since corporate earnings are the life bird of the market. Thus, the adverse implication of higher oil price in corporate earnings is a threat to the stock market. The implication is such that while the price of crude can generate short-term bullish effect, its long-run impact is bearish when the adverse impact sets in. It should also be noted that when the effect of crude price is decomposed by the upstream and downstream sector, the effect is different. With a rise in crude price, for example, firms in the upstream sector will make more profit. The downstream however, is adversely affected because of the attendant higher cost. To the extent that the downstream companies have more impact on consumer and business sub-sector, the ultimate effect may be bad for the market and company earnings being adversely affected.

II.1.1 Oil Price and Exchange Rate

Theories generally contend that crude oil price and exchange rate are positively correlated for oil exporting countries. That is, higher crude oil price will lead to currency appreciation in oil exporting countries and vice versa. Crude oil price shocks transmit to exchange rate through two channels. The first is the terms of trade channel, whereby negative terms of trade shock drive the price of non-tradable in the domestic economy, causing the real exchange rate in oil exporting economy to depreciate and vice versa. Secondly, the wealth effect channel through which a drop in crude price for example, leads to losses to oil exporters, but gains to the oil importer. This results in a shift in current account balances and portfolio reallocation between both oil trading companies. By implication, a negative oil price shock transforms wealth from oil exporter to oil importer or higher oil prices leads to high cost of production and the attendant higher inflation which leads to the contractionary effect on economy and trade balances. To restore or improve trade balance, the exchange rate has to adjust. It is important to note that the impact or relationship between exchange rate and oil price may vary in advanced vis-a-vis, emerging developing market economies.

II.1.2 Exchange Rate and Stock Returns

The relationship between the movement of exchange rate and stock returns could be explained with several perspectives. The flow-oriented model of exchange rate behaviour posits that depreciation in exchange rate for instance would lead to improved trade balance as exports become cheaper. This would result in upward shift in aggregate demand (AD), hence overall expansion in real gross domestic product with the attendant positive effect in stock market performance. The stock-oriented model, on the other hand, emphasises the role of capital account in the determination of a country's exchange rate. In this theory, exchange rate equates the demand and supply of financial assets (stock and bonds). Thus, expectation of future exchange rates affects the current price of financial markets. From another perspective, however, the arbitrage price theory argued that a rise in real interest rate will reduce the present value (PV) of the future cash flow. Consequently, stock returns will fall. This is because as the real interest rate rises, capital flows increase, causing the domestic currency to appreciate. This will in turn lead to a fall in stock returns.

II.1.3 Oil Price and Stock Prices

Oil price may impact stock performance through a number of channels such as uncertainty, fiscal, output and stock variation channels (Degiannakis, Filis & Arora, 2018). Oil price is susceptible to high volatility due to supply shocks and therefore, the risk of uncertainties occasioned by oil price volatility usually affect investors' portfolio, particularly, portfolio managers seeking to make optimal portfolio allocations (Arouri, 2011a, b, c); cited in Salisu and Oloko (2015). Also, Uncertainty channels views explain that rising crude oil prices heightens uncertainty in the real economy (firms and households) due to its effect on inflation, consumption and output (Brown & Yucel, 2002). For a firm, it tends to reduce the demand for irreversible investment and consequently, expected cash flow declines. On the household, increased uncertainty, resulting from higher cost of crude oil also increases the households' ability to save rather than consume. Given the above, the value of postponing investment and consumption decisions rises and hence, economic growth and stock market returns stifles.

Oil prices also impact stock performance through a more direct channel—that is, the stock variation channel. The nexus suggests that stock returns are impacted by factors that can alter expected cash flows and discount rates. However, this depends on whether the firm is an oil user or oil producer. Given that oil is a major production factor, any increase in oil price will result in an increased production cost (assuming a case of absence of substitution effect between production factors). This leads to reduced profit levels and also future cash flows. For the oil producer, increase in crude oil prices results in increased profit margins and thus, increased future cash flows (Basher & Sadorsky, 2006). Furthermore, higher interest rate response by the monetary authority to an inflationary pressure from the rising oil prices also affect the discount rate—an important factor in stock price formulation (Basher, Haug & Sardosky, 2012).

II.2 Empirical Review

The dynamic relationship among macroeconomic variables has attracted the attention of researchers and policy makers the world over. The empirical literature on oil prices, exchange rate and stock market is wide-ranging, covering studies on both advanced and developing economies, including Nigeria. Findings from these studies are mixed, due largely to differences in methodologies and heterogeneous economic fundamentals of the economies examined. For instance, empirical studies that found evidence of a relationship between oil price movements and stock prices or its volatilities include (Guo, 2002; Anoruo & Mustafa, 2007; Sadorsky, 2008; Aloui & Jammazi, 2009). To most, crude prices and stock market returns are co-integrated, rather than segmented, indicating causality that runs from stock market to oil market but not vice versa. As a corollary to the foregoing, market commentators and journalists like to draw direct lines between the behaviour of crude oil prices and market behaviour on a given day, with such headlines as "oil spike pummels stock market" or U.S stocks rally as oil prices fall" (Pescatori &Mowry, 2008). Papapetrou (2001), and Masih, Peters and De Mello (2011) also supported the argument that oil prices are important in explaining stock price movements.

Another area of concern about oil price volatility is the fact that changes in oil prices strongly predict future stock market returns in many countries of the world. Driesprong et al. (2003) in their study found a statistically significant predictability in 12 out of 18 countries and in a world market index. Similarly, Arouri and Rault (2010) study indicated that stock market returns significantly react to oil price changes in some Gulf Corporation Council (GCC) countries, thus providing evidence of a relationship between oil price volatility and stock market performance (see also, Jawadi & Leoni, 2008; Arouri & Rault, 2009). In a study conducted by Hwang (2011), the findings show that oil price and industrial production shocks explain significant portion of the fluctuations in stock price movement.

Also, in examining the dynamic relationship between oil price, exchange rate and emerging stock market using the structural Vector Autoregression (SVAR) model, Basher et al. (2012) found that positive shocks to oil prices tend to depress emerging market stock prices and the US dollar exchange rates in the short-run. The study also found evidence that increase in emerging market stock prices increase oil prices. Another study was carried out by Siddiqui (2014) on the impact of international oil price fluctuation on the performance of stock markets in Pakistan using the OLS method and KSE-100, oil price, exchange rate and foreign private portfolio investment as variables. The results showed that KSE-100 index, oil prices, exchange rate and foreign private portfolio investment had positive correlation with stock market performance.

Salisu and Oloko (2015) employed a vector autoregressive moving average-asymmetric generalized conditional heteroscedasticity (VARMA-AGARCH) model implemented within the context of BEKK framework to investigate the nexus between oil price and US stock prices. The adopted model, they claimed, allows for the estimation of returns, volatility and shock spillover, as well as the asymmetric effect. It also captures the news effect on own volatility in each market (oil) and how such news may fuel higher (lower) volatility in other market (stock). Their findings supported positive return spillover from the US stock market to oil price, and a bi-directional shock spillover between the two markets. Their findings further substantiated significant own asymmetric shocks in both markets, but no statistically significant evidence of cross-market symmetric effects.

Another study was conducted by Mechri, Ben Hamad, De Peretti and Charfi (2018) on the impact of exchange rate volatilities on stock markets dynamics in Tunisia and Turkey, using the GARCH estimation method. The variables used were stock market price returns, exchange rates, inflation rates, interest rates, gold prices and petrol prices index. The results indicated that exchange rate volatility has a significant effect on stock market fluctuations.

Alzyoud, Wang and Basso (2018) also examined the dynamics of Canadian oil price and its Impact on Exchange Rate and Stock Market performance. The authors adopted the cointegration technique and used stock index, exchange rate, and crude oil price as variables in the study. The findings indicated that oil price, exchange rate, and their variations had a positive and significant impact on the Canadian stock market returns. In contrast, the Filis, Degiannakis and Floros (2011) work on time-varying correlation between stock market prices and oil prices for oil importing and oil-exporting countries, using the DCC-GARCH-GJL approach, showed that oil prices exercise a negative effect in all stock markets, regardless of the origin of the oil price shock.

Also, Delgado, Delgado and Saucedo (2018) in their paper examined the relationship of oil price, exchange rate and stock market index in the Mexican economy. Monthly data covering the period January 1992 - June 2017 and vector autoregressive (VAR) model were used for analysis with oil price, nominal exchange rate, the Mexican stock market index and the consumer price index as variables. The findings showed that exchange rate had a negative significant effect on stock market index, indicating that an appreciation of the exchange rate is related to an increase in the stock market index; oil price had a significant negative effect on exchange rate, showing that an increase in oil prices creates an appreciation of the exchange rate. The consumer price index was seen to have a positive effect on the exchange rate and a negative effect on the stock market index.

Al-hajj, Al-Mulali and Solarin (2018) in their study analyzed the oil price shock and stock market returns nexus for Malaysia, using a Non-linear ARDL approach and oil price, interest rate, exchange rate, industrial production, inflation and stock market returns as variables in the study. Evidence from the non-linear ARDL test indicated that oil price shocks had an adverse impact on the stock market returns. It also showed the presence of long-run asymmetric link between oil price shocks and other variables at both the aggregate and sector level.

Similarly, Bai and koong (2018) examined the time-varying trilateral relationship among oil prices, exchange rate changes and stock market returns in China and the United States. The study adopted the Diagonal BEKK model for the analysis. The results showed the presence of a significant parallel inverse relationship between the US stock market and the dollar and between the China stock market and exchange rate.

