ASSESSMENT OF COLLECTIVE BARGAINING AND INDUSTRIAL CONFLICTMANAGEMENT IN NIGERIAN UNIVERSITIES: A STUDY OF FEDERALUNIVERSITY OF TECHNOLOGY, (FUT) MINNA

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EXAMINING THE IMPACT OF CRUDE OIL PRICE SHOCKS ON SOME MACROECONOMIC VARIABLES IN NIGERIA USING GARCH AND VAR MODELS

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DECLARATION

I declare that the work in this Dissertation titled "Examining the Impact of Crude Oil Price Shocks on Some Macroeconomic Variables in Nigeria Using GARCH and VAR Models" has been carried out by me in the Department of Mathematics. The information derived from the literature has been duly acknowledged in the text and a list of references provided. No part of this dissertation was previously presented for another degree or diploma at this or any other Institution.

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CERTIFICATION

This dissertation titled "EXAMINING THE IMPACT OF CRUDE OIL PRICE SHOCKS ON SOME MACROECONOMIC VARIABLES IN NIGERIA USING GARCH AND VAR MODELS" by Chinyere Sarah EJIEMENU meets the regulations governing the award of the degree of Masters of Science in Statistics of the Ahmadu Bello University, and is approved for its contribution to knowledge and literary presentation.

Dr. A. Isah Chairman, Supervisory Committee	___________________ (Signature)	__________________ (Date)
Dr. H.G. Dikko Member, Supervisory Committee	___________________ (Signature)	__________________ (Date)
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DEDICATION

This research work is dedicated to my adorable parents: Mr and Mrs Uche Anthony Ejiemenu.

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ABSTRACT

This study evaluates the impact of Crude Oil Price (COP) on the Exchange Rate (EXCHR), External Reserves (EXRS), Gross Domestic Product (GDP), Inflation Rate (INFL), International Trade (INTR) and Money Supply (MSUP) in Nigeria with quarterly data from 1995 to 2014 using GARCH and VAR models. From the analysis, all the variables were stationary at first difference with p-value less than 0.05. The presence of heteroscedasticity was found in exchange rate with some of its coefficient models being significant at 5% level; and the forecasting model for exchange rate is GARCH (2, 1). The findings further showed that negative crude oil shocks did not pose an inflationary threat on Nigerian economy, but rather it improved output growth in terms of GDP and enhanced the flow of MSUP. On the other hand, negative crude oil price shocks did affect external reserves and international trade due to the recent fall in the price of crude oil which calls for a diversification of economy in Nigeria.

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LIST OF ACRONYMS

ADF	Augmented Dickey Fuller
AIC	Akaike Information Criterion
ARCH	Autoregressive Conditional Heteroscedasticity
FOB	Free on Board
GARCH	General Autoregressive Conditional Heteroscedasticity
GDP	Gross Domestic Product
IRF	Impulse Response Function
MBPD	Million Barrels Per Day
MAE	Mean Absolute Error
OPEC	Organization of Petroleum Exporting Countries
PP	Philips and Perron
RSME	Root Square Mean Error
VAR	Vector Autoregressive
VD	Variance Decomposition
US	United States

DEFINITION OF TERMS

Autocorrelation: A lag correlation of a given series with itself, lagged by a number of time units.

Crude Oil: Mixture of natural hydrocarbon substance and refined products ranging from lighter oils to heavier oils and bitumen.

Diagnostic Checks: A statistical procedure that checks if the fitted model really captures the dependence in the series

External Reserves: Is the amount of revenue saved by country from trading with other nations. It is measured in millions of US dollars.

Freight on Board: A term requiring the seller to deliver goods on *board* vessel chosen by the buyer. The seller fulfills its duties to deliver when the goods have passed over the ship's rail.

Heteroscedasticity: Occurs when sub-populations have different variance from others.

Homoscedasticity: Occurs when sub-populations have the same variance with others.

International Trade: Refers to the exchange of capital, goods, and services across international borders or territories

Monetary Policy: A policy to financial markets and the supply of credit, money and other financial assets.

Money Supply: Total amount of monetary assets available in an economy at a specific time which include currency in circulations and demand deposits of financial institutions

Oil Price: A price in dollars at which a barrel of crude oil is sold for, in the international market.

Partial Autocorrelation: Measures the magnitude of linear dependence of two random variables generated by stationary process.

Residuals: Are differences between the observed values and the expected values that are predicted by the model and represent the variance that is not explained by the model.

Shale Gas: A natural gas found in any sedimentary rocks that contain solid bituminous material (called kerogen) that are released as liquid- petroleum.

Unit Root Test: A property of a non-stationary time series which can lead to false regressions and wrong inference.

Volatility: Fluctuations in the value of a variable, especially price.

White Noise/Purely Random Process: A stochastic process is purely random if it has zero mean, constant variance and is serially uncorrelated.

CHAPTER ONE

INTRODUCTION

1.1 Background of Study

Crude oil plays a central role in bringing wealth and power to the world as Mehrara and Mohaghegh (2011) underscored. Several countries around the globe have experienced existing financial crises in the last two decades, namely: the Mexican crisis (1994), the Asian crisis (1997), the Russian crisis (1998), the Brazilian crisis (1999), the Argentina crisis (2002), the Iraq crises (2004), the US subprime crisis (2008) and the Greek crisis (2010) which diverted macroeconomic variables to extreme volatility and to disorder noted by Gaye and Sercan (2013). Hamilton (1983) documented that sharp rises in oil prices caused worldwide recessions and stock market collapses.

Gaye and Sercan (2013) stated that the fluctuations in oil prices are the results of the global demand shocks, the demand growth in China and India and the recession in the US and European economies due to the sub-prime mortgage crises; or the supply shocks mainly stemming from the US invasion of Iraq and the output decisions of OPEC countries. According to Mulyadi (2012), the movements of oil price affected movement of macroeconomic variables and varies from net oil export countries to net oil import countries. For instance, oil boom during the 1970s paid a big share on output (Gross Domestic Product) in Indonesia, leading to higher inflation rate and immense increase in foreign exchange rate.

Regionally, Lauren (2013) indicated that Africa's oil history stretches over a period of several decades along with its changes in oil. For example, between 1973 and 1983 Ghana experienced an average decline in per-capita GDP of more than 3% a year due to crude oil price shocks; (Fosu and Aryeetey, 2008). This is because the period of poor economic performance in Ghana was associated with political instability, high levels of corruption and economic mismanagement. With crude oil prices averaging $28.3 per barrel in 2000, domestic prices of crude oil products rose by more than 20%; budget deficit also increased by 87.7% and economic growth fell from 4.4% in 1999 to 3.7% in 2000 with inflation rising to 40.8%. The nominal exchange rate between Ghana Cedi and the US dollar depreciated from GH¢0. 35 per dollar in January 2000 to GH¢0.63 per dollar in December 2000 (World Bank, 2012). Angola faced a period of decline in global oil prices from 2009 to mid-2011 resulting in the fall of oil revenue, inflation, output, GDP growth and a slowdown in domestic oil production that fell to an average of less than 1.6 million barrels per day (mbpd) in the first half of 2011 (Monday, 2010).

As the backbone of Nigeria's economy, Crude oil plays a substantial role in influencing the economic and political destiny of the country; yet as the 6th largest producer of crude oil in the world, Nigeria is vulnerable to fluctuations in the international oil market which presents its macro economy as fragile in nature due to heavy dependence on crude oil (Akpan, 2009).

Describing crude oil shocks, Ogundipe and Ogundipe (2012) refered to it as a sudden, unexpected change in oil price or production. Similarly, Akpan (2009) defined oil price shock as price fluctuations resulting from changes in either the demand or supply side of the international oil market (Hamilton, 1983; and Wakeford, 2006). These changes have been traditionally traced to supply-side disruptions such as OPEC supply quotas, political upheavals in the oil-rich Middle East and activities of militant groups in the Niger Delta region of Nigeria (Akpan, 2009).

Although, Nigeria's oil industry was founded at the start of the century, it was not until the end of Nigeria civil war (1967-1970) that the oil industry began to play a prominent role in the economic life of the country. Odularu (2008) and Agbede (2013) noted that between 1960 and 1966, agriculture contributed about 58 percent to the country's Gross Domestic Product (GDP) and employed over 60 percent of her work force. But in the 1970s, Agriculture lost its pre-eminent position to Mining and mostly to Petroleum due to occurrence of oil boom in the period.

In Nigeria, oil accounts for more than 90 percent of its exports, 25 percent of its Gross Domestic Product (GDP), and 80 percent of its government total revenues (Gunu and Kilishi, 2010). Thus, a small oil price change can have a large impact on the economy. For instance, a US$1 increase in the oil price in the early 1990s increased Nigeria's foreign exchange earnings by about US$650 million (2 percent of GDP) and its public revenues by US$320 million a year (Agbede, 2013).

Philip and Akintoye (2006) vividly stated that persistent oil price shocks could have severe macroeconomic implications that induced challenges for policy making either fiscal or monetary in both the oil exporting and oil importing countries over the past three decades. The studies of Hamilton (1996) and Cashin *et al*. (2000) suggested that rising oil prices reduced output and increased inflation in the 1970s to early 1980s and in contrast, falling oil prices boosted output and lowered inflation, particularly in the U.S mid-to late 1980s. Akpan (2009) stated that the shocks could be positive (a rise) or negative (a fall) in the macroeconomic variables and that two issues can be identified regarding these shocks. Firstly, is the magnitude of the price increase which can be quantified in absolute terms or as percentage changes; secondly, the timing of the shock, that is, the speed and persistence of the price increase.

Furthermore, the trend of demand and supply of Crude oil in the global economy along with OPEC’s activities consistently affects the crude oil price; and the current global economy melt down in which suddenly offset the increasing oil price observed to reduce GDP growth, boost real interest rate and inflation. At the start of the crisis, Gunu and Kilishi (2010) and Agbede (2013) noted that oil price crashed below $40/b in the world market which had severe consequences on Nigeria fiscal budget and led to the downward review of the budget. Recently, crude oil price is fluctuating between $60/b and $75/b, which has become of great concern to everyone including academia and policy makers; therefore, a study of this kind as contained herein is worth considering.

Naturally, the bigger the crude oil price increases and the longer higher prices are sustained, the bigger the macroeconomic impact (Akpan, 2009). Despite these perceived benefits of oil price change, Nigeria macro economy was undesirable during the booms. For instance, inflation was mostly double digit in the 1970s; money supply grew steeply and huge fiscal deficits resulted (Akpan, 2009). This had implications for the economies of oil exporting countries, particularly oil dependent countries like Nigeria. This study examines the impact of these fluctuations on the macroeconomic variables of Nigeria.

This study takes on quarterly data on crude oil prices by using the Bonny light crude oil (with 0.4% sulphur that credits it light and sweet crude) obtained from the Central Bank of Nigeria (CBN) online statistics database for its analysis, since the Bonny light crude accounts for more than 55 per cent of the Nigerian crude oil export over the years as against the UK Brent crude oil price and the Nigerian- Forcados crude oil price employed by other authors (Olomola and Adejumo, 2006; Akpan, 2009; Aliyu, 2009; Chuku, 2012; Akinleye and Ekpo, 2013). Therefore, this guarantees that the effect of shocks to crude oil price on key macroeconomic variables- such as, Exchange Rate, External Reserves, Gross Domestic Product, Inflation, International Trade and Money Supply- in Nigeria is captured using more reliable crude oil price data. This study also estimates oil price shocks and its impact on the Nigerian economy and as well forecasts the volatility of crude oil price shocks and the macroeconomic variables using General Autoregressive Conditional Heteroscedasticity (GARCH) and Vector Autoregressive (VAR) models. The aforementioned macroeconomic variables are used because they are internal variables that affect standardized policy in the country as earlier suggested by Akinleye and Ekpo, (2013).

1.2 Statement of Problem

Fluctuations in crude oil prices lead to fluctuations in macroeconomic variables since Nigeria is a mono-cultural economy (Ogundipe and Ogundipe, 2012). Likewise Obioma (2006) and Akpan (2009) maintained that the bigger the oil price increase and the longer higher prices of oil are sustained, the bigger the macroeconomic impact. Nigeria became more exposed to oil price fluctuations the moment she started importing refined petroleum products due to the collapse of local refineries in the late 1980s.

