UNIVERSITY OF KWAZULU NATAL

OIL PRICE SHOCKS, EXCHANGE RATES AND OUTPUT PERFORMANCE IN AFRICA'S OIL EXPORTING COUNTRIES

By

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Dedication

This thesis is dedicated to the glory of God for not leaving me alone to storms of life, and specially to my beloved wife, Comfort Omolayo Rotimi who in addition to putting her own career on hold, unconditionally and sincerely took care of our home to ensure that I completed the program.

Glossary of Acronyms

ADF: Augmented Dickey-Fuller

AfDB: African Development Bank

AGO: Automotive Gas Oil

AIC: Akaike Information Criteria

AOECs: Africa's Oil Economic Countries

AR: Autoregressive

BPD: Barrels Per Day

CBE: Central Bank of Egypt

CBN: Central Bank of Nigeria

CEMAC: Central African Monetary Zone named Communaute Economiqueet Monetaire de l'Afrique Centrale

CNPC: China National Petroleum Corporation

DF: Dickey-Fuller

DoF: Degree of Freedom

DPK: Dual-Purpose Kerosene

EGPC: Egyptian General Petroleum Corporation

ERC: Egyptian Refining Company

EXR: Exchange Rates

GCC: Gulf Cooperation Council

GDP: Gross Domestic Products

HQC: Hannan-Quinn Criteria

ILO: International Labour Organization

IMF: International Monetary Fund

INF: Inflation

INT: Interest Rates

LEXR: Log Exchange Rates

LINF: logarithm of Inflation

LMS: Logarithm of the money supply

LN: Logarithm

LNG: Liquefied Natural Gas

LOP: Logarithm of Oil Price

MS: Money Supply

NNPC: Nigerian National Petroleum Corporation

NOC: National Oil Corporation

OECD: Organization for Economic Cooperation and Development

OLS: Ordinary Least Square

OP: Oil Prices

OPEC: Organization of Petroleum Exporting Countries

PCI: Per-capita Income

PMS: premium motor spirit

PSVAR: Panel Structural Vector Autoregressive

SIC: Schwartz Information Criteria

SVAR: Structural Vector Autoregressive

UNE: Unemployment

US: United States

US IEA: United States International Energy Agency

VAR: Vector Autoregressive

WDI: World Development Indicators

WB: World Bank

Abstract

This thesis examines oil price shocks, exchange rates and output performance in a sample of Africa's Oil-Exporting Countries (AOECs) (Algeria, Egypt, Gabon, Libya, and Nigeria). Using quarterly data from 1980 to 2018, it is presented in three separate, but interrelated essays. The first essay presented in chapter three constructs a seven-variable Panel Structural Vector Autoregressive (PSVAR) model with the imposition of short-run restrictions to examine the oil price shocks transmission mechanism. In the same framework, trends in output growth and oil prices are examined and it is established that oil price shocks have statistically significant impacts on output and exchange rates in AOECs. The essay concludes that exchange rates is the channel through which oil price shocks are transmitted to the economy. It is thus recommended that stabilizing exchange rates is vital for sound economic performance in AOECs.

The second essay which is presented in chapter four forecasts the AOECs' exchange rates. Using quarterly data covering 1980 to 2018, it employs Autoregressive Distributed Lag (ARDL). The regression is estimated using data from 1980-2015 and forecasting data from 2016-2018. The forecasting model, which uses various forecasting evaluation criteria, supports the suitability of the model to forecast exchange rates. Furthermore, the results show that forecast combination methods may have a good predicting power on exchange rates. Combined forecasting is therefore recommended as a way to achieve predictive forecasting accuracy in AOECs.

Employing a Panel VAR model, the third essay investigates the asymmetric relationship between oil price and output. Using quarterly data from 1980 to 2018, oil prices are decomposed into positive and negative components to examine how output responds. The findings reveal an asymmetric relationship between oil prices and output. They show that, on average, positive oil price shocks positively impact output and this effect remains significant in the long run. The reverse is observed in negative oil price shocks. In terms of magnitude, the study finds that negative oil price shocks impact output at more than double the rate of positive oil price shocks. The results also reveal that low output in AOECs is associated with uncertain variations in oil prices and that an increase in oil prices results in increased inflation, which could result in higher levels of unemployment. This finding is associated with the inadequacy of refining capacity in the AOECs, causing them to import refined fuel at a high cost. It is thus established that the economies of the AOECs are vulnerable to negative oil price shocks that negatively affect exchange rates, while positive oil price shocks positively affect the cost of production. It is on this basis that the study recommends that AOECs should build sufficient external reserves to minimize the impact of negative oil price shocks on exchange rates.

Keywords: Oil Price, Exchange Rates, Output, Forecast, Africa, Oil Exporting, PSVAR, Assymetry

Thesis Distributions

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Table of Contents

List of Tables

Table of Contents

List of Figures

CHAPTER 1

INTRODUCTION

1.1 Preamble

Oil price shocks have received considerable attention since the aftermath of the oil price shocks of the 1970s and the attendant effects on economic behavior. This has generated controversy on the relationship between oil price shocks and their presumed role in macroeconomic behavior. The debate points to the important role that changes in oil prices[1] play in determining the path of exchange rates and economic output. A question that is often posed is whether oil price shocks explain variations in output and exchange rates. While this may be true, the process through which it occurs remains a puzzle.

Oil price shocks trigger economic imbalance and may lead to revenue losses (Hamilton, 1996; 2003) in oil-exporting countries, which can adversely affect output. Revenue losses could reduce capital expenditure and cause firms to delay investment (Mohaddes and Pesaran, 2017). Unexpected changes in oil prices can cause uncertainty in the economy and can also reduce investment and negatively affect consumption of durable goods. Although a number of empirical studies have been conducted on oil price shocks and their attendant effects on economic behavior, controversy continues to surround the connection between oil price shocks and their presumed role in macroeconomic performance, especially in terms of the role that oil price changes may play in determining the path of output growth and exchange rates. For example, Ahmed (2017), and Majid (2008) argue that positive oil price shocks[2] positively impact output performance such that, the national currency appreciates. The national currency of oil exporting country appreciates when the units of dollars used to buy barrel of oil increase, leading to more demand of the local currency to buy certain amount of crude. Ahmed (2017), and Majid (2008) add that this is stimulated by foreign exchange earnings and that the opposite holds in the case of negative oil price shocks. In contrast, scholars like Fattouh and Sen (2015) and Damechi (2012) argue that positive oil prices shocks may not always lead to currency appreciation among oil-exporting countries due to factors such as the level of local economic diversification, the nature of the change in oil prices, and the refining technique and refining capacity of the oil-exporting country. A currency appreciation is defined as an increase in the value of one

[1] It is denominated in US$ per barrel and determined by market activities at the international level which are independent of the forces in the regional market.

[2] Oil price shocks are broadly known as unanticipated changes in the global prices of oil per barrel over time. Oil price shocks could either be positive or negative. They are positive when the oil price shocks cause global oil prices to increase and negative when the oil price decreases

currency relative to another in foreign exchange markets. In this context, an increase in demand for oil will lead to an increase in demand for the currency of the country producing the oil. Therefore, the rates at which the currency exchanges on the foreign exchange market will increase in favour of the oil exporting country and vice versa. Stabilization of exchange rates is vital for sound economic performance but accurately estimating exchange rates is critical in the financial domain (Haskamp, 2017). Moreover, scholars and policymakers argue that the impact of positive and negative oil price shocks on the macroeconomy might differ in both magnitude and signs as well as across regions, hence causing economic imbalances (see Apergis *et al*., 2015; Narayan and Sharma, 2011; Narayan and Gupta, 2015).

Effective management of an economy requires sound knowledge of such shocks that could affect the working of an economy and the process of their transmission. While extensive research has been conducted on the impact of oil price shocks among different economic groups in developed countries, there is limited research on developing economies (see Iwayemi and Fowowe, 2011), where oil price variations are anticipated to significantly impact the economy.

While there is overall consensus that oil price movements affect economic activity (see Hamilton, 2013; Mork, 1989), the way in which they do so remains a subject of debate, particularly with regard to the mechanism by which movement in oil prices can impact output growth in oil-exporting countries (see Damechi, 2012; Fattouh and Sen, 2015). This debate continues and has been associated with the frequency of the fall or rise in oil prices. For instance, Vahid and Jabber (1997) and Majid (2008) argue that the impact of increases in oil prices in oil-exporting economies generally leads to appreciation of the currency as a result of earnings from foreign exchange. Accordingly, the output of these countries expand. They also observed that the opposite is the case when the shocks are negative. According to Damechi (2012) and Fattouh and Sen (2015), this chain of reaction may not occur as expected due to several factors, including the nature of the change in oil prices, the availability of local refining capacity and the level of economic diversification (see Kim and Roubini, 2000; Hamilton, 2003, 2009; Kilian and Park 2009). Furthermore, Iwayemi and Fowowe (2011) argue that an oil-exporting country with a lean economic base and low local capacity to refine might not enjoy a rise in output during periods of positive oil price shocks and exchange rates may not appreciate due to massive importation of refined petroleum products. Damechi (2012) notes that output may not necessarily fall in the event of negative oil price shocks if the oil-exporting country is extensively diversified and has sufficient local capacity to refine, thus reducing importation of goods and effectively preventing the currency from depreciating. Damechi (2012) also argues that the asymmetric response to positive and negative shocks assumed in most of the literature (see Kilian and Vigfusson, 2011; Moshiri 2015) may not reflect reality. These studies argue that a sharp drop in oil prices affects oil-producing countries through currency depreciation and decreased output. Thus, there is no consensus on the nature of the impact of oil price shocks on both output performance and exchange rates.

In view of this, while the AOECs' exchange rate policies seem inappropriate, the best direction to follow to determine appropriate exchange rates during oil price shocks remains open to debate. For instance, Iwayemi and Fowowe (2011) and Ushie, Adeniyi and Akongwale (2013) conclude that oil-exporting nations are faced with a decline in output during negative oil price shocks, particularly when the fall is sharp, and it is expected that they will devalue their currency in order to attract foreign investors, discourage importation and improve domestic output. However, some scholars argue that this may be counterproductive for several oil-exporting countries that rely on importation of basic items like raw material for local manufacturers and capital goods (see Oomes and Kalacheva, 2007; Spatafora and Stavrev, 2003). They note that this will further reduce domestic output. Sarno, Valente and Wohar (2004) and Oomes and Kalacheva (2007) assert that countries should always maintain a fixed exchange rate regime during an oil price decline by using their external reserves as a buffer. This will limit the adverse effects on the economy as it will ensure economic stability. In contrast, Habib and Kalamova (2007) and Nikbakht (2010) state that using external reserves as a buffer may not be sustainable, particularly if the decline in oil prices is prolonged. They are of the view that exchange rates should be left to the market to determine, as this will promote long-run economic stability. The question thus is: do oil price shocks impact the real exchange rate and what exchange rate policy should the AOECs follow when oil prices decline? This calls for an assessment of the factors that determine movement in the exchange rate. According to the International Monetary Fund (IMF) (2017) an appropriate exchange rate policy is highly dependent on the factors that affect its movement at a particular point in time and the economic instability caused by inappropriate exchange rate policy can be ameliorated by assessing the determinants of exchange rate movements. Furthermore, Eslamloueyan and Kia (2015) note that the success of an economy relies on exchange rates since they serve as a measure of price-cost competitiveness.

Unexpected movement in oil prices poses a significant macroeconomic risk to oil-exporting nations (see Beckers, 2015). In the past decade, oil prices have tripled, from $40 in 2003 to $140 in 2008 (see OPEC, 2016), and later dropped as low as $50 in late 2014, which was not expected. The crash in oil prices following the Lehman bankruptcy in the United States of America in 2008, the consequent rise between 2009 and mid-2014, and the sharp fall since then reveal that fluctuations in oil prices continue, with significant implications for overall economic uncertainty. Research has shown that oil price fluctuations have an effect on long-run economic growth due to disruptions in the long-term economic planning framework. For instance, Damechi (2012) argues that the asymmetric nature of oil prices has a larger impact on the output performance of oil-exporting nations than its symmetric counterpart. In contrast, Hamilton (2013) concluded that the asymmetric behavior of the oil price remains contentious in the economic literature.

This thesis contributes to the existing literature by investigating economic output performance and the factors determining exchange rate behavior under oil price shocks with a view to determining the appropriate exchange rate policy response in the AOECs.

1.2 A brief overview of the African economy (AOECs)

Africa has rich deposits of crude oil, which is among key players in crude oil exports (US EIA, 2018). Data from the US EIA (2018) and OPEC (2018) reveals that among the 54 countries on the continent, only a few are oil exporters, with about 500 companies participating in oil-related services. Furthermore, the data shows that there was significant growth of nearly 244 percent in proven oil reserves from 1980 to 2013. It is estimated that nearly one hundred billion barrels await discovery at the African offshore. Hence, Africa's potential for further oil exploration and discovery remains significant (OPEC, 2018). The general oil reserves, oil production and oil exports in Africa are expected to rise over time, with the production of crude oil concentrated in Equatorial Guinea, Nigeria, Algeria, the Gulf of Guinea and Angola (US EIA, 2018). This may also include Libya and Egypt. South Sudan and Sudan are latent key players, but their separation in 2011 caused a setback in their aggregate production.

Given Africa's enormous oil endowments, the continent remains an emerging player in global oil production, contributing about 10 percent of global oil exports in 2013, second to the Middle Eastern countries, which recorded about 45 percent of the world's crude oil output (see OPEC, 2018). Oil proceeds account for large foreign exchange earnings, providing significant resource inflows to governments over the years. The oil sector has remained economically critical in several AOECs (Iwayemi and Fowowe, 2011). However, some regard oil as a curse in disguise as a result of factors like theft, corruption, uneven wealth distribution, pilfering**,** and operational hitches, leading to low economic performance (Akpan, 2009). For instance, Caselli and Michaels (2013) assert that the spending of oil proceeds has not translated to positive economic outcomes. Indeed, some oil-producing nations in the Middle East and Africa have experienced a slowdown in economic performance. This is attributed to poor administration of oil resources that should be channeled into the real sector (Van der Ploeg and Venable, 2011; Hausmann and Rigobon, 1993). Similarly, Olomola (2010) and Sachs and Warner (2005) argue that countries endowed with abundant natural resources demonstrate poor economic performance in comparison with those with fewer natural resources. For instance, it has been observed that oil price increases do not correlate with an increase in employment (Al-Habees and Rumman, 2012). Nonetheless, oil continues to be the backbone of African oil-exporting nations' economies which depend on crude oil exports for foreign exchange earnings. Furthermore, oil proceeds have contributed immensely to their Gross Domestic Product (GDP).

Table 1.1 presents some major economic development indicators of the AOECs. The macroeconomic performance indicators translate into different categories of influence that determine the AOECs' position in various sectors of the global economy. These indicators have consistently enabled these countries to maintain their position in global business (Akpan, 2009).

The population of the AOECs in 2016 was estimated at about 323 million, constituting about 2.7 percent of the continent's population. They recorded around a 2.6 percent annual growth rate (US EIA, 2018) and inflation at the end of 2015 was in single digits, except for Egypt at 10.3 percent. The highest GDP growth rate within the period was recorded in Libya at 4.95 percent, compared with Algeria at 1.6 percent. Nigeria recorded the highest interest rate of 7.7 percent, suggesting a high cost of borrowing and doing business holding other factors constant, within the period compared to other oil exporters within the region.

Table 1.1: Development Indicators at the end of 2015

Indicators	Algeria	Egypt	Gabon	Libya	Nigeria
Population ('million)	39.87	93.77	1.93	6.23	181.18
Population Growth Rate (percent)	1.9	2.1	2.9	0.5	2.6
Population Ranking in Africa	8th	3rd	46th	36th	1st
GDP (Constant per capita at 2010, '$ billion)	4160.22	2665.35	9598.44	6073.40	2562.52
GDP Ave Annual Growth (percent)	3.8	4.4	3.9	-10.1	2.7
Major Resource owned	Crude	Crude	Crude	Crude	Crude
Inflation (percent)	4.7	10.3	-0.29	2.6	9.0
Exchange Rate (percent)	107.1	7.83	591.45	1.39	199.12
Money Supply ('$ million)	107,775	226,142	3,256	49,890	87,484
Unemployment (percent)	11.2	13.05	20.16	18.35	4.31
Interest Rate (percent)	6.25	4.72	2.95	3.50	7.70
Oil Reserves ('million barrels)	12.2	4.4	2.00	48.00	37.06
percent of Oil Reserves in Africa by countries	9.5	3.4	1.6	37.7	28.9
Oil Production ('million barrels)	1.37	0.51	0.21	0.40	2.33
percent of Africa Oil Exports by countries	14.2	2.3	2.8	16.3	29.6

Source*: Author's computation (2020), using data sourced from the WDI.*

In terms of oil reserves, Libya stands out, recording about 48 million barrels in 2015. This is larger than the sum of oil reserves for Algeria, Egypt and Gabon combined. Nigeria occupied second position at about 37 million barrels. In terms of oil production, Nigeria took the lead, producing about 2.33 million bpd[3], followed by Algeria at about 1.37 million bpd.

1.3 Scope of the study and justification

The African continent is abundantly endowed with human and non-human resources. There are fifty-four countries on the continent that is hugely endowed with various mineral resources. Crude oil resources form the focus of this study. Africa has about twenty oil-producing countries, of which about eleven are net exporters of oil (US EIA, 2018). The five leading oil-exporting countries, namely, Nigeria, Libya, Angola, Algeria, and Gabon are members of the Organization of Petroleum Exporting Countries (OPEC), an oil cartel founded in 1960 that primarily aims to regulate oil output among member states. In accordance with its statutes, OPEC aims to coordinate and unify the oil policies of its member states, and ensure oil market stabilization as well as a regular petroleum supply to buyers.

The following countries in Africa control the bulk of oil production on the continent: Nigeria (1st); Angola (2nd); Algeria (3rd); Egypt (4th); Libya (5th); Equatorial Guinea (6th); Sudan and South Sudan (7th); Congo (8th); Gabon (9th); South Africa (10th); Ghana (11th); Chad (12th); Cameroon (13th); and Tunisia (14th) (OPEC, 2016). These countries produce about 80 percent of the total oil exports in Africa (EIA, 2018). Of the global proven oil reserves standing at 1.66 billion barrels, OPEC controls about 73.0 percent while the six leading net oil-exporting nations in Africa (Libya, Nigeria, Algeria, Angola, Algeria, and Egypt) control about 10 percent of world reserves (OPEC, 2017).

It is against this background, that this study focuses on Libya, Nigeria, Algeria, Egypt, and Gabon to represent the AOECs. Angola is excluded due to a paucity of data. The choice of this selection is premised on OPEC's data classification shown in Table 1.2.

Table 1.2: Classification of AOECs

Segments	Country	Oil Exports ('000 bpd)	Proven oil reserve (Bn)
1st (Exports >1 million bpd)	Nigeria	2,317	37.07
	Angola	1,842	9.01
	Algeria	1,370	12.20
2nd 500,000≤Exports (bpd) ≤1 million	Egypt	667	4.40
3rd Exports < 500,000 bpd	Libya	404	48.36
	Sudan	262	3.75
	Equatorial Guinea	256	1.10
	Republic of Congo	250	1.60
	Gabon	213	2.00

Source*: Author's computation (2020), using data sourced from the WDI.*

[3] Barrels per day.

As shown in Table 1.2, Africa's oil-exporting countries are classified into three segments based on their production capacity. The first segment comprises countries whose oil output is more than 1,000,000 bpd, the second is countries with oil output greater than 500,000 bpd but less than 1,000,000 bpd and the third segment is those with oil output of less than 500,000 bpd. This study focuses on six countries, two from each of the segments, as representatives of AOECs. The total oil exports of these nations constitute about 90 percent and 70 percent of proven oil reserves and oil production in Africa, respectively. They are thus representative of the AOECs. While Nigeria is included as the country with the largest oil output, alongside Algeria, in the first segment, Angola was dropped due to a paucity of data on some of the variables needed for this study.

Libya, which used to be among the countries in the first segment, dropped to the third segment due to a decrease in production from 1,044,000 bpd in 2013 to about 450,000 bpd in 2018. This was largely associated with the internal crisis triggered by the Arab Spring. The country witnessed a severe interruption in oil supply during the Libyan civil war in 2011. Oil production declined from about 1.8 million bpd to about 846,000 bpd in early 2011 and plummeted to a daily average of 500,000 bpd during the course of that year. Prior to the end of 2018, the country's daily average oil output was 450,000 bpd (OPEC, 2016). Libya had previously maintained an average oil production range of above 1.7 million bpd and 1.85 million bpd for nearly six years. Egypt is included in this study as the only oil-exporting country in the second segment and due to the fact that the data required for this study were also available for Egypt. Two of the five countries in the third segment are also included. Three countries, comprising Equatorial Guinea, Gabon and Congo in this segment are from the Central African Monetary Zone, Communaute Economiqueet Monetaire de l'Afrique Centrale (CEMAC) and a single apex bank administers the monetary policy of countries within the zone.

We hence postulate that they share common features, including monetary policy management. Sudan, which is also in the third segment, does not necessarily have a similar monetary policy to Congo, Gabon, and Equatorial Guinea. The country is also characterized by incessant civil war and political unrest (OPEC, 2018), as a result of which the data required for this study was lacking. Thus, Gabon and Libya were included on the basis of the available relevant data and as countries within the third segment. Although Libya is not in the same monetary zone as the other countries in the segment, it contains the required variables.

1.4 Objectives of the study

This study's three specific but interrelated objectives are to:

i. examine oil price shocks and output performance in Africa's Oil Exporting Countries.

ii. forecast exchange rates in Africa's Oil Exporting Countries.

iii. investigate the asymmetric behavior of oil price shocks in Africa's Oil Exporting Countries.

1.5 Research Questions

i. Do oil price shocks impact output performance in Africa's Oil Exporting Countries?

ii. How can exchange rates be forecast in the AOECs?

iii. Is the behavior of oil price shocks symmetric or asymmetric in Africa's Oil Exporting Countries?

1.6 Research Contributions

This research sets out to provide answers to the fundamental question of whether oil price shocks significantly affect output growth in the context of the AOECs, and if so, to identify the transmission mechanisms through which they impact economic activities. This is consequent to the need to formulate policies that will optimize the AOECs' potential for economic growth. The AOECs are defined as developing countries in Africa with huge reliance on oil, a high mortality rate, low per capita income and a large population living in abject poverty (Iwayemi and Fowowe, 2011). The study contributes to knowledge in diverse ways. Firstly, it extends extant literature on energy economics. To the best of the author's knowledge, this is the first study to consider AOECs within a panel framework, using the Panel-SVAR estimating technique, to understand the relationship between oil price shocks and output growth. Secondly, as far as can be established, this is the first study to decompose oil prices in a panel context to evaluate the impact of oil price shocks on output in AOECs. To the best of our knowledge, previous studies have only considered country-specific and not panel data. Thirdly, through the exchange rates forecasting model, this study offers insights into the operations of exchange rates and their determination in the AOECs.

1.7 Structure of the study

The study is arranged in six chapters. The first chapter presents the context of the study and an overview of the AOECs' scope. It also provides the rationale for this study. Chapter two presents a review of the theoretical and empirical literature relevant to the study. Chapter three focuses on the study's first objective and examines oil price shocks and output performance in AOECs using a Panel Structural Vector Autoregressive (PSVAR) model. Chapter four dwells on the second objective and models the determinants of exchange rate behavior in AOECs. Chapter five investigates the asymmetric effects of oil prices in AOECs. This chapter is very broad because the analysis is carried out based on each country. Finally, chapter six draws conclusions, summarizes the findings, presents recommendations and identifies areas for further research.

CHAPTER 2

AN OVERVIEW OF AFRICA'S OIL EXPORTING COUNTRIES

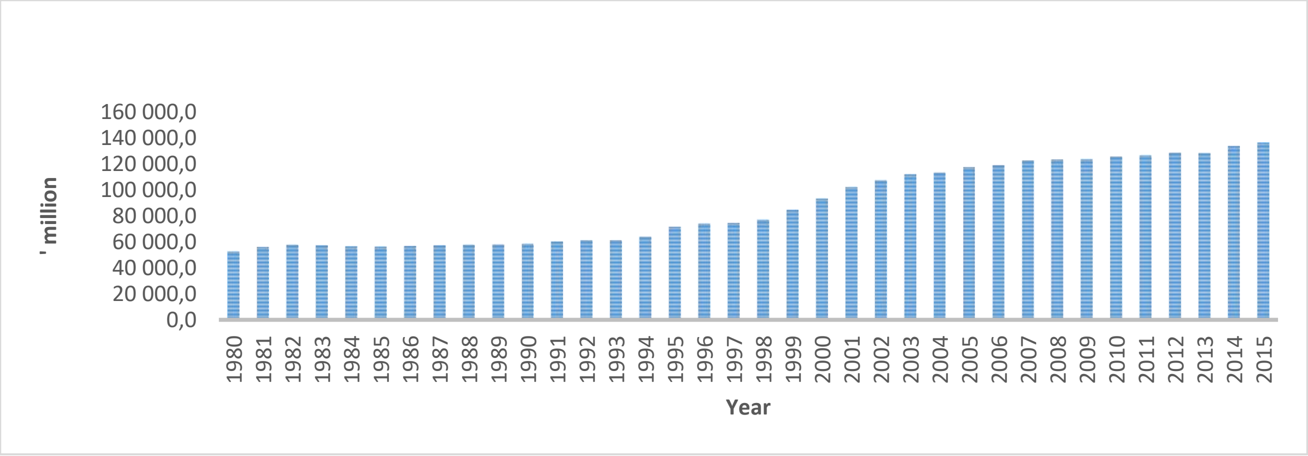
2.0 Introduction

The preceding chapter presented the background to the study, including the context, the motivation for the study, the problem statement and the objectives and research questions. This chapter presents an overview of oil reserves in Africa and AOECs. It examines oil reserves, oil output, and the relationship between oil prices and GDP in AOECs, and provides an overview of crude oil price movement, and of the AOECs, OPEC countries and economic diversification.

2.1 Africa's Proven Oil Reserves

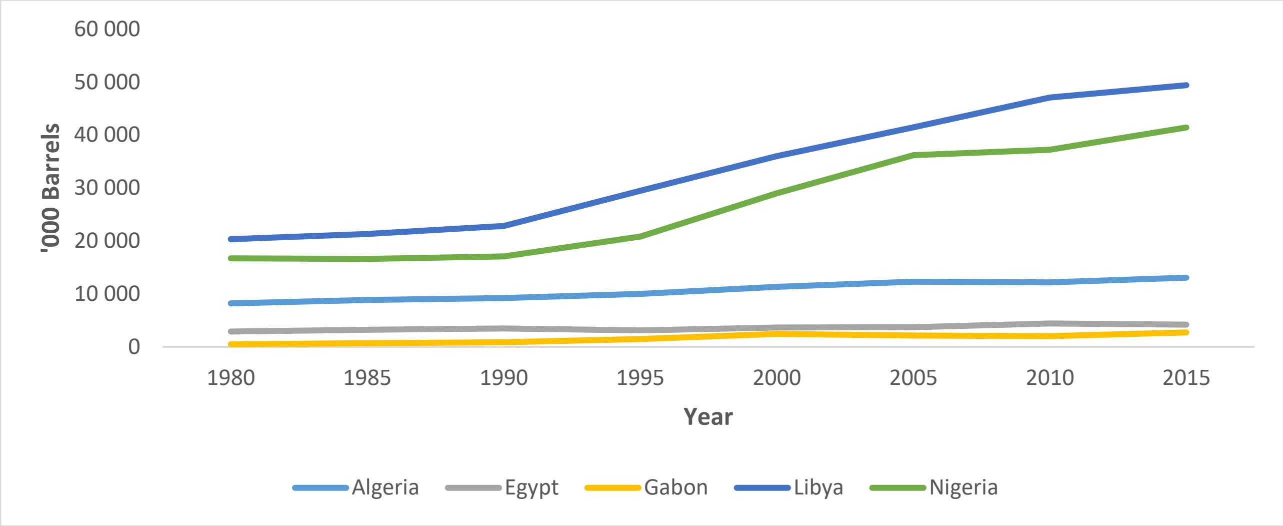
As shown in figure 2.1, proven oil reserves in Africa were estimated at 53 billion barrels in 1980. With more discoveries, they have consistently increased. Between 1980 and 1990, total proven oil reserves in Africa averaged 57 billion barrels with 90 percent found in Libya, Angola, Sudan, Algeria, and Nigeria. The continent's proven oil reserves increased from about 53 billion barrels in 1980 to about 117 billion in 2006, about 10 percent of global proven oil reserves. The major reserves are found in Nigeria and Libya, which respectively account for 3 percent and 3.4 percent of the world's reserves (OPEC, 2016). There was a major increase in oil reserves between 1991 and 2000, reaching 72 billion barrels. Oil reserves rose to about 126 billion barrels in 2010, about 2.2 times the total oil reserves between 1980 and 1990 and 1.8 times those between 1991 and 2010. They peaked in 2015, at a total of about 136 billion barrels. Proven oil reserves increased by an average 259 percent, 233 percent, 146 percent and 109 percent from 1980, to 1990, 2000, 2010 and 2015. This represents significant growth in oil discoveries among the countries of the region.

Figure 2.1**: Discovered Crude Oil Reserves in Africa**



Source*: Author's Computation (2020), using data sourced from the WDI.*

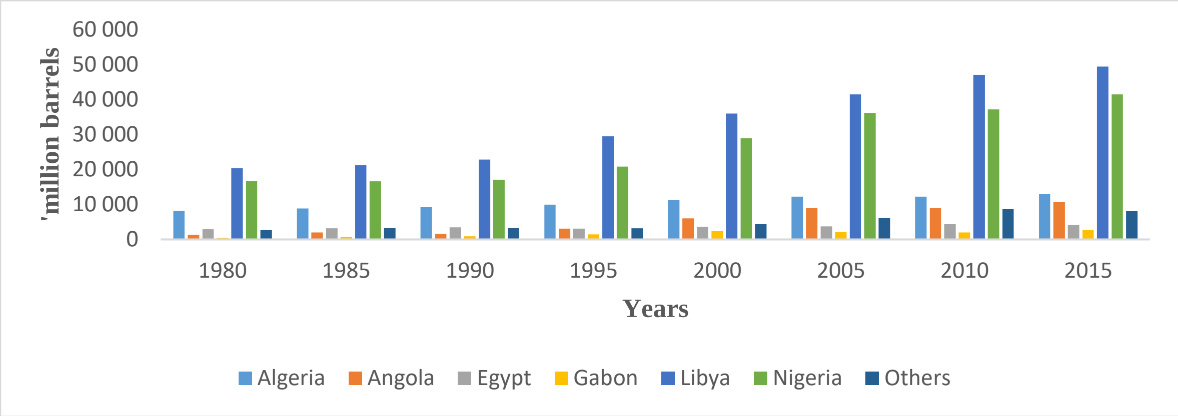
Figure 2.2: **Growth of Discovered Crude Oil Reserves in Africa by major countries**



Source: *Author's computation (2020), using data sourced from the WDI.*

Historically, discovered oil reserves in the world have trended upward over the years. As depicted in figure 2.1, Africa's oil reserves have followed a similar pattern. Figure 2.2 shows the growth pattern of proven oil reserves among the major oil-exporting countries in Africa. As at 1980, global proven oil deposits stood at about 643,999 billion barrels while Africa's proven reserves stood at about 53 billion barrels. By the end of 2015, discovered oil reserves had grown by 159 percent in Africa (see OPEC, 2015).

Figure 2.3: **Africa's Oil Reserves by major Countries**



Source: *Author's Computation (2020), using data sourced from the WDI).*

As depicted in figure 2.3, for the period under review spanning 1980 to 2015, Libya recorded the highest deposits of crude oil, followed by Nigeria, Algeria, Egypt, and Angola in that order, while Gabon had the lowest oil reserves. Gabon's oil reserves dropped slightly from 2.5 billion barrels in 2000 to 2 billion in 2005. Similarly, reserves in Angola declined slightly from 2.4 billion barrels in

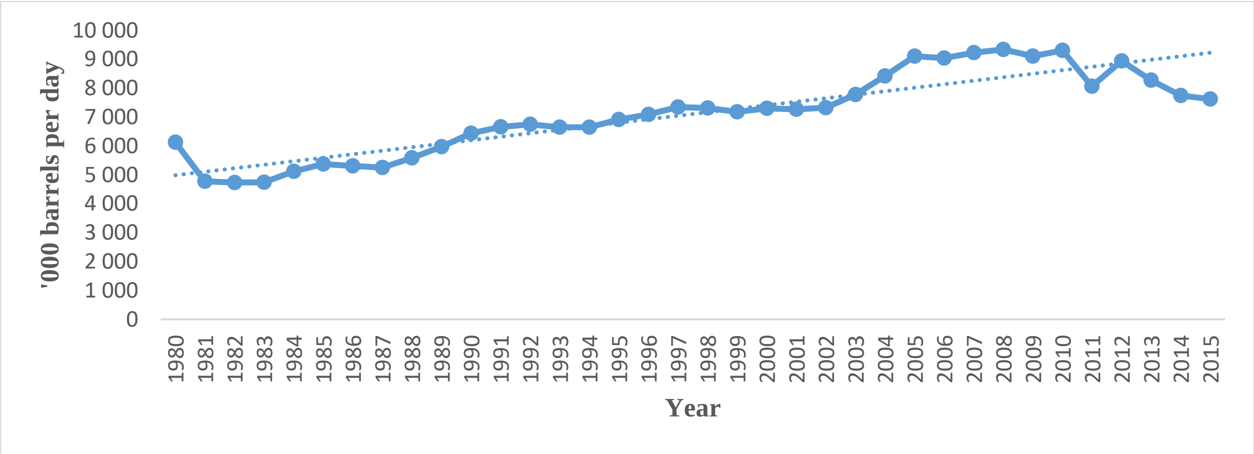
1985 to 1.8 billion barrels in 1990 while the leading countries in oil production, Libya and Nigeria experienced a continuous upward trend. For instance, oil reserves in Libya jumped from 29.5 billion barrels in 2000 to 48.36 billion in 2017 while in Nigeria, they increased from 22.5 billion barrels in 2000 to 37.5 billion in 2017.

2.2 Africa's Oil Production

Oil production in Africa commenced in earnest during the 1960s. Production increased (see figure 2.4) until in the 1980s, when a collapse in oil prices resulted in a slowdown. For instance, while Egypt's oil production increased from about 0.595 million bpd in 1980 to 0.670 million bpd in 1982, production in Algeria, Gabon, Libya and Nigeria dropped from 1.1 million/bpd, 2.1 million/bpd, 175,000/bpd and 1.8 million/bpd to 987,000/bpd, 1.3 million/bpd, 156,000/bpd and 1.2 million/bpd, respectively. During the same period, oil production in Africa and the world as a whole declined from 6.1 million/bpd and 59.5 million/bpd to 4.7 million/bpd and 53.4 million/bpd, respectively. In 1984, the trend changed as oil production in these countries increased slightly.

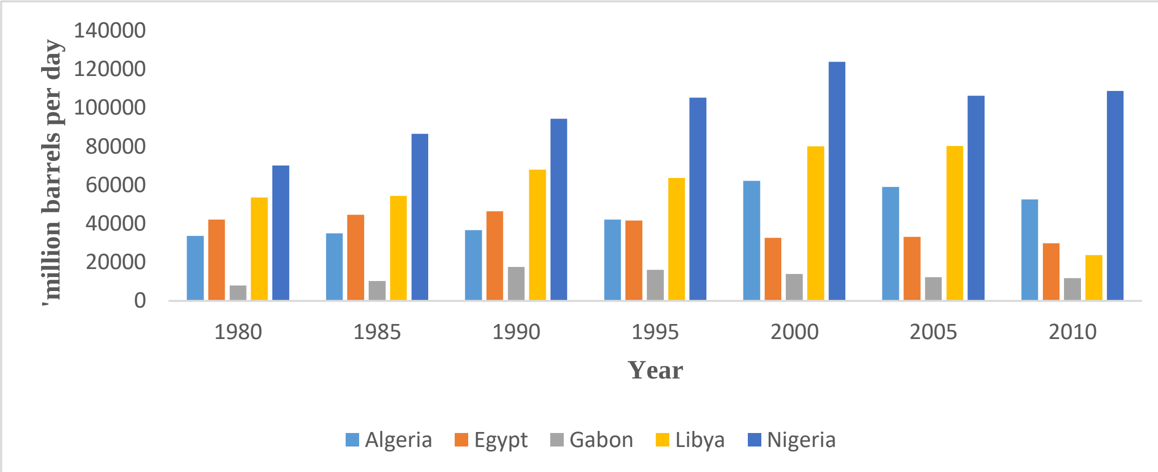
Table 2.2 shows that Nigeria records the highest oil production in bpd among the AOECs, followed by Algeria, Libya, Egypt, and Gabon in that order. The same applies to their average daily oil production. The lowest daily oil production in Nigeria (1,241,000 bpd) is more than the sum of the minimum oil produced by Egypt, Gabon and Libya combined which stood at 1,066,000 bpd in 2015. Figure 2.4 shows that during this period, oil production trended upward. Similarly, figure 2.5 illustrates that oil production in AOECs increased gradually during the period under study.

Figure 2.4: **Africa's oil production '000 barrels per day (1980-2015)**



***Source**: Source: Author's Computation (2020), using data sourced from the WDI.*

Figure 2.5: **Oil production Growth in Africa by countries**

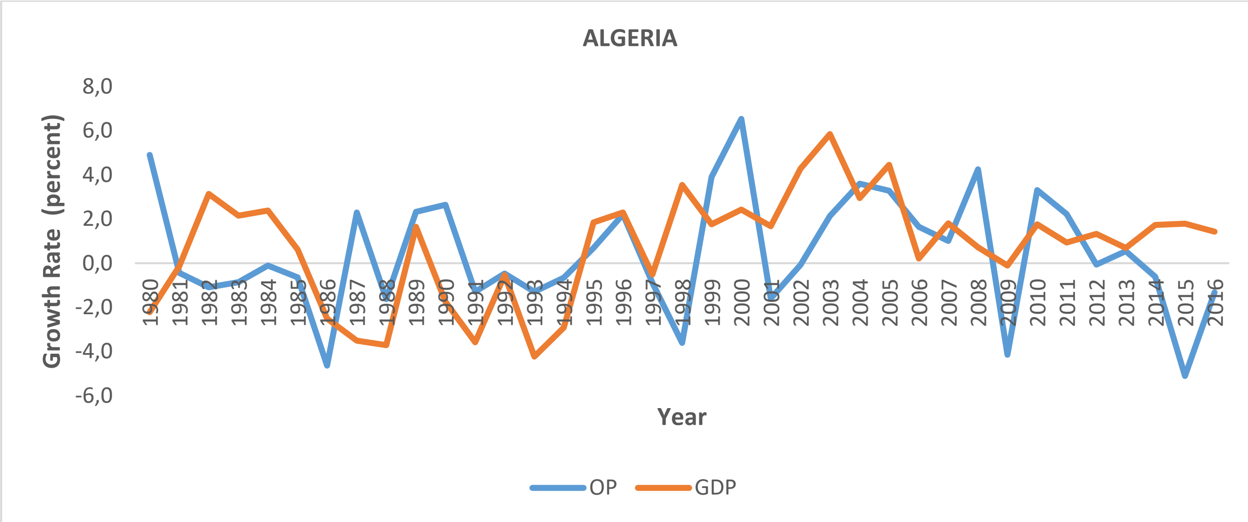


Source*: Author's computation (2020), using data sourced from the WDI.*

2.3 Relationship between Oil Prices and GDP in Africa's Oil Exporting Countries

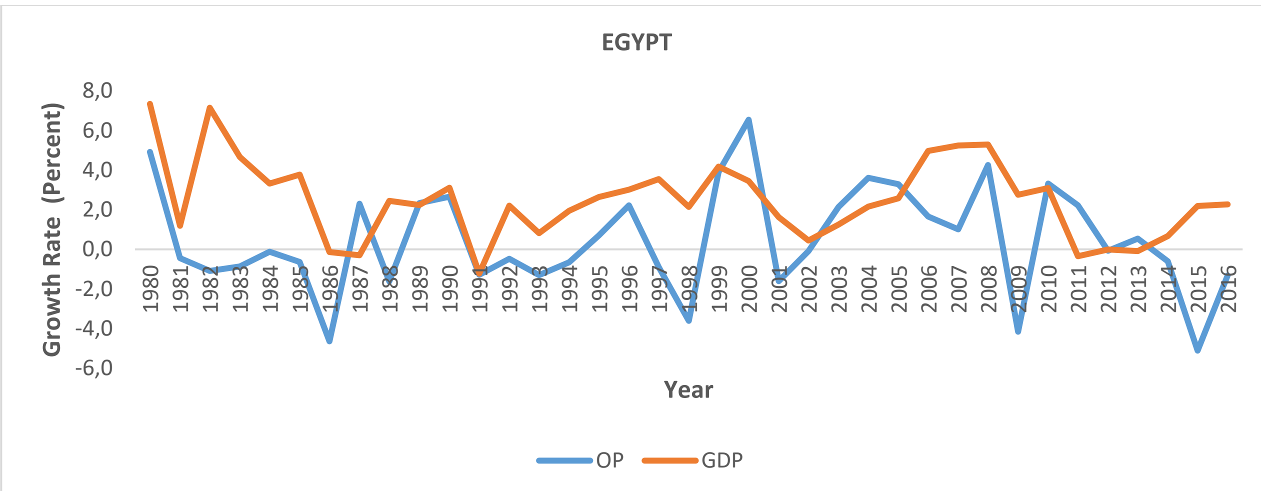
Figures 2.6a to 2.6e show the trends in variations in oil prices and output growth for Algeria, Nigeria, Egypt, Libya, and Gabon, respectively. There seems to be an association between oil prices and these countries' GDP at some points in time, as similar patterns can be observed in periods of increases in oil prices and periods that witnessed a fall in the price of oil. In 1980, apart from Algeria, which experienced a decline in output growth despite the remarkable increase in oil prices, other countries experienced increased output, but the reverse was the case in 1981 when a slight decline in oil prices was experienced. With a continuous drop in oil prices from $37.75 in 1980 to $14.44 in 1986, average oil production growth for these countries was Algeria, 0.5 percent, Egypt, 3.9 percent, Gabon, -0.5 percent, Libya, 15.1 percent and Nigeria, -2.9 percent. Positive oil price shocks from 1999 to 2000 resulted in a continuous increase in oil output until 2009, except for Libya that experienced an on-going decline in output. However, sharp rises in oil prices seem to have been accompanied by declining economic performance in some countries while there is an increase in output performance in others. Thus, despite the consistent rise in oil prices over time, some countries' economies expanded while others contracted even though they have similar characteristics. It is against the background of this ambiguity that this study empirically investigates how macroeconomic variables respond to oil price changes and seeks to determine the quantitative measure of their reactions.

Figure 2.6a: **Annual percentage change in crude oil price and Algeria's GDP**



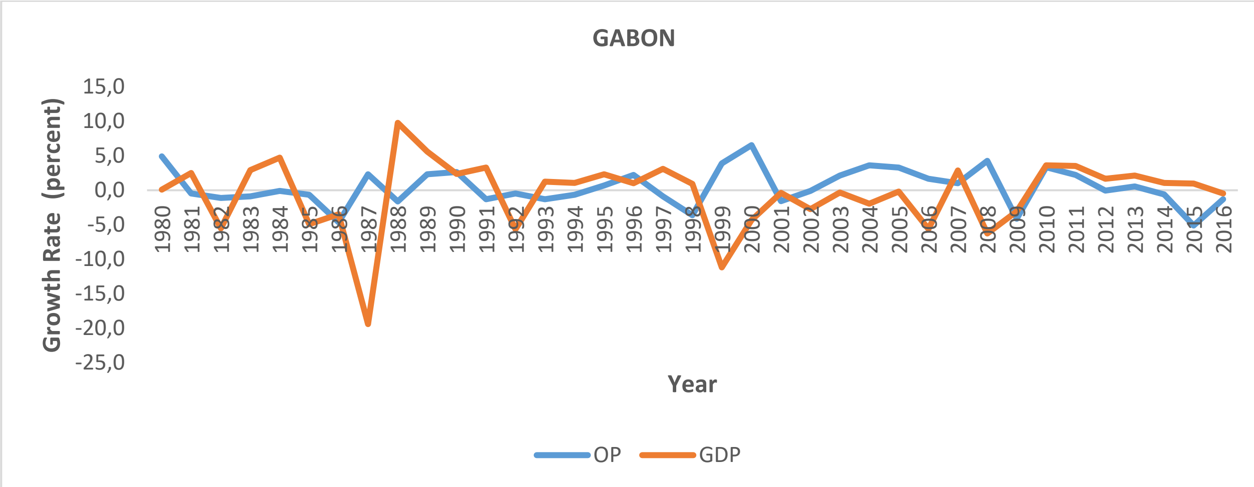
***Source**: Author's Computation (2020), using data sourced from the WDI.*

Figure 2.6b: **Annual percent change in oil price and Egypt's GDP**



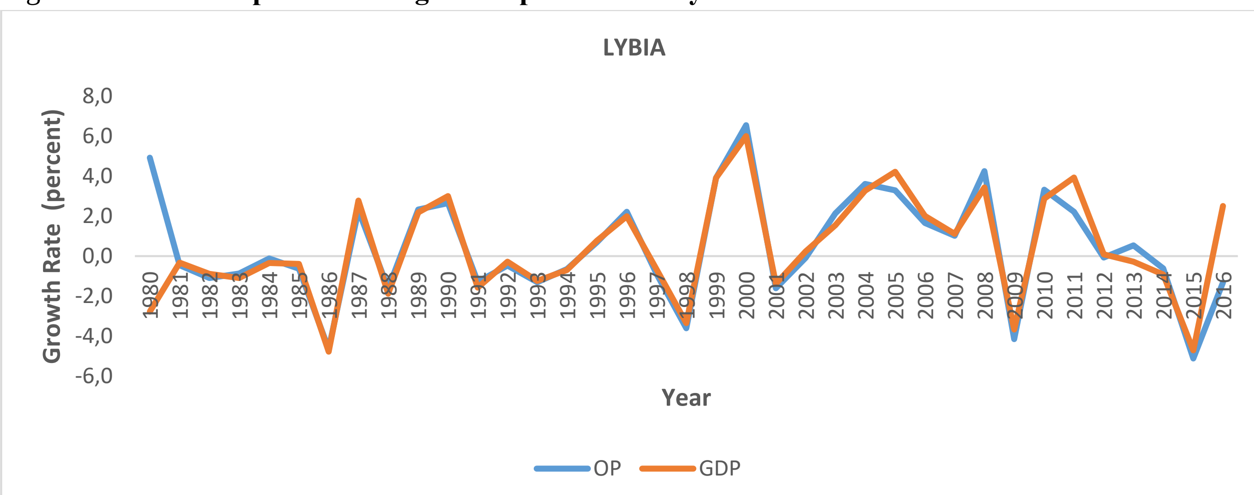
***Source**: Author's Computation (2020), using data sourced from the WDI.*

Figure 2.6c: **Annual percent change in oil price and Gabon's GDP**



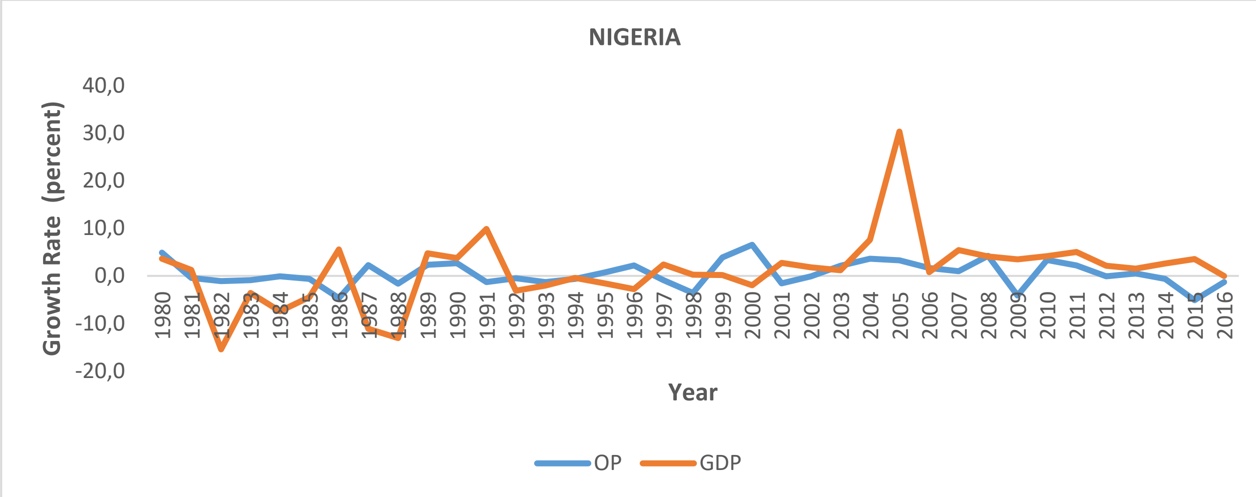
***Source**: Author's Computation (2020), using data sourced from the WDI).*

Figure 2.6d: **Annual percent change in oil price and Libya's GDP**



***Source**: Author's Computation (2020), using data sourced from the WDI.*

Figure 2.6e: **Annual percent change in oil price and Nigeria's GDP**



Source*: Author's Computation (2020), using data sourced from the WDI.*

2.4 Overview of Crude Oil price movement

2.4.1. Historical Path

Oil is an essential commodity and a key primary energy source for day to day business activities. According to Korhonen and Ledyaeva (2010), oil has the highest value of primary commodities traded, thus attracting the interest of both importers and exporters. Crude oil is commonly used among nations, firms, and individuals, and its annual average prices have witnessed remarkable fluctuations over time, leading to distortions in output and exchange rates.

The path of oil price variations is traceable to the 19^{th} century when the internal combustion engine was invented during the industrial revolution. According to Painter (1986), this period marks the most significant technological advancement. Painter (1986) notes that the combustion engine is widely used in the manufacturing, agriculture and transportation industries and these industries largely rely on petroleum, coal and natural gas. Since world economies rely more on oil-powered sources, global oil demand is constantly increasing. The gap between oil demand and supply has different impacts on an economy depending on whether it is a net oil-importing or net oil-exporting economy (Yan, 2012).

The year 1971 marked the beginning of the 1971-1973 oil crisis. It was during this time that the "Bretton Woods International Monetary" System was abandoned. The crisis extended into 1973, during the Yom Kippur War, when Arab oil-producing countries banned oil shipments to nations that offered support to Israel. This led to a vast increase in oil prices within a few months. The oil price jumped by about 367 percent (from \$2.48/barrel in 1972 to over \$11.58/barrel in 1974) as a result of the US embargo on oil exports. This resulted in the global economy moving into recession (Yan, 2012; Kutlu, 2015). Figure 2.7 shows the rise in oil prices, illustrating OPEC's success at the beginning of the 1970s, as demand exceeded output. It was during this time that OPEC came to appreciate the power that resides within its oil resources, which it could apply as a political and economic tool (see Kutlu, 2015).

This maiden oil price shock documented in the literature was a vital political and economic event that led to much debate in subsequent years. Gachara (2015) categorizes the various views and theories on the initial oil price shocks into three classes: conspiracy theories, traditional theories and the dependence theory. The traditional theory holds that the oil crisis was due to the oligopolistic structure of oil firms, involving OPEC's collective decisions, and the interaction between supply and demand on the global oil market. The dependence theory focuses on the oil crisis as a form of economic nationalism in developing countries in order to gain an equal position in their relationship with the industrial powers. Finally, the conspiracy theory is premised on the notion that the American government collaborated with oil firms and OPEC to deliberately cause the crisis.

The second oil crisis, which resulted in a doubling of oil prices, is accounted for by the Iranian revolution of 1978, leading to the Iraq-Iran war of 1980. Between 1974 and 1978, global oil prices increased from $11.580 to $14.020 per barrel. Between 1979 and 1980, the Iraq-Iran war caused another price hike. The Iranian revolution resulted in a loss of about 2.5 million bpd (see OPEC, 2016). Similarly, Iraq and Iran's joint oil production declined to 1 million bpd from 7.5 million bpd in previous years. In addition, the war between the countries caused crude oil prices to jump, rising from $14 bpd in 1978 to $35 bpd in 1981 (OPEC, 2016).

The third oil crisis started in 2003 when increasing demand from the BRICS countries (Brazil, Russia, India, China and South Africa) and some emerging nations set in motion a rising price trend that unexpectedly accelerated in the first half of 2008 at the time of the global economic crisis. The Brent Crude price jumped from $96 per barrel in January 2008 to $144 per barrel in July 2008 (OPEC, 2017). According to OPEC, this was the highest oil price level, both in nominal and real terms. Shortly thereafter, oil prices suffered a remarkable tumble at the height of the financial crisis during 2008. The average monthly crude price dropped from $130 per barrel in July to $40 per barrel in December 2008. In 2009, as oil-producing nations began to reduce output to sustain their revenue level, the average price of crude oil rose progressively to $80 per barrel. In 2010, economic salvage efforts created the strongest growth in demand for oil since 2004, driving the price up again. Prices climbed further in early 2011 in the wake of the Arab Spring. In March 2012, the price of Brent crude oil reached a new level of $128 per barrel before steadying at more than $100 per barrel in 2013 (see OPEC, 2017).

In the summer of 2014, oil prices collapsed, dropping from about $96 to below $50 per barrel at the start of 2015, notwithstanding increasing global oil demand (see OPEC, 2017). This was associated with an excess supply of crude oil, which was driven by shale oil production in the US. Saudi Arabia decided to protect its share of the market by maintaining OPEC's production levels, hoping to force the US shale gas firms to decrease their output. This eventually created a logjam. The price of Brent crude oil fell below $30 per barrel in January 2016, a level not witnessed since 2003. This created severe concerns among oil-exporting nations like Russia, Venezuela, and Algeria. By February 2016, oil prices start recovering, attaining $50 per barrel in June 2016, largely due to Qatar, Venezuela, Saudi Arabia and Russia's decision to halt oil production. However, uncertainty persisted into the middle of 2016. OPEC (2017) observed that general movement toward lower prices weakened investments, which might threaten oil availability in the future, leading to an upward movement in oil prices.

2.5 **Oil Price shocks: An Overview**

Empirical studies have attributed the rise in crude oil markets and price shocks to unanticipated economic developments over time (see Rafiq, Sgro and Apergis, 2016; Ahmed, 2017). For example, the unanticipated rise in energy demand in India and China and the falling weighted value of the United States Dollar (USD) caused unexpected fluctuations in the oil market. The first oil crisis of 1971-1973 was the starting point of a period of price instability, which is assumed to be responsible for slower global economic growth.

An analysis of the historical path of oil price movements reveals that various factors are responsible for instability in oil prices. However, recent frequent variations in oil prices appear to be unique as such variations have never before been documented. Gonzalez and Nabiyev (2009) classify the reasons for frequent variations in oil prices into economic and non-economic factors. The former are linked to economic growth and include substantial growth in demand for oil in industrialized and developing economies that cannot be met by oil supplies; investment in different forthcoming projects motivated by resource nationalism and maturing oil wells; an increase in the price of exploration technology; and depreciation of the dollar against world currencies (Gonzalez and Nabiyev, 2009). In essence, long-term global economic performance, and oil supply and demand forecasts may account for long-term fluctuations in crude oil.

In terms of non-economic factors, it is believed that they are motivated by politics. For instance, Gonzalez and Nabiyev (2009) note that countries manipulate data relating to oil to favour their political interests, considering it as a national security matter. They add that countries endowed with huge deposits of oil conceal oil data from investors. Investors that are uncertain of the returns they can expect from their investments may be reluctant to invest their resources in large projects, which ensure a greater and steady oil supply to buyers. The extent of a country's problem is associated with the so-called "Peak oil[4]" theory (see Gonzalez and Nabiyev, 2009). Other non-economic factors are instability in oil-producing regions triggered by wars over control of resources and weak protection of the rights of investors in resource-abundant countries.

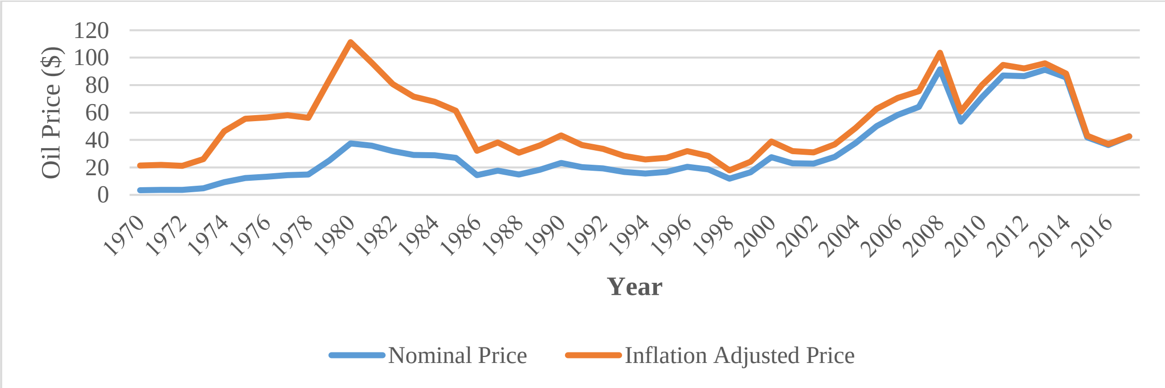
There are various explanations for oil price movements but in the long run, over a period longer than a year, prices are affected by global economic performance. Historical data shows that during recessions, the oil price drops. For instance, during the last quarter of 2008, there was a significant fall in oil prices from a peak of $147 to a low of $45 per barrel in global markets. This was associated with the world economic crisis and low oil demand in 2009. Such a situation can impede further investment in oil projects, leading to a decline in profitability and consequently to a marginal cost of production. However, when the global economy recovers, oil supply may fall by a larger margin than the decline in demand, leading to future high price variations.

2.5.1 **Factors Affecting Oil price fluctuations**

The historical trend of oil prices presented in figure 2.7 clearly displays the movement of oil prices and the several shocks experienced in the period under investigation. The oil price fluctuates when there is an imbalance between oil supply and demand. This section discusses the factors that could explain fluctuations in oil prices. For purposes of clarity, these are categorized under direct and indirect effects.

[4] The theory is premised on the observed increase, fall, peak and depletion of the aggregate production rate in oil fields at a given time.

Figure 2.7: **Nominal and Inflation Adjusted oil prices in US Dollar (1970-2017)**



***Source**: Author's computation (2020), using data sourced from the WDI.*

Alyousef (2012) identifies four factors that influenced the crude oil price from 1997 to 2011, including falling supply of crude oil from non-oil producing and exporting countries; the uncertain behavior of financial market participants; rapidly increasing demand for crude oil due to high transnational economic growth; and oil producers' cartel behavior. He concludes that demand for and supply of crude oil are the major factors that determine the oil price and that they are the two major channels through which oil shocks impact an economy. On the supply side, oil is a vital input in the production process, implying that an increase in oil prices may lead to a rise in the cost of production and an attendant fall in output (Chen, Liu, Wang and Zhu, 2016), which may increase inflation. On the demand side, studies affirm that changes in oil prices affect investment and consumption (see Hamilton, 2013; Chen and Chen, 2007). Thus, a rise in oil prices triggers inflation. As observed by Riman, Akpan and Offiong (2013), higher commodity prices lead to low purchasing power and a fall in consumers' real disposable incomes, which reduces aggregate demand. Dunlap, Swan and Riman *et al*. (2013) note that as countries advance, industrialization and a higher standard of living raise their demand for oil. Daily global consumption of oil increased by around 31 percent from about 67 million barrels in 1990 to 87.4 million barrels in 2010 and 93 million barrels in 2018 (see British Petroleum, 2018). In 2014, global consumption of oil grew by 1.4 million bpd, compared with the world oil production growth of 0.55 million bpd (British Petroleum, 2018).

2.5.1.1 **Direct Factors**

2.5.1.1.1 ***Global economic growth***

A rise in global demand for oil results in an increased oil price. Yan (2012) notes that growth could lead to inflated demand for crude oil that outstrips supply, leading to a rise in oil prices. An example is the rapid global development experienced at the beginning of the 21st century (Yan, 2012). In the same vein, the global financial crisis during the second half of 2008 resulted in stagnation of the world economy, a drastic drop in global oil demand and consequently a fall in the global oil price (see US EIA, 2016). It can thus be concluded that the global oil price movement is directly linked to international oil prices.

2.5.1.1.2 ***OPEC Production***

The controlled amount of crude oil produced by OPEC nations affects global oil output as well as its price. OPEC (2016) notes that its member states account for 43 percent of total global output. Given that OPEC policies guide member states' production of crude oil, OPEC's decisions dictate oil prices. For instance, an increase in output may cause a fall in oil prices. According to Chen and Chen (2007), the international oil price falls by 1.2 percent for every 1 percent rise in oil production by OPEC. Furthermore, oil prices have a tendency to increase when OPEC's future production plans are uncertain, as the risk premium rises.

2.5.1.1.3 ***Change in crude oil inventories***

When oil prices are low, producers tend to increase their inventories so as to push up the price. Once the price has risen, they will increase output. However, prices may decline as producers enter the market. Hotelling's[5] (1931) theory explains how producers decide when to commence extraction.

2.5.1.1.4 ***Limited global production capacity***

Based on the fundamental economic principles on the market forces of demand and supply, if the quantity of oil supplied exceeds that demanded, oil prices will drop and vice versa. Given that it is a non-renewable resource oil supply is limited to a certain extent. Nonetheless, constraints that lead to a fall in supply will result in a rise in the oil price. Tang, Wu, and Zhang (2010) note that from the early 1990s to 2008, no substantial oil field was discovered. In addition, no development has taken place in the oil refining and oil transportation sectors. According to these authors, few improvements have been made to enhance production capacity to meet the increase in global oil demand. However, recent technological developments have resulted in improved extraction methods. For instance, the invention of an innovative extraction technique for shale oil has transformed the crude oil market. Similarly, Apergis, Aslan, Aye, and Gupta (2015) note that horizontal and fracking drilling methods have made it easier to extract oil. Although this technique was discovered recently, it was not economically feasible. Nonetheless, it has led to a considerable rise in crude oil supply.

[5] The Hotelling Rule states that, extractors act in a profit-maximizing way which leads to extraction that provides no opportunities for intertemporal arbitrage. The theory implies that nations should be unresponsive to the time they extract.