These empirical findings notwithstanding, some scholars have maintained that fluctuations in oil prices do not have any relationship with stock market performance. In a study of 22 emerging economies (Nigeria not included), Maghyereh and Al-Kandari (2004) findings implied that oil shocks have no significant impact on stock index returns in emerging economies. Agren (2006) argued that the stock market's own shocks, which are related to other factors of uncertainty than the oil price, are more prominent in explaining stock price movements. Similarly, in Ghana, findings by Adjasi (2009) showed that higher volatility in Cocoa prices and interest rates increased volatility of the stock prices, whilst higher volatility in gold prices, oil prices, and money supply reduced volatility of stock prices.

Other studies, however, found the existence of a weak relationship among the variables. For instance, Sujit and Kumar (2011) evaluated the dynamic relationship among gold price, oil price, exchange rate and stock market returns. The authors used daily data from January 2, 1998 to June 5, 2011, constituting 3,485 observations and adopted the vector autoregressive and cointegration techniques. The results showed that exchange rate was highly affected by changes in the other variables, while stock market plays a minor role in affecting the exchange rate. The study suggested that there is weak long-term relationship among the variables.

Also, Sahu, Bandopadhyay, and Mondal (2015) investigated the dynamic relationships between oil price, exchange rate and the Indian stock market from 1993 – 2013. Results from the Johansen's cointegration test and vector error correction model showed that although there is a long run cointegrating relationships between crude oil price and Indian stock indices, no sufficient evidence existed to conclude that the direction of the relationship in the long-run was from oil price to the Sensex. However, the Granger causality test showed that the volatility of stock prices in India granger caused the movement in oil price and exchange rate in the short-run. The study further showed that the observed relationship between oil price and stock indices was not as a result of exchange rate fluctuations, because the change in exchange rate had no significant impact on oil prices or stock prices in India during the study period.

In Nigeria, attempts have also been made to examine the relationship among oil price, exchange rate and stock market returns. The findings from the study by Fowowe (2013) on the dynamic relationship between oil prices and stock market returns in Nigeria, using the GARCH-Jump model showed the existence of a negative, but insignificant effect of oil prices on stock returns in Nigeria. Using the vector error correction model (VECM) estimation technique, Akinlo, (2014), examined the relationship between changes in oil prices and stock market growth in Nigeria, using annual data series from 1981 to 2011. The study found the existence of long-run cointegrating relationship among oil price, exchange rate and stock market growth, and a unidirectional causality. According to the finding in the paper, however, the impact of oil price on the stock market growth in Nigeria was temporal. Similar findings were also evident in a paper by Ogbulu (2018) on the impact of crude oil price volatility, exchange rate and stock market in Nigeria for the period 1985-2017, using Johansen co-integration tests, ECM and granger causality GARCH (1,1). The results revealed the existence of one long-run dynamic co-integrating relationship among the variables (All-Share Index, crude oil price and exchange rate). The findings also showed that crude oil price significantly impacted on stock market prices.

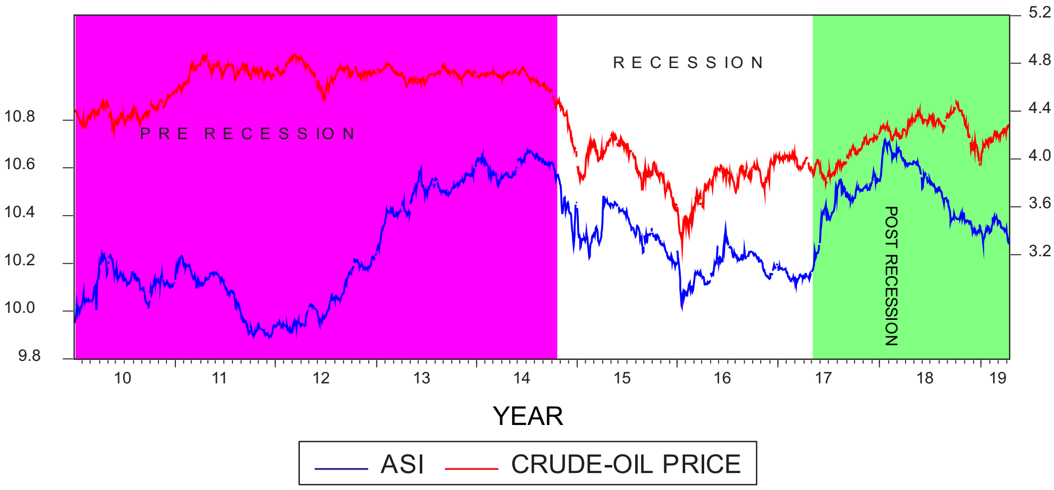
Some studies, however, observed the absence of cointegration between oil price, exchange rate and stock market in Nigeria. For example, Zubair (2013) carried out a study on the causal relationship between stock market index and exchange rate for the period 2001–2011. The study used monthly data on stock market index, exchange rate and broad money supply (M2) as variables, and the Johansen co-integration and Granger-causality as estimation technique. The findings suggested the absence of long-run relationship among the variables before and during the financial crisis. Also, the study found uni-directional causality from M2 to ASI before the crisis, but the absence of causality between the variables during crisis. Also, Raheem and Adebiyi (2016) examined the dynamic effects of oil price shock and exchange rate on the Nigeria stock market, using monthly data series from June 1999-December 2014. Their findings from Vector Autoregression (VAR) estimation showed that oil price, exchange rate and stock market are not co-integrated. In light of the mixed outcomes with respect to the investigation on the relationship among the variables, this study endeavors to explore further on the interaction among these variables. We not only examine their return series, but also consider the series' volatilities to determine if the relationship would be more discernible.

III. Trend Analysis of Oil Price and Stock Performance

As depicted in Figure 1, before 2012, the movement of crude oil price and ASI was to an extent inconsistent. Specifically, it was observed that as crude oil price increases stock behaviour was to an extent bearish, indicating that other factors could have predicted movements in stock prices. Again, beyond 2012, but before the 2016 recession, developments in the stock market were mostly bullish, notably from March 2012 through May 2014. Through this period, capital market indicators continued with greater push in the same positive direction, and were sustained through a greater part of the years, except from June to September in 2013, when stock market indices declined due to concerns of the US Federal Reserve adjustment of its quantitative easing policy. These periods also experienced higher and stable crude oil prices and increased economic activities. However, during the recession periods in Nigeria, both the ASI and crude oil prices declined substantially in September 2014 through April 2017.

The capital market experienced gains, such that market was listed among the best performing in the world. Compared with other global indices, the Nigerian stock Exchange (NSE) All Share index (ASI) increased by 47.19 per cent, crossed the 38,000 points to close at 38,016.80 by the end of the year. The key contributors to the upward movement of share prices included: strong corporate earnings by blue chip companies (banks and manufacturers of fast-moving consumer goods) and increased capital inflow and portfolio investments.

Figure 1: Trends in All Share Index and Crude Oil Price



The year 2014 started on a positive note with macroeconomic indicators such as exchange rate staying within projected range. However, activities in the capital market were bearish for most part of the year as foreign investors steadily withdrew from the Nigerian stock market due to the currency risk and the recovery of developed economies; and the effects of the US Federal Reserve adjustment of its quantitative easing policy. The bearish sentiments in the market exacerbated in the second half of 2014 as a result of the global economic recession.

The ASI began to decline consistently in the third quarter as crude oil prices in the international market crashed from US$110 per barrel for Bonny Light to as low US$40 per barrel.

With oil prices remaining depressed and its related pressure on the Naira, the conflict in the Niger Delta region by the militants also heightened, with attacks on oil installations. This led to the loss of about one million barrel of crude oil exports per day. The situation further impacted the stock market performance. Other macroeconomic developments that further contributed to the decline in market performance included: Nigeria's declining foreign reserves and weak corporate earnings. Thus, uncertainty that prevailed in the Nigerian capital market throughout 2014 caused investors to increasingly adopt a 'flight to quality' strategy.

In 2015, the activities in the stock exchange market started on a relatively flat note as the bearish atmosphere that prevailed in 2014 continued. The NSE's flagship index, the NSE ASI, fell by 17.4 per cent, closing at 28,642 points by the end of the year. This was due to a combination of factors which include: political risk, currency volatility, and uncertainty in global crude oil prices. The bearish trend in the Nigerian Stock Market persisted into 2016. In general, the stock market recorded a loss of 16.05 per cent at end-January 2016, representing the highest monthly loss recorded in the year. But in May 2016, activities in the stock market improved with a gain of 0.38 per cent, representing the highest monthly gain recorded in the year. As at December 19, 2016, the market recorded gains of 5.33 per cent. However, the NSE ASI remained in the negative in most trading days of the year. The index recorded an 18.0 per cent Year-to date (YTD) loss as at December19, 2016.

In 2017, the NSE gradually recovered from the macroeconomic overhang of the commodity downturn and economic recession. Activities in the market improved in the year with the NSE ASI index return recording an increase of 42.0 per cent. As a result, the NSE was rated the third best performing market in 2017 globally. The enhanced performance in the market was attributed partly, to the Central Bank's monetary policies that resulted in increased liquidity in the foreign exchange market.

As the Nigerian economy continued its path of recovery in 2018, activities in the NSE equities market started on a high note with the All Share Index (ASI) reaching a ten-year peak of 45,092.83 in January. This was driven largely by the positive performance of the ASI in the previous year. Towards the second quarter of 2018, however, activities in the market began to dwindle. The ASI fell by 17.81 per cent to close at 31,430.50 points at end-2018. Macroeconomic factors, including political risks, oil price volatility and rising global yields accounted, largely, for the bearish sentiments in the market.

Market sentiments in the first half of 2019 were driven by uncertainty in oil prices, as well as, the 2019 general elections. The volatility in equities market was, however, dampened by post-elections stability. With the approval and implementation of the 2019 budget and its consequent positive impact on companies' earnings, as well as consumer spending, it is expected that there will be an uptick in market activity during the second half of 2019. These periods also experienced higher and stable crude oil prices and increased economic activities.