Recently, Bernard (2014) in 'The Guardian Newspaper'- a daily publication in Nigeria- pointed out that crude oil prices collapsed from US$104 per barrel to about US$82 per barrel and dropped further to $50.28 in 2014, which is less than 90% of Nigeria's foreign exchange earnings resulting to a deficit of 0.5 per cent of GDP. From the foregoing, it is clear that crude oil price variations play a significant role in macroeconomic fluctuations in both oil importing and exporting countries (Akpan, 2009; Mehrara and Mohaghegh, 2011). For fiscal and monetary policy makers to know what effort to make in order to stabilize Nigeria's economy, the extent to which macroeconomic variables are affected by the recent fall of crude oil price shocks should be known. This is what this study considers herein so as to evaluate how much is the effect of these oil price shocks, and to predict how subsequent shocks in the future can be controlled and/or minimized by some control measures in order to reduce its effect on the economy of Nigeria.

1.3 Aim and Objectives of Study

1.3.1 Aim

The aim of this study is to evaluate the impact of crude oil price shocks on some selected macroeconomic variables (exchange rate, external reserves, gross domestic product, inflation, international trade and money supply) in relation to the overall economic advancement in Nigeria.

1.3.2 Objectives

In order to achieve the aim stated above, the following objectives are used to:

1) evaluate crude oil shocks and the macroeconomic variables in terms of heteroscedasticity test in order to forecast the volatility of macroeconomic variables using GARCH model.
2) investigate the response of macroeconomic variables due to crude oil price shocks using Vector Autoregressive model.
3) estimate oil price shocks and its impact in the economy using Vector Autoregressive model.

1.4 Significance of Study

Examining the impact of crude oil price shocks on macroeconomic variables is vital because it can assist the fiscal and monetary authorities to know the extent to which oil price shocks affect macroeconomic variables so that adequate policies can be put in place in order to absorb the shocks, caution the effects, stabilize, improve the economy and predict measures that may be applied to future oil price shocks occurrences.

1.5 Scope and Limitations of Study

1.5.1 Scope of study

The scope of this study is limited to crude oil prices only- Freight on Board (dollars per barrel) - obtained from CBN Statistical database (2014).

1.5.2 Limitation of Study

This study is limited to six macroeconomic variables which were collected within the period of twenty years by CBN. The model that is used in achieving the objectives is limited to VAR and GARCH models which by extension adopt models like ARCH, Impulse Response Function, and Variance Decomposition. These are well-known techniques in statistics.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

Oil price fluctuations and shocks have been topics discussed among different scholars. This chapter entails the review of the existing body of knowledge concerning the effects of oil price shocks on macroeconomic variables. Relevant subjects to be discussed shall include an overview of crude oil prices, inflation rate, exchange rate and gross domestic product. Review of conceptual, empirical and theoretical works of previous scholars linked to asymmetric impact of oil shocks, impact of oil shocks on Nigeria's macro-economy and finally estimate oil price shocks on Nigeria economy using General Autoregressive Conditional Heteroscedasticity (GARCH) and Vector Autoregressive (VAR).

2.2 Nigeria Crude Oil Price Shocks

The Nigerian economy is known to derive its revenue from crude oil exports since 1970's which is greatly vulnerable to changes in oil prices. According to Akpan, (2009) and Ogbonna (2012), crude oil price shock is a sudden, unexpected change in oil price or production; or price fluctuations resulting from changes in either the demand or supply side of the international oil market. Stating the fundamental drivers of demand and supply, Baghirov (2014) pointed out that the causes of these changes affecting different economies consisting of both oil-exporting and oil-importing countries have been traced to external driven forces like wars, changes in political regimes, economic crises, formation or breakdown of trade agreements, unexpected weather patterns and so on.

2.2.1 Transmission channels of oil price shocks

From the foregoing, oil price changes are commonly admitted to be a significant factor in both oil-exporting and oil-importing economies. Based on the study of Weiqi *et al* (2009) and Baghirov (2014), there are several transmission channels through which oil prices affect an economy and macroeconomic variables and that include:(i) supply-side shock effect; (ii) wealth transfer effect; (iii) inflation effect; (iv) real balance effect; (v) sector adjustment effect; and (vi) the unexpected (uncertainty) effect.

Elaborating on these shock effects, Chuku (2012) gave the following explanation:

Supply-side shock effect – This effect considers oil as a production input, thus an oil price increase would lead to an increase in the cost of production, which would result in reduction of output, hence reducing aggregate supply. This lowers economic activity and growth. For an oil-exporting economy, higher revenues resulting from oil price shocks can contribute either positively or negatively to macroeconomic variables.

Wealth transfer effect – This transmission channel explains how the income is transferred from an oil-importing economy to an oil-exporting economy after the oil price shock occurred. As a result, the consumer demand is decreased in oil-importing economy and increased in oil-exporting economy.

Inflation effect – Oil price shocks also trigger the inflation in economy. As previously mentioned, oil price shocks increased the costs of production, which considered price shock as a consequence.

Real balance effect – In this case, an oil price shock impacts money demand. As an example, consumers tend to borrow and not to save, it increases the interest rates and decreases the demand for cash.

Sector adjustment effect – When an oil price shock occurs, the cost of adjusting to these changes in each sector of an economy can be a reason for a slowdown. As a result, energy-intensive sectors should be diminished and energy-efficient sectors should be expanded.

The unexpected (uncertainty) effect – This channel of an oil price shock affect investment demand of both consumers and producers. The future investments plans can be on hold when people are uncertain about oil prices going up or down. Apparently, this causes investment demand to fall (Baghirov, 2014).

Monday (2010) points to the fact that Nigeria is Africa's largest oil-producing state and the world's sixth largest exporter of crude oil, with an average daily production of 2.6 million barrels per day. He noted that oil in 2006 accounted for 80% of government revenues, 90% of foreign exchange earnings, 96% of export revenues and almost half of GDP.

Nigeria is an essential oil supplier to the United States. In the year 2010, Nigeria exported approximately 2.2 million bbl/d of total oil and 1.8 million bbl/d of crude oil. Over 40 percent of the country's oil production (980,000 bbl/d of crude oil, and slightly over 1 million bbl/d of the total oil and products) is exported to the United States making Nigeria the 4th largest foreign oil supplier to the United States in 2010; at the same time, Nigeria exports crude oil to South Africa (4 percent), Brazil (8 percent), and Europe (20 percent) (Monday, 2010). However, Obinna (2014) in 'This Day Newspaper' (one of the daily publication in Nigeria) of December 2014 stated that the decline in crude oil price of the global market is due to the increasing utilization of shale gas and other alternative sources of energy by the United States and other advanced oil importing nations.

According to Fattouh (2011), the new OPEC reference basket was introduced in June 2005 and it is currently made up of the following: Saharan Blend (Algeria), Girassol (Angola), Oriente (Ecuador), Iran Heavy (Islamic Republic of Iran), Basra Light (Iraq), Kuwait Export (Kuwait), Es-Sider (Libya), Bonny Light (Nigeria), Qatar Marine (Qatar), Arab Light (Saudi Arabia), Murban (UAE) and Merey (Venezuela).

2.3 Oil Price-Inflation Relationship

Black (2002) described inflation as a persistent tendency for price and money wages to increase. Inflation is measured by the proportional changes over time in some appropriate price index commonly a consumer price index or a GDP deflator. According to the World Bank (2012), consumer price index measure of inflation shows the yearly percentage change in the cost to the average consumer of purchasing a basket of goods and services that may be fixed or changed at particular interval of time. While GDP deflator as a measure of inflation is the rate of change in prices of goods and services in the entire economy.

2.3.1 Types of Inflation

Different kinds of inflation are commonly heard of today (Ogbonna, 2012). They are identified in an italicized form and succinctly explained below:

Hyperinflation: This is an extreme period of inflation, usually caused by a rapid increase in money supply due to unrestrained printing of fiat currency. *Stagflation* is a condition of slow economic growth, high unemployment, accompanied by rising prices and a decline in GDP. *Asset inflation* is when the price of land, shares rises more quickly than the rate of economic growth. According to Guy *et al*. (1998), inflation is a social malady as well as a universal economic phenomenon. Besides distorting prices, it erodes savings, discourages investment, stimulates capital flight, inhibits growth, makes economic planning a nightmare and causes political unrest. Governments consequently regard inflation as a plague and try to squelch it by adopting sustained and consistent fiscal and monetary policies.

Inflation can have positive and negative impact on the economic performance of a country (Guy *et al*., 1998). Positively, inflation can lead to a higher sustained growth due to the effect it has on capital accumulation. Also, the negative impact of inflation on productivity in an economy had adverse effects on economic growth. Khan and Asif (2006) mentioned that inflation may reduce a country's international competitiveness, by making its exports comparatively more expensive, thus impacting negatively on the balance of payments and making budget deficits to reduce both capital accumulation and productivity growth. On the contrary, some theories advocated that there is a positive relationship between inflation and economic growth.

Nicola *et al* (2012) observed that oil price increase in 2008 led to inflationary pressures in many developing economies especially severe in net oil-exporting countries. In the period of 2003–7, the inflation rate in these countries was always higher and more volatile than in other countries, whereas in 2007–8, the growth in inflation was considerably higher. While many developing countries have faced particularly strong inflation pressures since 2007 as a result of their large consumption shares of food and fuel products, however, this is not explained by a higher share of fuel in aggregate consumption in oil-exporting countries, but by the tendency of these countries to apply expansionary fiscal policies.

Clarifying inflationary pressures, Adenuga *et al* (2012) noted that they manifest themselves when the overall demand for goods and services grow faster than the supply, causing a drop in the amount of unused productive resources. Monetary policy is another reason for any persistent change in the inflation rate. Many economists in the 1970s argued that relative price changes, even that of OPEC oil shocks would only be inflationary if accommodated by monetary policy. A study by Allegret and Benkhodjay (2011) for the period of 1990–2010 in Algeria concluded that, in order to stabilize output and inflation, monetary policy should focus on a core inflation target- structural change to the financial sector and financial regulation institutions in order to strengthen the role of the interest rate as a transmission channel for monetary policy.

Recently, National Bureau of Statistics (NBS, 2014) revealed the inflation rate in Nigeria to be 8.50 percent in August 2014. Inflation rate in Nigeria averaged 12.36 percent from 1996 until 2014, reaching an all-time height of 47.56 percent in January 1996 and a record low of -2.49 percent in January 2000.

From the foregoing, this study examines whether the impact of inflation under the influence of crude oil prices is positive or negative to the Nigerian economy within the period of twenty years (1995-2014).

2.4 Oil Price- Exchange Rate Relationship

The exchange rate measures the value of one currency in terms of another. The equilibrium exchange rate is the price at which demand for that particular currency equals supply (Sorensen and Whitta, 2010). The exchange rate channel works both through aggregate demand and aggregate supply effects. Oil price changes affect the real economy indirectly through the foreign exchange markets that facilitates international trade and financial transactions between open economies by allowing currencies to be exchanged. In oil-exporting countries, oil price fluctuations transmit to the exchange rate. Since any rise or fall in oil price is not permanent, oil revenue variation injects instability to the economy (Mohsen and Mohaghegh, 2011).

Korhonen and Juurikkala (2009) noted that real oil price has a significantly direct effect on the exchange rate of oil-producing countries. An increase in oil price triggers high demand for a country's currency likely leading to an appreciation of currency net exporting country. On the other hand, a decrease in oil price might lead to a depreciation of the currency as the demand for that particular currency decreases. This analogy concurs with the perception that changes in oil price might cause fluctuations in an oil-exporting country's exchange rate. Mishkin and Savastano (2001) noted also that exchange rate regimes is important for the response of the economy to oil price changes because the value of the currency keeps fluctuating along with the movements of the foreign exchange market. According to Rafiq (2011), several oil-producing countries have a fixed exchange rate regime to stabilize the domestic revenues of oil exports. In this case, oil exports cannot respond to a change in the exchange rate. However, Friedman (1953) stated that an advantage of flexible exchange rate regimes over fixed exchange rate regimes is that they allow a smoother adjustment to real shocks even under nominal rigidities.

Al-Abri (2008) also claimed that the flexible exchange regimes better absorbs real external shocks and the responses to positive oil price shocks of the real exchange rate, the inflation rate and growth in GDP exhibit a faster and smoother adjustment to their long run equilibrium. More so, Broda (2001) mentioned that monetary policy is another channel in which a flexible exchange rate regime is able to smooth shocks. In the presence of a negative real shock, the countries conducting flexible exchange rate can use monetary policy to reduce the interest rate by means of an expansionary policy. However, under fixed exchange rate regime, negative real shocks are deflationary. Exchange rate movements and fluctuations have become a vital issue of macroeconomic analysis, capturing the interest of academics, financial economists and policy makers. Hence, it is worth analyzing the impact of an oil price shocks on exchange rate.

