MULTIVARIATE TIME SERIES MODELLING OF SELECT MACROECONOMIC INDICATORS IN NIGERIA

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BEING A PROJECT SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF THE M.Sc DEGREE IN STATISTICS, UNIVERSITY OF NIGERIA

MARCH 2016

CERTIFICATION

This is to certify that the work embodied in this project is original and was carried out by Didigu, Chizoba Emmanuella with registration number PG/M.Sc/00/27819 and has not been submitted for any other degree(s) in this or any other universities.

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DEDICATION

This work is dedicated to

Almighty God

Who has given me life and made it possible for me to conclude this programme despite all odds and impediments.

ACKNOWLEDGMENT

I wish to express my profound gratitude to the Almighty God for his innumerable blessings and kindness in my life especially for giving me, the invaluable gift of life and making it possible for me to complete this programme despite the length of time which had elapsed and all the countless hurdles I had to surmount.

I also wish to thank the Mother of our Lord Jesus Christ and my Mother, Mary Queen of all Hearts for the graces She bestowed on me that made it possible for me to bring this educational pursuit to a logical conclusion, and to the glory of Her Son, Jesus.

My unalloyed appreciation goes to Prof. Fidelis I. Ugwuowo whom the good Lord used to ensure I achieved this feat. You encouraged and spurred me on to conclude the programme all these years to no avail. But as soon as the mantle of leadership fell on you; you did not fail to use it to ensure that many a student who had overstayed for any reason was encouraged to graduate. I sincerely appreciate your patience and understanding even when the pressures of work made it seem impracticable for me to forge ahead. I also thank you for painstakingly going through my work while giving fatherly corrections and guidance. May the good

Lord bless you abundantly. Words are not enough to express my gratitude. Once more, I say thank you, ñdarua ooò, ñeshe kpukpoò, ñsosongo eti et; Abasi odiong fiò.

I deeply cherish the support and concern shown to me by members of the department: both active and retired. Foremost among them is my lead supervisor and ñstochastic processes guruò, Prof. Pius I. Uche. My sincere thanks go to my former Head of Department, Professor Walford I.E. Chukwu, who assisted me with textbooks and journals. Worthy of mention is my undergraduate classmate and now senior colleague - Dr. Evarestus O. Ossai, who constantly lashed out at me for disappointing him, and provided me with a copy of his M.Sc thesis to serve as a guide. May God richly bless you all and your individual families.

I cannot proceed without mentioning my immediate family who stood by me through thick and thin. First and foremost, I treasured the immeasurable contributions of my wonderful husband - John C. Didigu who never let me rest during all these years of óslumberô and shelved many an appointment to ensure that I succeeded. My adorable children - Nonso, Onyinye, Uche and Emeogo who had to put in extra efforts at home to afford me time to do some research cannot be forgotten. May the good Lord bless you all.

I sincerely appreciate the efforts put in by my parents - Chief & Mrs. Ezike C. C. Amadi who had to pick me up very late at night severally and fast track my movement to and fro Nsukka among other sacrifices. I also appreciate them for all they have done for me from birth till date. I cannot forget my sister-in-law, Mrs. Uchenna Amadi who has been a rock for me to lean on and my brother, Mr. Chidiogo Amadi who has been of immense help. I love you both for always being there for me and running my errands without much ado. I also wish to thank Mr. Okenna Ojike for his assistance especially on the econometrics aspect of the work.

This programme would not have been completed without the constant prayers of these wonderful priests: Friars Oliver Emefu and Adolphus Nwandu as well as Rev. Fr. Kevin Onah. My heartfelt thanks and special mention goes to my sister from another mother and a lady who was always there when I needed her - Mrs. Agnes Aku. Your prayers and advice strengthened me to get thus far and can never be forgotten. You believed in me when it seemed all hope had been lost and prodded me on through all the moments of confusion and despair especially when I gave up on myself.

Lastly, to all my unsung heroes whom I may have forgotten because of the passage of time; I pray the good Lord who knows you all to bless you beyond your wildest imaginations, Amen.

ABSTRACT

This work, in trying to ascertain some of the major macroeconomic factors that would drive the nationôs economic growth, examined the causal relationship among all share index (ASI), nominal exchange rate, foreign direct investment, oil exports and GDP using quarterly data spanning from 1985Q1 to 2014Q4. In a bid to determine if long-run relationships existed among the variables, the Johansen cointegration approach was used after subjecting the series to the Augmented Dickey Fuller (ADF) test. The variables of interest were found to be stationary after first differencing and there was evidence of cointegration. Furthermore, the impulse response and Error Variance Decomposition analyses are used to examine the dynamic relations between stock indices and various macroeconomic variables. Lagrange Multiplier tests are run to ensure that the residuals from the chosen lag length are serially uncorrelated.

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CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND OF THE STUDY

Every good economy, whether developing or industrialized, has as its utmost object the attainment and sustenance of high economic growth rate (Onwukwe and Nwafor, 2014). Like every other country, Nigeria tries to put in place macroeconomic policies to induce and sustain economic growth. Broadly speaking, this growth (the state of any economy) is usually measured on the basis of the performance of designate macroeconomic indicators particularly the Gross Domestic Product (GDP). Macroeconomic variables or (macro)economic indicators are used by policymakers the world over especially in most developed nations and in some emerging markets, to predict the direction and extent of the nationôs overall economic wellbeing.

For any nation to achieve the desired economic stability, it is pertinent that the behavior of these indicators and their interactions with one another be put under constant watch. This is best done by a concurrent analysis of these macroeconomic indicators; which is the core of the multivariate time series modelling technique. This technique, which is used when one wants to model

and explain the interactions and co-movements among a group of time series variables, is very effective in taking vital decisions (Onwukwe and Nwafor, 2014). It helps ascertain the relationship amongst chosen variables over time utilizing the past values of a given time series and its future values. Thus, it is of utmost importance to econometricians, who use it to describe, summarize, and make forecasts with macroeconomic data; as well as advice policymakers based on their findings.

We adopted this technique in this work to construct a model using five select variables, namely: All Share Index (ASI), Exchange Rate (EXCH), Foreign Direct Investment (FDI), Gross Domestic Product (GDP) and Oil Exports (OILEX)..

1.2 SCOPE AND LIMITATIONS OF THE STUDY

The research work studied the relationship amongst the select macroeconomic variables within the Nigerian economy. The study covered a thirty-year time period from 1985 Q1 to 2014 Q4. The time period was chosen based on data availability and to ensure there were enough data points for a more meaningful analysis. The major challenge faced was lack of basic ideas of econometrics.

1.3 DEFINITION OF TERMS

Some terms appear quite frequently in the work and there is need to give a brief definition of them to aid the readers. Below are a few of them:

1.3.1 Exchange Rate:

According to the Macmillan Dictionary of Modern Economics, exchange rate is ôthe price of a currency in terms of another currencyõ. It could also be described as ôthe relative price of two currencies, so that any factor which influences the value of a currency will influence its international exchange rateõ.

1.3.2 Gross Domestic Product (GDP):

The Merriam-Websterõs Learnerõs Dictionary defined it as ñthe total value of the goods and services produced by the people of a nation during a year not including the value of income earned in foreign countries.ò It is used frequently as a means to evaluate a nationõs economy.

1.3.3 All Share Index:

This is an index that is used to measure the performance of a market. According to the Cambridge online dictionary, it is ña series of numbers which shows the changing average value of the share prices of all companies on as stock exchange, and which is used as a measure of how well a market is performingò

1.3.4 Foreign Direct Investment (FDI):

According to the Cambridge online dictionary, FDI is ñmoney that is invested in companies, property, or other assets by people or organizations from other countries.ò It is a substantial investment that is usually above 10% of the share capital of the receiving entity and makes the investor a bonafide major shareholder.

1.4 JUSTIFICATION AND SIGNIFICANCE OF THE STUDY

Nigeria, a country in the West African sub-region that is richly blessed with innumerable human and natural resources; could be said to be undergoing economic malaise due to gross mismanagement of the economy and shameless neglect of the social infrastructure by those at the helm of affairs. Every aspect of the economy has been affected especially international trade, investment and production of goods and services and in an especial way the volume of exports particularly oil exports, foreign direct investment into the economy and the activities of the Nigerian Stock Exchange (NSE); which was established as the Lagos Stock Exchange in 1961 to influence private capital investment and engender the capital market development.