IV. Model Specification

For the purpose of this study, we specify a simple stock return series as a function of exchange rate and crude-oil price, that is:

$$ASI = f\,(ER, P) \tag{1}$$

Where:
ASI = All share index

ER = Bureau-de-Change (BDC) exchange rate

P = Crude oil price

To further ascertain whether what matters is not the crude-oil price and exchange rate return series by themselves, but the volatility in these series[2], we therefore specify a variation of equation (1), such that All Share Index is a function of the volatilities in crude-oil price and exchange rate; hence:

$$ASI = g\,(\sigma_{ER}, \sigma_{P}) \tag{2}$$

Where
σ_{ER}, = Volatilities on Exchange rate, and
σ_{P} = Crude oil price, respectively.

The econometric representation of equations (1) and (2), in their VAR frameworks, is shown in equations 3, 4, and 5.

$$RET\_Share = \varphi_0 + \sum_{i=1}^{3} \gamma_i RET\_Share_{t-k} + \sum_{i-1}^{3} \beta_i RET\_Crudepr_{t-k} + \sum_{i=1}^{3} \delta_i RET\_Exch_{t-k} \varphi_0 + \varepsilon_i \tag{3}$$

$$RET\_Crudepr = \alpha_0 + \sum_{i=1}^{3} \gamma_i RET\_Share_{t-k} + \sum_{i-1}^{3} \beta_i RET\_Crudepr_{t-k} + \sum_{i=1}^{3} \delta_i RET\_Exch_{t-k} + \varepsilon_i \tag{4}$$

$$RET\_Exch = \lambda_0 + \sum_{i=1}^{3} \gamma_i RET\_Share_{t-k} + \sum_{i-1}^{3} \beta_i RET\_Crudepr_{t-k} + \sum_{i=1}^{3} \delta_i RET\_Exch_{t-k} + \varepsilon_i \tag{5}$$

Where k is the optimal lag length; φ, α, and λ are the intercepts; γ_i, β_i, and δ_i represent the short-run coefficients of the model's adjustment to long-run equilibrium, and ε_i equals the equation residuals.

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[2]This follows Friedman (1975) conjecture that business cycles were caused by the volatility or unpredictability of future prices, i.e., uncertainty regarding the inflation, rather than inflation itself, which was what actually led to the ARCH model derivations by Robert Engel in 1979.

IV.1 Data Description and Estimations

In this study, daily data series are collected on oil price, exchange rate and stock indices, represented by Bonny Light, BDC and ASI, respectively. Daily data series spanning January 5, 2010 through April 8, 2019 where sourced from Reuters and the Central Bank of Nigeria (CBN) database. All variables where transformed into natural logarithms.

V. Discussion of results

V.1 Descriptive Statistics

Descriptive statistics for the variables under study in their natural form are presented in Table 1. As shown in the table, the average All Share Index (ASI) during the period (2010-2019) was 30,369.72. Over these periods, the spread in the index was large, recording a minimum of 19,732 and a maximum of 45,092. The crude oil prices recorded a mean of US$82.24 per barrel, while the average exchange rate was N243.96 per US dollar. These averages, however, concealed the wide variations inherent in these variables. The crude price, which averaged US$82.24 recorded a lowest value of US$26.51 per barrel in January 20, 2016, but was at a peak of US$130.64 per barrel on March 13, 2012. By the same token, the average value of exchange rate at N243/US$1, notwithstanding, naira exchanged for as low as N151/US$1 on April 4, 2010, but was as high as N515/$1 on February 20, 2017.

The skewness, which measures the asymmetry of the distribution around the mean, indicated that ASI and exchange rates were positively skewed, at 0.32 and 0.74, respectively. Crude oil price is however slightly negatively skewed, at a relatively lower value of -0.01. The measures of kurtosis, at 1.95 for ASI, 1.58 for oil price and 2.06 for exchange rates, were all below 3.0, indicating that the distribution of each of these series was flat (platykurtic), relative to what was expected of a normal distribution. Also, the huge value of Jarque-Bera statistics, with each having associated probability value of 0.00, confirmed that we can strongly reject the null hypothesis of normality for each distribution.

Table 1: Descriptive Statistics

	SHARES	CRUDEPR	EXCH
Mean	*30369.72*	*82.23875*	*243.9609*
Median	*29243.91*	*78.91000*	*171.0000*
Maximum	*45092.83*	*130.6400*	*515.0000*
Minimum	*19732.34*	*26.51000*	*151.0000*
Std. Dev.	*6478.686*	*27.35168*	*102.9160*
Skewness	*0.317463*	*-0.014439*	*0.743271*
Kurtosis	*1.955666*	*1.583893*	*2.067350*
Jarque-Bera	*140.9741*	*189.3344*	*290.6413*
Probability	*0.000000*	*0.000000*	*0.000000*
Sum	*68787427*	*186270.8*	*552571.3*
Sum Sq. Dev.	*9.50E+10*	*1693732.*	*23979639*
Observations	*2265*	*2265*	*2265*

Source: Authors' Computation

Figures 2 to 4 also present the graphical representation of the trends in the levels and the associated returns of Daily ASI, crude oil price and exchange rate over the ten-year period under study. As depicted in these charts, the gyration in ASI was subtle, with slight downward trend from early 2010 to 2012. During the same period, crude oil price rose steadily, amid mild variability, reaching a global peak of US$130.64/bbl (barrel of oil) in March 2012. Exchange rates during these periods were also relatively steady, with slight depreciation.

The crude oil prices remain high, averaging more than US$100/bbl between 2012 and 2014 (Figure 2), just as the ASI rose substantially through the same period (Figure 1). As the crude price began experiencing steady fall from 2014 through 2015, steady drop in ASI followed suit, while exchange rate also experienced increasing depreciation. The depreciation in exchange rate became even more pronounced through 2016 (Figure 3), an era that also coincided with official downward adjustment in naira-dollar exchange rate, also setting the stage for the country's recession.

By the third quarter of 2016, crude oil price began a sluggish rise, which reflected in the improvement in the stock market as the ASI rallied considerably throughout 2017. The exchange rate also experienced relative stability. In 2018, crude prices, was again on the downward trend, which also reflected in the ASI performance. A general observation, as evident in the charts, was that crude prices behaviour demonstrates more volatility and volatility clustering than ASI and exchange rates. Furthermore, the volatility in ASI is higher than that of exchange rates.