2.5 Oil Price- GDP Relationship

Gross Domestic Product (GDP) refers to the value of all final goods and services produced within a country or an area in a period of time (a quarter or a year), and is often considered the best standard of measuring national economic conditions (Mankiw and Taylor, 2007). As one of the most important measures in macroeconomics, Gross Domestic Product per capita (GDP per capita) is often used as a tool to study macroeconomic situation and a measure of economic development of a country or a region.

The significance of GDP per capita as a measure of economic development can be seen in two aspects: Firstly, Yan (2011) reveals that GDP per capita reflects the level and degree of economic development in industrialized countries. Secondly, GDP per capita has been shown to be related to the level of social stability in a country (Chen and Chen, 1996).

When compiling Nigeria's GDP, three approaches were used namely, Output, Income and Expenditure. While the output approach is quarterly compiled, the income and expenditure approaches are annually compiled. However, the importance of presenting these three approaches on a quarterly basis is to aid proper policy decisions.

This research therefore, presents an attempt to undertake quarterly GDP series by output approach.

According to Sabiu and Kouhy (2014), the effect of changes in the price of oil on GDP can be understood via its demand or supply side effect. The demand side effect is the situation where the prices of petroleum products increases as a result of increased economic activity which results in high demand of oil and this is consistent with the theory that the higher the demand the higher the prices. In this context, the effect on GDP will be positive. On the other hand, if the increase in oil prices is due to supply side effect, then the effect on GDP could be negative which shows that rising oil prices are indicators to the reduced availability of essential input in production, leading to a reduction in prospective output (Barro, 1984; Brown and Yucel, 1999; Abel and Bernanke, 2001; Brown and Yucel, 2002).

Another empirical study that shows the relationship between oil prices and GDP is the one conducted by Hamilton (2005) and Brown and Yucel (2002). The findings of these studies show that oil price increases have negative effects on output. Reinforcing the importance of oil price on GDP, Maeda (2008) stated: "rising oil prices can fuel a decline across a country's domestic economy by raising production costs for companies". He further argued that "the International Energy Agency, (2004) calculated the effect of high oil prices on lowering gross domestic product (GDP) using a large scale computer simulation". Maeda, (2008) underscored that the agency computed the decline rate of GDP in some major countries by comparing two cases namely: a base line case showing what would happen if oil prices remained at US$25 per barrel for the five-year period starting in 2004, and a high price case showing what would happen if the price rose to US$35 per barrel and remained at that level. The result showed that in the high price case, GDP would fall to 0.3 per cent in the United States, 0.4 per cent in Japan, and 0.4 per cent in the Euro-zone countries. However, Sabiu and Kouhy (2014) noted that the above mentioned countries are developed and industrialized oil importing countries; therefore it cannot be concluded that the same scenario would be perceived in a net oil exporting developing country like Nigeria. Therefore, the effect of high oil price on the GDP in Nigeria is subject to this empirical study.

2.6 Conceptual Review

2.6.1 Crude Oil Shock

Chuku (2012) attested to the fact that oil price shocks are unexpected and unpredictable changes in global oil prices, caused by exogenous factors, which are likely to impact on endogenously determined economic variables. Similarly, Akpan, (2009) defined oil price shocks as price instabilities that bring about changes in either the demand or supply sides of the international oil market as earlier noted by Hamilton, (1983) and Wakeford, (2006). In other words, oil price shocks can also be understood as a sudden hike in prices that had been found to cause a fall in global output and a large boost in the relative international price of oil. Furthermore, Nordhaus (2007) defined oil price shock as an inward shift in the supply curve for crude oil that is triggered by political events exogenous to the oil market and the macro economy. In this study, the definition of Akpan (2009) is adopted for ease of quantification of crude oil shocks on macroeconomic variables.

2.6.2 Literature and Theoretical Issues on GARCH

A number of empirical studies on the impact of oil price shocks to the macroeconomic variables in some countries have been carried out using various estimation approaches. The analysis and results of the previous studies are synthesized into a brief summary. Furthermore, after comparing previous studies that have been done, this chapter looks for the gap in order to do further research that has not yet been done.

Janne (2012) specified the structure of GARCH model in forecasting time-varying volatility and volatility clustering in finance; and by extension used exponential GARCH model which responds asymmetrically to positive and negative excess spot prices, beginning with pre-estimating a sample of 3050 daily observations of USD/EUR exchange rates between January 1999 and November 2010. By using autocorrelation and partial autocorrelation functions, it is shown that the data is heteroscedastic. Then GARCH(1,1) model is fitted and the validation of it is tested using Ljung-Box-Pierce Q-test and Engle's ARCH test.

Similarly, Tatyana (2010) investigated the dynamics of oil prices (Brent and WTI crude oil markets) and their volatilities. Forecasting its volatility and determining fundamental factors that explain its dynamics, four GARCH-related models were compared namely: GARCH(1,1) GJR-GARCH(1,1), EGARCH(1,1) and APARCH(1,1). The findings suggest that oil shocks have permanent and asymmetric effects on volatility for both markets considered.

Kang *et al*. (2009) investigated the efficiency of a volatility model with regard to its ability to forecast for three crude oil markets (Brent, Dubai, and WTI). It was shown that the CGARCH and FIGARCH models are better equipped to capture persistence than are the GARCH and IGARCH models. On the other hand, Oyetunji (2013) examined the effects of oil price, external reserves and interest rate on exchange rate volatility in Nigeria using yearly data between 1970 and 2011 based on GARCH and EGARCH. It was observed that a proportionate change in oil price led to a more than proportionate change in exchange rate volatility in Nigeria by 2.8%.

Estimating and forecasting petroleum oil import prices in Ethiopia, Leykun (2012) studied monthly petroleum oil import from July 1999 to June 2011 using GARCH approach. GARCH(1,1) was found to be a suitable model in forecasting oil import prices of Ethiopia due to its ability to capture the non-constant conditional variance showing that import petroleum oil prices are expected to increase from July 2011 to June 2013 with some fluctuations as a result of volatility.

More so, Haydee (2008) delved into the volatility feature of Philippine monthly inflation from 1995 to August 2007, applying Generalized Autoregressive Conditional Heteroscedasticity (GARCH) model. Diagnostic tests and examination of forecast accuracy measures indicate that the specifications D(IR) (the first difference of month-on-month inflation) as the stationary series, AR(1) and SMA(12) for the mean, GARCH(0,1) or ARCH(1) for the variance with Student-t distribution having fixed degrees of freedom v = 10 for the errors, performs best in forecasting the volatility of the inflation rate for the Philippines. From the foregoing, a few works have been done examining and forecasting the volatility of crude oil shocks and macroeconomic variables; therefore this present study intends to fill this gap.

2.6.3 Literature and Theoretical Issues on VAR

Mulyadi (2012) investigated the effect of the world's oil prices on a quarterly-based GDP, inflation and exchange rate in Indonesia as a net oil exporter country and as a net oil importer country between 1999_{Q1} and 2011_{Q4}. Using VECM method, the findings revealed that while higher oil prices led to higher GDP in the long run, higher oil prices led to higher inflation and exchange rates in the short run and are insignificant. In the long run, higher oil prices contributed to higher GDP. As a net oil importer, higher oil prices elicited lower GDP, triggered inflation increases and exchange rates but insignificant in Indonesia than the period when Indonesia acted as net oil exporter.

In estimating the impact and transmission channels of oil price shocks on investment and how it affects the Nigerian economy, Ogundipe and Ogundipe (2012) used annual data on interest rate, exchange rate, savings and output measured by real GDP from 1970 to 2011, adopting a VAR approach along with its components- impulse response functions, variance decompositions and Granger Causality tests to examine the interrelationship among the variables. It was evident that oil price shocks influences other variables that significantly influences Real GDP (RGDP) like investment, exchange rates and savings. However, oil price shocks have little impact on Real GDP indirectly because effects of oil shocks on the other variables affect RGDP.

Baghirov, (2014) investigated the direct and indirect effects of an oil price shocks on economic growth of Lithuania taking into consideration its trade linkages with main trade partners numbering seven which include Russia, Germany, Netherlands, France, Poland, Lithuania and Latvia, from the 2nd quarter of 1995 till the 4th quarter of 2012 with sample size consisting of only 71 observations. Quarterly data on oil prices and Real GDP growth rates of selected countries were used under the estimated structural VAR model. The empirical analysis indicates that the indirect effects of a 50% increase in oil price growth rates on real GDP growth are positive, while the direct effects are negative. Moreover, the positive indirect effects through the trade linkages mitigate the negative direct effects of oil price shock both in short and long run. The case study of Lithuania proved the fact of Rasmussen and Roitman (2011) that "oil-importing economies can actually weaken and mitigate the direct negative effects from the oil price shocks by the indirect positive effects that may come through the intensive trade linkages with an oil-exporting economy"

Furthermore, in studying the impact of oil price fluctuations on macroeconomic variables in Nigeria as an oil exporting and oil dependent country, Gunu and Kilishi (2010) utilized VAR model to analyze four key macroeconomic variables namely real GDP, money supply, consumer price index and unemployment. The results show that oil prices have significant impact on real GDP, money supply and unemployment, while consumer price index is insignificant. This implies that the three macroeconomic variables in Nigeria are significantly explained by oil shocks termed exogenous and highly volatile variable. Hence, the economy is disposed to external shocks, macroeconomic performance would be volatile and macroeconomic management would become difficult. Gunu and Kilishi (2010) constituted these as serious implication for macroeconomic management of the country because money supply is a major macroeconomic policy instrument, while GDP and unemployment are key macroeconomic policy targets.

Akinyele and Ekpo, (2013) examined the macroeconomic implications of symmetric and asymmetric oil price and oil revenue shocks in Nigeria, using VAR estimation model on seven variables such as government expenditure, GDP, inflation rate proxy by the Consumer Price Index, interest rate, effective exchange rate, volume of import and external reserves collected quarterly between 1970 to 2010. Results show that both positive and negative oil price shocks influence government expenditure in the long run; positive oil price shocks have stronger short and long run effects on real GDP, triggering inflationary pressure and domestic currency depreciation as importation rises implying that the country exhibits the Dutch disease syndrome in the short and long run. Thus, oil revenue shocks are capable of impeding economic growth only in the long run.

Olomola and Adejumo, (2006) investigated the impact of oil price shocks on aggregate economic activity (output, inflation, real exchange rate and money supply) in Nigeria using quarterly data from 1970 to 2003 under VAR model. The findings revealed that contrary to previous empirical findings, oil price shocks do not affect output and inflation in Nigeria significantly. However, oil price shocks were found to significantly influence the real exchange rate. They argued that oil price shocks may give rise to wealth effect that appreciates the real exchange rate and may squeeze the tradable sector, giving rise to the "Dutch-Disease".

In a related study, El-Anshasy *et al.* (2005) assessed the effects of oil price shocks on Venezuela's economic performance from 1950 to 2001. They adopted VAR and VECM techniques to investigate the relationship between oil prices and the variables: governmental revenues, government consumption (spending), GDP and investment. The results show two long-run relationships consistent with economic growth and fiscal balance. Furthermore, they found out that this relationship is important not only for the long-run performance but also for short-term fluctuations.

Akpan (2009) ascertained the dynamic relationship between oil price shocks and major macroeconomic variables (government expenditure, industrial GDP per capita, inflation, effective exchange rate, import and money supply) within the length of 1970_{Q1} – 2007_{Q4} in Nigeria by applying a VAR approach which precedes unit root test and Johansen maximum-likelihood approach to test whether co-integration exist among variables. The result shows that positive and negative oil price shocks significantly increased inflation and also directly increased real national income through higher export earnings. It also shows a strong positive relationship between positive oil price changes and real government expenditures.

2.7 Gaps Identified in Literature

From the foregoing literatures, a gap is noticed in Akpan's work wherein the macroeconomic variables were merely assumed to be homoscedastic instead of subjecting the study variables to heteroscedasticity test to know which of them conformed to the assumption of GARCH model (presence of heteroscedasticity) or VAR model (absence of heteroscedasticity; that is, homoscedasticity). Therefore this study is subjecting the time series data to heteroscedasticity test using five of the variables (crude oil price shocks, exchange rate, gross domestic product, inflation and money supply) and two other variables (external reserves and international trade) with updated data (1995Q1 - 2014Q4).

CHAPTER THREE

METHODOLOGY

3.1 Introduction

In this chapter, the methods used in this dissertation is presented beginning with a brief introduction of the key models used to evaluate the effects of crude oil price shocks have on macroeconomic variables using GARCH and VAR approaches, discussion about their main properties, some of their modifications and statistical tools applied in time series modeling.