There have been persistent fluctuations and uncertainties surrounding the Naira exchange rate especially in relation to the US dollars. The exchange rate being a

volatile indicator is bound to experience rapid changes, and these volatilities invariably affect the other variables. As an aftermath of the recent global economic meltdown and an erstwhile ailing banking sector, there has been a plunge in the activities in the Nigerian Stock Exchange; which is believed to have an adverse effect on the domestic economy. This situation has been worsened by the recent crash in the price of crude oil in the international market; resulting in dwindling fortunes for the country which is greatly dependent on oil revenue. With less income at their disposal and the affairs of the nation to contend with, our policy makers have had to resort to using our ñsaved for the rainy dayò resources. As a result, there is a great depletion of our external reserves and this worrisome situation has caused our policy makers some sleepless nights. More so, with the high interest rates, and presumably good GDP indices that have not reflected in the living standards of the common man with its attendant consequences; there is an increasing loss of confidence in our domestic economy and this has resulted in a lot of capital flight especially from foreign investors. The interplay of these variables together with the consequent changes has an effect on the domestic economy, which is represented by the GDP; this necessitated investigating the likely outcome of the changes in these variables on the GDP and on themselves.

This growth is measured on the basis of the performance of macroeconomic indicators particularly the Gross Domestic Product (GDP).

Thus, this study would be of paramount importance to both our fiscal and monetary policy decision-makers, investors, and all other participants in the domestic financial system. It would also be of use to those who would like to carry out further research in this area.

1.5 OBJECTIVES

The major objectives of this work are:

a) To ascertain which of these select variables that could be classified as leading indicators by:
    i. Developing an appropriate time series model and ascertaining the direction and degree of relationship among the various indicators.
    ii. Establish the existence of a cause and effect relationship among the variables using quarterly data.

b) To obtain some forecast based on the fitted model.

CHAPTER TWO

LITERATURE REVIEW

2.0 PREAMBLE

In this chapter, we highlighted some of the earlier works carried out in related areas. The select macroeconomic variables described in the preceding chapter are interrelated and inadvertently influence one another one way or the other, and thus, though this a statistics research work, it is pertinent to have a brief discourse on these economic variables so as to better appreciate their underlying relationships. Consequently, we would casually gloss through their respective relationship with the GDP and their dynamic properties in the ensuing sections.

2.1 SHORT REVIEW OF THE MACROECONOMIC VARIABLES

2.1.1 FOREIGN DIRECT INVESTMENT

Recall that prior to Independence, Nigeriaôs domestic economy was agrarian-based with little subventions from primary exports; and in a bid to develop the economy after 1960, conscientious efforts were made to attract ñforeigners, their capital, technology and skillsò (Onu, 2012) to develop the economy which

resulted in foreign capital inflow and consequent ownership of those ventures. Onu (2012) citing Todaro (1977) reiterates that ñFDI encourages the inflow of technology and skills and fills the gap between domestically available supplies of savings, foreign exchange and government revenue. It also encourages the inflow of technology and skillsò. He went on to add that ñgaps in entrepreneurship, managerial and supervisory personnel, organizational experience and expertise, innovation in products and production techniques are presumed to be partially or wholly filled by foreign investorsò.

During the past two decades, foreign direct investment (FDI) has become increasingly important in the developing world, with a growing number of developing countries succeeding in attracting substantial and rising amounts of inward FDI (Khaliq and Noy, 2007). Akinlabi et al (2012) quoted Deutsche Bundesbank as saying that it had become evident from several studies that foreign direct investment (FDI) was the largest single component of net capital inflow into developing economies.

Nigeria, being a developing economy is not left out as Onu (2012) states that ñthe centrality of FDI as a prime mover in the growth process of the Nigerian economy has often been emphasized by the traditional neo-classical theory of the determinants of the growth processò. Based on the above summary, we included FDI in our model.

2.1.2 STOCK PRICES

Stock prices are essentially a reflection of the outlook of key players in the capital market on the performance of firms in particular and that of the economy in general taking cognizance of certain macroeconomic variables like inflation and interest rates, GDP growth among others. The accuracy of these outlooks could go a long way in forecasting the economic performance thereby moderating volatility of business cycles and ensuring better formulation and implementation of fiscal and monetary policies.

Osamwonyi and Evbayiro-Osagie (2012) state that the economy and stock prices have a bidirectional causality relationship; that is, they affect each other. Basically, it is believed that fluctuations in some macroeconomic variables like exchange rate, interest rates, inflation and money supply affect stock prices. This stance is reiterated by Anlas (2012) who believes that a countryôs economic condition is largely portrayed by the activities in its stock market. The foreign exchange rate has been identified as one of the principal factors that affect stock prices. These prices are not only affected by the home countryôs economy with its peculiarities but also by the economic activities or events in the rest of the world at large. Anlas (2012) quotes Mumcu (2005) as stating that the capital market is greatly influenced by increased volume of international

fund transfers between countries which is a result of globalization in itself. Anlas (2012) believes that the risky nature of stocks has also contributed to the volatility of the financial sector, which in turn rubs off on the entire economy.

Stock prices had been found to be a reliable indicator of the GDP especially in advanced economies a long time ago; as Mitchell and Burns (1938) in Ikoku (2014) states that for nearly a century the Dow Jones composite index of stock prices had been included in the index of leading indicators for the U.S. economy.

2.1.3 CRUDE OIL PRICES

It may seem absurd to carry out a research of this magnitude on Nigeria without incorporating oil prices whereas Nigeria, a major producer and marketer of crude oil in the world, is solely dependent on oil proceeds for its existence. Thus, our model will include oil prices and perhaps investigate its volatility and consequent effect on economic growth. In their study of how oil price shocks affect the growth rate of output of a number of developed countries, Cunado and Perez de Gracia (2005) employed alternative regime switching models and found out that ñpositive oil price changes, net oil price increases and oil price volatility have an effect on output growthò.

It is known that when oil prices rise, there is usually a shift in the terms of trade which according to Majidi (2006) results in ña transfer of income from importing to exporting countriesò. He went further to state that the extent of the effect of these price changes depend on certain factors which include: the degree of dependence on imported oil, the share of the cost of oil on national income, the ability of users to find commensurate alternatives, the degree of gas price changes in response to oil price changes, the impact of price changes on other forms of energy, the extent to which the populace use gas (what he termed gas-intensity) and the impact of these price changes on other forms of energy that compete with or are substitutes to oil and gas.

2.1.4 EXCHANGE RATE:

Exchange rate is the price one pays in oneôs own currency in order to get another countryôs currency. It is a relative price and thus affects short and medium term allocation of resources. Anlas (2012) describes it as ña national and international political, social and economic indicator,ò which ñreacts quickly to events like war, terrorism, and also to the changes in the political situation as well as to main economic indicators like unemployment, interest rateò in developed countries. This macroeconomic indicator plays a crucial role in both the micro and macro economy by the strong effects it has on firms and

the economy respectively. In fact, it would not be an exaggeration if one says that the entire economy seems to be oscillating about the exchange rate. Its role in determining the state of the economy cannot be overemphasized especially with increased flow of funds between economies as a result of international trade and globalization. Several researchers, like Ojo (2014) have expounded on the exchange rate and its effect on the economy or its relationship with other macroeconomic variables.

According to Ojo (2014), there exists a direct relationship between ñprices and /or profitability of traded and non-traded goodsò and exchange rate; which in its turn was influenced by vagaries caused by unforeseen alterations in both the local and international macroeconomic milieu. He opined that the developing economies were more susceptible to such scenarios since they were heavily dependent on external trade: ñexport to earn foreign exchange, imports to purchase consumer, intermediate and capital goods as well as external borrowing to finance the foreign exchange gap.ò He went on to state that the importance attached to the exchange rate increased in the seventies and attributed it to the following reasons: ñthe floating exchange rate variability and volatility as well as the need for foreign exchange risk exposure management; the globalization process and the resultant increased rate and volume of fund flows among nations; the trade liberalization undertaken by developing

countries since 1980s, resulting in opening up their economies; the internationalization of modern business; the continuing growth in world trade relative to national economies; the trends towards economic integration in some regions; and the rapid pace of change in the technology of money transfer.ò

2.1.5 THE INTERPLAY OF THE CHOSEN MACROECONOMIC VARIABLES

There are relationships among the selected variables: within themselves and with others. For instance, Granger et al. (2000) believe that there exist the traditional and portfolio approaches between the stock market and the exchange rates. Changes in exchange rates are attributed to the imbalance between money demand and supply as posited by the traditional approach. These changes affect the international trade and competitiveness of a country; which in turn rub off on the real income and the production levels in the economy (Dornbusch and Fisher, 1980).