Figure 2: Trends in Daily All Share Index and Its Returns

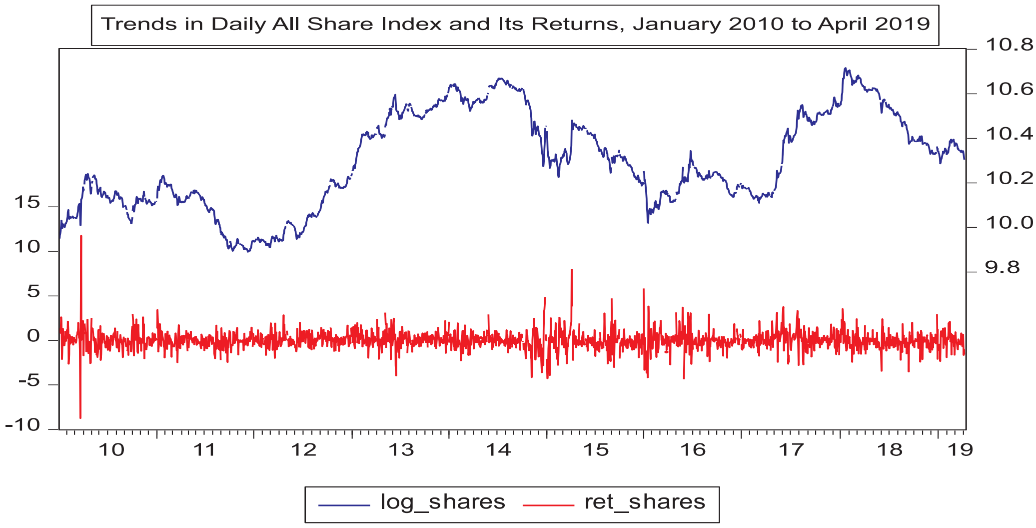


Figure 3: Trends in Daily Crude Oil Price and Its Returns

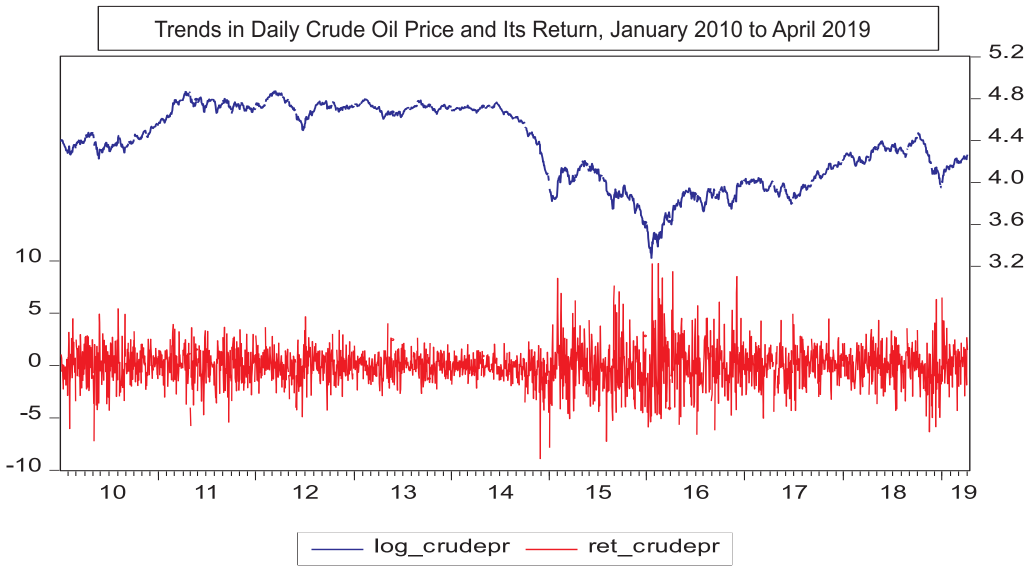
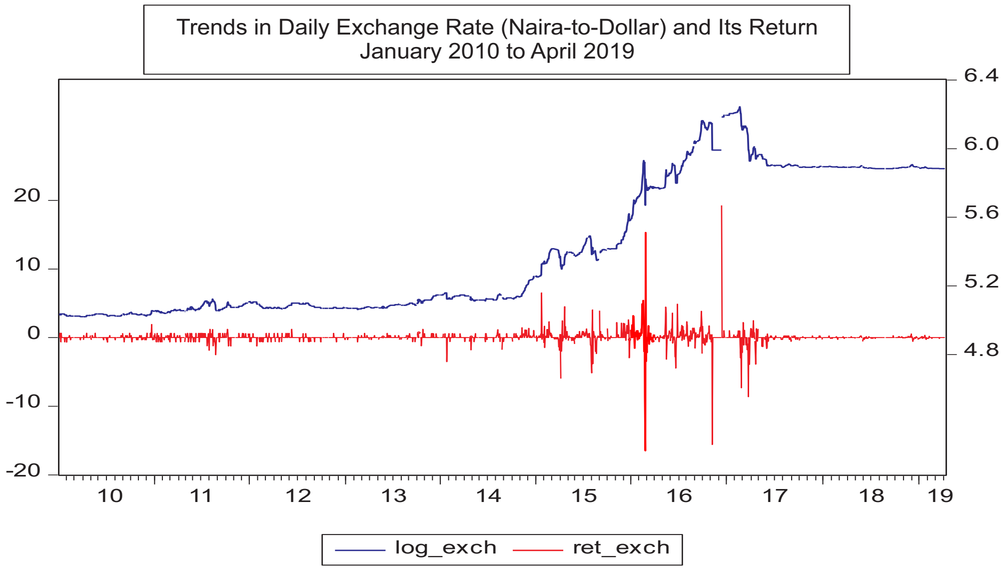


Figure 4: Trends in Daily Exchange Rate (Naira-to-Dollar) and Its Returns



V.2 Unit Root Tests

We conducted the unit root test to determine the order of integration of the series. As summarised in Tables 2a and 2b below, the results indicated that all the variables were not stationary at levels, but at first differences. Hence, we conclude that all the variables are integrated of order 1 series.

Table 2a: Unit Root Test

AUGMENTED DICKEY FULLER (ADF) TESTS						
	LEVEL			FIRST DIFFERENCE		
	NONE	CONSTANT	CONSTANT & TREND	NONE	CONSTANT	CONSTANT & TREND
LSHARES	[0.4457] (0.8103)	[1.8393] (0.3616)	[1.5630] (0.8072)	[30.4964] (0.0000)***	[30.4950] (0.0000)***	[30.5100] (0.0000)***
LCRUDEOIL	[0.2238] (0.6058)	[1.2847] (0.6388)	[1.6326] (0.7800)	[45.8816] (0.0001)***	[45.8717] (0.0001)***	[45.8615] (0.0000)***
LEXCH	[1.5261] (0.9692)	[0.5023] (0.8883)	[1.6977] (0.7523)	[24.2822] (0.0000)***	[24.3405] (0.0000)***	[24.3372] (0.0000)***

PHILLIPS PERRON (PP) TESTS

LEVELS				FIRST DIFFERENCE		
	NONE	CONSTANT	CONSTANT & TREND	NONE	CONSTANT	CONSTANT & TREND
LSHARES	[0.5178] (0.8275)	[1.8865] (0.3389)	[1.5394] (0.1859)	[35.2598] (0.0000)***	[35.2524] (0.0000)***	[35.2314] (0.0000)***
LCRUDEOIL	[0.2125] (0.6098)	[1.3170] (0.6237)	[1.6911] (0.7552)	[45.9071] (0.0001)***	[45.8973] (0.0001)***	[45.8873] (0.0000)***
LEXCH	[1.6745] (0.9776)	[0.4501] (0.8981)	[1.5853] (0.7988)	[47.0455] (0.0001)***	[47.0474] (0.0001)***	[47.0389] (0.0000)***

Note: * ** *** denotes 10%, 5% and 1% levels of significance respectively. [] () are used to represent the t-statistics and probability values. Lshares, Lcrudeoil and Lexch represents the logged values of (All shares index, Oil price and BDC) respectively.

Table 2b: Summary of Unit Root Tests' Results

	Augumented Dickry-Fuller (ADF)			Phillip-Perron (PP)		
	Level	first difference	I(d)	Level	First difference	I(d)
LASI	1.5630c	30.4964a***	I(1)	1.5394c	35.2598a***	I(1)
LCRUDEPR	1.6326c	45.8816a***	I(1)	1.6911c	45.9071a***	I(1)
LEXCH	1.6977c	24.2822a***	I(1)	1.5853c	47.0455a***	I(1)

Note: c is used to denote the model with constant and trend, again, 'a' denotes the model without constant and trend.

Given that all the variables are non-stationary, we conducted a cointegration test to ascertain whether there exist any long-run relationships among these variables. Doing this, however, requires the determination of the appropriate lag length. Following the FPE and AIC lag length criteria, 4 lags were chosen toward estimating the cointegration equations (see Appendix Table 1).

In conducting the cointegration test, we followed the conventional Johansen and Juselius (1990) cointegration techniques. Both unrestricted rank tests employed Trace and Maximum Eigenvalue test statistic, respectively. Table 3 presents the results from the cointegration tests. Both tests cannot reject the null of zero cointegrating vectors at the 5 per cent significant level. Based on the findings, we concluded that there was no evidence of any long-run relationships among these variables.

Table 3: Cointegration Tests Results

Trend assumption: Linear deterministic trend (restricted)
Series: LOG_SHARES LOG_CRUDEPR LOG_EXCH
Lags interval (in first differences): 1 to 4

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.007297	24.58699	42.91525	0.8100
At most 1	0.002087	8.035440	25.87211	0.9817
At most 2	0.001466	3.315003	12.51798	0.8372

Trace test indicates no cointegration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None	0.007297	16.55155	25.82321	0.4961
At most 1	0.002087	4.720437	19.38704	0.9906
At most 2	0.001466	3.315003	12.51798	0.8372

Max-eigenvalue test indicates no cointegration at the 0.05 level
** denotes rejection of the hypothesis at the 0.05 level*
***MacKinnon-Haug-Michelis (1999) p-values*

Since there is no cointegrating relationship among these variables, the appropriate specification follows an unrestricted VAR model, with the estimated variables' representation in first difference. We therefore transformed the variable accordingly and estimated the VAR to understand the nature of the short-run relationships among these variables. These variables, in their first differences, are labeled Ret_Shares, Ret_Crudepr and Ret_Exch, respectively, and the estimated equations specified thus:

$$RET\_Share = \varphi_0 + \sum_{i=1}^{3} \gamma_i RET\_Share_{t-k} + \sum_{i-1}^{3} \beta_i RET\_Crudepr_{t-k} + \sum_{i=1}^{3} \delta_i RET\_Exch_{t-k} + \varepsilon_i$$

$$RET\_Crudepr = \alpha_0 + \sum_{i=1}^{3} \gamma_i RET\_Share_{t-k} + \sum_{i-1}^{3} \beta_i RET\_Crudepr_{t-k} + \sum_{i=1}^{3} \delta_i RET\_Exch_{t-k} + \varepsilon_i$$

$$RET\_Exch = \lambda_0 + \sum_{i=1}^{3} \gamma_i RET\_Share_{t-k} + \sum_{i-1}^{3} \beta_i RET\_Crudepr_{t-k} + \sum_{i=1}^{3} \delta_i RET\_Exch_{t-k} + \varepsilon_i$$

Notice that the appropriate lag length for the variables in first difference is now t-k, where k is the number of lags specified for the variables in level (See Appendix I, Table 1). The results from the unrestricted VAR estimations are also presented in Appendix I, Table 2), since the objective here is to analyse the impulse response function, and not to interpret the coefficient estimate, which is generally considered to be complex. The associated stability test chart (Appendix Figure 1) illustrates that the estimated VAR is stable, since all roots lie within the unit circle and with the modulus less than 1[3]. Hence, it is safe to assume that the results from the impulse response functions and variance decomposition are valid (Lutkepol, 1991).