3.2 Data for the study

Data obtained for this study were sourced from CBN (2014) Statistical database comprising of quarterly Crude Oil Prices (COP), Exchange Rate (EXCHR), External Reserves (EXRS), Gross Domestic Product (GDP), Inflation Rate (INFL), International Trade (INTR) and Money Supply (MSUP) data located in **Appendix I**. Quarterly series are preferred as it increases the data points and provides greater degrees of freedom (Akpan, 2009). These time series data covers the period of twenty (20) years beginning from January 1995Q1 to December 2014Q4. The macroeconomic variables were all log transformed and differenced representing Exchange Rate, External Reserves, Gross Domestic Product, Inflation, International Trade and Money Supply as endogenous variables while crude oil price is denoted as exogenous variable. This study used E-views version 7 (2009) software for its analysis.

3.3 Stages Incorporated in Estimating Volatility Models

To structure a volatility model for price series of crude oil shocks and macroeconomic variables, the fundamental stages are outlined as follows:

1) Test for stationarity of the price series to avoid counterfeit results

2) Specify the mean equation by fitting an econometric model like AR (Autoregressive Model), MA (Moving Average), or ARMA (Autoregressive Moving Average) from the observation of ACF (Autocorrelation Function) and PACF (Partial ACF).
3) Use the residuals of the mean equation to test for ARCH effects.
4) If ARCH effects are statistically significant, specify volatility model by means of GARCH estimation.
5) Diagnostically check the fitted model, improving on it when needed.

3.4 Number of Lag Length

To capture the effect of one variable to the other variables in time series requires lag length and this can be optimally determined in two ways viz: frequency of the data - like using 12 lags for monthly data and 4 lags for quarterly data (Sims, 1980; Gronwald, 2006); and information criterion which are several like Akaike Information Criterion (AIC), Schwarz Information Criterion (SIC) and Hannan Quin Information Criterion (HQ), Bayesian Information Criterion (BIC). Going by the second option, the lag length would be determined by Akaike Information Criterion (AIC) in this study because it is better for small sample size (120 below) and takes care of over fitting of the models, in conformity to the suggestion of Akinyele and Ekpo (2013).

3.5 Normality Test (Using Jarque-Bera Test)

Jargue-Bera is a joint test of skewness and kurtosis that examines whether data series follow normal distribution or not (Henrik, 2010). This test was developed by Jargue and Bera (1980).

The null hypothesis is

H_o: $a_1,..., a_m$ is normally distributed versus $H_{1:}$ $a_1,..., a_m$ is not normally distributed and asymptotically the test statistic is χ^2 distributed with 2 degrees of freedom.

where are the study variables (COP, EXCH, EXRS, GDP, INFL, INTR, MSUP).

The Jarque-Bera test statistic is defined as:

$$\frac{N}{6}\left(S^2 + \frac{(K-3)^2}{4}\right) \sim \chi^2 \tag{3.1}$$

where *S*, *K*, and *N* represent Skewness, Kurtosis, and the size of the macroeconomic variables respectively.

Skewness is a measure of asymmetry of the slope in the normal distribution. If S > 0, the distribution is skewed to the right, having a tail of more observations that trail off to the right (Hun, 2008). It is statistically defined as (Henrik, 2010):

$$\text{Skewness} = \frac{\sum_{i=1}^{n}(x_i - \bar{x})^3}{nS^3} \tag{3.2}$$

Where x_i represents COP, EXCHR, EXRS, GDP, INFL, INTR and MSUP, while $\bar{x}$ signifies individual mean; n is the sample size, S is the standard deviation of each variables.

Kurtosis is a measure of flatness (platykurtic) or peakedness (leptokurtic) of the top of a normal distribution. If K < 3 for macroeconomic variables, lower peak with thicker tails results, but if K > 3, higher peak with thin tails results. A normally distributed random variable should have skewness and kurtosis near zero and three, respectively. It is defined as (Henrik, 2010):

$$\text{Kurtosis} = \frac{\sum_{i=1}^{n}(x_i - \bar{x})^4}{nS^4} \tag{3.3}$$

3.6 The Stationary Test (Augmented Dickey Fuller Test)

Stationarity of the data series is among the key assumptions in financial time series. If not stationary, data series should either undergo differencing by determining the order of integration (that is, number of times they are to be differenced to achieve stationarity) or transformation by log, square root and multiplicative inverse. There are various stationarity tests such as Dickey and Fuller (DF), Augmented Dickey and Fuller (ADF), Philips Perron (PP), Kwiatkowski, Phillips, Schmidt and Shin (KPSS). In this study, ADF test is chosen because it uses a parametric autoregressive structure to capture serial correlation. The unit root test proposed by Dickey and Fuller (1979) is given by

Null hypothesis is $H_0 : \phi_1 = 1$

Alternative hypothesis is $H_1 : \phi_1 < 1$

Test Statistic (t-ratio):

$$= \frac{\phi_1^n - 1}{S(\phi_1)}$$

$$= \frac{\sum_{t=1}^{T} P_{t-1} e_t}{\sigma^2 \sqrt{\sum_{t=1}^{T} P_{t-1}^2}} \qquad (3.4)$$

where $$\phi_1 = \frac{\sum_{t=1}^{T} p_{t-1} p_t}{\sum_{t=1}^{T} p_{t-1}^2},$$

$$\hat{\sigma}^2 = \frac{\sum_{t=1}^{T} (p_t - \hat{\phi}_1 p_{t-1})^2}{T-1}.$$

p_t is present data series, p_{t-1} is previous data series, e_t is the error term at time t, $P_0 = 0$ and T is the sample size.

The null hypothesis is rejected if the t calculated value is greater than t critical value ($t_{critical}$ = 2.45).

3.7 Model Selection

3.7.1 Akaike Information Criterion (AIC)

Akaike information criterion was proposed by Hirotsugu Akaike in 1974 as a measure of model selection for an estimated statistical model. When comparing models, the underlying aim is to choose the "best approximating model" from among competing models being considered. Various model selection criteria have been proposed based on different considerations.

The most prominently used method is the Akaike Information Criterion (AIC, 1974). The process selects the best model with the lowest AIC. Basically, AIC (1974) involves the idea of cross-validation, but only on theoretical sense.

The AIC (1974) values can be defined as follows

$$AIC = 2K - 2\ln(L) = 2K - 2\ln\left(\frac{RSS}{n}\right) \quad (3.5)$$

RSS = $\sum_{t=1}^{n} \varepsilon^2$

where K is the number of parameters in the model and L is the maximized value of the likelihood function for the model and RSS is the residual sum of squares.

3.8 Test for ARCH Effects (Heteroscedasticity)

An Autoregressive Conditional Heteroscedasticity (ARCH) effect is used to describe whether the residuals exhibit correlation among its squared data series. In testing for the presence of heteroscedasticity, Lagrange multiplier (LM) proposed by Engle (1982) is used over Ljung-Box test because residuals are often found to be serially correlated with their own lagged values (Leykun, 2012). To build an ARCH model (q), estimate the best Autoregressive Moving Average ARMA (p, q) model in order to remove any linear dependence in the residuals by determining its order via autocorrelation function (ACF) and partial autocorrelation function (PACF) of the residuals of ARMA model $\{\varepsilon_t\}$. For example, in ARMA (1,1) process, the conditional mean equation will be as:

$$r_t = \phi_1 r_{t-1} + \varepsilon_t + \theta_1 \varepsilon_{t-1} \quad (3.6)$$

after obtaining the residuals e_t, the next step is to regress the squared residual on a constant and its q-lags as in the following equation:

$$e_t^2 = \alpha_0 + \alpha_1 e_{t-1}^2 + \ldots + \alpha_q e_{t-q}^2 + v_t \quad (3.7)$$

The null hypothesis, that there is absence of ARCH effect up to order q can be formulated as:

$$H_0 : \alpha_1 = \ldots = \alpha_q = 0$$

against the alternative

$$H_a : \alpha_i \neq 0 \text{ for some } i \in \{1, \ldots, m\}$$

The test statistic for the joint significance of the q-lagged squared residuals is the number of observations times the R-squared (TR^2) from the regression. TR^2 is tested against $\chi^2_{(q)}$ distribution.

3.9 Generalize Autoregressive Conditional Heteroscedasticity Model

Bollerslev (1986) broadened Engle's (1982) inventive work by formulating a method called Generalized ARCH (p, q) model in which q lags of past conditional variance were added into the equation and that allows the conditional variance to be an ARMA process (Leykun, 2012). The GARCH (p, q) model is stated as follows:

$$\sigma_t^2 = \alpha_0 + \sum_{i=1}^{q} \alpha_i \varepsilon_{t-i}^2 + \sum_{j=1}^{p} \beta_j y_{t-j}^2 \quad (3.8)$$

where $\alpha_i > 0$ and $\beta_i > 0$ for all i and j

and σ_t^2 is the conditional variance of the estimated parameter, α_0 is the constant term, $\alpha_i = 1,2,..., q$ are the parameter coefficient of the ARCH term ε_{t-1}^2, and $\beta_j = 1,2,..., p$ are the parameter coefficient of the GARCH term y_{t-j}^2. The order of the ARCH is q while the order of the GARCH is p. The ARCH term captures the influence of the previous error terms, while the GARCH term captures the influence of the previous volatility values (Christoph and Nils, 2012).

Showing an explicit expression of GARCH model for a parameter

GARCH (1, 1) $$\sigma_t^2 = \alpha_0 + \alpha_1\varepsilon_{t-1}^2 + \beta_1 y_{t-1}^2 \qquad (3.9a)$$

GARCH (1, 2) $$\sigma_t^2 = \alpha_0 + \alpha_1\varepsilon_{t-1}^2 + \beta_1 y_{t-1}^2 + \beta_2 y_{t-2}^2 \qquad (3.9b)$$

GARCH (2, 1) $$\sigma_t^2 = \alpha_0 + \alpha_1\varepsilon_{t-1}^2 + \alpha_2\varepsilon_{t-2}^2 + \beta_1 y_{t-1}^2 \qquad (3.9c)$$

GARCH (2, 2) $$\sigma_t^2 = \alpha_0 + \alpha_1\varepsilon_{t-1}^2 + \alpha_2\varepsilon_{t-2}^2 + \beta_1 y_{t-1}^2 + \beta_2 y_{t-2}^2 \qquad (3.9d)$$

where α_2 is the coefficient of the previous day two square error ε_{t-2}^2; β_2 is the coefficient of the previous day two square volatility values y_{t-2}^2.

The GARCH (p, q) with z_t which is a discrete time stochastic process defined by:

$\varepsilon_t = z_t\sigma_t$, and equation is weakly stationary with

$$E(\varepsilon_t) = 0 \text{ and } var(\varepsilon_t) = \alpha_0\left[1 - \left(\sum_{i=1}^{p}\alpha_i + \sum_{j=1}^{q}\beta_j\right)\right]^{-1} \qquad (3.10)$$

and

$$cov(\varepsilon_t, \varepsilon_t) = 0 \text{ for } t \neq s \text{, if and only if } \sum_{i=1}^{p}\alpha_i + \sum_{j=1}^{q}\beta_j < 1, \ (\alpha_0 > 0) \qquad (3.11)$$

3.10 Diagnostic Check of the Residuals

When a model has been fitted to a time series, it is appropriate to check the adequacy of fitted estimated ARCH-GARCH models by examining whether there is presence of autocorrelation in the residuals. That is to say, if the model really does provide an adequate description of the study variables, σ_t. The Lagrange Multiplier of σ_t is used to check the adequacy of the mean equation and that of σ_t^2 is used to test the validity of the volatility equation (Peter and Richard, 2002).

3.11 Forecasting Evaluation

Evaluating the performance of varied forecasting models plays a very essential part in selecting the best accurate models, since fiscal and monetary authorities would need to make a decision based on evaluative criteria. To forecast conditional variance from the estimated GARCH model, statistical loss functions like the Mean Absolute Error (MAE) which computes the mean of all the absolute errors, instead of squared forecast errors and Root Mean Square Error (RMSE) are employed. MAE is more popular in use as it does not require squaring, hence, it is considered easier to implement. The performance measures are as follows Vee *et al* (2009):

$$\text{MAE} = \frac{1}{n}\sum_{t-1}^{n} | r_t^2 - \sigma_t^2 | \qquad (3.12)$$

and

$$\text{RMSE} = \sqrt{\frac{1}{n}\sum_{t=1}^{n} (r_t^2 - \sigma_t^2)^2} \qquad (3.13)$$

where r_t^2 is the realized or actual variance, σ_t^2 is the square root of the conditional forecasted variance and n is the number of fitted parameters.