Anlas (2012) states that since the value of a stock may be defined as the present value of the future cash flows, this value will reach an equilibrium point according to the economic environment. According to the traditional approach, there is a positive relationship between the stock prices and the exchange rates;

and the causality is from the exchange rate to the stock prices. However, the portfolio approach claims that a negative relationship exists between the stock prices and the exchange rates; and the causality is from the stock prices to the exchange rate. He went on to state that ñan increase in the stock prices causes a valuation in the national currency and pushes investors to sell the foreign securities in their portfolios and to buy stocks. The increase in the national money demand and supply causes an increase in the value of national currency and also causes decreases in the foreign currenciesò.

He also posited that there is a positive relationship between stock prices, money demand and interest rates. He went on to state that higher interest rates attract foreign portfolio investments causing foreign portfolio managers to sell the foreign currencies in their possession thereby creating a demand for the national currency and a downward pressure on the exchange rate. He went on to paint the opposite scenario of a decreasing stock market, when foreign funds managers sell the national currency they hold and buy foreign currencies thereby exerting an upward pressure on the exchange rate.

McPherson and Rakovsk (2000) stated that ñthe monetary theory of the balance of payments, which relates movements in international reserves (if exchange rates are fixed) or the exchange rate (if it is floating) to shifts in the relative

demand for and supply of money, yields a similar functional relationshipò. They went on to state that the nominal exchange rate being a sensitive policy indicator, the real exchange rate instead should be used for purposes of growth analysis.

The interactions between the capital market and macroeconomic variables have been in the front burner for the last few decades and the likes of (Omole, 1999; Christopher Minsoo, Huahwa and Jun, 2006; Ikoku, 2007; and Maku and Atanda, 2009) have addressed the issue as cited by Osisanwa and Atanda (2012). The duo, however, went on to enumerate the variables that were closely entwined with it. They stated that ñstock prices were determined by some fundamental macroeconomic variables such as the interest rate, gross domestic product (GDP), exchange rate, inflation and money supplyò.

2.2 LITERATURE REVIEW

So many researchers including Nigerians have tried to investigate the domestic economy of several nations using multivariate time series techniques. Their works which are based on different perceptions and using different combination of indicators have resulted in various models; linear, simultaneous and mixed models based on the objective of the study.

In his work, Almohaisen (2015) investigated the effects of the exchange rate volatility on the Jordanian International Trade for the period ($1997Q_1$-$2013Q_2$). Using the Autoregressive Conditional Heteroscedasticity (ARCH) and the Generalized Autoregressive Conditional Heteroscedasticity (GARCH) models proposed by Engle (1982) and Bollerslev (1986) respectively, he tried to estimate volatility using the following the variables: Real Exchange Rate (RER), volatility on Real Gross Domestic Product (RGDP), Exports (EX) and Imports (IMP). The study revealed that real exchange rate volatility had a positive effect on real GDP while having negative effects on exports and imports.

Ani et al (2014) tried to ascertain the existence of causal relationship between oil prices and inflation, interest rate, exchange rate and real gross domestic product using times series data from 1980 to 2010. Their result showed that oil prices had no significant impact on real GDP and exchange rate which is not in tandem with theory; this thus suggested that ñNigeria has a special case of the Dutch Disease, where a countryôs seeming good fortune proves ultimately detrimental to its economy.ò Ani et al (2014)

Ngerebo-a and Ibe (2013) investigated the underlying relationship between exchange rate, balance of payment, external debt, external reserves, gross domestic product growth rate and inflation rate in Nigeria post-Structural Adjustment Programme (SAP) using annual time series data 1987-2011 obtained from CBN Statistical Bulletin and Annual Reports of various years. Their work revealed that there exist long-run equilibrium relationships among the indicators. The Granger causality test between the dependent and independent variables revealed a unidirectional causality from exchange rate to BOP, external reserves and gross domestic product growth rate.

In their research on the Multivariate Time Series modeling of Major Economic Indicators in Nigeria, Onwukwe and Nwafor (2014) examined the dynamics of certain macroeconomic indicators like price deflator, currency in circulation, et cetera. The study used the multivariate time series estimation technique via Vector Autoregressive modeling to model the economic indicators which yielded ća stable and sustainable economic model for the six economic variables in the study.ô They found that the gross domestic product and external reserves were good predictors of the other economic indicators; and that a bidirectional positive relationship existed among the variables.

Amadi and Aboko (2013) in their research on the forecasting of Nigerian Gross Domestic Product for the period 1980 ï 2011, employed the Box-Jenkins approach. The work which is a detailed expose on modeling resulted in an ARIMA (2,1,2) model. Using the model, they made forecasts for the next fifteen years and these forecasts exhibited an increasing trend.

Osamwonyi and Evbayiro-Osagie (2012) in their study determined the relationship between certain macroeconomic variables including interest rates, inflation rates, exchange rates, fiscal deficit, GDP and money supply and the Nigerian capital market index; using yearly data from 1975 to 2005. The Vector Error Correction Model (VECM) was used to study the short-run dynamics between the All Share Index and the six selected macroeconomic variables from the Nigerian economy. They also studied the long-run relationship and the study revealed that the chosen macroeconomic variables all had reasonable influences on the All Share Index of the Nigerian stock market.

Alvan Ikoku (2014) in an effort to fill the void in the studies of leading indicators for Nigeria and other African economies examined the underlying relationships among stock market prices, real GDP and the index of industrial production in Nigeria, using quarterly data from 1984Q1 to 2008Q4. The

granger causality tests indicated a bidirectional relationship between stock prices and GDP while none existed between stock prices and industrial production nor between GDP and industrial production. The co-integration which existed between GDP and stock prices led to the estimation of vector error correction (VEC) models. He used the AR(1), ARIMA, structural ARIMA, and VEC models to construct óout-of-sample forecastsô and these showed that stock prices contained óinformation that can be used to improve the accuracy of GDP forecasts and enhance the conduct of macroeconomic policy in Nigeriaô. (Ikoku, 2014)

CHAPTER THREE

RESEARCH METHODOLOGY

3.0 OVERVIEW

In this chapter, we stated the general form of a multivariate time series model and discussed the steps of estimating its parameters. We applied the Box-Jenkins methodology to identify an appropriate time series model by comparing the behaviors of the sample autocorrelation function (ACF) and partial autocorrelation function (PACF) of the model to their hypothetical functions, among other criteria. Furthermore, we crosschecked the significance of the parameter estimates and their diagnostics, and validated the forecasts.

3.1 THE THEORETICAL MODEL SPECIFICATION

A model is a set of mathematical equations. (Kujarati,2013). The model type is determined by the number of equations: if the model has only one equation, it is called a single-equation model and a multiple-equation model if more than one equation exists. A model could easily be termed a concept drawn from reality to help unravel the uncertainties or complexities of life. Usually, models are typified by mathematical equations that are usually deterministic since they

proffer an exact relationship between the variables. However, in real life, an exact relationship is usually not possible between economic variables, for instance. We then resort to statistical models having stochastic or error term *(□□)* whose inclusion in the model helps to capture the impact of other variables that are not included in the model. Thus in this work, we constructed a stochastic model for all shares index, exchange foreign direct investment, gross domestic product, and oil exports.