2.5.1.2 **Indirect Factors**

2.5.1.2.1 ***Fluctuations in Dollar Exchange Rates***

The official linking of the oil price to the USD in 1974 means that several global oil trades are transacted and invoiced in US dollars. Therefore, fluctuations in the dollar's exchange rate have a direct impact on global oil prices and the policies guiding the oil business in both oil-importing and oil-exporting countries (Yan, 2012). When the USD depreciates, the real profits of oil-exporting nations drop. In such situations OPEC normally raises crude prices to minimize losses. In this regard, Chen, Liao, Tang and Wei (2016) find that a one percent rise in the dollar exchange rate causes the oil price to decline by 3.06 percent in the long run.

2.5.1.2.2 ***Practices in the future market***

Forecasts into the future account for oil price disruptions. Lombardi and Van Robays (2011) state that the global oil price provides benchmark prices to evaluate the present-day price. Opportunistic factors thus affect spot oil prices on the forthcoming market. Lombardi and van Robays (2011) show how projections could interrupt price information by triggering oil prices to diverge from acceptable points and no-arbitrage circumstances. Agents could regulate their consumption and production policies in line with false assumptions. This will inevitably impact oil spot prices in the short run (see Lombardi and van Robays, 2011).

2.5.1.2.3 ***Geopolitical turbulence***

Fear of geopolitical risk increases the risk premium of global crude oil prices, causing the price of oil to increase. Various oil reserves are located in politically disturbed zones and many of the major international oil producers are regarded as turbulent countries (e.g., Iran, Russia, Venezuela, Iraq, and Nigeria). Political and social conflicts have both indirect and direct impacts on oil prices. For example, the US invasion of Iraq had a direct impact, leading to a decline in oil production in Iraqi. Similarly, disruptions of Nigerian pipelines in the Niger delta zone have a direct effect on oil prices. According to Hamilton (2008), events that have resulted in indirect influences on oil prices include the tension surrounding Iran's nuclear program, and the lack of a remedy to the conflict between Palestine and Israel.

Table 2.1: Percentage of proven oil reserves in AOECs (1980-2018)

	1980	1984	1988	1990	1994	1998	2000	2004	2008	2010	2012	2014	2016	2018
Algeria	15.6	15.9	15.9	15.7	15.6	14.7	12.1	10.0	9.9	9.7	9.5	9.7	9.7	9.6
Egypt	5.5	5.7	5.8	5.9	5.1	4.9	3.9	3.2	3.5	3.5	3.4	3.1	3.1	3.1
Gabon	0.9	0.9	1.6	1.5	2.2	3.3	2.6	1.9	1.6	1.6	1.6	2.0	2.0	2.0
Libya	38.6	37.9	39.4	38.5	35.7	38.3	38.6	34.6	35.9	37.5	37.8	36.3	36.3	36.3
Nigeria	31.7	29.4	27.7	29.2	32.8	29.2	31.1	31.7	30.1	29.6	28.9	30.4	30.4	30.4
Others	5.5	6.4	6.1	6.1	4.0	4.3	5.3	1.6	11.2	10.9	11.8	11.7	11.7.8	10.8

Source*: Author's computation (2020), using data sourced from the WDI.*

2.5.2 **OPEC's Oil Production**

Table 2.1 shows the percentage share of proven oil reserves among individual oil-exporting countries in Africa. In 1980, Libya held about 38 percent of the total oil reserves followed by Nigeria with about 32 percent, while Algeria accounted for 16.6 percent, Egypt 5.5 percent, and Gabon 0.9 percent. Other African oil-producing countries together with Sudan accounted for 5.5 percent. While Algeria and Egypt maintained a consistently falling trend, Gabon, Libya, and other AOECs recorded an increased share of total proven oil reserves.

Algeria's share rose from 15.6 percent in 1980 and peaked at 15.9 percent in 1988, followed by a continuous decline to as low as 9.7 percent in 2018. Following a similar trend, Egypt's share was 5.5 percent in 1980, rising to 5.9 percent in 1990 and trending downward to 3.1 percent in 2018. Libya and Nigeria's shares dropped slightly from 31.7 percent and 38.6 percent in 1980 to 29.2 percent and 38.5 percent in 1990, respectively. Overall, during the period under study, Angola and Gabon's shares were somewhat constant. Other AOECs experienced an increase in their share of proven oil reserves. A careful look at the shares of Libya and Nigeria shows that they are inversely related. That of Libya increases and that of Nigeria decreases.

Overall, proven oil reserves in Africa rose by an average of 147 percent from 1980 to 2018. This is due to further discovery of oil and increased exploration activities on the continent.

Table 2.2a: Basic statistics of the selected AOECs (Average Proven Crude Oil Reserves (million barrels)) 1980-2018

Countries	Algeria	Egypt	Gabon	Libya	Nigeria	Africa Total	World Total
Maximum	13,053.4	4,400.0	2,800.0	49,422.6	41,435.1	136,329.96	1,489,865.0
Minimum	8,080.0	2,880.0	463.5	20,330.0	15,980.0	52,643.2	643,999.2
Mean	10,635.5	3,652.3	1,625.8	32,658.2	26,652.6	87,918.8	1,082,738.3
Range	4,973.4	1,520.0	2,336.5	29,092.6	25,455.1	83,686.8	845,865.8

Source*: Author's computation (2020), using data sourced from the WDI.*

As illustrated in Table 2.2a, during the period 1980 to 2018, the highest proven oil reserves for the selected oil-exporting countries in Africa was 13.05 billion barrels, 4.40 billion barrels, 2.80 billion barrels, 49.42 billion barrels and 41.44 billion barrels for Algeria, Egypt, Gabon, Libya, and Nigeria, respectively. This constitutes a significant portion of proven oil deposits in Africa. Libya recorded the highest followed by Nigeria, and Gabon recorded the least. Within the same period, the minimum proven oil reserves were 8.08 billion, 2.88 billion, 0.46 billion, 20.33 billion and 15.98 billion barrels for Algeria, Egypt, Gabon, Libya, and Nigeria, respectively. Libya had the largest reserves at 32.65 billion barrels followed by Nigeria with 26.65 billion barrels, with Algeria at 10.63 billion barrels, Egypt 3.65 billion barrels and Gabon 1.62 billion barrels. The range of the distribution is 4.97 billion barrels, 1.52 billion barrels, 2.33 billion barrels, 29.09 billion barrels and 25.45 billion barrels for Algeria, Egypt, Gabon, Libya, and Nigeria, respectively.

Table 2.2b: Statistics of the selected AOECs (1980-2015) Crude Oil Export ('000 barrels per day)

Countries	**Algeria**	**Egypt**	**Gabon**	**Libya**	**Nigeria**	**Africa**	**World**
Maximum	46,504	26,149	8,904	46,344	72,391	255,806	2,356,414
Minimum	961	511	151	404	1,241	4,733	53,167
Mean	1,292	726	247	1,287	2,011	7,106	65,456
Range	45,543	25,638	8,753	45,940	71,150	251,073	2,303,247
Total	**46,504**	**26,149**	**8,904**	**46,344**	**72,391**	**255,806**	**2,356,414**

Source*: Author's computation (2020), using data sourced from the WDI..*

Table 2.2b presents crude oil exports by country and overall oil exports in Africa and the world. Nigeria exports the most oil per day at about 72 billion barrels, followed by Algeria at 46 billion barrels per day, with Gabon having the least at about 9 billion barrels per day. Africa as a whole, exports about 256 billion barrels per day out of global exports of 2.356 billion barrels per day.

Table 2.3: Oil Contribution to Africa's Country GDP and Foreign Export Earning in 2014

S/N	**Country**	**Contribution to Exports Earning (%)**	**Contributions of other sectors (%)**	**Shares of Oil to GDP**	**Shares of other sectors to GDP**
1.	Algeria	19.8	80.2	18.7	81.3
2.	Egypt	19.8	80.2	9.1	90.9
3.	Gabon	7.7	92.3	37.1	62.9
4.	Libya	14.8	85.2	37.7	62.3
5.	Nigeria	82	18	31.2	68.8

Source*: Author's computation (2020), using data sourced from the WDI..*

As shown in Table 2.3, in 2014, oil contributed about 82 percent, 19.8 percent, 19.8 percent, 14.8 percent and 7.7 percent to the foreign export earnings of Nigeria, Algeria, Egypt, Libya and Gabon, respectively. During the same period, it contributed 31.2 percent to GDP in Nigeria, 18.7 percent in Algeria, 9.1 percent in Egypt, 37.7 percent in Libya and 37.1 percent in Gabon.

Table 2.4: Ranking AOECs by barrels of Oil Exported and Oil Proven Reserves

Countries		Algeria	Egypt	Gabon	Libya	Nigeria
World Ranking	*	17th	27th	37th	29th	13th
	**	16th	25th	35th	9th	11th
African Ranking	*	3rd	4th	9th	5th	1st
	**	3rd	5th	6th	1st	2nd

***Sources**: Author's Compilation (2020).* ; * and ** denote position as Oil Exports and Oil Proven reserves respectively.

Table 2.4 ranks the AOECs according to their oil exports and proven oil reserves. Nigeria is ranked as the first and thirteenth oil-exporting country in Africa and the world, respectively. Libya is ranked the fifth and twenty-ninth oil producing country in Africa and the world, respectively, while Algeria is third in Africa and seventeenth in the world in oil exports. In terms of proven reserves, Nigeria ranks second in Africa and eleventh in the world; Libya ranks first in Africa and ninth in the world, and Algeria is third in Africa and sixteenth in the world.

Table 2.5: Oil Export and Reserves Ratio for the AOECs in 2018

Countries	Algeria	Egypt	Gabon	Libya	Nigeria
Oil Export reserve ratio	1:40	1:29	1:82	1:79	1:31

***Source**: Author's computation (2020), using data sourced from the WDI.*

Table 2.5 presents oil production and total oil proven reserves in AOECs. In Algeria, 1/40th, about 3 percent of the country's total crude oil endowment, is produced while the rest is left unproduced. In Egypt and Nigeria, only about 1/30th (3.3 percent) of the crude endowment is produced while in Gabon and Libya, 1/80th (1.2 percent) is produced. Egypt records the highest production-reserve relationship followed by Nigeria, Algeria, Libya and Gabon in that order.

2.6 An Overview of Africa's Oil Exporting Countries

2.6.1 Algeria

Algeria is currently the third major producer of oil in Africa and ranks 17th in the world, producing about 1.37 million bpd, second to Angola that produces about 1.8 million bpd. Algeria largely relies on oil (OPEC, 2016), although its impact has declined since the turn of the century due to the government's decision to diversify the economy. For instance, oil's contribution to Algeria's GDP dropped from 40.2 percent in 2005 to 36.7 percent in 2011. Nevertheless, oil remains the mainstay of the economy as it constitutes about 97 percent of the country's total exports. In turn, Algeria's foreign reserves increased from $181 billion in 2011 to over $190.7 billion in 2012 (US EIA, 2016).

Revenue from oil has been used to modernize the economy and build infrastructure, with government expenditure increasing by 2.3 percent, widening the budget deficit to 3.3 percent of GDP in 2012 (OPEC, 2016).

2.6.2 Egypt

According to US EIA (2018), oil provides about 87 percent of primary energy consumption in Egypt and accounts for about 35 percent of its export revenue. Unlike other AOECs, Egypt's economy has experienced great changes within the past three decades. Prominent among these is the 2011 revolution, which led to the toppling of President Hosni Mubarak's administration. Prior to this turbulence which resulted in a fall in the real GDP growth rate from 5.5 percent in 2010 to 2.2 percent in 2011, the Egyptian economy was reasonably stable as it is more diversified than those of other AOECs. As such, it does not rely heavily on oil. Similarly, its total investment growth rate, which was about 16.7 percent in 2010, fell to 15.5 percent in 2011/2012. Public consumption as a proportion of GDP rose from 73 percent in 2005 to 79 percent in 2011/2012.

2.6.3 Gabon

In the early 1970s, manganese and timber contributed about 80 percent of Gabon's foreign earnings. However, with the discovery of oil, it became the mainstay of the economy. Oil contributed about 37.1 percent of Gabon's GDP in 2014, and 39 percent in 2015 and more recently, the sector accounted for about 50 percent of GDP and 80 percent of exports (see OPEC, 2018). Despite various decreases in global oil prices, oil continues to play a prominent role in the economy. In 2016, the oil sector accounted for 70 percent of Gabon's foreign earnings, 20 percent of GDP and 40 percent of its budgeted revenue (US EIA, 2018). According to OPEC (2018), the country produces about 213,000 bpd, making it one of the major oil producing countries in Africa. Gabon ranks 6th and 37th among the oil producing countries in Africa and the world, respectively. The drop in oil prices in 2018 to about US$40 negatively affected the country's economy and economic growth fell from 5.6 percent to 4 percent in the fourth quarter of 2018 (US EIA, 2018). This is associated with a 50 percent cut in public investment. In response, the government began to invest in programs to boost growth notwithstanding lower oil revenue. The economy has shown recovery since 2019 which is linked to improved performance of investment in non-oil sectors (palm oil, timber, rubber, and mines). Real GDP grew by an estimated 3.4 percent in 2019 against 0.8 percent in 2018. Economic recovery has also been driven by the discovery and exploitation of new oil wells, up by 11.8 percent; non-oil exports (an increase of 18.6 percent) and total investments, up by 4.5 percent. The inflation rate also dropped significantly from 4.8 percent in 2018 to 3.4 percent in 2019, close to the 3 percent CEMAC target.

2.6.4 Libya

Libya is a major net producer of crude in Africa, producing about 404,000 bpd. Oil has been the main source of foreign exchange in the country, constituting approximately 95 percent of total exports and about 70 percent of total government revenue. Prior to the conflict in 2013, which led to an interruption in oil supply, Libya produced about 1.7 million bpd day over a six-year period.

2.6.5 Nigeria

As shown in Table 2.2b, Nigeria is the largest oil-exporting nation in Africa and the 13th largest oil exporter globally. It produces about 2.4 million bpd, with an oil export reserve ratio of 14.8. Oil contributes 31.2 percent of GDP and is a major source of government revenue. Between the year 2000 and 2013, Nigeria earned about US$975,656 million from oil exports (OPEC, 2016) and according to the CBN (2015), oil contributed about 95 percent of foreign earnings over this period and 85 percent of government revenue. Recently, the country's oil output has been hindered by supply disruptions and instability, which have resulted in unplanned outages. Furthermore, oil has been associated with massive corruption, militancy, oil spills and theft. Nonetheless, it remains the leading source of foreign earnings. The World Bank (2018) and IMF (2017) note that this has not translated into wide scale economic development, a characteristic Nigeria shares with other AOECs.

Table 2.6: Major African Oil Fields, 2015

Country	Deposit Name	Size of Resources ('million Barrels)	Status
Algeria	South and North; Hassi Messaoud	>300m	*
	Zerzan Tine, Hassi Berkine South, Rhourde El Baguel and Edj'leh	All 4 resources: 160m-300m	*
Egypt	July Oil field and El Morgan	160m-300m	*
Gabon	Loango; Emaraude	> 300m	*
Libya	Zelten	160m-300m	Derelict mine
	Amal, Waha, Serir, Dahra, and Giallo	All resources: 160m-300m	**
Nigeria	Ukot, Agabami, Aparo, Usan and Bonga SW	All resources: 160m	**
	Jones Creek	160m-300m	*

Source: *Council for Gasoline and Mintek (2015)*. ** (Continuously Producing [All]); *(Continuously Producing).

The major oil fields distributed across the AOECs are presented in Table 2.6. A few, like South and North, and Hassi and Messaound are located in Algeria. Ukot, Agabami, Aparo, Usan and Bonga oil fields are found in Nigeria, while Loango and Emaraude are in Gabon.

2.7 The oil economy's minimal linkages to other sectors

The oil sector is noted to have minimal links with other sectors and does not create large numbers of jobs. For instance, the oil sector in Angola employs less than 2 percent of the workforce (US EIA, 2018). This may not be unconnected with, poor management, red tapism, corruption and gross underutilization of installed oil refineries. While it is assumed that proceeds from the oil-driven economy stimulate other sectors, thus enhancing employment, some AOECs like Gabon, Equatorial

Guinea, Nigeria, and Angola, have large income inequality. For example, 70 percent of Nigerians live below the poverty line (World Bank, 2018). Corruption and revenue losses mean that the economy does not always benefit and many residents regard the fuel subsidy as the only advantage of living in an oil-rich country. Strategies to diversify these economies have had mixed results.

2.8 Oil Price shocks and the economic importance of oil

Oil is key to economic activity. As observed by Painter (1986), the invention of the internal combustion engine highlighted the economic importance of oil. According to Lescaroux and Mignon (2008), oil is a latent driver of currencies. Movement in oil prices could also have an important impact on oil producers' exchange rates. Oil has been the world's major commercial energy source for years and it is likely to remain important well into the twenty-first century. Bernanke, Gertler and Watson (2004) note that the US EIA (2018) forecasts that by 2035, the uncertainty surrounding the crude oil price will persist with the highest oil prices reaching $235 per barrel. Aside from the direct and indirect job opportunities created in various oil firms and oil-related or oil-based businesses, oil provides fuel for automobiles, machinery and manufacturing plants. It supports the agricultural, manufacturing and mining sectors and is a major source of energy for other sectors. Oil thus promotes economic activity. Amuzegar (1998), Vahid and Jabber (1997) and Majid (2008) note that several oil-exporting nations have taken advantage of the forward-linkage effect of the oil industry to enhance the growth of other economic sectors.

Lescaroux and Mignon (2008) assert that, the relevance of oil has risen to the point where an economy that lacks it will collapse as vital distribution systems that enable economic transactions on a local basis and beyond will fail, with severe implications for the global economy. In contrast, some studies have found a negative relationship between oil abundance and the growth of the macroeconomy of key oil-exporting nations. For instance, Gylfason, Herbertsson and Zoega (1999) found a strong negative correlation between economic growth and oil abundance. The fact that oil-exporting regions have persistently witnessed slow and, in some cases, unstable growth even during consistent increases in oil prices negates the assumption of a positive relationship. Hence, it is often tagged as a "resource curse" in the energy economic literature.

Oil price shocks from 1970 to 2015 resulted in fluctuating levels of oil consumption and revenue. The oil price reached its peak in 2012 and plummeted thereafter. Such fluctuations account for variations in revenue among AOECs, OPEC members and other oil exporters. For instance, the US EIA (2018) reports that the 12-member OPEC bloc earned $404 billion in net oil export revenue in 2015, the lowest level since 2004. Based on the US EIA estimates, earnings dropped by 46 percent to $404 billion compared with $753 billion in 2014. Africa's oil-exporting countries and OPEC's revenues from oil have fallen with the drop in global oil prices over the past two years. For instance, since the first major drop in the oil price in June 2014, prior to which Brent stood at US$112 per barrel, prices have only recovered to US$50.30. The US EIA (2018) forecast that OPEC's revenue would fall further to $341 billion in 2016 before partially rebounding to $427 billion in 2017.

These statistics foreshadowed tough fiscal times for the world's least developed oil-exporting nations. Nations like Algeria, Venezuela, and Nigeria depend on revenue from energy exports to import consumer goods for their citizens. In 1980, OPEC governments generated $3,500 in inflation-adjusted revenue per person through oil exports alone. In 1990, that figure dropped to just $606. However, the level of the oil price crisis' effect on national economies varies according to the importance of energy exports relative to total revenue. Indonesia's oil revenue accounted for five percent of total export revenue in 2015, whereas almost all Iraq's revenue in 2015 came from the energy sector. The US EIA report idtified Kuwait, Saudi Arabia, the UAE, Qatar and Kuwait (the Persian Gulf States) as less vulnerable to the bearish energy market due to their sizable financial assets while Africa's less financially-endowed oil-exporting members, Libya, Angola, 1990Egypt, Gabon, Cameroon, Algeria and Nigeria are more exposed to the whims of the oil market due to a lack of effective financial planning, as well as security issues.

Therefore, uncertainty with regard to oil prices and the associated effects on output performance remain a vital issue confronting many growing AOECs, business stakeholders and policymakers.

2.9 OPEC countries and Economic diversification

Given that oil is their major source of revenue, the AOECs' economic structure continues to hinge on the oil industry. Their substantial reliance on the proceeds from oil for budgetary allocations and other government expenditure has resulted in little attention been paid to other industries (Karl, 2005). This has also hindered these nations from allocating both intellectual and financial capital to the development of the non-oil sector (see Karl, 2005). Consequently, many AOECs' economies are not adequately hedged against the possibility of a decline in demand for oil or a significant, unexpected decline in oil prices. As noted by Chen, Liao, Tang and Wei (2016), several AOECs are experiencing economic decline due to low global oil prices, especially Nigeria and Venezuela. However, in recent years, countries have woken up to the realities and have become more aware of the consequences of their heavy reliance on crude oil. Major adjustments occurred in the aftermath of the 2008 financial crisis when rising oil prices allowed the AOECs to improve their non-oil sectors (Chen *et al.*, 2016; Yan, 2012) with the aim of increasing their contribution to GDP. Sound economic diversification will assist the AOECs to improve their economies in the face of potential fluctuations in oil prices.

2.10 Africa's Oil Refineries: An Overview

According to OPEC (2018), a petroleum refinery is a processing plant that transforms crude oil into refined and other useful products. Among the oil-producing regions, Africa has the least petroleum refineries, with forty-six compared to the US' 140 that make up about 20 percent of the world's refineries (US IEA, 2018). Globally, there are about 700 petroleum refineries, which are highly concentrated in the developed world. Given that the US IEA projected consumption of 4.5 million bpd by 2018, the lack of refining capacity may be crippling.

Nigeria, with an estimated oil output of 2.4 million bpd in 2015, the largest in Africa and the 5th largest in the world, has four refineries (see OPEC, 2017), one each in Warri and Kaduna, and two in Port Harcourt. Angola has only one full-scale refinery with capacity to produce about 1.8 million bpd and Egypt, the 4th largest oil exporter in Africa has nine refineries, the largest number on the continent, with a capacity of 723,000 bpd. Notwithstanding that Africa produces about 3.5 times the quantity of the oil that it consumes, its refineries struggle to keep up with demand and rising consumption of petroleum products. The continent thus imports fuel from other oil-exporting counties. To satisfy the market's need for fuel, producers balance the difference between high crude exports and low refining volume by becoming net importers of refined oil products. This could prevent net oil-exporting countries from optimally benefitting from positive oil price shocks.

Governments have adopted the strategy of subsidizing pump prices to prevent their large populations from suffering a fall in their disposable income when oil prices increase. This approach has been severely criticized as the long-run consequences include the government spending large sums of dollars on import charges, export charges, and subsidy payments each year. For instance, the Nigerian National Petroleum Corporation (NNPC) spends between US$16 million and $20 million daily on fuel imports, amounting to about $1.9 billion dollars each quarter (see NNPC, 2017). Similarly, the Egyptian government paid $7 billion to import petroleum products during the first nine months of the 2016/2017 fiscal year, a jump from $6.2 billion in the previous year, to meet local demand (CBE, 2018). This amounted to more than 38 percent of the government's total commodities import budget, making it by far the biggest import bill (CBE, 2018). In contrast, exports were only worth $1.8 billion, up from $1.5 billion the previous year.

Such a context is ripe for the development of new refineries. Prudent investment in this critical sector could ease the burden on public funds from subventions and subsidies; reduce reliance on imported products and create new opportunities for employment and investment.

2.10.1 Algeria

The Skikda Petroleum Refinery is the largest refinery in Algeria and Africa. Established in 1980, it comprises eight crude oil refining units with a capacity of 356,500 bpd. The refinery has the capacity to produce sixteen million tons of Saharan blend and sour crude oil annually. It comprises 235 large crude and refined oil storage tanks where processed gasses are stored in twelve huge sphere tanks. The refinery produces Liquefied Natural Gas (LNG), Premium Motor Spirit (PMS), Automotive Gas Oil (AGO) and Dual-Purpose Kerosene (DPK).

Adrar Refinery was established in 2007 with a production capacity of 12,500 bpd. It is a joint venture, with Sonatrach holding a 30 percent share and China National Petroleum Corporation (CNPC) 70 percent for a 23-year contract term. The refinery produces products like LNG, AGO, DPK and PMS.

2.10.2 Egypt

Egypt has the largest number of petroleum refineries in Africa, with 10 refining companies and twelve refineries. Second-placed South Africa has six refineries (EGPC, 2018). Egypt's refineries produce 732,550 bpd. Nine are owned by the government and the tenth by a private firm, the Egyptian Refining Company (ERC). The refineries only supply 65 percent of local demand for oil products. The petroleum refineries are:

2.10.2.1 Alexandria MIDOR Refinery

MIDOR was established in 1994 by EGPC, which owns 98 percent of its shares, with the remainder owned by Suez Canal Bank. It is regarded as the most innovative oil refining company in Egypt, with state-of-art equipment. It has an optimum refining capacity of 0.1 million bpd. The firm aims to increase its production capacity to refine 160,000 bpd by 2020 (see EGPC, 2018).

2.10.2.2 Cairo Oil Refining Company (CORC)

The EGPC established this petroleum refining company in 1982. Its two refineries are in Mostorod, with a production capacity of 142,000 bpd and Tanta, with a production capacity of 35,000 bpd. The refineries produce PMS, DPK, LNG, AGO and spare parts for refineries (EGPC, 2018).

2.10.2.3 Egyptian Refining Company (ERC)

Established in 2007, the ERC is privately-owned refinery and has a maximum refining capacity of about 28 million tons per annum. Its product portfolio includes 2.3 million tons of Europe-compliant diesel; 800,000 tons of gasoline and 600,000 tons of IATA-spec jet fuel. Other products include liquefied petroleum gas reformate, Dual Purpose Kerosene, fuel oil, and naphtha. This assists the government in meeting local demand for petroleum products (EGPC, 2018).

2.10.2.4 Alexandria El Mex Refinery

This refinery was established in 1954 as a subsidiary of the EGPC and has a maximum refining capacity of about 117,000 bpd. Among its product portfolio are turbine jet fuel, gas oil, gas oil for maritime use, fuel oil, Dual Purpose Kerosene, three types of liquefied propane and octane 92 and octane 80 fuel for the pumps (see EGPC, 2018).

2.10.2.5 Alexandria National Refining and Petrochemicals Company (ANRPC)

The Alexandria refinery was established in 1999. It produces high-octane fuel to meet local demand and has a refining capacity of 81,000 bpd. Its product portfolio includes two alternative automatic transmission oils and paraffin wax, three categories of base oil, fuel oils and transformer oils. They are produced in two separate complexes; one for gas oil production and the second for lubricants and other oils.

2.10.2.6 Nasr Petroleum Company (NPC)

This is the oldest refinery in Africa. It was, established in 1913 and is owned by the EGPC. Its production capacity stands at 146,000 barrels a day. In addition to its own Suez-based refinery (99,000 barrels a day), NPC operates the Wadi Feran refinery (8,550 barrels a day) in the Gulf of Suez, overlooking the Red Sea.

2.10.3 Gabon

Gabon’s sole oil refinery is the Societe Gabonaise de Raffinage (SOGARA) refinery, located in the commercial city of Port Gentil. Its production capacity is about 25,000 bpd, but it operates below its designed crude oil distillation capacity, resulting in fluctuation in output due to maintenance challenges.

2.10.4 Libya

The RAS lANUF Refinery and Terminal was established in 1985 as a subsidiary of National Oil Corporation (NOC). The largest refinery in Libya, it has a capacity of 220,000 bpd. The refinery primarily produces kerosene, naphtha, gasoline, light Vacuum Gate Oil and fuel oil which are sold locally and exported to the US and Europe.

Zawia Petroleum Refining Company (ARC) was established in 1976 as a subsidiary of NOC. It is Libya’s second largest oil refinery after the ARC operated Zawia Refinery, which was built in 1974. The refinery primarily produces kerosene, naphtha, gasoline, light Vacuum Gate Oil, fuel oil, and base lubricating oils.

2.10.5 Nigeria

Nigeria has four refineries, all of which are owned by the federal government through the NNPC and they are sited in Kaduna, Warri and Port Harcourt. Their total capacity is 446,000 bpd. Two other refineries are under construction with a proposed capacity of 667,000 bpd, to meet local demand for petroleum products.

Kaduna Refinery is a subsidiary of the NNPC. Established in 1989, it has the capacity to produce 111,000 bpd. The refinery occupies a land area of about 2.9 square kilometers. The petroleum products refined there include PMS, LPG, AGO, DPK, Sulphur and Fuel oil, Asphalt (Bitumen), Base Oil, and waxes.

Port Harcourt (P/H) Refinery Complex is also a subsidiary of the NNPC. Managed by the P/H Refining Company (PHRC) Limited, it comprises two refineries, both at Alesa-Eleme bye P/H in Rivers State. The older one was established in 1965 with 60,000 bpd refining capacity and the newer refinery was established in 1989 with 150,000 bpd capacity. Both plants utilize bonny light to produce refined oil. Their products include LPG, High Pour Fuel Oil, PMS, AGO, Low Pour Fuel Oil, DPK and unleaded gasoline of international standard (see NNPC, 2017; OPEC, 2016).

Warri Refinery is the first indigenous refinery in Nigeria. Established in 1978, it had the plate capacity to refine 100,000 bpd but was later debottlenecked to refine 125,000 bpd.

Other refineries undergoing construction to mitigate the shortage of refined oil output are the Dangote Refinery, which is expected to produce 650,000 bpd and the Azikel Refinery with an estimated output capacity of 12,000 bpd.

Table 2.7: Refineries and their Capacities in AOECs

Country	Refinery	Capacity bpd	Date of Est	Ownership	Status
Algeria	Skikda Refinery	0.357m	1980	Public	Operational
	Adrar Refinery	12,500	2007	Joint	Operational
	Algiers Refinery	55,000	1963	Public	Operational
	Arzew Refinery	50,000	1973	Public	Operational
	Hassi Messaoud Refinery	25,000	NA	Public	Operational
Egypt	Alexandria America Refinery	81,000	1999	Public	Operational
	Alexandria El Mex Refinery	0.117m	1954	Public	Operational
	Alexandria MIDOR Refinery	0.1m	1994	Public	Operational
	Asyut Refinery	47,000	1987	Public	Operational
	Cairo Mostorod Refinery	0.142m	1982	Public	Operational
	Tanta Refinery	35,000	1982	Public	Operational
	El Nasr Refinery	0.132m	1913	Public	Operational
	Wadi Feran Refinery	8,550	1913	Public	Operational
	El Suez Refinery	70,000	1921	Public	Operational
	Egyptian Refining Company (ERC)	28m tons	2007	Private	Operational
	Bashandy Oil	0.3m	NA	Public	UC*
Gabon	Port Gentil Refinery	25,000	1967	Public	Operational
Libya	Zawia Refinery	0.12m	1976	Public	Operational
	Ras Lanuf Refinery	0.22m	1985	Public	Operational
	El-Brega Refinery	10000	NA	Public	Operational
	Tobruk Refinery	20000	NA	Public	Operational
	Sarir Refinery	10000	1989	Public	Operational
Nigeria	Kaduna Refinery	0.111m	1989	Public	Operational
	Port Harcourt Refinery (1)	60000	1965	Public	Operational
	Port Harcourt Refinery (2)	0.15m	1989	Public	Operational
	Warri Refinery	0.125m	1978	Public	Operational
	Dangote Refinery	0.65m	NA	Private	UC*
	Azikel Refinery	12,000	NA	Private	UC*

Source: *Council for Gasoline and Mintek (2015).* UC*=> under construction

Table 2.7 lists the twenty-eight refineries in AOECs. Three are privately owned, including the Egyptian Refining Company and Dangote and Azikel Refineries, both in Nigeria, which are under construction. The remainder of the refineries are government-owned.

2.11 Prospects and Challenges in the oil industry

2.11.1 Prospects

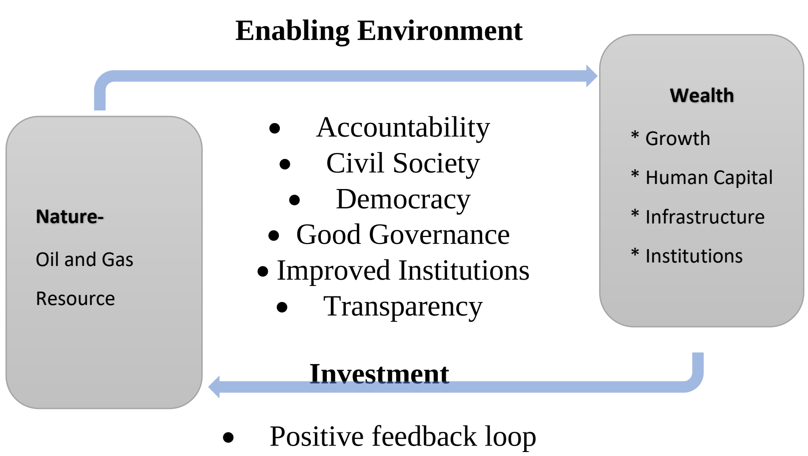
2.11.1.1 Making Oil and Gas Wealth Work for the Poor

This section examines the challenges and prospects confronting AOECs in transforming oil resources into economic wealth to enhance output growth. The oil demand-supply balance in Africa is positive considering the continent's rich oil endowment, which is large enough to satisfy regional demand, with a surplus for export. However, multidimensional issues in the AOECs raise challenges in terms of both expanding access to oil and gas on the continent, and transforming oil resources into economic wealth to enhance output growth (see AfDB, 2017). High and volatile crude prices may necessitate an all-inclusive method in both the short and long term. In the short term, viable strategies are required to manage the instant effect of rising oil prices while, in the long term, the sustainability of oil resources needs to be addressed.

2.11.1.2 **Oil Wealth and the Enabling Environment**

This section discussed Oil Wealth and the Enabling Environment. As noted in Sachs and Warner (2001) and Olomola (2010), a nation rich in abundant natural resources may record poorer economic performance than countries with few natural resources. Rational decisions about oil resources are fundamental to making natural wealth work and maximizing crude's effect on the economic growth of the emerging AOECs. The AfDB (2017) identifies three key interactive elements that offer a useful framework to discuss how oil wealth could enhance economic growth (see figure 2.8 above). These elements are nature (gas and oil resources); wealth (human capital, growth, infrastructure, and institutions); and the enabling environment (accountability, civil society, governance, and the power structure).

Figure 2.8: **Procedure to Transform Oil and Gas Resources into Wealth**



***Source**: Adopted from AfDB (2017).*

Experience in Africa and elsewhere reveals that policies and investments that identify and apply these three elements produce positive development results (For instance, see AfDB, 2017). Figure 2.8 above illustrates the causal relationship among oil and gas resources, the enabling environment and wealth. Assuming that the necessary principles of good governance like strengthened institutions, transparency and accountability are in place, the model shows that opportunity abounds to transform oil and gas resources into wealth and human capital, and institutional development, among others things (see AfDB, 2017). Economic growth and other positive results create a potential positive feedback circle by turning the growth into investment and improved resource utilization and management.

2.11.2 **Challenges**

This section presents factors and challenges influencing oil production among the oil exporting countries in Africa. These cut across the AOECs since they are characterised by similar challenges, including corruption, prolonged military rule, poverty, resource curse, poor respect for the rule of law, heavy reliance on importation of finished and semi-finished goods and high mortality rates. Among other things, this study suggests establishment of anticorruption bodies to check excesses in the oil sector.

2.11.2.1 **Limited refining capacity**

Refinery capacity has been a major challenge confronting African oil-producing and exporting countries. The continent's refining capacity remains limited because of the available facilities' low capacity. As depicted in Table 2.7, the oil-producing countries do not have the capacity to refine the oil required for local consumption and export. By implication, the supply of refined oil to meet demand is in disequilibrium. Several refineries in Africa have been over-utilized and have been forced to close because of low worldwide refining capacity and margins, the high cost of operations (due to their small size), small local markets, and poor yields (see US EIA, 2018). These are significant problems for Africa's oil exporters. Following the World Bank/IMF's insistence on market liberalization in the early 1980s, the remaining refineries are faced with significant challenges. Although installed capacity in Africa is higher than current consumption, the continent is still confronted by severe shortages of refined products that are balanced by imports. For instance, countries like Angola and Nigeria export crude oil resources, only to import refined oil at an additional cost. This suggests low net returns from oil and high dependence of Africa's oil exporters on refined oil for local consumption. In some African countries, the refining industry is characterized by poor turnaround maintenance, corruption, theft, and other operational issues. In addition, the oil-producing arena is characterized by conflict in some countries such that the flow of crude to refineries is interrupted and sometimes shut down. Worldwide, non-economic factors such as environmental and local concerns, more stringent environmental laws, and effective community organizations have resulted in slow growth in refining capacity, making it problematic to build new refineries. Low refinery capacity may be considered as a significant reason for high domestic oil prices. Therefore, increasing the capacity of African refineries would go a long way in reducing the cost of refined oil products. However, this must be done in an environmentally friendly manner.

Due to scarcity and the need to maximize profit by placing the refinery close to the source, several initiatives are underway to establish new refineries in Nigeria, Egypt, Gabon, and Algeria. Subsidies have also been cited as contributing to low capacity utilization at refineries. For instance, the subsidy schemes in Nigeria encourage oil exporters to sell oil overseas rather than to local refineries. This increases the volume of refined product imports at enormous cost to the economy. Despite governments' plan to build more refineries, little new global refining capacity has been added in the past three years. Nevertheless, significant refinery capacity additions are planned, although a major concern is that construction costs are rising with the inflationary prices experienced in Africa. It is necessary that the government encourages establishment of more refineries to cater for the needs of the public. This may be through Private Public Partnerships (PPP).

2.11.2.2 **Weak Revenue Management**

Weak revenue management may result in slow growth among oil-exporting countries (Sachs and Warner, 2001). Properly managed oil proceeds spur growth and may lead to conflict, causing inflationary pressure, cyclical government expenditure, and weak export industries (see Sachs and Warner, 2005; Majid, 2008; AfDB, 2017). There is thus a need to identify an appropriate revenue management model for oil-exporting countries which would close the loopholes and prevent revenue losses in the oil sector. The literature notes that, the various revenue models in the oil industry seek to answer two questions **-** "how much to spend and invest; and how much to spend and save?" The responses to these questions are dictated by several factors such as the level of petroleum resources and oil exports, fiscal sustainability, and the uncertainty surrounding oil prices, among others. Three models have been suggested, namely, the hand-to-mouth rule, the bird-in-hand rule, and the permanent income rule. As outlined by the AfDB (2018), the hand-to-mouth rule requires that the government applies all revenue generated and is commonly used by countries where the size of revenue is insignificant, or where development challenges are enormous. The bird-in-hand rule advocates that petroleum revenue is placed in a petroleum bond and invested in financial instruments whilst the government spends only the returns on the investment. The permanent income rule allows for the spending of discounted net revenue annually computed over the lifespan of an investment project. This ensures that a permanent proportion of the petroleum wealth is spent every year into eternity, whilst the balance invested through a sovereign wealth bond will continue to grow beyond the life of the project.

Another issue relating to revenue management is the sharing of oil revenue between government stakeholders. Some countries have not been able to come up with an acceptable sharing formula. Allegations are made that the revenue allocated to some stakeholders is not fair and adequate. In

Nigeria, this has resulted in hoodlums vandalizing pipes and other refinery property, and the kidnapping of staff of oil exploration firms. Oil pipeline vandalization[6] in the country dates back to the early 1990s and has since gained momentum. In 1995, seven cases were reported, with 33 before the end of 1996, 91 cases between 1997 and 1998 and an astounding 497 cases of oil pipeline breaks between 1999 and 2005 (see Onuoha, 2008). The Port Harcourt and Warri oil routes were reported to have the most cases, with the Port Harcourt axis alone recording about 600, rising to about 1,650 vandalized pipelines before the end of 2006 (Onuoha, 2008). The effects are enormous in terms of both human and non-human resources, not to mention the possible loss of revenue and the oil spillages that result[7].

In responding to these challenges, the Nigerian government introduced a 13 percent derivative oil sharing formula in Section 162 (2) of the 1999 Constitution as amended. It mandates the payment of not less than 13 percent of oil revenue to the nine oil-producing states in the country with the aim of reducing conflict and encouraging community development. In response to struggles and conflicts in areas with huge oil deposits, the government created the Niger Delta Development Commission in 2000. The Niger Delta people have continued to demand greater autonomy and control of the petroleum resources in the area. The commission is charged with the responsibility of developing the oil-rich region. To strengthen this effort, the federal government announced the creation of the Niger Delta Ministry in 2008, with the Niger Delta Development Commission becoming a parastatal under the ministry. The ministry is charged with coordinating efforts to address infrastructural development and other oil-related challenges such as environmental protection and youth empowerment in the Niger Delta area.

Despite the adoption of a special formula aimed at equitable distribution of funds taking into account criteria such as poverty levels and population, agitation and complaints about the revenue allocated persists. The lack of clarity on how state governments should spend the oil revenue ceded to the oil-producing areas makes these areas prone to ethnic competition and rivalry. Hence, improper oil revenue management in such areas may escalate conflict, calling for the central government to take cognizance of the demands of the states when adopting its revenue-sharing system. It is therefore necessary that the government should engage all relevant oil

[6] According to Hopkins and Perth (2008), pipeline vandalization involves the deliberate destruction of pipelines that transfer liquid oil from one geographical point to another.

[7] Oil spillages have negatively impacted the environment of petroleum exploration host communities. They degrade farmland and natural resources like rivers, which constitute an integral part of the agricultural sector. This would have a direct bearing on the economy of the host state.

stakeholders and assign fair conpensation to them. Furthermore, appropriate mechanisms should be deployed to prudently manage proceeds from oil.

2.11.2.3 **Economic Distortion**

Another notable challenge confronting the AOECs is the risk of the Dutch Disease, which is a vital management challenge for oil-producing countries. According to Corden and Neary (1982) and Hamilton (2013), the Dutch Disease refers to the causal connection between the rise in the oil sector and a fall in other sectors (like the agricultural and manufacturing sectors). It points to the negative impact of oil on an economy, giving rise to a sharp inflow of foreign currency (see Egert and Leonard, 2008). This results in currency appreciation but makes the country's other products less price competitive on the export market. The AU (2007) suggests that policies to avert hyperinflation and uphold monetary reliability can reduce the risk of the Dutch Disease. This study alludes that it is necessary to promote non-oil industries or fortify linkages that can be leveraged by the revenue from oil in order to reduce dependence on a single commodity.

2.11.2.4 **Weak Institutional Framework**

African settings are generally characterized by a weak and inadequate institutional regulatory framework, creating opportunities and gaps for fraud and corruption in the petroleum sector. For instance, the AfDB (2017) notes that the ministry of petroleum and cabinet secretary's power to issue petroleum agreements creates room for rent-seeking behavior[8] and corruption on the part of state officials. Conflicts of interest are not always declared and state interests are undermined in favour of individual interests as the terms of negotiated petroleum agreements can be used to secure personal payments and favours from oil companies (AfDB, 2017). There is thus a need for checks and balances in the relevant institutions. The institutional regulatory framework also needs to be strengthened to explore the full potential of the petroleum basin in the various oil-exporting countries. For such a framework to fulfill its functions, this study suggests that internal capacity upgrading may be required to properly administer the granting of operational permits; enforce compliance; and regulate the issuing, modification, renewal, suspension or revoking of licenses and permits for various undertakings and activities in the oil sector.

[8] In economics, rent-seeking behavior is a public choice theory that refers to seeking to increase one's share of existing wealth without generating new wealth, which according to Majid (2008) does not promote productivity.

2.11.2.5 **Inadequate Capacity**

Several African oil producing countries are still confronted with the problems associated with exploration due to poor capacity in terms of sector knowledge and human resources. According to OPEC (2017), human capacity resources refer to the number of knowledgeable people graduating from tertiary institutions with the requisite knowledge and applicable skills to manage oil processing firms, national petroleum companies, and ministries. Sector knowledge refers to experience in licensing design, the ability to properly negotiate contracts, especially those relating to petroleum matters, health hazards, environmental safety and pollution, exploration programs and development plans, as well as state capacity[9] (see OPEC, 2017).

According to the US EIA (2018), the oil sector consists of the downstream, midstream and upstream, each of which is required to develop their own skilled experts, specialists, technicians and person power. Experts like engineers, surveyors, geologists, and lawyers are in short supply in the AOECs' petroleum sectors. This results in a lack of capacity building and prudent management of revenue flows, as well as insufficient attention to environmental issues, community resettlement, and compensation. To improve the oil production capacity, necessary procedures should be employed to train and retrain professionals to improve oil output.

2.11.2.6 **Continuous exchange rates volatility**

As observed in the literature, the African oil sector is characterized by high price volatility (see Iwayemi and Fowowe, 2011). Foreign currency volatility is a major issue confronting the AOECs in relation to the US dollar and other major currencies of the world. The currencies of the AOECs have consistently devalued over time. For instance, Nigeria's naira, Egypt's pound and Libya's dinar have lost about a third of their original value when compared with the US dollar. As a result, these countries have adopted currency control measures which impede investment opportunities.

Exchange rate volatility has also had a dramatic impact on net oil-importing countries in Africa, resulting in high commodity prices and on-going unrest in several countries. For instance, the unrest in Mozambique in February 2008 is associated with the 50 percent increase in public transport fares due to a sudden hike in the pump prices of petrol and diesel (see AfDB, 2017). High commodity prices have been noted as motives for civil unrest and uprisings in many other oil-importing African nations. The situation is even worse for poor households that rely on kerosene for cooking, lighting

[9] The state's ability to effectively enact relevant laws, legislate, control and observe the activities and performance of the petroleum sector and collect petroleum profit tax.

and other domestic tasks. Inadequate resources render it difficult to adopt price smoothing and stabilization mechanisms (AfDB, 2017). While most countries have adopted mechanisms to partly or wholly pass on increases in international oil prices or introduce price subsidies, in general African countries have not responded adequately to high oil prices. Like the oil-importing countries, Africa's net oil-exporting countries are confronted with several challenges, including management of the oil wealth, a lack of institutional, technical, and human capacity, environmental challenges and economic distortions (AfDB, 2017). The monetary authority needs to intervene in stabilizing the exchange rates of the countries to enhance further output.

2.11.2.7 **Poor Accountability and Transparency in the Sector**

Poor accountability and transparency are characteristic of AOECs. Transparency and accountability require that people are informed of operations within the sector and that proper records are kept. This is lacking in the industry, undermining economic growth that oil revenue would have spurred (see AfDB, 2017). The processes involved in licensing oil blocs lack transparency in several oil-exporting countries. They are kept confidential and sometimes used for political gain (see AfDB, 2017). Corruption continues to plague the petroleum industry, with public officers embezzling and misappropriating public funds. Despite anti-corruption programs by the government at various levels, corruption is endemic across the continent (see AfDB, 2017). Examples include paying facilitation fees or bribes to circumvent bureaucratic bottlenecks, inefficiencies and the costs of interruptions to firms.

2.11.2.8 **Low bargaining power with foreign countries**

Most African oil-exporting countries rely on foreign companies for exploration, giving them weak bargaining power when negotiations ensue because the foreign companies have access to information, technical-know-how and the required capital to initiate exploration. In short, AOECs need foreign companies more than the companies need them. As a result, negotiations between host states and oil companies on the division of rents tend to short-change the former (see AfDB, 2017). Information asymmetry is a major challenge to the sustainable use of oil resources in Africa. Countries tend to lack appropriate information on demand and supply by end-users, inventory movement, investment, trade flows, price and cost. The dearth of timely and consistent information results in poor decision-making and negotiations that may disadvantage the oil-exporting countries. Effective policymaking, a national strategy for oil extraction and analysis of dependable and timely information are required to plan and fund capacity development. A dearth of necessary data (essentially market information) may result in weak bargaining power in concession and contract negotiations and suboptimal capturing of rents from oil resources. Therefore, timely data update is ggested.

CHAPTER 3

OIL PRICE SHOCKS AND OUTPUT PERFORMANCE IN AFRICA'S OIL EXPORTING COUNTRIES

3.1 Introduction

The aftermath of the oil price shocks of the 1970s, when the world experienced its first oil price shocks that triggered economic imbalance, led macroeconomists to examine the relationship between a country's output variations and oil price changes, especially in the US, which is considered the dominant economy in the world (see Hamilton, 1996, 2003). Many of these studies explored the price-GDP nexus, mainly focusing on OECD economies (see Hamilton, 1983; Mork, 1989; Cunado and De Gracia, 2003; Jimenez-Rodriguez and Sanchez, 2005). The findings of such studies are largely irrelevant to oil-exporting countries due to their divergent characteristics (Cunado, Jo and De Gracia, 2016). The literature on developing oil-exporting countries focuses on a single country. Few studies have examined groups of developing oil-exporting economies with the aim of identifying possible differences. While numerous empirical studies have examined oil price shocks' effects on economic behavior, controversy has surrounded the connection between oil price shocks and their role in macroeconomic performance, particularly the significant role that oil price changes may play in determining the path of output growth and exchange rates. Vahid and Jabber (1997) and Majid (2008) argue that positive oil price shocks positively impact output performance such that, the foreign exchange earnings will appreciate the country's currency. The reverse will hold in the case of negative oil price shocks. In contrast, Fattouh and Sen (2015) and Damechi (2012) assert that positive oil price shocks may not always lead to appreciation of oil-exporting countries' currencies due to factors such as local economic diversification, the nature of the change in oil prices, and refining techniques and refining capacity (see Fattouh and Sen, 2015; Damechi, 2012).

Despite the fact that oil is an essential factor of production in the aggregate output of every economy, empirical evidence on the economic consequences of oil price shocks and their transmission mechanism in an oil-exporting country remains contentious[10] (see Olomola, 2010). This raises a vital

[10] Mork *et al.* (1994) observe a statistically significant negative (-) correlation between oil price increases and GDP growth for Canada, France, Germany, Japan and the US over the period 1967 to 1994. Burbidge and Harrison (1984) estimate a closed-economy VAR for Canada. They find that oil price shocks negatively impact Canada's industrial production. However, based on more recent data for 1980:1 to 2003:3, Cologni and Manera (2008) find that oil price shocks have an insignificant stimulative effect on Canadian GDP. The relationship between oil prices and the exchange rate is also a topic of debate. Amano and Van Norden (1995) report a negative relationship between energy prices and the Canadian dollar, implying that higher real energy prices lead to a depreciation of the Canadian dollar. However, Issa *et al.*'s (2008) later work reveals that such a relationship broke down in the early 1990s.

question: through what channels do oil price shocks impact the economic activity of oil-exporting countries? Establishing the extent of the impact of oil price shocks on various macroeconomic variables would be very helpful in making economic forecasts and designing appropriate economic policies for oil-exporting countries.

On the oil price-output nexus, Ahmed (2017) and Karl (2005) observe that the presence of oil in Arab countries like Saudi Arabia, Libya, Iraq, Algeria, Egypt, and Syria seriously impairs output growth, based on the phenomenon of the resource curse and Dutch Disease. However, Majid (2008) and Amuzegar (1998) argue that many oil-exporting countries have utilized the forward linkage effect of the oil industry to improve the growth of their economies. Debates among macroeconomists focus on whether or not significant economic performance is oil price-led. The procedure through which this variation may impact output also remains a puzzle. This is a crucial question because it is essential for policymakers to understand this relationship in order to effectively manage the economy and adopt appropriate development policies and strategies in the face of possible shocks that could affect the functioning of the economy (see Hameed, Iqbal and Devi, 2012).

In summary, there are two opposing views on the relationship between oil prices and the economic growth of an oil-exporting country. It is clear from the various arguments that the nature of this relationship could vary from one context to another. The precise relationship between oil prices and output growth in AOECs is yet to be clearly established. This motivated the current study. Furthermore, earlier studies have employed various estimating techniques such as the vector autoregressive model (VAR), vector error correction model (VECM), and Granger causality to determine the relationship between oil price shocks and economic growth (see Olomola and Adejumo, 2011; Iwayemi and Fowowe, 2011; and Akpan, 2010) leaving out the possibilities of a different technique changing the narratives. Therefore, a panel structural vector autoregressive model (PSVAR) estimating technique has been employed in this study with the belief that estimations and findings from it would shape the existing narrative regarding the relationship in the context of AOECs. This attempt is considered novel to this study.

The study contributes to existing knowledge in macroeconomics and the energy economics literature by analyzing how selected macroeconomic variables respond to variations in oil prices. Furthermore, it offers policy options that could serve as a catalyst to boost output growth within the AOECs. Using panel data analysis, the study investigates (i) whether oil price shocks have statistically significant impacts on output growth in AOECs, (ii) the medium through which oil price movement may affect output growth, and (iii) trends in output growth and oil prices in AOECs.

While this study may appear similar to those by Iwayemi and Fowowe (2011), Olomola and Adejumo (2006), Farzanegan and Markwardt (2009) and Kilian (2010), it differs in a number of ways. Firstly, Olomola and Adejumo (2006) rely on annual data, covering the period 1988 to 2004, similar to other scholars that covered earlier periods, while this study relies on lengthier and more updated quarterly data, covering the period 1980 to 2018. Secondly, Farzanegan and Markwardt (2009) follow the literature on macroeconomic variables' asymmetric response to oil price shocks, distinguishing between positive and negative oil price shocks. This approach has been criticized by Kilian (2010), who asserts that decomposing positive and negative oil price shocks results in unreliable and biased parameter estimates, implying that the impulse responses have been incorrectly computed. The current study does not consider the decomposition of the oil price because the asymmetric behavior of oil price shocks in relation to output growth is not its focus. Thirdly, taking into consideration the "Dutch Disease" phenomenon, Farzanegan and Markwardt (2009) and Kilian (2010) employ industrial production as a proxy for output, while this study employs GDP growth as a measure of output. Fourthly, following Eslamloueyan and Kia (2015), the current study uses nominal exchange rates while Farzanegan and Markwardt (2009), and Kilian (2010) rely on effective exchange rates as a benchmark to measure exchange rates. In addition, Farzanegan and Markwardt (2009) use an error correction technique comprising variables like world inflation, world output, and effective exchange rates to test their model. This study also differs from their study in that it emphasizes trade, while we emphasize the interrelation among domestic variables and oil prices which is treated as an exogenous variable.

The remainder of this chapter is arranged as follows. Section 3.2 reviews the relevant literature; section 3.3 discusses the theoretical framework for the study and section 3.4 presents the transmission mechanism. The methodological framework that characterizes the panel structural sector autoregressive (PSVAR) model, identification of the structural shocks, sources of data, measurement and definition of variables is presented in section 3.5. Section 3.6 presents the estimation of results. The study's findings and their implications are discussed in section 3.7 while section 3.8 summarises and concludes the chapter.

3.2 Literature Review

The role of crude oil in the global economy cannot be overemphasized. Oil is of great importance to the day-to-day running of the world economy, serving as a source of revenue and input factor in oil-exporting and oil-importing countries. It is therefore not surprising that fluctuations in the price of oil and the attendant effect on growth have been widely documented by researchers and economists (see Iwayemi and Fowowe, 2011; Olomola, 2010; Hou, Mountain and Wu, 2016).

The earliest studies examining the relationship between oil prices and economic growth mainly focused on the US economy, while a few studies have recently emerged on developed oil-importing countries (see Jimenez-Rodriguez and Sanchez, 2005; Hamilton, 1983; Cunado and De Gracia, 2003). These studies relied on the Granger causality technique to determine the relationship between economic growth and oil prices. They concluded that there was a linear association between the US' GDP and oil prices. Based on this linear model, they conclude that oil price variations were an important factor in almost all US recessions after World War II. For example, Hamilton (1983) found that nine out of about eleven post-World War II economic recessions in the US were associated with increases in oil prices and that variations in oil prices Granger cause output and unemployment in that country. Burbridge and Harrison (1984), Gisser and Goodwin (1986) and Ferderer's (1996) studies confirmed that a change in oil price leads to a change in output and unemployment.

Mork (1989) established that an increase in the price of crude oil negatively affected US production and that a fall in oil prices had no statistically significant effect on output, suggesting an asymmetric relationship between the variables. Hamilton (2003) supported this claim which was later verified by Berument *et al.* (2010). Further research findings from Hamilton (1996 and 2003) which focused on the asymmetric effects of oil shocks triggered the interest of critics who assumed that the oil price-output relationship is symmetric (see Hooker, 1996; Mork, 1989; Mork *et al.*, 1994; Mory, 1993).

During the 1980s, the application of the vector autoregressive (VAR) model to determine the association between oil prices and macroeconomic variables began to gain ground. Burbidge and Harrison (1984) used the VAR estimating technique to show that oil price shocks have a significantly negative impact on industrial production. Hamilton (1996) introduced net oil price increase (NOPI) as a new variable, using the VAR model to illustrate the robustness of the association between oil prices and real GNP. Following a similar technique, Balke *et al.* (2002) constructed a VAR model of the US economy and found that the economy responds to oil price increases with a decline in real GDP, and a rise in the general price level and interest rate.

The second strand of studies that considers the relationship between oil price movements and GDP broadened previous perspectives by including other developed countries in addition to the US, with most of these countries being net importers of crude oil. Some of these studies, which include Mork *et al.* (1994), Jimenez-Rodriguez and Sanchez (2005), Papapetrou (2001), and Lescaroux and Mignon (2008) were influenced by the seminal work of Hamilton (1983). Several OECD economies are included in these empirical studies and in most instances, they find a negative association between oil prices and GDP. Employing a multivariate VAR technique, Jimenez-Rodriguez and Sanchez (2005) find that a rise in oil prices negatively impacts GDP growth, while a fall does not. This validates the earlier results of Mork (1989) and Hamilton (2003), confirming the existence of an asymmetric relationship between the oil price and GDP within developed oil-importing countries.

The third strand of studies is the more recent one. It includes Rentschler (2013) who examined the significance of oil price volatility in several countries in the developing and developed worlds and among oil-importing and exporting nations. These countries comprise India, Japan, Germany, India, Malaysia, the US, Japan and the Republic of Korea. Using a VAR estimating technique, Rentschler (2013) concludes that a rise in oil price volatility could have negative implications for the economies of both oil-importing and exporting nations. He also asserts that an economy that relies heavily on oil trade may be prone to price shocks. Other empirical studies like Rentschler (2013) on the effects of oil price shocks in oil-producing countries, have been carried out in Venezuela (Mendoza and Vera, 2010), Norway (Baumeister and Kilian, 2014), Algeria (Bouchaour and Al-Zeaud, 2012), Mexico (Cantore, Antimiani, and Anciaes, 2012) and Russia (Fang and You, 2014).

Fewer empirical studies have been carried out in developing oil-exporting countries. Berument *et al.* (2010) examine how oil price shocks impact output growth in selected net-exporting and net-importing nations in the Middle Eastern and North African (MENA) region, using GDP figures from 1952 to 2005. Their results reveal that oil price shocks have a significant positive effect on output growth in Kuwait, Algeria, Iran, Iraq, Libya, Oman, United Arab Emirates, Qatar, and Syria, the majority of which are OPEC members, except for Syria and Oman. However, it has not been shown that oil price shocks have an impact on the output of Tunisia, Morocco, Jordan, Israel, Egypt, Djibouti and Bahrain, all of which are net-importing countries (see Berument, Ceylan and Dogan, 2010). The study also shows the existence of an asymmetric relationship between oil prices and GDP. Mendoza and Vera's (2010) findings support this assertion. Fluctuations stemming from volatile oil prices are harmful to the non-oil sector with regard to capital formation (Korhonen and Juurikkala, 2007); price level or inflation, money supply and GDP or the overall growth of an economy (Kasekende, Mlambo, Murinde, Zhao, 2009; Hou *et al.,* 2015).

Mehrara and Mohaghegh (2011) examine output variations among Arabian countries, including Kuwait, Iran, Indonesia, and Saudi Arabia, which are OPEC members. The study imposed long-run restrictions on a VAR model to determine the driving forces behind output variations. It identifies four structural shocks, namely, nominal oil demand, real oil demand, oil price shocks, and oil supply and finds that oil price shocks are the driving force behind GDP fluctuations in Iran and Saudi Arabia, while supply shocks show the highest impact in Indonesia and Kuwait. The authors attribute these results to limited resource-based production in Indonesia and a well-managed savings fund in Kuwait.

Other studies on the relationship between oil prices and economic growth in developing oil-exporting countries include Eltony and Al-Awadi (2001) on Kuwait, and Olomola and Adejumo (2006) on Nigeria. The closest to this study in terms of the methodology and variables employed are Iwayemi and Fowowe (2011) and Farzanegan and Markwardt (2009) For instance, Farzanegan and Markwardt (2009) employ a VAR model to examine the effect of oil price shocks on Iran's economy. However, these studies differ with respect to the choice of variables and the time period.

Variations in oil prices have been shown to have a significant impact on economic performance. Eika and Magnussen (2000) and Kilian (2010) find that movements in crude oil prices influence the world economy at different levels, from family budgets to corporate earnings and the national economy. The IMF (2017) states that a 10 percent rise in oil prices leads to a 0.2 percent decline in global GDP. Hence, when the oil price peaked at $145 per barrel in 2008, and then started to decrease sharply from 2014, bottoming at $29 per barrel in early 2016, this led to significant revenue shortfalls and economic stress in many energy exporting nations such as Russia and Saudi Arabia. On the other hand, the availability of cheaper oil has been noted as a potent economic stimulus for many net oil-importing countries like India and China, while keeping inflation in check.

Finally, the earlier studies on the relationship between the oil price and output do not capture current variations in the oil price which are widely believed to impact the economies of the AOECs. For instance, Iwayemi and Fowowe's (2011) dataset begins in 1970 and stops in 2006. Similarly, Boye (2001) begins in 1970 and stops in 2000. The current study uses quarterly data with an updated dataset to address this gap and offer a more reliable policy direction to the AOECs. Various empirical studies have been conducted on the economic effects of oil price increases. Similarly, a price decrease has been examined, focusing more on developed oil-importing nations. In many cases, these studies conclude that increases in oil prices negatively affect GDP and other macroeconomic variables. However, this study focuses on the AOECs, as there is a paucity of published empirical studies on these countries. It examines whether oil price shocks have a significant impact on AOECs' economic growth using the PSVAR to portray the interrelation among the variables.

3.3 Theoretical Framework

This section discusses the theoretical framework[11] employed in this study. Following Mork *et al.* (1994) and Gonzalez and Nabiyev (2009), the study adopts the Real Business Cycle (RBC) theory to explain how external shocks, like oil price shocks, to an economy have a short-run effect on capital

[11] Maree (2007) defines a theoretical framework as the roadmap for the study that presents the theory which describes and explains the research problem under study.

and labour, which in turn reflect output growth. Kim and Roubini (2000) illustrate how the variable oil is included in the RBC model. This section discusses the cost components when the global oil price rises. It also offers an explanation as to why the effect of an oil price increase on growth could be different from a fall in oil prices.