3.12 Variance Autoregressive (p)-Models With More Than Two Variables

Vector Autoregressions (VARs) introduced by Sims (1980) provide a flexible and tractable framework where changes in a particular variable (oil price) are related to changes in its own lags and to changes in macroeconomic variables (EXTR, GDP, INFL, INTR and MSUP) and the lags of those variable. VAR model is also known for its ability to avoid imposing *a priori* restrictions on structural relationships and VAR treats all variables as endogenous.

A VAR (p)-Model is given as Eltony, (1999):

$$\mathrm{Y}_t = \alpha + \sum_{i=1}^{k} \mathrm{A}_i y_{t-1} + \varepsilon_t \tag{3.14}$$

where Y_t = (COP, EXTR, GDP, INFL, INTR and MSUP) is a k vector of endogenous variables; α is vector of constants, y_{t-1} are corresponding lag term for order i; A_i is the $n \times n$ matrix of coefficients to be estimated, k is the number of lagged terms and ε_t is the $n \times 1$ vector of innovations that may be contemporaneously correlated with each other but are uncorrelated with their own lagged values and all of the right-hand side variables.

Expanding Equation (3.14) gives:

$$\begin{bmatrix} Y_{1t} \\ . \\ . \\ . \\ . \\ Y_{6t} \end{bmatrix} = \begin{bmatrix} \alpha_1 \\ . \\ . \\ . \\ . \\ \alpha_6 \end{bmatrix} + \begin{bmatrix} A_{11} & . & . & . & . & A_{16} \\ . & . & . & . & . & . \\ . & . & . & . & . & . \\ . & . & . & . & . & . \\ . & . & . & . & . & . \\ A_{61} & . & . & . & . & A_{66} \end{bmatrix} \begin{bmatrix} y_{1t-1} \\ . \\ . \\ . \\ . \\ y_{6t-1} \end{bmatrix} + \begin{bmatrix} e_{1t} \\ . \\ . \\ . \\ . \\ e_{6t} \end{bmatrix} \tag{3.15}$$

The order of variables Y_t = (COP, EXTR, GDP, INFL, INTR and MSUP) is important mainly for innovation accounting (Akpan, 2009).

Since the VAR expresses the dependent variables in terms of predetermined lagged variables, it is neither recursive nor structural but a reduced-form model formulated as (Akpan, 2009):

$$Y_t = A_0 + A_1Y_{T-1} + A_2Y_{T-2} + A_3Y_{T-3} + A_4Y_{T-4} + A_5Y_{T-5} + A_6Y_{T-6} + a_t \quad (3.16)$$

This can also be written as

$$Y_t = A_0 + \sum_{n=1}^{k} A_iY_{T-1} + a_t \quad (3.17)$$

3.13 Assumption of Variance Autoregressive Models

To test the adequacy of the model structure for crude oil price shocks and macroeconomic variables, the following conditions (assumptions) have to be fulfilled:

1) Absence of serial correlation between residuals to avoid spurious results.
2) Test for absence of heteroscedasticity (thatis, homoscedasticity) in the residuals.

3.14 Impulse Response Function (IRF)

An impulse response function comes after VAR estimation which traces the effect of a one-time shock to one of the innovations on current and future values of the endogenous variables. The innovations, ε_t, are usually correlated. So, in order to interpret the impulses (associated with a specific variable), it is common to apply a transformation, so that they become uncorrelated (Eltony, 1999). The equation of IRF is given as (Akpan, 2009):

$$z_t = \sum_{i=1}^{\infty} \phi_i e_{t-i} \quad (3.18)$$

Showing explicitly with the study variables, a six-variable VAR (1) model can be rewritten as

$$z_t = \begin{bmatrix} LCOP_{t\,t} \\ LEXRS_t \\ LGDP_t \\ LINFL_t \\ LINTR_t \\ LMSUP_t \end{bmatrix}, \quad \phi_i = \begin{bmatrix} \phi_{11}^{(i)} \phi_{12}^{(i)} \cdots \phi_{16}^{(i)} \\ \phi_{21}^{(i)} \phi_{22}^{(i)} \cdots \phi_{26}^{(i)} \\ \phi_{31}^{(i)} \phi_{32}^{(i)} \cdots \phi_{36}^{(i)} \\ . \\ . \\ \phi_{61}^{(i)} \phi_{62}^{(i)} \cdots \phi_{66}^{(i)} \end{bmatrix}, \quad e_t = \begin{bmatrix} e_{1t} \\ e_{2t} \\ . \\ . \\ . \\ e_{6t} \end{bmatrix} \tag{3.19a}$$

$$\text{cov}(\varepsilon_1 \varepsilon_2 \ldots \varepsilon_6) = 0 \tag{3.19b}$$

where z_t is a vector of (LCOP, LEXCHR, LEXRS, LGDP, LINFL, LINT and LMSUP) endogenous variables, ϕ_i are the matrices *impulse response functions* of the variables, vector e_t is called *innovations* and e_{t-1} is the corresponding lags of the matrices.

Interpretation:

$\phi_{21}^{(0)}$ – expected instantaneous impact of a one-unit change in ε_{1t} on y_t

$\phi_{21}^{(1)}$ – expected one-period response of a one-unit change in ε_{1t-1} on y_t

$\sum_{i=1}^{p} \phi_{11}^{(i)}$ – the cummulated effect of a change in ε_{1t-1} on the sequence of $\{y_{t+i}\}$, $i = 1,2,\ldots,p$

3.15 Variance Decomposition (VD)

The estimation of impulse response is denoted by VD and is also known as Forecast Error Variance Decomposition (FEVD) which assesses the relative importance of a variable in generating variations in its own value and in the value of other variables; that is, to say, VD assesses the relative importance of oil price shocks in the volatility of the macroeconomic variables in the system, indicating the amount of information forecast error variance of each of the variables that can be explained by exogenous shocks to the other variables in a VAR model (Sims, 1986).

In obtaining the forecast error variance of the study variables, deductive equation is derived from VAR (p) model as (Apere and Ijomah, 2013):

$$Y_t = A_t y_{t-1} + A_2 y_{t-2} + ... + A_p y_{t-p} + \varepsilon_t \quad (3.20)$$

where Y_t = (COP, EXTR, GDP, INFL, INTR and MSUP) is vector of endogenous variables y_{t-1} are corresponding lag term for order i; A_i is the $n \times n$ matrix of coefficients to be estimated, and ε_t is the $n \times 1$ vector of innovations.

The above equation can be restated in an infinite moving average form as:

$$Z_t = \sum_{j=0}^{\infty} A_j u_{t-j} \quad (3.21)$$

where z_t is a vector of (LCOP, LEXCHR, LEXRS, LGDP, LINFL, LINT and LMSUP) endogenous variables, A_j is the $n \times n$ matrix of coefficients, u_{t-j} is corresponding lag term for order j.

The matrix A_j is computed using the recursive relation, (Apere and Ijomah, 2013)

$$A_j = \phi_1 A_{j-i} + ... + \phi_p A_{j-p} \quad (3.22)$$

The forecast error of predicting Z_{t+N} conditional on information at time $t-1$ is given as:

$$\xi(N) = \sum_{\ell=0}^{N} A_\ell u_{t+N-\ell} \quad (3.23)$$

where $\xi(N)$ - predicted vector of the endogenous variables

A_ℓ - matrices of the forecast error for each variables

$u_{t-N-\ell}$ - corresponding lags for the forecast error matrices of the variables

N - is the number of forecasted lags

CHAPTER FOUR

ANALYSIS, RESULTS AND DISCUSSION

4.1 Introduction

This chapter presents in detail key empirical results of the analysis regarding evaluating crude oil shocks and the macroeconomic variables (exchange rate, external reserves, gross domestic product, inflation, international trade and money supply) under GARCH model estimation in order to forecast the volatility model; and as well fit in VAR model to explore the response of macroeconomic variables to asymmetric and innovations in crude oil shocks.

In the first phase of this analysis, the data collected is log transformed to get rid of big outliers. Following that, is the descriptive statistics of the macroeconomic variables, time plot (trend) for data series, unit root test, specification of the suitable mean equation for data series, test for ARCH effect, estimation of the parameters of the volatility models, forecast performance evaluation of GARCH models using Mean Absolute Error and Root Mean Square Error. Subsequently, VAR model through the Impulse Response Function and Variance Decomposition would be estimated.

4.2 Descriptive Statistics

Beginning with the statistical properties to determine the normality of the study variables, the probability of the Jarque-Bera statistics tells whether the distribution is normal or not. Therefore if the probability is less than 0.05, we reject the null hypothesis and conclude that the distribution is not normal. Table 4.1 shows the descriptive statistics variables used in this study.

Table 4.1 Descriptive statistics of the macroeconomic variables

STATISTICS	LCOP	LEXCHR	LEXRS	LGDP	LINFL	LINTR	LMSUP
Mean	1.638373	2.103145	4.188198	6.472774	1.762451	6.084931	6.141282
Median	1.658447	2.139233	4.259344	6.447593	1.783290	6.260163	6.134508
Std. Dev.	0.319582	0.103431	0.453583	0.379605	0.284525	0.767719	0.547123
Skewness	-0.06617	-0.638248	-0.531372	-0.007765	-0.083102	-3.788616	-0.202457
Kurtosis	1.608424	2.062668	2.309943	1.636698	1.801822	25.08430	1.639225
Jarque-Bera	6.513325	8.360118	5.352015	5.886305	4.877512	1817.102	6.718879
Probability	0.038517	0.015298	0.068837	0.052699	0.087269	0.000000	0.034755

Table 4.1 indicates that GDP has the highest mean, while crude oil has the least mean. The Jarque-Bera shows that external reserves, GDP and inflation are normally distributed as the p-values were greater than 0.05 level of significance, the other variables are not.

4.3 Graphical Representation

The graphical representations of the data series visually aided the comprehension of the behavioral movements or trend of each of the time series variables.

The graphical plots in **Appendix II** indicate that the variables are non-stationary because they are not oscillating within their respective mean values. However, time series data is meant attain stationarity in order to avoid spurious implications.

4.4 Test for Stationarity (Unit Root)

The analysis is based on time series data which requires some specific approaches as an econometric estimation of a model such as the series attaining stationarity since non-stationary series usually result in distorted inferences. Engle and Granger (1987) provide a standard technique to deal with this type of problem. This involves testing the variables of an equation for stationarity. The estimation therefore begins by employing Augmented Dickey and Fuller (1979) test which is reported in Table 4.2.

Table 4.2 Unit Root Test using ADF (1979)

Variable	t-statistic	Probability	Remark
LCOP	-6.6915	0.0000 I(1)	First differencing stationarity
LEXCHR	-6.9723	0.0000 I(1)	First differencing stationarity
LEXRS	-8.3759	0.0000 I(1)	First differencing stationarity
LGDP	-8.5353	0.0000 I(1)	First differencing stationarity
LINFL	-4.3117	0.0052 I(1)	First differencing stationarity
LINTR	-9.1602	0.0000 I(1)	First differencing stationarity
LMSUP	-8.2442	0.0000 I(1)	First differencing stationarity

1% level = -4.08; 5% level = -3.47; 10% level = -3.16

The results above shows that crude oil price and all macroeconomic variables assumed stationarity at first level. The stationary time plots are in **Appendix III**.

4.5 Specifying the Mean Equation

In determining the conditional heteroscedastic models, the mean equations were specified as either autoregressive (AR), moving average (MA) or a combination of AR and MA processes (ARMA) (Leykun, 2012). To identify a suitable fitted model for the mean equation and its order, autocorrelation (ACF) and partial autocorrelation (PACF) plots were obtained applying Akaike information criterion and the principle of parsimony, which states that the best model is the simplest model that captures the important features of the data in order to bring out the best specification mean equation as shown in Table 4.3.