It is best practice to check for the stability of the series under study since the variance of a time series is most often not time-invariant. The series have to undergo transformations to become stable, after which they are arranged in vector/matrix form as shown below:

□□□□ = □□□□□□ □□□□□ □□□ □□□□□□□ □□□□□□□ □□□□□□□ □□□□□ □□□□ é é é é é é . (3.1)

Given *m* time series variables $\{y_{1t}\}$, ... , $\{y_{mt}\}$, a multivariate time series is the (m×1) vector time series $\{Y_t\}$ where the i^{th} row of $\{Y_t\}$ is $\{y_{it}\}$. Thus, for any given time t, $Y_t = (y_{1t}, y_{2t,} y_{3t,} . . . , y_{mt})$Nj For such a time series $y_{it} = \{y_{1t}\}$, ... , $\{y_{mt}\}$,with *i*=1, é .,m and where t= 1,2, é ..,T is the common

length of the time series. The vector auto regression model of order *p* (VAR (*p*)) is constructed as given below:

$$y_t = \bar{u}_0 + \bar{u}_1 y_{t-1} + \bar{u}_2 y_{t-2} + \ldots + \bar{u}_p y_{t-p} + \epsilon_t \quad \text{é é é é .(3.2)}$$

where y_t and ϵ_t are *m* x1 vector stochastic processes and vector white noise process with the additional assumption that $E_{t-1}[\epsilon_t] = 0$, respectively; $\bar{u}_0$ is a *m* by 1 vector of intercept parameters, $\bar{u}_j$, *j* = 1, . . . , p are *m* by *m* parameter matrices. It is common practice to work with series where $\bar{u}_0 = 0$

This vector white noise process like the univariate white noise ñis mean zero, has finite covariance and is uncorrelated with its past although the elements of a vector white noise process are not required to be *contemporaneously* uncorrelated.ò This implies that

$$E[\epsilon_t] = 0_t$$

$$E[\epsilon_t \epsilon'_{t-j}] = 0_{t-j}$$

$$E[\epsilon_t \epsilon'_t] = \text{Æ}; \quad \text{é é é é .. (3.3)}$$

where Æ is a finite positive definite matrix.

The equation (3.2) can be simplified further by adopting the matrix form of a log polynomial to get

$$\bar{u}(L) = (1 - \bar{u}_1 L - \cdots - \bar{u}_p L^p) \quad \text{é é é é . (3.4)}$$

where ? is the identity matrix.

As in the univariate autoregression, we arrive at a centralized series which is the matrix equation of the cross-dependencies between the series:

ū ?L?y□□ ∈□ é é é é . (3.5)

This VAR model is believed to give a very reliable summary of the relationship between variables and equally accounts for the causality effects in the model. It resembles simultaneous equations since it considers several endogenous variables together. Each endogenous variable is explained by its lagged values and the lagged values of all other endogenous variables in the model, and there are usually no exogenous variables in the model. In order to choose the best model, the variance-covariance matrix of the estimated residuals is determined. The Akaike Information Criterion (AIC) suggests that the largest order be used, while the Schwartz Criterion (SC) chooses the smallest order with the Hannan-Quinn (HQ) sandwiched in between them. It is used when there is no cointegration among the variables and it is estimated using time series that have been transformed to their stationary values.

There are two principal types of the Vector AutoRegressive (VAR) model namely: the unrestricted or ordinary VAR and the restricted VAR models. One of the most common forms of the restricted model form of VAR is the

Vector Error Correction (VEC) Model. This model is best employed where the variables in question are stationary at first difference *1(1)* not at levels and presence of cointegration is established. The error correction model is derived by running a regression using all the variables at their stationary level and incorporating the lag of the residual as one of the independent variables. the short-run Vector Error Correction model was used to determine the speed of the adjustment to equilibrium.

The VAR (p) model, stated in equation 3. 2 could be re-written by applying the transform $\Delta = 1 - L$ where L is the lag operator and the system becomes

Δy ..... where

$\Pi = \sum$ and $\Gamma = -\sum$ é é é .. (3.6)

In considering an m-dimensional vector time series

Y(t) = é é é é . é é é . (3.7)

with a VARMA (p, q) representation as

$$Y(t) = C_{\square} + \sum_{i=1}^{p} \Phi_i Z(t-i) + \sum_{i=1}^{q} \theta_i a(t-i) + a(t) \quad .(3.8)$$

The elements of the autoregressive coefficient matrices $\square_{\square}$ can be denoted by $\{\square_{r,s,i}\}$ where r = 1, 2, é , k and s = 1, 2, ..., k. It should be noted that $\square_{r,s,i}$ is a coefficient quantifying the lead-lag relation between the rth element of Y(t) and the sth element of Y(t-*i*).

Similarly. {ϕ,r,s,i}, the (r,s) element of ◖1 is a coefficient representing the lead-lag relation between the rth element of a(t) and the sth element of a(t-i).

The intercept term $C_{\square}$ and μ, the mean of the vector process Y. where

μ = E [y(t)] are related to each other according to the equation below:

$$\mu = (I - \phi_1 - \phi_2 \ldots \phi_p)^{-1} C_{\square} \quad \text{é é é . (3.9)}$$

where I is the K x K identity matrix.

The autoregressive matrix polynomial of order p denoted as

$$\phi(B) = \phi_0 - \phi_1 \text{ é é é ..} - \phi_p \quad \text{é é é é (3.10)}$$

where $\phi_0 = \square$ and B is the lag operator.

A vector time series process is stationary if the zeros of the determinant polynomial |A(B)| are all outside the unit circle. A stationary VARMA model can be characterized by its cross-correlation matrices denoted by:

p(l) = Corr |Y(t). Y (t - L)| for all integers L.

When p = 0 that is Y (t) is a vector AR(P) process. the partial auto regression matrices P(L) are zero for L > q. The cut-off properties provide very useful information for identifying the order of the underlying VARMA model.

Given a vector time-series of n observations Y (t), Y (1), ... ,Y (n), we can compute the sample cross correlation matrice SCCM

$\hat{P}(L) = \hat{P}_{ij}(L)$

Where $\hat{P}_{ij}(L)$ are the sample cross correlations matrix (SCCM) for the ith and jth

component series $\hat{P}_{ij}(L) = \frac{\sum (Y_{it} - \bar{Y}_i)(Y_{jt} - \bar{Y}_j)}{\sqrt{\sum (Y_{it} - \bar{Y}_i)^2 \sum (Y_{jt} - \bar{Y}_j)^2}}$

The standard error of each element of the SCCM is approximately $1/\sqrt{n}$

The sample partial auto correlation matrices (SPAM) P(L) and their standard errors can be obtained by fitting autoregressive models of successively higher order by least square.

It is recommended that using the likelihood rating statistics to test the null hypothesis P (L) Í 0. To conduct such test we compute:

U = |× (L)| / |× (L-1)

where × (L) is the matrix of residual sum of squares and cross products after fitting a Vector AR(L) to the data. According to Bartlettôs (1938) approximation, the likelihood statistic

M (L) = (n - $\frac{3}{2}$ - L - L.K)1nU is a null hypothesis asymptotically which is distributed as X2 with K2 degree of freedom (where K is the dimension of the model).

But SCCM and SPAM are complex when the dimension of the vector is increased. To reduced the problem due to the complexity of the matrices. Tiao & Box (1981) suggested summarizing these matrices using the indicators +, -, . and where + denotes a value greater than twice the estimated stand error. -

denotes a value less than twice the estimated standard error and . denotes an insignificant value based on the above criteria.

When the order of the VARMA model is tentatively selected, asymptotically efficient estimates of these parameters can be determined using the maximum likelihood approach according to Chans K. S. &Tong H. (1990)

The approximate standard errors of the estimates of the elements ◖i and ◖j can also be obtained and used to test for the significance of the parameters to gain the efficiency of the estimate, we eliminate the parameters that one found to be statistically insignificant from Riesel (1997, Chapter 5).

According to Chans W S (1992). the maximization of the likelihood function can be conducted by conditional likelihood method or exact likelihood method. The conditional 1ikelihood method is computationally convenient but may 'be inadequate if the sample size is small.

In this work we use Least Square and Maximum Likelihood Estimate in the estimation of the parameters and eliminate the parameters that are small relative to their standard error.

To check the adequacy of the model, we carry out a detailed diagnostic analysis of the residual. This includes an examination of the SCCM and SPAM of the

residuals. At this stage the M (L) statistics provide a criterion for checking the residuals serial correlation

CHAPTER FOUR

DATA ANALYSIS AND PRESENTATION OF RESULTS

4.0 OVERVIEW

This study is motivated by the desire to bring to the fore the need to keep a close watch over certain economic variables that are perceived to play a pivotal role in our economy. It was an arduous task choosing the macro economic variables to include in the study since each and every variable played a role in the economy. However, the select variables were chosen based on our objectives and a priori expectations. Multivariate time series analysis and modeling techniques as had been earlier stated help us to investigate the interactions among a given set of variables. Thus, we used this approach to establish whether relationships existed among the variables: ASI, EXCH, FDI, GDP and OILEX; with a view to forecasting their future values.

The following models were considered: the Vector Autoregressive model of order p VAR(p); Vector Moving Average model of order q VMA(q); Vector Autoregressive Moving Average model of order (p, q) VARMA(p, q). The data used in this study were analyzed using the Stata 12, eViews 5 packages and R.