3.3.1 The Real Business Cycle Theory (RBC)

The RBC theory states that to a large extent, fluctuations in the business cycle are subject to real shocks that affect market dynamics. It holds that economic fluctuations and crises are consequent to external shocks like technology shocks. Previous research found that many cyclical events cannot be solely explained by a model-driven framework (see Kim and Roubini, 2000). This resulted in the development of models that include additional disturbances such as periods of natural disaster, oil shocks, environmental factors like bad weather, and safety policies. One way to classify RBC models is to differentiate the strongest impulses that drive the cycle: "Do they arise from a demand shock or a supply shock in the economy?" Some economists associate the 2008 oil price shocks with restrictions in the oil supply by OPEC, while others attribute it to demand by the Asian nations.

Kehoe and Kydland (1992) note that, the fundamental assumption of the RBC theory is that, if an external shock occurs and directly changes the effectiveness of labour and/or capital, this has an impact on workers and firms' decisions as they change their patterns of production and consumption, which negatively impacts output. Employing the RBC theory in this study has implications for the results because it assumes that prominent oil price shocks impact growth. Changes in the business cycle vary substantially over time and in extent in response to various shocks to the economy. Therefore, business cycles may not necessarily behave in the same way that oil prices vary. In addition, the business cycle's response to oil price changes in the past may not be the same as in more recent times. For instance, the degree of business cycle responses to the 1974 and 1979 oil price shocks and their length of variation may not be the same as that of the 1987 and 2008 price shocks. This validates the choice of the period covered by this study that captures recent variations in oil prices.

3.3.2 Modeling Output growth treating energy as a variable in the RBC theory

Following the RBC theory, this study considers the fact that economic output fluctuations arise from oil price shocks. To build a model that permits the inclusion of the energy variable, proxied by the oil price, into an output growth model, it follows Prescott and Kidland's (1982) model as a benchmark that serves as a starting point, since the study indicates that the neoclassical growth model is appropriate to replicate various features of modern business cycles. Prescott and Kidland's (1982) RBC model has been modified to include various variables that target several directions: labour indivisibilities (Ghysels and Wright, 2009); home production (Ghysels and Wright, 2009); preference shocks (Ghysels and Wright, 2009); and the role of energy price shocks (Kim and Loungani, 1992).

In view of these studies and their contributions to knowledge, this study disregards whether or not the state of technology has an impact on output growth. This assumption is in line with Ghysels and Wright (2009) and Kim and Loungani (1992). Therefore, the extension of Kim and Loungani's (1992) model specifically considers the impact of energy price shocks on output. In the model, the representation of short-run business cycles is generated by energy price shocks as well as productivity shocks or supply constraints. This model serves as a benchmark upon which to build a reduced form of macroeconomic model later used by Mork *et al.* (1994) which will be extended in this study using oil prices as an exogenous variable for the period 1980 to 2018.

3.3.3 **Cost components**

According to Greene (2003), the cost implications of variations in oil prices are such that when the oil price rises above the competitive prevailing market level, economies are confronted with three kinds of cost: production output falls because a major production input has become more expensive; unanticipated variations in oil prices push up unemployment, causing a decrease in output growth, and a portion of the wealth of oil-importing countries is transferred to the foreign economies producing oil.

An abrupt rise in oil prices warns the world that a basic economic resource will be scarcer. The gain of potential GDP for oil exporters is the currency assigned to the expansion of output when a primary resource in the country becomes scarcer. Such gain in output is expected to be larger among net oil exporters. Inversely, for oil-importing economies, the loss of possible output is due to the shrinkage of output when a primary production input in the country suddenly becomes scarcer (see Greene, 2003). Even if all resources are fully employed, the potential to produce output declines because of the scarcity of oil input. Hence, economic output decreases below its full potential. Since such economic adjustment costs result from the economy's inability to respond quickly, they are temporary and are believed to dissipate over a period of three to five years (see Greene, 2003).

Lee, Ni and Ratti (1995) assert that, the adjustment costs stimulated by macroeconomic adjustment are the most complex of the three cost components because they depend not only on the price shocks, but also on policy responses (such as expansion and contraction of the money supply) and on expectations about the duration of the price increase. However, economies, both net oil exporters and importers introduce different policies to mitigate against the potential consequences of oil price shocks. Despite these efforts, a rise in production costs results in a rise in wages to cover increases in the cost of living. The attendant effect is an increase in the aggregate price level of the economy. The impact of expansion and contractions in the money supply depends on each country's economic policies. If the money supply in terms of real money does not expand, the money supply adjusted for the price level declines. In addition, interest rates rise, impeding investment, and through the multiplier effect result in declining growth (see Greene, 2003). Greene (2003) finds that oil price shocks cause job destruction rather than creating an opportunity for labour engagement. He adds that most energy-intensive sectors suffer more than twice the employment losses of least energy-intensive industries. A country with a large energy-intensive sector in which oil is a primary resource will feel the oil shock more and probably for a longer time (Greene, 2003).

The transfer of wealth from oil-importing nations to oil-exporting ones is one of the cost components of oil price shocks. With regard to oil-importing countries, oil price shocks are believed to worsen the terms of trade as consuming countries need to trade more resources in exchange for the same quantity of oil due to the monopoly held by oil-producing economies. Nonetheless, the transfer of wealth is not seen as a loss of the world's economic output since resources lost by consuming nations are kept by producing nations. However, it is a real economic loss to oil-importing countries (see Greene, 2003).

3.4 **Oil Price Transmission Mechanisms and Theoretical Framework**

Theoretically, changes in oil prices affect macroeconomic performance. Price fluctuations have negative consequences for the aggregate economy (see Gospodinov and Ng, 2013; Filardo and Lombardi, 2014). Similarly, an increase in the oil price leads to higher general commodity price levels and consequently reduces aggregate demand for commodities, translating to a fall in demand and in output (Dornbusch, Fischer and Startz, 2003).

Balke *et al.* (2002) show that changes in the oil price can affect the performance of macroeconomic variables through the following transmission channels:

3.4.1 *Supply-side shock channel*

This channel places emphasis on the direct effect of oil price changes on output due to variation in marginal production costs triggered by oil price shocks;

3.4.2 *Wealth transfer channel*

This channel focuses on the various marginal consumption rates of ordinary trade surplus and the petrodollar. The channel can be split into:

3.4.3 *Inflation channel*

The inflation channel analyzes the connection between domestic inflation and oil prices.

3.4.4 *Real balance channel*

The real balance channel investigates the change in money demand and monetary policy;

3.4.5 *Sector adjustment channel*

The sector adjustment channel evaluates the adjustment cost of the industrial structure, which is mainly used to explain asymmetry in the impact of an oil price shock;

3.4.6 Unexpected *channel*

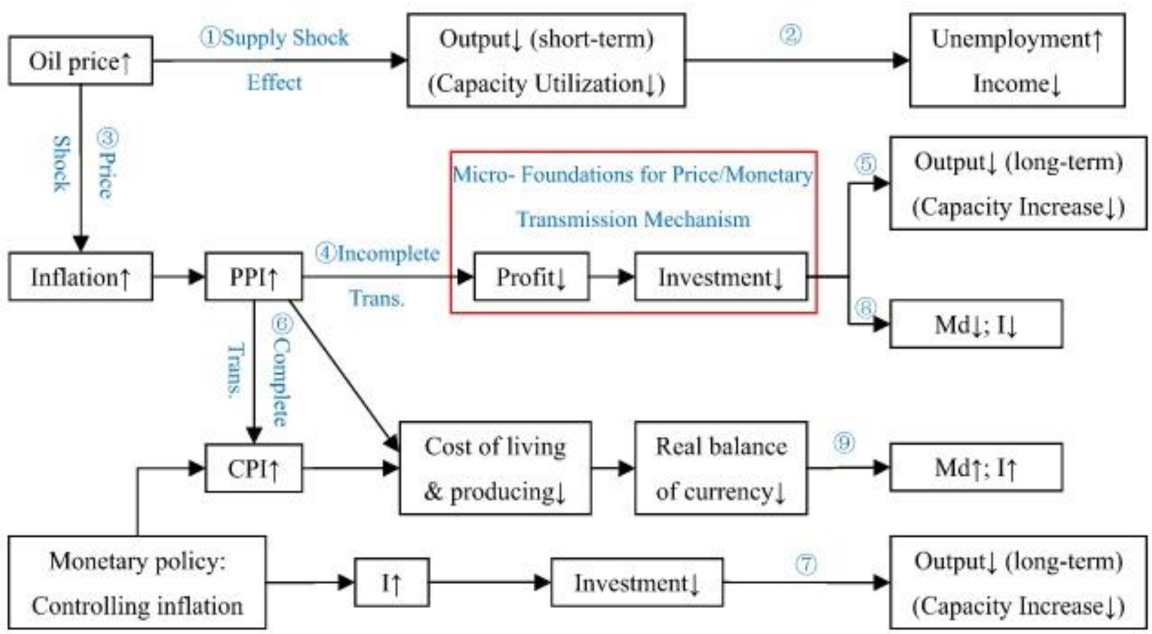
It concentrates on uncertainty about the oil price and its impact on the economy.

Following Balke *et al*. (2002) and Tang *et al*. (2010), oil is a fundamental input for industrial production. Therefore, the supply channel focuses on the direct impact of oil price shocks on output, arising from variations in marginal production costs. From the transmission channel in figure 3.1, the direction of oil price shocks determines the economic response over time. Generally, positive oil price shocks (see arrow 1) can increase the marginal cost of production, hence, reducing the firm's capacity utilization and resulting in a fall in production, and unemployment which persists, as indicated in the panel. This is called the supply-side shock effect. Similarly, oil price volatility reduces investment activity (see Filardo and Lombardi, 2014). A perpetual rise in oil price volatility could lead to a situation where future production capacity will always be low. A fall in production due to capacity utilization can recover swiftly within the range of capacity. Therefore, oil price shocks also have a long-term impact on production which usually occurs through the Price/Monetary Transmission Mechanism (see arrow 3). Hamilton (2013) stresses that concerns relating to oil price variability and oil price disruptions could delay investment decisions. When the price of oil increases, there may be a structural shift and a period of adjustment. As the price situation persists or becomes relatively more expensive in relation to other intermediate goods, industries that rely on energy for production begin to reduce production while less energy-intensive ones begin to expand their output. According to the West African Monetary Agency (2008), during such a period, production is characterized by high costs arising from oil price increases, which eventually lead to higher unemployment and underutilization of available resources.

Producers in upper stream industries can transmit cost shocks to end-users. A well-built, advanced industrial chain can transmit inflationary shocks from the upper stream downstream, leaving producers' profit marginally affected. This may increase the total cost for consumers and producers, decreasing the real balance for consumers. Overall, this transmission leads to a decrease in consumption as well as a decline in real output.

According to Balke *et al.* (2002) and Tang *et al*. (2010), these channels have been shown to be valid in industrialized and most developed countries. However, it remains an open question whether this is true in AOECs. This is because AOECs experience excess oil production resulting from limited local demand, and tough price determination in the export sector of oil-exporting economies (see arrow 4). Balke *et al.* (2002) also note that, due to limited scope for mark-up, downstream producers can only reduce their profit to integrate the increase in cost, which would cause a decrease in their investment. Since investment influences the rate at which production capacity rises, that is, possible production ability, which may not recover in a short time even when the cost of a shock disappears, a fall in investment will reduce productivity in the long run. In view of this, this channel is more important and may apply to AOECs.

Figure 3.1: **Oil-price shocks transmission channels**



Source: Adopted from Tang *et al.* (2010).

Figure 3.1 shows that an increase in oil prices results in a rise in the prices at which producers sell their commodities in the market. According to Jimenez-Rodriguez and Sanchez (2005), when the prices of products rise, the purchasing power of money is reduced and the cost of living increases (see arrows 6 and 9). In addition, the transfer of income and resources from oil-importing to oil-exporting countries is more likely to reduce aggregate global demand, as demand in the oil-importing countries is likely to decrease more than it will increase in oil-exporting countries (Hunt, Judge and

Ninomiya, 2003). The subsequent lower purchasing power for oil-importing countries leads to a fall in demand.

An increase in oil prices may increase the general price level. In terms of the policy response, the resultant inflationary pressures could motivate the tightening of monetary policy (Hunt *et al*., 2003; Filardo and Lombardi, 2014). This may require that the Central Bank applies monetary policy tools to mitigate against the adverse effects of such shocks (see panel 4). The Central Bank usually targets interest rates to influence the direction of commodity demand and inflation in the economy. Nevertheless, Hunt *et al*. (2003) find that the monetary authority's reaction to oil price shocks could affect its credibility if it is inconsistent with the policy objectives announced. Therefore, management of the inflation procedure could be interrupted (Hunt *et al*., 2003). As noted by Ferderer (1996), money supply plays a vital role in the negative relationship between economic growth and oil prices. Through the real money balances channel, a rise in oil prices leads to an increase in the general price level, which decreases the real balances in the economy. In addition, a highly restrictive monetary policy designed to maintain inflation at very low levels would decrease output because of the trade-off between output and inflation (see Filardo and Lombardi, 2014; Ferderer, 1996).

3.5 **Research Methodology**

This chapter examines the relationship between the oil price and output growth among AOECs using the PSVAR estimating technique employed in Kutu and Ngalawa (2016) and Akande and Kwenda (2017). The technique is built on the VAR, PVAR and SVAR frameworks (see Canova and Ciccarelli, 2012). The model has been found suitable because it focuses on multivariate correlation among variables (Akande and Kwenda, 2017). According to Kutu and Ngalawa (2016) and Akande and Kwenda (2017), the PSVAR model offers ways to create several lags because the effects of oil price shocks may not be immediate. Furthermore, the technique involves pooling cross-sectional data together and deploying a panel data estimation. The choice of this technique is informed by the identical yet idiosyncratic characteristics of the oil-producing economies in Africa. In particular, these economies are net oil exporters that rely on oil as a major source of revenue. The AOECs are also confronted by poverty, corruption, high exchange rates, inadequate refineries and susceptibility to external oil price shocks which may have a degrading impact on their economies (see WDI, 2018).

The VAR model developed by Sims (1980) is the model most favoured by monetary economists to study the short-run relationship among variables (see Dungey and Pagan, 2000; Rebucci, 2010; Beetsma and Giuliodori, 2011; Canova and Ciccarelli, 2012; Davoodi, Dixit, and Pinter 2013; Boubtane, Coulibaly and Rault, 2013). Nonetheless, it has been severally criticized on the grounds that it does not cater for the need of researchers whose research interest is in shocks different from monetary policy shocks (see Bernanke *et al*., 2004; Elbourne, 2008). These shortcomings led to the evolution of the Structural Vector Autoregressive (SVAR) technique, which is capable of not only addressing the deficiencies of VARs but also of accounting for the economic information that provides the rationale for restrictions in a model that make it possible to identify other non-monetary policy shocks. Several researchers have employed the SVAR model in their empirical studies (see Berkelmans, 2005; Sousa and Zaghini, 2007; Elbourne, 2008; Ncube and Ndou, 2011), as have oil-related studies. For instance, Omolade and Ngalawa (2014) employ this model to investigate whether or not the exchange rate regime matters in the monetary policy transmission mechanism and growth of the manufacturing sector in Libya and Nigeria. Omolade and Ngalawa (2014) also employed this model to measure oil resources and oil price shocks in the individual economies of five net oil-producing nations in Africa. Kose and Baimaganbetov (2015) apply the model to examine the asymmetric impact of oil price shocks on Kazakhstan's macroeconomic dynamics. Ahmed and Wadud (2011) employ it to examine the role of oil price shocks in macroeconomic activities and Malaysia's monetary responses. Sek and Lim (2016) use the SVAR model to investigate the impact of oil price shocks on domestic inflation in two groups of countries, namely, oil importing countries, the US, China, and Japan, and oil exporting nations, Saudi Arabia, and Russia. Studies related to banking and finance have also applied the SVARs model (see De Graeve and Karas, 2010; Love and Zicchino, 2006). Notwithstanding that this model and VARs are generally accepted, they usually only analyze time-series data pertaining to a single economy. These weaknesses call for panel data analysis in an investigation involving more than one economy. In addition, efforts to capture the effects of the interdependence of variables and transmission mechanisms across various countries led to the Panel Vector Autoregressive (PVARs) model (see Canova and Ciccarelli, 2012) which various researchers have employed in their studies (see Canova and Ciccarelli, 2012; Prasad and Espinoza, 2012). However, the PVARs has been associated with the problem of dimensionality (Davoodi *et al.*, 2013). The PSVAR was employed in this study to overcome the identified limitations and weaknesses of VARs, SVARs, and PVARs.

The PSVAR is built on the same principles as the PVAR but overcomes its weaknesses through the imposition of structural restrictions, rendering it much more efficient and powerful to deal with monetary, energy and economic policy issues. Similarly, the PSVAR model is premised on the principle of a VAR but overcomes the weakness of being limited to time series analysis through a panel framework. Furthermore, the PSVARs benefits from the gains of VARs, SVARs, and PVARs and overcomes their inherent weaknesses. Beyond the study of monetary policy shocks that the PSVAR model is used for in Kutu and Ngalawa (2016), the model is suitable for studies focusing on shock related matters, yet capable of pooling data across locations and various economies (see

Akande and Kwenda, 2017). Kutu and Ngalawa (2016) apply the PSVAR model to analyze the relationship between monetary policy shocks and industrial output in BRICS countries while Akande and Kwenda (2017) investigated competition, regulation, and stability in the sub-Saharan African region. Following these studies, this study applies PSVARs to investigate the relationship between oil prices and output growth, making the study novel, as we are not aware of any oil-related study that has employed this model to develop a PSVAR estimation for developing net oil-exporting countries in Africa. Therefore, this study contributes to knowledge by employing a PSVAR estimating technique to analyze the relationship between oil price shocks and output growth in AOECs.

Khan and Ahmed (2014) employ the SVAR technique to determine the macroeconomic effects of oil and food price shocks on the Pakistani economy. Ahmed and Wadud (2011) utlilize the SVARs to investigate the impact of oil price shocks on macroeconomic activities in Malaysia and corresponding monetary responses. Similarly, Akinyele and Ekpo (2013) estimate the relationship between oil price shocks and macroeconomic performance in Nigeria. Farzanegan and Markwardt (2009) examine the effect of oil price shocks on the Iranian economy using the VARs estimating technique. Lippi and Nobili (2008) employ SVARs to investigate the relationship between oil and the macroeconomy. In related studies, Mahmud (2009) uses an SVAR approach to investigate oil price shocks and monetary policy aggregates in Nigeria and Mehrara and Mohaghegh (2011) examine the macroeconomic dynamics in oil-exporting countries using a PVARs approach. These studies constitute the premise and methodological guide upon which this study builds the PSVARs estimating technique.

While previous studies have empirically examined the relationship between oil prices and output growth as well as oil prices, oil price shocks and macroeconomic performance in developed oil-importing countries, little has been documented in developing net oil-exporting countries. This results in a dearth of policy guidelines to mitigate the economic imbalance resulting from oil price shocks. More specifically, the degree of impact of oil price variations on the economies of these countries remains open to debate. Furthermore, there is no clear consensus on the transmission mechanism through which oil price movement may affect output growth. It is against this background that the PSVARs estimating technique is considered suitable for this study to capture the dynamic behavior of the macroeconomic variables in the model. In addition, the PSVAR model is considered suitable to obtain a more efficient estimation of the parameters which are compatible with this study. De Graeve and Karas (2010) and Canova and Ciccarelli (2012) note that the power of SVARs is premised on the fact that it permits the recovery of stimulating patterns in the VARs model. Furthermore, Canova and Ciccarelli (2012) found that the VARs framework upon which the PSVAR is premised is advantageous because it does not lose focus on the dissimilarities in the AOECs that are considered in this study. Canova and Ciccarelli (2012) add that the framework allows for the flexibility of dynamic cross-section and slope heterogeneity and assert that the SVAR, a framework upon which PSVARs is built, enables the explanation of contemporary circumstances and a forecast of what the future holds drawing on previous trends.

3.5.1 **Research Procedures**

Davoodi *et al.* (2013), Canova and Ciccarelli (2012), and Prasad and Espinoza (2012) employ the PVAR technique in studies on transmission mechanisms. Similarly, Hou *et al.* (2016), and Hoffmaister, Solano, Solera and Vindas (2000) utilize VARs estimating techniques in studies relating to the oil price transmission mechanism, upon which the PSVAR estimating technique is built. This study employs a PSVAR to capture the dynamic behavior of the variables in the model and to provide a more efficient estimation of the parameters. A PSVAR estimating technique has the same structure as PVAR models (see Davoodi *et al.,* 2013; Canova and Ciccarelli, 2012; Prasad and Espinoza, 2012), in the sense that all variables are assumed to be independent and endogenous, excluding those recognized as exogenous. Similarly, Buckle *et al.* (2002) develop the traditional SVAR that forms the hybrid approach to structural identification of the restrictions which is employed for the PSVAR technique.

The PSVAR technique follows the logical principles that apply in the standard PVAR except for the structural restrictions, which are imposed on the former, thus making it a different and more consistent estimator to address macroeconomic and related policies. To derive reasonable economic structures, the PSVAR technique allows for the imposition of restrictions only on the contemporaneous structural parameters. The rationale for this limitation follows Dungey and Pagan's (2000) conclusion that, restrictions imposition limits attention to rotations that produce shocks which moderate the anticipated sign-in responses of major variables.

3.5.2 **Rationale for panel data estimation**

According to Gujarati (2004), pooled data analysis involves the combination of elements of both time series and cross-sectional data, which is generally used to offer an overall summary of subgroup data or information from an interrelated study. This study pools time series and cross-sectional data because of the advantages attached to the choice of the panel data technique over time series and cross-sectional techniques. The advantages of using a panel data approach over time series analysis are presented in Gujarati (2004), Baltagi (2008) and Hasio (2014). For example, Baltagi (2008) holds that panel data offers more explanatory power and data variability; fewer collinearities among the variables; additional degrees of freedom; and is more efficient when compared to time-series cross-sectional data. The author also notes that panel data can control for heterogeneity in individual data. Baltagi (2008) maintains that panel data is well suited to a study of dynamic adjustment and useful to determine and measure the unnoticeable or incomputable effects inherent in pure time-series or cross-sectional data. In addition, it has been claimed that panel data permits the formation and analysis of more complex behavioral models (see Baltagi, 2008; Hasio, 2014), like economies of scale and technological change (Gujarati, 2004). This technique has also been argued to be a suitable estimator to remove the problem of non-standard distributions that characterize the unit-roots tests in the time-series analysis (see Baltagi, 2008; Mahembe, 2014; Hasio, 2014).

3.5.3 **Non-stationarity and Panel Unit Root**

A unit root process deals with the stationarity of a data series used in the analysis (see Gujarati, 2004). According to Gujarati (2004), a time series having a unit root shows that a systematic pattern is unpredictable. Dendramis, Spungin and Tzavalis (2014) argue that, a unit root test is a required precondition for any VARs process to be estimated. All data series must be integrated of the same order but may not necessarily cointegrate. However, this study argues that estimation at levels prevents the possibility of efficiency loss or losing vital information about the sets of data that are regularly associated with a differenced VAR and SVARs. In addition, this study follows Elbourne (2008), Feve and Guay (2006), Peersman and Smets (2001), Uhlig (2005), and Ibrahim and Amin (2005) who unambiguously estimated VARs and SVARs at levels. Buttressing this approach, Afandi (2005) argues that it is advantageous as it can produce consistent parameter estimates regardless of whether or not the time series are cointegrated due to the restrictions imposed on the model, making it possible to produce a more robust result than a cointegrated VARs or SVARs model.

It has also been observed that the inclusion of lags into variables may give a more robust result in the context of VARs and SVARs techniques. For instance, Berkelmans (2005) claims that the insertion of lagged variables into the VARs and SVARs enables the residuals to be stationary even with I(1) variables. In support of this assertion, Ncube and Ndou (2011), Ngalawa and Viegi (2011), Sharifi-Renani (2010), Mordi and Adebiyi (2010), Farzanegan (2011) and more recently, Akande and Kwenda (2017) found the inclusion of lagged variables to be relevant in the estimations of VARs and SVARs models.

3.5.4 **Model Specification and Set-up of the P-SVAR**

Similar to Kamin and Rogers (2000) and Berument and Pasaogullari (2004), the PSVARs has the same structure as PVAR and SVAR models, in the sense that all variables are assumed to be endogenous and inter-reliant, except for those identified as exogenous. The PSVARs estimating technique employed in this study is estimated using seven variables classified into endogenous and exogenous variables. The endogenous variables are gross domestic product (GDP), money supply (MS), exchange rates (EXR), inflation (INF), interest rates (INT) and unemployment rate (UNE). Oil price (OP) is treated as an exogenous variable. The inclusion of the exogenous variable shows the openness of the oil-exporting countries in relation to the rest of the world. The study employs the PSVAR model to capture the dynamics of world oil price shocks on the selected domestic oil-exporting economies. This model assumes that the six endogenous variables of each country cannot affect world oil prices. The PSVAR is built alongside the principle applying to the standard PVAR, excluding the structural restrictions, which are imposed on the former, making it a different and much stronger tool for addressing macroeconomic policy. The PSVAR methodology suggests the imposition of restrictions on the contemporaneous structural parameters only for reasonable economic structures to be derived.

Suppose that oil-exporting countries are denoted using the following structural panel equation:

$$\lambda\Phi_{it} = \Omega_{io} + \Psi_1\Phi_{it-1} + \Psi_2\Phi_{it-2} + \ldots + \Psi_p\Phi_{it-p} + \mathrm{M}\theta_t + \Delta\varepsilon_{it} \qquad (1)$$

Where λ represents an invertible $(\upsilon \times \upsilon)$ matrix that describes the contemporaneous relationship among the variables employed; Φ_{it} symbolizes $(\upsilon \times 1)$ a vector of endogenous variables such that $\Phi_{it} = \Phi_{1t,} \Phi_{2t,} \ldots \Phi_{nt}$. Ω_{io} is a $(\upsilon \times 1)$ vector of constants representing country-specific intercept terms; Ψ_i is a $(\upsilon \times \upsilon)$ matrix of coefficients of lagged endogenous variables (for every $i = 1 \ldots p$); and M and θ_t are vectors of coefficients and the exogenous variable, respectively. The latter captures external shocks; Δ is a $(\upsilon \times \upsilon)$ matrix whose non-zero diagonal elements allow for direct effects of some shocks on more than one endogenous variable in the system; and ε_{it} is a vector of uncorrelated error terms (white-noise structural disturbances).

Equation (1) presents the PSVAR model. According to Enders (2004), this model cannot be estimated directly due to the feedback that is inherent in the SVAR process. The structure of the system incorporates feedback, which makes it difficult to estimate because the endogenous variables can affect each other in the current and past realization time path of $\lambda\Phi_{it}$. Nevertheless, the information in the system can be estimated and recovered by estimating a reduced-form SVAR implicit in the equations (see Ngalawa and Viegi, 2011). Pre-multiplying equation (1) by λ^{-1} gives:

$$\Phi_{it} = \lambda^{-1}\Omega_{io} + \lambda^{-1}\Psi_1\Phi_{it-1} + \lambda^{-1}\Psi_2\Phi_{it-2} + \ldots + \lambda^{-1}\Psi_p\Phi_{it-p} + \lambda^{-1}\mathrm{M}\theta_t + \lambda^{-1}\Delta\varepsilon_{it} \qquad (2)$$

For the sake of simplicity, we represent that,

$$\lambda^{-1}\Omega_{io} = C_i,\ \lambda^{-1}\Psi_1 \ldots\ldots \lambda^{-1}\Psi_p = D_i \ldots\ldots D_p,\ \lambda^{-1}\mathrm{M} = \alpha \text{ and } \lambda^{-1}\Delta\varepsilon_{it} = \mu_{it} \qquad (3)$$

We, therefore, transform equation 3 to derive equation 4:

$$\Phi_{it} = C_i + D_1\Phi_{it-1} + D_2\Phi_{it-2} + \cdots \dots \dots .. + D_p\Phi_{it-p} + \alpha\theta_t + \mu_{it} \qquad (4)$$

The difference between equations (1) and (4) is that, equation (1) is called a PSVAR or primitive system where all variables have contemporaneous effects on each other while equation (4) is called a reduced form of PSVAR or a PSVAR expressed in standard form in which all the variables that are contained in the right-hand side are predetermined at time *t* and no variable has a direct contemporaneous (immediate) effect on another in the model. Furthermore, Enders (2004) concludes that the error term (μ_{it}) is a composite of shocks in Φ_{it}.

For the sake of simplicity, equation (4) can be expressed in a short form shown in (5):

$$\Phi_{it} = C_i + \lambda(L)\Phi_{it} + G(L)\theta_t + \mu_{it} \qquad (5)$$

Where Φ_{it} and θ_t are $(n \times 1)$ vectors of variables given by

$$\Phi_{it} = (GDP, MS, EXR\ INF, INT, UNE) \qquad (5.1)$$

$$\theta_t = (op) \qquad (5.2)$$

Equation (5.1) embodies the vector of the oil-exporting countries that are treated as endogenous variables as used in the study. Equation 5.2 represents the vector of the exogenous variable. C_i is a vector of constants which represents the country intercept terms. $\lambda(L)$ and $\Delta(L)$ symbolize the matrices of polynomial lags that capture the relationship between the endogenous variables and their lag lengths. $\mu_{it} = \lambda^{-1}\Delta\varepsilon_{it}$ denotes a vector of random disturbances, which can also be expressed as $\lambda\mu_{it} = \Delta\varepsilon_{it}$.

The features of equations (4) and (5) are similar because both are reduced forms of the PSVAR technique which has been derived from the primitive PSVAR system of equation (1) where all variables are assumed to have simultaneous effects on each other and are also assumed to describe the performance of AOECs. For the information in the structural equation to be recovered, it is necessary to impose restrictions in matrices λ and Δ in the system of equations (6) and (7). Given that equation (6) equals equation (7).

$$\lambda = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ c_{21} & 1 & 0 & c_{24} & 0 & 0 & 0 \\ 0 & c_{32} & 1 & 0 & 0 & 0 & 0 \\ c_{41} & 0 & c_{43} & 1 & 0 & 0 & 0 \\ c_{51} & c_{52} & c_{53} & c_{54} & 1 & c_{56} & 0 \\ 0 & c_{62} & c_{63} & c_{64} & c_{65} & 1 & c_{67} \\ c_{71} & c_{72} & c_{73} & c_{74} & c_{75} & 0 & 1 \end{bmatrix} \begin{bmatrix} \mu_t^{OP} \\ \mu_{it}^{GDP} \\ \mu_{it}^{MS} \\ \mu_{it}^{INF} \\ \mu_{it}^{INT} \\ \mu_{it}^{UNE} \\ \mu_{it}^{EXR} \end{bmatrix} \quad (6)$$

$$\Delta = \begin{bmatrix} b_1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & b_2 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & b_3 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & b_4 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & b_5 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & b_6 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & b_7 \end{bmatrix} \begin{bmatrix} \varepsilon_t^{OP} \\ \varepsilon_{it}^{GDP} \\ \varepsilon_{it}^{MS} \\ \varepsilon_{it}^{INF} \\ \varepsilon_{it}^{INT} \\ \varepsilon_{it}^{UNE} \\ \varepsilon_{it}^{EXR} \end{bmatrix} \quad (7)$$

Equation (6) equals (7) and both present the restricted matrices. The first matrix in equation (6) represents the λ-matrix which pertains to the non-recursive restrictions in the model and the second matrix in equation (7) represents the Δ-matrix known as a diagonal matrix. The terms μ_t^{OP}, $\mu_{it}^{GDP}, \mu_{it}^{MS}, \mu_{it}^{EXR}, \mu_{it}^{INF}, \mu_{it}^{INT}$ and μ_{it}^{UNE} are residuals in reduced-form disturbances to both the endogenous (domestic) and the exogenous (foreign) variables which further symbolize the unexpected movements (shocks, given information in the system) of each variable. The associated structural shocks with the corresponding equations are denoted with the following residuals: $\varepsilon_t^{OP}, \varepsilon_{it}^{GDP}, \varepsilon_{it}^{MS}, \varepsilon_{it}^{EXR}, \varepsilon_{it}^{INF}, \varepsilon_{it}^{INT}$ and ε_{it}^{UNE}.

In the short run PSVAR, we develop identification by placing restrictions on the λ and Δ matrices, which are assumed to be non-singular, ensuring exact identification of the scheme. Nevertheless, since there are $p(p+1)/2$ free parameters in the $\sum_{\varepsilon}$, given its symmetric nature, several parameters may be estimated in matrices λ and Δ. As there are $2p^2$ parameters in matrices λ and Δ, the order condition for identification requires that $2p^2 - 0.5p(p+1)$ restrictions be jointly placed on the elements of matrices λ and Δ. For justification and procedural purposes, however, our study follows Amisano and Giannini (1997) and Kutu and Ngalawa (2016), suggesting that the PSVAR needs $2p^2 - 0.5p(p+1)$ or 70 restrictions and these restrictions must be jointly placed on matrices λ and Δ. (p is the number of the variables in the study; therefore, $p = 7$). Consequently, for the scheme to be precisely identified, since matrix Δ is assumed to be a non-singular diagonal matrix, there will be a need to impose 42 restrictions on it while 22 restrictions are expected to be imposed on matrix λ. However, since our non-recursive PSVAR has imposed 22 zero restrictions on matrix λ, the system is characterized as over identified and 20 free parameters in matrix λ and 7 in matrix Δ are presented in the system components of equations (6) and (7).

3.5.5 **Identification of Structural Shocks**

Economic theory guides the way that variables influence one another in this model, and this depends on the position that a variable assumes in the identification scheme. For instance, oil prices are internationally determined and can therefore influence the domestic variables, while shocks from domestic variables cannot influence oil prices. Furthermore, the transmission of international shocks from other variables to the domestic economy could be rapid in the sense that oil prices is an exogenous variable. Therefore, given the fact that the selected countries in this study are oil producing, such an assumption is plausible (see Berkelmans, 2005). Similarly, exchange rates could influence inflation.

Consequently, the oil price shock is captured in row 1, while rows 2 and 3 are equations respectively representing GDP and MS. Rows 4 and 5 respectively denote equations for INF and INT, while in rows 6 and 7, we have the UNE and EXER, respectively. Based on the λ matrix in equation 6, oil prices in row 1 does not respond contemporaneously to the other variables used in this study. It is independent of other variables as it places external pressure on the local economies of the selected countries. Rather, other variables may contemporaneously respond to it. Row 2 presents the GDP equation. Gross Domestic Product responds contemporaneously to oil prices shocks, MS, and INF. Their restrictions have been denoted c_{21}, c_{24}, c_{27}. This implies that GDP responds to positive shocks from oil prices. This transmission confirms Kamin and Rogers' (2000) assertion that oil production accounts for a large share of the GDP of oil-exporting countries and that oil prices directly increase the value of a country's currency. A similar trend is expected for unemployment in oil-exporting countries. It declines when more job opportunities are created from oil proceeds. This, in turn, creates and increases the income level of both individuals and the economy. Money supply responds contemporaneously to only GDP, represented as c_{32}, and captured in the MS equation in row 3. Rows 4 and 5 respectively present the exchange rate and inflation rate equations. As shown, c_{21} confirms that GDP contemporaneously responds to oil price shocks. Similarly, rows 6 and 7 contain the unemployment rate and exchange rate. Therefore, c_{61} confirms that exchange rates contemporaneously respond to oil price shocks. This result is similar to Elbourne's (2008) finding that oil price fluctuations affect output growth.

3.5.6 **Data, Sources of Data and Measurement of variables**

The study relies on quarterly time series data for the period 1980 to 2018 for the five developing AOECs. In addition to covering the recent oil price shocks, the choice of cut-off dates was informed by the availability of data which corresponds with the variables of interest. Main data sources are the central banks and statistics offices of the individual countries considered in this study, the World Bank's World Development Indicators (WDI) and the IMF. The choice of macroeconomic variables is in line with Olomola (2010), Iwayemi and Fowowe (2011), and Cavalcanti, Mohaddes and Raissi (2011). This study also draws SVAR insight from studies by Kose and Baimaganbetov (2015), Ahmed and Wadud (2011), Khan and Ahmed (2014), and Chen *et al.* (2016).

3.5.6.1 **Crude oil prices (OP)**

The oil price refers to the amount at which crude oil is sold per barrel on the international oil market. It is expressed in US dollars. For this study, the Brent Blend (also referred to as the Brent crude oil price) is used as the oil price measure because it is the largest in Africa among many major classifications of oil consisting of Brent Crude, Brent Sweet Light Crude, Oseberg Crude and Forties Crude oil (OPEC, 2016). This variable is treated as exogenous because it is externally determined. None of the oil-exporting countries is expected to influence the price of this commodity at any time. Oil-exporting countries may only regulate their production and sometimes their pump prices of oil.

3.5.6.2 **Real Gross Domestic Product (GDP)**

Gross Domestic Product is a measure of all goods and services produced at constant national prices for each country annually at a given base year for all the selected countries. Following Berkelmans (2005) and Dungey and Pagan (2000), the study includes this variable to examine the impact of shocks arising from the exogenous variable on the total output of the economy. This is done to further examine how oil price shocks stimulate the economy. In addition, the inclusion of GDP seeks to assess the validity of the view that stabilization of output and inflation can be left to monetary policy to achieve Pareto optimality (see Mishkin, 2001; Erceg, Henderson and Levin, 2000).

3.5.6.3 **Exchange Rates (EXR)**

Exchange rates measure the price of each country's currency in another country's currency. For consistency, the study uses the US dollar (USD) exchange rate as the benchmark for comparison of the currency of the domestic economies investigated. This is due to universal acceptability of dollars as well as the fact that the currency is the most traded on the foreign exchange market (Ibrahim and Amin, 2005; IMF, 2017). Moreover, the US dollar is the primary invoicing currency in international crude oil markets (see Ibrahim and Amin, 2005). Following Iwayemi and Fowowe (2011), the exchange rate is used to investigate how variations in the value of the USD affect selected variables among the oil-exporting countries in Africa. In line with Ihsan and Anjum (2013), and Kose and Baimaganbetov (2015), EXR enters the PSVAR model as an intermediate target of monetary policy. The middle exchange nominal exchange rates of the various oil-exporting countries vis-a-vis the USD are employed as a proxy for EXR. The exchange rates data is available in annual frequency. This calls for data interpolation. This approach follows several studies that have used interpolated monthly and quarterly data series in VARs and SVARs (see Chen and Chen 2007; Borys, Horváth and Franta 2009). For example, Borys *et al.* (2009) used the quadratic match average procedure to interpolate data series from high frequency to lower frequency in the Czech Republic. This study follows the Friedman time series interpolation approach to compute the required quarterly EXR series from the annual data time series. Similarly, the idea of interpolating low-frequency data to high frequency is an acceptable standard and technique in the literature (Ngalawa and Viegi, 2011; Chen and Chen, 2007; Borys *et al.,* 2009; Davoodi *et al*., 2013).

3.5.6.4 **Inflation Rate (INF)**

Inflation refers to a general increase in prices and a fall in the purchasing value of money. It is key in monetary policy responding to oil price shocks. Hence, it enters the PSVAR as a monetary policy goal. Inflation also serves as a control variable with a link with monetary policy decisions, especially as regards interest rates through which economic stability is attained.

3.5.6.5 **Money Supply (MS)**

Money supply, also referred to as money stock, includes safe assets such as cash, coins, and balances held in savings and checking accounts that individuals and businesses can use to make payments and/or hold as short-term investments. This study employs M2, which is the amount of currency in circulation and other liquid instruments, savings, checking deposits and time deposits in each country. For clarity, M2 is a calculation of MS that includes all the elements of M1 as well as "near money." M1 includes cash and checking deposits, while near money refers to savings deposits, money market securities, mutual funds, and other time deposits (see Ihsan and Anjum, 2013). In this study, M2 enables the determination and assessment of the process through which the monetary authorities employ the operating tools of monetary policy to achieve their targets (see Kutu and Ngalawa, 2016). Therefore, this variable is chosen as it serves as an intermediate target of monetary policy in response to oil price shocks.

3.5.6.6 **Interest Rate (INT)**

The interest rate is the average monthly real Repo rate set by the central bank of an individual country as a monetary policy indicator. It is used as the benchmark at which a country's central bank provides short term credit to discount houses and commercial banks in its function as a lender of last resort (see Bernanke *et al.,* 2004; Agung, 1998; Iturriaga, 2000; Disyatat and Vongsinsirikul, 2003). The choice of interest rates in this study is to allow an assessment of the procedure through which the interest rate is used as a monetary tool to counter inflation. It is also used to manage the movement of intermediate targets of monetary policy. According to Agung (1998) and Bernanke *et al.* (2004), during periods of rising inflation, central banks increase the repo rate. This hinders banks from borrowing from the central bank and consequently leads to a fall in MS and inflation is tackled.

3.5.6.7 **Unemployment Rate**

An unemployed person refers to someone who is currently not working but willing and able to work for pay, currently available to work and has actively searched for work but could not find a job (ILO, 2016). The unemployment rate is therefore, the proportion of the workforce that is not gainfully engaged in any job. It is introduced in this study to measure how oil price shocks transmit to GDP. Unemployment is introduced as a variable enhancing the GDP of a nation (Al-Habees and Rumman, 2012).

Apart from inflation, and interest and unemployment rates, all variables are expressed in their natural logarithms. In addition, the variables are seasonally adjusted, applying Time Series Regression Moving Average (TRAMO) with Autoregressive Moving Average (ARIMA) Noise, Missing Observations, and Outliers, and Signal Extraction in ARIMA Time Series (SEATS) with a forecast horizon of three months. The former estimates, forecasts, and interpolates regression models with missing observations and ARIMA errors in the occurrence of perhaps several types of outliers, while the latter performs an ARIMA-based decomposition of an observed time series into unobserved components. Seasonal adjustment eliminates cyclical seasonal movements common in time series, noticed at the quarterly and monthly occurrence. The underlying trend element of the series is, however, retained after the data has been seasonally adjusted.

Table 3.1: **Data Summary**

	LGDP	**INT**	**LEXR**	**INF**	**LMS**	**LOP**	**UNE**
Mean	2.225822	13.56230	2.684439	3.661234	10.05901	3.498246	14.57996
Median	2.247691	12.75341	3.063842	4.035510	10.02047	3.358552	14.29234
Maximum	25.86516	18.35499	3.778236	5.224590	10.93128	4.762899	17.42875
Minimum	12.09772	11.38486	1.051896	1.811068	9.480946	2.515241	10.17734
Std. Dev.	5.111274	1.865396	0.900002	0.937251	0.435367	0.665938	1.557821
Skewness	1.616538	0.756578	-0.547551	-0.445928	0.673838	0.543138	-0.098098
Kurtosis	10.41255	2.429929	1.690127	1.887111	2.217869	2.016979	2.831892
Jarque-Bera	392.3921	15.68772	17.49008	12.20358	14.56775	12.87796	0.400520
Probability	0.000000	0.000392	0.000159	0.002239	0.000687	0.001598	0.018518
Sum	320.5184	1952.972	386.5593	527.2177	1448.498	503.7474	2099.514
Sum Sq. Dev.	3735.893	497.5973	115.8305	125.6168	27.10486	63.41663	347.0334

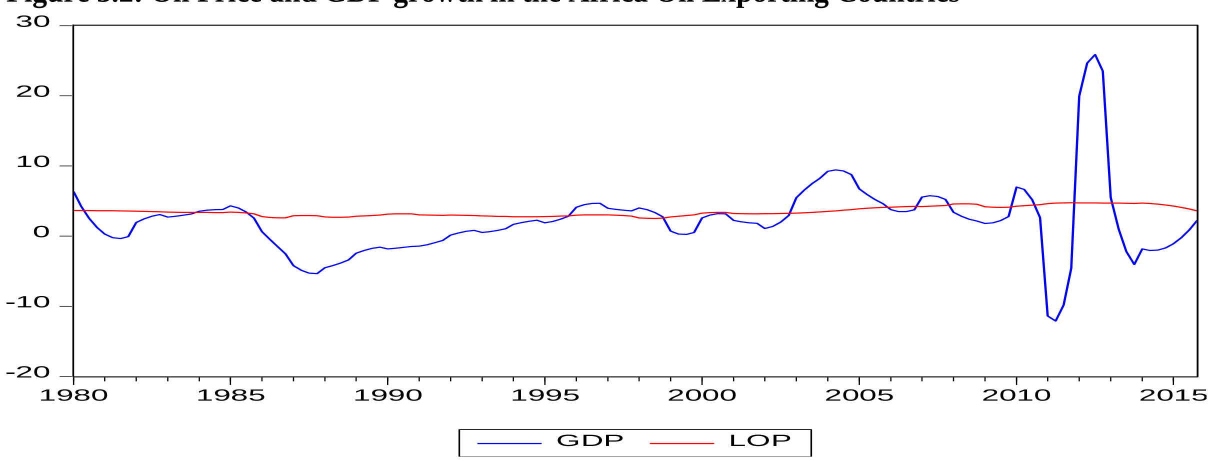
***Source**: Author's Computation (2020), using data sourced from the WDI.*

Table 3.1 presents summary statistics of the data series used in the study for the period under consideration. Gross Domestic Product, interest, and unemployment are expressed in rates while the other variables appear in their log forms, showing their elasticities.

The mean is the average value of the data series. The study focuses on oil prices and output as variables of interest, as it seeks to determine whether or not the oil price has a significant impact on output. The minimum value for GDP is 12.1 and the maximum is 25.9. The average value of GDP is 2.2, indicating that the mean falls at the lower side of the distribution. This suggests that the bulk of the data on the values of GDP for the selected countries has a high concentration at the lower end. Relatively, the 2.2 average suggests that GDP for these countries may be considered low. It further suggests that the various positive oil price shocks experienced during the period under review may not have significantly impacted output growth positively. In comparison, the average value of the oil price is expressed as $3.49. The maximum oil price is $4.8 and the minimum is $2.5, with a middle value of $3.35. This indicates that the mean oil price lies at the upper side of the distribution. Nevertheless, it is not significantly far from the lower value, suggesting a moderate oil price over time.

As shown in Table 3.1, the standard deviation of GDP is 5.11 and that of the oil price is 0.66. This suggests that the series representing GDP growth has more dispersed distribution than the oil price data series over time. That is, the GDP series for the oil-exporting countries appears to have a larger variance than the data on oil prices. By implication, this suggests that the pattern of GDP growth in these countries may not have been stable during the period investigated.

Figure 3.2: Oil Price and GDP growth in the Africa Oil Exporting Countries



***Source**: Author's Computation (2020), using data sourced from the WDI.*

Figure 3.2 describes the movement of oil prices and GDP growth. The depicted movement corroborates the descriptive statistic results and claims in table 3.1 that, the GDP growth rate is more dispersed than oil prices. The pattern of GDP growth shows more variations through the rippling line graph than the oil price, which nears a straight-line graph across the board. The oil price line graph trails a non-negative path, fairly above the origin for the countries, while the GDP growth rate is undulating and unstable, though revolving around the origin. Gross Domestic Products declines continuously from 1985 through to some point in 1987 and begins to increase up until 1997. Between 2008 and 2014, movement in GDP is highly undulating, further confirming its instability. In view of these patterns for the selected countries which constitute more than 80 percent of the AOECs, it could, therefore, be concluded and generalized that GDP growth for the other AOECs that could not be captured in this panel study could have been unstable.

Table 3.2: Panel Correlation Matrix

Variable	LGDP	LOP	UNE	LMS	INF	LEXR	INT
LGDP	1.000000						
LOP	0.240742	1.000000					
UNE	0.203425	-0.268216	1.000000				
LMS	0.055507	0.815679	-0.425482	1.000000			
INF	0.234718	0.533140	0.156334	0.338202	1.000000		
LEXR	0.264903	0.785239	0.242369	0.221467	0.986089	1.000000	
INT	-0.148748	-0.696967	0.024447	-0.732503	-0.097087	-0.060816	1.000000

***Source**: Author's Computation (2020), using data sourced from the WDI.*

Table 3.2 presents the covariance and correlation of the variables employed in the panel estimating technique. As shown in the table, the variables exhibit various forms of relationship with one another. While some variables are positively correlated, some have a negative relationship. Nevertheless, the study pays special attention to the correlation between oil prices and output growth, as the main variables. The correlation between GDP growth and oil price is 0.24074. The result is positive, suggesting an increase in output whenever the oil price rises. At the same time, the magnitude of the correlation is low, suggesting a weak relationship between oil prices and GDP growth.

The table shows that MS has a high correlation with the oil price. This supports the claim that a positive oil price increases the money stock of oil-exporting countries. Similarly, the oil price correlates highly with inflation, validating claims that positive oil price shocks might trigger inflation in the economies of AOECs since they heavily rely on the importation of refined oil to meet local consumption due to their low refinery capacity. Given the correlation between oil prices and exchange rates, the result reveals that oil prices correlate significantly with exchange rates. This validates claims that the exchange rates of the oil-exporting countries appreciate whenever positive oil price shocks occur because more of their local currency will be required to purchase crude oil (see Allegret, Couharde, Coulibaly and Mignon, 2014). It also supports the claim that the exchange rate is a transmission medium through which positive oil price shocks impact the economies of oil-exporting countries. Contrary to the correlation of oil prices with money supply, inflation, and exchange rates, the oil price has a negative correlation with unemployment and interest rates. This suggests that positive oil price shocks could lead to an increase in money stocks and consequently a fall in lending rates. This may, in turn, enhance opportunities for investments that could reduce unemployment and enhance output.

3.6 Estimation and Empirical Results

This study investigates the causal relationship expected between oil prices, output and exchange rates. In particular, distinct transmission from oil prices to output and exchange rates is expected. Therefore, the PSVAR model attempts to establish the relationship between oil price, output, exchange rates and other macroeconomic variables considered in this study. In addition, multiple relationships/causalities are expected among the variables.

The need to mitigate against the consequences of oil price shocks on the macroeconomy of oil-exporting countries is emphasized in the literature (see Ahmed and Wadud, 2011; Cunado and De Gracia, 2005). However, the consequences for the regional bloc of oil-exporting countries have not been the focus of research. Therefore, this study employs the PSVAR technique to establish this relationship.

3.6.1 Lag Length Selection

Optimal lag selection involves choosing the appropriate lag for a model. The lag with the least Akaike Information Criterion (AIC) is the most preferred. The lower the Akaike value, the better the reliability of the model. The lag length selection process is vital in the autoregressive technique. Asghar and Abid (2007) observe that the determination of the lag length of an autoregressive technique is one of the most problematic parts of ARIMA modeling. However, following empirical studies and theory, lag length determination has been found to be appropriate, as it allows for no serial correlation in the residuals (Elbourne, 2008; Ngalawa and Viegi, 2011). Lag length selection is also important because it helps in eliminating residual autocorrelation in VAR models. The estimation of the lag length of an autoregressive process for a time series is a vital econometric exercise in many economic studies. As noted by Canova and Ciccarelli (2012), lag selection is a crucial component of the VAR technique. Inappropriate selection of lag length could result in various econometric errors. For instance, Canova and Ciccarelli (2012) note that over-specification of lags may lead to error in forecast, multicollinearity, serial correlation in the error terms, waste of degrees of freedom and misspecifications errors. Under-specification, on the other hand, could leave out useful information which would render the equations potentially misspecified, with the possibility of causing autocorrelation in the residuals of a model (see Stock and Watson, 2007). Consequently, Canova and Ciccarelli (2012) conclude that this issue is an empirical matter and that there is no hard and fast rule on the choice of lag length selection. Nonetheless, various lag length selection criteria have been suggested, namely, Akaike Information Criterion (AIC), Sequential Modified LR test, Corrected version of AIC (CVAIC), Hannan-Quinn Information Criterion (HQIC), Schwarz Information Criterion (SIC), Final Prediction Error (FPE) and Schwarz's Bayesian Information Criterion (SBIC) (see Gospodinov and Ng, 2013; Filardo and Lombardi, 2014; Gachara, 2015; Gerni, Kabadayi, Yurttancikmaz and Emsen, 2013).

Gachara (2015) and Gerni *et al.* (2013) suggest that for annual data, the number of lags should typically be small, ranging from 1 to 2 periods, and 1-8 lag lengths for quarterly data. Therefore, considering the quarterly data series employed in this study, the study tests for the optimal lag length by means of various lag length selection criteria found in the literature (see Asghar and Abid, 2007; Stock and Watson, 2007; Canova and Ciccarelli, 2012; Asghar and Abid, 2007; Filardo and Lombardi, 2014; Gachara, 2015; Gerni *et al.*, 2013; Elbourne, 2008; Sharifi-Renani, 2010). The Sequential Modified LR tests statistic (LR), suggests an optimal 6-lag length; the FPE suggests 6-lag length; the AIC suggests 6-lag length; the SIC suggests 3-lag length; and the HQIC suggests 6-lag length for the PSVAR model. The study adopts 6-lag length as suitable for the PSVAR model, being the lag length that is supported by the majority of the criteria (that is, the LR, FPE, AIC, and HQIC). In addition, the procedures offer more robust and reliable dynamics without having to drastically shorten the estimation sample that may concede the degrees of confidence. The results also show that all the criteria are efficient (see appendix A-0).1

3.6.2 Granger Causality Test

The concept of Granger causality is an econometric term of causation based on the forecast. Following Engle and Granger (1987), if a given variable X "Granger causes" another variable Y, it means that the previous value of X may contain certain information that supports the prediction of Y beyond and outside the information contained in previous values of X alone. In other words, a Granger causality test refers to a formal procedure used to assess whether one variable has a possibility or tendency to influence another variable (see Gospodinov and Ng, 2013; Gerni *et al.*, 2013). For instance, variable X is said to Granger cause variable Y if variable X is useful in forecasting variable Y. This implies that X Granger causes Y if the historical values of X are sufficient to increase the correctness of the forecast of the present Y. However, a relationship between variables may not necessarily prove that there is causality or a direction of influence, unlike as found in regressions involving time series data. As noted by one author, the situation may be somewhat different[12].

The Granger causality technique has been noted to be philosophical with all kinds of debates (see Gujarati, 2004). At one extreme are those who believe that "everything causes everything," while at the other are people who refute the existence of causation altogether. While Leamer (1985) prefers the term precedence to causality, Diebold and Li (2006) prefer predictive causality (see Gujarati, 2004).

The Granger causality test is sensitive to the number of lagged terms used in a model and it relies on the F-test to understand and determine whether lagged information, for instance, variable X, provides statistically significant information about variable Y, as seen in equation 10 below, or whether lagged information on variable Y provides statistically significant information about variable X, as shown in equation 11 below:

$$X_t = \beta_0 + \beta_1 X_{t-1} + \cdots + \beta_q X_{t-q} + \alpha_1 Y_{t-1} + \alpha_q Y_{t-q} + v_{X_t} \quad (8)$$

$$Y_t = \beta_0 + \beta_1 Y_{t-1} + \ldots + \beta_q Y_{t-q} + \alpha_1 X_{t-1} + \alpha_q X_{t-q} + v_{Y_t} \quad (9)$$

We present the hypotheses for the study below:

$H_0: if\ all\ \beta_i = 0$ => Granger causality does not exist between variables

$H_1: if\ all\ \beta_i \neq 0$ => Granger causality exists between variables

Where H_0 represents the null hypothesis and H_1 denotes the alternate hypothesis.

3.6.3 Diagnostic Tests

The study presents different diagnostic tests to examine the robustness of the PSVAR model employed. These tests are considered relevant based on previous studies (see Glynn, Perera and Verma, 2007; Canova and Ciccarelli, 2014). They include serial correlation, normality, and heteroskedasticity tests. Following Glynn, Perera and Verma (2007) and Canova and Ciccarelli (2012), the benchmark null (H_0) testing for the heteroscedasticity, normality and serial correlation are:

$H_0: \alpha = 1$, there is no heteroscedasticity; no serial correlation and the residuals are distributed normally.

[12] Time does not run backward. That is, if event A happens before event B, then it is possible that A is causing B but, it is not possible that B can cause A. Events in the past can cause events to happen today and in the future, but future events cannot cause previous events (see Gujarati, 2004).

$H_1: \alpha \neq 1$, there is heteroscedasticity; serial correlation, and non-normality of residuals.

The details of the serial correlation test are presented in appendix A-1. Similarly, appendix A-2 presents the result of the heteroscedasticity test and the normality tests results are presented in Table 3.3. Appendix A-1 reveals that there is no serial correlation or similarity among the observations in the model.

For the serial correlation test, various approaches are suggested to check for the existence of serial correlation in a model. One of these is the Durbin Watson (DW) statistic which does not apply the multi-lagged model. To avoid the issue posed by this limitation, this study uses the LM technique suggested in Gujarati (2003) to overcome this weakness of the Durbin Watson statistic.

As shown in appendix A-1, there is no serial correlation in the model. Similarly, the probability value of the results of the heteroscedasticity test for the model reveals that the model is free from heteroscedasticity. This validation corroborates the optimal lag selection process employed in this study, showing that, if the model had been misspecified, it would have resulted in a serial correlation problem. It also shows that there is no cross-sectional dependence. The possibility holds that the PSVAR may largely account for cross-sectional interdependence across various panels or economic units as it was originally built to identify and account for transmissions and effects of one unit on another as global interdependence became apparent with globalization (Canova and Ciccarelli, 2012).

Table 3.3: Normality Test

Comp	Skewness	Chi-sq	Df	Prob.	Kurtosis	Chi-sq	Df	Prob.	Jarque-Bera	Df	Prob.
1	2.0567	100.11	1	0.000	35.252	6154.7	1	0.000	6254.8	2	0.000
2	-0.5336	6.7394	1	0.009	12.837	572.60	1	0.000	579.34	2	0.000
3	0.3089	12.258	1	0.001	9.6526	261.86	1	0.000	264.12	2	0.000
4	-0.0692	10.136	1	0.003	6.4348	69.806	1	0.000	69.919	2	0.000
5	-0.8141	15.688	1	0.000	8.6144	186.50	1	0.000	202.19	2	0.000
6	0.1806	0.7723	1	0.049	8.5835	184.45	1	0.000	185.23	2	0.000
Joint		125.68	6	0.0		7430.0	6	0.000	7555.7	12	0.000

***Source**: Author's Computation (2020), using data sourced from the WDI.*

To show that the variables are normally distributed as illustrated in table 3.3, the study tests for multivariate relationships among the variables using Cholesky of covariance (Lutkepohl) techniques based on the three recognized tests in the literature (see Bouoiyour and Selmi, 2015; Oladosu, 2009). These tests are the skewness, kurtosis and Jarque-Bera tests. The results show that the variables contained in the model are statistically and jointly significant. This claim is evidenced by the 5 percent level of significance. Consequently, the results validate that the distribution and residuals of the model for the AOECs are distributed normally.

3.6.4 Impulse Response Functions Analyses

This section presents the detailed impulse response function analyses. This procedure follows the maiden impulse response function analysis introduced to VAR modeling by Sims (1980). Sims' (1980) seminal paper and Sharifi-Renani (2010) argue that dynamic analysis of the VAR model is regularly carried out by means of the 'orthogonalized' impulse responses, where the underlying shocks to the VAR model are orthogonalized by means of the Cholesky decomposition before the impulse responses or forecast error variance decompositions are computed. However, the impulse response function process highlights the state of the economic system in the future, in the event of any change in any of the model's components. The impulse response definition and procedure answers the question of how the future of a system is affected by variation in one of its variables. It also illustrates the extent to which these variables react to one another as changes occur in the future, given the assumptions that innovation returns to zero in the following periods and that all other innovations equal zero (see Amisano and Giannini, 1997; Sim *et al.,* 1990). Following Sharifi-Renani (2010), the impulse responses constitute the orthogonalized standard deviations of estimated residuals of the models. Hence, the impulse responses are constructed for all the variables considered in the model, allowing us to recognize how the economy reacts to oil price shocks (see Bernanke *et al*., 2004).

In view of this background and to achieve appropriate analysis, the impulse response functions (IRFs) analyses are divided into nine horizon periodic bases on the Y-axis and twenty-four horizon periods on the X-axis as shown in figures 3.3 and 3.4 to highlight the response of the economy to oil price shocks, identify the transmission mechanism of occurrence and arrive at a more suitable analysis of the IRFs. To this end, since the stability of the VAR framework has been achieved, we examine the economic system impulse response of the AOECs to oil price shocks via GDP growth, money supply, exchange rates, inflation rate, interest rates, and unemployment. In the impulse response graphs, the X-axis represents the periods that the analysis covers, which are expressed on a quarterly basis. Generally, the results show that the macroeconomic variables considered in this study are statistically significant. This validates Eltony and Al-Awadi's (2001) findings in Kuwait that oil price shocks are significant in explaining fluctuations in the macroeconomic variables of oil-exporting countries. The economies considered in this study rely heavily on oil. Oil drives their economies, and it largely influences other economic indicators. Furthermore, many of the other macroeconomic variables are endogenously determined unlike oil, which is exogenously determined

3.6.4.1 Impulse Responses of Selected Macroeconomic Variables to Oil price shocks

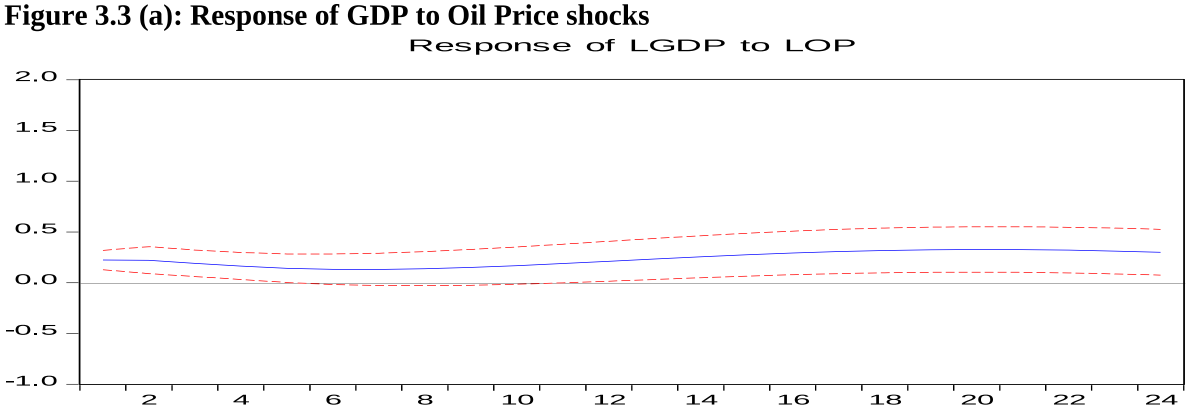
One of the aims of this research is to analyze how oil price shocks impact macroeconomic variables in the AOECs and explain the transmission mechanism of oil price shocks in oil-exporting economies.