Table 4.3 Mean specification of each variable

VARIABLE	MODEL	α_0	P-value	α_1	P-value	β_1	P-value	AIC value
D(LCOP)	MA(1)	0.0150 0.0118 0.0096 0.0070	0.1417 0.2047 0.2860 0.4696			0.5391 0.5212 0.4951 0.4913	0.0000 0.0000 0.0000 0.0000	-2.7611 -2.8204 -2.7828 -2.7779
D(LEXCHR)	MA(1)	0.0025 0.0035 0.0018 0.0029	0.1132 0.1904 0.3676 0.2953			0.5729 0.9952 0.7283 0.9999	0.0000 0.0000 0.0000 0.0000	-5.6519 -5.5572 -5.6235 -5.5184
D(LEXRS)	ARMA(1,1)	0.0062 0.0062 0.0122 0.0052	0.6441 0.6471 0.3776 0.6832	0.7174 0.7170 0.7181 0.6907	0.0000 0.0000 0.0000 0.0000	-0.1870 -0.1844 -0.1675 -0.0759	0.2926 0.3452 0.3883 0.7119	-3.3650 -3.3395 -3.3724 -3.3563
D(LGDP)	AR(1)	0.0163 0.0159 0.0169 0.0166	0.0000 0.0000 0.0000 0.0000	-0.0957 -0.7947 -0.1198 -0.1238	0.2116 0.1507 0.0183 0.0007			-4.0586 -3.9761 -4.0215 -3.9826
D(LINFL)	MA(2)	0.0098 0.0100 0.0098 0.0108	0.0000 0.0000 0.0000 0.0000			-0.0825 -0.0857 -0.0723 -0.1697	0.6177 0.5845 0.6422 0.1218	-6.0417 -6.0439 -6.0826 -6.0998
D(LINTR)	MA(1)	-0.0975 -0.0174 -0.0408 -0.0643	0.4090 0.8640 0.7354 0.6172			0.0236 -0.1521 -0.1018 -0.1066	0.9448 0.6887 0.6594 0.7320	1.7209 1.7513 1.7186 1.7824
D(LMSUP)	MA(1)	0.0203 0.0198 0.0205 0.0203	0.0000 0.0000 0.0000 0.0000			0.0316 0.0437 0.0551 0.0571	0.6314 0.3838 0.3043 0.6006	-4.3938 -4.3637 -4.3900 -4.3652

α_0 *stands for the intercept,* α_1 and β_1 *stand for the coefficient values of Arch and Garch term respectively.*

4.6 Testing for ARCH Effects (Heteroscedasticity)

Attaining the mean equation for crude oil price shocks and the macroeconomic variables led to the use of the obtained residuals to test for the presence of ARCH effect (heteroscedasticity) through Lagrange Multiplier (LM) test proposed by Engle (1982). The F- Statistic and P- values obtained are summarized in Table 4.4.

Table 4.4 Heteroscedasticity test for residual series

Variable	F-statistic	Probability
D(LCOP)	0.1040	0.7480
D(LEXCHR)	10.6941	0.0016
D(LEXRS)	0.3715	0.5440
D(LGDP)	2.4161	0.1245
D(LINFL)	0.3989	0.5296
D(LINTR)	1.7807	0.1860
D(LMSUP)	0.3651	0.5475

The result shows that only exchange rate is significant (that is, have the presence of heteroscedasticity); while the other variables are having the absence of heteroscedasticity (that is, they are homoscedastic), which implies that they did not fulfill the condition of GARCH or volatility estimation rather the six macroeconomic variables fulfill the condition of VAR estimation and as such they are all homoscedastic except exchange rate.

4.7 Estimation of GARCH

Table 4.5: Volatility Models of Exchange Rate

	Models	Constant	p-values	ARCH				GARCH			
				θ_1	p-values	θ_2	p-values	θ_3	p-values	θ_4	p-values
D(LEXCHR)	GARCH(1,1)	0.0001	0.0000	1.0908	0.0000			-0.0676	0.1852		
	GARCH(1,2)	8.94E-05	0.0083	0.7825	0.0000			0.2033	0.1568	-0.0859	0.0001
	GARCH(2,1)	3.91E-05	0.3144	1.1325	0.0000	-0.6936	0.0923	0.5907	0.1315		
	GARCH(2,2)	0.0001	0.2517	0.6135	0.0059	-0.3111	0.2750	0.4821	0.3028	-0.0513	0.6866

Table 4.5 shows the parameter volatility of exchange rate which from the estimated coefficient of the models indicates that some of the parameter models are significant at 5%

level. The high values in the parameter θ_1 >1 revealed that EXCHR volatility is spiky and quick to react to market movements; whereas, low values in θ_3 <1 parameter shows that volatility of EXCHR is persistent and takes a short time to change. Hence, when the volatility of EXCHR is high, it will tend to fall over time but when the volatility is low, it will tend to rise over time (Leykun, 2012).

4.7.1 Diagnostic Checking

On fitting different volatility models, diagnosis is executed using Lagrange Multiplier test to check if ARCH effect is still present, thus examining the reliability of the analytical results as presented in Table 4.6.

Table 4.6: Diagnostic Checking of the Residuals

VARIABLE	**MODEL**	**F-statistic**	**P-value**
D(LEXCHR)	GARCH(1,1)	0.1009	0.7516
	GARCH(1,2)	0.4810	0.4901
	GARCH(2,1)	0.1610	0.6893
	GARCH(2,2)	0.0259	0.8727

Table 4.6 above shows that the ARCH effects initially present in exchange rate was entirely removed by each of the heteroscedastic models considered. The F-statistic was very low for all of the models and the probability values were also greater than 0.05 for all models fitted. Hence, the initial heteroscedasticity present has been completely removed by each of the heteroscedastic models.

4.8 Forecasting Volatility Models

In order to determine the performance of the fitted model in forecasting future volatility, Root Mean Square Error (RMSE) and Mean Absolute Error (MAE) of different GARCH models for exchange rate were obtained.

Table 4.7: Forecasting volatility of the model

	MODEL	RSME	MAE	AIC
D(LEXCHR)	GARCH(1,1) GARCH(1,2) GARCH(2,1) GARCH(2,2)	0.1828 0.1591 0.1363 0.1491	0.1628 0.1413 0.1204 0.1322	-5.4931 -5.4832 -5.5154 -5.4128

Table 4.7 shows that RMSE and MAE with the least value is the appropriately fitted model for forecasting volatility of the variable. Hence, the forecasting model for EXCHR is GARCH (2,1).

4.9 Parameter Estimates of Vector Autoregressive (VAR) Model

In order to investigate the impact of oil price shocks on one macroeconomic variable to the other variables in Nigeria, VAR model was employed. According to Sims (1980), VAR is useful in examining the interrelationship among variables in the system which includes crude oil price, external reserves, GDP, inflation, international trade and money supply exception of exchange rate which did not conform to the assumption of VAR model. The term autoregressive is due to the presence of lagged value of the dependent variable on the left-hand side and the term vector is due to the fact that two or more variables are dealt with according to Mulyadi (2012). Table 4.8 presents the estimated values for VAR in this work.

Table 4.8 Estimated values for VAR

	D(LCOP,1)	D(LEXRS,1)	D(LGDP,1)	D(LINFL,1)	D(LINTR)	D(LMSUP,1)
D(LCOP(-1),1)	0.381959 (0.13542) [2.82060]	0.260340 (0.09701) [2.68363]	0.146180 (0.06801) [2.14924]	-0.009324 (0.02766) [-0.33714]	2.321336 (1.60735) [1.44420]	0.134689 (0.05549) [2.42744]
D(LCOP(-2),1)	-0.302629 (0.13216)	-0.007785 (0.09467)	0.122903 (0.06638)	-0.003910 (0.02699)	-0.224288 (1.56864)	0.046659 (0.05415)

	[-2.28994]	[-0.08223]	[1.85162]	[-0.14485]	[-0.14298]	[0.86167]
D(LEXRS(-1),1)	-0.157959	0.270926	-0.029148	0.010119	-1.193372	-0.037398
	(0.08935)	(0.06401)	(0.04488)	(0.01825)	(1.06053)	(0.03661)
	[-1.76789]	[4.23273]	[-0.64952]	[0.55450]	[-1.12526]	[-1.02154]
D(LEXRS(-2),1)	-0.039267	0.240722	-0.121489	-0.015270	-0.495495	0.005922
	(0.08283)	(0.05934)	(0.04160)	(0.01692)	(0.98315)	(0.03394)
	[-0.47407]	[4.05688]	[-2.92031]	[-0.90267]	[-0.50399]	[0.17450]
D(LGDP(-1),1)	-0.255110	0.065056	-0.262061	0.000662	-0.140946	0.036904
	(0.22914)	(0.16415)	(0.11508)	(0.04680)	(2.71974)	(0.09389)
	[-1.11336]	[0.39633]	[-2.27712]	[0.01414]	[-0.05182]	[0.39308]
D(LGDP(-2),1)	0.419080	0.013157	-0.308384	0.008934	0.019172	0.151792
	(0.22786)	(0.16323)	(0.11444)	(0.04654)	(2.70454)	(0.09336)
	[1.83924]	[0.08060]	[-2.69468]	[0.19198]	[0.00709]	[1.62587]
D(LINFL(-1),1)	-0.578198	-0.646409	0.576966	0.177772	-5.960105	-0.602458
	(0.61730)	(0.44222)	(0.31004)	(0.12607)	(7.32704)	(0.25293)
	[-0.93666]	[-1.46175]	[1.86094]	[1.41006]	[-0.81344]	[-2.38193]
D(LINFL(-2),1)	-0.570990	2.101319	-0.432423	-0.271079	-3.945954	-0.205231
	(0.56162)	(0.40233)	(0.28208)	(0.11470)	(6.66617)	(0.23012)
	[-1.01669]	[5.22287]	[-1.53300]	[-2.36332]	[-0.59194]	[-0.89186]
D(LINTR(-1))	0.013695	0.008453	-0.003716	-0.003556	-0.612687	-0.009337
	(0.01153)	(0.00826)	(0.00579)	(0.00236)	(0.13687)	(0.00472)
	[1.18764]	[1.02326]	[-0.64158]	[-1.50985]	[-4.47642]	[-1.97615]
D(LINTR(-2))	0.005350	0.006880	-0.008046	-0.004225	-0.306653	-0.019870
	(0.01160)	(0.00831)	(0.00583)	(0.00237)	(0.13769)	(0.00475)
	[0.46115]	[0.82782]	[-1.38093]	[-1.78331]	[-2.22705]	[-4.18036]
D(LMSUP(-1),1)	0.179465	0.226412	0.058832	0.097982	0.380492	0.107632
	(0.27456)	(0.19669)	(0.13790)	(0.05608)	(3.25893)	(0.11250)
	[0.65364]	[1.15111]	[0.42662]	[1.74733]	[0.11675]	[0.95674]
D(LMSUP(-2),1)	-0.222689	-0.291924	-0.133220	0.022823	1.416882	0.063689
	(0.27656)	(0.19812)	(0.13890)	(0.05648)	(3.28264)	(0.11332)
	[-0.80521]	[-1.47346]	[-0.95908]	[0.40407]	[0.43163]	[0.56205]
C	0.026423	-0.008782	0.025513	0.011066	0.125675	0.024061
	(0.01426)	(0.01021)	(0.00716)	(0.00291)	(0.16923)	(0.00584)
	[1.85326]	[-0.85983]	[3.56274]	[3.80014]	[0.74261]	[4.11862]
R-squared	0.318962	0.495042	0.361595	0.255694	0.271908	0.333501
Adj. R-squared	0.182754	0.394051	0.233914	0.106833	0.126290	0.200202
F-statistic	2.341729	4.901819	2.832021	1.717670	1.867264	2.501890
Akaike AIC	-2.679082	-3.346181	-4.056374	-5.856042	2.268874	-4.463560
Schwarz SC	-2.271192	-2.938291	-3.648484	-5.448152	2.676764	-4.055670

where standard errors in ( ) & t-statistics in [ ].

Although the estimates of individual coefficients in VAR do not have a straightforward interpretation (Eltony, 1999); a glance at the table generally shows that none of the variables are significant to crude oil shocks at 5% level; COP and INFL are observed to be significant to shocks in external reserves; COP and EXRS are significant to GDP shocks; shocks to inflation and international trade shows that none of the variables are significant; whereas in the case of money supply shocks, the variables COP, INFL, INTR are significant.

From the summary statistics of the VAR estimates in Table 4.8, all the variables were best fitted because the R-squared fell within the range; that is $0 < R^2 \leq 1$ (David and Gregory, 1999). The F-statistic shows that INFL and INTR parameters were significant with approximately 1.72 and 1.87 respectively against the F-statistic tabulation which is equal to 2.29; while the best predictive variable among the six is INFL with the smallest AIC value of -5.86.

4.10 Estimate of Impulse Response Function

This indicates the response of macroeconomic variables to one standard-deviation shock in itself and in other variables in the model shown out to ten periods. The plots located in **Appendix IV** picture how the variables respond individually. The dash lines indicate positive and negative two-standard errors band (upper and lower boundary).