4.1 THE DATA

Secondary time series data on the select variables obtained from various issues of the Central Bank of Nigeria Statistical Bulletin including (CBN, 2008, 2009 and 2014) were utilized in the study. The sample covers quarterly data from 1985Q1 to 2014Q4. Some of the series did not have quarterly data in the Statistical Bulletins, thus their annual data series were interpolated to derive the quarterly equivalents. This equally applied to some which had partly annual and partly quarterly. In like manner, the data sets which had only monthly series were condensed in 3-months batches to arrive at the quarterly series too.

Table 4.1 Times series variables used in the work

Variable	**Definition**
GDP	Gross Domestic Product (current basic prices)
ASI	All Share Index
EXCH	Exchange rate is annual exchange rate (naira/US dollar) valued in rate
FDI	Foreign Direct Investment
OILEX	Value of oil exports in billions of Naira; which a proxy for oil prices

4.2 EXPLORATORY ANALYSIS OF THE ORIGINAL DATA

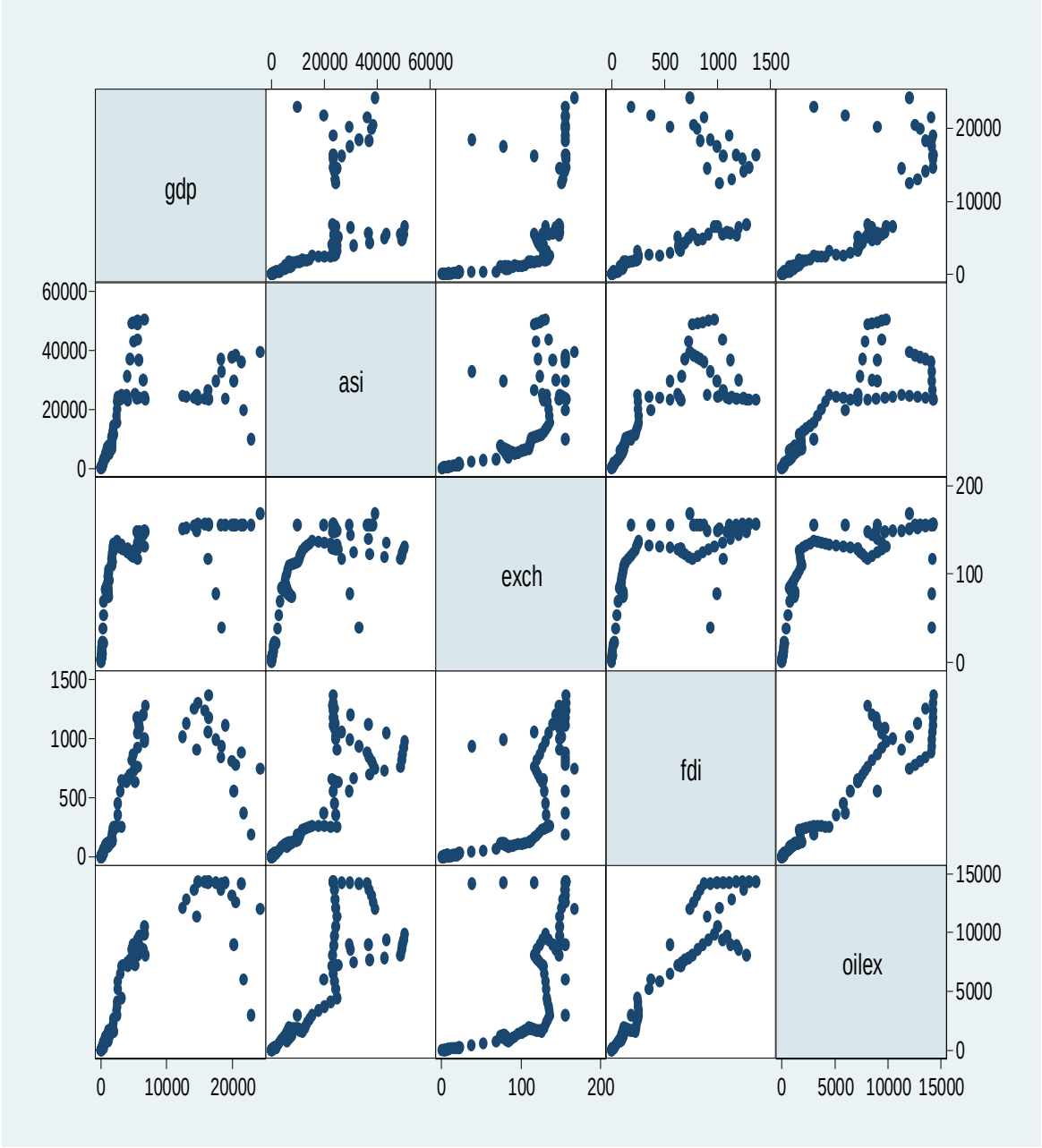
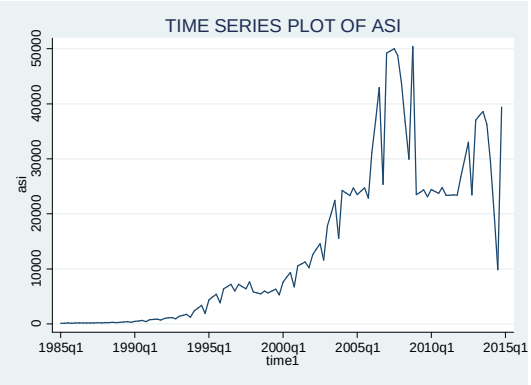
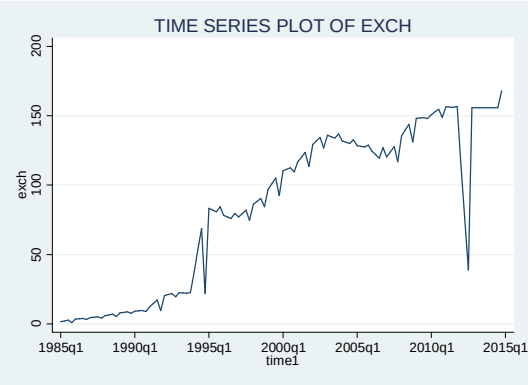


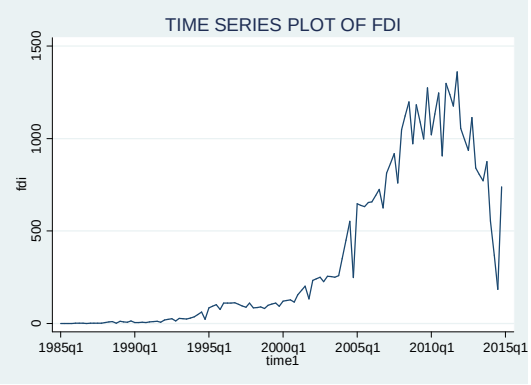
FIG 4.1 SCATTERPLOT MATRIX OF THE VARIABLES

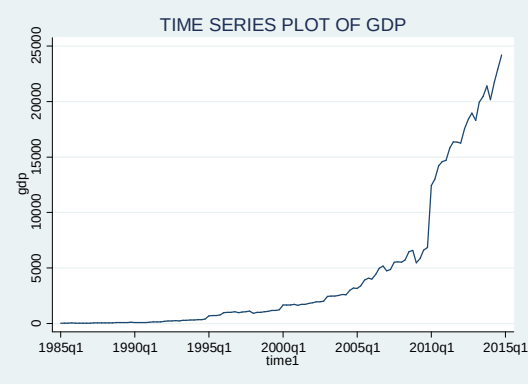
The scatter plot matrix above shows that there exist positive relationships between GDP and the other variables; the relationships among the other

variables were found to be positive too. However, some outliers were observed in the plot between GDP and EXCH, GDP and OILEX, EXCH and all other variables. All the variables exhibited an initial upward relationship with the GDP but thereafter, a downward relationship set in as is observed in the plots between ASI, EXCH, FDI, OILEX and GDP respectively.