This entails analyzing how oil price shocks spread to other prices, resulting in overall variation in the price level within the economy. In doing this, we plot the IRFs of variables which include GDP, INF, INT, MS, EXR and UNE as shown in figure 3.3 to show the one standard deviation structural response of these macroeconomic variables. These impulse responses also show how oil price shocks affect the economy of the AOECs.

3.6.4.2 Impulse Response of GDP to Oil Price shocks

As noted earlier, one of the study's objectives is to investigate whether or not oil price shocks affect the economy, specifically, whether or not such shocks significantly impact output. This is demonstrated in figure 3.3a. The result shows that GDP positively and significantly responds to one structural standard deviation innovation in oil price shocks. Contrary to our expectation, output initially declines, and this continues until period five before it begins to rise until at least period twenty. The initial fall in output could be associated with the lag element introduced to output growth, suggesting that the lagged variable may result in a sluggish response to fluctuations evolving from its explanatory variables. Greene (2003) observes that such economic adjustment costs result from the economy's inability to respond quickly; they are temporary and are believed to dissipate over a time frame of three to five years. Nevertheless, after period five, output begins to increase, and this extends into period twenty-four. This indicates that positive variation in oil prices leads to positive change in output, as evidenced by the output response in the oil-exporting countries. It corroborates the outcome in Table 3.2 that an oil price shock positively correlates with output.

Figure 3.3 (a): Response of GDP to Oil Price shocks



Source*: Author's Computation (2020)*, *using data sourced from the WDI.*

This result validates Kamin and Rogers' (2000) finding that oil transmits to GDP. In addition, their study reveals that oil production frequently accounts for a large share of oil-exporting countries' GDP. They also show that, when the oil price rises, output increases. This aligns with previous studies that concluded that increases in oil prices result in a rise in economic activity and vice versa. For instance, Salai-I-Martins and Subramanian (2003), Smith (2004), and Karl, Kaldor and Said (2007) find that oil price shocks have a positive impact on economic growth. Majid (2008) also concluded that, the higher the increase in oil prices and the longer the prices are sustained, the larger the impact on the macroeconomy. Eltony and Al-Awadi (2001) examined the impact of oil price shocks on Kuwait's economy and found that oil price shocks are significant in explaining fluctuations in macroeconomic variables in an oil-exporting economy. The current study's findings also support Iwayemi and Fowowe's (2011) assertion that positive oil price shocks have a positive impact on output. Similar results were obtained by Ward, Bert and Hermanto (2000) who examined the relationship between oil price shocks and GDP in the Indonesian economy, Boye (2001) on the Ecuador economy, Farzanegan and Markwadt (2009) on the Iranian economy and Berument *et al.* (2010) on oil-exporting countries. These studies conclude that the effects of oil price shocks on output are significant and positive. In addition, this result corroborates the assertion that the effects of international oil prices on GDP are positive and significant in most oil-exporting countries like Iraq, Iran, Algeria, Kuwait Jordan, Syria, Qatar, and UAE. Similarly, our result aligns with Stern and Cleveland (2004) who assert that there is a strong correlation between oil prices and oil-exporting countries' economic growth. As shown in figure 3.3a, this result is associated with the first channel of oil price transmission where increases in oil prices cause an immediate transfer of wealth from oil importers to oil exporters.

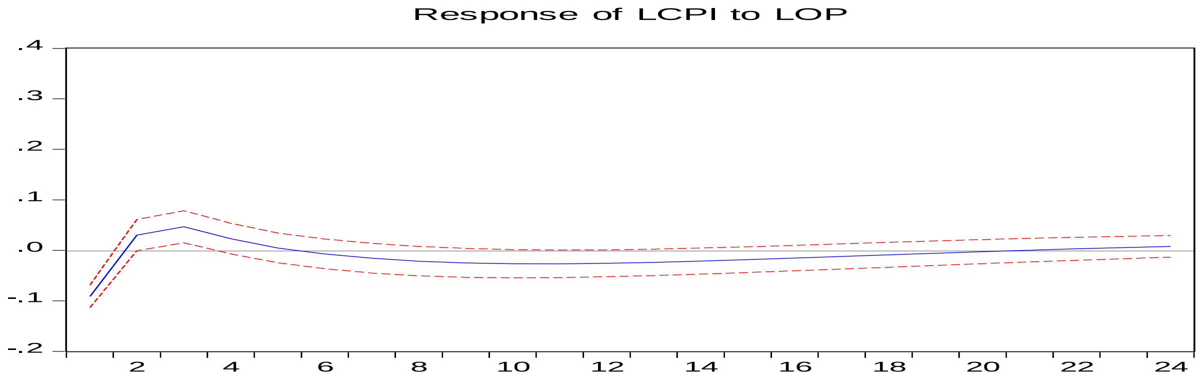
In addition, it aligns with the income effect channel of transmission where total revenue from oil rises as the value and volume of oil production rise. In the medium to long term, these effects may depend on what the government of an oil-producing country does with the extra income. For instance, if the proceeds realized from oil are used for current production in the real sector, increased oil prices will generate an additional level of economic activity in the domestic economy. This will reduce unemployment as it will, in turn, increase overall national wealth and demand in the oil-exporting economy.

Overall, GDP's positive significant response to oil price shocks suggests that oil prices play a central role in explaining fluctuations in output in the short run. This supports the general claim that, for net oil-exporting countries, a rise in oil prices may affect economic activity by directly increasing real national income through higher earnings from exports.

3.6.4.3 **Impulse response function of inflation to oil price shocks**

With regard to the impulse response of inflation proxied by a consumer price index, the results show that inflation does not significantly respond to one structural standard deviation innovation in oil prices. Inflation rises in the first and second periods in response to the innovation in oil prices and attains its peak in the third period. It later declines, bottoming in period ten (see figure 3.3b). The initial increase may be associated with the rational expectations hypothesis[13]. Similarly, the slight response leading to an increase in inflation within the first three periods could be due to an increase in oil prices causing an increase in the quantity of money within the economy. Such increases could be used to facilitate a greater level of economic activity via investment in other sectors.

Figure 3.3 (b): Response of Inflation to Oil Price shocks



Source*: Author's Computation (2020), using data sourced from the WDI.*

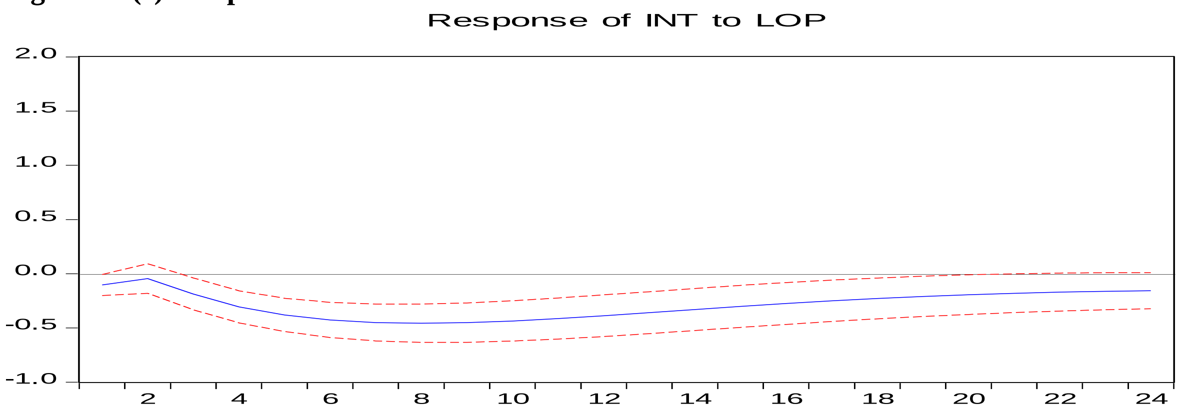
On the other hand, an increase in inflation following one structural standard deviation innovation in oil price shocks may be associated with oil-exporting companies' weak refinery capacity. These countries rely on the importation of refined oil to meet domestic demand for fuel. Therefore, a rise in the price of crude will lead directly to a rise in the cost of importing refined oil. This validates Haldane's (1997) finding that responses to a structural one standard deviation innovation may often lead to price increases in oil-exporting countries. It also seemingly agrees with the assertions of studies on developed oil-importing countries that positive oil price shocks lead to inflation, increased production input costs, lower investment, and reduced non-oil demand. This position holds as non-oil sectors are neglected during positive oil price shocks. Furthermore, this may cause tax revenue to fall and the budget deficit to increase due to rigidities in government expenditure, which drive interest rates up. The result also validates Akpan (2009) who uses the VAR estimating technique to analyze the dynamic relationship between oil price shocks and major macroeconomic variables in Nigeria. The study posits that positive oil price shocks significantly increase inflation and directly increase real national income through higher export earnings.

[13] The rational expectations hypothesis states that individuals base their decisions on three major factors: their past experiences, the information available to them, and human rationality.

3.6.4.4 **Impulse response function of interest rate to oil price shocks**

In terms of the response of interest rates to one structural standard deviation innovation in oil price shocks, figure 3.3c reveals that interest rates significantly respond to oil price shocks over time. The response of interest rates to a structural one standard deviation innovation is negative. Interest rates decline from period two, bottoming in period eight, and begin to rise continuously up until at least period twenty-four. This supports Hooker's (1996) conclusion that a long-run cointegrating relationship exists between oil prices and interest rates. The fall in the interest rate therefore, supports the claim that positive oil price shocks lead to an increase in the volume of money supply, hence, putting downward pressure on the interest rate.

Figure 3.3(c): Response of Interest to Oil Price shocks



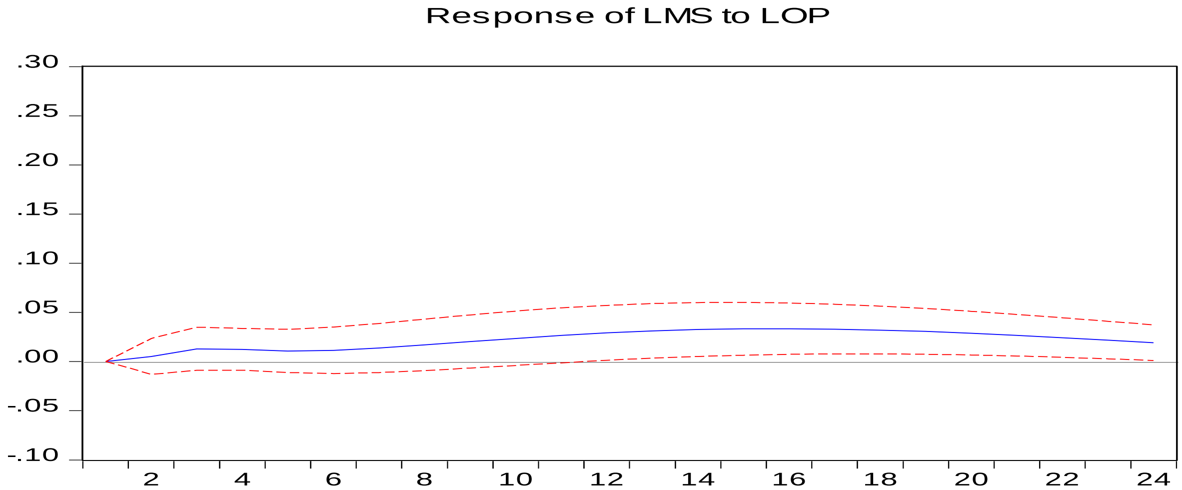
Source: *Author's Computation (2020), using data sourced from the WDI.*

An increase in the volume of money may also cause a further drop in the interest rate at which banks lend. In addition, the study asserts that, as proceeds from oil continue to increase as a result of positive oil price shocks, causing an increase in the volume of money, the interest rate drops further. Our result supports Ushie *et al.*'s (2002) assertion that, in terms of the interest rate structure, the transmission mechanism of oil price shocks occurs through the systematic response to monetary policy.

3.6.4.5 **Impulse response function of money supply to oil price shocks**

Like the response of GDP to oil price shocks, MS positively responds to one structural standard deviation innovation in oil price shocks. Although it was not significant within the first ten periods, it becomes significant after that up until period twenty-four (see figure 3.3d).

Figure 3.3(d): Response of Money Supply to Oil Prices Shocks



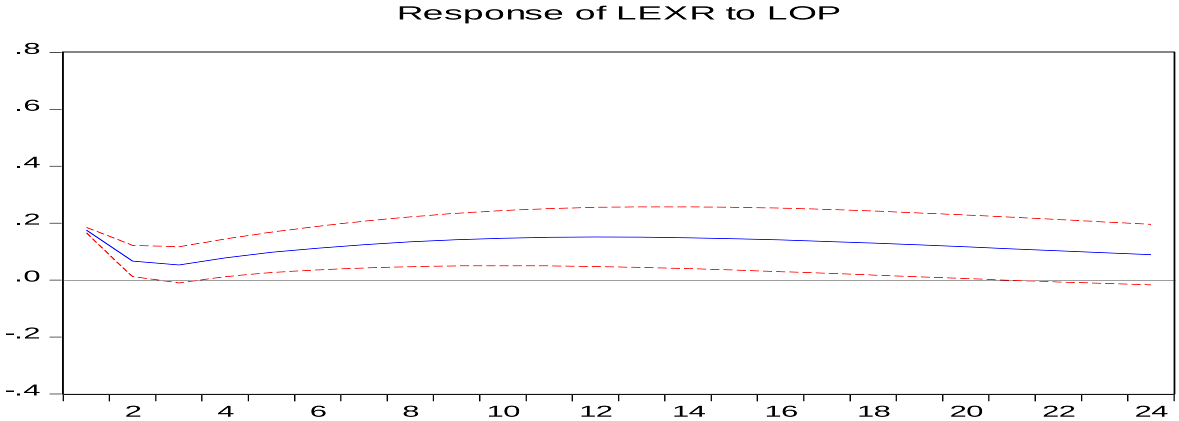
Source*: Author's Computation (2020)*, *using data sourced from the WDI*.

The MS gradually and continuously rises to a peak in period fifteen. This suggests that positive shocks in oil prices cause an increase in the quantity of money in oil-exporting countries. The result validates that of Olomola and Adejumo's (2006) study that examines the effects of oil price shocks on real exchange rates, output, money supply, and inflation in Nigeria and finds that that oil price shocks significantly affect the economy in the short and long run. The findings of Olomola and Adejumo (2006) suggest that if oil price shocks are positive and persist, the proceeds arising from oil price increases will lead to increase in the quantity of money in circulation and consequently a fall in interest rates.

3.6.4.6 **Impulse response function of exchange rates to oil price shocks**

Figure 3.3(e) shows that exchange rates significantly positively respond to oil price shocks. Exchange rates slightly decrease and bottom within the first two periods. The trend begins to rise as it goes towards the third period and the upward trend continues until it peaks in period ten. It stabilizes until at least period fourteen before it begins to gradually decline and this continues until period twenty-four.

Figure 3.3(e): Response of Exchange Rates to oil Prices Shocks



***Source**: Author's Computation (2020), using data sourced from the WDI.*

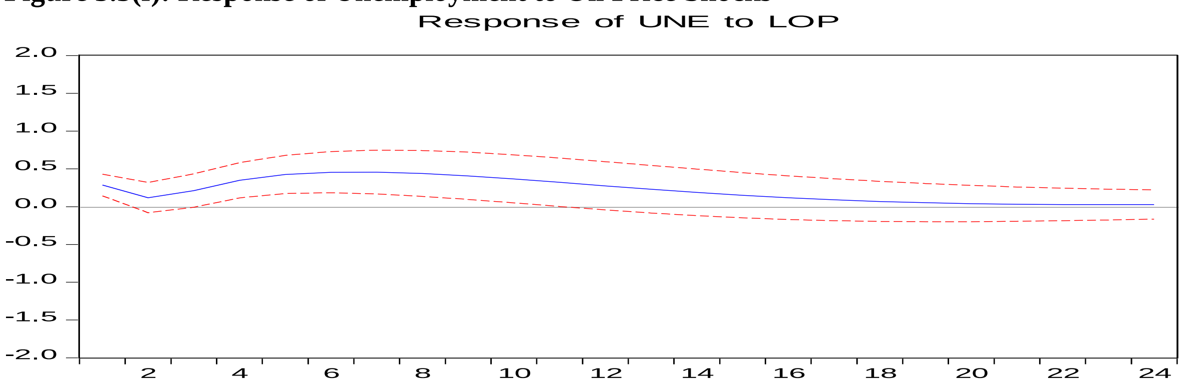
The decline could be associated with the manifestation of the Dutch Disease syndrome, causing a decrease in the contributions of other sectors to strengthen the local currency. The rise in the impulse response of exchange rates suggests that the value of oil-producing economies' local currency appreciates and becomes stronger when positive oil price shocks occur. During a period of positive oil price shocks, the highest internationally traded currency, the USD exchanges more for the local currencies of these countries to trade in their crude oil. Hence, a large volume of oil exchanges for more foreign currency will strengthen the value of local currencies in these countries and if this is sustained, they may compete favourably with other currencies of the world. This claim holds because positive oil price shocks depreciate the currency of an oil-importing economy as the supply of its domestic currency in the foreign exchange market rises. Supporting this assertion, Jimenez-Rodriguez and Sanchez (2005) observe that the appreciation of exchange rates in Norway was much less severe than in the UK, thereby pointing to less of a dampening effect on the Norwegian economy. Golub (1983), Corden (1984), and Akram (2004) also recognize the theoretical argument that oil-exporting countries may experience exchange rate appreciation (depreciation) when the oil price rises (falls). This discussion confirms and brings to the fore the standard theory of exchange rate determination which suggests that an increase in the oil price causes the value of an oil-exporting country's currency to appreciate. As demand for its currency increases in the foreign exchange market, the value of the currency appreciates.

In the foregoing discussion, the overall response of exchange rates to a structural one standard innovation in oil price shocks is significant. The positive response of exchange rates to oil price shocks suggests that positive oil price shocks positively correlate with exchange rates. This further validates the claim that oil price shocks' transmission significantly occurs through the exchange rates of the AOECs to other prices in the economy.

3.6.4.7 **Impulse response function of the unemployment rate to oil price shocks**

Figure 3.3(f) presents the response of unemployment to oil price shocks. Similar to the responses of other variables, unemployment responds significantly to a structural one standard deviation innovation in oil price shocks. The unemployment rate declines slightly in period one and later rises and peaks at period seven. After this, it starts declining and becomes insignificant after period twelve up until period twenty-four. The downward trend in the unemployment rate may not be unconnected with factors like direct consumption of oil revenue rather than it being reinvested in job creating ventures for the economy. It may also be due to a high level of corruption, especially among the AOECs where several cases of corrupt practices have been oil related. Another possible reason is the leadership problem among African leaders whose main interest may not be to reduce unemployment, but self-enrichment.

Figure 3.3(f): Response of Unemployment to Oil Price Shocks



***Source**: Author's Computation (2020)¸ using data sourced from the WDI.*

The movement in period twelve supports Hooker's (1996) finding that there is a long-run cointegrating relationship between oil prices and unemployment. As revealed in Lescaroux and Mignon (2008), a decline in unemployment is expected for oil-exporting countries, indicating that, positive oil price shocks would boost employment in the economies of these countries. This implies that declines in unemployment occur when more job opportunities are created from oil proceeds, increasing the income level of both individuals and the economy.

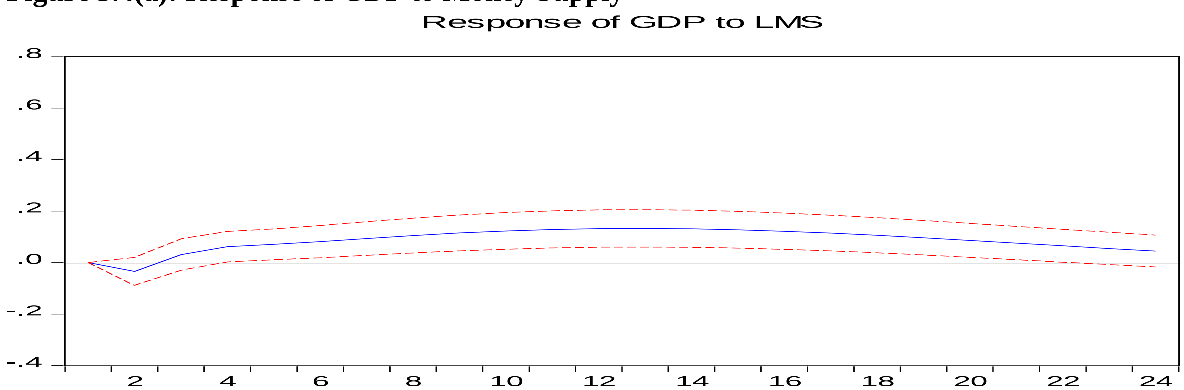
3.6.4.8 **Impulse response function of GDP to monetary policy variables**

It was noted in sections 3.6.4.3 and 3.6.4.4 that oil price shocks affect monetary variables' behavior. This section examines the response of output to a structural one standard deviation innovation in monetary variables. It examines and establishes the impulse response of oil price among monetary variables. The monetary variables considered are money supply, inflation rate, interest rates, and exchange rates. Figures 3.4(a), 3.4(b), 3.4(c) and 3.4(d) depict the responses of money supply, inflation, interest rates and exchange rates to GDP, respectively.

3.6.4.8.1 ***Impulse response function of GDP to Money supply***

Figure 3.4(a) shows that GDP positively responds to money supply. It insignificantly responds to money supply in the first two periods, but as it advances into the fourth period, it begins to respond significantly.

Figure 3.4(a): Response of GDP to Money Supply



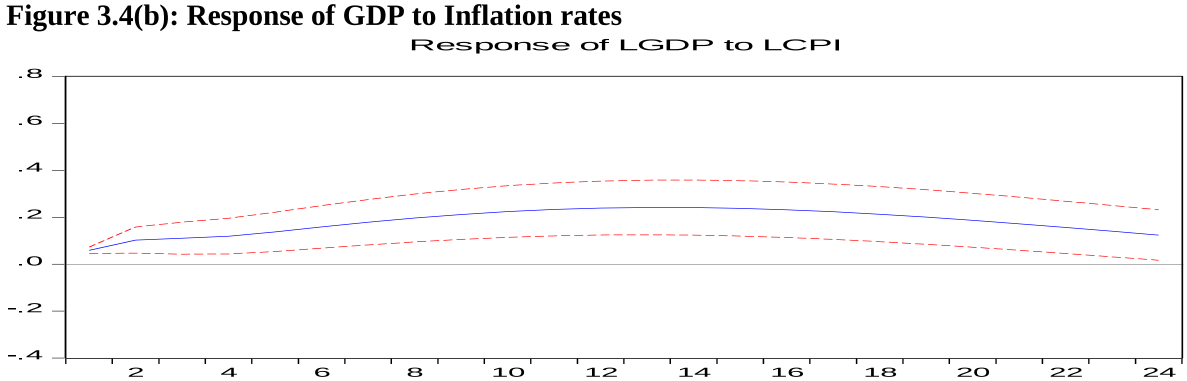
Source: *Author's Computation (2020), using data sourced from the WDI.*

This trend continues up until period twenty. It peaks at period fifteen and begins to decline as it moves towards period twenty-four. This result is in line with the theory that GDP rises with money supply and that money supply is associated with economic growth. The initial decline in GDP that causes a delay in allowing GDP to proportionately respond to money supply might be due to the lag element introduced to the model. Nevertheless, this result validates the claim by Olomola (2010) that GDP and money supply are positively correlated, with money supply associated with output growth in the AOECs.

3.6.4.8.2 ***Impulse response function of GDP to Inflation***

Figure 3.4(b) shows the response of GDP to a structural one standard deviation innovation in inflation. In economics, inflation is referred to as an increase in the general price level over time.

Figure 3.4(b): Response of GDP to Inflation rates



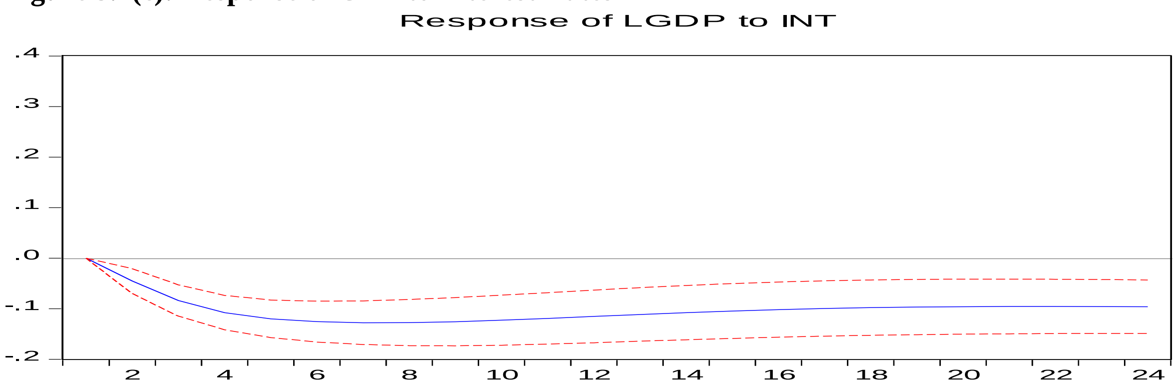
Source: *Author's Computation (2020), using data sourced from the WDI.*

The Phillips curve traditional hypothesis that explains the relationship between unemployment and inflation shows that a high inflation rate is consistent with low unemployment rates, suggesting that inflation has a positive impact on output. The findings of this study align with this theoretical postulation that, a one standard innovation deviation to inflation leads to a positive and significant response in GDP. The GDP response is significant throughout the period under study, gently rising from period one through two, peaking at period fifteen and steeply declining thereafter.

3.6.4.8.3 ***Impulse response function of GDP to Interest Rates***

Figure 3.4(c) presents the response of GDP to interest rates. It shows that GDP negatively and significantly responds to interest rates throughout the period under investigation, suggesting that a structural one standard deviation innovation in interest rates reduces GDP consequent to a probable slowdown in demand for money for investment opportunities.

Figure 3.4(c): Response of GDP to Interest Rates

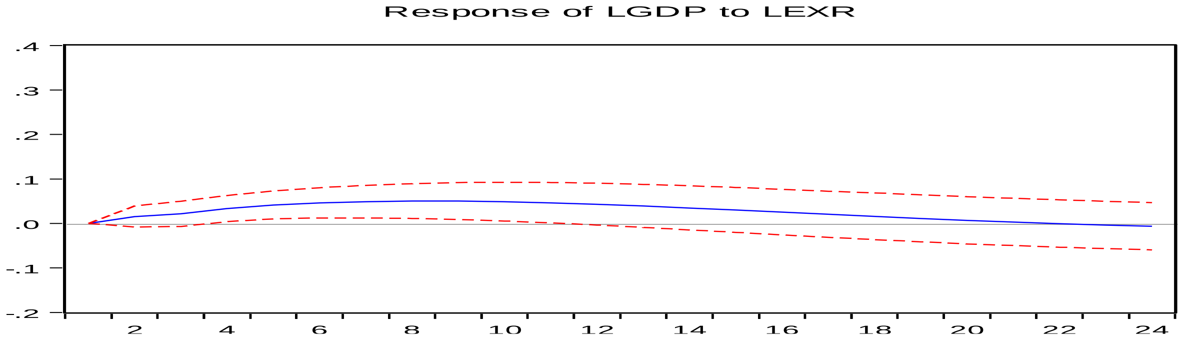


Source*: Author's Computation (2020), using data sourced from the WDI.*

3.6.4.8.4 ***Impulse response function of GDP to Exchange Rates***

The response of GDP to a one standard deviation innovation in exchange rates is presented in figure 3.4(d) showing that GDP significantly responds to exchange rate shocks. GDP progressively rises to peak at period ten and then declines continuously as it advances to period twenty-four.

Figure 3.4(d): Response of GDP to Exchange Rates



***Source**: Author's Computation (2020), using data sourced from the WDI.*

3.6.5 Panel Granger Causality Results

This section discusses the outcomes from the Granger causality test conducted as shown in appendix A-3. While some of the variables reveal unidirectional causality, others show bi-directional causality. For instance, the result reveals that at a 5 percent level of significance, oil price shocks Granger cause the GDP of the AOECs. Similarly, other selected macroeconomic variables jointly Granger cause GDP with oil price shocks for the period under investigation. These findings validate the positive response of GDP established in the impulse response function above. Apart from money supply that Granger causes GDP at a 10 percent significance level, other monetary policy variables (interest rates, exchange rates, and inflation rates) significantly Granger cause GDP at a 5 percent significance level.

On the relationship between the monetary variables and oil price shocks, the results reveal that oil price shocks Granger cause money supply, inflation, and exchange and interest rates. On the other hand, the monetary variables insignificantly Granger cause oil price shocks at a 5 percent significance level. Among the monetary variables, all the variables significantly Granger cause money supply at a 5 percent significance level, except interest rates. However, money supply, inflation, and interest rates jointly Granger cause exchange rates at a 5 percent significance level. Similarly, money supply, inflation and exchange rates Granger cause interest rates at a 5 percent significance level.

Finally, the result reveals that money supply, interest rates, and exchange rates jointly Granger cause inflation at a 5 percent significance level. Our results validate Boheman and Maxen's (2015) finding that, there is a transmission and causal relationship among the monetary variables.

3.6.6 Variance Decomposition

Variance decomposition shows the degree of information that each variable of a VAR framework contributes to variations in other variables. Raghavan and Silvapulle (2008) refer to variance decomposition as the percentage of a shock attributable to a specific variable that is related to either its own innovations or those innovations that are associated with other dependent variables in a model, at various forecast time periods in a fitted model. A variance decomposition, which is also referred to as the forecast error variance decomposition is used to aid interpretation of our PSVAR as it has been fitted. It is used to determine how much of the forecast error variance of each of the variables can be explained by the exogenous shocks to the other variables. Variance decomposition accounts for the information about the proportion of the movements in a sequence that is due to the shocks in the variable itself and other identified shocks (see Adarov, 2019). It analyzes the relative importance of shocks in describing variations among variables. Therefore, for this study, variance decomposition helps to determine the comparative share of shocks on all the variables in evaluating the impact of oil price shocks on output growth in AOECs. Furthermore, the variance decomposition helps to divulge the significant effect of the external shocks on the selected variables in our model. In achieving this, the analysis covers a six-period horizon, having allowed twenty-four periods, to ascertain the impacts of shocks when the variables are permitted to affect each other over time. Tables 3.4-3.9 present variance decompositions for each variable in the generic model over a six-period forecast horizon. It determines the relative relevance of each structural innovation in explaining fluctuations of the variables in the generic model.

Table 3.4 presents the variance decomposition of GDP. It shows the importance of each structural innovation in explaining fluctuations in output. The result reveals that very little share of the variations in GDP is attributed to unemployment.

Table 3.4: Variance Decomposition of Gross Domestic Product

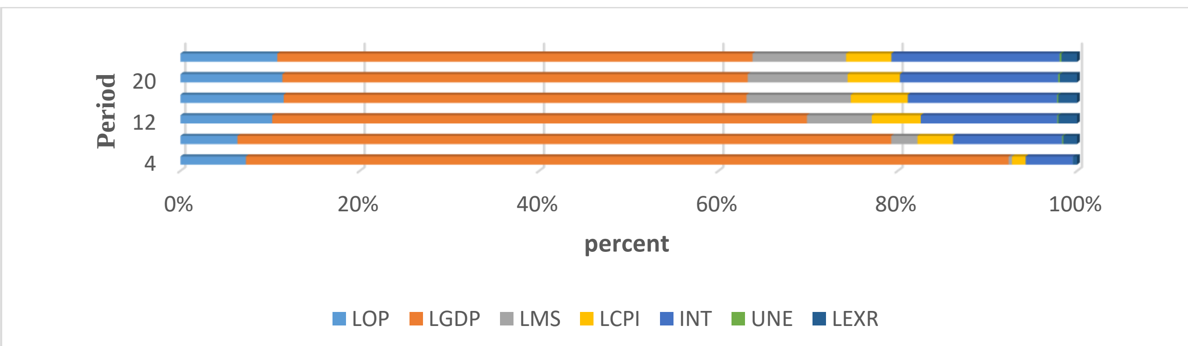
Period	Oil Price (OP)	Gross Domestic Product (GDP)	Money Supply (MS)	Inflation Rate (INF)	Interest Rates (INR)	Unemployment Rates (UNE)	Exchange Rates (EXR)
4	7.301261	85.06961	0.367426	1.520794	5.279949	0.003098	0.457866
8	6.358754	72.91982	2.925081	3.961599	12.16806	0.135535	1.531153
12	10.23335	59.63617	7.241507	5.450194	15.23241	0.126237	2.080142
16	11.51379	51.61553	11.64466	6.343674	16.65071	0.130611	2.101026
20	11.37503	51.89260	11.14221	5.825327	17.67160	0.174848	1.918374
24	10.80508	53.00403	10.43897	5.042152	18.75557	0.198533	1.755661

Source*: Author's Computation (2020), using data sourced from the WDI.*

The table reveals that after periods four, eight, twelve, sixteen, twenty and twenty-four, unemployment shocks respectively account for 0.003 percent, 0.135 percent, 0.126 percent, 0.130 percent 0.174 percent and 0.198 percent of the variations in GDP. The insignificant impact is supported in the literature that notes that, a high unemployment rate contributes insignificantly to economic growth. The contribution of exchange rates to GDP ranges from 0.45 percent in period four, to 1.5 percent in period eight, 2.08 percent in period twelve, and 2.10 percent in period sixteen and declines to 1.91 percent in period twenty and further to 1.75 percent in period twenty-four. The oil price follows a similar trend to exchange rates although occurring in a higher magnitude, contributing 7.30 percent in period four, 6.35 percent in period eight, and 10.23 percent in period twelve, and peaking at 11.5 percent in period sixteen. The contribution of interest rate shocks, which may reflect GDP, is relatively high among other shocks, indicating that interest rates have a noticeable influence on GDP. Money supply follows the path of the interest rate. The result shows that money supply shocks are associated with fluctuations in GDP. Unexpected inflation accounts for 1.5 percent of the fluctuations in output in the fourth period, 3.96 percent after the eighth period, 5.45 percent after the twelfth period, 6.34 percent in the sixteenth period, 6.8 percent in the twentieth period and 7.04 percent in period twenty-four. For this period the results show that inflation shocks are associated with fluctuations in GDP.

The bar chart displayed in figure 3.5 offers a clearer understanding of the results shown in table 3.4. It shows that, cumulatively, GDP responds significantly to variations in oil prices. Similarly, interest rates show a significant response to variations in GDP.

Figure 3.5: Variance Decomposition of Gross Domestic Price Bar Chart



Source*: Author's Computation (2020)*, *using data sourced from the WDI*.

To understand the role of the monetary authorities in influencing output growth and determining the proportion of fluctuations in output, we further examine the inputs of the operating tools of monetary policy to intermediate monetary policy targets and thus relate the same to the preceding discussion, with output as a monetary policy goal. Table 3.5 shows the variance decomposition of exchange rates, which have a significant impact on GDP growth between the fifth and twelfth periods.

Table 3.5: Variance Decomposition of Exchange Rates

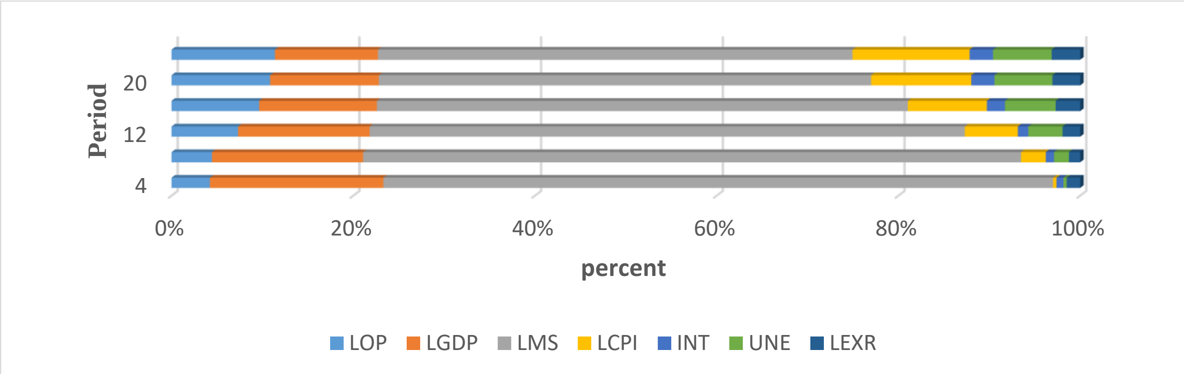
Period	Oil Price (OP)	Gross Domestic Product (GDP)	Money Supply (MS)	Inflation Rate (INF)	Interest Rates (INR)	Unemployment Rate (UNE)	Exchange Rates (EXR)
4	66.83367	3.031735	1.307833	7.568354	2.049010	0.980554	18.22884
8	67.27970	4.010223	1.628630	9.462395	4.662403	2.965150	9.991502
12	67.77930	4.867851	2.851918	11.11924	8.271824	4.841711	0.268154
16	55.27751	5.520388	4.085502	12.54077	11.35042	5.974636	5.250781
20	49.82454	5.969269	5.038882	13.82232	13.15864	6.356665	5.829681
24	46.79640	6.254843	5.693215	15.00499	13.80880	6.321781	6.119980

***Source**: Author's Computation (2020), using data sourced from the WDI.*

As shown in table 3.5, besides exchange rates' own shocks, exchange rates fluctuations are largely attributed to oil price shocks at about 66.83 percent in period four, and 67.27 percent in period eight, peaking at 67.77 percent in period twelve before it starts decline to 55.27 percent in period sixteen, 49.82 percent in period twenty and 46.79 percent in period twenty-four. Consistent with earlier findings, the oil price movement accounts for a large proportion of the fluctuations in exchange rates.

On the other hand, GDP makes remarkable contributions to exchange rate fluctuations. Table 3.5 illustrates that GDP accounts for 3.03 percent of the variations in exchange rates in period four, increasing to 4.01 percent in period eight and 4.8 percent in period twelve. At the end of period sixteen, the total proportion of GDP accounting for fluctuations in exchange rates is 5.52 percent, while it is 5.96 percent in period twenty and 6.25 percent at the end of period twenty-four. There is thus a consistent rise throughout the period. Similarly, fluctuations in exchange rates associated with interest rates are expressed thus: 2.04 percent in period four, 4.66 percent in period eight, 8.27 percent in period twelve, 11.3 percent in period sixteen, 13.1 percent in period twenty and 13.8 percent in period twenty-four. It can therefore, be concluded that the effect of interest rates is more pronounced and noticeable than the effect of money supply on GDP. Furthermore, it is observed that interest rates and inflation have comparable effects on exchange rates fluctuations. Similar to interest rates, the inflation rate progressively increases from 7.5 percent in period four to 9.46 in period eight. It continues to rise until it reaches 11.11 percent in period twelve, 13.82 in period twenty and 15.00 percent in period twenty-four. The contribution of each innovation to money supply is presented in figure 3.6.

Figure 3.6: Variance Decomposition of Exchange Rates Bar Chart



***Source**: Author's Computation (2020)*, *using data sourced from the WDI.*

The variance decomposition of the money supply is presented in table 3.6. The table reveals that the interest rate's contribution to the fluctuations in the money supply are relatively very small compared with those from other variables in the study. The interest rate accounts for 0.75 percent of the fluctuations in the money supply in the fourth period, 0.90 percent in the eighth period and rises slightly to 1.15 percent in the twelfth period. By the end of the sixteenth period, the interest rate accounts for 1.99 percent of the fluctuations in the money supply.

Table 3.6: Variance Decomposition of Money Supply

Period	Oil Price (OP)	Gross Domestic Product (GDP)	Money Supply (MS)	Inflation Rate (INF)	Interest Rates (INR)	Unemployment Rate (UNE)	Exchange Rates (EXR)
4	4.224452	19.08823	73.70349	0.374725	0.758879	0.359502	1.490717
8	4.447694	16.63429	72.41405	2.717665	0.906759	1.636936	1.242607
12	7.323851	14.47712	65.50679	5.827437	1.151296	3.770025	1.943486
16	9.641851	12.95474	58.43183	8.697793	1.998684	5.576258	2.698847
20	10.84543	11.96861	54.17923	11.02229	2.545111	6.377922	3.061406
24	11.37918	11.34007	52.22677	12.88729	2.570584	6.457347	3.138770

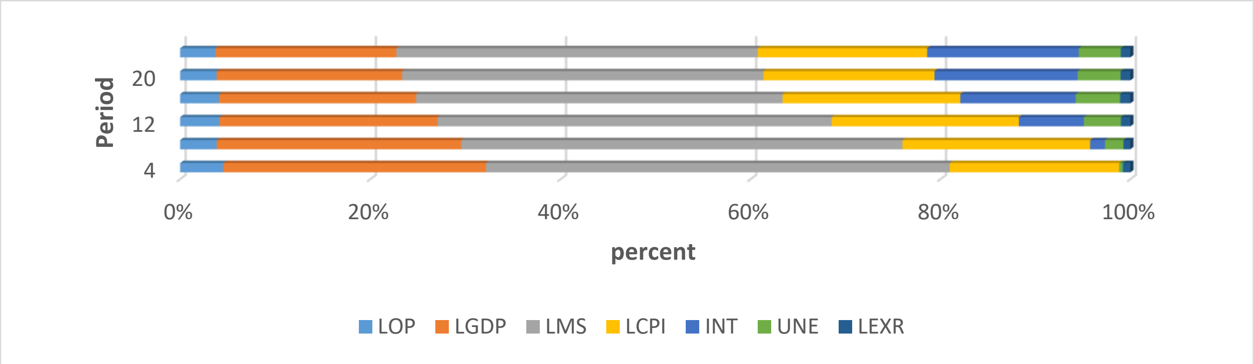
***Source**: Author's Computation (2020), using data sourced from the WDI.*

The appreciating trend in the interest rate's contribution continues and rises to 2.54 percent at the end of the twentieth period and, in the twenty-fourth period, it accounts for 2.57 percent of the fluctuations in the money supply. The interest rate's low contributions in explaining fluctuations in money supply suggest that the monetary authority might not have regarded or employed the interest rate as a relevant primary operating tool in controlling money supply within the economy. Exchange rates' contribution to fluctuations in the money supply closely corresponding with that of the interest rate. Exchange rates are associated with 1.49 percent of the fluctuations in money supply in period four but decline slightly to 1.24 percent as it moves to period eight. It begins to increase, reaching 1.94 percent at the end of period twelve and grows to 2.69 percent in period sixteen. In periods twenty and twenty-four, exchange rates respectively account for 3.06 percent and 3.13 percent of the fluctuations in the money supply.

The table shows that the oil price is associated with significant fluctuations in the money supply during the periods under study. For instance, the oil price explains 4.22 percent in period four and 4.44 percent in period eight. This increases to 7.32 percent in period twelve and 9.64 in the sixteenth period. By the end of period twenty, the oil price accounts for 10.84 percent of the fluctuations in money supply and 11.37 percent by the end of the twenty-fourth period. The table also shows that, besides own shocks, money supply fluctuations are hugely attributed to GDP. In period four, GDP explains 19.08 percent of the fluctuations in the money supply. In periods eight and twelve, it is respectively associated with 16.63 percent and 14.47 percent of the fluctuations in the money supply. In period sixteen, 12.95 percent of the fluctuations in money supply are attributed to GDP and by the end of the twentieth and twenty-fourth periods, GDP respectively accounts for 11.96 percent and 11.34 percent.

Unemployment during the period noticeably accounts for fluctuations in money supply. In period four, unemployment marginally accounts for such fluctuations, while it contributes 1.63 percent in period eight and 3.77 percent in the twelfth period. Unemployment accounts for 5.57 of the fluctuations in the money supply in period sixteen, 6.37 percent in period twenty and 6.45 percent in the twenty-fourth period. These results suggest that unemployment is responsive to every other variable in the system, especially from the end of period four to the end of the period investigated. A summary of this discussion is provided in figure 3.7.

Figure 3.7: Variance Decomposition of Money Supply Bar Chart



***Source**: Author's Computation (2020), using data sourced from the WDI.*

Table 3.7 presents the variance decomposition of the inflation rate. It shows that changes in money supply account for large fluctuations in the inflation rate that weaken over the period under investigation. The money supply records the largest contribution to fluctuations in inflation rates over the whole period under investigation. In period four, money supply contributes 48.83 percent to the fluctuations in inflation. The contribution of money supply is greater than the contributions of the other variables employed in the study combined. Similarly, in period eight, money supply accounts for 46.43 percent of the fluctuations in inflation, 41.45 percent in period twelve and 38.56 percent in period sixteen. Its contribution weakens as it reaches period twenty, contributing 37.98 percent to the variations in inflation and it later rises slightly to 38.02 percent in period twenty-four.

Table 3.7: Variance Decomposition of Inflation

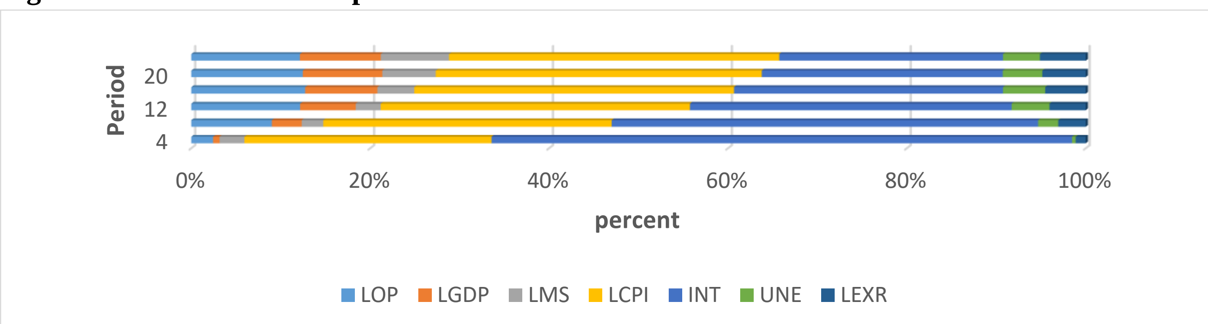
Period	Oil Price (OP)	Gross Domestic Product (GDP)	Money Supply (MS)	Inflation Rate (INF)	Interest Rates (INR)	Unemployment Rate (UNE)	Exchange Rates (EXR)
4	4.534105	27.60276	48.83330	17.85665	0.005635	0.363456	0.804095
8	3.844441	25.71415	46.43159	19.76130	1.562347	1.954470	0.731709
12	4.134165	22.93950	41.45242	19.72517	6.839522	3.910185	0.999032
16	4.083473	20.70610	38.56483	18.71836	12.17094	4.664995	1.091298
20	3.843958	19.50343	37.98929	18.02111	15.08396	4.523304	1.034939
24	3.715133	19.00463	38.02258	17.84925	15.97525	4.413540	1.019610

Source*: Author's Computation (2020), using data sourced from the WDI.*

Gross Domestic Product is the second largest contributor to fluctuations in the inflation rate. The table shows that GDP makes a considerable contribution to fluctuations in inflation over time, although it weakens as it moves from the lower periods to higher periods. For instance, GDP contributes 27.60 percent and 25.71 percent to inflation variations in periods four and eight, respectively. In periods sixteen and twenty, it contributes 22.93 percent and 20.70 percent to the variations in the inflation rate. The figure stands at 19.5 percent in period twenty and drops to 19.00 percent at the end of period twenty-four. Besides own shocks, oil prices make notable contributions to variations in the inflation rate, contributing 4.53 percent and 3.8 percent respectively in periods four and eight. In period twelve, oil prices account for 4.13 percent of inflation rate variations. This declines to 4.08 percent in the sixteenth period, 3.84 percent in period twenty and 3.71 percent in period twenty-four. Thus, while money supply shocks have significant effects on fluctuations in exchange rates and the inflation rate, which in turn spur output growth, they also have inflationary effects.

Another noticeable contributor to the fluctuations in the inflation rate is interest rates, marginally contributing 0.005 percent in period four, but rising to 1.56 percent in period eight. Its contribution to variations in the inflation rate rises significantly to 6.83 percent and 12.1 percent in periods twelve and sixteen, respectively. Furthermore, at the end of the twentieth period, interest rates contribute 15.08 percent, peaking at 15.9 percent in period twenty-four. Exchange rates do not contribute significantly to variations in the inflation rate especially within the first three periods, as they contribute less than 1 percent of the variations. They contribute 0.80 percent, 0.73 percent, and 0.99 percent in periods four, eight and twelve, respectively. This increases marginally to 1.09 percent in period sixteen and declines to 1.03 percent in period twenty and 1.01 percent in period twenty-four. Unemployment's contribution to inflation rate variations marginally accounts for 0.36 percent in period four, but rises to 1.95 percent in period eight and 3.91 percent in the twelfth period. The contribution peaks at 4.66 percent in period sixteen, declines to 4.52 percent in period twenty and further declines to 4.41 percent in period twenty-four. For the sake of simplicity and clarity, this is depicted in figure 3.8.

Figure 3.8: Variance Decomposition of Inflation Bar Chart



Source: Author's Computation (2020), using data sourced from the WDI.

Table 3.8 shows the variance decomposition of interest rates. Besides own shocks, inflation rates contribute to the fluctuations in the interest rate over time. It accounts for most of the fluctuations in interest rates within AOECs. This suggests that the monetary authorities could adjust interest rates in response to expected inflation. It is estimated that inflation rates account for 27.61 percent of the fluctuations in interest rates during the fourth period.

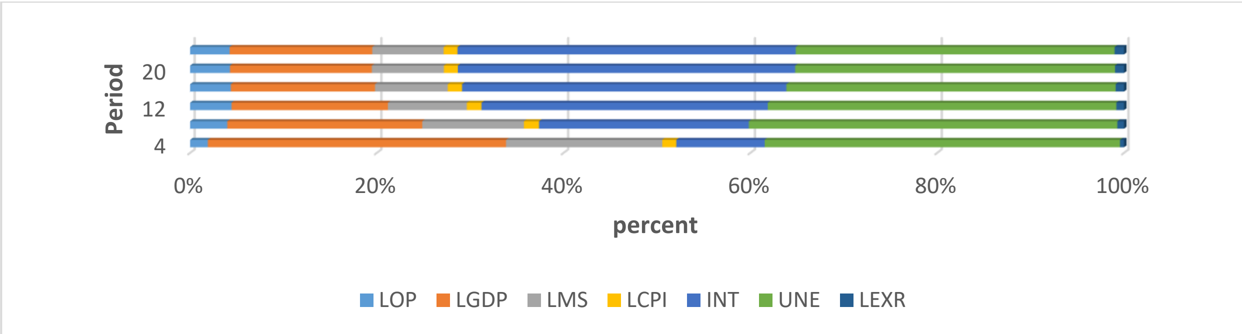
Table 3.8: Variance Decomposition of Interest Rates

Period	Oil Price (OP)	Gross Domestic Product (GDP)	Money Supply (MS)	Inflation Rate (INF)	Interest Rates (INR)	Unemployment Rate (UNE)	Exchange Rates (EXR)
4	2.432925	0.722853	2.785366	27.61873	64.90878	0.403265	1.128077
8	9.004817	3.338400	2.409378	32.24529	47.66890	2.262155	3.071057
12	12.16793	6.214796	2.793597	34.56559	35.96921	4.233667	4.055212
16	12.72497	8.079959	4.120313	35.75123	30.06633	4.717118	4.540081
20	12.46290	8.883897	5.985573	36.44668	26.93677	4.430236	4.853942
24	12.14693	9.042681	7.632631	36.90544	25.00997	4.129510	5.132840

Source*: Author's Computation (2020), using data sourced from the WDI.*

This rises to 32.24 percent in period eight and 34.56 percent in period twelve, and 35.75 percent, 36.44 percent, and 36.90 percent in periods sixteen, twenty and twenty-four, respectively. The table also reveals that oil price shocks are the second most important factor in explaining fluctuations in interest rates, contributing 2.43 percent in the fourth period. In the eighth period, oil price shocks' contribution jumps to 9.00 percent and rises slightly to 12.16 percent in period twelve, peaking at 12.72 percent in the sixteenth period before declining to 12.4 percent in period twenty and 12.14 percent in period twenty-four. Table 3.7 shows that exchange rate shocks account for 1.12 percent of the fluctuations in interest rates at period four, 3.07 percent at period eight, 4.05 percent at period twelve and 4.54 percent at period sixteen. This rises slightly to 4.8 percent in period twenty and peaks at 5.13 percent in period twenty-four. This implies that the AOECs' monetary authorities could adjust interest rates to influence exchange rates. It is also observed that money supply explains fluctuations in interest rates. At period four, money supply explains 2.7 percent of the variation in interest rates. This decreases to 2.40 percent after a three-period interval before rising slightly to 2.79 percent in period twelve. In period sixteen, money supply's contribution is 4.12 percent and it is respectively associated with 5.98 percent and 7.63 percent of the fluctuations in the interest rate in periods twenty and twenty-four. Both GDP and unemployment contribute marginally to fluctuations in interest rates during the fourth period with their contributions estimated at 0.72 percent and 0.40 percent, respectively. In periods eight, twelve, sixteen, twenty and twenty-four, GDP contributes 3.33 percent, 6.21 percent, 8.07 percent, 8.88 percent and 9.04 percent, respectively to variations in interest rates. Similarly, unemployment explains 2.26 percent, 4.23 percent, 4.71 percent, 4.43 percent and 4.12 percent, respectively of the variations in interest rate in periods eight, twelve, sixteen, twenty and twenty-four. Figure 3.9 provides further clarity on this discussion.

Figure 3.9: Variance Decomposition of Interest Bar Chart



Source: Author's Computation (2020), using data sourced from the WDI.

Table 3.9 presents each innovation's contribution to unemployment for the period under investigation. Besides unemployment's own shocks which contribute about 38.04 percent in period four, GDP, money supply, interest rates and oil price shocks respectively contribute 31.92 percent, 16.72 percent, 9.45 percent and 1.90 percent to unemployment fluctuations, while exchange rates contribute less than 1 percent in period four.

In period eight, interest rates contribute 22.46 percent, followed by GDP at 20.88 percent, money supply at 10.88 percent and interest rates at 1.61 percent. In period twelve, interest rates record the largest contribution to unemployment fluctuations, contributing 30.65 percent, followed by GDP contributing 16.73 percent, money supply at 8.45 percent and inflation rate at 1.56 percent in that order.

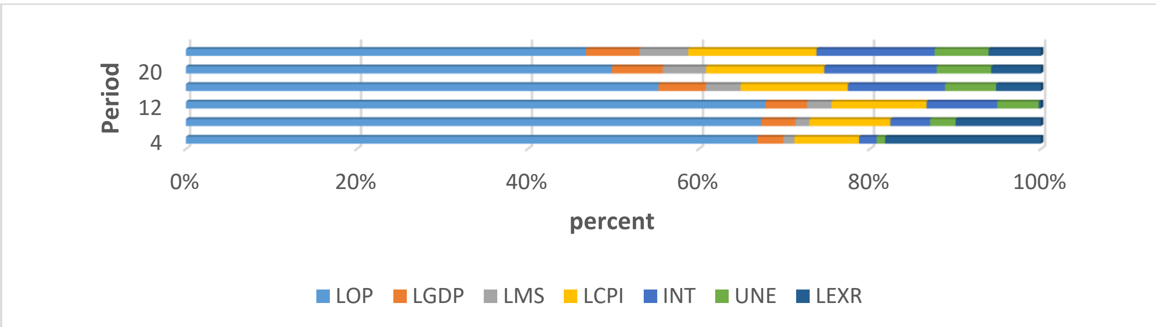
Table 3.9: Variance Decomposition of Unemployment

Period	Oil Price (OP)	Gross Domestic Product (GDP)	Money Supply (MS)	Inflation Rate (INF)	Interest Rates (INR)	Unemployment Rate (UNE)	Exchange Rates (EXR)
4	1.900148	31.92559	16.72982	1.503862	9.454571	38.04874	0.437268
8	3.967614	20.88401	10.88667	1.612820	22.46918	39.46126	0.718441
12	4.434823	16.73867	8.453128	1.568787	30.65378	37.32127	0.829545
16	4.356399	15.43641	7.796885	1.521004	34.73496	35.24938	0.904953
20	4.270647	15.18485	7.713687	1.492612	36.11620	34.25377	0.968236
24	4.232619	15.26218	7.653325	1.477904	36.21711	34.14020	1.016660

***Source**: Author's computation (2020), using data sourced from the WDI.*

In period sixteen, GDP's contribution to unemployment declines to 15.43 percent, while it stands at 15.18 percent in period twenty and 15.26 percent in period twenty-four. Money supply's contribution to unemployment drops to 7.79 percent in period sixteen, 7.71 percent in period twenty and 7.65 percent in period twenty-four. Similarly, inflation rate's contribution drops to as low as 1.52 percent in period sixteen, 1.49 percent in period twenty and 1.47 percent in period twenty four. The interest rate's contribution increases over time, standing at 30.65 percent in period twelve, 34.25 percent in period sixteen, and 36.11 percent in period twenty and by the end of the period, it contributes 36.21 percent to fluctuations in unemployment (see figure 3.10).

Figure 3.10: Variance Decomposition of LEXR Bar Chart



Source*: Author's Computation (2020), using data sourced from the WDI.*

3.7 Inferences and Discussion of the Findings

This study set out to investigate the short-term relationship among oil price shocks, output growth and the exchange rate in AOECs. More specifically, it examines how oil price shocks affect output growth within the context of the AOECs and seeks to establish the probable transmission mechanisms and/or channels among the selected macroeconomic variables. To achieve this goal, the study employs the PSVARs estimating technique inherent in Sims' (1980) VAR framework. Overall, the PSVARs technique includes seven variables comprising oil prices treated as an exogenous variable, GDP proxied by the growth rate, exchange rates, money supply, interest rates, inflation rates and unemployment. Based on previous studies, this study considers the PSVARs techniques suitable to analyze short-run relationships among the selected variables. A normality test is carried out to show that the variables are normally distributed. The results show that the variables contained in the model passed the normality test independently and jointly.

The study finds that oil price shocks significantly impact output variations. Positive oil price shocks increase output. In addition, besides interest rates, oil price shocks account for large variations in output growth from period four to twenty-four. While oil price shocks initially decrease output, it increases significantly over a relatively long period of time. The results also reveal that oil price shocks contribute an estimated 10 percent to variations in output in period twelve and about 11 percent in period twenty-four. This follows interest rates and own shocks that contribute about 15 percent and 59 percent, respectively in periods twelve and twenty-four. Therefore, it is safe to say that oil price shocks are a major individual factor affecting AOECs' output. A primary reason for this is the fact that the revenue associated with oil prices provides support for government expenditure.

The study also examines how oil price shocks impact macroeconomic variables and how these shocks spread to other prices over time, leading to variations in the overall price level within the economy. The attendant effect of a positive oil price shock on GDP is also reflected in a positive and significant response. This implies that an unanticipated change from the external environment increases AOECs' output over time. The results from the variance decomposition are robust and similar to those obtained from the IRFs. The findings reveal that oil price shocks have a significant impact on all the macroeconomic variables.

Monetary policy shocks are shown to significantly explain variations in output growth. For instance, after own shocks, the interest rate contributes to variations in GDP, contributing 5.27 percent in period five and rising to 16.6 percent in the sixteenth period and 18.7 percent by the end of period twenty-four. Similarly, money supply and inflation significantly account for variations in GDP during the period under investigation. While money supply marginally contributes to variations in GDP in period four at 0.36 percent, it accounts for 10.43 percent of the variation in GDP by the end of period twenty-four. The trend in money supply's contribution to fluctuations in GDP is similar to that of the inflation rate that contributes 1.5 percent in period four, gradually rising to 3.9 percent in period eight and 5.0 percent in period twenty-four. This finding indicates that besides oil price shocks, monetary policy shocks are significantly responsible for variations in GDP. It suggests that policymakers should be conscious of the influence of this variable when formulating monetary policy aimed at enhancing output.

The results show that exchange rates significantly impact GDP. It is also observed that oil prices significantly account for variations in exchange rates and exchange rates in turn account for significant variations in money supply and interest rates.

The outcomes from the Granger causality test are presented in appendix A-3. Within the specified time frame, bidirectional causality is established among some variables, while some reveal uni-directional causality. At a 5 percent level of significance, oil price shocks Granger cause GDP, validating our previous results in the impulse response function and the variance decomposition that, oil price shocks significantly impact output growth in the AOECs. Similarly, the results validate the finding that oil price shocks significantly explain variations in the AOECs' GDP. Furthermore, oil prices Granger cause inflation, suggesting that positive oil price shocks may trigger inflation. It is also evident from our findings that oil price shocks Granger cause unemployment. This result validates Burbridge and Harrison (1984) and Gisser and Goodwin's (1986) findings that, oil price movements Granger cause variation in unemployment and output in the US.

3.8 Summary and Conclusions

This study estimated a seven variable PSVAR model to investigate the short-run relationship between oil prices and selected macroeconomic variables to establish the potential transmission processes and mechanisms through which oil price shocks affect output growth in AOECs. It used quarterly data for the period spanning 1980-2018 to construct this model with short-run restrictions among the variables. The variables considered in the study include inflation, money supply, interest rates, exchange rates, GDP, unemployment and oil prices. Oil prices are treated as an exogenous variable while the other variables are endogenous variables. The study revealed that output responds positively and significantly to oil price shocks. Similarly, the results show that money supply has a large impact on output, while oil price shocks have the largest impact on exchange rates, among other variables. The causality results validate the study's hypothesis that oil price shocks Granger cause GDP. In addition, the findings reveal that oil price shocks Granger cause exchange rates. This implies that strong monetary control measures should be put in place to enable monetary policy to be used to regulate and ensure sustainable output growth whenever oil price shocks ensue.

The results show that the selected variables significantly respond to oil price shocks. Other tests conducted offer evidence that supports this claim. In contrast to oil-importing countries, the results reveal a significant positive relationship between oil price shocks and GDP in AOECs. This shows that oil price shocks play a significant role in determining variations in output, which stimulates economic activity. An increase in oil prices is a catalyst for GDP. Positive oil price shocks account for higher earnings from exports. The study also finds that oil price shocks significantly influence exchange rates. Positive oil price shocks lead to currency appreciation which may enhance economic activity among oil-exporting countries. There is a positive correlation between oil prices and GDP, resulting in higher growth rates and reduced unemployment rates. This correlation is significant but sluggish. However, this finding may not necessarily point to an automatic and continuous reduction in unemployment in the future due to other factors like political will to invest oil revenue in public ventures that will create an enabling environment for job creation. Other factors such as corruption, unprofitable investments using oil proceeds and political unrest which is prevalent in oil-led economies like Nigeria, Libya and Angola may also come into play. The study also revealed that, with an increase in oil prices, money supply rises, which might result in increased inflation.