Since the response of macroeconomic variables to crude oil price shocks is the sole interest of this study, the plots pictured in **Appendix IV** show that one standard deviation to negative crude oil prices changes caused a positive (increase) response in the first four quarters of EXRS, GDP and MSUP with consistent fluctuations that led to a momentary drop in EXRS, GDP increasing and MSUP at stability in the later quarters; while INFL and INTR responded negatively as it decreases with steady variations leading to a stable increase in INFL and a momentary drop in INTR through the later quarters. This implies that while negative shock to crude oil price triggered steady increase in gross domestic product, money supply and inflation, there was a temporary drop that occurred in external reserves and international trade in a short term that appeared stable as regards the Nigerian economy.

4.11 Estimation of Variance Decomposition

The forecasting error variance decomposition was further examined to determine the proportion of the movements in the time series (macroeconomic variables) that are due to shocks in their own series as opposed to shocks in the other variable- crude oil price. It reduces the uncertainty in one equation to the variance of error terms in all equations.

Table 4.9 Estimate of Variance Decomposition

	D(lcop,1)	**D(lexrs,1)**	**D(lgdp,1)**	**D(linfl,1)**	**D(lintr,1)**	**D(lmsup,1)**
D(lexrs,1)						
1|qtr	24.88	97.12	0.00	0.00	0.00	0.00
4|qtr	24.85	59.26	0.43	12.08	1.61	1.76
7|qtr	24.81	59.05	0.59	12.06	1.72	1.77
10|qtr	24.81	59.03	0.60	12.05	1.73	1.77
D(lgdp,1)						
1|qtr	4.56	0.32	95.12	0.00	0.00	0.00
4|qtr	8.44	4.15	75.34	8.40	3.13	0.55
7|qtr	9.22	4.04	74.04	8.34	3.77	0.59
10|qtr	9.25	4.03	73.94	8.35	3.84	0.58
D(linfl,1)						
1|qtr	2.56	1.31	1.53	94.59	0.00	0.00

4|qtr	5.03	2.37	1.68	82.16	4.99	3.76
7|qtr	5.65	2.36	1.71	81.38	5.12	3.77
10|qtr	5.67	2.36	1.72	81.85	5.12	3.77
D(lintr,1)						
1|qtr	17.98	3.76	2.48	0.04	75.75	0.00
4|qtr	14.23	3.21	2.50	1.04	78.75	0.27
7|qtr	14.15	3.23	2.64	1.06	78.65	0.28
10|qtr	14.13	3.23	2.65	1.06	78.62	0.28
D(lmsup,1)						
1|qtr	0.84	2.90	0.28	0.06	0.18	95.74
4|qtr	4.08	2.90	2.45	8.15	15.91	66.53
7|qtr	4.50	3.05	2.43	8.06	16.28	65.68
10|qtr	4.51	3.05	2.44	8.05	16.34	65.60

Table 4.9 explains the percentages of the variations in EXRS, GDP, INFL, INTR and MSUP that are attributed to COP changes. The variance decomposition indicates that Nigerian crude oil price shocks are significant source of variation for Nigerian EXRS, GDP, INFL, INTR and MSUP.

4.11.1 External Reserves

COP accounted for the largest share of shocks as it contributed about 25% in the Q_{1st} and slightly dropped through the Q_{10th}. However, GDP made the least input averaging 1% through Q_{10th}. INFL shocks explained on average 12%; INTR and MSUP contributed less than 0.1% in the Q_{1st} and increased on an average of 2% through the Q_{4th} to the $Q1_{0th}$. This confirms the evidence found by Imarhiagbe (2014) that crude oil prices significantly affects **EXRS** shocks.

4.11.2 Gross Domestic Product

COP shocks explained changes in GDP from about 5% in the Q_{1st} to 9% (sharp rise) in the Q_{10th}; Shocks to EXRS explains less than 0.1% in the Q_{1st} with 4% growth in the Q_{4th} but dropped steadily; INFL and MSUP decreased from 4% through the Q_{10th} in varied proportions; while INTR input slight percentage rise to GDP shocks. This contradicts expectations that oil price shocks tend to lower **GDP** (Gordon, 1998) implying that crude oil shocks do not significantly affect **GDP** (output) in Nigeria, which is consistent with Olomola and Adejumo (2006).

4.11.3 Inflation Rate

The input of COP is from about 3% in the Q_{1st} rising to 5% in the Q_{4th} and consistently increasing to about 6% in the $Q_{10th.}$ The effects of EXRS, GDP, INTR and MSUP changes to inflation shocks increased from the Q_{1st} to the Q_{10th} at their respective level of percentages. This finding confirms that **COP** may not be necessarily inflationary contrary to the finding of Basky and Kilian (2002) but consistent with Akpan (2009).

4.11.4 International Trade

Changes in COP shocks accounted for the biggest share of shocks to INTR by about 18% in the Q_{1st} declining to 14% in the Q_{4th} to the Q_{10th}. EXRS contributed about 4% in the Q_{1st} but marginally dropped to 3% in the Q_{10th}. However, MSUP made the least input and alongside GDP and INFL shocks, a percentage increase occurred from the Q_{1st} to the Q_{10th} respectively. This showed that **INTR** is significantly affected by crude oil price shocks due to the recent fall in crude oil export and other imported resources.

4.11.5 Money Supply

While changes in INTR contributed highly to MSUP shocks, INTR alongside with COP, EXRS, and GDP increased gradually from the Q_{4th} to the Q_{10th} at their respective level of percentages. However, INFL did not contribute well in the Q_{1st} but sharply rises to 8% with little falls along the later Quarters. This suggests that negative COP shocks significantly affected **MSUP**. This supports earlier studies that monetary policy responds to changes in crude oil price (Olomola and Adejumo, 2006; Akpan, 2009).

Policy Implications

The estimated result suggests that crude oil price shocks lead to reduced funds of about 24% for the government that hampers on its initiative to fulfill unfinished developmental projects. Again, an increase in money supply leads to 4% an increase in inflation rate in the long run. Besides, although oil prices shocks have significant positive impacts on economic output, money shocks are the main causes of gross domestic product fluctuations as an increase in money supply generates high price level (inflation) of commodities. From these, it can be infered that crude oil still has a very important indirect impact on these economies and the monetary policy is the channel through which this indirect impact transmits.

Therefore, to tame inflationary pressures in Nigeria, the excessive fiscal expansion has to be curtailed. The banks credit management approach need be tailored in line with the monetary objective of the government. Also, increasing the supply of goods and services will reduce the pressure on price level; that is, increase in real output can also be used to stop a measure of inflationary pressure.

Furthermore, a momentary drop in international trade lowers market by 14% which discourages the producers and the investor to increase the investment to produce more goods and as well reduces about 25% external or foreign reserves in Nigeria, thus increasing deficit in balance of payment for the country.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

In this chapter, the researcher presents discussion of findings by way of summary, conclusion and recommendations centered on results obtained from chapter four.

5.2 Summary

This study entitled "Application of GARCH and VAR models in the impact of Crude oil shocks on Nigerian Macro economy" investigated the quarterly data series of crude oil prices and six macroeconomic variables namely: exchange rate, external reserves, gross domestic product, inflation, international trade and money supply between the span of January 1995_{Q1} and December 2014_{Q4}. In an attempt to achieve the objectives in Section 1.3.2, the study utilized the well-known GARCH and econometric VAR modeling approach. The results indicated that external reserves, GDP and inflation were normally distributed as the p-values were greater than 5% level of significance.

5.2.1 GARCH Results

The log transformed macroeconomic variables were all stationary at first difference and there was presence of ARCH effect (Heteroscedasticity) on exchange rate only; whereas the rest variables were Homoscedastic. While some of the parameter volatility for exchange rate was significant at 5% level, an increase in the standard errors brings about an increase in exchange rate volatility which takes a short time to change. The fitted model in forecasting exchange rate future volatility is GARCH (2, 1).

5.2.2 VAR Estimated Results

Since the individual coefficients in the VAR models appeared hard to interpret (Eltony, 1999), the summary statistics of the VAR estimate indicated that all the variables were best fitted because the R-squared fell within the range, that is $0 < R^2 \leq 1$ according to David and Gregory (1999). The F-statistic shows that inflation and international trade parameters were significant with 1.72 and 1.87 approximately against the tabulated F-statistic of 2.29; while the best predictive variable among the six was inflation with the smallest AIC value of -5.86.

The impulse response function and forecast error variance decomposition estimated results showed that one standard deviation to negative crude oil price changes caused a positive (increase) response in the first four period of external reserves, gross domestic product, and money supply with consistent fluctuations that led to a momentary drop in external reserves, gross domestic product increase and money supply at stability in the later periods, while inflation and international trade responded negatively as it decreases with steady variations leading to a stable increase in inflation and a momentary drop in international trade through the later periods. This implies that, while negative shock to crude oil price triggered steady increase in gross domestic product, money supply and inflation, there was a temporary drop that occurred in external reserves and international trade in a short term.

5.3 Conclusions

Conclusively, exchange rate tends to react quickly to market movements. When the volatility is high, it tends to fall over time but when the volatility is low, it tends to rise over time while the forecasting model for exchange rate was GARCH (2, 1).

Crude oil price shocks did not pose significant inflationary threat to the Nigerian economy in the short run; rather, it improves the level of real gross domestic product. However, external reserves and international trade were significantly affected due to the recent fall in crude oil export. Oil price shocks also enhanced the increased flow of money supply, showing monetary policy responds to oil price changes. However, while oil price shocks did not significantly affect output growth (GDP) in Nigeria, money supply did affect GDP; thus indicating the critical need for governments at all levels in the country to develop the non-oil sector, exercise expenditure restraint, strengthen their tax base as well as internally generate revenue in order curtail high dependence on crude oil.

5.4 Recommendations

Moreover, while this study focused on the responses of macroeconomic variables to crude oil price shocks as well as its effects on the Nigerian economy, the study suggestions sheds light on the direction of possible causality between pairs of variables by using Granger causality which examines whether past values of x aid in the prediction of y_t since correlation does not imply causality, (Sims, 1980).

The results obtained in this work can be employed for the necessary microeconomics evaluation of crude oil price shocks in Nigeria.

The present study considered short run interrelationship between crude oil price shocks and the macroeconomic variables; hence the long-run equilibrium relationship (cointegration) between variables as well as other macroeconomic variables could be further researched upon using Vector Error Correction Model (VECM).

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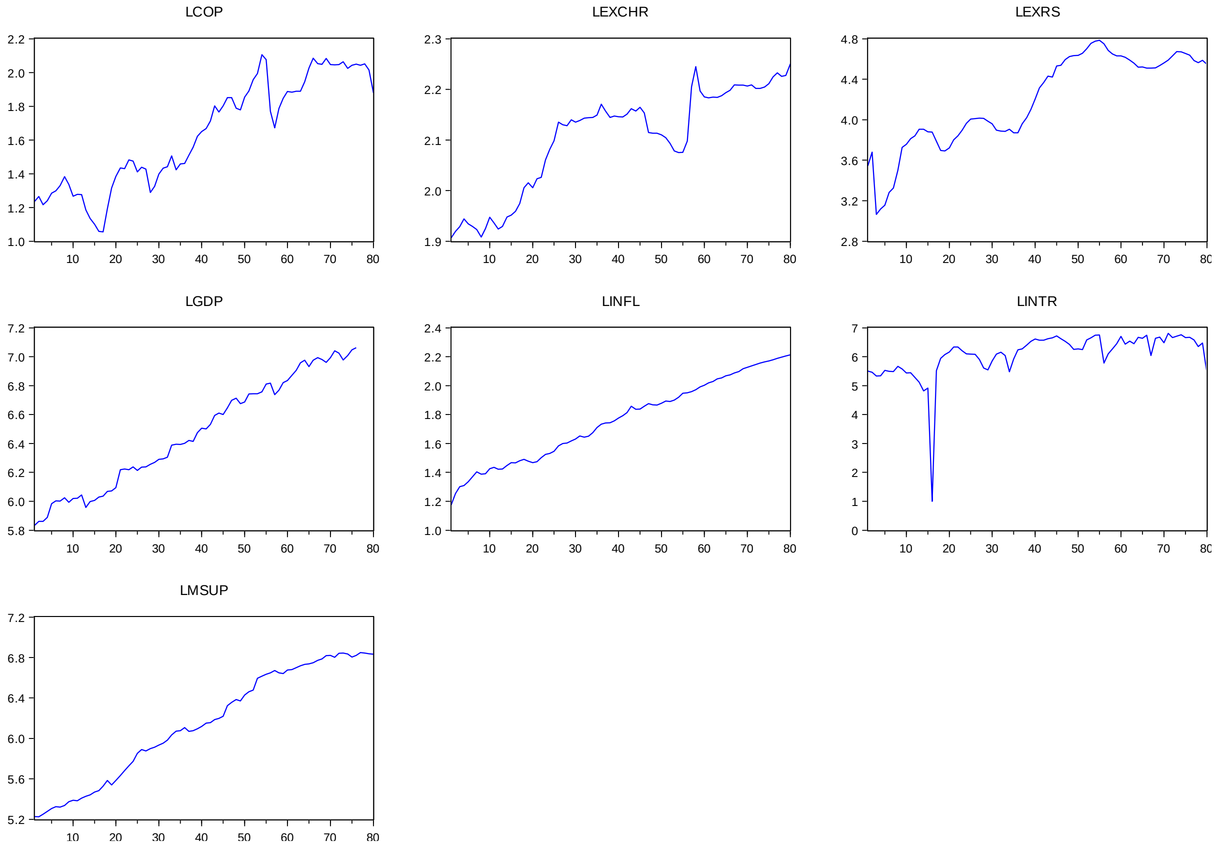
APPENDICES