V.3 Impulse Response Function

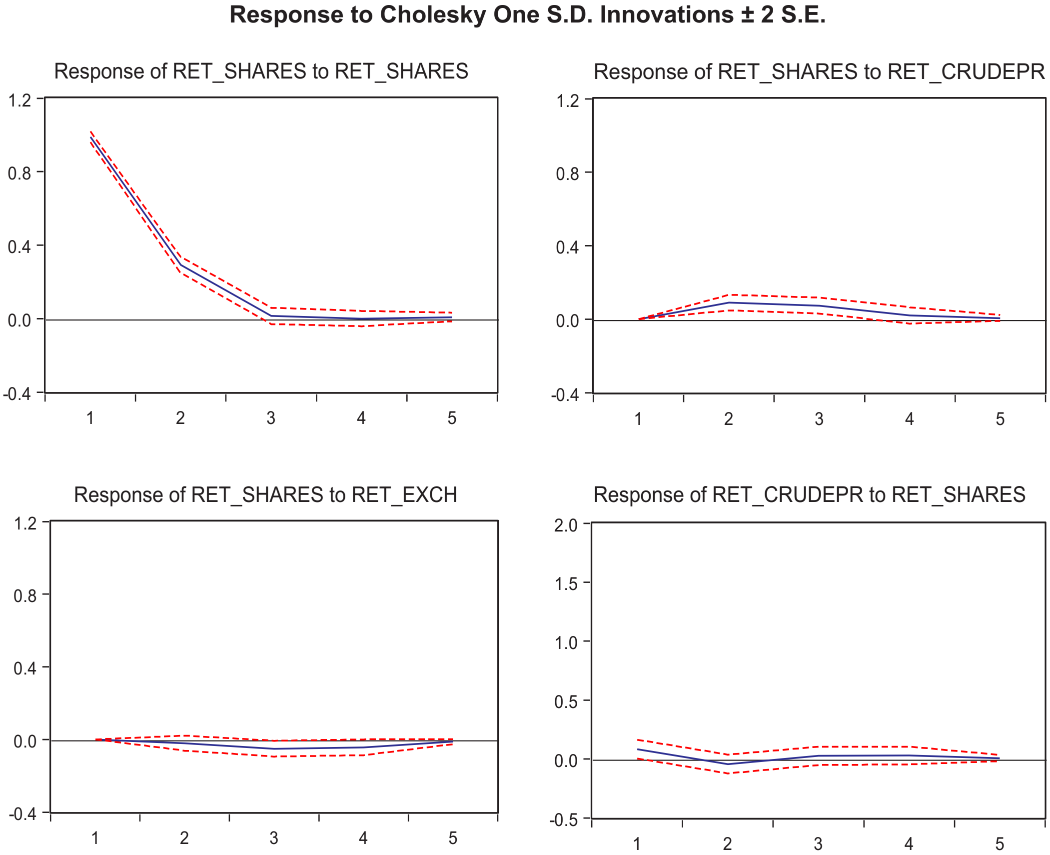
The impulse response function (IRF) traces the effect of a shock to one endogenous variable onto other variables in the VAR. It is used here to explain the reaction of the endogenous variable to one of the innovations and also to trace the effects on present and future values of the endogenous variable of one standard deviation shock to one of the innovations. A one standard deviation shock to ASI causes a substantial initial jump in own returns in the first period ahead (the next day), and then decline through the second and third periods, when it restored back to equilibrium (Panel A).

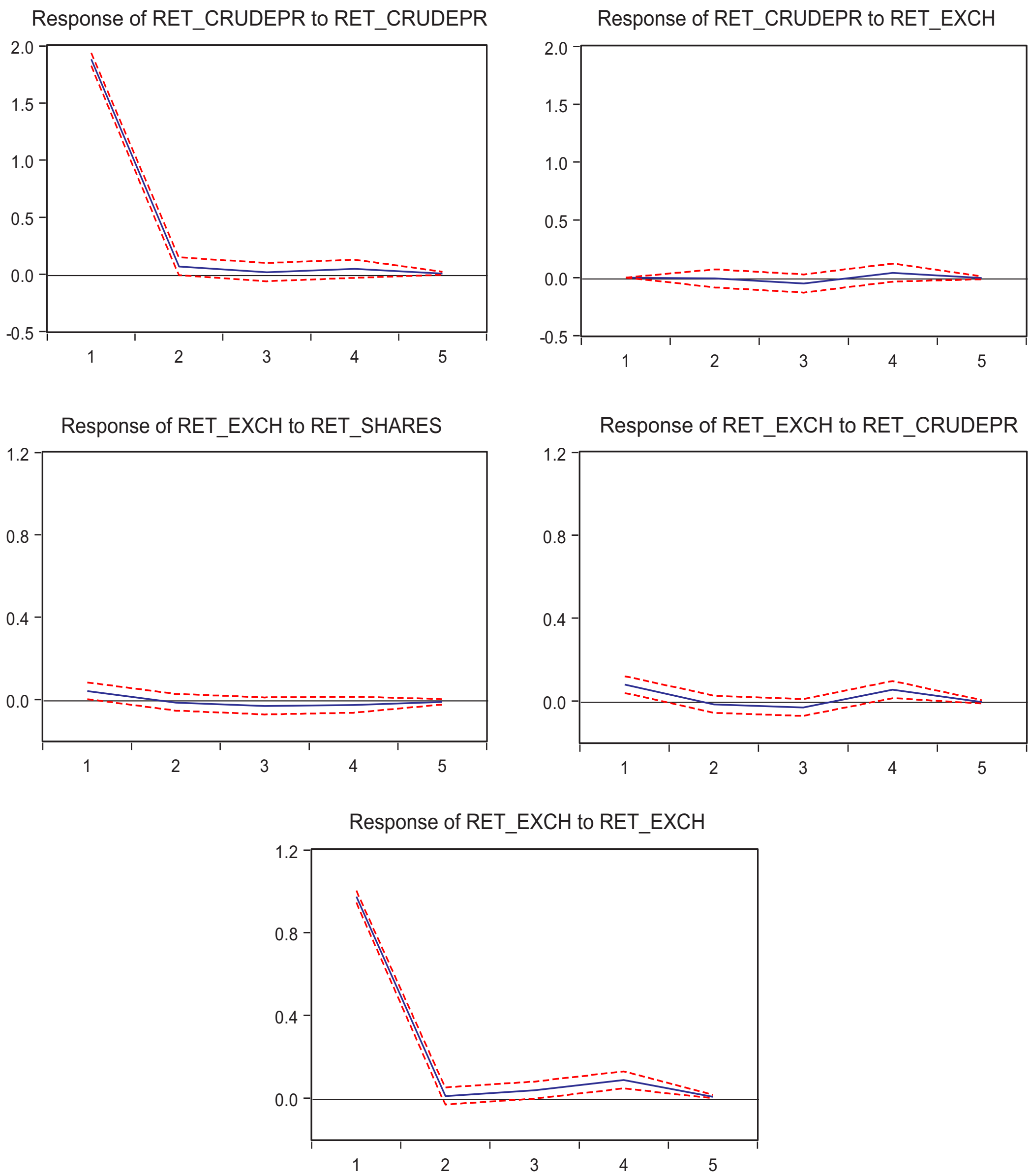
We find that oil price has a temporal, but a weak positive impact on the ASI, as the stock returns response to a one standard deviation shock to the oil price is

[3]Estimated impulse responses are inconsistent at long horizons in unrestricted VAR with some unit roots.

positive, but very marginal by the second period ahead. The impact slows down to the equilibrium by the fourth period ahead (Panel B). This minimal impact of the crude oil price on the Nigerian ASI can be attributed to the fact that the share of oil sector to the total composition of ASI is very small, at approximately 5 per cent. Overall, increases in crude oil prices have minimal impact on stock return.

A one standard deviation shock on exchange rate had a negative impact on returns on shares (Panel C), with the plausible inference that instability in the exchange rate may bring about uncertainty. The impact, which is sluggish and almost negligible in the first two periods ahead, declined slightly deeper through the third period before showing a rebound to the equilibrium by the fifth period ahead.





As can be observed in other panels, the impact of one standard deviation innovations from shares to crude oil price and exchange rate were statistically insignificant in either direction of the endogenous variables. It is also noteworthy that for every one standard deviation innovation from each of the variables to itself, there is an initial substantial and significant impact, which fades back to the equilibrium by the second period, except in the case of exchange rate that demonstrates a more persistent reverberation before it fizzles out by the fifth period ahead.

V.4 Forecast Error Variance Decomposition

The Forecast Error Variance Decomposition (FEVD) separates the variation in an endogenous variable into the component shocks to the VAR. It provides information about the relative importance of each random innovation in affecting the variables in the VAR. Table 5 shows the variance decomposition for each of the variables in our model. Decomposition of the ASI return indicates that, in the first period, 100 per cent of the variation in shares is contributed by own innovation. For the next four periods ahead, own shocks contribute no less than 98.3 per cent to the variation in ASI. Throughout these periods also, shocks to the crude oil price and exchange rate contributed no more than 1.3 and 0.47 per cent, respectively, to the variation in ASI returns. It is noteworthy that beyond five periods, shocks to endogenous variables have no further contribution or relative importance in the model.

Table 4: Variance Decomposition

Variance Decomposition of RET_SHARES

Period	S.E.	RET_SHARES	RET_CRUDEPR	RET_EXCH
1	0.989728	100.0000	0.000000	0.000000
2	1.036022	99.21343	0.744045	0.042528
3	1.039893	98.49362	1.225671	0.280704
4	1.041007	98.28302	1.257942	0.459036
5	1.041130	98.26574	1.260578	0.473678

Variance Decomposition of RET_CRUDEPR:

Period	S.E.	RET_SHARES	RET_CRUDEPR	RET_EXCH
1	1.884173	0.191088	99.80891	0.000000
2	1.885990	0.245914	99.75289	0.001199
3	1.886935	0.264184	99.66190	0.073916
4	1.888276	0.287817	99.58638	0.125807
5	1.888300	0.288779	99.58534	0.125880

Variance Decomposition of RET_EXCH:

Period	S.E.	RET_SHARES	RET_CRUDEPR	RET_EXCH
1	0.978770	0.180478	0.637660	99.18186
2	0.979079	0.202832	0.668362	99.12881
3	0.980876	0.310762	0.777489	98.91175
4	0.986503	0.378398	1.064198	98.55740
5	0.986609	0.393093	1.067074	98.53983

Cholesky Ordering: RET_SHARES RET_CRUDEPR RET_EXCH

The variance decomposition for oil price indicates that the fraction of overall forecast variance for its return cannot be attributed to the innovations in either ASI returns or exchange rate. Both variables, combined, contributed less than 0.5 per cent of the variation in oil price. Hence, both variables are not important in either short- or long-run in driving the movement in oil price. This is not unexpected, though, since oil price is exogenously determined. Comparable evidence is found with respect to the variance decomposition for exchange rate, except that a one standard shock to the oil price contributes up to 1.1 percent by the fifth period ahead.