In terms of the correlation of oil prices with the other variables used in the study, the results show that money supply has a high correlation with oil prices. This supports the claim that positive oil prices increase the money stock of oil-exporting countries. Similarly, oil prices highly correlate with inflation, validating claims that positive oil price shocks might trigger inflation in the economies of AOECs since they rely heavily on imported refined oil. With regard to the correlation between oil prices and exchange rates, the results reveal that oil prices significantly correlate with exchange rates. This validates claims that oil-exporting countries' exchange rates appreciate when positive oil price shocks occur because more of their local currency will be required to purchase crude oil.

Finally, our results support the claim that exchange rates serve as a transmission medium through which oil price shocks impact on selected macroeconomic variables in AOECs. Contrary to the correlation of oil prices with money supply, inflation, and exchange rates, the oil price has a negative correlation with unemployment and interest rates.

CHAPTER 4

OIL PRICE SHOCKS AND EXCHANGE RATES IN AFRICA'S OIL EXPORTING COUNTRIES: A FORECASTING MODEL

4.1 Introduction

In chapter three a PSVAR model was employed to examine oil price shocks and their transmission mechanism in AOECs. It was shown that oil price shocks significantly impact the economy and that, variation in exchange rates is the medium through which such shocks transmit to other macroeconomic variables and influence output performance in the AOECs. While stabilizing the exchange rate is thus vital for sound economic performance, accurately estimating exchange rates is critical in the financial domain (Haskamp, 2017). According to Taylor and Allen (1992), it is not easy to consistently estimate exchange rates as various factors account for why exchange rates may deviate from their values. Therefore, the expectations of exchange rates forecasters could move in the opposite direction of the exchange rate's actual value (see Beneki and Yarmohammadi, 2014; Haskamp, 2017). In contrast, the forecaster's expectations could be correct, but unanticipated factors may abruptly cause the movement of exchange rates to vary. It is important to note that forecasters estimate the movement of currency in the future and that forecasting exchange rates allows economic agents to better anticipate future market conditions. Consequently, economic agents will be confronted with the risks of exchange rates. The serious consequences of these risks could be mitigated by reliable exchange rates forecasts.

However, the best manner in which to achieve dependable exchange rates forecasts has remained a puzzle in the field of economics. Taylor and Allen (1992) observe that the accuracy of exchange rates forecasts will determine the success or failure of individuals, firms, investors and government programs because the degree to which such forecasts vary from the actual price impacts on both financial success and the quality of policy decisions. Meese and Rogoff (1983) note that classical exchange rates models were not able to forecast better than a naive random walk. Cheung, Chinn and Fujii (2009) confirmed this finding for alternative models and a longer sample.

The foreign currencies market is the largest and most liquid global financial market in an increasingly globalized world and it will continue to be relevant and have significant impact on the economic stabilization of open economies (see Pincheira and Medel, 2015; Etuk, Nwokolo and Agbasi 2016; Haskamp, 2017). Changes in exchange rates have implications for policy and business decision making. According to Ahmed (2017), exchange rates tend to be unstable, leading to economic uncertainty. Changes in exchange rates due to unexpected shocks like oil prices have economic costs in the form of price stability, profitability of firms and a country's financial stability (Haskamp, 2017). An unexpected surge in oil prices resulting in sudden fluctuations in exchange rates might lead to imbalances in several essential macroeconomic variables such as the international account balance. Therefore, exchange rates forecasting is necessary. This chapter models exchange rates for the AOECs.

Variations in exchange rates have undesirable consequences for the value of a country's currency and could negatively impact the negotiable terms of any economic agreement. The question remains as to whether variations in exchange rates impact output growth. Khosa, Botha and Pretorius (2015) and Héricourt and Poncet (2013) argue that exchange rate variations have a significant negative impact on economic performance in emerging markets. This is consistent with Verheyen (2012), Aghion *et al.* (2009), Clark, Wei, Tamirisa, Sadikov and Zeng (2004), and Chit, Rizov and Willenbockel (2010) who argue that variations in exchange rates impact trade flows and productivity growth.

Exchange rates risks may be alleviated by reliable exchange rates forecasts to give direction to agents in the exchange rates market. Unfortunately, forecasting exchange rates with a reasonable degree of certainty appears to be a challenge in economics. For instance, Chen and Rogoff's (2003) seminal paper notes that classical exchange rates models are not able to forecast better than a naive random walk. Chen *et al.* (2016) confirm this finding for newer models and a longer sample. Consequently, international economic agents are continuously looking for opportunities to protect themselves against exchange rates uncertainties and fluctuations due to the negative consequences for the economy (see Gali and Monacelli, 2005).

Modern macroeconomics largely depends on the dynamics of foreign exchange rates (Pincheira and Medel, 2015) to perform well. Devarajan, Ames, Brown and Izquierdo (2001) suggest that stable exchange rates contribute to the development of a safe macroeconomic arena, leading to improvement in growth and investments. Similarly, Hina and Qayyum (2015) note that modeling and forecasting exchange rates are crucial for decision making as the exchange rate has a substantial impact on fundamental macroeconomic variables like interest rates, wage rates, the level of economic growth and unemployment.

As noted earlier, it is difficult to achieve exchange rates stability (see Gali and Monacelli, 2005) and while several forecasting approaches have been advanced, they have not achieved the desired results in foreign exchange markets (see Pincheira and Medel, 2015). Forecasting exchange rates has thus become a key preoccupation in economic decision making. It is imperative to understand exchange rate behavior and how the exchange rate mechanism works, as well as to determine how a forecasting model can achieve the confidence and trust that the market requires in the AOECs. It is thus necessary to understand the forces involved in fluctuations in currency values. In seeking answers to these policy issues, scholars have engaged in extensive conceptual and empirical research aimed at forecasting the behavior of exchange rates (see Hina and Qayyum, 2015). However, efforts to understand the behavior of exchange rates in the AOECs have met with limited success (Iwayemi and Fowowe, 2011; Olomola, 2011). While policy guidelines have evolved, and lessons have been learned, new questions have arisen as to the best strategies to adopt to maintain macroeconomic stability in an evolving world economy.

Accurate exchange rates forecasts are key for investment opportunities, exporters and importers of goods and services, currency traders, and the government sector that manages the economy. It is generally believed that the success of an economy depends on its exchange rates (see Tsen, 2011; Eslamloueyan and Kia, 2015). Kao (1999), Uz and Ketenci (2008), and Kia (2013) conclude that the exchange rate serves as a measure of price-cost competitiveness. An accurate forecast would reduce the risks to currency traders as they seek to earn profit on future exchange rate movements. In addition, accurate forecasts can benefit exporters and importers through improved management decisions on the timing of exports and imports, thus enhancing the firm's profitability (see Pincheira and Medel, 2015). For the government sector, accurate exchange rates forecasts enable sound management of a nation's foreign exchange reserves which directly impacts monetary policy.

This study contributes to the literature in a number of ways. Firstly, it promotes understanding of the exchange rates dilemma by clarifying the roles that different variables play in the forecasting process. Secondly, it enhances understanding of the most suitable combination of evaluating techniques, such as mean absolute percentage error (MAPE), root mean square error (RMSE) and other fundamental macroeconomic variables to forecast exchange rates. Thirdly, the study considers Brent oil prices, which are the most traded among the AOECs (see Babatunde, 2015). Previous studies employed the United Arab Emirates price of oil (Dubai), the real US refiners' acquisition cost (RAC), the US West Texas Intermediate price of oil (WTI) and bonny light, among others (see, Alquist and Kilian, 2010; Baumeister and Kilian, 2014, 2016; Wang, Zhu and Wu, 2017). Although factors like productivity differentials and interest rate differentials have been investigated (see Mark and Choi, 2001), the researcher is not aware of any study that has assessed the role of oil prices in predicting exchange rates over long horizons in the AOECs' context. This study fills this gap by exploring the ability of oil prices to explain exchange rates behavior in a predictive regression framework. In this respect, it seeks to show that using information on the global oil price significantly improves the exchange rates of Africa's oil producing countries to the extent that they can aim to stabilize their currency (purchasing power).

There is a rich body of theoretical and empirical evidence on the connection between oil prices and exchange rates forecasts in oil-dominated economies around the world. However, appropriate research that offers effective policy guidelines to the AOECs is lacking (see Chen and Chen, 2007; Coleman, Cuestas and Mourelle, 2011; Ferraro, Rogoff and Rossi, 2015; Habib and Kalamova, 2007). The fact that oil prices significantly account for movements in exchange rates (as noted in Chapter Three) does not preclude other macroeconomic fundamentals from forecasting exchange rates. Therefore, it is necessary to forecast exchange rates using existing methods, guided by appropriate theories[14]. This will serve as a guide and offer explanations on what accounts for exchange rates variation in the AOECs.

Following this introduction, the remainder of the chapter is structured as follows: Section 4.2 presents stylized facts on exchange rates in the AOECs for the period under study. Section 4.3 discusses the key concepts in exchange rates and section 4.4 reviews the relevant literature. Section 4.5 presents the methodological framework employed, including ARDL, data and data sources, definition of variables and measurement of variables. Results estimation is discussed in section 4.6, while section 4.7 discusses the results and their implications, and a summary and conclusions are presented in section 4.8.

4.2 **Stylized facts on Exchange Rates**

Several empirical studies have revealed equivocal behavior in exchange rates as a result of unpredictable oil prices (see Babatunde, 2015) and unclearly documented exchange rates forecasts (Eslamloueyan and Kia, 2015). This study seeks to ascertain whether information on exchange rates and their determinants improves exchange rates stabilization. It also analyzes various factors' ability to forecast exchange rates.

The role played by oil prices in global imbalances has been the subject of much debate. Some scholars have pointed to "the monetary policy dilemma of oil exporters triggered by the so-called Dutch disease" (see Ahmed, 2017; Hamilton, 2013; Corden and Neary, 1982; Kamps, 2006) within the context of the curse of natural resources phenomenon (see Herrera and Pesavento, 2009; Sachs and

[14] Exchange rates refer to the movement of the currency of one country against another country's currency (Mankiw, 1997). It could also be referred to as the price of a nation's currency in terms of another currency. The components of the exchange rate are divided into two parts - the domestic currency and a foreign currency, and these can be quoted either directly or indirectly. Exchange rates are officially quoted in values against the USD (Dooley *et al.,* 2004).

Warner, 2005) and the general impact of foreign exchange rates volatility on the real economy (see Aghion *et al.,* 2005). Understanding the relationship between oil price developments and exchange rates might alter our insight into past and current oil price shocks. The initial conclusions in the preceding chapter suggest that oil price movements contain vital additional information pertaining to exchange rates behavior among the AOECs. Furthermore, the chapter found that exchange rates are the medium through which oil price shocks transmit to other macroeconomic variables and influence output performance in the AOECs. Therefore, a composite model can be constructed of exchange rates behavior in the AOECs with the assumption and understanding that, amidst other factors, the exchange rates of these countries always respond to movement in oil prices.

Based on the foregoing discussion and the findings in the previous chapter, it is important for the regulatory authorities, policymakers and researchers to understand the following: Firstly, there is need to identify appropriate factors to forecast exchange rates in AOECs and have a good understanding of the working of these factors, which can assist in maintaining an equilibrium in exchange rates. Secondly, it is important to investigate strategies to tackle some of the consequences of exchange rates movement or misalignment. In this regard, it is obvious that forecasting exchange rates within the context of AOECs can only be empirically determined.

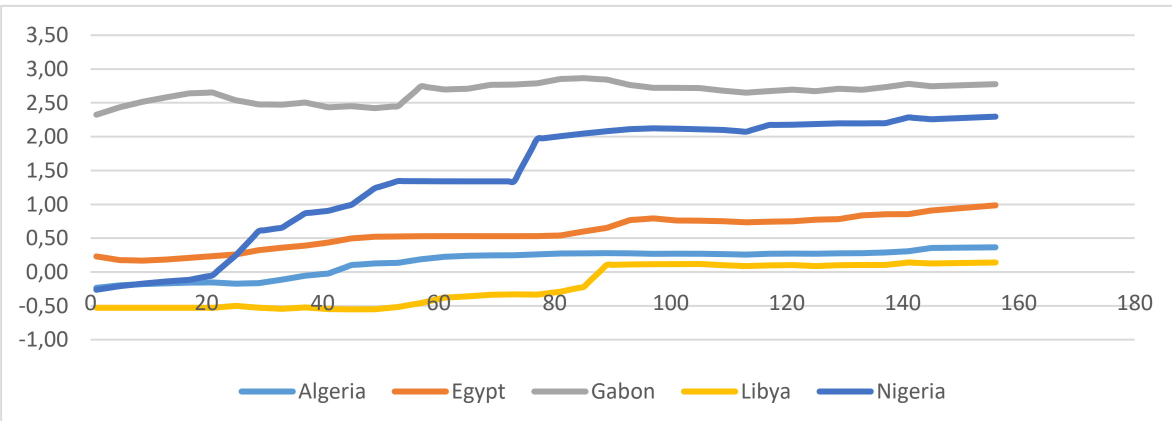
According to Kia (2013), exchange rates in a small open economy can be influenced by both internal and external factors[15]. Evidence shows that exchange rates movement has a significant effect on macroeconomic factors such as money supply, unemployment, and trade (see Mpofu, 2013). While various studies have considered how exchange rates may impact these factors, little attention has been paid to the role such factors, other monetary factors (interest rates, money supply, and inflation) and GDP may play in forecasting exchange rates within these developing oil-exporting countries. Although a few studies have forecast exchange rates in developed countries and at country specific level, there is a paucity of such research on developing AOECs (see Eslamloueyan and Kia, 2015; Aastveit *et al.*, 2015).

Given the fundamental features of open developing monocultural economies with high dependence on oil revenue, being in possession of a huge amount of foreign reserves could present a good case for empirical investigation. Many studies have empirically analyzed exchange rates forecasts in

[15] Internal factors include debt financing, government deficits, institutional economics (opportunism, economic freedom, shrinkage, and risk) and structural regime changes (policy constraints, political regime changes, and revolution) among others. External factors include foreign interest rates as well as the rest of the world's attitudes (sanctions, conflicts, risk generating activities, wars) towards the country, oil prices movement and a country's terms of trade.

developed and emerging countries, but little attention has been paid to developing oil-exporting countries (see Goudarzi *et al*., 2012; Khan and Ahmed, 2014; Cruz Zuniga, 2011; Twarowska and Kakol, 2014). This study fills this gap and contributes to the extant literature by forecasting exchange rates and shedding more light on these empirical concerns within the context of AOECs. In addition, it examines the historical trends in foreign exchange markets in these countries. In carrying out this empirical examination, this study relies on the theoretical underpinnings of exchange rate determinants and associated theories such as the Behavioral Equilibrium Exchange Rate (BEER) approach. Korhonen and Juurikkala (2007) applied this technique and introduced several variables as determinants of exchange rates.

Figure 4.1: **Exchange Rates Movement (1980Q1-2018Q4)**



Source: Author's computation (2020), *using data sourced from the WDI*.

Figure 4.1 presents the movement in exchange rates in the AOECs considered in this study during the period 1980-2018. The trend is positive and rises steadily over 156 periods constituting the quarters within 1980Q1 to 2018Q4.

4.3 Key concepts used in exchange rates

This section discusses key concepts employed to describe and discuss various measures of exchange rates.

4.3.1 Nominal Exchange Rate (NER)

The nominal exchange rate is the number of units of the domestic currency that are needed to buy a unit of a given foreign currency. For instance, if the value of dollar in terms of the Euro is 1.5, the nominal exchange rate between the dollar and the Euro will be 1.5. Nominal exchange rates express the price of one currency in terms of another (see Edwards, 1989). The US EIA (2018) notes that the exchange rates of a dollar to the currencies of the selected AOECs at the end of 2014 averaged

$1/80.58 Peso (Algeria); $1/7.08 pounds (Egypt); $1/494.41 francs (Gabon); $1/1.3 Dinar (Libya) and $1/158.55 Naira (Nigeria). Another term used for nominal exchange rates is the bilateral exchange rate. This is computed by the central bank of each country on a regular basis. The original data is expressed as the ratio of domestic currency (that is, the currency of each AOEC) and foreign currency ($). Therefore, a rise in the nominal exchange rate shows that the currency of the individual country is depreciating.

4.3.2 ***Nominal Effective Exchange Rate (NEER)***

The NEER offers a view of movements in a country's exchange rate by measuring this movement against a weighted average of other currencies, making it unnecessary to study several bilateral exchange rates (Kutu and Ngalawa, 2016). The size of a country's trade with a foreign country is used as a weight in the calculation. The OECD and IMF compute the NEER. While the NEER uses nominal exchange rates to create the index on a weighted basis over time, it does not indicate anything about the true value of the currency, or anything related to purchasing power. However, it is used to calculate the real effective exchange rate, which is also an index.

4.3.3 ***Real Effective Exchange Rate (REER)***

The REER measures the competitiveness of an economy compared with her trading partners. Similarly, it deals with development in a country's price levels relative to the average price level of foreign countries computed in the same currency. The weights for foreign trade used to compute the NEER are also used to compute the REER. Real appreciation occurs when an economy loses its competitiveness as measured by the REER. The REER of an oil-exporting country is measured in relation to its trading partners, indicated by a rise in price levels relative to that of other countries, measured in the same currency.

There are several methods to calculate the REER. The first is relative wholesale prices, which are measured by comparing development in relative wholesale prices with those of the country's trading partners. The second is relative export unit values, which measures development in the price levels of a country's exports compared to its trading partners' export price levels. The third method is called relative GDP deflators or total production since it measures development in the price level of a country's GDP deflator relative to the GDP deflators in other countries. The GDP deflator is calculated as follows: $\left(\frac{\text{nominal GDP}}{\text{real GDP}} \text{x} \frac{100}{1}\right)$. The fourth method measures development in the labour cost of producing one unit in relation to the cost in the country's trading partners, and the method is consequently called relative unit labour cost.

The volatility of exchange rates can be measured in two ways. The first involves taking the standard deviation over a certain period, which will result in a representation of historic volatility that may not be repeated in the future. The second way is to measure volatility based on the premium on foreign currency options traded in the foreign exchange market. In contrast to the first method, this method is referred to as implicit exchange rates volatility and depicts the future exchange rates volatility expected by traders.

4.4 Review of Literature

4.4.1 Theoretical Literature

Theoretically, exchange rate variations have a positive or negative effect on output growth. These can lead to expenditure switching between domestic and foreign goods both at home and among trading partners across international boundaries. Consequently, such variations can affect net exports, and firms' output and profitability, with the possibility of a second-round effect on firms' investment (Aghion *et al.*, 2010; Chit *et al.,* 2010). Duasa (2009) argues that exchange rates variations significantly affect fluctuations in exports and import prices. This concurs with Kandil and Mirzaie's (2005) finding that the impact of variations in exchange rates can determine economic performance either positively or negatively as some countries are susceptible to external shocks such as exchange rates. Such shocks could include an increase or a decrease, depending on whether exchange rates appreciate or depreciate, or whether or not this is anticipated. Thus, exchange rates depreciation may stimulate economic activities through the initial increase in the price of foreign goods, while appreciation decreases net exports through the initial decrease in the price of such goods.

Several theories in the literature on exchange rates offer explanations on the circumstances surrounding variations in exchange rates across various economies. Theoretically, it is well established that an oil-exporting country might experience an appreciation in exchange rates when there is an increase in oil prices and a depreciation when oil prices decline (see Golub, 1983; Corden, 1984; Tsen, 2011; Eslamloueyan and Kia, 2015). For instance, strong appreciation in the Nigerian Naira and Algerian Dinar in 1996/1997 and the subsequent depreciation of both currencies in 1998/1999 are generally attributed to the increase and decrease in oil prices during these periods (see OPEC, 2016). Similarly, depreciation in the currencies of these countries and other oil-exporting countries in 1986 is often explained with reference to low oil prices in 1985/1986 (see OPEC, 2016).

This chapter is based on the theoretical framework of exchange rates determination developed by Cashin, Sahay and Céspedes (2004), premised on De Gregorio and Wolf (1994). The framework emphasizes that an improvement in the terms of trade (the relative price of exports in terms of imports) produces appreciation of the domestic currency. According to this model, the economy comprises two different sectors: one produces an exportable good, and the other produces a non-traded good. In this context, a positive shock to the terms of trade leads to an increase in wages in the exporting sector and vice versa. Similar to the dynamics of the Balassa-Samuelson model of exchange rates, under the assumption of wage equalization across the two sectors, this translates to an increase in wages and prices in the non-traded goods sector and appreciation of the real exchange rate (see Habib and Kalamova, 2007; Canada *et al.*, 2016).

Several other hypotheses result in the same conclusions on the relationship between oil prices and exchange rates (see Chen and Chen, 2007). For example, aside from the described supply-side purchasing power channel, there is debate on the demand-side local price channel. According to Aastveit *et al.* (2015), disequilibrium occurs in the crude oil market when the exchange rate of the USD fluctuates. Therefore, depreciation in dollars causes the oil price to be less expensive for consumers in non-dollar regions, resulting in an increase in their commodity demand, which ultimately creates adjustments in the prices of oil denominated in USD. As the USD depreciates, the returns on dollar-denominated financial assets in foreign currencies increase the attractiveness of oil and other commodities as a class of alternative assets for foreign investors (see Crepso Cuaresma and Breitenfellner, 2008). This may lead to inflation since depreciation of the dollar increases the risks of inflationary pressures in a dollar-denominated economy like the US. The monetary variable response to movement in the dollar could be reduced by a monetary channel, as dollar depreciation may entail currency appreciation elsewhere, including oil-producing countries with currencies that are pegged to the dollar. Thus, Chen and Chen (2007) assert that lower interest rates increase liquidity, and this in turn stimulates demand for commodities. Finally, a currency market channel may also be at work if foreign exchange markets are more efficient than oil markets and it anticipates development in the real economy that affects demand for and supply of oil (Chen *et al.,* 2016).

As noted in the literature, failure to forecast exchange rates has negative consequences for international transactions and prices (see Brignall and Modell, 2000). In order to avert such consequences, theoretical constructs offer clues that could help to identify what drives the movement of exchange rates and possible measures to contain such movement within advantageous ranges. The classical theories discussed here include the traditional approach (TA), purchasing power parity (PPP), the balance of payments (BOP), Quantity Theory of Money (QTM) and the monetary approach (MA) to offer an explanation for forecasting exchange rates. Common to these theories is the fact that they highlight interest rates as a significant factor in the value of a country's currency which is considered in this study.

4.4.1.1 ***Traditional Approach (TA)***

According to Dornbusch *et al.* (2003), the TA is rooted in the premise that movement in exchange rates is consequential to changes in demand for and supply of foreign currency. This implies that equilibrium is attained when demand for foreign currency equals supply of foreign currency. Therefore, exchange rates equilibrium is attained at a point of convergence and it is in a state of disequilibrium when it is otherwise. For instance, if the demand for dollars is greater than for any of the AOECs' currencies, there is exchange rates disequilibrium between the US and the concerned country. The implications of the disequilibrium scenario are that whenever any of the oil-exporting countries experience an oil price surge, leading to more imports from other countries relative to the available supply of foreign currency, this will initiate depreciation of the domestic currency. This theory is premised on the claim that the interest rate and income trigger exchange rates movements. For example, if domestic income rises, demand by nationals of the affected countries is assumed to rise and vice versa. The attendant effects may trigger exchange depreciation and vice versa. On the other hand, a rise in the movement of interest rates in an oil-exporting country will suggest that it is profitable to invest in the local economies of oil-exporting countries. As a result, foreign investors will demand more local currency for their transactions. This will bring about a rise in the value of the local currencies compared with the exchange rates of their counterpart oil-importing countries.

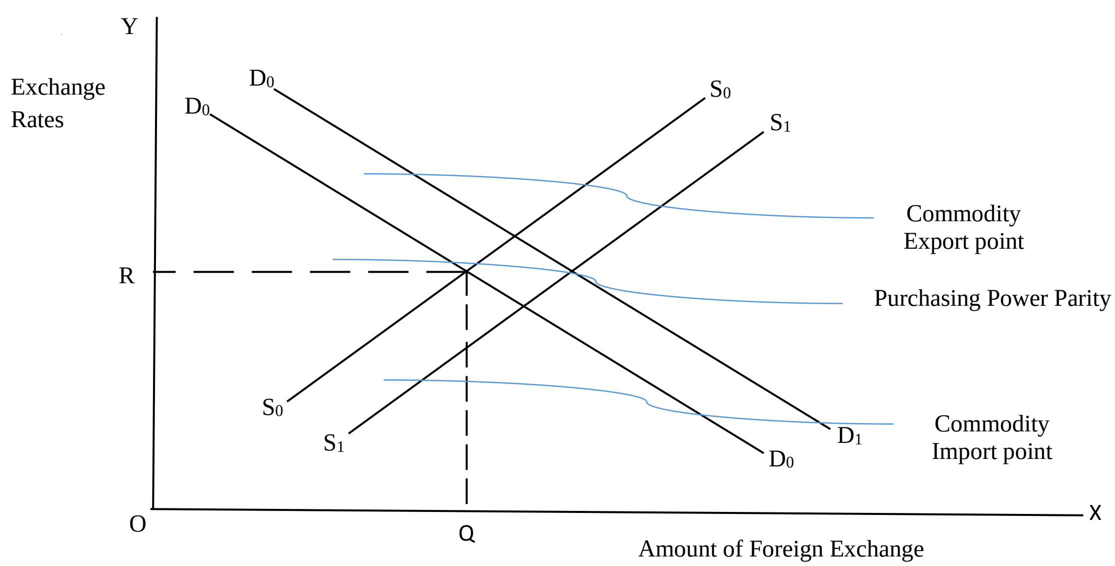
4.4.1.2 ***Monetary Approach (MA)***

The MA evolved as a result of efforts to address the weaknesses of the portfolio approach. It places emphasis on the monetary policies of two countries to determine their currency exchange rates. Two dynamics are used to determine an exchange rate: price dynamics and interest rates dynamics. The MA argues that a change in domestic money supply leads to a change in the level of prices, which in turn, results in a change in exchange rates. Hence, Frankel (1979) contends that changes in money stock have implications for other economic activities and the effects are reflected through changes in relevant economic indicators. Such indicators are presumed to include domestic output and the inflation rate and these economic indicators will also cause exchange rates to change. This is important in economies such as oil-exporting countries where exchange rate movements are not only a function of portfolio balances but of other economic activities. The MA assumes a freely-floating exchange rate regime (rather than a fixed one); minimal intervention by central banks; that the aggregate supply curve is vertical; prices of tradable goods are immediately adjusted to any change in the dynamics that affect them; and that the transmission mechanism through prices to the exchange rate is immediate.

4.4.1.3 ***Purchasing Power Parity model (PPP)***

The PPP, also referred to as the law of one price, assumes that exchange rates are proportional to relative prices between two countries. Thus, relative international prices between the two countries will closely reflect the exchange rate between them (Van Thiel and Leeuw, 2002). This approach argues in favour of making the necessary adjustment to exchange rates between countries in order for the exchange to be equivalent to each currency's purchasing power. It is important to note that the PPP advocates for the existence of "the law of one price" in which similar goods do not have the same price outside one nation's borders. It illustrates how inflation may cause movement in the domestic currency of oil-exporting countries. The PPP is based on the assumption that there are homogeneous products and there are no trade restrictions. The approach has been criticized on several grounds. For example, PPP analysis is limited to tradeable goods. Only the prices of internationally traded goods tend to balance out. According to Van Thiel and Leeuw (2002), PPP analysis is useful in forecasting long-term currency valuation and is particularly useful for corporations, carry traders, and other long-term thinkers. However, it is not appropriate for short-term currency traders.

Figure 4.2: **Purchasing Power Parity (PPP) theory is explained through**



Source: *Author's Computation (2020), using data sourced from the WDI.*

Figure 4.2 shows that, the PPP curve is characterized by fluctuations, suggesting parity movement. Alongside this, the curves indicate that both commodity export and commodity import points are prone to fluctuation. Therefore, the intersection of the demand and supply curves determines the foreign exchange rate. For instance, the market rates of exchange are OR while the quantity of foreign exchange demanded and supplied is expressed at OQ. When there is a change in demand for and supply of foreign exchange, the demand and supply curves can undergo shifts as shown by the D_1 and

S_1 curves. The direction of the shift depends on market activities and forces. If importers' demand for oil commodities rises, the exchange rate of the oil commodity exporter appreciates and vice versa, all other things held constant. Clarida *et al.* (2003) assert that this phenomenon leads to variations in the market rates of exchange around the normal rates of exchange, determined by purchasing power parity. However, the market rates of exchange will invariably lie between the limits specified by the commodity export and commodity import points.

4.4.1.3.1 **Criticism of the PPP Theory**

The main criticism of the PPP theory relates to the notion that substitutability is the mechanism employed to realign domestic prices with the internal prices of products whose prices are adjusted according to changes in the exchange rate (Clarida *et al.*, 2003). This is usually feasible when the commodities traded are identical, where spatial arbitrage takes place. However, commodities can differ in quality, quantity, and specifications, which makes a high degree of arbitrage pricing very feasible. Regardless of the criticisms leveled against the PPP approach, it continues to serve as an invaluable tool in economics (see Clarida *et al.*, 2003). Indeed, some studies argue that a model should not be criticized on the basis of its assumptions but on its ability to explain the situation at hand (see Kia, 2013). According to this theory, the exchange rate or the price parity between two countries is formulated and can be determined as expressed below:

$$\mathrm{E} = {}^{\mathrm{P_d}}/_{\mathrm{P_f}}$$

This can also be written as:

$$\mathrm{P_d} = \mathrm{E} * \mathrm{P_f}$$

where E is the PPP equilibrium exchange rate value; $\mathrm{P_d}$ is the domestic price level of a commodity; and $\mathrm{P_f}$ is the foreign price level of a commodity.

4.4.1.4 ***Balance of Payments (BOP) Approach***

The BOP theory argues that the rate at which exchange rates vary can be determined by factors that are independent of internal money supply and price level. It holds that a country's balance of payments position significantly accounts for variations in exchange rates. According to Frankel (2010), the BOP approach differs from the PPP theory in the sense that, the BOP theory is premised on the view that there exists both external and internal equilibrium. While the former assumes the existence of full employment in the economy, the later postulates BOP equilibrium. According to Brignall and Modell (2000), the external equilibrium deals with the weaknesses of the PPP.

When the exchange rate changes, it either appreciates or depreciates. Depreciation of the exchange value of the home currency of an oil-exporting country results in an increase in exports and a fall in imports. Therefore, the BOP shortfall is reduced, leading to appreciation in the domestic currency.

Similarly, if demand or supply, or both, vary, this will influence the rate of exchange. Apart from changes in demand and supply, exchange rates are affected by the foreign elasticity of demand for exports, the domestic elasticity of supply of exports, the foreign elasticity of supply of imports, and the domestic elasticity of demand for imports. For the equilibrium rate of exchange to be stable, supply elasticities are expected to be low, but demand elasticities should be high (see Clarida *et al.*, 2003). According to Clarida *et al.* (2003), the BOP theory of exchange rate determination is associated with a few advantages. The theory aims to determine exchange rates using the market forces of demand and supply, bringing exchange rate determination within the purview of the general theory of value. This theory relates the exchange rate to the balance of payments situation. This implies that, unlike the PPP theory, the BOP approach does not restrict the determination of exchange rates to merchandise trade but includes those forces that may have some effect on the demand for and supply of foreign currency or the balance of payments. It is also superior to the PPP theory from a policy point of view. It suggests that disequilibrium in the BOP can be adjusted through marginal variations in the exchange rate, viz., devaluation or revaluation (see Brignall and Modell, 2000).

Nevertheless, there are some criticisms of the BOP theory. Firstly, it rests on the assumption of perfect competition and free international trade which is unrealistic. Secondly, there is no causal connection between the rate of exchange and the price level; variations in the internal price level can certainly impact the balance of payments situation which, in turn, can affect the rate of exchange (see Rodrick, 2008). Thirdly, the theory neglects the basic value of currency. Under the gold standard, the metallic content of the standard unit of money shows the basic or optimum value of the currency. Therefore, the demand and supply theory that applies to inconvertible paper currency cannot measure the optimum or basic value of the currency.

4.4.1.5 ***Quantity Theory of Money (QTM)***

The QTM is one of the models for determining long-run equilibrium exchange rates. This theory has its origins in the monetarist school of thought, and stipulates that any change in the quantity of money affects only the price level, leaving the real sector of the economy unaffected. In the framework of international economics, a rise in money supply manifests through a proportional rise in exchange rates (see Oleka, Eyisi and Mbgodile, 2014). Therefore, exchange rates can be viewed as determined by demand for money, which is positively influenced by the growth rate of the real economy and negatively by the inflation rate. It thus cannot be ruled out that, the growth of the real economy impacts significantly on a nation's currency position. A defect of the international QTM is that it cannot account for fluctuations in real exchange rates, but only in nominal exchange rates.

4.4.2 **Empirical Literature Review**

Since the early 1920s, various studies and econometric models have sought to produce efficient forecasts and estimation of the equilibrium of exchange rates (Van Thiel and Leeuw, 2002). However, exchange rates prediction remains one of the most challenging applications of modern time series forecasting as these rates are fundamentally noisy, non-stationary and deterministically chaotic (see Kim *et al.*, 2017; MacDonald and Taylor, 1992; Chen and Rogoff, 2003; Frankel 1979; Dornbusch *et al.*, 2003). These features suggest that no perfect information is obtainable from the previous behavior of such markets to fully capture the dependency between future rates and those of the past. In such situations, it is widely assumed that historical data captures past behavior to some extent. As a result, historical data is a major player or input in the prediction process. Time series modeling is the conventional technique used to model exchange rates. However, these techniques have limitations as the exchange rate series are non-stationary and noisy (Chen and Rogoff, 2003).

Some studies have observed the predictability of the dynamics of exchange rates of non-linear models like Artificial Neural Networks (ANN), Genetic Algorithms (GA), expert systems or fuzzy models, leading to conflicting results (see Clarida *et al.*, 2003; Hassani, Soofi and Zhigljavsky, 2010; Brooks, 2019; Chen *et al.*, 2016). Others have compared traditional time series models with computational models for forecasting. These models are unsatisfactory because they are parametric, and some are based on the assumption that the time series forecast are linear and stationary. Many previous studies, for instance, Bara, Mugano and Le Roux (2016) and Giles (2013) suggest that non-linear models such as neural network models perform better than traditional time series linear models. Regardless of these views, several studies relating to financial market predictions have suggested that foreign exchange rates are predictable with high accuracy (see Haskamp, 2017; Macdonald and Taylor, 1992). Empirical studies on oil prices and exchange rates have established that both are important macroeconomic variables and that their variation may impair economic growth. Supporting this claim, Cunado and De Gracia (2005) provide evidence that variations in real exchange rates lead to decreases in per capita income.

Exchange rate volatility is one of the central mechanisms in the so-called Dutch Disease. A resource-rich country has the tendency to contract this disease when a higher resource price leads to real exchange rates appreciation which, in turn, undercuts the competitiveness of domestic industries producing traded goods (Cunado *et al.,* 2016). A decrease in competitiveness causes the tradable goods industry to contract and it could have difficulty in recovering from the ultimate price slump. Not only may firms be unwilling to invest in the face of future volatility, but they may also have lost their comparative advantage during the period of contraction. This may lead to de-industrialization which could inhibit long-term growth as the manufacturing industry tends to be more competitive and innovative than other sectors.

Various empirical studies on exchange rate forecasts among individual and groups of oil-exporting nations have emphasized the importance of factors such as terms of trade or the Balassa-Samuelson “productivity hypothesis”. In these studies, terms of trade are commonly approximated by real oil prices (see Backus and Crucini, 1998; Baxter and Kourparitsas, 2000), while some studies have used labels like “Petrol-currency” or “oil currency” to describe the apparent significance of this factor in explaining real exchange rate movements. Nonetheless, empirical evidence has not been consistent (see Baxter and Kourparitsas, 2000; Korhonen and Juurikkala, 2007; Tiwari, Mutascu and Albulescu, 2013; Canada *et al.,* 2016).

In individual country settings, there have been attempts to explain changes over time in the estimated extent of covariation between real oil prices and real exchange rates. For example, Sosunov and Zamulin (2006) point to the relative importance of oil exports in the domestic economy following oil price hikes to account for the degree of appreciation. Habib and Kalamova (2007) discuss the likely importance of policy responses and revenue management. From the perspective of the monetary approach to the BOP, a rise in money supply reduces purchasing power which increases the price level and as a result reduces real exchange rates. The same is the case with debt to GDP of a foreign country, with the demand for foreign currency decreasing, leading to lower real exchange rates in the domestic economy (Kia, 2013).

While it is believed that variations in oil prices may trigger currency movements in some oil-exporting countries, there seems to be little evidence for the relationship in some of the biggest oil exporters in the world (see Rickne, 2009). Studies that document that oil prices play an important role in exchange rates determination include those of Korhonen and Juurikkala (2007), who focus on a group of nine OPEC countries (Venezuela, Saudi Arabia, Kuwait, Nigeria, Iran, Indonesia, Gabon, Ecuador, and Algeria) and Rickne (2009). These studies also examine the role played by institutions in oil prices and real exchange rate movements in oil-exporting countries. From a country-specific perspective, Koranchelian (2005) and Zalduendo (2006) document the key role played by the oil price as a trigger of real exchange rates movements in countries such as Venezuela. Other studies provide empirical evidence in favour of the Russian Ruble being an oil currency (see Oomes and Kalacheva, 2007; Spatafora and Stavrev, 2003). Contrary to these findings, Bjornland and Hungnes (2008) and Akram (2004) reported either numerically weak or statistically insignificant relationships between the Norwegian Krone and oil prices. Similarly, there has been considerable unwillingness to label the Canadian dollar as a Petro currency, with researchers reporting negative and even insignificant relationships (Amano and van Norden, 1995).

Finally, Habib and Kalamova's (2007) empirical study of the world's largest oil exporters, Russia, Norway, and Saudi Arabia, finds that the oil price influences the movement of the Russian Ruble, but that the currencies of Norway and Saudi Arabia remain unaffected by price shocks.

Empirical studies on the relationship between oil prices and exchange rates conducted in different countries using various estimating techniques have concluded that there is no certainty that oil prices affect the movement of the real exchange rate (see Coleman *et al.*, 2011; Bouoiyour and Selmi, 2014). Using a combination of nonlinear causality tests and wavelet analysis, Bouoiyour and Selmi (2014) reveal that the relationship between the USD and oil prices is very complex, and that it depends on the frequency range or time scale.

Al-mulali and Sab (2009)'s research on the impact of oil prices on the real exchange rates of the UAE Dirham shows that for every one percent rise in the oil price from 1977-2007, exchange rates increased by 0.16 percent. Tiwari *et al.* (2013) used the Discrete Wavelet Transform (DWT) and found that oil prices had a strong effect on the real exchange rate in both the short and the long run in Romania, where a rise in oil prices was observed to lead to real appreciation of the national currency.

Goudarzi *et al*. (2012) and Mariano, Sablan, Sardon and Mae (2015), used a VAR model and suggest that oil prices account for about 29 percent of real exchange movement in Iran from 1978 to 2008. Using variance decomposition, the study also reveals that the oil price has a positive impact on real exchange rates.

Ahmad and Hernandez (2013) examine the long-run relationship and asymmetric adjustment between real oil prices and the real bilateral exchange rates of twelve major oil producers and consumers in the world. They employ a monthly data set and implement threshold autoregressive (TAR) and momentum threshold autoregressive (M-TAR) models. Their findings show that a rise in oil prices leads to real appreciation of exchange rates. Beckmann and Czudaj (2012) empirically examine the effect of oil prices on effective dollar exchange rates using data on trade-weighted and real effective exchange rates from the Federal Reserve in the US. Their findings also show that there is a relationship between oil prices and real exchange rates, with the real dollar value appreciating after a rise in oil prices.

Jahan-Parvar and Mohammadi (2011) examine the relationship between real exchange rates and real oil prices in oil-exporting countries using a Bounds Testing Approach, to test the validity of the Dutch Disease hypothesis. The authors use the ARDL model and the results show a stable long-run relationship between real exchange rates and real oil prices in fourteen oil-exporting countries.

Using a VAR model, Al-mulali (2010) examines the impact of oil prices on exchange rates and economic growth in Norway. The findings reveal that an increase in oil prices leads to real exchange rates depreciation. His findings are similar to Iwayemi and Fowowe (2011), who use GARCH-type models to analyze the relationship between oil prices and the exchange rate in South Africa. Their results show that the South African rand depreciates against the USD when the oil price increases.

Using various causality tests, Tiwari *et al*. (2013) investigate the connection between the oil price and the exchange rate and show that oil prices have no significant effect on exchange rates and vice versa. Lizardo and Mollick (2010) find that a rise in real oil prices leads to depreciation of the USD relative to net oil exporter nations and a decline in the currency value among importing countries.

A considerable number of empirical studies have recognized a positive relationship between stock prices and real exchange rates (see Kasman, 2003). Le and Chang (2003) use monthly data and employ cointegration and Granger causality estimating techniques to empirically investigate the causal relationship between the real exchange rates of the Chinese Renminbi (RMB) in terms of Hong Kong dollars (REX) and the Hong Kong Stock Market Index in terms of the Hang Seng Index (HSI) and China. Their results reveal that there is a long-run equilibrium relationship between the REX and the HSI. The study concludes that movement in the real exchange rate of the RMB leads to movement of the HSI to a certain degree. However, when the RMB appreciates against the Hong Kong dollar (HKD), the HSI also appreciates. This might imply that the positive effect of capital flows to goods and assets markets in the Hong Kong stock market is leading to the revaluation of the RMB against the HKD. Buttressing this claim, Kasman (2003) attests to the existence of a long-run relationship between the stock price and exchange rate using high-frequency data on exchange rates and aggregate stock indices in Turkey, involving time series techniques. This means that, the stock indices of the HSI and exchange rates move together in the long run.

On the relationship between GDP and exchange rates, a few studies such as Patosa and Cruz (2013), Goudarzi *et al*. (2012) and Rodrik (2008) argue that a rise in GDP leads to appreciation in real exchange rates. Patosa and Cruz (2013) conducted research on the factors affecting exchange rate movements in selected Asian countries, namely, China, Malaysia, Thailand, Philippines, and Singapore using data from the World Bank for the period 1977 to 2010. The real interest differential (RID) model supported by the Keynesian and Chicago price theories (K and CPT) was used in the study. Their results showed that industrial production or GDP has a negative coefficient in the RID model, indicating that when industrial production increases, the currency appreciates. This is true for all five countries in the study. A rise in domestic industrial production or output level raises domestic money demand, leading to a fall in the long-run domestic price level. Similarly, Patosa and Cruz (2013) tackle the Dutch Disease phenomenon. Their study emphasizes that real exchange rates tend to appreciate as the price of non-tradable goods increases.

In practice, analysis of the factors influencing the exchange rate must consider their interdependence and the connection between them, which ultimately lead to currency appreciation or depreciation. Mariano *et al*. (2015) examine the factors affecting exchange rate changes in Pakistan from 1975 to 2000. The stationarity of the data is determined using the Augmented Dickey-Fuller (ADF) test and the ordinary least square (OLS) method is used to analyze the results. According to this study, the factors influencing exchange rates are exports, imports, economic growth, and inflation. The findings from the model reveal that 98.2 percent of changes in exchange rates are associated with these four factors. The findings further reveal that economic growth ranks second to significantly account for variations in exchange rates. Contrary to this claim, previous study like Twarowska and Kakol (2014) reveal that, as GDP increases, exchange rates depreciate. Studies produce similar results despite the fact that they use different methodologies. For instance, Goudarzi *et al.* (2012) use the evolution of the thirty-quarter rolling correlation coefficient between the cyclical components of real GDP and real effective exchange rates (REER), obtained by using HP-filtered series and their findings suggest that the real exchange rate depreciates when economic growth is strong.

Various empirical studies focus on exchange rates forecasts. The asset approach highlights the importance of asset prices in the exchange rate forecast. In this approach, the interest rates differential is identified as the main driving force behind exchange rate movement between countries. Therefore, the covered and uncovered interest parity conditions are used to forecast exchange rates. Another line of research uses the PPP hypothesis to study exchange rate dynamics. In these models, the relative price level mainly forecasts exchange rates movement. This strand of research can be linked to the money market to examine how money supply and demand can influence exchange rates through changing the interest rate, price levels, and expectations about future exchange rates variations. In brief, many monetary models of exchange rates forecasts are derived from the PPP hypothesis, interest parity condition, money demand, and money supply functions.

The monetary approach to BOP has also been used to examine the exchange rates forecast and these studies have found evidence in support of monetary models as mechanisms to forecast exchange rates (see Pedram and Ebrahimi 2014; Crespo-Cuaresma *et al*., 2005; Bitzenis and Marangos, 2007; Uz and Ketenci, 2008; Hsing, 2008). Most empirical studies have used time series models to determine exchange rates between two countries while others have employed panel data models. For instance, Camarero and Tamarit (2002), Crespo-Cuaresma *et al*. (2005) and Uz and Ketenci (2008) use panel cointegration models to examine exchange rates movement. Camarero and Tamarit (2002) employ a monetary approach to determine the bilateral real exchange rate of the Peseta relative to nine EU members. Their results show that both supply and demand variables were important in the evolution of the Peseta during the study period. Crespo-Cuaresma *et al*. (2005) use a panel dataset for six Central and Eastern European countries (CEECs) to estimate the monetary exchange rate model with the panel cointegration method. They show that the monetary model can explain the long-run exchange rates relationships of a group of CEECs. Uz and Ketenci (2008) utilize different panel cointegration tests and show that there is a long-run relationship between nominal exchange rates and monetary variables such as the interest rate differential, price differential, monetary differential and output differential among ten EU members and Turkey. Although, the panel estimating technique to forecast exchange rates is well supported (see Al Mamun *et al.*, 2013), it might not be found suitable to forecast the exchange rates of a group of countries like the AOECs because of difference in their national set up and economic system which may influence the factors determining exchange rates in these countries.

Jahan-Parvar and Mohammadi (2011) use the ARDL bounds testing approach to examine the validity of the Dutch Disease hypothesis by examining the relationship between real oil prices and real exchange rates in a sample of fourteen oil-exporting countries. Their results support the existence of a relationship between real exchange rates and real oil prices in the countries under investigation. Tsen (2011) studies the effect of the oil price through the terms of trade on the real exchange rate in Hong Kong, Japan, and Korea. The study finds that the real oil price, along with the productivity differential, terms of trade, and reserve differential, are important factors in forecasting exchange rates.

The existing literature on exchange rates forecasting ignores the fact that external factors such as foreign countries' debt and debt management (how governments finance their debt) as well as a crisis can affect the degree of competitiveness (exchange rate) of an oil-producing country. In addition, it is possible that a small deviation from a long-run equilibrium is ignored which could cause agents to react to a large deviation. This situation is also ignored in the existing literature. In addition to its focus, this study extends the literature by focusing on those factors that may forecast the exchange rates of oil-producing countries that rely heavily on revenue from exporting oil resources. More precisely, the study is narrowed down to consider those factors within the context of AOECs (Algeria, Egypt, Gabon, Libya, and Nigeria). Consequently, the model estimated is capable of investigating the effect of the factors that have been ignored in the literature on exchange rates forecasts for these countries.

Studies have found that, over the long run, besides money supply, domestic GDP and government expenditure, price level and interest rates also influence exchange rates. Eslamloueyan and Kia's (2015) study on MENA shows that, over the short run, changes in domestic and US interest rates as well as the US debt per GDP, the US stock market crisis of 1987, and the economic crisis of 2008 affected exchange rates in these countries. Furthermore, the study reveals that economic agents in these countries ignore a small deviation from equilibrium but react considerably to a huge deviation in such a way as to depart more from the long-run equilibrium. It also shows that, over two periods, market forces and/or monetary or fiscal policy bring exchange rates back to equilibrium.

4.5 **Methodology**

This study aims to model the exchange rates of the AOECs to understand their exchange rate behavior in order to guide policy makers in their decision making. In doing so, it establishes how global oil prices impact exchange rates or how exchange rates respond to variations in oil prices. The study uses the dataset of each country covering the period 1980 to 2018. Data availability dictated the choice of both the starting and cut-off dates, as well as the number of countries considered in this study. In addition, the choice of the countries follows the OPEC benchmark classification of exporting countries (see OPEC, 2014). The researcher considered all the oil-producing countries in Africa as defined by OPEC and eliminated those where data for selected macroeconomic indicators was not available, reducing the number of countries to five which is consistent with OPEC net exports benchmarking. The five AOECs under investigation are Algeria, Egypt, Gabon, Libya, and Nigeria. Although Angola has large oil deposits and is a major net exporter in Africa, it was dropped from the sample due to a lack of the required data.

The existing literature employs several estimating techniques to forecast fundamental macroeconomic variables. Prominent among these are Autoregressive and Seasonal Exponential Smoothing models (see Ezeabasili *et al*., 2011), the SARIMA model (see Etuk *et al*., 2016;

Osarumwese and Waziri, 2013; Onasanya and Adeniji, 2013), GARCH Models (see Musa *et al*., 2014), State Space Models (see Khashif *et al*., 2008), ARIMA Models (see Onasanya and Adeniji, 2013), and Time Series and Neural Networks approaches (Pedram and Ebahimi, 2014). Each of these techniques comes with its own strengths and weaknesses.

Following Kia (2013) and Asghar, Qureshi and Nadeem (2015), this study employs the ARDL in the time series context. This is similar to, but deviates slightly from Eslamloueyan and Kia's (2015) study. Unlike Eslamloueyan and Kia's (2015) research that is based on panel investigation, this study focuses on the time series technique based on the belief that the factors that determine exchange rates may vary among the countries and over a given period of time (see Hueng, 1999). The choice of this technique is influenced by several reasons, discussed in section 4.5.1 below.

4.5.1 Model Specification

This study adopts the utility function of Kia (2013) and Eslamloueyan and Kia (2015) as presented in (1). This is also in line with Hueng (1999) and Goudarzi *et al.* (2012) who employ a model that assumes that the economy is a single consumer (representing many identical consumers), that labour is inelastic in supply, and that total output is exogenous. Note that none of the results will be affected if we relax these assumptions. The consumer is assumed to maximize the following utility function:

$$E\left\{\sum_{t=0}^{\infty} \propto^{t} U\left(\dot{C}_t, \dot{C}_t^{*}, \varpi_t, {}^{n_t}/_{k_t}, {}^{n_t^*}/_{k_t^*}\right)\right\} \tag{1}$$

$$\varpi = \omega/p \tag{1.2}$$

where: $\dot{C}_t$ and $\dot{C}_t^*$ respectively, represent single real domestic and foreign consumption goods; n_t and n_t^* respectively represent the holdings of domestic real $\left({}^{n}/_{p}\right)$ and foreign real $\left({}^{n^*}/_{p^*}\right)$ cash balances; E symbolizes the expectation operator, and the discount factor satisfies the $0 < \propto < 1$ condition; and ϖ represents real government expenditure on services and goods, and it is assumed to be a "good" in itself (see Eslamloueyan and Kia, 2015).

This study also follows Hueng (1999) and Kia (2013) in assuming that domestic and foreign goods are respectively purchased with domestic and foreign currencies. This suggests that the services of both domestic and foreign currencies can go into the utility function. Consequently, the study selects the units such that the services of domestic money and the services of foreign money are respectively equal to n and n^*. Then the risks inherent in holding n and n^* are respectively reflected by k_t and k_t^*. This implies that if the associated risks of holding n and n^*increase, the number of services that domestic currency and its counterpart, foreign currency could purchase will fall.

If we assume that the services of domestic money change for oil-exporting countries as the oil price changes, we specifically postulate that over the long run,

$$\log(k_t) = k_0 + k_1 \log(OP_t) \tag{2}$$

Where:

k_0 and k_1 are parameters, OP denotes oil price. The variable oil price is the price at which oil is sold on the international market and it is considered as exogenous. Ceteris paribus, it is expected that as the prices of oil rise, the associated risks of withholding the currency of an oil-exporting economy decline, suggesting that $k_1 < 0$. Inversely, the associated risks of withholding the currency of an oil-importing economy increase, implying that $k_1 > 0$. As the prices of oil rise, the demand for the money of net oil-exporting countries will simultaneously rise, resulting in appreciation in the value of their currency.

Following Kia (2013), this study assumes that (k^*) summarizes the risk associated with holding foreign currency (e.g., USD), given by:

$$\log(k_t^*) = k_0^* + k_1^* \xi gdp_t^* + k_2^* \zeta gdp_t^* \tag{3}$$

where, k_0^*, k_1^* and k_2^* are parameters. Variables ξgdp^* and ζgdp respectively, represent outstanding foreign debt per GDP and foreign-government financed debt per foreign GDP. A rise in foreign debt is assumed to be associated with future monetization of debt and a decline in the value of the foreign currency (i.e., a fall in demand for foreign currency), and thus, $k_1^* > 0$. Similarly, a rise in the amount of government debt held by foreign investors/governments may be considered a reason for future foreign currency devaluation, inferring that $k_2^* > 0$. It is necessary to note that the currency holders of net oil-importing nations consider that the deficit and/or outstanding debt of these countries increases the risk of holding the currency of these countries (see Eslamloueyan and Kia, 2015). Conversely, currency holders of net oil-exporting countries do not. The associated cause is that investors expect the various governments of net oil-exporting nations to finance their debt obligations and deficits solely through crude oil exports. Therefore, the change in the oil price is only relevant to the risk associated with the currency holding of these countries.

Thus (3) holds, subject to the short-run dynamics of the system. To be specific, it is assumed that the short-run dynamics of the risk variable associated with holding foreign currency [log $(k)^*$] include a set of interventional dummies that account for political changes, economic crisis, and policy regime changes that influence the value of money. According to Kia (2013), the utility function (U) is assumed to be rising in all its claims (except variables k and k*, which are declining), and is strictly concave and uninterruptedly differentiable. Accordingly, following Kia (2013) and Sidrauski (1967), demand for the services of money (both domestic and foreign), $\mathrm{ƀ}[=n]$ and $\mathrm{ƀ}^*[=n^*]$, will always be greater than zero (i.e >0), if we assume that $\lim_{\mathrm{ƀ}\to 0} U_{\mathrm{ƀ}}\left(\dot{C}_t, \dot{C}_t^*, \varpi_t, {n_t}/{k_t}, {n_t^*}/{k_t^*}\right) = \infty$ and $\lim_{\mathrm{ƀ}^*\to 0} U_{\mathrm{ƀ}}\left(\dot{C}_t, \dot{C}_t^*, \varpi_t, {n_t}/{k_t}, {n_t^*}/{k_t^*}\right) = \infty$, for all $\dot{C}$ and $\dot{C}^*$, where, for instance,

$U_{\mathrm{ƀ}} = \partial U\left(\dot{C}_t, \dot{C}_t^*, \varpi_t, {n_t}/{k_t}, {n_t^*}/{k_t^*}\right)\partial \mathrm{ƀ}$. Similarly, let us assume that the USD denotes foreign currency. Therefore, given ϖ, the consumer maximizes equation 1, subject to the following budget constraint:

$$\phi_t + z_t + (1+\Delta_t)^{-1}n_{t-1} + q_t(1+\Delta_t^*)^{-1}n_{t-1}^* + (1+\Delta_t)^{-1}(1+\text{И}_{t-1})d_{t-1} + q_t(1+\Delta_t^*)^{-1}(1+\text{И}_{t-1}^*)d_{t-1}^* = \dot{C}_t + q_t\dot{C}_t^* + n_t + q_t n_t^* + q_t d_t^* \tag{4}$$

where: ϕ denotes the real value of any lump-sum transfers/taxes received/paid by consumers; z_t represents the current real endowment (income) received by the individual; Δ denotes the price level proxied by the consumer price index; q denotes the real exchange rate[16]. n_{t-1}^* represents the foreign real money holdings at the beginning of the period; d_t is the one-period real domestically funded government debt, which pays И rate of returns; and d_t^* symbolizes the real foreign-issued one-period bond, which pays a risk-free interest rate И_t^*. Assume further that d_t and d_t^* are the only two storable financial assets.

We define $U_{\dot{C}} = \partial U\left(\dot{C}, \dot{C}_t^*, \varpi_t, {n_t}/{k_t}, {n_t^*}/{k_t^*}\right)\partial \dot{C}$; $U_{\dot{C}^*} = \partial U\left(\dot{C}_t, \dot{C}_t^*, \varpi_t, {n_t}/{k_t}, {n_t^*}/{k_t^*}\right)\partial \dot{C}^*$; $U_n = \partial U\left(\dot{C}_t, \dot{C}_t^*, \varpi_t, {n_t}/{k_t}, {n_t^*}/{k_t^*}\right)\partial n$; $U_{n^*} = \partial U\left(\dot{C}_t, \dot{C}_t^*, \varpi_t, {n_t}/{k_t}, {n_t^*}/{k_t^*}\right)\partial n^*$ and $\lambda_t =$ marginal utility (MU) of wealth in period t. To derive the first-order conditions, we maximize the preferences with respect to $\dot{C}$, $\dot{C}^*$, n, n^*, d, and d^*, subject to the budget constraints (4) for the given output and fiscal variables.

$$U_{\dot{C}_t} = \lambda_t \tag{5}$$

$$U_{\dot{C}_t^*} = \lambda_t q_t \tag{6}$$

[16] The real exchange rate is defined as $q_t = E_t\left(\frac{P_t^*}{p_t}\right)$ where: E_t represents the nominal market (nonofficial/black-market rate in some developing countries) exchange rate (domestic price of foreign currency); and P_t^* and P_t are the foreign and domestic price levels of foreign and domestic goods, respectively (see Kia, 2013).

$$U_{n_t} + \lambda_t - \alpha\lambda^e_{t+1}\,(1+\Delta^e_{t+1})^{-1} = 0 \tag{7}$$

$$U_{n^*_t} + \lambda_t q_t - \alpha\lambda^e_{t+1} q^e_{t+1}\,(1+\Delta^{*e}_{t+1})^{-1} = 0 \tag{8}$$

$$\lambda_t - \alpha\lambda^e_{t+1}(1+И_t)\,(1+\Delta^e_{t+1})^{-1} = 0 \tag{9}$$

$$\lambda_t q_t - \alpha\lambda^e_{t+1} q^e_{t+1}(1+И^*_t)\,(1+\Delta^{*e}_{t+1})^{-1} = 0 \tag{10}$$

We derive equation (11) from (5) and (6)[17]. The equation shows that the marginal rate of substitution (MRS) between domestic and foreign goods equals their relative price.

$$\frac{U_{\dot{C}_t}}{U_{\dot{C}^*_t}} = \frac{1}{q_t} \tag{11}$$

However, equation 12 evolves by solving (6), (8) and (10):

$$U_{\dot{C}^*_t}\,(1+И^*_t)^{-1} + U_{n^*_t} = U_{\dot{C}^*_t} \tag{12}$$

Building from these equations (i.e., (6), (8) and (10)) to derive (12), this suggests that the expected marginal advantage of adding to holdings at time t must be equal to the marginal utility from consuming foreign goods at time t. Note that the holding of foreign currency directly yields utility through its services($U_{n^*_t}$). Consequently, from (6) and (10), we have $(-U_{\dot{C}^*_t}) = \alpha\lambda^e_{t+1} q^e_{t+1}(1+И^*_t)\,(1+\Delta^{*e}_{t+1})^{-1}$. This implies that the probable real foreign currency invested in foreign bonds has a forgone value of $U_{\dot{C}^*_t}$. Thus, the Total Marginal Benefit (TMB) of holding money at period t is $U_{\dot{C}^*_t} + U_{n^*_t}$.

Similar to (12), we derive (13) below by solving (6), (8) and (10):

$$U_{\dot{C}_t}\,(1+И_t)^{-1} + U_{n_t} = U_{\dot{C}_t} \tag{13}$$

This equation (13) evolves with the implication that the expected marginal benefit from adding to domestic currency holdings at the time (t) must be equal to the marginal utility (MU) of consuming domestic goods at a time (t). Consequently, we assume that the utility has an immediate function to construct a parametric demand for real balances. Therefore, given that:

[17] Note that, $y^e_{t-1} = E(y_{t+1}|I_t)$ is the conditional expectation of y_{t+1}, given current information I_t.

$$U(\dot{C}_t, \dot{C}^*_t, \varpi_t, n_t, k_t, n^*_t, k^*_t) = (1-\varphi)^{-1}\left(\dot{C}_t^{\varphi_1}\dot{C}_t^{*\varphi_2}\ \varpi_t^{\varphi_3}\right)^{1-\varphi} + v(1-r)^{-1}\left[\left({n_t}/{k_t}\right)^{r_1}\left({n^*_t}/{k^*_t}\right)^{r_2}\right]^{1-r} \quad (14)$$

where $\varphi_1 > 0, \varphi_2 > 0, \varphi_3 > 0, \varphi > 0, r_1 > 0, r_2 > 0, r > 0$ and $v > 0$. They are all positive parameters. $0.5 < \varphi < 1$ and $0.5 < r < 1$. For the sake of convenience, these parameters are all assumed to be equal to one (1), since none of the following results is sensitive to the magnitude of $\varphi_1, \varphi_2, \varphi_3, r_1$ and r_2.[18] The utility function derived in equation (14) is similar to what Kia (2006) assumes. Nevertheless, the fact that there is also risk associated with holding foreign currency is ignored (see Kia, 2006). Using equations (11) and (14), we have equation (15) below:

$$\dot{C}^*_t = \left({\varphi_2}/{\varphi_1}\right)\dot{C}_t q_t^{-1}$$

Given that ${\varphi_2}/{\varphi_1} = 1$, we can express (15) as:

$\dot{C}^*_t = \dot{C}_t q_t^{-1}$, or linearize $\log\dot{C}^*_t = \log\dot{C}_t + \log(q_t^{-1})$

$$\log\dot{C}^*_t = \log\dot{C}_t + \log q_t^{-1} \quad (15)$$

Following Kia (2006) and the assumption that $\varphi_1 = \varphi_2 = \varphi_3 = r_1 = r_2 = 1$, we solve (12), (14) and (15) to derive:

$$\left({v}/{k^*_t}\left({n_t}/{k_t}\right)^{r_1(1-r)}\left({n^*_t}/{k^*_t}\right)^{-r} \Big/ \left[\varphi_2 \dot{C}_t^{\varphi_1(1-\varphi)}\dot{C}_t^{*(\varphi_2-1)-\varphi_2\varphi}\varpi_t^{\varphi_3(1-\varphi)}\right] \right) = \left({И^*_t}/{1-И^*_t}\right) \quad (15.1)$$

Substituting (15) in (15.1) and solving for n^*_t,

$$n^*_t = k_t^{*\,{(r-1)}/{r}}\left({И^*_t}/{(1+И^*_t)}\right)^{(-1/r)}\left(\beta_t^{(1-2\varphi)}\omega_t^{(1-\varphi)}q_t^{\varphi}\right)^{(-1/r)} v^{(-1/r)}(k_t^{-1}n_t)^{(1-r/r)}, \text{ or}$$

$$\log(n^*_t) = {(r-1)}/{r}\log(k^*_t) - (r^{-1})\log\left({И^*_t}/{(1+И^*_t)}\right) - (r^{-1})(1-2\varphi)\log(\dot{C}_t) - (r^{-1})\varphi\log(q_t) - (r^{-1})(1-\varphi)\log(\varpi_t) + (r^{-1})\log(v) + (r^{-1}-1)\log(n_t) - (r^{-1}-1)\log(k_t) \quad (16)$$

[18] However, if the assumption of inelastic supply of labour (income is exogenous) is relaxed, there would be a need to add an extra term: for instance, $-(1-\varphi_3)^{-1}(N_t)^{1-\varphi_3}$ (14). N denotes hours worked and $\varphi_3 \geq 0$, denotes Frisch labour elasticity of supply. In a situation like this, one can easily verify that none of our results will be different.