Appendix I: Quarterly data for each study variables

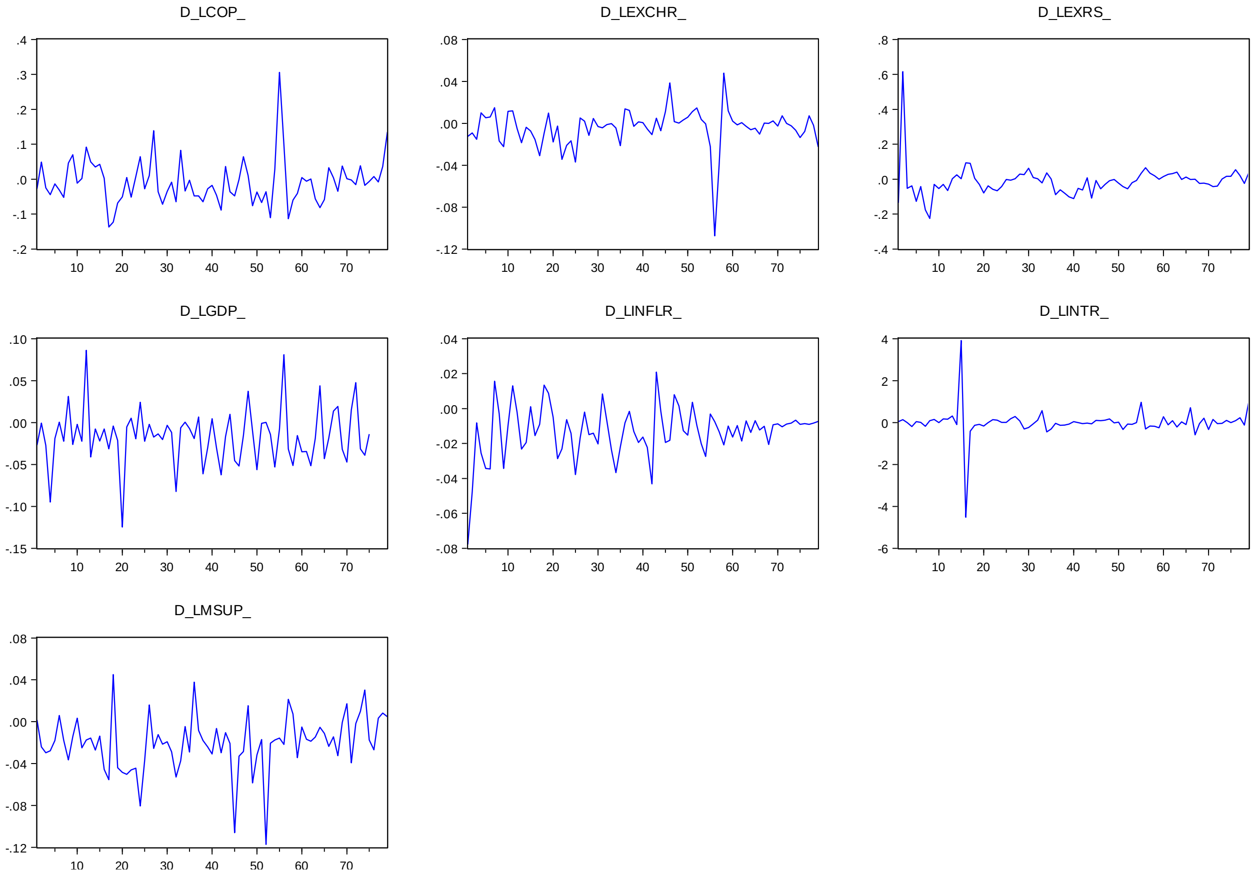
Year	COP	EXCHR	EXRS	GDP	INFLR	INTR	MSUP
1995Q1	17.23	80.72	3513.77	681,533.59	14.98	31762.22	168668.39
Q2	18.38	83.08	4796.67	725,339.66	17.92	29109.28	168060.04
Q3	16.44	84.88	1161.17	726,723.77	20	21591.19	177665.4
Q4	17.4	87.92	1310.07	773,761.16	20.38	21707.12	190207.13
1996Q1	19.28	85.93	1429.83	962,864.51	21.61	33710.44	202754.84
Q2	19.91	84.9	1915.4	1,006,120.12	23.39	30984.8	211350.35
Q3	21.38	83.75	2113.1	1,005,237.86	25.33	30716.48	208496.3
Q4	24.13	80.93	3173.6	1,058,077.85	24.43	46774.32	217172.26
1997Q1	21.69	84.17	5337.77	984,800.75	24.6	38015.21	236260.01
Q2	18.46	88.6	5726.17	1,046,011.33	26.62	27344.01	244095.54
Q3	18.96	86.3	6486.03	1,051,387.18	27.23	28038.32	242238.13
Q4	18.89	83.98	6947.43	1,107,050.50	26.43	19184.95	256575.96
1998Q1	15.3	84.95	8062.23	907,843.66	26.56	13207.98	267098.49
Q2	13.66	88.66	8033.93	997,619.21	28.02	6522.37	276948.19
Q3	12.6	89.45	7598.53	1,015,393.70	29.3	8267.67	294818.61
Q4	11.43	90.99	7564.23	1,068,593.71	29.23	-2129.33	304338.26
1999Q1	11.36	94.29	6110.53	1,087,911.77	30.29	33052.49	338042.61
Q2	15.57	101.26	4958.77	1,169,305.77	30.93	87092.53	384023.02
Q3	20.67	103.57	4903.77	1,180,990.12	29.99	118618.73	346265.74
Q4	24.21	101.26	5263.33	1,241,004.39	29.39	145348.95	383257.4
2000Q1	27.21	105.54	6322.27	1,653,875.33	29.73	215964.5	428428.09
Q2	26.93	106.17	6917.27	1,674,669.46	31.76	216614.39	480974.23
Q3	30.35	114.94	7903.87	1,654,745.44	33.49	160062.62	534942.35
Q4	29.83	120.67	9219.67	1,730,284.61	33.99	125284.02	592507.97
2001Q1	25.73	125.4	10169.6	1,636,688.09	35.12	122891.15	713418.4
Q2	27.41	136.57	10232.23	1,723,306.06	38.32	121087.4	777131.87
Q3	26.76	134.99	10385.93	1,732,259.70	39.84	79865.46	748933.7
Q4	19.46	134.36	10322.2	1,802,944.47	40.03	40897.19	794251.68
2002Q1	21.15	138.01	9661.13	1,860,314.82	41.43	34748.47	817188.53
Q2	24.97	136.58	9101.47	1,949,947.77	42.8	71496.21	858717.1
Q3	27.08	137.58	7885.4	1,965,437.71	44.84	122921.44	897666.57
Q4	27.62	138.99	7720.03	2,020,058.06	43.98	141946.13	959073.2
2003Q1	32.06	139.38	7671.9	2,441,890.36	44.7	110161.07	1083525.8
Q2	26.53	139.49	8053.17	2,477,782.21	47.22	29841.37	1180782.4
Q3	28.67	141	7421.17	2,475,970.16	51.38	83455.38	1193735.9
Q4	28.9	148.1	7421.07	2,517,875.45	54.04	171938.79	1276444
2004Q1	32.3	143.51	9120.3	2,631,255.55	55.08	187468.76	1170271.2
Q2	36.09	139.5	10500.4	2,592,273.17	55.29	253061.17	1193460.8
Q3	41.88	140.42	12644.53	2,985,541.81	56.98	340200.52	1244104.4
Q4	44.63	139.98	15985.8	3,201,996.38	59.58	406646.83	1315266.6
2002Q1	46.48	139.82	20651.57	3,169,613.44	61.87	371201.33	1412545.2

Q2	51.66	141.61	23289.27	3,399,351.82	65.12	375537.65	1433946.8
Q3	63.42	145.19	26917	3,924,774.99	71.92	418532.41	1535592.3
Q4	58.34	143.62	26425.23	4,078,498.85	68.56	448629.3	1573448.2
2006Q1	63.39	146.01	33946.17	3,986,279.51	68.8	523671.37	1650898.1
Q2	70.86	142.33	34545.77	4,426,083.77	71.96	415713.18	2107192.5
Q3	71.08	130.26	39259.97	4,986,489.42	75.03	340346.5	2273574.5
Q4	61.33	129.81	42072.47	5,165,742.02	73.68	264566.57	2428074.3
2007Q1	59.94	129.79	42898.43	4,740,806.79	73.44	179016.75	2344215.6
Q2	71.38	128.83	43108.5	4,853,839.25	75.63	185521.75	2682386
Q3	77.76	127.14	45401.5	5,524,363.80	78.32	175802.71	2887127.1
Q4	90.77	123.9	50168.83	5,538,294.61	77.68	377595.91	3003416.3
2008Q1	98.71	119.79	56960.23	5,535,963.74	79.41	450482.46	3933866.1
Q2	127.35	118.81	59717.73	5,720,249.45	83.17	550935.1	4125793.8
Q3	119.13	119	60875.23	6,461,894.67	88.59	563457.15	4295204.4
Q4	58.9	125.25	56338.37	6,578,221.42	89.23	60639.6	4454035.7
2009Q1	47.06	160.38	48434.57	5,460,764.42	90.78	124420.87	4683536.4
Q2	61.14	175.68	44737.87	5,872,694.58	93.6	185111.36	4458912.3
Q3	70.25	157.36	42816.33	6,608,436.40	98.19	283759.14	4384212.9
Q4	77.16	153.16	42820.67	6,852,343.26	100.5	501939.13	4745126.3
2010Q1	76.35	152.49	41384.27	7,426,523.80	104.36	268943.56	4802696.5
Q2	77.37	153.04	38868.73	8,043,198.10	106.72	345873.58	4993182.9
Q3	77.29	152.83	36171.3	9,055,632.90	111.39	282349.65	5212247.6
Q4	88.03	153.89	32998.53	9,459,399.30	113.24	466862.34	5392753.9
2011Q1	106.29	156.11	33199.9	8,553,988.30	116.86	436898.63	5460240.6
Q2	121.65	157.81	32275.67	9,444,841.30	118.76	552709.92	5601658.1
Q3	112.84	161.68	32392.3	9,856,176.30	122.18	109779.54	5913936.6
Q4	111.83	161.63	32453.23	9,554,854.70	125.07	429755.66	6114334
2012Q1	121.23	161.63	34397.13	9,142,858.50	131.12	478777.53	6590149.6
Q2	111.25	160.82	36304.3	9,840,226.90	133.98	302395.93	6600907.5
Q3	110.91	161.79	38811.83	10,967,272.90	136.73	644702.89	6346867
Q4	111.49	159.19	42855.37	10,593,741.60	140.08	458005.94	6947896.8
2013Q1	115.61	159.21	47001.43	9,493,779.40	142.99	515032.59	6977226
Q2	105.87	160.12	46854.33	10,204,837.90	145.75	569517.6	6820093.7
Q3	110.4	162.62	45123.8	11,166,026.40	148	457821.7	6362124
Q4	112.06	167.85	43472.2	11,532,121.96	151.13	468499.01	6623627.6
2014Q1	110.16	170.89	38330.13		154.17	382701.25	7046443.1
Q2	112.3	168.09	36611.13		157.4	224052.11	6991506.5
Q3	103.41	168.9	38683.25		160.46	300327.48	6859133.1
Q4	75.73	177.91	35256.82		163.21	26017.45	6784003.4

Appendix II: Time plots of the transformed variables before stationarity



Appendix III: Time plots of the study variables at stationarity



Appendix IV

Plots featuring the responses of each variable to crude oil price shocks in Nigeria