V.5 Granger Causality

We conducted the Granger non-causality test to establish if any of the endogenous variables in our model could be treated as exogenous. For each equation in the VAR, the output (Table 6) displays the Chi-Square (Wald) Statistic (the last row—ALL, in each case) for the joint significance of each of the other lagged endogenous variables in that equation. The results, as shown in the table, suggest that there is a joint statistical significance of oil price and exchange rate, at 1 per cent, in Granger causing Shares. However, the oil price strongly Granger-causes Shares (1 per cent significant level), while the direction from exchange rate to Shares is very weak (10 per cent significant level).

The causality test with the oil price as dependent variable suggests that Shares and exchange rates do not Granger-cause oil price, either jointly, or individually. This finding underscores the exogenous nature of crude oil price determination. In the third case, it is found that there is joint significance of Shares and oil price on exchange rate. Individually, however, Shares do not Granger-cause exchange rate, while oil price causes exchange rate at 5 per cent level of significant. It is noteworthy that the Granger Causality tests support the findings from the IRF and FEVD.

Table 5: VAR Granger Causality/Block Exogeneity Wald Tests

	Dependent variable: RET_SHARES		
Excluded	Chi-sq	df	Prob.
RET_CRUDEPR	24.55678	3	0.0000
RET_EXCH	7.516266	3	0.0571
All	31.11005	6	0.0000

Dependent variable: RET_CRUDEPR

Excluded	Chi-sq	df	Prob.
RET_SHARES	2.299261	3	0.5127
RET_EXCH	2.948679	3	0.3996
All	5.310055	6	0.5047

Dependent variable: RET_EXCH

Excluded	Chi-sq	df	Prob.
RET_SHARES	5.574190	3	0.1343
RET_CRUDEPR	9.653368	3	0.0218
All	14.50416	6	0.0245

V.6 Estimating the Relationships among the Variables' Volatility Series

Several studies have investigated the linkage between the levels of an economic variable or other financial variables, and their uncertainties (or volatilities). For instance, Friedman (1976) noted that "as uncertainty leads to erratic policy response, increased volatility in inflation further fuels the distortion and friction that render market prices a less efficient system for coordinating economic activities . . ." Furthermore, Cuckierman and Meltzer (1986) argued that an exogenous increase in the variance of shock, which raises the variance of inflation [or any other variable] also raises average inflation [or average value of the variable] in the discretionary equilibrium. By the same token, findings from the studies have also established either positive or negative relationship, while others have found little or no relationship [Okun (1971), Engel & Kraft (1983); Cuckierman & Meltzer (1986), Casimano & Jansen (1988), Grier & Grier (1998), Fountas, Karanasos & Kim (2002) and Adenekan (2012)], among others.

Drawing from the foregoing, this study endeavours to ascertain, further, how the volatilities in the variables might be driving the relationship between and among themselves. Specifically, we examined the effect of the volatility of oil price and exchange rate on share performance. Doing this requires that we first generated the volatilities from the variables. Thus, we started by checking the correlograms of the variable series to determine their autoregressive moving average (ARMA) representations. Based on the preliminary estimation, findings suggested that ASI and crude-oil price follow ARMA (1, 1) process, while BDC exchange rate followed ARMA (3, 3) process. Appendix II also presents detailed information on the procedures and output of all estimations that generated the volatility series for the variables, the correlograms tables and associated charts, the respective conditional variance charts, as well as, the relevant AR inverse root charts that validates the model stability.

The charts below provide the relevant impulse response functions (IRF) as well as the forecast error variance decomposition (FEVD) tables. As depicted in the IRF charts, a one standard deviation shock to the volatilities of ASI have very small positive impact on the returns to shares in the second period ahead.

Figure 6: Impulse Response Function ASI on Returns to Shares

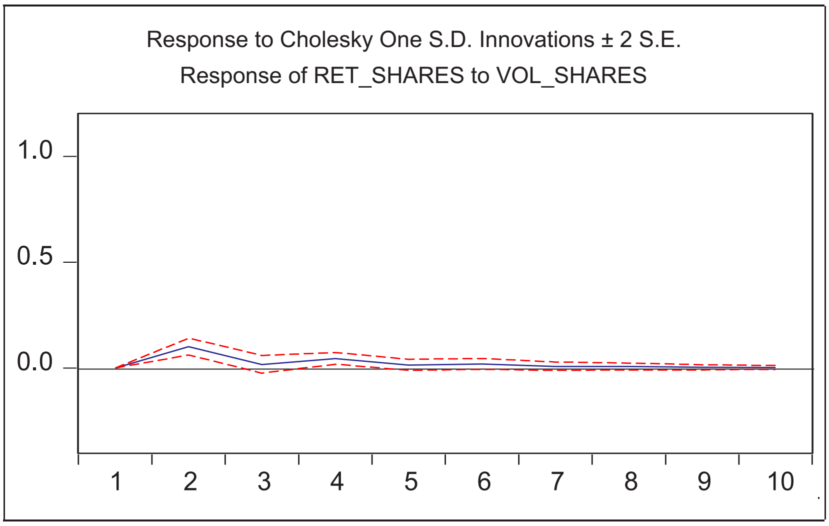


Figure 7: Impulse Response Function ASI on Oil Price

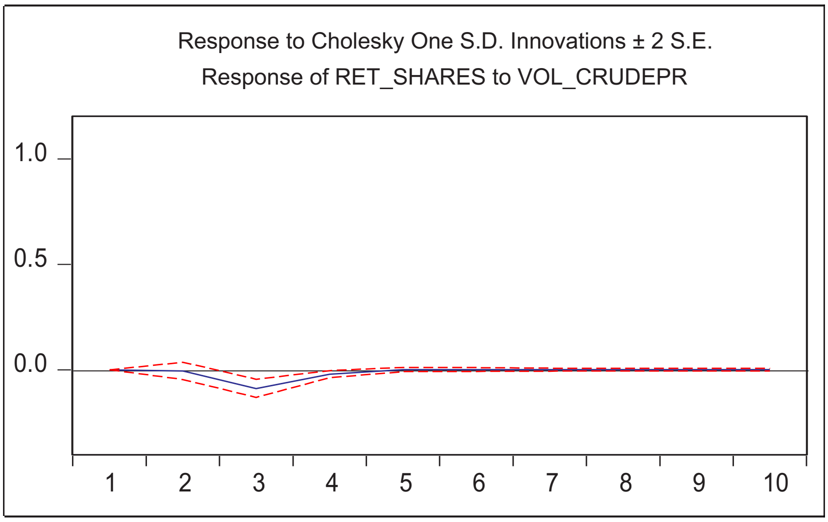
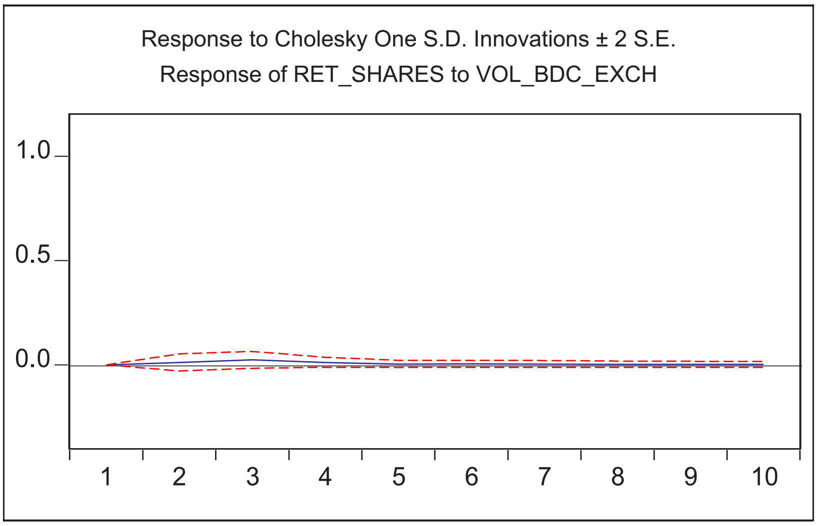


Figure 8: Impulse Response Function ASI on Exchange Rate



It reverted to a zero level by the third period and softly restored to equilibrium by the fifth period. Also, from one standard deviation innovation to the oil price, the response is negative and very minimal. This didn't occur until the third period ahead and bounced back in the fourth period before fizzling out to its equilibrium level. The response of the returns to share, given the Cholesky one standard deviation innovations to the volatilities in exchange rate is virtually negligible. The findings from the variance decompositions validate those from the IRF. By implication, therefore, the evidences from volatilities' estimations and their impact on stock market movements revealed that information content in the volatility series are not any more potent than the average return series of the variables under study.