As noted in (16), $r < 1$. Therefore, a rise in the foreign risk leads to a reduction in demand for foreign currency while a rise in the domestic risk leads to a rise in demand for foreign currency. It should be noted that (16) is not a final equilibrium condition. With reference to our assumption of a utility function that is found in (14), a representative consumer must have both currencies in his/her satisfaction function (see Kia, 2006). The elimination of one will lead to the elimination of the other. For the sake of simplicity, we use (13), (14), (15), and (16), and assume that domestic real consumption($\dot{C}_t$) is some constant proportion ($\mho$) of domestic real income z_t, where for simplicity's sake, we further assume that $\mho = 1$. We will then have:

$$\log((n_t) = n_0 + n_1 \mathrm{Int}_t + n_2 \log(z_t) + n_3 \log(\varpi_t) + n_4 \log(k_t) + n_5 \log(q_t) + n_6 \log(I_t) + n_7 \log(k_t^*) \quad (17)$$

[19]

where; $I_t^* = \log\left[И_t^* / (1 + И_t^*) \right]$; $I_t = \log\left[И_t / (1 + И_t) \right]$, using $0.5 < \varphi < 0.5$ and $0.5 < r < 1$, we will have,

$n_0 = -1\left(1/(1 - 2r) \right) \log(v) > 0$; $n_1 = r(1 - 2r)^{-1} < 0$; $n_2 = (1 - 2r)^{-1}(1 - 2\varphi) > 0$; $n_3 = -(1 - \varphi) < 0$; $n_4 = (1 - 2r)^{-1}(1 - r) < 0$; $n_5 = -(1 - 2r)^{-1}(r - 1)\varphi - r(1 - r)] < 0$; $n_6 = -(r - 1)(r - 2r)^{-1} < 0$ and $n_7 = (1 - 2r)^{-1}(1 - r) < 0$.

Consequently, it is important to understand that, as the risk associated with any of these currencies increases, demand for a bond, as well as goods and services, will rise. At the equilibrium, we will have log $((n_t)$ = log (n_t^s), where m^s denotes the supply of money. Substituting log (n^s) for log (n) in Equation (17) and Equations (2) and (3), for log(k) and log(k^*) in Equation (17), and solving for log (q_t) gives:

$$\log(q_t) = ȝ_0 + ȝ_1 lnms_t + ȝ_2 int_t + ȝ_3 lngdp_t + ȝ_4 lnop_t + ȝ_5 I_t + ȝ_6 dbtgdp_t + U_t \quad (18)$$

where q is the exchange rates, ȝ represents the parameters of the forecasting model; lnms denotes log of money supply; int represents interest rates; lngdp denotes log of GDP; lnop is the log of the price of oil on the international market; I denotes inflation, and the $dbtgdp$ is the percent of external debt to GDP.

[19] The coefficients of both k_t and k_t^* are negative. This implies that both the domestic and foreign risks associated with holding domestic and foreign currencies reduce demand for domestic currency. This is because, as indicated in (16), demand for domestic currency (n) has a positive relationship with demand for foreign currency(n^*). Therefore, as (k^*) goes up, (n^*) will fall, which results in a fall of (n).

Further defining the parameters, they are expressed below:

$$\text{ȣ}_0 = -\left({}^{n_0}/{}_{n_5}\right) - \left({}^{n_4}/{}_{n_5 k_0}\right) - \left({}^{n_7}/{}_{n_5 k_0^*}\right) > 0;\ \text{ȣ}_1 = \left({}^{1}/{}_{n_5}\right) < 0;\ \text{ȣ}_2 = -\left({}^{n_1}/{}_{n_5}\right) < 0;$$

$$\text{ȣ}_3 = -\left({}^{n_2}/{}_{n_5}\right) > 0;\ \text{ȣ}_4 = -\left({}^{n_4}/{}_{n_5 k_1}\right) > 0;\ \text{ȣ}_5 = -\left({}^{n_6}/{}_{n_5}\right) > 0;\ \text{ȣ}_6 = -\left({}^{n_7}/{}_{n_5 k_1^*}\right) < 0$$

Equation (18) expresses a long-run real exchange rates relationship. The error term U is added and assumed to be white noise or random walk in the model. Following Eslamloueyan and Kia (2015) and Kia (2006), this equation assumes that an increase in the interest rate and money supply may lead to lower exchange rates over the long-run period. This is associated with the fact that a rise in the interest rate or money supply could cause a rise in prices over the long run, which eventually results in lower real exchange rates. This validates Kia's (2006) view that, given the time path of fiscal policy and that government interest-bearing debt can be sold only at a real interest rate above the growth rate n, the tighter the current monetary policy, the higher must the rate of inflation eventually be. Higher real income leads to higher real exchange rates in the long run. Similarly, higher real income may also result in higher real demand for money and a lower price level and hence, higher exchange rates (See Eslamloueyan and Kia, 2015). A higher oil price leads to higher demand for domestic currency and lower demand for goods and services and prices. Subsequently, a higher oil price results in appreciation of the real exchange rates.

A higher oil price, leading to a rise in exchange rates affects those factors that impact the risk associated with holding foreign currency. Factors such as foreign debt will lead to lower real exchange rates. The reason may be that these factors reduce demand for money, which may result in higher demand for goods and services and price levels (lower real exchange rates). It should be emphasised that the long-run Equation (18) is also subject to short-run dynamics, which include stationary variables that represent a crisis as well as policy regime changes and other exogenous factors that affect the system in both domestic and foreign countries (See Eslamloueyan and Kia, 2015; Sarno *et al.,* 2004).

The long-run exchange rates relationship specified in equation (18) varies from the one found in the literature on real exchange rates for commodity-resource-oriented countries. For instance, Cashin *et al*.'s (2004) real exchange rate model is a function of the productivity differentials between the export and import (foreign) sectors, the commodity terms of trade (or the price of the primary commodity with respect to the intermediate foreign good) and the productivity differentials between local and foreign nontraded sectors. Chen and Rogoff's (2003) real exchange rates model is a function of commodity prices and terms of trade, and Bodart Candelon and Carpantier's (2012) real exchange rates model is only a function of the commodity price. While Musyoki and Kadubo (2012) argue in favour of foreign debt in any economy, especially developing countries that could resort to foreign financing to foster internal growth and increase the resources available for investment, none of these models incorporate foreign debt. This could be due to low savings in these countries.

Most of these countries do not borrow in their own currencies on international capital markets, but instead, borrow in one of the major currencies, which affects the exchange rate. Nevertheless, Cavallo and Wu (2006) assert that these factors may contribute to exchange rate fluctuations, a sudden halt to capital flow and a drop in output in the domestic market because the value of the foreign currency denominates the debt of oil-exporting countries. Furthermore, Musyoki and Kadubo (2012) point out that exposure to foreign liabilities magnifies the exchange rate depreciation cost especially in a situation where the foreign debt is in the public sector.

The model specified in (18) is very similar to but different from Kia (2013). For instance, Kia (2013) employs a country like Canada that has the highest degree of openness. Kia's (2013) model incorporates both foreign and domestic external (US) fiscal variables, which include commodity prices rather than oil prices. Our model varies by focusing on developing net oil-exporting countries whose fiscal variables are solely financed by proceeds from crude oil exports. This explains why the risk associated with holding domestic money is only a function of international oil prices which may have nothing to do with fiscal domestic variables. However, due to the indispensable nature of and heavy reliance of oil-exporting countries on oil production and exports, the oil price is essential to determine economic performance. It is used as a basis to determine how much the government of these countries can spend and how it can finance and manage its debt. This approach differentiates this study from Kia (2013) and other earlier studies.

The ARDL estimating technique is employed to forecast the exchange rates of each of the AOECs. The choice of country specific ARDL estimation follows Shin *et al.* (2014). Let us assume that the ARDL regression model for each AOEC is specified as:

$$\Delta q_t = \varphi_0 + \varphi_1 \Delta\vartheta_{t-1} + \varphi_2 \Delta\vartheta_{t-2} + \cdots + \varphi_p \Delta\vartheta_{t-p} + \Pi_1 \Delta q_{t-1} + \Pi_2 \Delta q_{t-2} + \ldots \Pi_q \Delta q_{t-q} + v_t \quad (19)$$

where q_t is a (k x 1) vector of endogenous variables capturing the exchange rates; φ_0 is a vector of intercept/drift components of the constant term; Δ represents the first difference operator; ϑ_{t-q} and q_{t-q} are lagged explanatory variables in the long and short run and in the long run, respectively; $\varphi_1 -$

φ_p represent the short-run dynamics of the model; $\Pi_1 - \Pi_p$ represent the long-run relationships; and v_1 is a vector of disturbance terms/random walk.

As earlier expressed, recall that,

$\mathfrak{g}_0 > 0;\ \mathfrak{g}_1 < 0; \mathfrak{g}_2 < 0; \mathfrak{g}_3 > 0; \mathfrak{g}_4 > 0; \mathfrak{g}_5 < 0; \mathfrak{g}_6 < 0.$

In addition to examining the factors for forecasting exchange rates in the AOECs, this study analyzes the short-run relationships between exchange rates and the forecasting factors to determine whether the effect of these factors may foster output growth.

For suitable modeling to establish the connections between exchange rates and the selected macroeconomic variables, this study considers the existence of unit roots and cointegration of data to determine the proper methodology. To achieve these preliminary tests, the study follows Giles (2013) who enumerates four circumstances that usually confront data and afterwards determines the choice of technique.

Firstly, the Ordinary Least Squares (OLS) estimating technique is suitable for analysis when all data series are I(0) and thus stationary.

Secondly, when data are not cointegrated, but series are proven integrated of the same order (e.g., I(1)), the appropriate estimating technique is an estimation in first differences comprising no long-run elements.

Thirdly, when all data series are found to be integrated of the same order as well as cointegrated, the two types of regression estimating models suggested are: (a) a Vector Error Correction Model (VECM) or Error Correction Model (ECM), estimated by the OLS technique (see Gujarati, 2004) which represents the short-run dynamics of the connection between the selected variables; and (b) an OLS regression approach, using the levels of the data. This approach is advantageous because it is believed to provide a long-run equilibrium relationship between the examined variables.

Finally, the fourth situation differs from the other three scenarios and is seen to be more complex. In this situation, some of the variables examined are stationary in levels (that is, I(0)) while some are stationary at first differences (i.e., I(1)) or even proportionally integrated, resulting in no definite integration order as in the other scenarios above. Giles (2013) and Pesaran, Shin and Smith (2001) suggest a more advanced estimating technique that is suitable to handle fractional integration order referred to as the ARDL model. This study falls into that category, necessitating the choice of the

ARDL model introduced in Pesaran *et al.* (2001). Various studies have applied this estimating approach and found it suitable for capturing series with varied integration order. For instance, Mercan, Gocer, Bulut and Dam (2013) use the ARDL model to examine the effect of openness on economic growth in the BRICS-T (Brazil, Russia, India, China and South Africa - Turkey) countries. Al Mamun *et al.* (2013) employ the ARDL dynamic analysis technique to identify the financial determinants of corporate social responsibility (CSR) in Bangladesh's banking industry. Bakar, Abdullah and Abdullah (2013) employ the ARDL model to examine the determinants of fertility in Malaysia, while Dritsakis (2011) employs it to estimate demand for money in Hungary and recently, Shin, Yu, and Greenwood-Nimmo (2014) model asymmetric cointegration and dynamic multipliers in a nonlinear ARDL framework.

4.5.2 **Data, Data Sources and Measurement of Data**

The study uses quarterly time series data covering 1980Q1 to 2018Q4. The starting date is chosen to capture a period of major oil price shocks that caused an imbalance in the world economy and the exchange rates of oil-exporting countries. The cut off period coincides with the period when the latest data of interest was available. The data were mainly sourced from the World Development Indicators (WDI), a World Bank database of social and economic indicators, St Fred Louis - http://research.stlouisfed.org/fred2/, OPEC and the US EIA. The choice of the variables employed in this study is informed by theory and previous studies (see Yin, Peng and Tang, 2018; Eslamloueyan and Kia, 2015; Lee and Huh, 2017). They are modeled in the ARDL forecasting framework. The exchange rate is the dependent variable and the independent variables are money supply, interest rates, GDP, dbtgdp and inflation rates. Apart from interest and inflation rates, the other variables are expressed in their natural logarithms. Due to the requirements for using the ARDL model, the variables are subjected to a test for stationarity which reveals that the variables are a mixture of I(0) and I(1) but not I(2) variables (see tables 4.2a to 4.2e). Consequently, the study proceeds with an estimation of the ARDL forecasting technique in equation 21.

4.5.3 **Brief Description of Variables**

4.5.3.1 **Exchange Rates (EXR)**

Exchange rates measure the price of a country's currency in another country's currency. The USD exchange rates are selected as the benchmark in this study due to their wide acceptability and the fact that the USD is the most traded currency on the foreign exchange market (Kutu and Ngalawa, 2016;

Kia, 2006). Following Eslamloueyan and Kia (2015), the study uses the Consumer Price Index (CPI) as a basis to construct the real exchange rates q[20].

4.5.3.2 **Money Supply (MS)**

Money supply is referred to as money stock comprising M2, which is the amount of currency in circulation plus demand deposits. Following Ihsan and Anjum (2013), M2 is defined as a combination of M1 and short-term time deposits in banks and twenty-hour money market funds. M2 is employed in this study to determine and assess the process through which the monetary authorities employ monetary policy tools to achieve their targets (see Ngalawa and Viegi, 2011).

4.5.3.3 **Interest Rate (INT)**

The interest rate represents the average monthly real REPO rate sets by the central bank of an individual country as a monetary policy indicator. According to Bernanke *et al.* (2004), Iturriaga (2000), and Disyatat and Vongsinsirikul (2003), the interest rate is used as a benchmark at which a country's central or reserve bank provides short-term credit to commercial banks and discount houses in its function as the lender of last resort. The interest rate is a monetary tool that is used to counter inflation as well as manage the movement of the intermediate targets of monetary policy. For example, during inflationary periods, the central bank increases the repo rate to discourage banks from borrowing from the central bank. Ultimately, this diminishes money supply in an economy and thus, curbs inflation.

4.5.3.4 **Gross Domestic Product (GDP)**

GDP refers to an inflation-adjusted measure of all goods and services produced at constant national prices for each country annually at a given base year. Following Berkelmans (2005) and Dungey and Pagan (2000), the study includes this variable to examine the extent to which it impacts exchange rates. In addition, the inclusion of GDP seeks to assess the validity of the view that stabilization of output and inflation can be left to monetary policy to achieve Pareto optimality (see Mishkin, 1995; Erceg *et al.*, 2000).

4.5.3.5 **Oil Price (OP)**

Oil price refers to the price in dollars at which a barrel of crude oil is sold each day in the global oil market. The Brent Blend (also known as Brent Crude) oil price is used as the oil price measure because Brent Crude oil dominates the oil market in Africa, among other major classifications such

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[20] The real exchange rate is denoted by q. This is based on the USD, which is the most traded currency in the world. Note that the US dominates trade relations with these countries. (i.e., $q = \psi \left({CPI^*}/{CPI} \right)$, where ψ denotes nominal exchange rates, CPI^* is the international consumer price index and CPI is the domestic consumer price index.

as Brent Sweet Light Crude, Brent Crude, Forties Crude and Oseberg Crude (OPEC, 2016). This variable is treated as exogenous in the model because it is externally determined. It is added to the model because, as suggested in Chapter Three, oil price variations largely account for fluctuations in exchange rates among AOECs.

4.5.3.6 **Inflation (INF)**

Inflation refers to a persistent increase in the general price level. It is a key monetary policy instrument that has been empirically proven to impact exchange rates (see Kutu and Ngalawa, 2016). Hence, it enters the model as a monetary policy goal. Inflation also serves as a control variable that is linked to monetary policy decisions, especially the interest rate through which economic stability and equilibrium could be attained (see Kia, 2006).

4.5.3.7 **Debt to GDP**

Debt simply means the sum of money that is owed. External debt comprises the portion of a country's debt borrowed from *foreign* lenders. These include commercial banks, governments or international financial institutions. Such loans are usually paid in the currency in which the loan was made within the agreed terms. It is usually measured as a ratio of GDP. External debt could severely constrain economic growth, particularly when interest on loans takes up a large percentage of the country's export proceeds, thus reducing domestic currency. The variable is introduced to the study to capture capital mobility among partner countries, specifically to account for the view that the supply of and demand for currencies with flow concept determines the equilibrium value of currencies (Eslamloueyan and Kia, 2015).

Table 4.1: Description of Variables Forecasting Oil Price

Variables	**Abbreviation**	**Description**
Exchange Rates	LNEXR	Quarterly average Rates
Money Supply	LNMS	Quarterly average supply
Interest Rate	INT	Quarterly Average Rates
Gross Domestic Products	LNGDP	Quarterly average Amount
Oil Price	LNOP	Quarterly average price, $/barrel
Inflation	INF	Quarterly average Rates
Debt to GDP	LNDBT	Quarterly average Amount

Source: *Author's compilation (2020).*

Table 4.1 presents the variables and their descriptions as used to forecast the exchange rates of the selected AOECs.

4.5.4 **Estimation Technique**

The study adopts Pesaran *et al.*'s (2001) ARDL estimating technique. In addition to the forecasting, the model examines whether short-run and long-run relationships exist between exchange rates and the identified forecasting variables of exchange rates. The choice of this technique is premised on Al Mamun *et al.* (2013), Cavalcanti *et al.* (2014) and Eslamloueyan and Kia (2015). The reasons presented in these studies for preferring an ARDL to other conventional short-run and long-run techniques are as follows: (a) the ARDL is suitable for combining the I(0) and I(1) series, implying that variables integrated of order zero and one can be estimated in one regression. The variables can be mutually cointegrated, disregarding their integration order but not I(2) (see Katircioglu, 2009; Sari *et al.*, 2008). This renders the ARDL model a more advantageous estimating technique over other approaches to estimate short-run and long-run relationships; (b) the ARDL has the capacity to concurrently estimate the long-run and short-run parameters of a model (Dritsakis, 2011; Shin *et al.*, 2014); (c) the ARDL model is suitable for both large and small sample sizes (Narayan and Gupta, 2015; Rafindadi and Yosuf, 2013); (d) according to Giles (2013), the ARDL model is a contemporary method to examine short-run and long-run dynamics; (e) variables used in a ARDL estimating technique can be assigned different lags (see Giles, 2013); (f) an ARDL involves a single-equation set-up, making it easy to implement and interpret (Giles, 2013); and (g) the ARDL model can accept more than two lags and up to seven variables (see Giles, 2013).

4.5.4.1 **Unit Root Tests**

The concept of unit root tests is emphasized in the literature (see Bornhorst and Baum, 2006; Moon *et al.*, 2007). Following these studies, the properties of the variables to be estimated are examined prior to conducting an ARDL analysis. This is necessary because if the variables are non-stationary as well as non-co-integrated, this may lead to incorrect specification of a model, which may eventually lead to misleading values of R-square, F and t-statistics (see Al-Yousef, 2005) and spurious results (see Hamid and Shabri, 2017). To investigate this, the study also follows Bornhorst and Baum (2006) in conducting the Dickey Fuller (DF), Augmented Dickey Fuller (ADF) and Philip-Perron (PP) unit root tests to test for stationarity of the variables included in the study to forecast exchange rates. Furthermore, the choice of the various criteria used is informed by the need to confirm the validity and reliability of our results as well as their consistency (see Moon and Perron, 2004; Frimpong and Oteng-Abayie, 2006).

Testing whether a series, say π_t, is integrated or equivalent to testing for significance of α_2 i.e. $H_0: \alpha_2 = 0$, in the regression below where, η is a linear trend.

$$\Delta\pi_t = \alpha_0 + \alpha_1\eta + \alpha_2\pi_{t-1} + \sum_{i=1}^{k}(\zeta\pi_{t-1} + \pi_t) \tag{20}$$

4.5.4.2 **Lag length**

The lag length indicates the number of times between the exchange rate's responses to changes in the factors that forecast it (see Lutkepohl, 2006). In selecting an appropriate optimal lag length, the study is guided by established criteria in the literature that the lag with the lowest criterion be considered (see Lutkepohl, 2006). This suggests that the lower the criterion value, the better the model (see Suzuki, 2004; Sharifi-Renani, 2010). Therefore, to determine the optimal number of variable lags suitable for this study, regressions are estimated separately to find the optimal lag length for each variable. The study tests for various order lag selection criteria to allow for adjustments in the model and the attainment of well-behaved residuals. Following Raza, Shahbaz and Nguyen (2015), the order of lag is selected using the robust criteria comprising SIC, FPE, HQIC and AIC.

4.5.4.3 **Diagnostic Tests**

Alquist and Kilian (2010) assert that basic diagnostic tests need to be conducted to examine the reliability of ARDL model. Therefore, this study conducts various diagnostic tests consisting of serial correlation, heteroscedasticity, normality and stability tests to demonstrate the suitability, robustness, and reliability of the model. The serial correlation test which is also referred to as the autocorrelation test examines whether there is a relationship between the current and past errors. Heteroscedasticity refers to a situation where the variability of a variable is not equal across the range of values of a second variable that forecasts it (see Gujarati, 2004). The normality test examines whether variables are normally distributed. According to Gujarati (2004), a model that follows normal distribution is valid, reliable, and has efficient parameter estimates.

Consequently, the study tests for the null and alternative hypotheses of serial correlation, heteroscedasticity, and normality which are hypothesized as:

Null Hypothesis: $\mathrm{H}_0: \theta = 0$, there is no serial correlation; no heteroskedasticity and residuals are normally distributed.

Alternative Hypothesis: $\mathrm{H}_1: \theta \neq 0$, there is serial correlation, heteroskedasticity and residuals are not normally distributed.

The stability test investigates whether the model is stable. It is based on the recursive chow test, suggesting that for a model to be reliable, it must be stable over time. The graphical CUSUM is employed to determine the stability of the ARDL model. Thus, the benchmark hypotheses for the stability test are specified as:

Null Hypothesis(H_0): $\alpha = 1$, there is stability in the model

Alternate Hypothesis (H_1): $\alpha \neq 1$, there is no stability in the model

4.5.4.4 **Forecasting: An overview**

Heizer and Render (2004) refer to forecasting as the science and art of predicting a future event. "It is the estimating of a future outcome of a random process". The data forecasting procedure is well discussed in the literature. The main assumption guiding data forecasting is that the outcome obtained from a random process provides accurate and dependable evidence of the future. Therefore, there is a limitation to the outcome of a forecast. Forecasting may offer much insight, but it is hardly ever flawless (Mendenhall, Reinmuth and Beaver, 1993). Various unpredictable situations could affect the actual result. Nonetheless, the economy and businesses cannot afford to eliminate forecasting as effective policymaking and planning in both the short and long run rely significantly on forecasts (see Heizer and Render, 2004; Mendenhall *et al.*, 1993).

The approach employed in this study is common in institutions like stock exchanges and central banks (see Heizer and Render, 2004). High and aggregated data relating to GDP and inflation is usually employed, and in some scenarios, a forecast disaggregated level is used where a comparison is made between sectors of an economy, or institutional performance (see Heizer and Render, 2004). However, the accuracy of data forecasts as a means of making a judgment about (economic) performance has lately been subject to intense scrutiny by professionals across the world (see Friedman, 2013).

4.5.5.1 **ARDL Forecasting of Variables**

Using the ARDL model, this study forecasts the AOECs' exchange rates and also examines the accuracy and predictive power of the model. This approach follows the graphical technique of Batten and Thornton (1983), Beneki and Yarmohammadi (2014) and Haskamp (2017). The study employs the out-of-sample forecasting procedure to illustrate the different trend types that comprise irregular components, seasonal components, and trend components. Using an ex-post forecasting (all sata are known), it follows Diebold and Li (2006) to estimate a regression model using data for the period 1980 to 2015 to estimate the ARDL model and forecasting data for the period 2016 to 2018 for the out of sample (the forecast is beyond the ARDL regression model). The results are presented in static and dynamic forecasting. Following Crepso Cuaresma and Breitenfellner (2008) and MacDonald and Taylor (1994) in determining the benchmark for the forecasting, the model is computed and compared based on several evaluations of forecast statistics comprising the mean absolute error (MAE), Root Mean Squared Error (RMSE), Mean Absolute Percentage Error (MAPE), and Theil Inequality Coefficient (TIE). These statistics were derived for a forecast horizon of twelve periods, for the three-year out-of-sample space.

4.5.5.2 **Root Mean Square Error (RMSE)**

The "root mean squared error" is a benchmark to evaluate an estimated regression model and ascertain the variance between the forecasted and the actual values (see Clarida *et al.*, 2003). According to Hassani *et al.* (2010) and Pradhan and Kumar (2010), the RMSE is a common technique to estimate forecasting accuracy and is frequently cited in forecasting literature. The approach suggests that the lower the RMSE (value) or the smaller the error margin (i.e., the gap between the forecasted value and the actual value), the more satisfactory the predictive power of the model. On the other hand, the higher the RMSE (value), or the larger the gap between the forecasted and actual values, the lower the satisfactory power of the model. In addition, the forecasting procedure presents a line graph obtained with the use of scientific software, e-views, to verify the true correlation and movement path between the forecasted and actual values in order to substantiate and validate the forecasting strength of the model. However, given that $P_i^f(n)$ is the ith prediction of a given model for oil price for $n -$ steps into the future, and $P_i^{\propto}$ is the actual output realized in the future, then the RMSE and Theil U[21] statistics can be expressed as:

$$\mathrm{RMSE}(n) = \sqrt{\frac{1}{T}\sum_{i}^{T}(P_i^{\propto} - P_i^f(n))^2} \tag{21}$$

4.5.5.3 **Theil's U Inequality Test (TUIT)**

This test suggests that if the RMSE of the unrestricted ARDL model (RMSEUR) is less than the RMSE of the restricted model (RMSFER), that is ($\mathrm{RMSE_{UR}} < \mathrm{RMSE_R}$), then the model has a "better" forecasting ability with a low forecasting error. Consequently, if $U(n)$ in equation (22) below holds, such that $U(n) < 1$, it shows that the unrestricted ARDL model forecast is good and reliable[22]. The Theil's U coefficient is expressed as follows:

$$U(n) = \sqrt{\frac{1}{T}\sum_{i}^{T}(P_i^{\propto} - P_i^f(n))^2} \Bigg/ \sqrt{\frac{1}{T}\sum_{i}^{T}(P_i^{\propto} - P_i^*(n))^2} \tag{22}$$

Where T is the forecast computed and $P_i^*(n)$ is the forecasted value based on the "naive forecast" $n -$ steps into the future, using the data ranging up to $i - T$. T is the number of out-of-sample forecasts

[21] The Theil's U inequality coefficient employs a random walk model procedure as a benchmark. However, this study follows Rapach and Weber (2004) in the applications of the Theil's U coefficient, using the Autoregressive (AR) model as a benchmark. Nonetheless, the study refers to the ratio of the RMSE from the restricted and unrestricted models as the Theil's U coefficient.

that is carried out. Root Mean Squared Errors (RMSE) are computed for forecasting horizons (n), spanning from one quarter ahead to quarter twelve ahead. It is apparent that a Theil U statistic greater than 1 ($U > 1$) suggests that the model used for the forecast is worse in terms of quality of forecasting than a "naive forecast"[23]. However, a Theil U statistic less than one ($U < 1$) suggests that the model used for the forecast is appropriate and reliable in terms of predictability or the quality of forecasting (see Gupta and Sichei, 2006).

4.5.5.4 **Mean Absolute Percentage Error (MAPE)**

The MAPE overcomes one shortcoming of using the Mean Absolute Deviation (MAD) and Mean Square Error (MSE) in estimating forecasting accuracy (see Heizer and Render, 2004). This shortcoming occurs because the values of the two are dependent on the magnitude of the items that are forecasted. The values of MSE and MAD have a tendency to be very large when the forecasted item is measured in real terms. Using the MAPE eliminates this shortcoming. However, the MAPE may not be effective when a forecasted item is measured in very insignificant terms. Following Mendenhall *et al.* (1993) and Heizer and Render (2004), the MAPE is estimated using the formula:

$$\mathrm{MAPE} = \frac{100 * \left(\sum_{i=1}^{n} \frac{|ð_i - g_i|}{ð_i}\right)}{n} \qquad (24)$$

where the MAPE=> the mean absolute error; $\sum_{i=1}^{n} =>$ the summation of the nth period; $ð_i$ is the actual value in the nth period; g_i is the forecasted value in the nth period; and $|ð_i - g_i|$ is the absolute value of the difference in absolute and actual values. Given that the MAPE is estimated as a percentage, it is easy to interpret its outcome. According to Heizer and Render (2004), application of the MAPE method is mainly useful to compare the performance of a model for a variety of series.

4.5.5.5 **Forecasting Variables: Static and Dynamic models**

This study forecasts AOECs' exchange rates. As noted in the previous chapter, oil prices significantly determine exchange rates movement in the AOECs. This section performs a forecasting analysis to show the influence of oil prices and other factors in forecasting exchange rates in the AOECs. In view of this, exchange rates and other variables are forecasted within the ARDL framework, using the RMSE evaluation technique. Following Eslamloueyan and Kia (2015) and Kia (2013), the specification may be interpreted as a monetary model of exchange rates determination augmented by oil prices (see Crepso Cuaresma and Breitenfellner, 2008; MacDonald and Taylor, 1994). Exchange

[23] Naive Forecast: an estimating method in which the actual values of the previous period are used as the present period's forecast, without having to adjust them or attempting to establish causal factors. It is usually only used for comparison with forecasts generated by the better (sophisticated) methods.

rates behavior is assumed to be influenced by changes in the relative money supply, and variations in the interest rate, inflation rate, debt, output and oil price. In achieving this, two major approaches that are widely discussed in the literature on forecasting are employed. They are the Dynamic Forecasting Model (DFM) and the Static Forecasting Model (SFM). Different studies have employed these techniques (see Bauwens, Koop, Korobilis and Rombouts, 2011; Drachal, 2016; Wang *et al.*, 2015). Bauwens *et al.* (2011) use the DFM and SFM to forecast macroeconomic variables, while other studies on forecasts such as Drachal (2016), Kose and Baimaganbetov (2015) and Wang *et al.* (2015) employed the DFM model for forecasting economic variables. According to them, the DFM and SFM are superior and suitable for forecasting economic variables. Kose and Baimaganbetov (2015) argue that the superiority of these techniques not only captures the time-varying property of the variables, but could also automatically select the optimum model. Baumeister and Kilian (2014) propose these techniques with inverse recursive mean-squared prediction error (MSPE). Similarly, Manescu and Van Robays (2016) utilize this method to predict real Brent oil prices. The methods significantly improve forecasting accuracy with a combination of six models: a VAR model of the global oil market; a forecast based on the price of non-oil industrial raw materials; a no-change forecast; a forecast based on oil futures prices; the spread between spot prices of gasoline and crude oil; and the time-varying parameter model of the gasoline and heating oil spreads.

This study carries out combined forecasting, differentiating between the dynamic and static methods using the RMSE, Theil coefficient, and MAE as a benchmark. Engle and Granger (1987) introduced the combined forecasting technique and since then, it has been widely applied in the literature (see Clemen, 1989; Armstrong, 2001; Haskamp, 2017; Yin *et al.,* 2018). In addition, this procedure adheres to strict scientific means of achieving empirical outcomes which is usually done using a robust Popperian methodological approach(es) as a way of proving its scientific existence (see Heizer and Render, 2004). Generally, the static forecasting (simulation modeling) technique is based on existing exposures and therefore, assumes a constant balance with no new growth. The procedure uses actual rather than forecasted values (this is only possible when actual data or series are available). On the other hand, dynamic forecasting depends on detailed assumptions concerning distinctions (rises or falls) in the economy. It relies on a formerly forecasted outcome of a lagged variable. According to De Menezes *et al.* (2000), a review of the two techniques leads to different preferences. Hibon and Evgeniou (2005) are of the view that it is not that the combined forecast is more beneficial than possible individual forecasts, but that it could be less risky in practice because it combines more forecast methods than is possible when forecasting methods are individually selected. Therefore, they posit that using both static and dynamic forecasting in a study offers researchers the chance to make a better choice than alternative forecasting techniques. It also helps them to choose the outcome with the highest level of forecasting accuracy and offers more reliable information on future events and behavior. Such an outcome could serve as a guide in making objective decisions, given the possibility of the margin of errors in the final forecast outcomes.

4.6 Results and Discussion

4.6.1 Unit Root Results

Tables 4.2a to 4.2e present results of the DF, ADF and PP tests for unit roots at individual intercept, and trend and individual intercept for various variables employed in this study. The findings reveal that oil prices are stationary in levels (i.e., I(0)) for each of the AOECs. Apart from Algeria and Egypt, where inflation is stationary in first differences, the inflation rates in Gabon, Libya and Nigeria are stationary in levels. DBT/GDP is stationary in levels for Egypt but stationary in first differences in the other countries. Similarly, interest rates are stationary in levels for Egypt but in first differences for the other countries. No variable is stationary in second differences (i.e., I(2)). The stationarity results reveal a combination of I(0) and I(1) variables. Therefore, the results are appropriate and satisfy the condition for using the ARDL model (see Peseran *et al.,* 2001; Dritsakis, 2011; Shin, Yu, and Greenwood-Nimmo, 2014 and Bakar *et al.*, 2013). Consequently, the study employs the ARDL model.

Table 4.2a: **The Dickey Fuller (DF), Augmented Dickey Fuller (ADF) and Philip-Perron (PP) Unit Root Tests for Algeria**

Variable	**DF (individual intercept)**			**DF (individual intercept and trend)**		
	Order of integration	**t* Statistics**	**P-Value**	**Order of integration**	**t* Statistics**	**P-Value**
LNEXR	I(1)	-3.369479	0.0003	I(1)	-3.5764	0.0002
LNMS	I(1)	-2.7042	0.0004	I(1)	-3.8298	0.0005
INT	I(1)	-2.6319	0.0002	I(1)	-4.1394	0.0000
LNGDP	I(1)	-3.3346	0.0000	I(1)	-3.7342	0.0000
LNOP	I(0)	-3.0352	0.0000	I(0)	-4.3932	0.0002
INF	I(1)	-3.1964	0.0000	I(1)	-4.5139	0.0000
LNDBT	I(1)	-2.7112	0.0001	I(1)	-3.7653	0.0000

"***", "**" and "*" respectively represent statistical sign at 1 percent, 5 percent and 10 percent.
Source: *Author's computation (2020), using data sourced from the WDI.*

Variable	**ADF (individual intercept)**			**ADF (individual intercept and trend)**		
	Order of integration	**t* Statistics**	**P-Value**	**Order of integration**	**t* Statistics**	**P-Value**
LNEXR	I(1)	-3.8957	0.0333	I(1)	-4.1228	0.0284
LNMS	I(1)	-3.8507	0.0359	I(1)	-4.0356	0.0187
INT	I(1)	-4.1942	0.0209	I(1)	-4.1940	0.0488
LNGDP	I(1)	-3.6313	0.0146	I(1)	-4.5686	0.0295
LNOP	I(0)	-3.2346	0.0200	I(0)	-4.3666	0.0460
INF	I(1)	-3.0160	0.0357	I(1)	-4.0258	0.0288
LNDBT	I(1)	-3.7223	0.0027	I(1)	-4.9829	0.0140

"***", "**" and "*" respectively represent statistical sign at 1 percent, 5 percent and 10 percent.
Source: *Author's computation (2020), using data sourced from the WDI.*

Variable	Philip-Perron (individual intercept)			Philip-Perron (individual intercept and trend)		
	Order of integration	**t* Statistics**	**P-Value**	**Order of integration**	**t* Statistics**	**P-Value**
LNEXR	I(1)	-3.3650	0.0137	I(1)	-3.5195	0.0408
LNMS	I(1)	-4.0229	0.0017	I(1)	-4.0434	0.0093
INT	I(1)	-3.8520	0.0030	I(1)	-3.8429	0.0168
LNGDP	I(1)	-3.3228	0.0155	I(1)	-4.3325	0.0046
LNOP	I(0)	-4.1550	0.0011	I(0)	-4.0550	0.0089
INF	I(1)	-4.3447	0.0005	I(1)	-4.3247	0.0038
LNDBT	I(1)	-4.0143	0.0018	I(1)	-4.0626	0.0087

"***", "**" and "*" respectively represent statistical sign at 1 percent, 5 percent and 10 percent.
Source: *Author's computation (2020), using data sourced from the WDI.*

Table 4.2b: **The Dickey Fuller (DF), Augmented Dickey Fuller (ADF) and Philip-Perron (PP) Unit Root Tests for Egypt**

Variable	DF (individual intercept)			DF (individual intercept and trend)		
	Order of integration	**t* Statistics**	**P-Value**	**Order of integration**	**t* Statistics**	**P-Value**
LNEXR	I(1)	-3.3568	0.0003	I(1)	-3.3461	0.0000
LNMS	I(1)	-2.9123	0.0001	I(1)	-4.2888	0.0002
INT	I(0)	-3.0713	0.0000	I(0)	-4.2033	0.0000
LNGDP	I(1)	-2.8759	0.0008	I(1)	-2.9531	0.0001
LNOP	I(0)	-3.0352	0.0000	I(0)	-4.3932	0.0002
INF	I(1)	-2.8290	0.0010	I(1)	-3.5789	0.0021
LNDBT	I(0)	-2.5525	0.0002	I(0)	-3.9786	0.0000

"***", "**" and "*" respectively represent statistical sign at 1 percent, 5 percent and 10 percent.
Source: *Author's computation (2020), using data sourced from the WDI.*

Variable	ADF (individual intercept)			ADF (individual intercept and trend)		
	Order of integration	**t* Statistics**	**P-Value**	**Order of integration**	**t* Statistics**	**P-Value**
LNEXR	I(1)	-3.7228	0.0046	I(1)	-3.6748	0.0270
LNMS	I(1)	-4.1469	0.0226	I(1)	-4.2693	0.0447
INT	I(0)	-4.1669	0.0219	I(0)	-4.1318	0.0235
LNGDP	I(1)	-2.8759	0.0067	I(1)	-4.9021	0.0164
LNOP	I(0)	-3.2346	0.0200	I(0)	-4.3666	0.0460
INF	I(1)	-3.7850	0.0360	I(1)	-4.7312	0.0225
LNDBT	I(1)	-3.8977	0.0480	I(1)	-4.8151	0.0194

"***", "**" and "*" respectively represent statistical sign at 1 percent, 5 percent and 10 percent.
Source: *Author's computation (2020), using data sourced from the WDI.*

Variable	Philip-Perron (individual intercept)			Philip-Perron (individual intercept and trend)		
	Order of integration	**t* Statistics**	**P-Value**	**Order of integration**	**t* Statistics**	**P-Value**
LNEXR	I(1)	-3.8253	0.0033	I(1)	-3.7513	0.0219
LNMS	I(1)	-4.2073	0.0009	I(1)	-4.1920	0.0058
INT	I(0)	-3.8323	0.0032	I(0)	-3.7651	0.0210
LNGDP	I(1)	-3.3263	0.0154	I(1)	-3.8883	0.0148
LNOP	I(0)	-4.1550	0.0011	I(0)	-4.0550	0.0089
INF	I(1)	-3.8771	0.0028	I(1)	-3.8255	0.0177
LNDBT	I(0)	-3.1626	0.0242	I(1)	-3.6844	0.0263

"***", "**" and "*" respectively represent statistical sign at 1 percent, 5 percent and 10 percent.
Source: *Author's computation (2020), using data sourced from the WDI.*

Table 4.2c: **The Dickey Fuller (DF), Augmented Dickey Fuller (ADF) and Philip-Perron (PP) Unit Root Tests for Gabon**

Variable	DF (individual intercept)			DF (individual intercept and trend)		
	Order of integration	**t* Statistics**	**P-Value**	**Order of integration**	**t* Statistics**	**P-Value**
LNEXR	I(1)	-3.1111	0.0000	I(1)	-3.6063	0.0001
LNMS	I(1)	-2.6302	0.0011	I(1)	-3.7615	0.0000
INT	I(1)	-3.1193	0.0000	I(1)	-3.6396	0.0007
LNGDP	I(1)	-3.2770	0.0002	I(1)	-3.5765	0.0030
LNOP	I(0)	-3.0352	0.0000	I(0)	-4.3932	0.0002
INF	I(0)	-3.2627	0.0009	I(0)	-3.5406	0.0004
LNDBT	I(1)	-3.0055	0.0001	I(1)	-3.8529	0.0006

"***", "**" and "*" respectively represent statistical sign at 1 percent, 5 percent and 10 percent.
Source: *Author's computation (2020), using data sourced from the WDI.*

Variable	ADF (individual intercept)			ADF (individual intercept and trend)		
	Order of integration	**t* Statistics**	**P-Value**	**Order of integration**	**t* Statistics**	**P-Value**
LNEXR	I(1)	-3.0392	0.0337	I(1)	-3.0392	0.0337
LNMS	I(1)	-3.2172	0.0209	I(1)	-3.5822	0.0348
INT	I(1)	-3.1214	0.0271	I(1)	-4.1760	0.0093
LNGDP	I(1)	-3.6018	0.0068	I(1)	-3.7406	0.0226
LNOP	I(0)	-3.2346	0.0200	I(0)	-4.3666	0.0460
INF	I(0)	-3.5187	0.0088	I(0)	-3.5461	0.0384
LNDBT	I(1)	-3.8606	0.0500	I(1)	-4.8817	0.0171

"***", "**" and "*" respectively represent statistical sign at 1 percent, 5 percent and 10 percent.
Source: *Author's computation (2020), using data sourced from the WDI.*

Variable	Philip-Perron (individual intercept)			Philip-Perron (individual intercept and trend)		
	Order of integration	**t* Statistics**	**P-Value**	**Order of integration**	**t* Statistics**	**P-Value**
LNEXR	I(1)	-4.0086	0.0018	I(1)	-3.9922	0.0108
LNMS	I(1)	-4.2281	0.0008	I(1)	-4.3164	0.0039
INT	I(1)	-4.0996	0.0013	I(1)	-4.0568	0.0089
LNGDP	I(1)	-4.0014	0.0018	I(1)	-3.9626	0.0118
LNOP	I(0)	-4.1550	0.0011	I(0)	-4.0550	0.0089
INF	I(0)	-3.6122	0.0065	I(0)	-3.6573	0.0283
LNDBT	I(1)	-4.0690	0.0015	I(1)	-4.0273	0.0097

"***", "**" and "*" respectively represent statistical sign at 1 percent, 5 percent and 10 percent.
Source: *Author's computation (2020), using data sourced from the WDI.*

Table 4.2d: **The Dickey Fuller (DF), Augmented Dickey Fuller (ADF) and Philip-Perron (PP) Unit Root Tests for Libya**

Variable	DF (individual intercept)			DF (individual intercept and trend)		
	Order of integration	**t* Statistics**	**P-Value**	**Order of integration**	**t* Statistics**	**P-Value**
LNEXR	I(1)	-3.0885	0.0004	I(1)	-3.6992	0.0010
LNMS	I(1)	-2.9344	0.0107	I(1)	-3.6432	0.0037
INT	I(1)	-10.1251	0.0000	I(1)	-10.0917	0.0000
LNGDP	I(1)	-4.2063	0.0008	I(1)	-2.6602	0.0003
LNOP	I(0)	-3.0352	0.0000	I(0)	-4.3932	0.0002
INF	I(0)	-3.4498	0.0012	I(0)	-3.6594	0.0011
LNDBT	I(1)	-2.6827	0.0001	I(0)	-3.7302	0.0020

"***", "**" and "*" respectively represent statistical sign at 1 percent, 5 percent and 10 percent.
Source: *Author's computation (2020), using data sourced from the WDI.*

Variable	ADF (individual intercept)			ADF (individual intercept and trend)		
	Order of integration	**t* Statistics**	**P-Value**	**Order of integration**	**t* Statistics**	**P-Value**
LNEXR	I(1)	-3.2393	0.0197	I(1)	-4.2243	0.0387
LNMS	I(1)	-3.6052	0.0284	I(1)	-4.8961	0.0013
INT	I(1)	-3.9063	0.0470	I(1)	-4.9008	0.0165
LNGDP	I(1)	-3.4552	0.0106	I(1)	-3.6046	0.0327
LNOP	I(0)	-3.2346	0.0200	I(0)	-4.3666	0.0460
INF	I(0)	-3.5516	0.0080	I(0)	-4.4917	0.0022
LNDBT	I(1)	-3.6740	0.0410	I(1)	-4.7688	0.0113

"***", "**" and "*" respectively represent statistical sign at 1 percent, 5 percent and 10 percent.
Source: *Author's computation (2020), using data sourced from the WDI.*

Variable	Philip-Perron (individual intercept)			Philip-Perron (individual intercept and trend)		
	Order of integration	t* Statistics	P-Value	Order of integration	t* Statistics	P-Value
LNEXR	I(1)	-3.9328	0.0023	I(1)	-3.9161	0.0136
LNMS	I(1)	-3.8183	0.0034	I(1)	-4.0187	0.0086
INT	I(1)	-4.2272	0.0008	I(1)	-4.1999	0.0057
LNGDP	I(1)	-4.2558	0.0007	I(1)	-4.0597	0.0088
LNOP	I(0)	-4.1550	0.0011	I(0)	-4.0550	0.0089
INF	I(0)	-4.2404	0.0008	I(0)	-4.2278	0.0052
LNDBT	I(1)	-4.1397	0.0011	I(1)	-4.1085	0.0076

"***", "**" and "*" respectively represent statistical sign at 1 percent, 5 percent and 10 percent.
Source: *Author's computation (2020), using data sourced from the WDI.*

Table 4.2e: The Dickey Fuller (DF), Augmented Dickey Fuller (ADF) and Philip-Perron (PP) Unit Root Tests for Nigeria

Variable	DF (individual intercept)			DF (individual intercept and trend)		
	Order of integration	t* Statistics	P-Value	Order of integration	t* Statistics	P-Value
LNEXR	I(1)	-2.7715	0.0000	I(1)	-3.9843	0.0001
LNMS	I(1)	-2.9495	0.0211	I(1)	-4.2479	0.0000
INT	I(1)	-2.6193	0.0002	I(1)	-3.6392	0.0005
LNGDP	I(1)	-3.4412	0.0000	I(1)	-3.6518	0.0000
LNOP	I(0)	-3.0352	0.0000	I(0)	-4.3932	0.0002
INF	I(0)	-2.5095	0.0040	I(0)	-3.5833	0.0014
LNDBT	I(1)	-2.6332	0.0022	I(1)	-3.8904	0.0011

"***", "**" and "*" respectively represent statistical sign at 1 percent, 5 percent and 10 percent.
Source: *Author's computation (2020), using data sourced from the WDI.*

Variable	ADF (individual intercept)			ADF (individual intercept and trend)		
	Order of integration	t* Statistics	P-Value	Order of integration	t* Statistics	P-Value
LNEXR	I(1)	-3.7932	0.0017	I(1)	-3.4960	0.0435
LNMS	I(1)	-3.5751	0.0015	I(1)	-4.6671	0.0251
INT	I(1)	-3.5383	0.0086	I(1)	-4.6537	0.0275
LNGDP	I(1)	-3.8181	0.0052	I(1)	-4.1091	0.0133
LNOP	I(0)	-3.2346	0.0200	I(0)	-4.3666	0.0460
INF	I(0)	-3.8655	0.0029	I(0)	-3.8417	0.0170
LNDBT	I(1)	-6.5039	0.0000	I(1)	-6.5031	0.0000

"***", "**" and "*" respectively represent statistical sign at 1 percent, 5 percent and 10 percent.
Source: *Author's computation (2020), using data sourced from the WDI.*

Variable	Philip-Perron (individual intercept)			Philip-Perron (individual intercept and trend)		
	Order of integration	t* Statistics	P-Value	Order of integration	t* Statistics	P-Value
LNEXR	I(1)	-4.0153	0.0017	I(1)	-4.0453	0.0092
LNMS	I(1)	-2.9351	0.0437	I(1)	-4.9616	0.0146
INT	I(1)	-4.3878	0.0005	I(1)	-4.3313	0.0037
LNGDP	I(1)	-3.9030	0.0026	I(1)	-4.0684	0.0086
LNOP	I(0)	-4.1550	0.0011	I(0)	-4.0550	0.0089
INF	I(0)	-4.7889	0.0001	I(0)	-4.7727	0.0008
LNDBT	I(1)	-4.05270	0.0015	I(1)	-4.0292	0.0097

"***", "**" and "*" respectively represent statistical sign at 1 percent, 5 percent and 10 percent.
Source: *Author's computation (2020), using data sourced from the WDI.*

4.6.2 **Lag length**

The optimal lag length selection order for this study is presented in Tables 4.3a, 4.3b, 4.3c, 4.3d and 4.3e for Algeria, Egypt, Gabon, Libya and Nigeria, respectively. Since different variables can be assigned different lags as they enter the model, the study tests for the optimal lag length of each variable. This is carried out by estimating regressions differently to obtain the appropriate lag length for each variable. As indicated in the result, the various criteria suggest lag 2 to be the most appropriate for this study.

Table 4.3a: **Optimal Lag Length Selection Criteria for Algeria**

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-665.7723	NA	0.000353	9.078003	9.199512	9.127372
1	2076.299	5224.757	4.64e-20	-27.49052	-26.63996	-27.14494
2	2462.963	705.4015	2.19e-22*	-32.91129*	-30.64962*	-31.58744*
3	2471.676	15.18788	3.18e-22	-32.57618	-29.55182	-30.92248
4	2487.774	26.75891	4.08e-22	-32.37840	-28.55383	-30.35733
5	2527.257	62.42518	4.07e-22	-32.22923	-27.87184	-30.10818
6	2657.435	195.2674*	5.92e-22	-31.86048	-28.41547	-31.08465
7	2668.637	15.89436	7.83e-22	-31.59155	-27.35131	-30.45332
8	2690.001	28.58200	7.60e-22	-31.63861	-26.42447	-29.95933

Source: *Author's Computation (2020), using data sourced from the WDI.*

Table 4.3b: **Optimal Lag Length Selection Criteria for Egypt**

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-460.5881	NA	2.21e-05	6.305245	6.426754	6.354614
1	2089.725	4859.380	3.87e-20	-27.67196	-26.82140	-27.32638
2	2512.814	167.8408*	1.44e-22*	-33.33073*	-31.32328*	-32.26110*
3	2520.439	13.43760	2.14e-22	-32.97222	-30.21079	-31.58144
4	2535.913	22.14077	2.93e-22	-32.70938	-29.20435	-31.00785
5	2576.580	771.8522	2.07e-22	-32.90290	-28.53837	-30.77471
6	2688.474	13.29221	3.06e-22	-32.51945	-28.83492	-31.50409
7	2697.945	25.71992	4.08e-22	-32.24207	-27.74735	-30.84937
8	2714.494	64.29845	3.90e-22	-32.30514	-26.75546	-30.29032

Source: *Author's Computation (2020), using data sourced from the WDI.*

Table 4.3c: **Optimal Lag Length Selection Criteria for Gabon**

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-751.6975	NA	0.001127	10.23916	10.36066	10.28852
1	1576.228	4435.641	3.99e-17	-20.73281	-19.88225	-20.38722
2	1899.105	589.0323	3.08e-19*	-25.66082*	-23.02991*	-23.96773*
3	1912.217	22.85893	4.53e-19	-25.31359	-21.99157	-23.36223
4	1936.174	39.81918	6.14e-19	-25.06206	-21.09977	-22.90327
5	2014.041	123.1143	8.29e-19	-24.60952	-20.93649	-23.17283
6	2120.901	160.2899*	1.14e-18	-24.30024	-21.16500	-23.83418
7	2131.206	14.62178	1.35e-18	-24.13748	-20.08872	-23.19074
8	2148.592	23.26076	7.82e-19	-24.70325	-19.10814	-22.64300

Source: *Author's Computation (2020), using data sourced from the WDI.*

Table 4.3d: **Optimal Lag Length Selection Criteria for Libya**

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-610.8447	NA	0.000168	8.335740	8.457248	8.385108
1	1626.021	4262.136	2.04e-17	-21.40569	-20.55513	-21.06011
2	1942.243	576.8917	1.90e-19*	-26.14392*	-23.61286*	-24.55068*
3	1956.302	150.6286*	2.61e-19	-25.86605	-22.58730	-23.95796
4	1982.983	21.90396	2.72e-19	-25.87498	-21.73232	-23.53582
5	2056.231	49.04629	4.63e-19	-25.19248	-21.50663	-23.74297
6	2156.650	24.50712	6.26e-19	-24.89597	-21.64810	-24.31728
7	2172.087	44.34843	7.18e-19	-24.77004	-20.64118	-23.74319
8	2208.748	115.8118	4.42e-19	-25.27339	-19.92105	-23.45591

Source: *Author's Computation (2020), using data sourced from the WDI.*

Table 4.3e: **Optimal Lag Length Selection Criteria for Nigeria**

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-1211.370	NA	0.561965	16.45094	16.57245	16.50031
1	1205.579	4605.267	5.98e-15	-15.72404	-14.87348	-15.37846
2	1599.547	156.2873*	3.25e-17*	-21.00250*	-14.58675	-19.91965*
3	1608.218	18.28584	4.62e-17	-20.69017	-18.98184*	-19.25413
4	1626.027	33.36220	5.65e-17	-20.54067	-17.88347	-18.71209
5	1671.994	718.7258	4.75e-17	-20.56145	-15.46530	-18.55057
6	1776.185	15.11565	6.91e-17	-20.19214	-16.90859	-19.17586
7	1789.072	29.60114	8.94e-17	-19.94631	-16.31423	-18.56731
8	1814.010	72.67721	7.95e-17	-20.08100	-16.50668	-18.12161

Source: *Author's Computation (2020), using data sourced from the WDI.*

4.6.3 Interpretation of Results for Algeria

This section presents the findings for Algeria. Among other things, these include ARDL Dynamic Regression, wald test, serial correlation results, heteroskedasticity result, normality test, stability test and exchange rates forecasting results. The section ends with a discussion of these findings and inferences, a summary, and conclusions.

4.6.3.1 Interpretation of the ARDL Regression Model

Table 4.4: **ARDL Dynamic Regression Estimates**

Dependent Variable: LNEXR				
Method: ARDL				
Sample (adjusted): 1980Q3 2018Q4				
Included observations: 154 after adjustments				
Maximum dependent lags: 2 (Automatic selection)				
Model selection method: Akaike info criterion (AIC)				
Dynamic regressors (2 lags, automatic): INF INT LNDBT LNGDP LNMS LNOP				
Selected Model: ARDL(2, 2, 2, 0, 2, 0, 0)				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.***
LNEXR(-1)	1.758654	0.055303	31.80010	0.0000
LNEXR(-2)	-0.779286	0.055797	-13.96641	0.0000
INF	0.001279	0.000338	3.786685	0.0002
INF(-1)	0.002215	0.000623	3.557432	0.0005
INF(-2)	-0.000869	0.000372	-2.336010	0.0209
INT	-0.004998	0.002290	-2.182302	0.0308
INT(-1)	0.007930	0.004121	1.924277	0.0564
INT(-2)	-0.003448	0.002166	-1.592282	0.1136
LNDBT	0.005016	0.003712	1.351416	0.0178
LNGDP	0.715119	0.223839	3.194791	0.0017
LNGDP(-1)	1.073041	0.422253	2.541229	0.0121
LNGDP(-2)	-0.405240	0.230037	-1.761631	0.0803
LNMS	0.017250	0.007354	2.345593	0.0204
LNOP	0.000544	0.003347	0.162496	0.8712
C	0.277648	0.220522	1.259050	0.2101

Source: *Author's computation (2020), using data sourced from the WDI.*

Table 4.4 presents the ARDL estimates for the short-run relationship between exchange rates and the series that forecast it in Algeria. A total of six independent variables, namely, inflation rates, interest rates, debts, GDP, money supply and oil prices are regressed against exchange rates adding up to seven variables. The analysis shows that debts are statistically significant to impact exchange rates by 0.5 percent in the short run. The implication is that debts in Algeria weakly influence exchange rates. However, its coefficient suggests that a fall in debts will lead to currency appreciation. A region with high levels of debt is expected to suffer exchange rates depreciation. Therefore, this study supports Eslamloueyan and Kia's (2015) conclusion that increases in debts may hamper exchange rates appreciation. Interest rates show a negative relationship with exchange rates at 5 percent significance level. This implies that an increase in interest rates will cause a 0.4 percent appreciation in exchange rates. That is, higher interest rates tend to attract foreign investors, which may increase demand for domestic currency. This finding aligns with Olomola (2011) who asserts that higher interest rates will offer lenders in an economy a higher return relative to other countries. Consequently, higher interest rates attract foreign capital and cause exchange rates to rise. The opposite relationship occurs when interest rates decrease, that is, lower interest rates tend to reduce exchange rates.

Money supply shows a positive relationship with exchange rates at 5 percent level of significance. This implies that an increase in money supply will lead to 1.7 percent depreciation in exchange rates. That is, higher money supply in Algeria tends to reduce interest rates, which may lead to a fall in the demand for Dinar. In addition, an increase in money supply can cause depreciation in exchange rates because there will be a decrease in demand for the currency and its value tends to fall. This finding validates earlier studies (see Ushie *et al.*, 2013; Demary, 2010; Olomola, 2011) that found that higher money supply accounts for lower interest rates and consequently currency depreciation. The opposite relationship occurs when the money supply decreases. Inflation rates is statistically significant in influencing exchange rates in the short run. The findings suggest that an increase in inflation rates leads to 0.12 percent depreciation in the Dinar. This supports Iwayemi and Fowowe's (2011) conclusion that a very low rate of inflation does not guarantee favourable exchange rates for a country, but an extremely high inflation rate is very likely to negatively impact the country's exchange rates with other nations.

Oil prices show a negative relationship with exchange rates at 5 percent level of significance. The implication is that rises in oil prices lead to 0.05 percent appreciation in exchange rates. That is, higher oil prices account for currency appreciation in Algeria. This finding validates earlier studies that assert that increase in oil prices Granger cause currency appreciation in oil-exporting countries (Iwayemi and Fowowe, 2011; Ahmed, 2017). It relates to the current study's objective of determining the ability of oil prices to explain behavior in exchange rates. Given this result, information on global oil prices can be used to improve the exchange rates of AOECs.

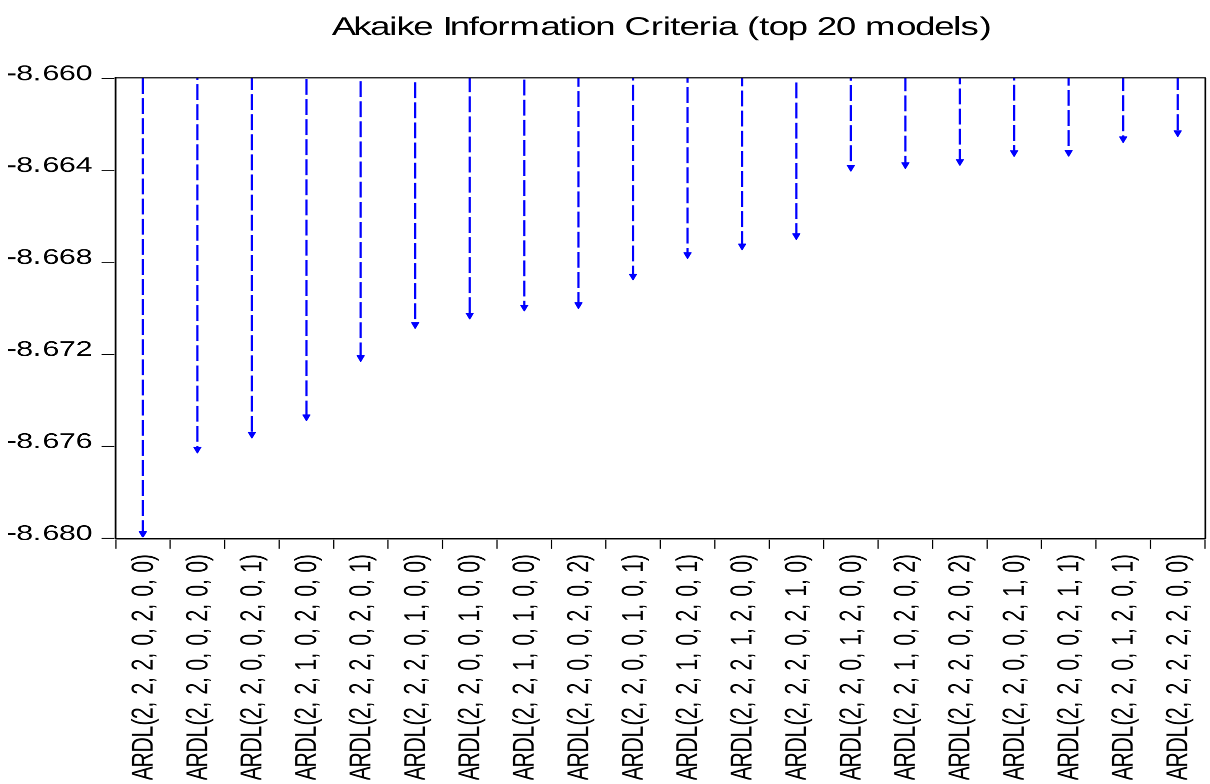
Understanding that the exchange rate in Algeria is driven by movement in oil prices reveals that the country's economy is susceptible to changes in oil prices. This relationship aligns with expectations, empirical evidence and economic theory (see Iwayemi and Fowowe, 2011, Olomola, 2011, Beneki and Yarmohammadi, 2014; Haskamp, 2017). It may result in a fall in the value of the domestic currency when oil prices plummet.