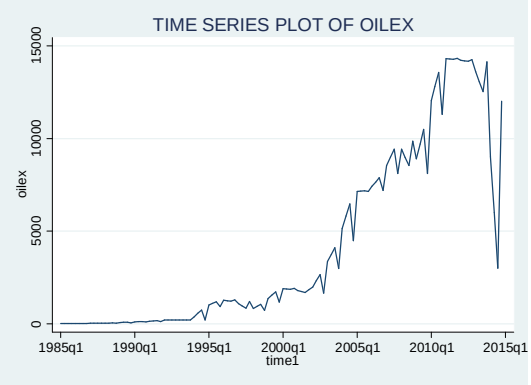


FIG 4.2 TIME PLOT OF THE ORIGINAL VARIABLES: ASI, EXCH, FDI, GDP AND OILEX

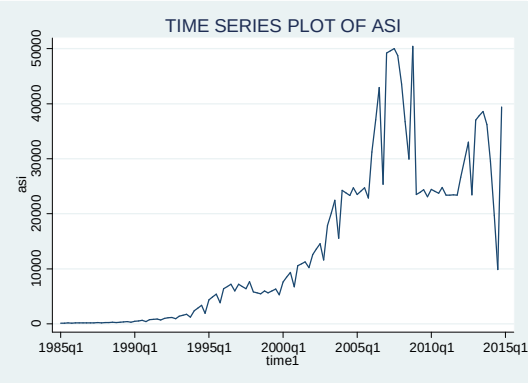
This is reaffirmed by the time plots of the series (as shown) where all five series exhibit strong upward trends, and all except the GDP experience significant downward spikes at some point in the series. There is an indication that the series are neither stationary nor stable. The autocorrelation plots of each of the series are suggestive of absence of randomness and non-stationary series since the ac values are not close to zero and are seen to gradually taper off respectively (see Appendix A.1)

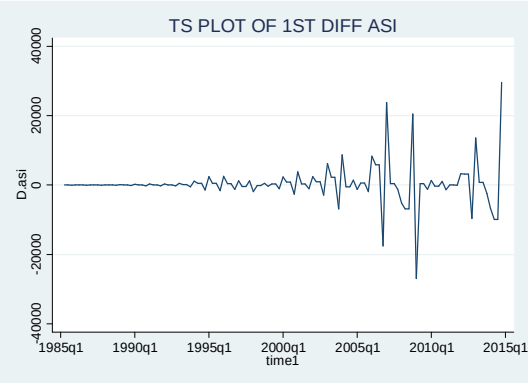
The GDP series is observed to have a curved upward trend; thus it is likely to undergo a logarithmic or square root transformation. (Chapter 3)

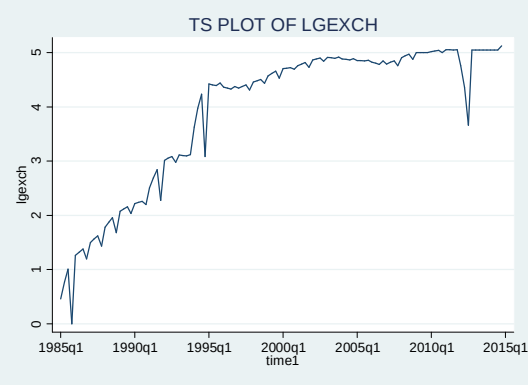
A óladdercô analysis using Stata 12 was carried out on each of the series to find the appropriate transformation to adopt to ensure stability of the series. (see Appendix B). The result suggested that all the series except GDP and ASI undergo logarithmic transformation. The GDP does better with a square root transform while ASI remains as it is.

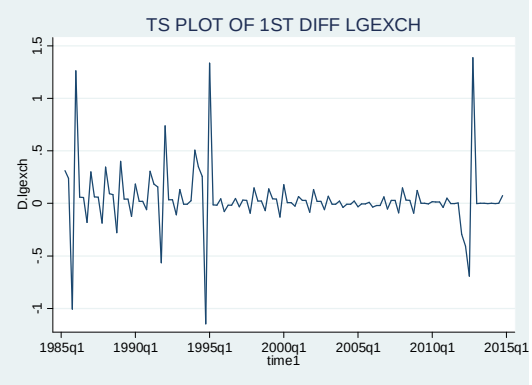
4.3 PRELIMINARY ANALYSIS OF THE TRANSFORMED DATA

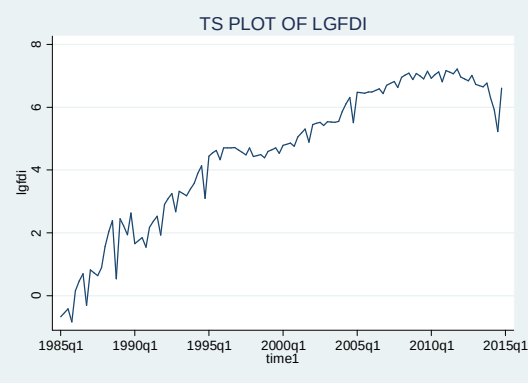
The transformed series are now LGEXCH, LGFDI, SQRTGDP and LGOILEX. As shown in Appendix C.1, the time plots of the transformed series still exhibited strong upward trend which is an indication that the series are non-stationary. The ac plots indicate a gradual tapering off towards zero of the autocorrelation coefficients for the five series which confirms the visual analysis as shown by the time plots. (see Appendices C.1 and C.2) A formal test would be conducted to confirm this though the time plots of the first differences of these transformed series indicate the series are stationary. (see Appendix C.1)

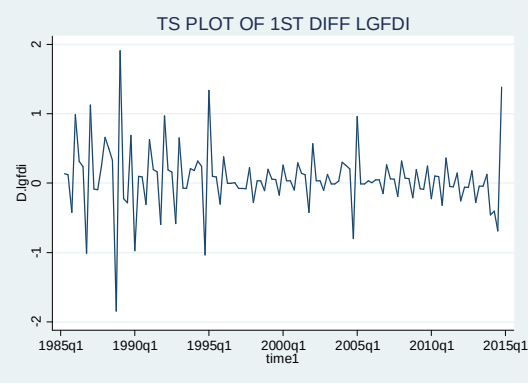


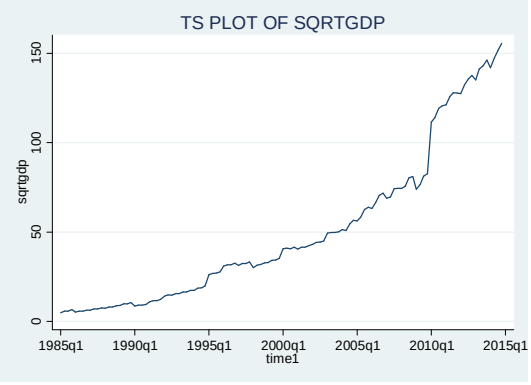


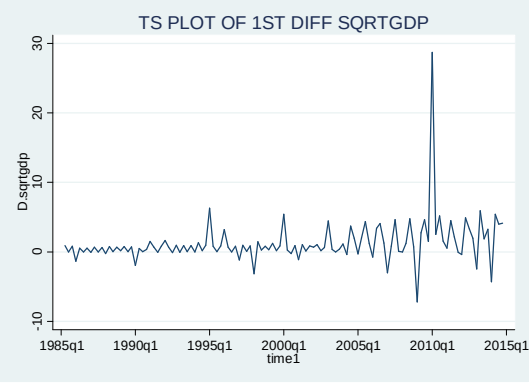

TS PLOT OF LGEXCH
lgexch
0
1
2
3
4
5
1985q1
1990q1
1995q1
2000q1
2005q1
2010q1
2015q1
time1

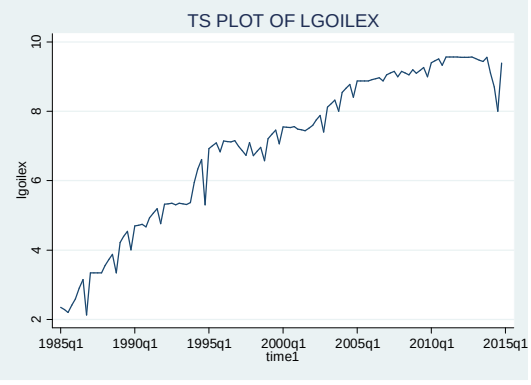

TS PLOT OF 1ST DIFF LGEXCH
D.lgexch
-1
-.5
0
.5
1
1.5
1985q1
1990q1
1995q1
2000q1
2005q1
2010q1
2015q1
time1


TS PLOT OF LGFDI
lgfdi
0
2
4
6
8
1985q1
1990q1
1995q1
2000q1
2005q1
2010q1
2015q1
time1