Table 6: Forecast Error Variance Decomposition

		Variance Decomposition of RET_SHARES:			
Period	S.E.	RET_SHARES	VOL_SHARES	VOL_CRUDEPR	VOL_BDC_EXCH
1	0.984038	100.0000	0.000000	0.000000	0.000000
2	1.033396	99.02096	0.936061	0.001351	0.041630
3	1.037202	98.30934	0.957533	0.623313	0.109818
4	1.038568	98.05117	1.149625	0.680639	0.118566
5	1.038706	98.02899	1.171267	0.680995	0.118746

Variance Decomposition of VOL_SHARES:

Period	S.E.	RET_SHARES	VOL_SHARES	VOL_CRUDEPR	VOL_BDC_EXCH
1	0.861458	0.110800	99.88920	0.000000	0.000000
2	1.055886	1.178888	98.68541	0.122970	0.012727
3	1.267302	1.729432	97.88097	0.361733	0.027866
4	1.347771	1.551225	97.92901	0.479888	0.039880
5	1.399847	1.554715	97.81563	0.572424	0.057232

Variance Decomposition of VOL_CRUDEPR:

Period	S.E.	RET_SHARES	VOL_SHARES	VOL_CRUDEPR	VOL_BDC_EXCH
1	0.430284	0.055294	0.000216	99.94449	0.000000
2	0.610499	0.261455	0.005256	99.61260	0.120687
3	0.751221	0.228816	0.055161	99.37702	0.339006
4	0.868300	0.174402	0.123199	99.24790	0.454501
5	0.969811	0.139803	0.247755	99.11303	0.499413

Variance Decomposition of VOL_BDC_EXCH:

Period	S.E.	RET_SHARES	VOL_SHARES	VOL_CRUDEPR	VOL_BDC_EXCH
1	1.038383	0.035433	0.011367	0.025973	99.92723
2	1.613835	0.026980	0.027262	0.029742	99.91602
3	2.018735	0.021032	0.020191	0.029410	99.92937
4	2.320504	0.020007	0.015447	0.082221	99.88233
5	2.555882	0.019115	0.017191	0.188399	99.77530

Cholesky Ordering: RET_SHARES VOL_SHARES VOL_CRUDEPR VOL_BDC_EXCH

VI. Conclusion

This study examined the relationship among crude oil price, exchange rate and stock performance in Nigeria. Theories posited that various mechanisms and outcomes of the relationships among these variables have either strong positive or negative correlation, or little or no impact. Empirical reviews also corroborate this theoretical assertion. The evidence from our investigation, despite the battery of econometric tools employed, could not ascertain that stock market performance in Nigeria is driven by the developments in the crude oil or foreign exchange markets. There is no evidence of any long-run cointegration among these variables. Similarly, the impulse response functions and variance decomposition analysis from the VAR estimates showed no strong response or contributory impact to the variances in each variable. In most cases, each variable's own shocks were the major drivers of whatever movements that were observed. The findings from the estimations, using the volatility series also mimicked the results from the return series.

In other climes, especially the more advanced economies, developments in the crude oil and foreign exchange markets significantly impact the stock market. The contrasting findings in this study may be due to several reasons. First, the transmission mechanism, through which the developments in oil or foreign exchange markets could impact the stock market in Nigeria, may have an inherent structural or institutional rigidity. A change in oil price, for example, will reflect mainly, a corresponding change in government revenue, since crude oil sector is strictly owned by the government. By implication, shocks to the oil price have little or negligible direct impact on the entities listed on the NSE. In other words, any change in oil price does not go through the private sector, hence could not have agitated a direct effect that could have reflected in the stock market.

By the same token, Nigeria is a petroleum product importing economy, with a structure that entrenches highly regulated and subsidised prices of petroleum products. This, by implication, creates a distortion in the theoretical relationship between and among the variables under study. The possible effect of any change in oil price or exchange rates could have been filtered significantly, as the effect does not transmit to the consumer directly such that the true reaction or behaviour is captured. This would also be the case for how such developments would impact the balance sheets or corporate earnings of the listed companies, and ultimately, the overall stock index.

Furthermore, the inability of the empirics to capture any robust connection from oil price to exchange rate could, plausibly, be attributed to the long-established frequent and steady monetary authority's intervention in the foreign exchange market. As part of its price stability objective, the monetary authority has not minced its policy stance on defending the naira exchange rate, and has steadily monitored its prescribed band on the exchange rate spread or margin.

Overall, our findings demonstrate that stock prices are not totally affected by oil price changes; however, it is affected by exchange rate—as a one standard deviation innovation to exchange rate had negative impact on shares. The result matters for investors, given that participants in the stock market are usually exposed to exchange rate risks. In this light, the monetary authority is urged to move toward a unified exchange rate regime. This could establish clarity and transparency that would boost investors' confidence, thus attracting investment. It would also eliminate sharp practices, such as roundtripping, and remove the distortion in the stock market.

The findings further connote that while the monetary authority strives to attain the objectives of a stable exchange rate, it is germane to factor in the implication of such objective on the financial market. Conventionally, it is perceived that stock prices often rise on account of expectation of an increase in the quantity of money, which occurs independently of oil prices. Stock prices also exhibit bearish or bullish trends, based on future corporate earnings statistics, investors risk tolerance and a host of other factors. Thus, this makes it difficult to conclude that only one commodity could drive all other business activity in a predictable way, given the complexity of the global economy.

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Appendices

Appendix I

APPENDIX TABLE 1

VAR Lag Order Selection Criteria
Endogenous variables: LOG_SHARES LOG_CRUDEPR LOG_EXCH
Exogenous variables: C

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-718.1474	NA	0.000381	0.640166	0.647783	0.642946
1	20078.32	41519.10	3.69e-12	-17.81298	-17.78252	-17.80186
2	20185.48	213.6460	3.38e-12	-17.90012	-17.84680*	-17.88066*
3	20199.75	28.42098	3.36e-12	-17.90480	-17.82863	-17.87700
4	20214.98	30.27917	3.34e-12*	-17.91033*	-17.81131	-17.87419
5	20221.93	13.78994	3.35e-12	-17.90850	-17.78664	-17.86402
6	20227.92	11.88188	3.36e-12	-17.90583	-17.76112	-17.85301
7	20239.58	23.09456	3.35e-12	-17.90819	-17.74063	-17.84704
8	20241.12	3.053567	3.37e-12	-17.90157	-17.71116	-17.83208
9	20250.79	19.08968*	3.37e-12	-17.90216	-17.68890	-17.82433
10	20258.20	14.62948	3.38e-12	-17.90076	-17.66465	-17.81458
11	20261.12	5.740240	3.39e-12	-17.89536	-17.63639	-17.80084
12	20266.47	10.52925	3.41e-12	-17.89212	-17.61031	-17.78927

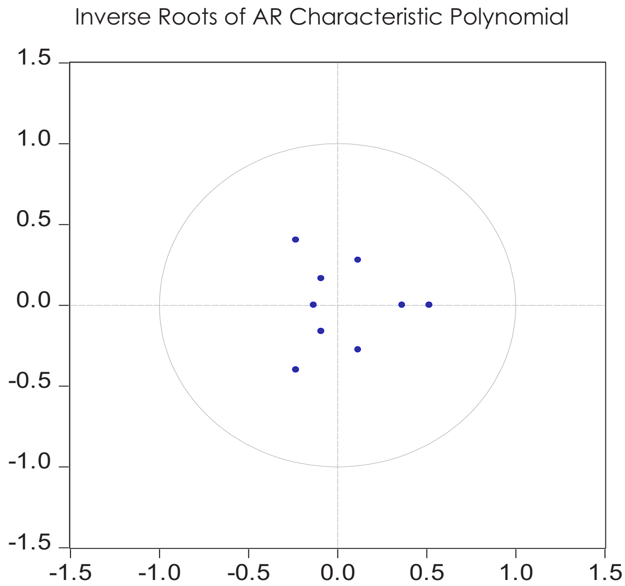
* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Appendix Table 2

Vector Autoregression Estimates
Standard errors in ( ) & t-statistics in [ ]

	RET_SHARES	RET_CRUDEPR	RET_EXCH
RET_SHARES(-1)	0.292055	-0.047587	-0.014445
	(0.02111)	(0.04019)	(0.02088)
	[13.8329]	[-1.18395]	[-0.69185]
RET_SHARES(-2)	-0.070639	0.042743	-0.028798
	(0.02193)	(0.04175)	(0.02169)
	[-3.22135]	[1.02388]	[-1.32797]
RET_SHARES(-3)	0.015964	0.012432	-0.023513
	(0.02098)	(0.03994)	(0.02075)
	[0.76092]	[0.31128]	[-1.13329]
RET_CRUDEPR(-1)	0.048385	0.037255	-0.009583
	(0.01112)	(0.02116)	(0.01099)
	[4.35297]	[1.76056]	[-0.87179]
RET_CRUDEPR(-2)	0.024578	0.012471	-0.017850
	(0.01116)	(0.02125)	(0.01104)
	[2.20183]	[0.58687]	[-1.61702]
RET_CRUDEPR(-3)	0.001404	0.022258	0.028111
	(0.01117)	(0.02127)	(0.01105)
	[0.12563]	[1.04626]	[2.54377]
RET_EXCH(-1)	-0.021918	-0.006701	0.009867
	(0.02128)	(0.04051)	(0.02104)
	[-1.02999]	[-0.16540]	[0.46885]
RET_EXCH(-2)	-0.045157	-0.052928	0.037936
	(0.02125)	(0.04045)	(0.02101)
	[-2.12534]	[-1.30854]	[1.80547]
RET_EXCH(-3)	-0.027530	0.045438	0.086098
	(0.02127)	(0.04050)	(0.02104)
	[-1.29410]	[1.12197]	[4.09255]
C	0.013790	-0.004111	0.033371
	(0.02086)	(0.03972)	(0.02063)
	[0.66093]	[-0.10350]	[1.61730]
R-squared	0.096343	0.004382	0.016059
Adj. R-squared	0.092730	0.000401	0.012125
Sum sq. resids	2204.991	7991.295	2156.436
S.E. equation	0.989728	1.884173	0.978770
F-statistic	26.66545	1.100790	4.082070
Log likelihood	-3179.863	-4635.528	-3154.690
Akaike AIC	2.821639	4.109268	2.799372
Schwarz SC	2.846953	4.134583	2.824687
Mean dependent	0.013156	-0.004919	0.037433
S.D. dependent	1.039076	1.884551	0.984758
Determinant resid covariance (dof adj.)		3.297887	
Determinant resid covariance		3.254322	
Log likelihood		-10958.63	
Akaike information criterion		9.720152	
Schwarz criterion		9.796095	