The overall results for the ARDL permit heterogeneous short-run dynamics in influencing exchange rates. This finding further confirms the appropriateness of the model. Furthermore, the model suggests that the explanatory variables are suitable for forecasting exchange rates.

4.6.3.2 **Measuring the Strength of the Model Selection Criteria**

Figure 4.3 presents the strength of the AIC model compared to the HQIC and Schwarz criterion used in the ARDL regression model. This is to ascertain the short-run relationship of the ARDL model. To determine the top twenty ARDL models, the study employs a criteria graph. Following prevailing model benchmark analysis, the smaller the AIC value, the better the ARDL model (see Bakar *et al.*, 2013; Giles, 2013). The figure shows that the ARDL criteria graph with (2, 2, 2, 0, 2, 0, 0) and -8.680 value is the most preferred, as it has the least value. This is followed by the ARDL (2, 2, 0, 0, 2, 0, 0) at -8.676 value, as the second most preferred model.

Figure 4.3: Strength of the ARDL Model Selection



Source: *Author's Computation (2020), using data sourced from the WDI.*

4.6.3.3 **Wald Test**

In this section, the study validates the short-run association between the independent variables and exchange rates. This is achieved by testing for a null hypothesis of no short-run cointegration amongst the variables. The benchmark hypotheses of the Wald test are specified below:

$$\mathrm{H_0: Short - run\ cointegration\ does\ not\ exist\ among\ the\ regressors\ and\ regressand}$$
$$\mathrm{H_1: Short - run\ cointegration\ exists\ between\ the\ regressors\ and\ dependent\ variables}$$

Decision rule:

Accept $\mathrm{H_0}$ when P-Value is higher than 5 percent or Reject $\mathrm{H_1}$ when P-Value is smaller than 5 percent.

As displayed in Table 4.5, the Wald test reveals the existence of a short-run relationship between the independent variables and exchange rates at the P-value of 1 percent. This suggests that the null hypothesis cannot be accepted.

Table 4.5: **Wald Test Result**

Test Statistic	Value	Df	Probability
F-statistic	2146.466	(6, 139)	0.0000
Chi-square	12878.79	6	0.0000

Source: *Author's Computation (2020), using data sourced from the WDI.*

4.6.3.4 **Serial Correlation Results**

Table 4.6 presents the results of serial correlation. There is no evidence of serial correlation because the probability of the F-statistics is 45 percent which is greater than 5 percent. This suggests that the null hypothesis cannot be rejected. The findings suggest that the model is free from serial correlation. The results also support that the parameter estimates of the model do not suffer an autocorrelation problem.

Table 4.6: **Breusch-Godfrey Serial Correlation LM Test**

F-statistic	0.809696	Prob. F(2,137)	0.4471
Obs*R-squared	1.799072	Prob. Chi-Square(2)	0.4068

Source: *Author's Computation (2020), using data sourced from the WDI.*

4.6.3.5 **Heteroskedasticity Result**

Table 4.7 presents the results for the heteroskedasticity test. Both the chi square and F-statistics are insignificant at 5 percent. This indicates that the null hypothesis, no heteroskedasticity, cannot be rejected. Hence, the study concludes that the estimated model is reliable and there is no problem of heteroskedasticity. This result could be considered suitable for the parameter of the study's estimates in the estimated models.

Table 4.7: **Heteroskedasticity Test: Breusch-Pagan-Godfrey**

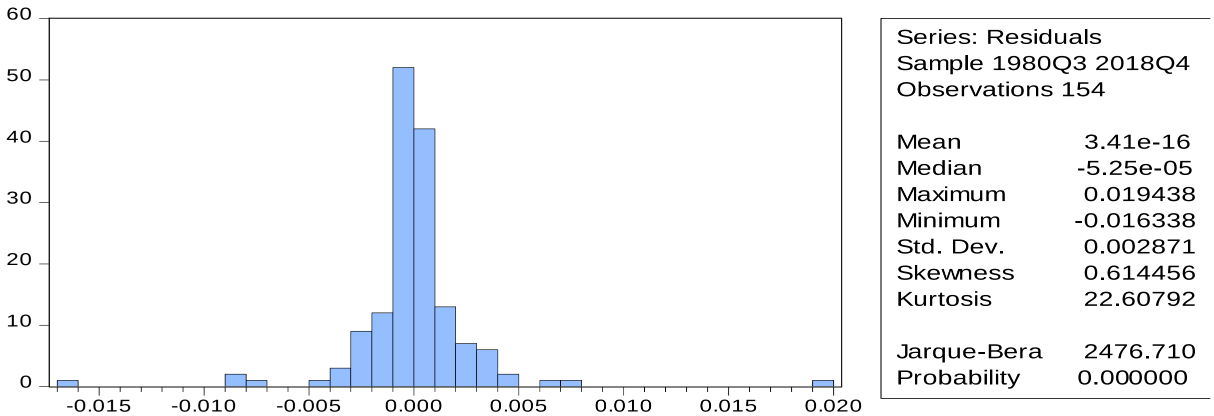
F-statistic	1.842640	Prob. F(14,139)	0.3810
Obs*R-squared	24.10683	Prob. Chi-Square(14)	0.4550
Scaled explained SS	212.1833	Prob. Chi-Square(14)	0.0000

Source: *Author's Computation (2020), using data sourced from the WDI.*

4.6.3.6 **Normality Test**

The normality test result is presented in figure 4.4. The result indicates that the model is normally distributed. This is evident from the Jarque-Bera statistics which is statistically insignificant at 5 percent (that is, 2476.71). It indicates that the model is normally distributed. Therefore, the various parameters in the model are reliable and valid.

Figure 4.4: **Normality Test Results**



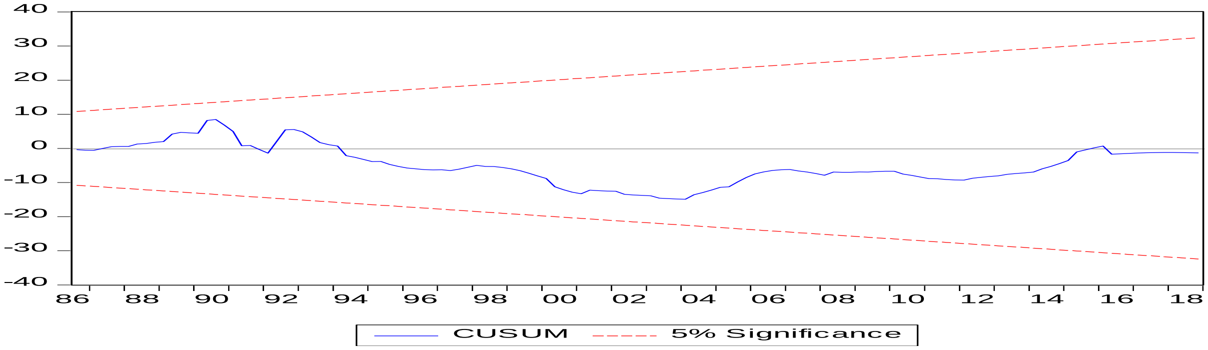
Source: *Author's Computation (2020), using data sourced from the WDI.*

The normality test is carried out based on the three familiar tests in the literature, consisting of the Jarque-Bera, kurtosis and skewness tests. The findings reveal that variables are normally distributed as is evident in the probability value in figure 4.4 (0.000). Furthermore, they show that the residuals are distributed normally, and the data sets are appropriately modelled. This is evident in the probability values of 1 percent significance level. Consequently, the findings imply that the distribution of data and residuals of the model for Algeria are distributed normally. Buttressing this, the findings show that the model is suitable and consistently disposed to analyze exchange rates forecast in Algeria.

4.6.3.7 **CUSUM Stability Test**

Figure 4.5 presents the CUSUM stability test for the ARDL model. The result suggests that that the model is stable because the line capturing our data falls between the 5 percent confidence interval.

Figure 4.5: **CUSUM Test Result**

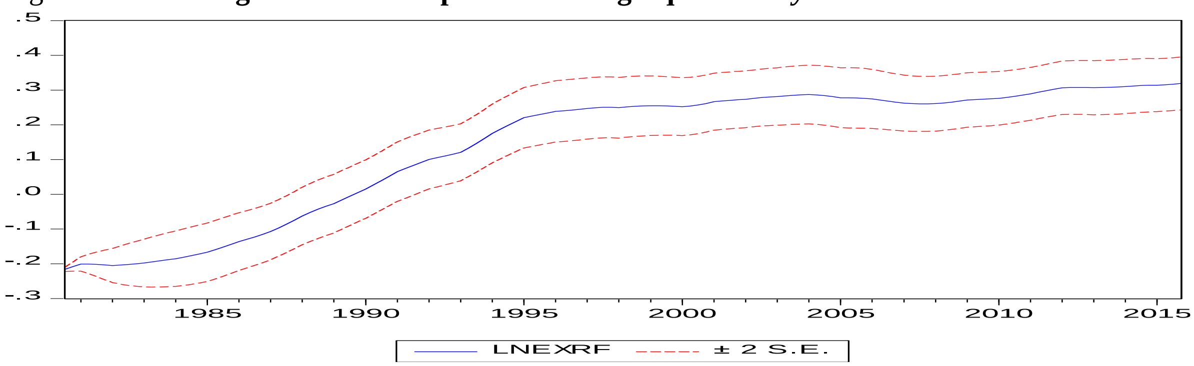


Source: *Author's computation (2020), using data sourced from the WDI.*

4.6.3.8 **Forecasting Exchange Rates: Static and Dynamic Results**

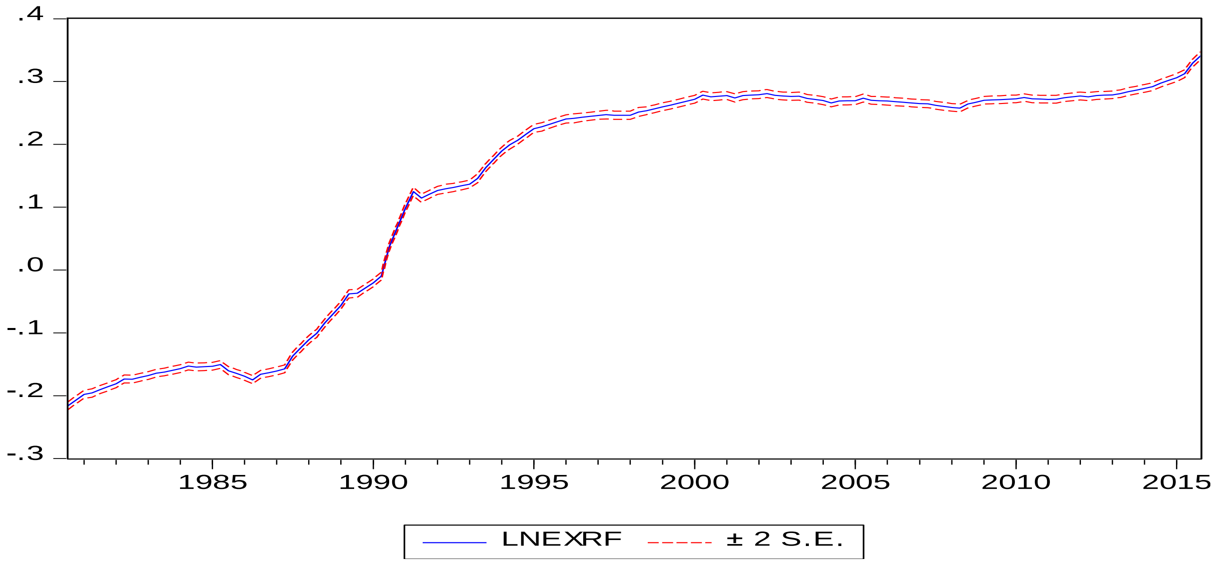
Having established that the ARDL results are free from statistical errors, the study proceeds to forecast exchange rates. Various diagnostics tests are carried out to measure the reliability and suitability of the model to carry out exchange rate forecast. The estimated data for exchange rates range from 1980Q1 to 2018Q4, of which data ranging from 1980Q1 to 2015Q4 accounts for the ARDL sample regression model for both dynamic and static forecasts as shown in figures 4.6 and 4.7, respectively. The outcomes of these sample regressions for dynamic and static forecasts show that they are both significant at 95 percent confidence interval as the lines of the sample pass through the two dotted red lines. This validates their appropriateness and suitability to make dynamic and static forecasts of exchange rates.

Figure 4.6: **Exchange Rates In-Sample Forecasting Equation: *Dynamic***



Source: *Author's computation (2020), using data sourced from the WDI*

Figure 4.7: **Exchange Rates In-Sample Forecasting Equation: *Static***



Source: *Author's computation (2020), using data sourced from the WDI.*

Forecasting evaluation criteria like the RMSE, MAE, and MAPE, that serve as a benchmark for forecasting, offer support for the appropriateness of the forecasting models for both the dynamic and static forecasts models. For example, the RMSE, MAE and MAPE coefficients for the dynamic forecast are 0.002075, 0.010267 and 0.019846, nearing the zero (0) benchmark. Similarly, the RMSE, MAE and MAPE coefficients for the static forecast are 0.002914, 0.001555 and 0.004269 in that order, also nearing the zero "0" benchmark. Table 4.8 presents the Theil coefficients for both the dynamic and static forecasts and they are respectively estimated as 0.001660 and 0.000278. These results also support the reliability of the model to forecast exchange rates. In addition, the movements of exchange rates within the confidence interval confirm that the forecasting model is satisfactory. The fact that the RMSE, MAE, MAPE and Theil coefficients near zero validates the forecasting model.

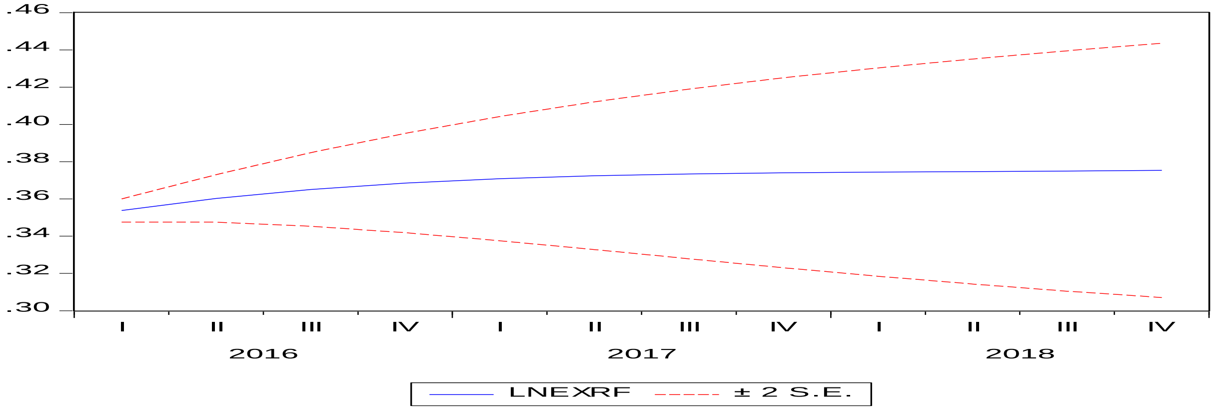
Table 4.8: **Exchange Rates In-Sample Forecast Equation 1980Q1-2015Q4**

	EVALUATION COEFFICIENTS			
	RMSE	**MAE**	**MAPE**	**THEIL**
Dynamic	0.002075	0.010267	0.019846	0.001660
Static	0.002914	0.001555	0.004269	0.000278

Source: *Author's computation (2020), using data sourced from the WDI.*

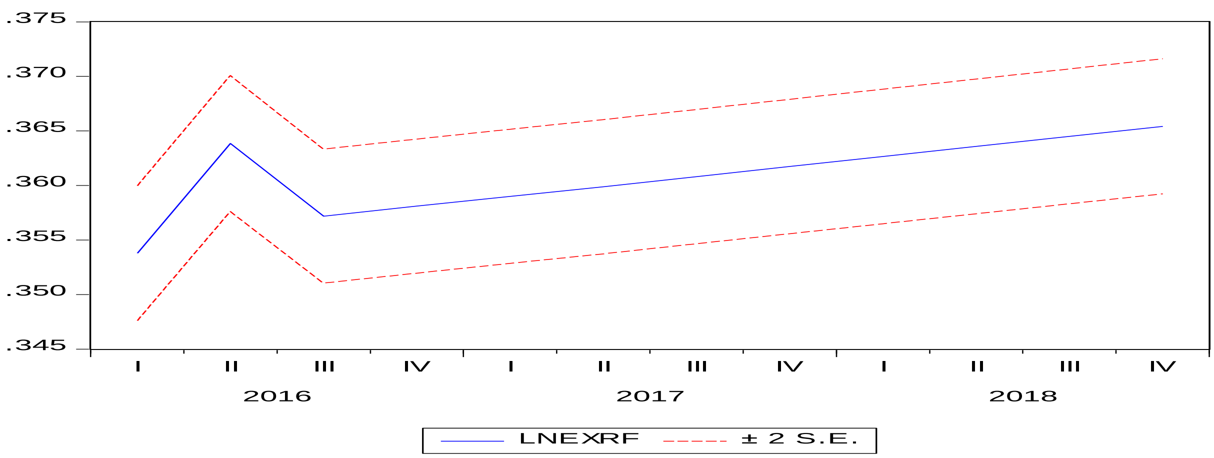
The out-of-sample forecasting horizon runs from 2016Q1 to 2018Q4. The results reveal that the forecasts are significant as the two red lines confirm a 95 percent confidence interval within the two (± 2) standard deviation error lines. These results support the suitability of the sample regression models to forecast exchange rates.

Figure 4.8: **Exchange Rates Out-of-Sample Forecast: *Dynamic***



Source: *Author's computation (2020), using data sourced from the WDI.*

Figure 4.9: **Exchange Rates Out-of-Sample Forecast: *Static***



Source: *Author's computation (2020), using data sourced from the WDI.*

The forecasting evaluation criteria considered for out-of-sample forecasting lines are RMSE, MAE, and MAPE. The goodness of these criteria offers support for the appropriateness of the forecasting models for both the dynamic and static out-of-sample forecasts models. However, as presented in Table 4.9, the RMSE, MAE and MAPE coefficients for the dynamic forecast are 0.010159, 0.009600 and 0.005762, nearing the zero (0) benchmark. Similarly, the RMSE, MAE and MAPE coefficients for the static forecast are 0.000156, 0.000919 and 0.000720 in that order, also nearing the zero "0" benchmark. The Theil coefficients for both the dynamic and static forecasts are also presented in Table 4.9. The finding reveals that the Theil coefficients for the dynamic and static out-of-sample forecasting models are respectively estimated as 0.006190 and 0.002422. These findings validate the forecast model.

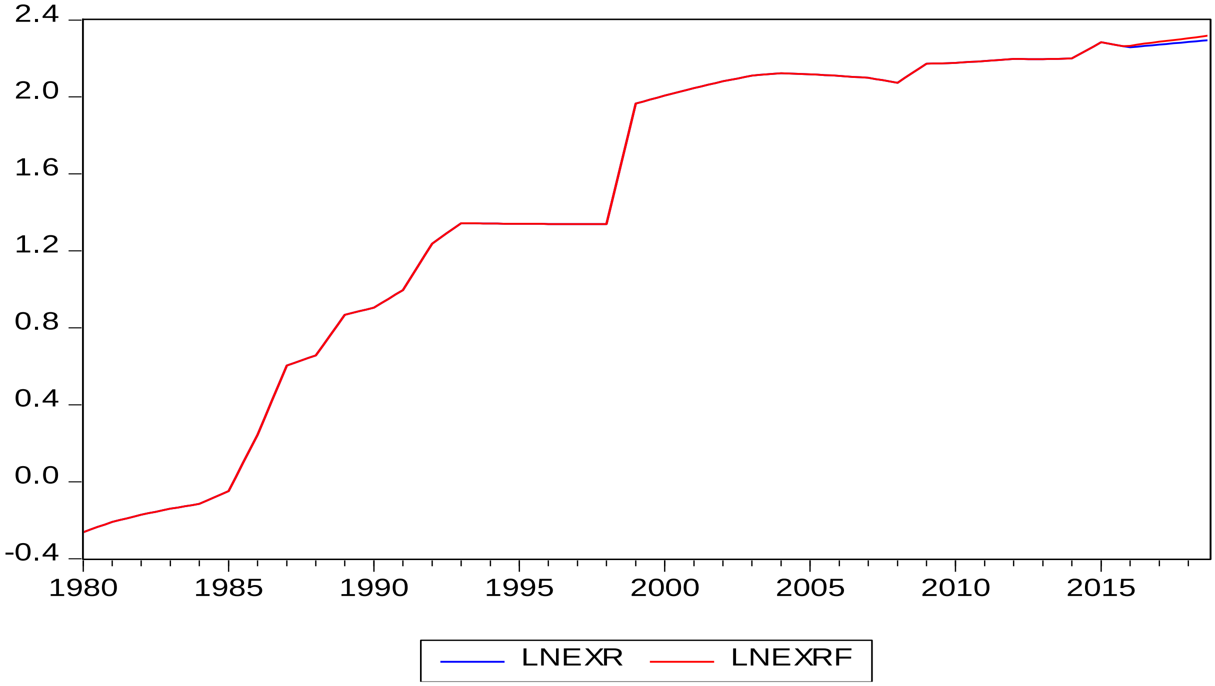
Table 4.9**: Exchange Rates Out-of-Sample Forecast lines: 1980Q1-2015Q4**

	EVALUATION COEFFICIENTS			
	RMSE	**MAE**	**MAPE**	**THEIL**
Dynamic	0.010159	0.009600	0.005762	0.006190
Static	0.000156	0.000919	0.000720	0.002422

Source: *Author's computation (2020) using data sourced from the WDI.*

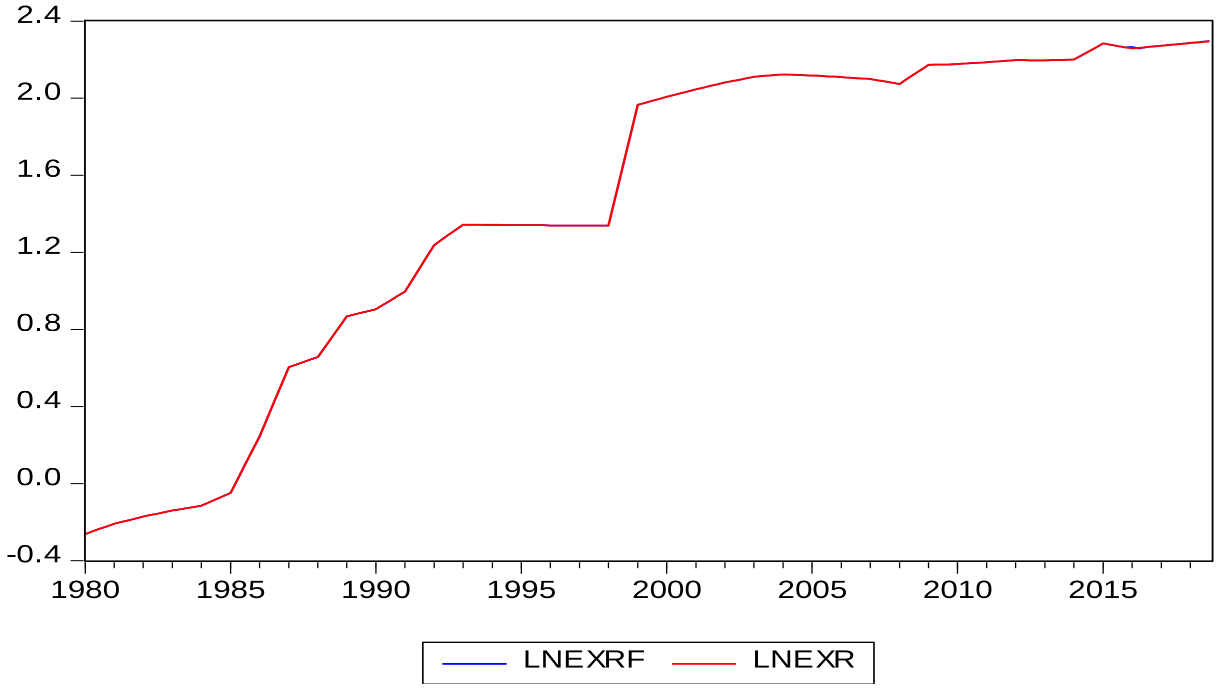
Figures 4.10 and 4.11 show the actual and forecasted exchange rates. They display strong co-movement in the actual and forecasted values of exchange rates. This is evident from the Theil coefficients values, where the variation between the actual and forecasted values of exchange rates is low and near-zero (see Table 4.9). Furthermore, the dynamic forecasting graph also has a low RMSE. This is satisfactory and validates strong predictive power as displayed in figures 4.10 and 4.11 for the dynamic and static model, respectively. The moving together of the actual and forecasted exchange rates can guide policy makers in their efforts to achieve exchange rates stability in Algeria.

Figure 4.10: Dynamic forecast



Source: *Author's computation (2020), using data sourced from the WDI.*

Figure 4.11: **Static forecast**



Source: *Author's computation (2020), using data sourced from the WDI.*

4.6.3.9 **Discussion and Inferences**

This study develops and estimates a forecasting model for exchange rates in Algeria. The model serves as a guide to exchange rates determination. The forecasting model is developed using sample variables for the period 1980Q1-2015Q4, and out-of-sample variables covering 2016-2018. This model is found satisfactory, following the various evaluation coefficients complementing the significance of our various tests of significance for the regressions and forecasting lines for both the dynamic and static estimates; sample and out-of-sample. The various evaluation coefficients comprising the RMSE, MAE, MAPE and the Theil coefficients are approaching zero. This is in line with the stretch of the benchmark for the suitability of the forecasting model. By implication, the satisfactory outcome of the sample model and the significant results obtained in both the dynamic and static forecasts strongly support the claim that the selected explanatory variables are suitable to forecast exchange rates in Algeria. This finding aligns with Eslamloueyan and Kia (2015), Kao (1999) and Kia (2015). Consequently, while the forecast may not be entirely accurate when the movements between the actual and forecasted exchange rates are compared, the results suggest that the forecasted exchange rates contain very little error. Since a manageable degree of error is anticipated in forecasting exercises, the forecasting could be considered effective and successful. Our claim that future exchange rates can be forecast by INF, INT, LNDBT, LNGDP, and LNMS in addition to LNOP which is reported significant and highly correlated with exchange rates, is acceptable. This finding contributes to knowledge by showing that exchange rates forecasting in Algeria strongly depends on these factors. Hence, the study offers insight into what is driving exchange rates and thus enables policymakers to explore appropriate guidelines to regulate exchange rates within the monetary context and external shocks.

Furthermore, the forecasting ability of the model used in this study is appropriate and suitable to explain variations in both the external and domestic values of the currency (exchange rates system) as shown in figures 4.8 and 4.9. In addition, figures 4.10 and 4.11 offer satisfactory evidence that the actual and forecasted exchange rates closely co-move in a similar direction. Therefore, to overcome the possibility of an exchange rates surge arising from oil price shocks causing economic imbalances as noted in Gali and Monacelli (2005) and emphasized in Hameed *et al.* (2012), which Etuk *et al*. (2016) describe as a major issue in the global economy, this study offers information to international economic agents who are continuously seeking opportunities to guard themselves against uncertainties and unforeseen fluctuations. In addition, the stability of exchange rates in Algeria and the satisfactory forecasting of this model contribute to the development of a safe macroeconomic arena which may influence investment decision making that enhances economic growth.

Reiterating the study's finding, exchange rates directly impact output behavior in Algeria. In all its ramifications, besides the method employed, the study makes specific significant contributions to knowledge through a satisfactory forecasting model for exchange rates. Furthermore, the exchange rates have not simply been modeled to generate accurate out-of-sample forecasts, but the model could be used to generate projections of how the exchange rates forecast would deviate from the unconditional baseline forecast, conditional on alternative economic scenarios such as a surge in speculation similar to historical events and a resurgence of the global business cycle, or increased oil production and demand. The proposed technique allows users and policymakers to examine the risks associated with movement in oil price projections. In addition, this study offers information as a guide to ascertain the direction of the foreign exchange rates market. The reported exchange rate is for the Dinar against the USD.

4.6.4 **Interpretation of Results for Egypt**

This section presents the results for Egypt. Among other things, the results include results of the ARDL Dynamic Regression, wald test, serial correlation test, heteroskedasticity test, normality test, stability test, and exchange rates forecasting. The section ends with discussion and inferences, summary and conclusions.

4.6.4.1 **Interpretation of the ARDL Regression Model**

Table 4.10: **ARDL Dynamic Regression Estimates**

Dependent Variable: LNEXR				
Method: ARDL				
Sample (adjusted): 1980Q3 2018Q4				
Included observations: 154 after adjustments				
Maximum dependent lags: 2 (Automatic selection)				
Model selection method: Akaike info criterion (AIC)				
Dynamic regressors (2 lags, automatic): INF INT LNDBT LNGDP LNMS LNOP				
Selected Model: ARDL(2, 2, 2, 0, 2, 0, 0)				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.***
LNEXR(-1)	1.781023	0.045322	39.29697	0.0000
LNEXR(-2)	-0.807335	0.044171	-18.27764	0.0000
INF	2.85E-05	7.80E-05	0.365530	0.7153
INT	-0.004104	0.002728	-1.504464	0.1347
INT(-1)	0.010719	0.004886	2.193949	0.0299
INT(-2)	-0.006114	0.002562	-2.386357	0.0184
LNDBT	0.004027	0.007288	0.552541	0.0058
LNGDP	-0.643634	0.285938	-2.250953	0.8260
LNGDP(-1)	1.062534	0.527515	2.014226	0.0459
LNGDP(-2)	-0.391383	0.281643	-1.389644	0.1669
LNMS	0.047463	0.030722	1.544917	0.1246
LNMS(-1)	-0.106221	0.055046	-1.929667	0.0557
LNMS(-2)	0.061762	0.031495	1.961036	0.0519
LNOP	-0.001484	0.002419	-0.613448	0.0406
C	-0.303071	0.098271	-3.084037	0.0025

Source: *Author's computation (2020), using data sourced from the WDI.*

Table 4.10 presents the results of the ARDL model for Egypt in the short run, showing the relationship between exchange rates and its corresponding regressors (exchange rates, inflation rates, interest rates, debt, GDP, money supply, and oil prices). It reveals that, at level, an increase in inflation rates is statistically significant in affecting exchange rates. By implication, this suggests that a unit increase in inflation rates will lead to about 2.8 percent depreciation in exchange rates. An increase in interest rates is found to significantly lead to exchange rates appreciation. This shows that a unit rise in interest rates will lead to 0.4 percent appreciation in exchange rates. This finding aligns with the theoretical claim that higher interest rates provide lenders in the economy with higher returns relative to other countries. Hence, higher interest rates attract foreign capital, causing exchange rates to appreciate. Inversely, a decrease in interest rates tends to decrease exchange rates. This result validates Ushie, Adeniyi and Akongwale's (2013) findings. Debts have a significant negative impact on exchange rates, suggesting that an increase in total debts in Egypt could lead to exchange rates depreciation. In this finding, a unit rise in the volume of debts will cause exchange rates to depreciate by 0.4 percent.

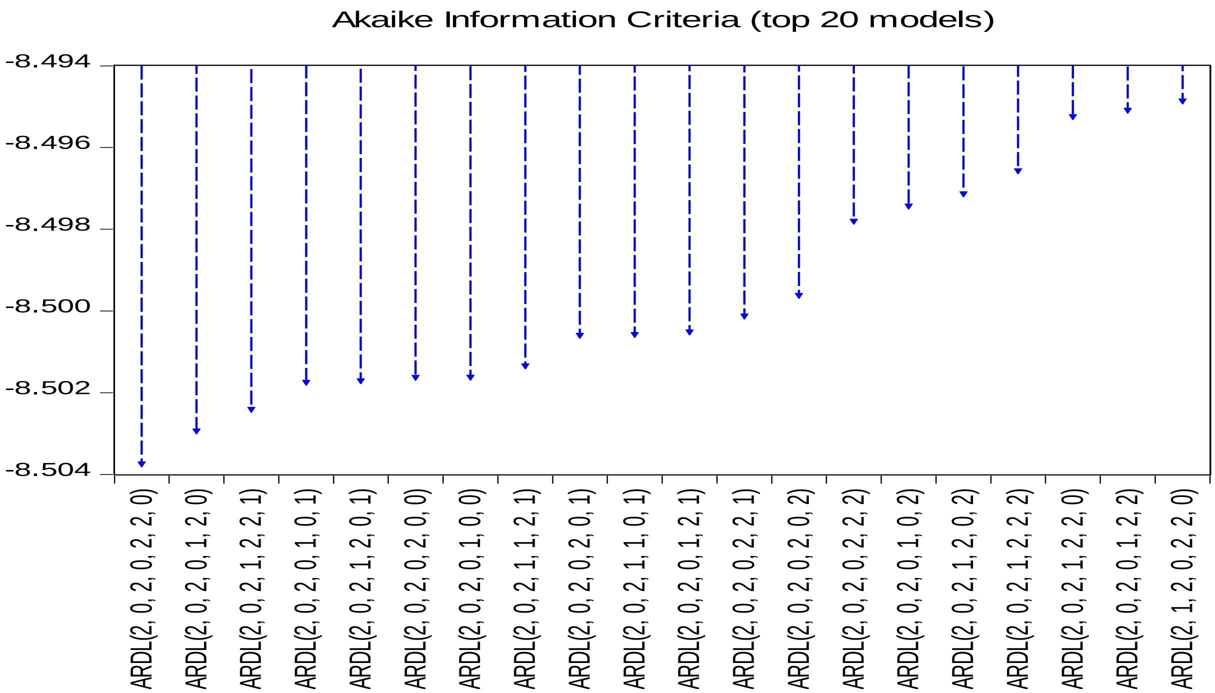
Our findings also show that money supply at both level and one period lag has a significantly negative impact on exchange rates. This suggests that an increase in money supply leads to a fall in interest rates which may in turn retard demand for local currency by foreign investors, and consequently lead to depreciation in the currency of the local economy. As shown, a unit increase in money supply will cause exchange rates to depreciate by 4.7 percent and 10.6 percent at level and one lagged period, respectively. Oil prices are statistically significant in affecting exchange rates. The sign of the coefficient suggests that an increase in oil prices will lead to exchange rates depreciation. This finding validates the claim that positive oil price shocks will lead to appreciation in the currency of an oil-exporting country. As revealed in this study, a unit rise in oil price will cause the Egyptian pound to appreciate by 1.4 percent.

The overall finding from the ARDL results is that the model allows for heterogeneous short-run dynamics to vary exchange rates. Therefore, the selected explanatory variables to forecast exchange rates in Egypt are appropriate.

4.6.4.2 **Measuring the Strength of the Model Selection Criteria**

Figure 4.12 presents the strength of the AIC model selection compared to other models comprising the Schwarz criterion and HQIC employed in the ARDL regression model. It aims to ascertain the short-run relationship of the ARDL model. Consequently, the criteria graph determines the top twenty ARDL models. The selection procedure follows the prevailing model benchmark analysis of Bakar *et al.* (2013) and Giles (2013), which asserts that the ARDL model with the smallest AIC value is most preferred. Therefore, the ARDL criteria graph having (2, 1, 2, 0, 2, 2, 0) and -8.504 as criteria values is the most preferred because it has the least value while the ARDL model (2, 1, 2, 0, 2, 2, 0) has the highest value, -8.494.

Figure 4.12: **Strength of the ARDL Model Selection**



Source: *Author's computation (2020), using data sourced from the WDI.*

4.6.4.3 **Wald Test**

This section presents the Wald test result to validate the short-run association between the regressors and regressand (exchange rates). This is carried out by testing for a null hypothesis of "no short-run cointegration amongst the variables", using the benchmark hypotheses of the Wald test specified below:

$$H_0: \text{Short} - \text{run cointegration does not exist between the regressors and regressand}$$

$$H_1: \text{Short} - \text{run cointegration exists between the regressors and regressand}$$

Decision rule:

Accept H_0 when P-Value is higher than 5 percent or Reject H_1 when P-Value is smaller than 5 percent.

The result of the Wald test is presented in Table 4.11, revealing the existence of a short-run relationship between the independent variables and exchange rates at the P-value of 1 percent. This finding suggests that the null hypothesis cannot be accepted.

Table 4.11: Wald Test Result

Test Statistic	Value	Df	Probability
F-statistic	4483.369	(6, 139)	0.0000
Chi-square	26900.22	6	0.0000

Source: *Author's computation (2020), using data sourced from the WDI.*

4.6.4.4 **Serial Correlation Results**

Table 4.12 presents the serial correlation result. There is no evidence of serial correlation in the model because the probability of the F-statistics is about 95 percent, greater than the 5 percent benchmark. This implies that the null hypothesis cannot be rejected. In addition, the finding reveals that the parameter estimates are free from the autocorrelation problem.

Table 4.12: **Breusch-Godfrey Serial Correlation LM Test**

F-statistic	0.044287	Prob. F(2,137)	0.9567
Obs*R-squared	0.099501	Prob. Chi-Square(2)	0.9515

Source: *Author's computation (2020), using data sourced from the WDI.*

4.6.4.5 **Heteroskedasticity Result**

Table 4.13 shows the heteroskedasticity test result. Both the chi square and F-statistics are insignificant at 5 percent. This indicates that the null hypothesis, no heteroskedasticity, cannot be rejected. Hence, the study concludes that the estimated model is reliable because there is no evidence of heteroskedasticity in the model.

Table 4.13: **Heteroskedasticity Test: Breusch-Pagan-Godfrey**

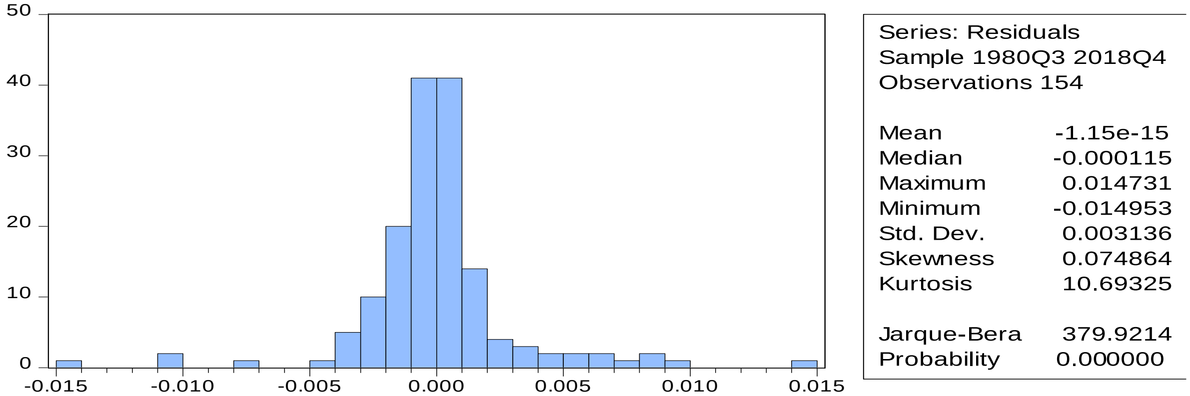
F-statistic	4.618718	Prob. F(14,139)	0.1830
Obs*R-squared	48.89451	Prob. Chi-Square(14)	0.5044
Scaled explained SS	193.0580	Prob. Chi-Square(14)	0.1100

Source: *Author's computation (2020), using data sourced from the WDI.*

4.6.4.6 **Normality Test**

The normality test is carried out based on the three common tests in the literature, consisting of the Jarque-Bera, kurtosis and skewness tests. The findings reveal that the variables are normally distributed as is evident in the probability value (0.000) shown in figure 4.13. Furthermore, the findings show that the residuals are distributed normally, and the data sets are appropriately modeled.

Figure 4.13: **Normality Test Results**



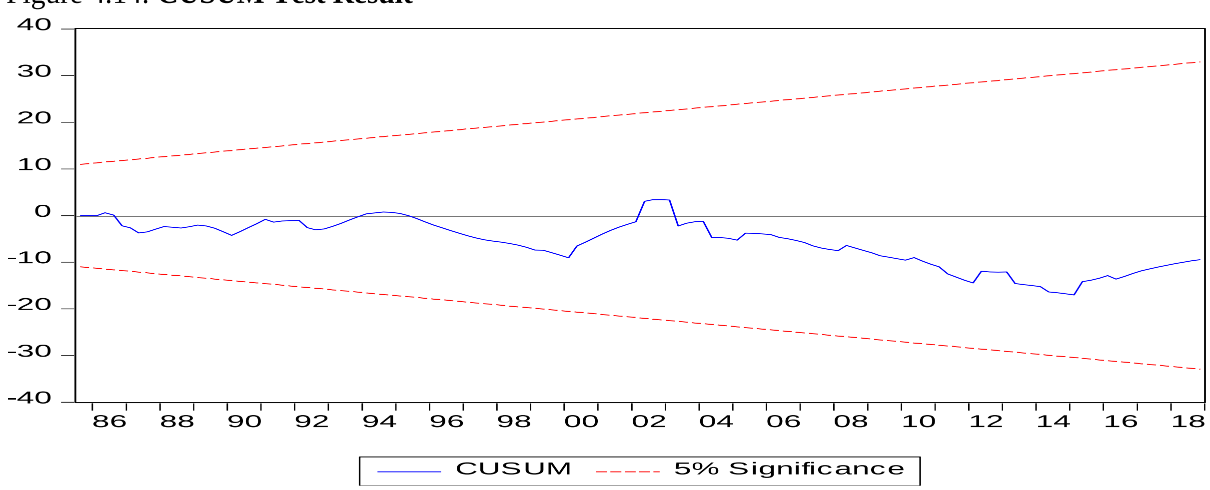
Source: *Author's computation (2020), using data sourced from the WDI.*

This is evident in the probability values at 1 percent significance level. Consequently, the findings imply that the data and residuals of the model for Egypt are distributed normally and are, hence, reliable and valid to forecast exchange rates for this country.

4.6.4.7 **CUSUM Stability Test**

The results of the CUSUM stability test are presented in Figure 4.5. It shows that the ARDL model is stable to forecast exchange rates in Egypt because the line capturing our data falls between the 5 percent confidence interval lines.

Figure 4.14: **CUSUM Test Result**

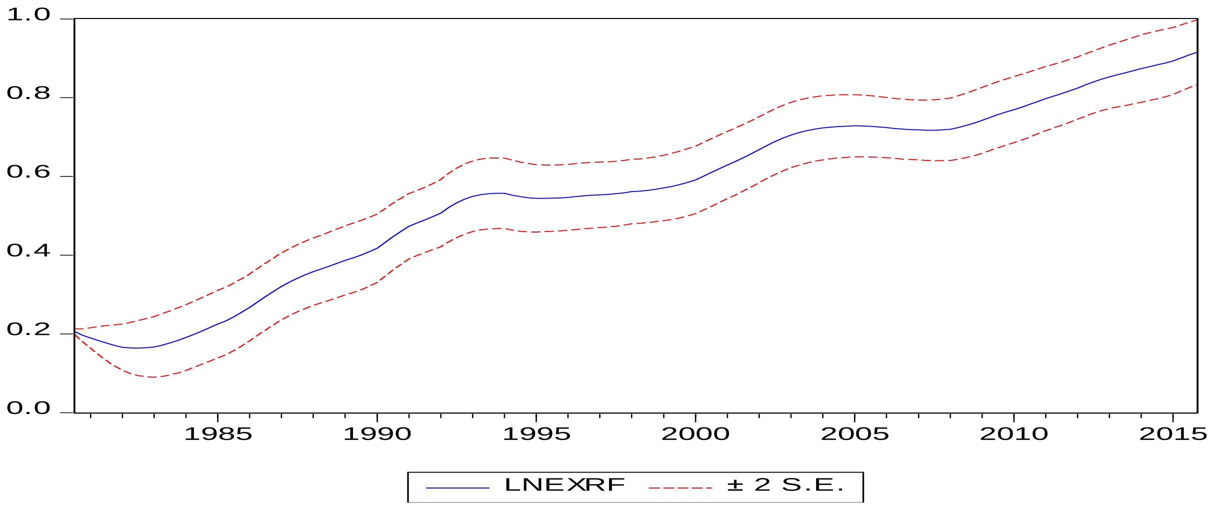


Source: *Author's computation (2020), using data sourced from the WDI.*

4.6.4.8 **Forecasting Exchange Rates: Static and Dynamic Results**

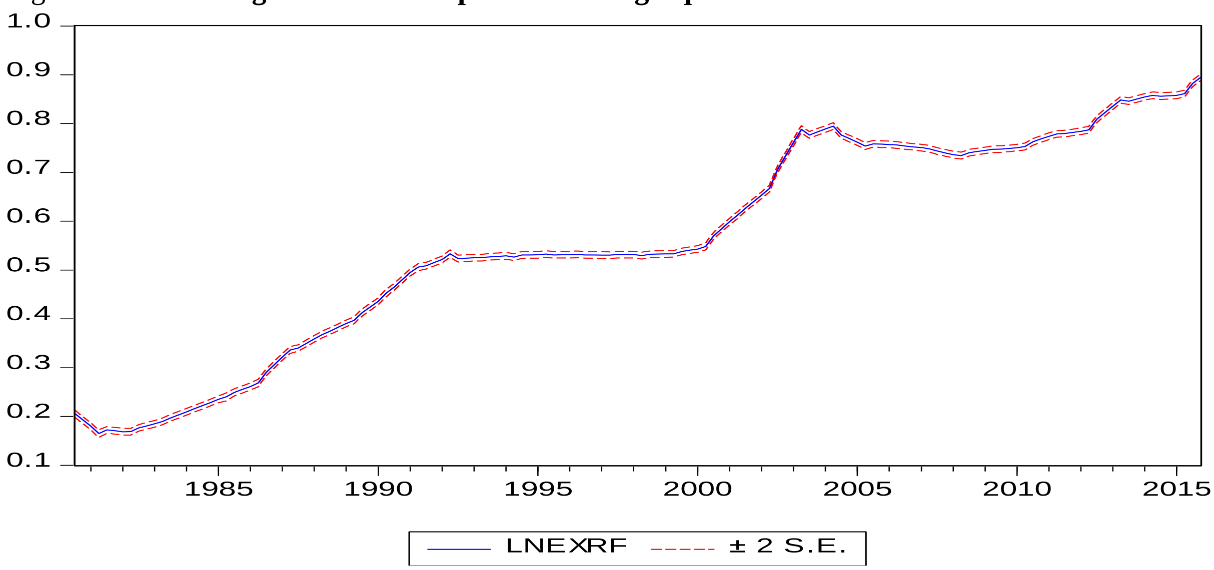
Following the estimated ARDL model and the various diagnostic tests conducted to ascertain that the model is valid and suitable for forecasting, the study forecasts exchange rates. The data for exchange rates spans 1980Q1 to 2018Q4, of which data spanning 1980Q1 to 2015Q4 accounts for the sample regression model for both dynamic and static forecasts as shown respectively in figures 4.15 and 4.16. The outcomes of these sample regressions for dynamic and static forecasts reveal that they are both significant at 95 percent confidence interval because the lines of the sample equation fall within the two dotted red lines. These findings further corroborate the earlier diagnostic tests that showed that the model is appropriate to forecast exchange rates.

Figure 4.15: **Exchange Rates In-Sample Forecasting Equation: *Dynamic***



Source: *Author's computation (2020), using data sourced from the WDI.*

Figure 4.16: **Exchange Rates In-Sample Forecasting Equation: *Static***



Source: *Author's computation (2020), using data sourced from the WDI.*

Furthermore, the forecasting evaluation criteria presented in Table 4.14 support the validity of the model to forecast exchange rates. The RMSE, MAE, and MAPE which serve as benchmarks for forecasting offer support for the appropriateness of the forecasting models for both the dynamic and static models. For example, the RMSE, MAE and MAPE coefficients for the dynamic forecast are 0.002668, 0.022167 and 0.041480, nearing the zero (0) benchmark. Similarly, the RMSE, MAE and MAPE coefficients for the static forecast are 0.003125, 0.001831 and 0.036815 in that order, also nearing the zero "0" benchmark. Table 4.14 also presents the Theil coefficients for both the dynamic and static forecasts and they are respectively estimated as 0.022167 and 0.002474.

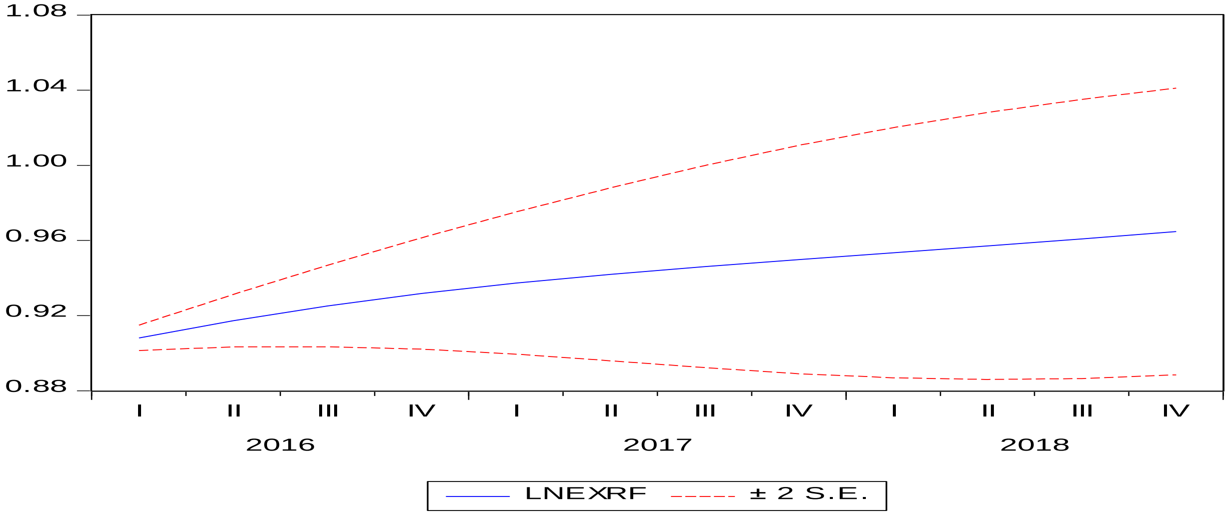
Table 4.14: **Exchange Rates In-Sample Forecast Equation: 1980Q1-2015Q4**

	EVALUATION COEFFICIENTS			
	RMSE	**MAE**	**MAPE**	**THEIL**
Dynamic	0.002668	0.022167	0.041480	0.022167
Static	0.003125	0.001831	0.036815	0.002474

Source: *Author's computation (2020), using data sourced from the WDI.*

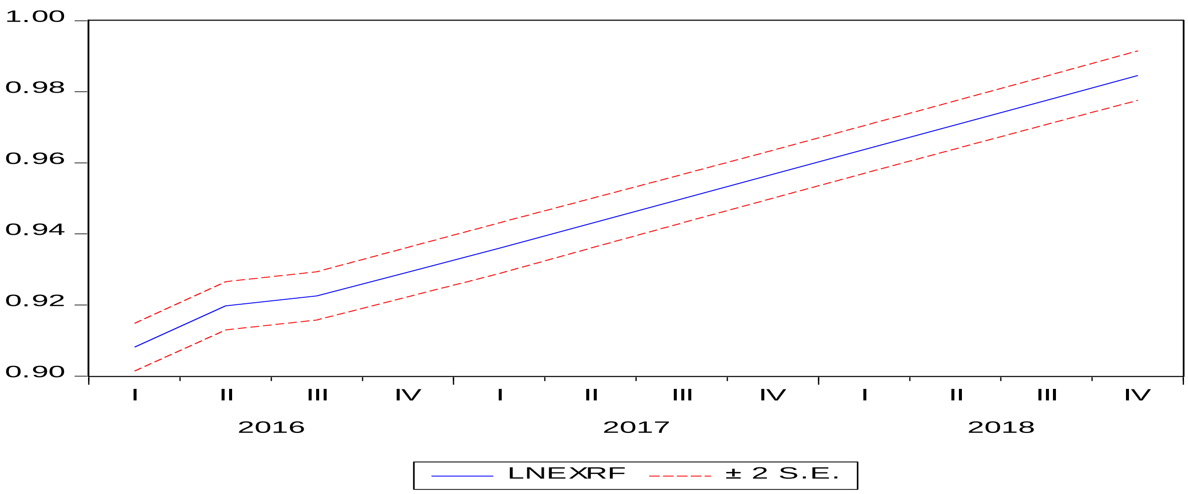
The out-of-sample forecasting horizon runs from 2016Q1 to 2018Q4. The results are presented in Tables 4.17 and 4.18 and both reveal that the out-of-sample forecasts equations are significant as confirmed by the 95 percent confidence interval level and the forecast line falling within the two (± 2) standard deviation error lines. Thus, the results offer support for the suitability of the sample regression models to forecast exchange rates. The forecasting evaluation criteria which consist of RMSE, MAE, and MAPE which serve as benchmarks for forecasting, support the appropriateness of the forecasting models for both the dynamic and static out-of-sample forecast models. As presented in Table 4.15, the RMSE, MAE and MAPE coefficients for the dynamic forecast are 0.009913, 0.007064 and 0.005247, nearing the zero (0) benchmark. Similarly, the RMSE, MAE and MAPE coefficients for the static forecast are 0.001370, 0.001202 and 0.012779 in that order, also nearing the zero "0" benchmark. The Theil coefficients for the dynamic and static forecasts are also presented in Table 4.15. The finding reveals that the Theil coefficients for the dynamic and static out-of-sample forecasting models are respectively estimated as 0.005247 and 0.000723. These results also support the reliability of the model to forecast the exchange rates because the coefficients are nearing zero, the benchmark for the analysis.

Figure 4.17: **Exchange Rates Out-of-Sample Forecast: *Dynamic***



Source: *Author's computation (2020), using data sourced from the WDI.*

Figure 4.18: **Exchange Rates Out-of-Sample Forecast: *Static***



Source: *Author's computation (2020), using data sourced from the WDI.*

Table 4.15**: Exchange Rates Out-of-Sample Forecast lines 1980Q1-2015Q4**

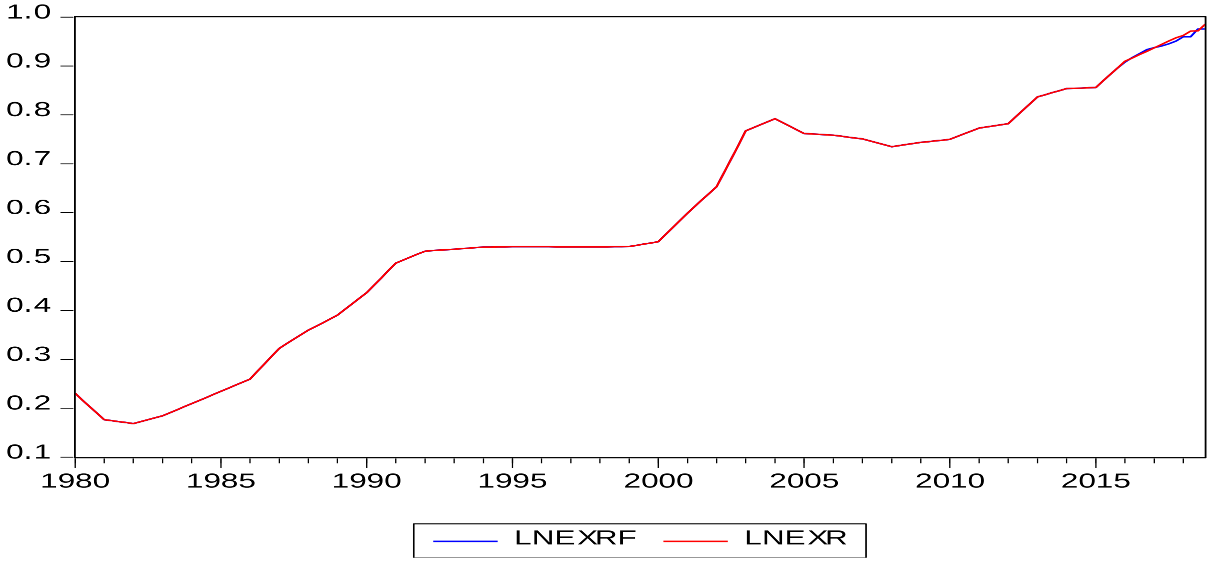
	EVALUATION COEFFICIENTS			
	RMSE	**MAE**	**MAPE**	**THEIL**
Dynamic	0.009913	0.007064	0.007064	0.005247
Static	0.001370	0.001202	0.012779	0.000723

Source: *Author's computation (2020), using data sourced from the WDI.*

Figures 4.19 and 4.20 show co-movements in the actual and forecasted exchange rates for the period under investigation. The result displays strong co-movement in the actual and forecasted values of exchange rates. This is also evident from the Theil coefficients values, showing that the variation between the actual and forecasted values of exchange rates is low and near-zero (see tables 4.19 and

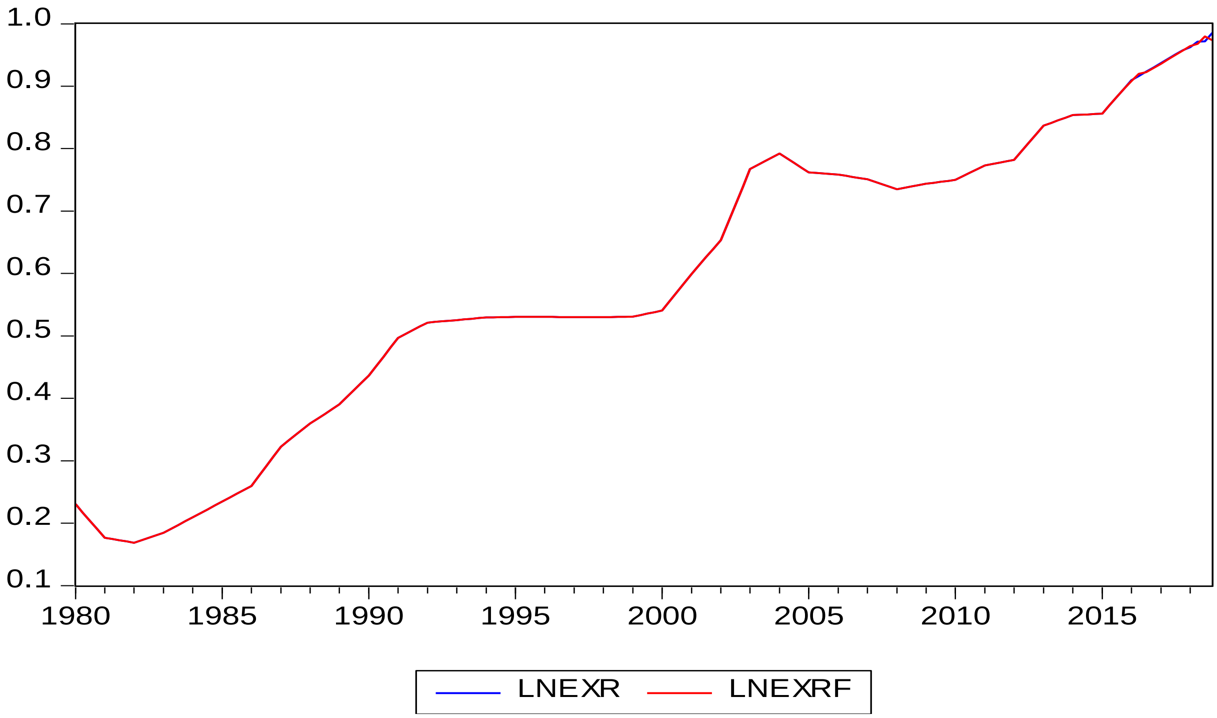
4.20). Furthermore, the dynamic forecasting graph also has a low RMSE coefficient. This is satisfactory and validates strong predictive power as displayed in figures 4.19 and 4.20. Policymakers can use the co-movement of the actual and forecasted exchange rates to guide decision-making to ensure exchange rates stability.

Figure 4.19**: Dynamic forecast**



Source: *Author's computation (2020), using data sourced from the WDI.*

Figure 4.20: **Static forecast**



Source: Author's computation (2020).

4.6.4.9 **Discussion and Inferences**

This section forecasts an exchange rates model for Egypt to serve as a guide for decision making and to help mitigate against exchange rates risks. Variables spanning 1980Q1-2015Q4 were used for the sample forecasting equation and 2016Q1-2018Q4 for the out-of-sample forecasting equation. Based on the various diagnostic tests and estimations of evaluation coefficients, the model is found satisfactory. The evaluation coefficients in the dynamic forecasting are 0.002668, 0.022167, 0.041480 and 0.022167 for RMSE, MAE, MAPE and Theil, respectively. Static forecasting reveals 0.003135, 0.001831, 0.036815 and 0.002474 as evaluating coefficients for RMSE, MAE, MAPE and Theil. The evaluation coefficients are near zero, the analysis benchmark. This confirms the validity of the sample forecasting models to forecast exchange rates.

Buttressing this claim is the gaps between the actual and forecasted exchange rates that are often very close, confirming that the model is valid. Although the forecast may not be entirely accurate when the movement between the actual and forecasted exchange rates is compared, the results suggest that the forecasted exchange rates contain very little error. Since a manageable degree of error is anticipated in forecasting exercises, the forecasting can be considered effective and successful. Therefore, it can be accepted that inflation rates, interest rates, debt, GDP and oil price significantly forecast exchange rates in Egypt. This finding aligns with Eslamloueyan and Kia (2015), Kao (1999) and Kia (2015).

The forecasting ability of the model used in this study is appropriate and suitable to explain variations in both the external and domestic values of the currency (exchange rates system). Figures 4.19 and 4.20 offer satisfactory evidence that the actual and forecasted exchange rates co-move in a similar direction and with negligible difference. Therefore, to overcome the possibility of an exchange rates surge arising from oil price shocks, causing economic imbalances as noted in Gali and Monacelli (2005) and emphasized in Hameed *et al*. (2012), which Etuk *et al*. (2016) conclude is a major issue in the global economy, this study offers information for international economic agents who are continuously seeking guidance to deal with uncertainties and unforeseen fluctuations.

4.6.5 **Interpretation of Results for Gabon**

This section presents the results for Gabon. Among other things, the results include ARDL Dynamic Regression, wald test, serial correlation results, heteroskedasticity result, normality test, stability test exchange rates forecasting results. The section ends with discussion and inferences, summary and conclusions.