TS PLOT OF 1ST DIFF LGFDI
D.lgfdi
-2
-1
0
1
2
1985q1
1990q1
1995q1
2000q1
2005q1
2010q1
2015q1
time1


TS PLOT OF SQRTGDP
sqrtgdp
0
50
100
150
1985q1
1990q1
1995q1
2000q1
2005q1
2010q1
2015q1
time1


TS PLOT OF 1ST DIFF SQRTGDP
D.sqrtgdp
-10
0
10
20
30
1985q1
1990q1
1995q1
2000q1
2005q1
2010q1
2015q1
time1


TS PLOT OF LGOILEX
lgoilex
2
4
6
8
10
1985q1
1990q1
1995q1
2000q1
2005q1
2010q1
2015q1
time1

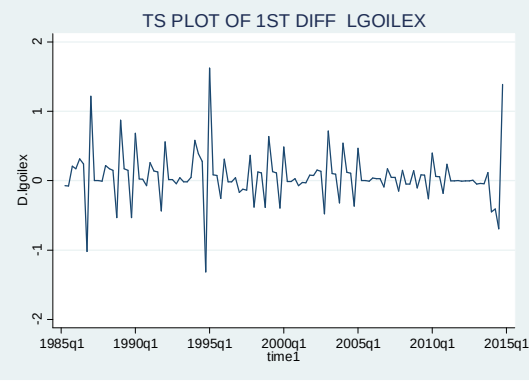

TS PLOT OF 1ST DIFF LGOILEX
D.lgoilex
-2
-1
0
1
2
1985q1
1990q1
1995q1
2000q1
2005q1
2010q1
2015q1
time1

FIG 4.3 TS PLOTS OF THE TRANSFORMED VARIABLES AND THEIR FIRST DIFFERENCES

4.4 UNIT ROOT TESTS

One of the conditions for fitting a multivariate time series to a set of say m variables is that they are all stationary series. Unit root tests, which ascertain the order of integration of the individual series under consideration, are formally used to confirm stationarity. A couple of alternative unit root tests are available of which the Augmented Dickey-Fuller (ADF), Phillips-Perron (PP) and Kwiatkowski, Phillips, Schmidt and Shin (KPSS) (1992) tests are included.

Bierens (2003) as cited by Alvan Ikoku describes an AR (p) process as specified below:

$$y_t = \quad y_t \quad = \sum_{i=1}^{p} y_t y_{t-i} + \quad y_t$$

$$y_t \sim \text{iid } N(0,\sigma^2) \qquad \text{é é é é . (4.1)}$$

This could be re-written as a recursive replacement of the lagged values as eqn. 4.2 below

$$\Delta y_t = y_t \quad + \sum_{i=1}^{p} y_t \Delta y_{t-i} + \quad y_t y_{t-i} + \quad y_t$$

$$y_t \sim \text{iid } N(0,\sigma^2) \qquad \text{é é é é} \quad (4.2)$$

The ADF tests the null hypothesis that the series has a unit root (is not stationary) that is $\delta_2 = 0$ against the alternative that the series is stationary, that is, $\delta_2 < 0$. When the null hypothesis is rejected the series is considered stationary and integrated of order one I(1). (Onwukwe and Nwafor, 2014)

Since the series involved are quarterly and exhibit trend, we would be reporting the ADF tests with the inclusion of trend and at 4 lags. (http://stats.stackexchange.com/questions/55805/how-do-you-interpret-results-from-unit-root-tests)

Table 4.2 below shows the results of the ADF tests on ASI, LGEXCH, LGFDI, SQRTGDP and LGOILEX at 1%, 5% and 10% significance levels. The results confirmed that all the series are non-stationary at levels since their p-values of the ADF exceed the 1%, 5% and 10% critical values and stationary for the first-order differenced series respectively. Thus, all the variables are integrated of order one, that is, I(1).

TABLE 4.2 - AUGMENTED DICKEY-FULLER TEST

ADF TESTS - LEVEL AND 1ST DIFFERENCE

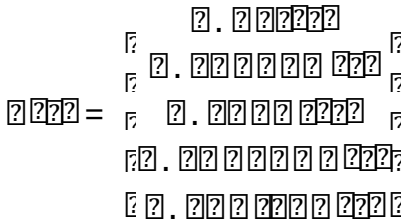
Null Hypothesis: Variable has a unit root

	LEVEL			**1ST DIFF**	
	CONSTANT AND TREND			**CONSTANT AND TREND**	
Variable	ADF Statistic	MacKinnon prob-values:	**Variable**	ADF Statistic	MacKinnon prob-values:
ASI	-2.365	0.3986	**D(ASI)**	-4.918	0.0003
LGEXCH	-1.736	0.7341	**D(LGEXCH)**	-6.399	0

LGFDI	-0.316	0.9891	**D(LGFDI)**	-5.697	0
SQRTGDP	-0.142	0.9925	**D(SQRTGDP)**	-5.043	0.0002
LGOILEX	-0.091	0.9932	**D(LGOILEX)**	-4.925	0.0003
Test Critical Values	1%	-4.035	Test Critical Values	1%	-4.035
	5%	-3.448		5%	-3.448
	10%	-3.148		10%	-3.148

Source: Author's Calculation

The stationary variables are D.ASI, D.LGEXCH, D.LGFDI, D.SQRTGDP and D.LGOILEX; and they are arranged in vector/matrix form as shown below:



é é é é .. (4.3)

4.5 CORRELATION COEFFICIENTS

Correlation coefficients help the researcher get a glimpse of the relationship among the variables. The table below provides the correlation coefficients between each pair of variables at a glance.

ASI has positive relationships with FDI, GDP and OILEX , and so did OILEX have with ASI, EXCH, FDI. Surprisingly, GDP has negative relationships with EXCH and FDI which may be attributed to the fluctuations in exchange rate and the resulting capital flight.

TABLE 4.3 – CROSS CORRELATION MATRIX

```
. corr d.asi d.lgexch d.lgfdi d.sqrtgdp d.lgoilex
(obs=119)
```

	D.asi	D.lgexch	D.lgfdi	D.sqrtgdp	D.lgoilex
asi					
D1.	1.0000				
lgexch					
D1.	-0.0928	1.0000			
lgfdi					
D1.	0.1745	0.5307	1.0000		
sqrtgdp					
D1.	0.0914	-0.0030	-0.0093	1.0000	
lgoilex					
D1.	0.3437	0.4836	0.6791	0.1612	1.0000

.

4.6 GRANGER CAUSALITY TEST

Granger Causality could be simply defined as in the case of two time-series variables, X and Y as "X is said to Granger-cause Y if Y can be better predicted using the histories of both X and Y than it can by using the history of Y alone. Granger (1969) developed a method of testing causal relationship that exists between two or more time series. For any two series, it denoted thus:

$$\square_{\square\square} = \square_{\square} + \square_{\square}\square_{\square\square\square\square} + \ldots + \square_{\square}\square_{\square\square\square\square} + \ldots + \square_{\square}\square_{\square\square\square\square} + \ldots + \square_{\square}\square_{\square\square\square\square} + \square_{\square} \quad \ldots (4.4)$$

Ngerebo-a and Ibe (2013) states that when the causality test between two independent variables indicates bidirectional causality between, it implies that past values of both variables have predictive ability in determining their present values while a unidirectional causality between two variables, A and

B implies that A has a predictive ability on the present value of B. Alvan Ikoku sounds the warning that researchers should note that ôthe Granger-causality test is actually a test of precedenceô and does not imply that changes in one variable causes changes in another as is perceived by many people.

The result of the granger causality that was run using the ôvargrangerô command showed that there existed a bi-directional granger-causality amongst the variables at all three levels of significance. However, a uni-directional relationship exists between d.sqrtgdp and d.lgoilex at 10% level of significance with only d.lgoilex granger causing d.sqrtgdp. (see Appendix

4.7 COINTEGRATION TEST

According to Hall and Henry (1989), if two or more series move closely together despite having a trend, their difference is usually a constant; the series are defined as having long-run equilibrium relationships, since the difference between them is stationary. Co-integration tries to verify the existence of such long-run relationship between variables. A lack of co-integration suggests that such variables have no long-run relationship: in principle they can wander arbitrarily far away from each other (Dickey et.

al., 1991). Conversely, co-integrated series drift above and below each other in the long-run.

According to Engle and Granger (1987), if two variables are both I(*1*), it is generally true that a linear combination of the variables will also be I(*1*). However, a linear combination of the variables may exist that is I(*0*).