Appendix Figure 1: VAR Estimation Stability Test

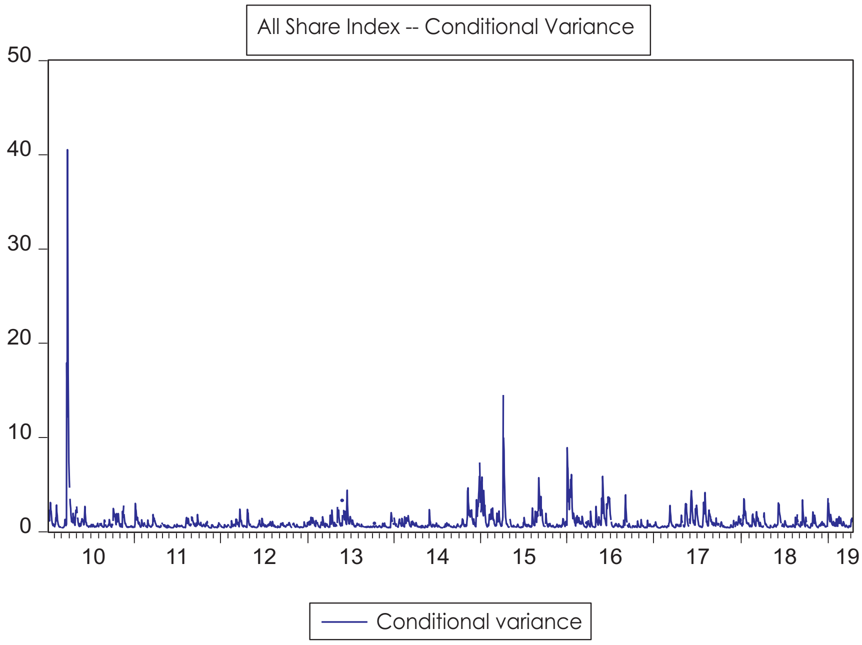


Appendix II

GENERATING THE VOLATILITRY SERIES

The Correlograms of RET_SHARES used to determine the ARMA specification. From the Table below, RET_SHARES series has ARMA(1,1) process

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
|** |	|** |	1	0.282	0.282	180.15	0.000
| |	*| |	2	0.017	-0.068	180.80	0.000
| |	| |	3	0.003	0.019	180.82	0.000
| |	| |	4	0.042	0.041	184.87	0.000
| |	| |	5	0.040	0.018	188.51	0.000
| |	| |	6	-0.036	-0.055	191.39	0.000
| |	| |	7	-0.038	-0.011	194.64	0.000
| |	| |	8	-0.015	-0.004	195.15	0.000
| |	| |	9	0.019	0.023	196.01	0.000
| |	| |	10	0.002	-0.010	196.02	0.000



Dependent Variable: RET_SHARES
Method: ML ARCH - Normal distribution (BFGS / Marquardt steps)
Coefficient covariance computed using outer product of gradients
Presample variance: backcast (parameter = 0.7)
GARCH = C(3) + C(4)*RESID(-1)^2 + C(5)*GARCH(-1)

Variable	Coefficient	Std. Error	z-Statistic	Prob.
AR(1)	0.224732	0.100788	2.229753	0.0258
MA(1)	0.010335	0.107162	0.096443	0.9232
	Variance Equation			
C	0.152472	0.015882	9.600336	0.0000
RESID(-1)^2	0.238757	0.016587	14.39429	0.0000
GARCH(-1)	0.615441	0.026072	23.60523	0.0000
R-squared	0.077511	Mean dependent var		0.013995
Adjusted R-squared	0.077103	S.D. dependent var		1.039009
S.E. of regression	0.998150	Akaike info criterion		2.622473
Sum squared resid	2252.642	Schwarz criterion		2.635121
Log likelihood	-2962.328	Hannan-Quinn criter.		2.627088
Durbin-Watson stat	1.871715			
Inverted AR Roots	.22			
Inverted MA Roots	-.01			

The Correlograms of RET_CRUDEOIL PRICE used to determine the ARMA specification

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
| |	| |	1	0.036	0.036	2.9069	0.088
| |	| |	2	0.010	0.009	3.1540	0.207
| |	| |	3	0.027	0.026	4.7488	0.191
| |	| |	4	-0.013	-0.015	5.1432	0.273
| |	| |	5	-0.003	-0.002	5.1635	0.396
| |	| |	6	0.057	0.057	12.500	0.052
| |	| |	7	0.010	0.006	12.714	0.079
| |	| |	8	-0.037	-0.039	15.860	0.044
| |	| |	9	0.034	0.034	18.565	0.029
| |	| |	10	-0.000	-0.001	18.565	0.046

RET_CRUDEOIL series has ARMA(1,1) process. The estimation results is below:

Dependent Variable: RET_CRUDEPR
Method: ML ARCH - Normal distribution (BFGS / Marquardt steps)
Convergence achieved after 43 iterations
Coefficient covariance computed using outer product of gradients
Presample variance: backcast (parameter = 0.7)
GARCH = C(3) + C(4)*RESID(-1)^2 + C(5)*GARCH(-1)

Variable	Coefficient	Std. Error	z-Statistic	Prob.
AR(1)	-0.148339	0.420969	-0.352376	0.7246
MA(1)	0.183206	0.419101	0.437141	0.6620
	Variance Equation			
C	0.018566	0.006388	2.906256	0.0037
RESID(-1)^2	0.060109	0.006618	9.083192	0.0000
GARCH(-1)	0.936647	0.006782	138.0989	0.0000

R-squared	0.001147	Mean dependent var	-0.004850
Adjusted R-squared	0.000705	S.D. dependent var	1.883814
S.E. of regression	1.883150	Akaike info criterion	3.905606

The Correlograms of RET_EXCH to determine the ARMA specification.

Sample: 1/05/2010 4/08/2019
Included observations: 2264

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
| |	| |	1	0.012	0.012	0.3369	0.562
| |	| |	2	0.035	0.035	3.1496	0.207
|* |	|* |	3	0.092	0.091	22.394	0.000
| |	| |	4	-0.022	-0.025	23.453	0.000
| |	| |	5	-0.014	-0.021	23.925	0.000
| |	| |	6	0.021	0.015	24.941	0.000
| |	| |	7	-0.013	-0.007	25.296	0.001
*| |	*| |	8	-0.071	-0.070	36.810	0.000

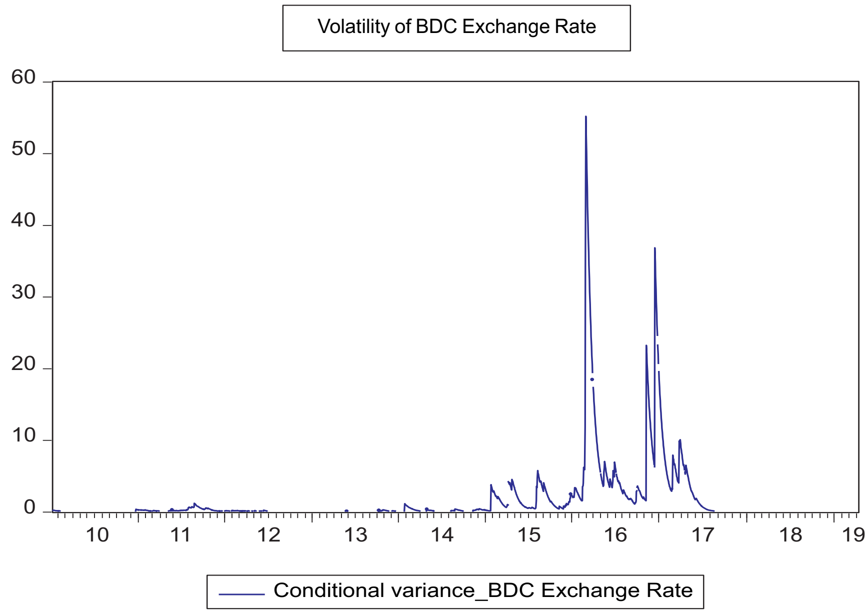
Correlograms indicates ARMA(3,3)

Dependent Variable: RET_EXCH

Method: ML ARCH - Normal distribution (BFGS / Marquardt steps)
Presample variance: backcast (parameter = 0.7)
GARCH = C(7) + C(8)*RESID(-1)^2 + C(9)*GARCH(-1)

Variable	Coefficient	Std. Error	z-Statistic	Prob.
AR(1)	-0.322678	0.447120	-0.721680	0.4705
AR(2)	-0.799539	0.271790	-2.941754	0.0033
AR(3)	0.279878	0.434714	0.643822	0.5197
MA(1)	0.360837	0.466319	0.773798	0.4391
MA(2)	0.843494	0.278136	3.032668	0.0024
MA(3)	-0.231995	0.459257	-0.505152	0.6135
	Variance Equation			
C	9.05E-05	1.43E-05	6.335158	0.0000
RESID(-1)^2	0.087838	0.002997	29.30818	0.0000
GARCH(-1)	0.943686	0.001377	685.2994	0.0000

R-squared	-0.011700	Mean dependent var	0.037433
Adjusted R-squared	-0.013943	S.D. dependent var	0.984758


Volatility of BDC Exchange Rate
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10
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12
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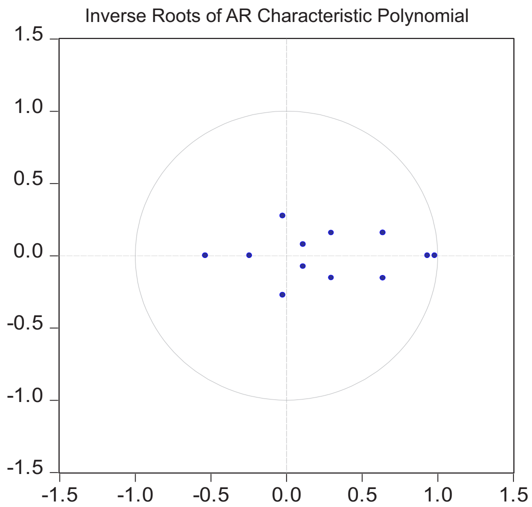
15
16
17
18
19
Conditional variance_BDC Exchange Rate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-0.5
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-1.5
-1.5
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-0.5
0.0
0.5
1.0
1.5