On the other hand, Johansen developed two likelihood ratio tests for testing the number of co integration vectors (*r*): the trace test and the maximum eigenvalue test. The equations are given as stated below

$$\lambda \text{trace}(r) = -T \sum_{i=r+1}^{n} \ln(1 - \hat{\lambda}_i) \qquad (4.3)$$

where T is the number of usable observations, and $\lambda_{1,s}$ are the estimated eigenvalue from the matrix.

$$\lambda \max(r, r+1) = -T \ln(1 - \lambda r + 1) \qquad (4.4)$$

The trace statistics tests the null hypothesis of $r = 0$ (i.e. no cointegration) against the alternative that $r > 0$ (i.e. there is one or more co-integrating vectors); while the maximum eigenvalue statistics test the null hypothesis that the number of co-integrating vectors is *r* against the specific alternative of $r + 1$ cointegrating vectors.

The result of our unit root test, presupposes we check for co-integration among the variables since they were non-stationary at levels. We employed the Johansen maximum-likelihood test.

Table 4.4 Number of Co-integrating Relations by Model

Data Trend:	None	None	Linear	Linear	Quadratic
Test Type	No Intercept No Trend	Intercept No Trend	Intercept No Trend	Intercept Trend	Intercept Trend
Trace	2	2	1	0	0
Max-Eig	2	0	0	0	0

Using the trace test as shown in the table above, there exist five co-integrating equations, thus we can conclude that there exist one or more stationary linear combinations of the variables under study. This implies that there is a stable long-run relationship among the variables.

Table 4.5 Result of the Unrestricted Co-integration Rank Test

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.245553	71.90356	69.81889	0.0338
At most 1	0.143924	39.50002	47.85613	0.2409
At most 2	0.101562	21.62947	29.79707	0.3196
At most 3	0.053161	9.313245	15.49471	0.3372
At most 4	0.026014	3.031265	3.841466	0.0817

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

4.8 VECTOR ERROR CORRECTION MODELS (VEC) MODELS

There are two principal types of the Vector AutoRegressive (VAR) model namely: the unrestricted or ordinary VAR and the restricted VAR models. One of the most common forms of the restricted model form of VAR is the Vector Error Correction (VEC) Model. This model is best employed where the variables in question are stationary at first difference *1(1)* not at levels and presence of cointegration is established.

The error correction model is derived by running a regression using all the variables at their stationary level and incorporating the lag of the residual as one of the independent variables.

The result from table 6 below shows the signs and coefficients of the regressors. Two of the explanatory variables namely: oil exports (OILEX) and exchange rate (EXCH) conform to a priori expectations while the other two: all share index (ASI) and foreign direct investment (FDI) did not.

TABLE 4.6 : RESULT OF THE ERROR CORRECTION MODEL

VARIABLE	COEFF.	STD. ERROR.	T-STATISTIC	PROB
C	196.5703	49.14488	3.999812	0.0001
D(ASI)	-0.035379	0.011030	-3.207423	0.0017
D(EXCH)	-0.176209	3.461871	-0.050900	0.9595
D(FDI)	-2.789471	0.553967	-5.035449	0.0000
D(OILEX)	0.380001	0.062742	6.056524	0.0000
ECM(-1)	0.039139	0.020508	1.908458	0.0589

$R^{2 =}$ 0 344955 Adjusted R^2= 0.315971

F-statistic= 11.90146 Durbin-Watson stat = 1.461847

Source: Author's Calculation

The coefficient of All Share Price Index (ASI) is -0.035379 which shows a negative relationship with the Gross Domestic Product (GDP). This implies that a unit increase in ASI would cause a 3.5 per cent decrease in GDP. This is not in line with the economic a priori expectation of an increase in ASI leading to an increase in GDP.

The exchange rate (EXCH) has a negative relationship with the Gross Domestic Product (GDP) with a coefficient of -0.176209 . This relationship is in tandem with the economic a priori expectations since a unit rise in EXCH would cause a 17.6 per cent reduction in GDP.

The foreign direct investment (FDI) surprisingly has a negative relationship with the Gross Domestic Product (GDP) with a coefficient of -2.789471. This relationship does not conform to the economic a priori expectations since a unit rise in FDI should cause a unit rise in GDP rather it is causing an alarming 278.9 per cent reduction in GDP.

The oil exports (OILEX) coefficient established a 38 per cent positive relationship with the Gross Domestic Product (GDP). With a coefficient of 0.380001, this relationship conforms to the economic a priori expectations.

The ECM(-1) represents the speed of adjustment of any short run disequilibrium. It is statistically significant at 5% level though positive. The coefficient of 0.39139 indicates that about 39% departure from the long run equilibrium should have been corrected in the short run. The positive sign indicates that there may be no long run relationship after all as indicated by the co-integration test. This goes to support the findings of S.G Hall as cited by Gujarati, 2013 where he warned ñwhile the concept of cointegration is clearly an important theoretical underpinning of the error correction model there are still a number of problems surrounding its practical application; the critical values and small sample performance of many of these tests are unknown for a wide range of models; informed inspection of the correlogram may still be an important toolò

The R^2 of the model is 0.344955, showing that the explanatory variables (or independent variables) jointly explain about 34.5% of the variations in the dependent variable. This implies that the estimated model does not have a

very good fit. The adjusted coefficient of determination (R^2) also shows that the estimated model does not achieve a good fit (R^2 adjusted=31.6%).

The F-statistic of 11.90146 with a probability of 0.0000, measuring the joint significance of all regressors in the model is statistically significant at 5% level. Therefore, we reject H_0 and accept H_1; and conclude that the model is well specified. Since the overall regression is significant, it is considered good and adequate for forecasting and policy analysis.

The Studentôs t-test shows the significance of the individual variables.

CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSION, AND POLICY RECOMMENDATIONS

5.1 SUMMARY OF FINDINGS:

The research work is centered on GDP and all share index, foreign direct investment and oil exports in Nigeria. Its main objective was to ascertain if there exists a relationship between GDP and these variables; and if they impact on GDP in Nigeria. To achieve this, secondary data collected from the Central Bank of Nigeria Statistical Bulletins (2008,2009 and 2014). These variables were then subjected to multivariate time series analysis, using Johansen cointegration, VAR analysis and granger causality using all the variables as endogenous variable together with their lagged values. The summary of the findings are given below;

- The variables were all non-stationary at levels and had to be transformed and differenced to ensure stability and stationarity. They were all found to be stationary at first difference; they were all I(1).
- There was cointegration amongst the transformed variables. Hence, there is a long-run relationship amongst them.
- A VEC model was identified for the time series variables used.
- There existed a bi-directional causality relationship between the variables: GDP, ASI, EXCH, AND FDI.

- There existed a uni-directional causality relationship between the variables: GDP and OILEX at the 10% level of significance, with OILEX granger causing GDP.
- There were strong indications that ASI strongly affected FDI; FDI on the other hand affected ASI, EXCH and GDP tremendously. The EXCH was found to have strong effects on FDI, GDP and OILEX; and OILEX had strong impact on ASI, EXCH, and FDI. Thus, it could be seen that EXCH, FDI, and OILEX played prominent roles in determining the activities within the economy.
- It was also evident that EXCH and FDI affected GDP more than the other variables.

5.2 CONCLUSION

Every national government tries to ensure a stable economic growth of its local economy of which GDP is a good proxy. It has been ascertained that exchange rate, all share index, foreign direct investment and oil exports have significant impact on economies around the world. Our study yielded results that are were in line with theory.

5.3 RECOMMENDATIONS

The relationship between GDP and the variables pose a dilemma for our policy formulators, since instead of increasing GDP as is expected, EXCH and FDI have a negative relationship instead. Thus, of great importance is the need for constructive and well-specified policy recommendations that will help to streamline economic activities in Nigeria. Below are some policy prescriptions, which will help in Nigeria.

i. Government should investigate the areas the foreign investors are channeling their funds; since it is obvious their activities is not impacting positively on the economy. Policies should be put in place to ensure they invest in job-creating industries especially the manufacturing sub-sector.

ii. It is also strongly recommended that special attention be given to policy implementation. In this regard, the government should set up a policy implementation committee in the presidency for the purpose of monitoring government policies and ensuring that they are implemented according to prescriptions.

iii. The findings of this research work would serve as a basis for further research especially for financial policy makers.

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