4.6.5.1 **Interpretation of the ARDL Regression Model**

Table 4.16: **ARDL Dynamic Regression Estimates**

Dependent Variable: LNEXR				
Method: ARDL				
Sample (adjusted): 1980Q3 2018Q4				
Included observations: 154 after adjustments				
Maximum dependent lags: 2 (Automatic selection)				
Model selection method: Akaike info criterion (AIC)				
Dynamic regressors (2 lags, automatic): INF INT LNDBT LNGDP LNMS LNOP				
Selected Model: ARDL(2, 2, 0, 2, 2, 2,2)				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.***
LNEXR(-1)	1.689799	0.055909	30.22413	0.0000
LNEXR(-2)	-0.730565	0.052473	-13.92262	0.0000
INF	0.002867	0.000347	8.263348	0.0000
INF(-1)	-0.004854	0.000596	-8.141783	0.0000
INF(-2)	0.002228	0.000349	6.388133	0.0000
INT	-0.001084	0.000367	-2.956239	0.0037
LNDBT	0.126000	0.038463	3.275882	0.0013
LNDBT(-1)	-0.220256	0.069680	-3.160964	0.0019
LNDBT(-2)	0.100673	0.038217	2.634253	0.0094
LNGDP	-0.802161	0.154664	-5.186482	0.0000
LNGDP(-1)	1.363338	0.287111	4.748463	0.0000
LNGDP(-2)	-0.589988	0.159623	-3.696131	0.0003
LNMS	1.021663	0.097458	10.48307	0.0000
LNMS(-1)	-1.774586	0.186548	-9.512741	0.0000
LNMS(-2)	0.778481	0.111092	7.007511	0.0000
LNOP	-0.268783	0.031852	-8.438596	0.0000
LNOP(-1)	0.461062	0.058351	7.901530	0.0000
LNOP(-2)	-0.207893	0.033954	-6.122724	0.0000
C	0.235419	0.218093	1.079441	0.2823

Source: *Author's computation (2020), using data sourced from the WDI.*

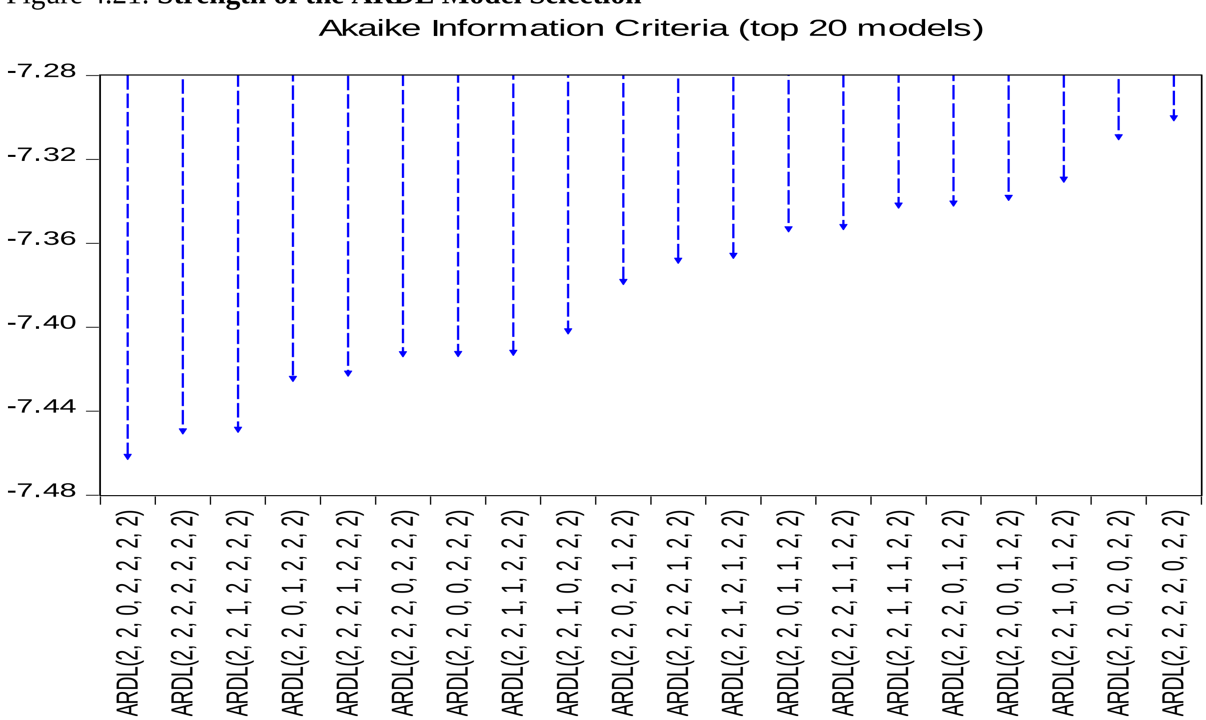
Table 4.16 presents the ARDL results for Gabon, showing the short-run relationship between exchange rates and its corresponding regressors comprising inflation rates, interest rates, debts, GDP, money supply and oil prices. The findings reveal that, at level, debts (0.1260) negatively impact exchange rates. This suggests that, as the volume or amount of debts increases in Gabon, the exchange rate has the tendency to depreciate. Inflation rates (0.002867), interest rates (-0.001084), and money supply (1.021663) are positively related with exchange rates, suggesting that a rise in inflation rates, interest rates and money supply will lead to appreciation in the Gabon Franc. Contrary to the findings in Algeria on how GDP impacts exchange rates, this result revels that GDP (-0.802161) in Gabon negatively impacts exchange rates. However, the results of one lagged period in GDP (-1) show otherwise, that a rise in GDP will lead to currency appreciation in Gabon. While this appears contrary to theory, at the same time, it suggests that there might be time lag in GDP affecting exchange rates.

The positive relationship of exchange rates with interest rates, inflation rates and money supply is in line with theory and this finding validates Eslamloueyan and Kia (2015) and Ahmed (2107). Furthermore, the result shows that an increase in oil prices will lead to appreciation in the Franc. This also aligns with theory as, when more Francs are demanded by oil importers to enable them to make oil purchases, the local currency appreciates and vice versa. Earlier studies reported similar results (see Iwayemi and Fowowe, 2011; Haskamp, 2017; Beneki and Yarmohammadi, 2014). Our ARDL results and various signs aligning with theory suggest that the selected macroeconomic variables are suitable to forecast exchange rates in Gabon.

4.6.5.2 **Measuring the Strength of the Model Selection Criteria**

The criteria graph in Table 4.21 determines the strength of the AIC over other criteria (the SIC and HQIC) for model selection in the regression as well as the short-run relationships in this study. Furthermore, it evaluates the top twenty ARDL models based on the benchmark analysis, postulating that the lower the value of the AIC, the more reliable the model. The figure reveals that the first ARDL (2, 2, 0, 2, 2, 2, 2) model appears to be preferred over the other nineteen models because it gives the lowest (most negative) AIC value.

Figure 4.21: **Strength of the ARDL Model Selection**



Source: *Author's computation (2020), using data sourced from the WDI.*

4.6.5.3 **Wald Test**

In this section, the study validates the short-run association between the independent variables and exchange rates. This is carried out by testing for a null hypothesis of no short-run cointegration amongst the variables. The benchmark hypotheses of the Wald test are specified below:

$$H_0: \text{Short} - \text{run cointegration does not exist among the regressors and regressand}$$
$$H_1: \text{Short} - \text{run cointegration exists between the regressors and dependent variables}$$

Decision rule:

Accept H_0 when P-Value is higher than 5 percent or Reject H_1 when P-Value is smaller than 5 percent.

As displayed in Table 4.17, the Wald test reveals the existence of a short-run relationship between the independent variables and exchange rates at the P-value of 1 percent. This suggests that the null hypothesis cannot be accepted.

Table 4.17: **Wald Test Result**

Test Statistic	Value	Df	Probability
F-statistic	3618.719	(6, 135)	0.0000
Chi-square	21712.32	6	0.0000

Source: *Author's computation (2020), using data sourced from the WDI.*

4.6.5.4 **Serial Correlation Results**

Table 4.18 presents the results of serial correlation. It shows no evidence of serial correlation because the probability of the F-statistics is 45 percent which is greater than the 5 percent benchmark for analysis. This suggests that the null hypothesis cannot be rejected. It is therefore suggested that the model is free from the serial correlation problem. Furthermore, the results confirm that the parameter estimates of the model do not suffer from an autocorrelation problem.

Table 4.18: **Breusch-Godfrey Serial Correlation LM Test**

-statistic	0.544539	Prob. F(2,137)	0.5814
Obs*R-squared	1.250795	Prob. Chi-Square(2)	0.5350

Source: *Author's computation (2020), using data sourced from the WDI.*

4.6.5.5 **Heteroskedasticity Result**

Table 4.7 shows the heteroskedasticity results. It reveals that both the chi square and F-statistics are insignificant at 5 percent. This shows that the null hypothesis, no heteroskedasticity, cannot be rejected. Hence, the study concludes that the estimated model is reliable and there is no problem of heteroskedasticity.

Table 4.19: Heteroskedasticity Test: Breusch-Pagan-Godfrey

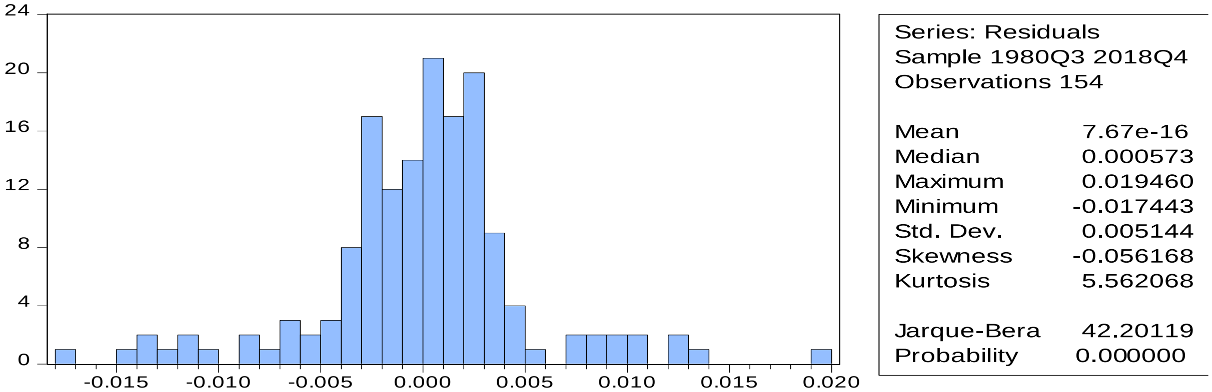
F-statistic	1.805749	Prob. F(14,139)	0.0304
Obs*R-squared	29.88317	Prob. Chi-Square(14)	0.0386
Scaled explained SS	52.38230	Prob. Chi-Square(14)	0.0000

Source: *Author's computation (2020), using data sourced from the WDI.*

4.6.5.6 **Normality Test**

The result of the normality test is presented in figure 4.22. It shows that the residuals of the model are normally distributed. This is evident from the Jarque-Bera statistics which is statistically insignificant at 5 percent (that is, 42.20119).

Figure 4.22: **Normality Test Results**



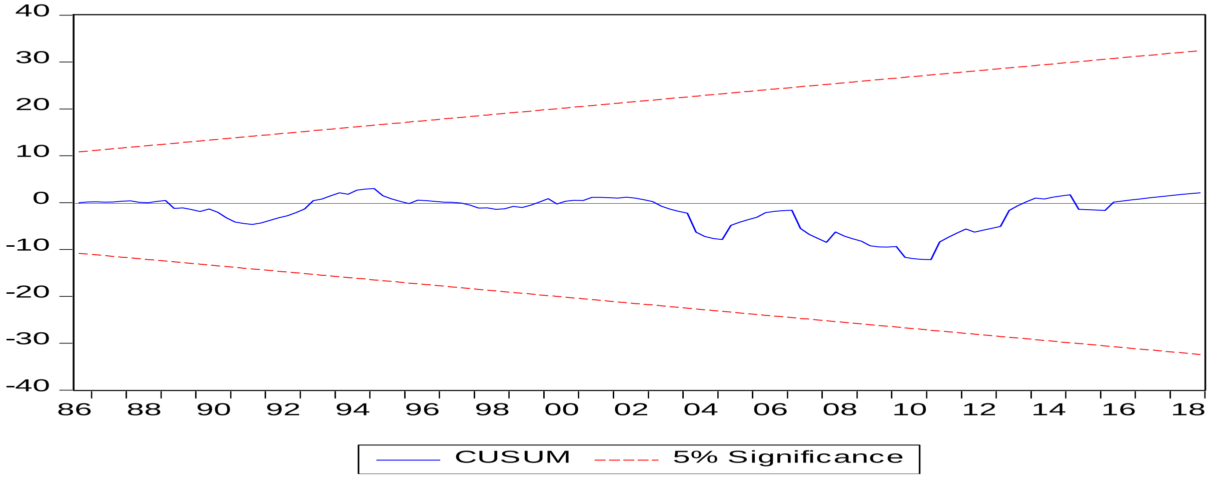
Source: *Author's computation (2020), using data sourced from the WDI.*

The normality test is conducted based on the three common criteria (Jarque-Bera, kurtosis and skewness) in the literature. The findings reveal that the variables are normally distributed as evident in the probability value in figure 4.22 (0.000). Furthermore, the results confirm that the data sets are appropriately modeled.

4.6.5.7 **CUSUM Stability Test**

Figure 4.5 presents the CUSUM stability test for the ARDL model. The result suggests that that the model is stable because the line capturing our data falls between the 5 percent confidence interval lines.

Figure 4.23: **CUSUM Test Result**

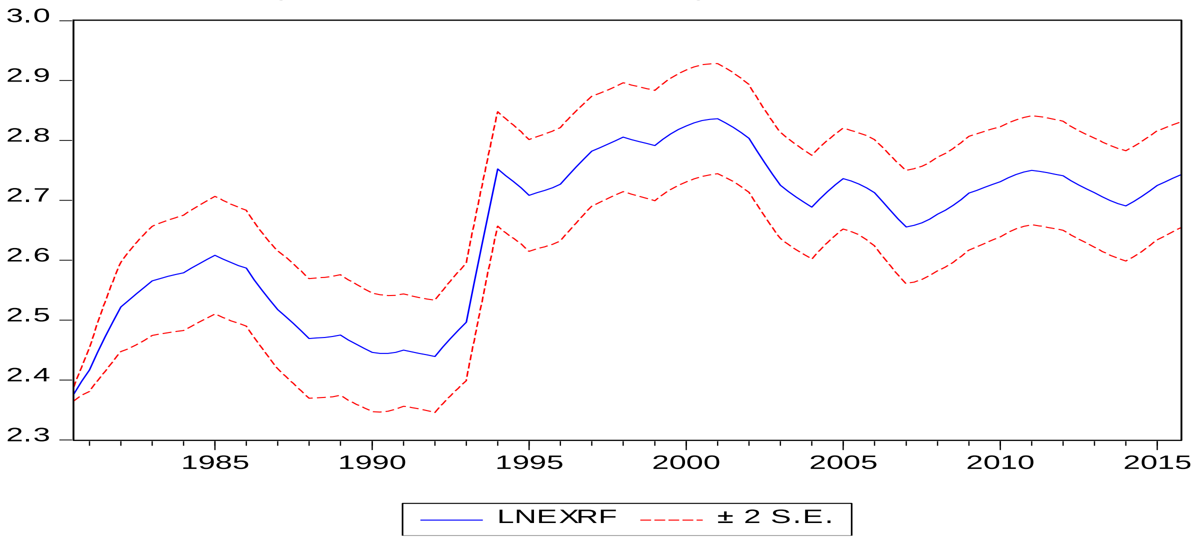


Source: *Author's computation (2020), using data sourced from the WDI.*

4.6.5.8 **Forecasting Exchange Rates: Static and Dynamic Results**

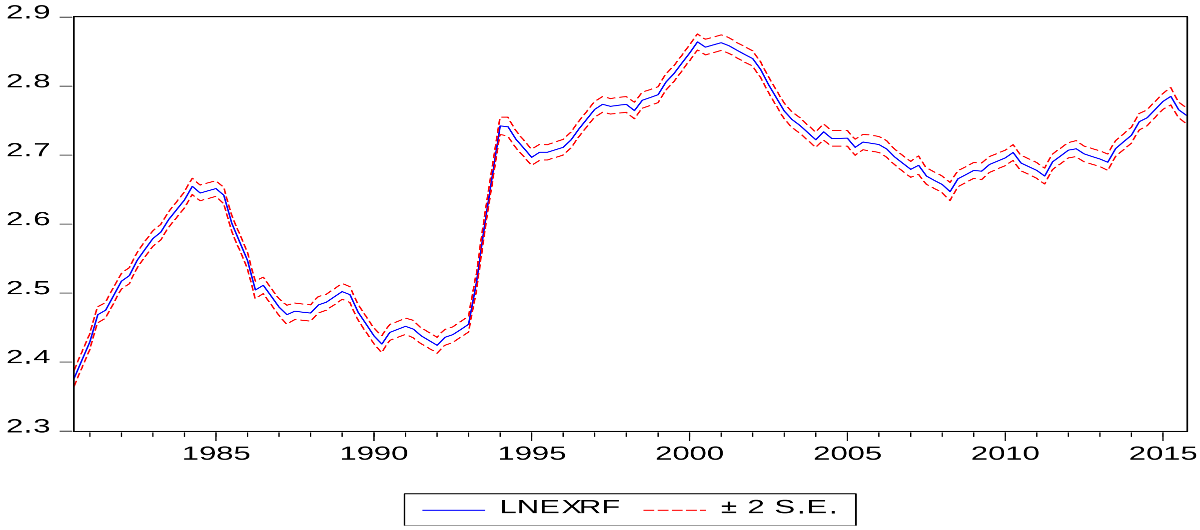
Having validated the suitability of the ARDL model, the study proceeds to forecast exchange rates. The data estimated covers the period 1980Q1 to 2018Q4, of which data ranging from 1980Q1 to 2015Q4 accounts for the sample regression model for both the dynamic and static forecasts shown in figures 4.24 and 4.25, respectively and data covering the period 2016Q1 to 2018Q4 accounts for out-of-sample regression as shown in figures 4.26 and 4.27 for dynamic and static regressions, respectively. The results show that the sample regressions for dynamic and static forecasts are both significant at 95 percent confidence interval. This validates the appropriateness and suitability of the model to make dynamic and static forecasts of exchange rates.

Figure 4.24: **Exchange Rates In-Sample Forecasting Equation:** ***Dynamic***



Source: *Author's computation (2020), using data sourced from the WDI.*

Figure 4.25: **Exchange Rates In-Sample Forecasting Equation: *Static***



Source: *Author's computation (2020), using data sourced from the WDI.*

The forecasting evaluation criteria consisting of RMSE, MAE, MAPE and Theil offer satisfactory results to buttress the suitability of the exchange rates forecasting model. For instance, the RMSE, MAE, MAPE and Theil coefficients for the dynamic forecast sample regressions are estimated as 0.029857, 0.024704, 0.009258 and 0.005622. These results fall within the acceptable benchmark of zero "0". The RMSE, MAE, MAPE and Theil coefficients for the sample static exchange rates forecasts are estimated as 0.005289, 0.003703, 0.014066 and 0.000996 in that order. These results also fall within the acceptable analysis benchmark of zero "0".

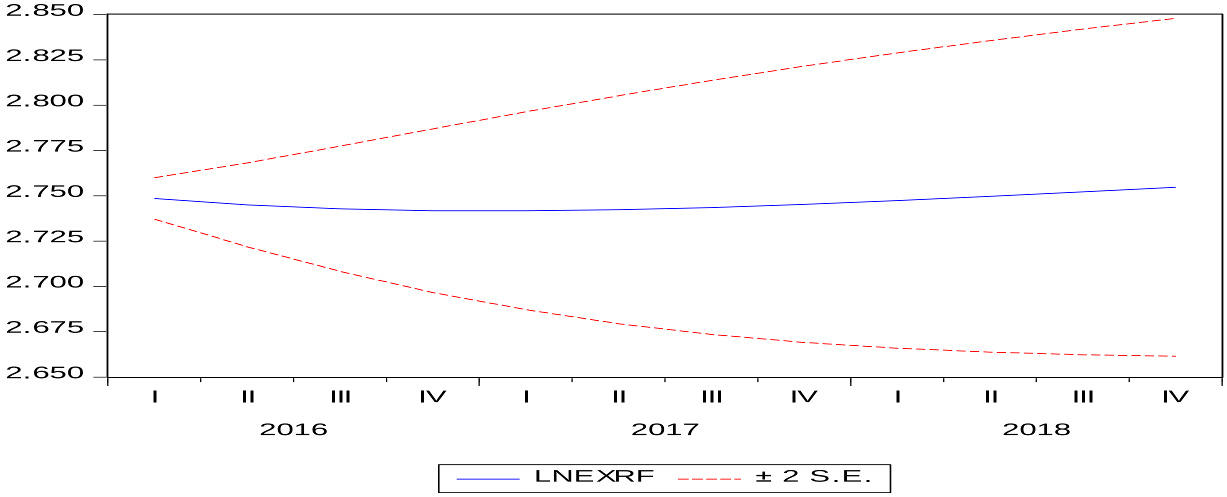
Table 4.20: **Exchange Rates In-Sample Forecast Equation 1980Q1-2015Q4**

	EVALUATION COEFFICIENTS			
	RMSE	**MAE**	**MAPE**	**THEIL**
Dynamic	0.029857	0.024704	0.009258	0.005622
Static	0.005289	0.003703	0.014066	0.000996

Source: *Author's computation (2020), using data sourced from the WDI.*

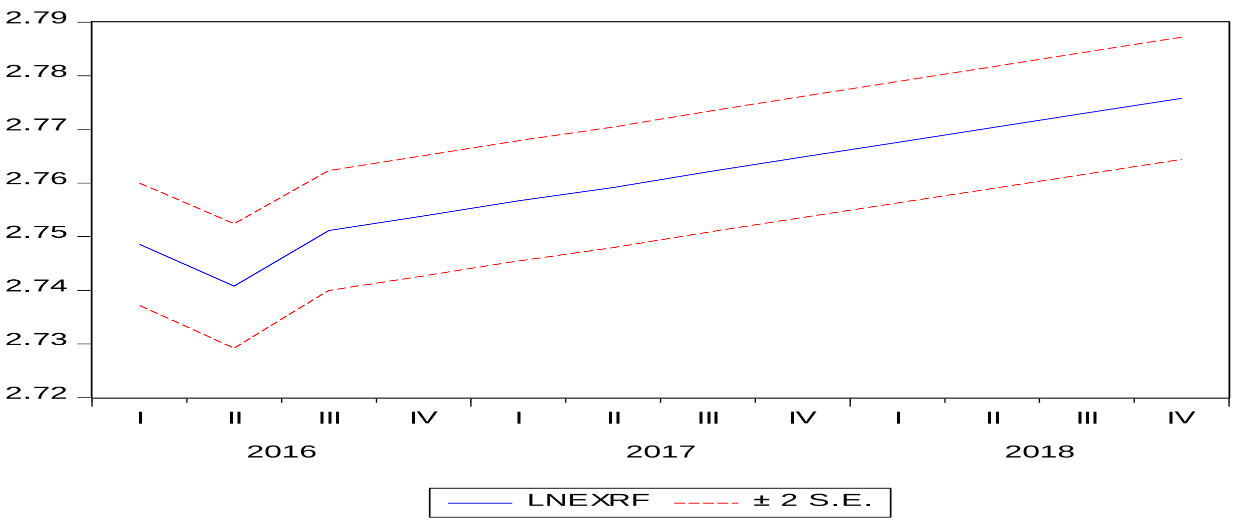
For the out-of-sample forecasting horizon from 2016Q1 to 2018Q4, the results reveal that the forecasts are significant at 95 percent confidence interval within the two (± 2) standard deviation error lines. These results support the suitability of the out-of-sample regression models to forecast exchange rates.

Figure 4.26: **Exchange Rates Out-of-Sample Forecast: *Dynamic***



Source: *Author's computation (2020), using data sourced from the WDI.*

Figure 4.27: **Exchange Rates Out-of-Sample Forecast: *Static***



Source: *Author's computation (2020), using data sourced from the WDI.*

The forecasting evaluation criteria considered for out-of-sample forecasting of both dynamic and static regressions are presented in Table 4.21 as RMSE (0.016956), MAE (0.015560), MAPE (0.026880) and Theil (0.003079) for the dynamic regression and RMSE (0.02526), MAE (0.001467), MAPE (0.053250) and Theil (0.000458) for the static regression. These results are found suitable because their coefficients are within the acceptable analysis benchmark. They thus validate the forecast model.

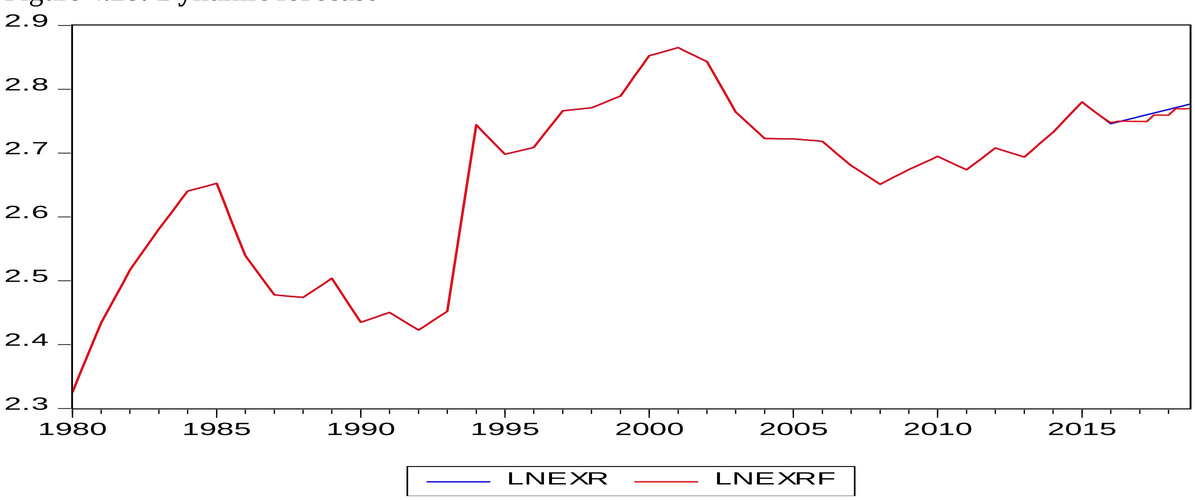
Table 4.21**: Exchange Rates Out-of-Sample Forecast lines: 1980Q1-2015Q4**

	EVALUATION COEFFICIENTS			
	RMSE	**MAE**	**MAPE**	**THEIL**
Dynamic	0.016956	0.015560	0.026880	0.003079
Static	0.002526	0.001467	0.053250	0.000458

Source: *Author's computation (2020), using data sourced from the WDI.*

In figures 4.28 and 4.29, the actual and forecasted exchange rates are presented for the dynamic and static models. They depict strong co-movement in the actual and forecasted values of exchange rates. This is evident from the Theil coefficients values, showing that the variation between the actual and forecasted values of exchange rates is low and near-zero. This is found satisfactory and the forecast suggests that there is strong predictive power in the model. The moving together of the actual and forecasted exchange rates strongly suggests that this could serve as a guide to policymakers in decision-making to stabilize exchange rates.

Figure 4.28**: Dynamic forecast**



Source: *Author's computation (2020), using data sourced from the WDI.*

Figure 4.29: Static forecast

Source: *Author's computation (2020), using data sourced from the WDI.*

4.6.5.9 **Discussion and Inferences**

This study develops and estimates a forecasting model for exchange rates in Gabon. The forecasting model serves as a guide to exchange rates determination in decision making and policy formulation. The forecasting model is developed using sample variables for the period 1980Q1-2015Q4, and out-of-sample variables covering 2016-2018. This model is found satisfactory, following the various evaluation coefficients that complement the significance of our various tests for significance for the regressions and forecasting model. The satisfactory outcome of the sample model and the significant results obtained in both the dynamic and static forecasts strongly support the claim that the selected explanatory variables are suitable to forecast exchange rates in Gabon. It also shows that the model has strong predictive power to forecast exchange rates in this country. This finding aligns with Eslamloueyan and Kia (2015), Kao (1999) and Kia (2015). While the forecast may not be entirely accurate when the movements between the actual and forecasted exchange rates are compared, the results suggest that the forecasted exchange rates contain very little error. Since a manageable degree of error is anticipated in forecasting exercises, the forecasting could be considered effective and successful. Hence, future exchange rates in Gabon could be forecast using inflation rates, interest rates, debts, GDP, money supply and oil prices. This finding offers useful information to international economic agents who continuously seek guidelines to address uncertainties and unforeseen fluctuations. In addition, the result contributes to the development of a safe macroeconomic arena which may influence investment decision making that enhances economic growth in Gabon.

4.6.6 **Interpretation of Results for Libya**

The results for Libya are presented in this section. Among other things, the results include ARDL Dynamic Regression, wald test, serial correlation results, heteroskedasticity result, normality test, stability test exchange rates forecasting results. The section ends with discussion and inferences, summary and conclusions.

4.6.6.1 **Interpretation of the ARDL Regression Model**

Table 4.22: **ARDL Dynamic Regression Estimates**

Dependent Variable: LNEXR				
Method: ARDL				
Sample (adjusted): 1980Q3 2018Q4				
Included observations: 154 after adjustments				
Maximum dependent lags: 2 (Automatic selection)				
Model selection method: Akaike info criterion (AIC)				
Dynamic regressors (2 lags, automatic): INF INT LNDBT LNGDP LNMS LNOP				
Selected Model: ARDL(2, 2, 2, 2, 2, 0, 0)				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.***
LNEXR(-1)	1.698523	0.062479	27.18551	0.0000
LNEXR(-2)	-0.709091	0.064331	-11.02256	0.0000
INF	0.002260	0.000789	2.863744	0.0048
INF(-1)	0.003221	0.001435	2.245520	0.0263
INF(-2)	-0.001433	0.000797	-1.797550	0.0445
INT	-0.076837	0.023765	-3.233196	0.0015
INT(-1)	0.141855	0.042388	3.346590	0.0011
INT(-2)	-0.067500	0.024209	-2.788190	0.0061
LNDBT	0.085587	0.015669	5.462093	0.0000
LNDBT(-1)	-0.145396	0.029732	-4.890250	0.0000
LNDBT(-2)	0.058774	0.017295	3.398298	0.0009
LNGDP	-0.288803	0.037018	-7.801678	0.0000
LNGDP(-1)	0.480103	0.068375	7.021661	0.0000
LNGDP(-2)	-0.195503	0.040413	-4.837666	0.0000
LNMS	0.008683	0.006801	1.276704	0.0039
LNOP	-0.005828	0.007266	-0.802013	0.4239
C	-0.076526	0.091415	-0.837129	0.4040

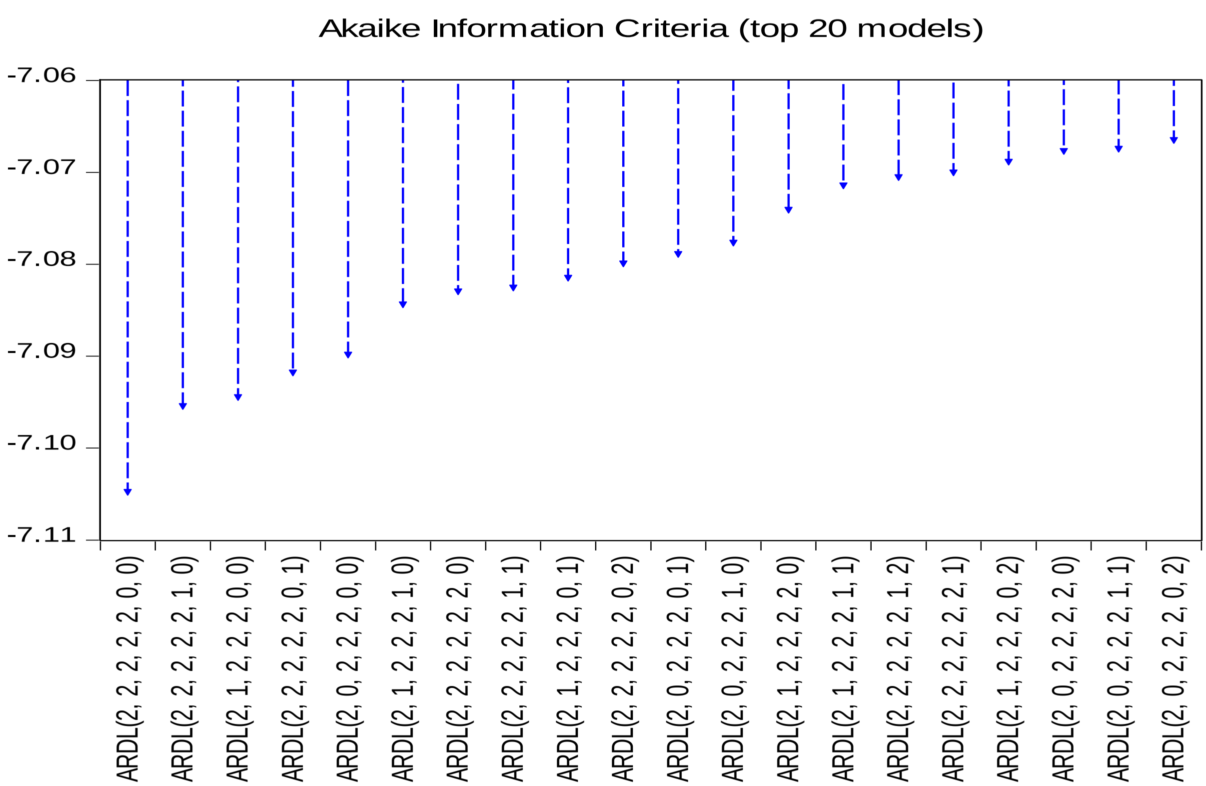
Source: *Author's computation (2020), using data sourced from the WDI.*

The estimated results of the ARDL for Libya are presented in Table 4.22. They show that in the short run, except for oil prices, all other independent variables are statistically significant to explain exchange rates variations at level. It is also revealed that inflation, interest rates and GDP have a negative short-run impact on exchange rates in Libya. This implies that, as these variables increase by one unit each, inflation, interest rates and GDP will cause exchange rates to appreciate by 0.2 percent, 7.6 percent and 28.8 percent, respectively. This relationship aligns with theory and a few studies (see Beneki and Yarmohammadi, 2014; Ahmed, 2017; Ahmad and Hernandez; 2013; Aliyu, 2009; Al-mulali and Sab, 2011; Babatunde, 2015) which conclude that an increase in these variables will lead to exchange rates appreciation. The results also reveal that debts and money supply have a positive short-run impact on exchange rates in Libya. This relationship is in line with theory, economic expectations and empirical studies (see Babatunde, 2015; Iwayemi and Fowowe, 2011; Beneki and Yarmohammadi, 2014; Ahmad and Hernandez; 2013; Ahmed, 2017) that conclude that an increase in money supply leads to a fall in interest rates which consequently leads to exchange rates depreciation.

4.6.6.2 **Measuring the Strength of the Model Selection Criteria**

Figure 4.30 presents the strength of the AIC model selection compared to other models comprising the HQIC and Schwarz criterion used in the ARDL regression model. It ascertains the short-run relationship of the ARDL model. Therefore, the study uses a criteria graph to determine the top twenty ARDL models. Following prevailing model benchmark analysis, the smaller the AIC value, the better the ARDL model (see Bakar *et al.*, 2013; Giles, 2013). Hence, the ARDL criteria graph with (2, 2, 2, 2, 2, 0, 0) and -7.105 AIC value is the most preferred because it has the least value. Conversely, the ARDL criteria graph with (2, 0, 2, 2, 2, 0, 2) and -7.65 AIC value is the least preferred because it has the highest AIC value.

Figure 4.30: **Strength of the ARDL Model Selection**



Source: *Author's computation (2020), using data sourced from the WDI*.

4.6.6.3 **Wald Test**

This section confirms the existence of a short-run relationship between exchange rates and the independent variables. The test is carried out by testing for a null hypothesis of no short-run cointegration amongst the variables. The benchmark hypotheses of the Wald test are specified below:

$$H_0: \text{Short} - \text{run cointegration does not exist among the regressors and regressand}$$
$$H_1: \text{Short} - \text{run cointegration exists between the regressors and dependent variables}$$

Decision rule:

Accept H_0 when P-Value is higher than 5 percent or Reject H_1 when P-Value is smaller than 5 percent.

The result is presented in Table 4.25. It reveals that there is a short-run relationship between the independent variables and exchange rates at the P-value of 1 percent. Consequently, the null hypothesis cannot be accepted.

Table 4.23: **Wald Test Result**

Test Statistic	Value	df	Probability
F-statistic	3620.303	(6, 137)	0.0000
Chi-square	21721.82	6	0.0000

Source: *Author's computation (2020), using data sourced from the WDI.*

4.6.6.4 **Serial Correlation Results**

The study conducts a serial correlation test to investigate the presence of serial correlation. The result is presented in Table 4.24 and shows that there is no evidence of serial correlation because the probability of the F-statistics is 10 percent which is greater than the 5 percent benchmark. The result suggests that the null hypothesis cannot be rejected. In addition, the study suggests that the model is free from serial correlation. The results also support the view that the parameter estimates of the model do not suffer from an autocorrelation problem.

Table 4.24: **Breusch-Godfrey Serial Correlation LM Test**

F-statistic	2.302918	Prob. F(2,135)	0.1039
Obs*R-squared	5.080724	Prob. Chi-Square(2)	0.0788

Source: *Author's computation (2020), using data sourced from the WDI.*

4.6.6.5 **Heteroskedasticity Result**

Table 4.25 shows the heteroskedasticity results. Both the chi square and F-statistics are insignificant at 5 percent. This implies that there is no heteroskedasticity. Hence, the study concludes that the estimated model is reliable and valid to forecast the Libyan Dinar.

Table 4.25: **Heteroskedasticity Test: Breusch-Pagan-Godfrey**

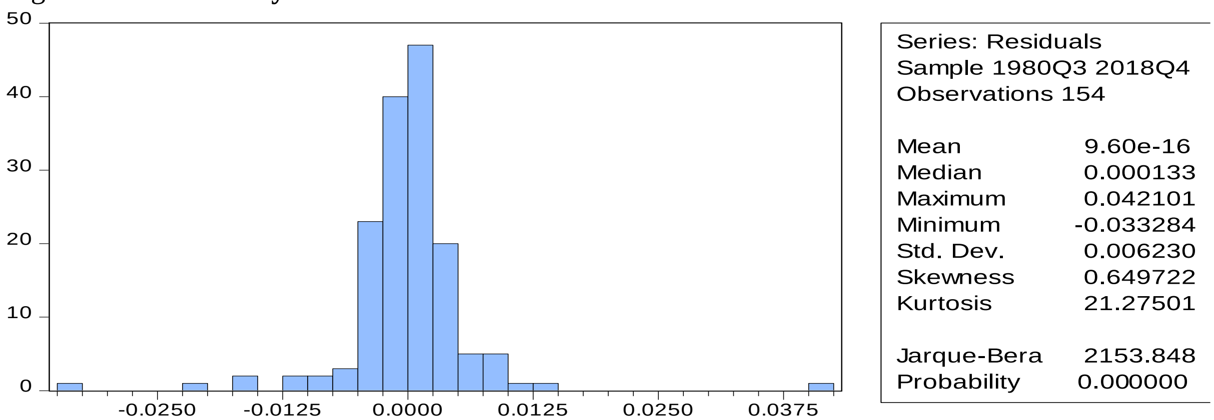
F-statistic	2.379511	Prob. F(16,137)	0.3700
Obs*R-squared	33.48971	Prob. Chi-Square(16)	0.6400
Scaled explained SS	268.6842	Prob. Chi-Square(16)	0.0000

Source: *Author's computation (2020), using data sourced from the WDI.*

4.6.6.6 **Normality Test**

Figure 4.31 presents the normality result. It indicates that the model is normally distributed, as evident from the Jarque-Bera statistics which is statistically insignificant at 5 percent (that is, 2153.8480).

Figure 4.31: **Normality Test Results**



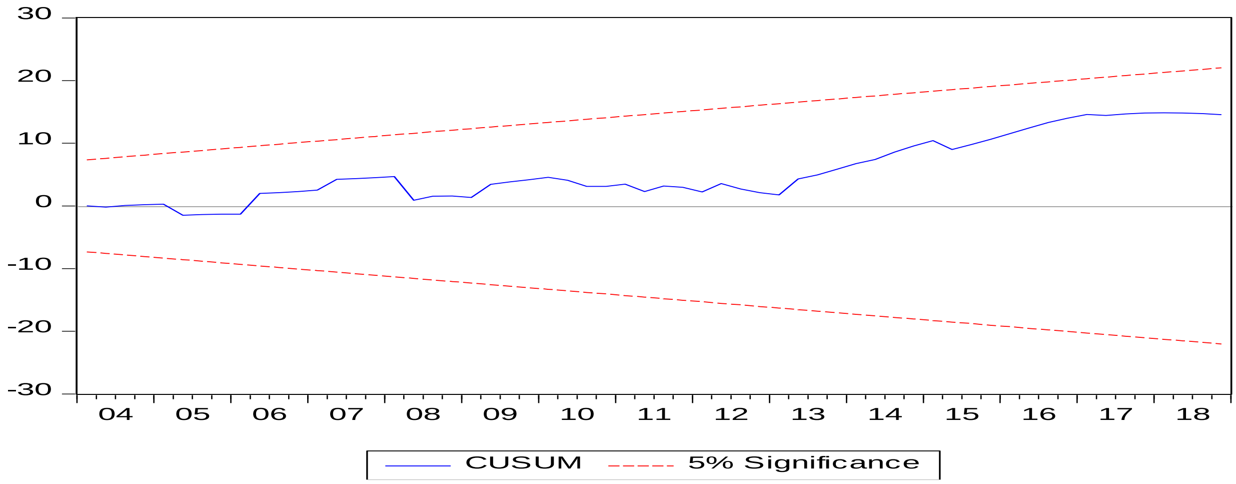
Source: *Author's computation (2020), using data sourced from the WDI.*

The normality test is carried out based on the three common tests in the literature, consisting of the Jarque-Bera, kurtosis and skewness tests. The findings reveal that the variables are normally distributed as is evident in the probability value estimated as 0.0000. Furthermore, the findings reveal that the residuals are distributed normally, and the data sets are appropriately modelled. In addition, the study reveals that the distribution of the data and residuals of the model for Libya are distributed normally. Thus, the exchange rates forecasting model is suitable and consistent.

4.6.6.7 **CUSUM Stability Test**

Figure 4.32 presents the CUSUM stability test for the ARDL model. The result suggests that the model is stable because the line capturing our data falls between the 5 percent confidence interval lines.

Figure 4.32: **CUSUM Test Result**

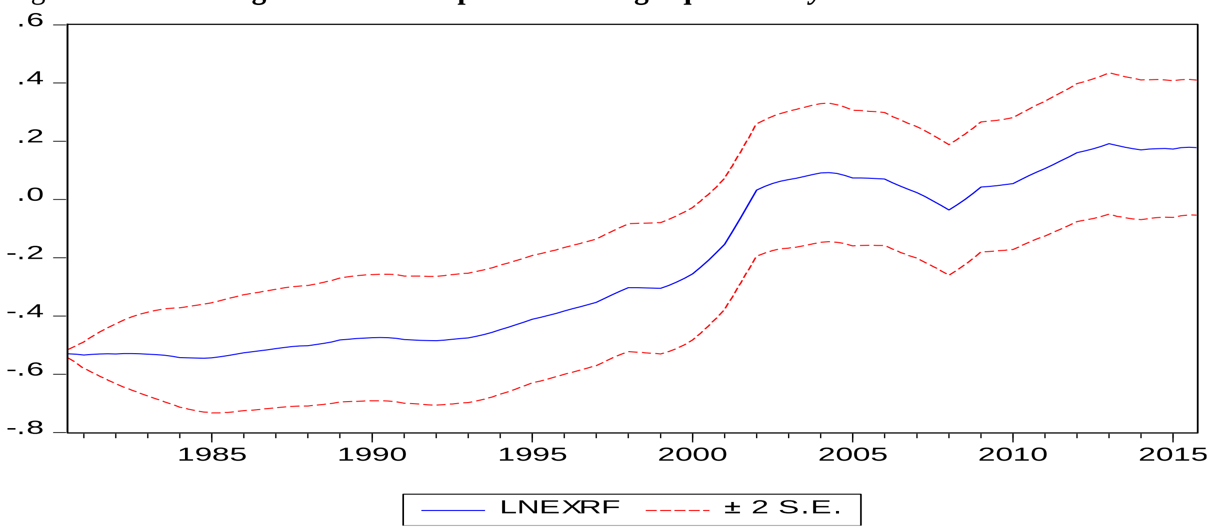


Source: *Author's computation (2020), using data sourced from the WDI.*

4.6.6.8 **Forecasting Exchange Rates: Static and Dynamic Results**

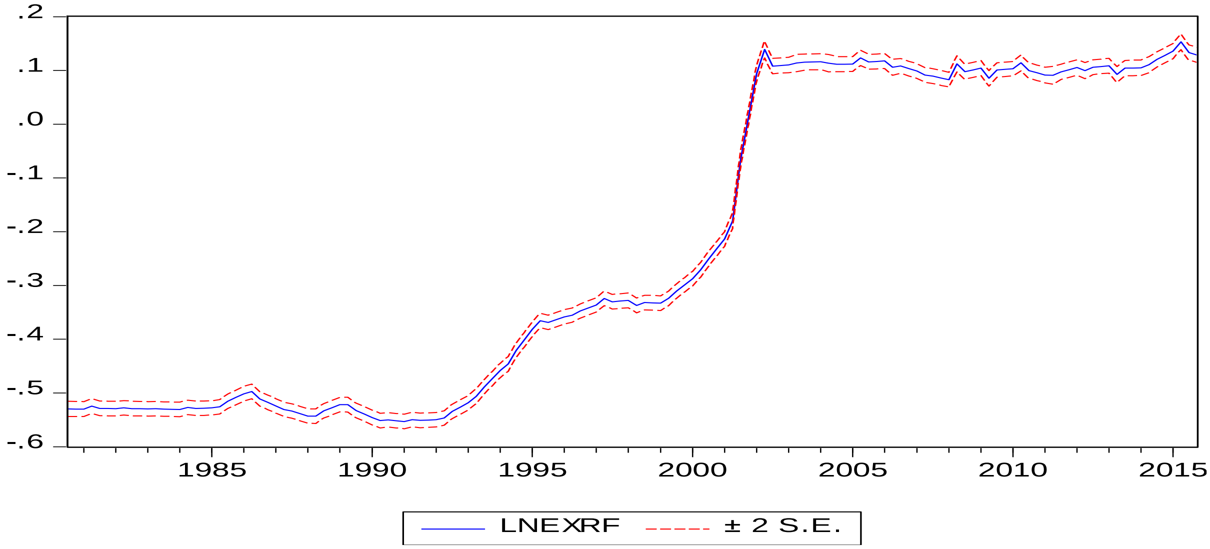
This section forecasts exchange rates having confirmed that the ARDL model is free from possible statistical errors. The estimated data for exchange rates ranges from 1980Q1 to 2018Q4, of which data ranging from 1980Q1 to 2015Q4 accounts for the sample regression model for both the dynamic and static forecasts shown respectively in figures 4.33 and 4.34. The outcomes of these sample regressions for dynamic and static forecasts show that they are both significant at 95 percent confidence interval. This implies that the models are appropriate and valid to forecast Libya's exchange rates.

Figure 4.33: **Exchange Rates In-Sample Forecasting Equation: *Dynamic***



Source: *Author's computation (2020), using data sourced from the WDI.*

Figure 4.34: **Exchange Rates In-Sample Forecasting Equation: *Static***



Source: *Author's computation (2020), using data sourced from the WDI.*

The exchange rates forecasting evaluation criteria presented in Table 4.26 include the RMSE, MAE, MAPE and Theil. They offer support for the appropriateness of the forecasting models for both the dynamic and static forecasts models. For example, the RMSE, MAE and MAPE coefficients for the dynamic forecast are 0.047167, 0.039166 and 0.026255, respectively. Similarly, the RMSE, MAE and MAPE coefficients for the static forecast are 0.006414, 0.003508 and 0.267296 in that order, all nearing the zero "0" analysis benchmark. Table 4.26 also presents the Theil coefficients for both the dynamic and static forecasts and they are respectively estimated as 0.065183 and 0.008720. Both results support the reliability of the exchange rates forecast model for Libya.

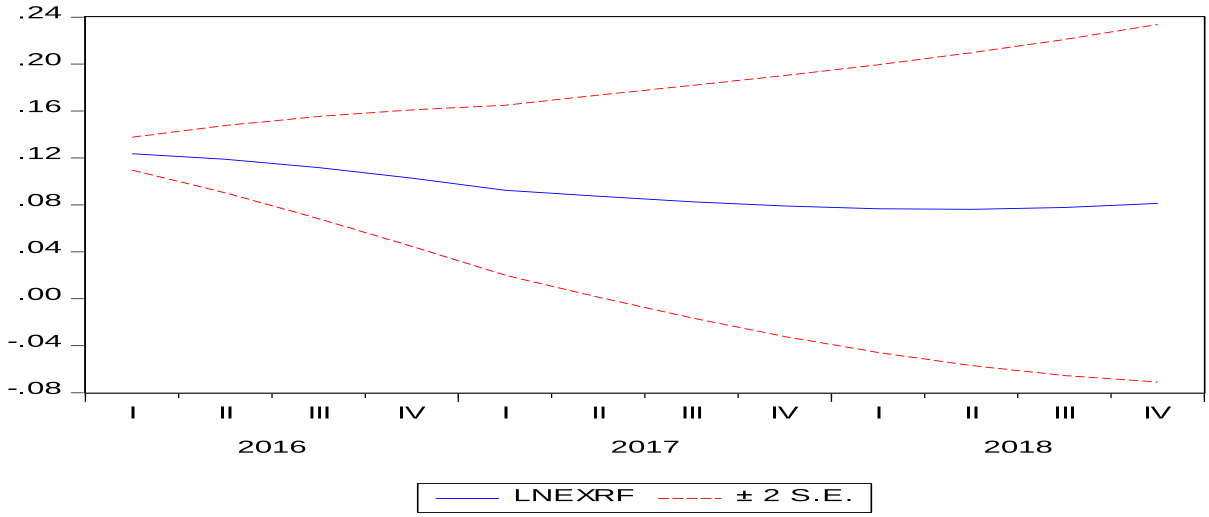
Table 4.26: **Exchange Rates In-Sample Forecast Equation 1980Q1-2015Q4**

	EVALUATION COEFFICIENTS			
	RMSE	**MAE**	**MAPE**	**THEIL**
Dynamic	0.047167	0.039166	0.026255	0.065183
Static	0.006414	0.003508	0.000296	0.008720

Source: *Author's computation (2020), using data sourced from the WDI.*

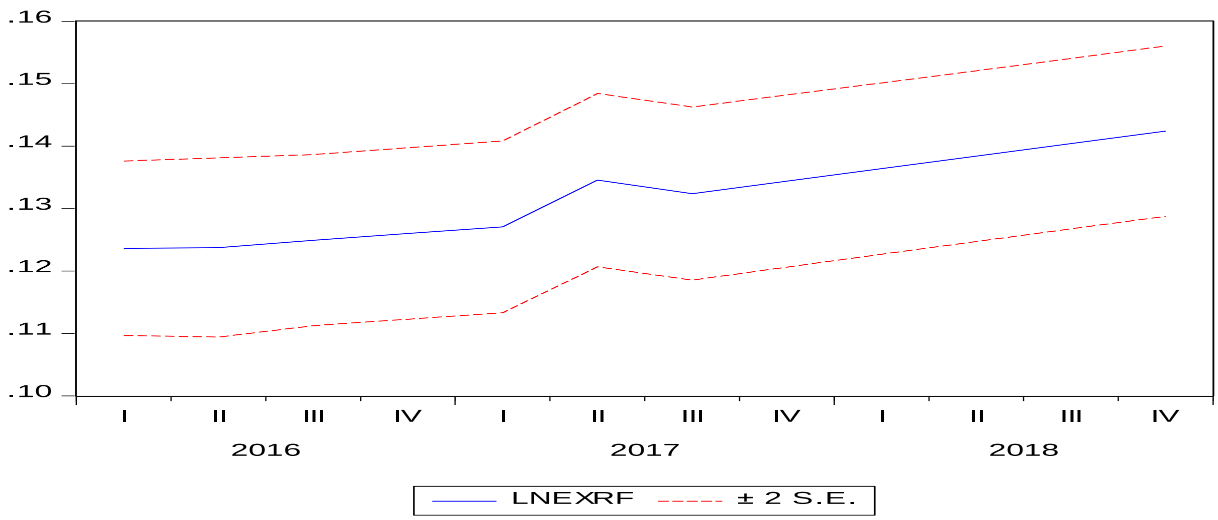
The out-of-sample forecasting horizon runs from 2016Q1 to 2018Q4. The findings show that the out-of-sample forecasting model for both the dynamic and static forecasts is statistically significant at 95 percent confidence interval within the two ($\pm$ 2) standard deviation error lines. These results support the suitability of the sample regression models to forecast exchange rates.

Figure 4.35: **Exchange Rates Out-of-Sample Forecast: *Dynamic***



Source: *Author's computation (2020), using data sourced from the WDI.*

Figure 4.36: **Exchange Rates Out-of-Sample Forecast: *Static***



Source: *Author's computation (2020), using data sourced from the WDI.*

The forecasting evaluation criteria considered for out-of-sample forecasting lines are RMSE, MAE, and MAPE. The goodness of these criteria offers support for the appropriateness of the forecasting models for both the dynamic and static out-of-sample forecast models. However, as presented in Table 4.9, the RMSE, MAE and MAPE coefficients for the dynamic forecast are 0.010159, 0.009600 and 0.005762, nearing the zero (0) benchmark. Similarly, the RMSE, MAE and MAPE coefficients for the static forecast are 0.002156, 0.000919 and 0.025720 in that order, also nearing the zero "0" benchmark. The Theil coefficients for both the dynamic and static forecasts are presented in Table 4.9. The finding reveals that the Theil coefficients for the dynamic and static out-of-sample forecasting models are respectively estimated as 0.006190 and 0.002422. These findings validate the forecast model.

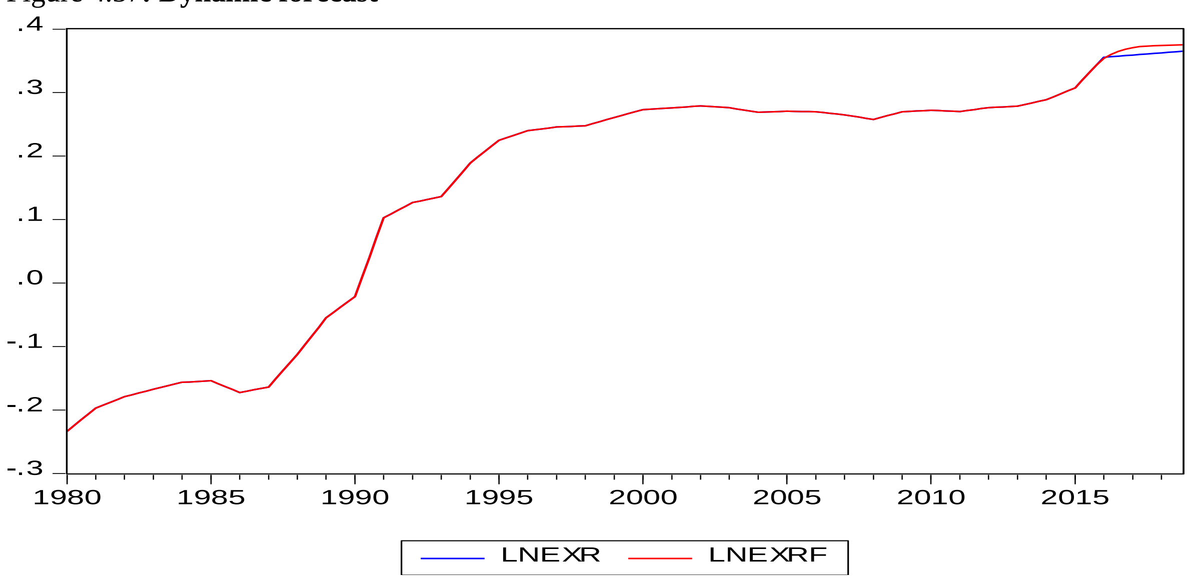
Table 4.27**: Exchange Rates Out-of-Sample Forecast lines: 1980Q1-2015Q4**

	EVALUATION COEFFICIENTS			
	RMSE	**MAE**	**MAPE**	**THEIL**
Dynamic	0.248800	0.226552	2.283112	0.012645
Static	0.001998	0.001146	0.011460	0.001005

Source: *Author's computation (2020), using data sourced from the WDI.*

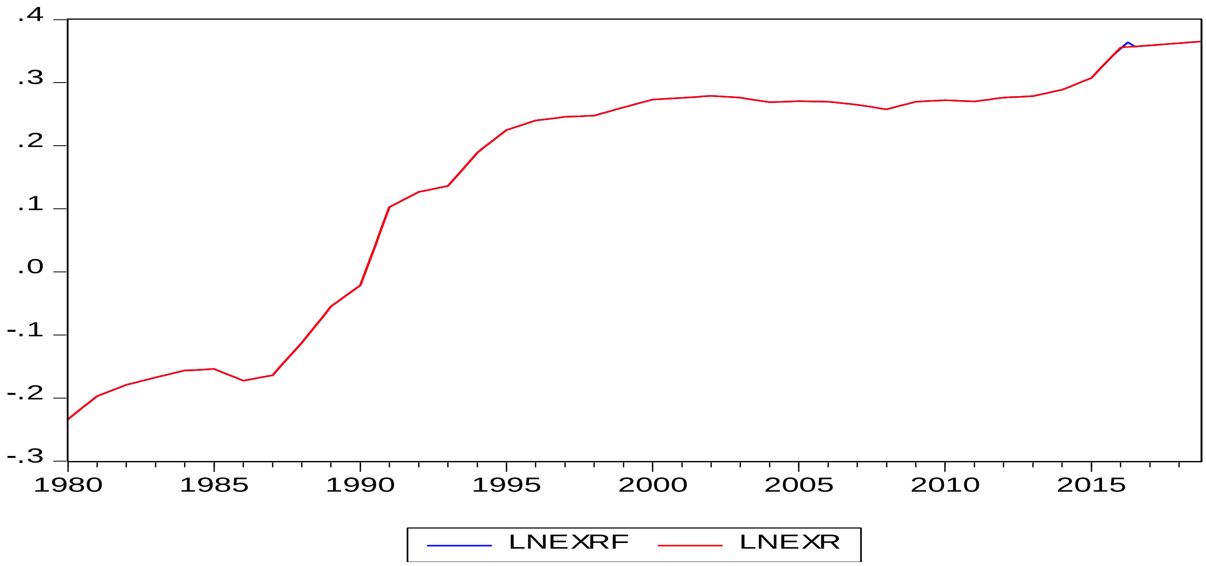
Figures 4.37 and 4.38 respectively present the actual and forecasted exchange rates for the dynamic and static forecasts. Both show strong co-movement in the actual and forecasted values of exchange rates. This is evident from the Theil coefficients values, showing that the variation between the actual and forecasted values of exchange rates is low and near-zero. Furthermore, the dynamic forecasting graph has a low RMSE. This is satisfactory and validates strong predictive power as displayed in figures 4.37 and 4.38 for the dynamic and static model, respectively. The static forecast model behaves well, having stronger predictive power than the dynamic forecast (see figures 4.37 and 4.38). The simultaneous movement in the actual and forecasted exchange rates could serve as a guide to policymakers in making decisions that target exchange rates stability in Libya.

Figure 4.37**: Dynamic forecast**



Source: *Author's computation (2020), using data sourced from the WDI.*

Figure 4.38: **Static forecast**



Source: *Author's computation (2020), using data sourced from the WDI.*

4.6.6.9 **Discussion and Inferences**

This study forecasts exchange rates in Libya. The forecasting model offers a guide to exchange rates determination to aid decision making. The model is developed using sample variables spanning 1980Q1-2015Q4, and out-of-sample variables covering 2016Q1-2018Q4. The model satisfies the necessary diagnostic tests. The evaluation coefficients which consist of RMSE, MAE, MAPE and the Theil coefficients are found satisfactory. This is in line with the stretch of the benchmark for the suitability of a forecasting model. By implication, the satisfactory outcome of the sample model and the significant results obtained in both the dynamic and static forecasts strongly support the claim that the selected explanatory variables are suitable to forecast exchange rates in Libya, except for oil prices which prove otherwise. This could be explained by the incessant unrest in Libya which has been associated with a fall in crude exports and a decline in the country's oil revenue. This finding contributes to knowledge that exchange rates forecasting in Libya strongly depends on these factors, except for oil prices.

4.6.7 **Interpretation of Results for Nigeria**

This section presents the results for Nigeria. Among other things, the results include ARDL Dynamic Regression, wald test, serial correlation results, heteroskedasticity result, normality test, stability test exchange rates forecasting results. The section ends with discussion and inferences, summary and conclusions.

4.6.7.1 **Interpretation of the ARDL Regression Model**

Table 4.28: **ARDL Dynamic Regression Estimates**

Dependent Variable: LNEXR				
Method: ARDL				
Sample (adjusted): 1980Q3 2018Q4				
Included observations: 154 after adjustments				
Maximum dependent lags: 2 (Automatic selection)				
Model selection method: Akaike info criterion (AIC)				
Dynamic regressors (2 lags, automatic): INF INT LNDBT LNGDP LNMS LNOP				
Selected Model: ARDL(2, 2, 2, 0, 2, 0, 0)				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.***
LNEXR(-1)	1.646047	0.060810	27.06889	0.0000
LNEXR(-2)	-0.685843	0.062078	-11.04810	0.0000
INF	0.001114	0.000636	1.752773	0.0019
INF(-1)	-0.002080	0.001156	-1.799740	0.0741
INF(-2)	0.001364	0.000635	2.147145	0.0335
INT	-0.010863	0.002919	-3.721539	0.0003
INT(-1)	0.016942	0.005165	3.280500	0.0013
INT(-2)	-0.007361	0.002942	-2.501786	0.0135
LNDBT	0.012365	0.015222	0.812303	0.4180
LNGDP	-1.530751	0.372797	-4.106126	0.0001
LNGDP(-1)	3.010639	0.679766	4.428932	0.0000
LNGDP(-2)	-1.475198	0.370187	-3.985003	0.0001
LNMS	0.033843	0.015157	2.232792	0.0272
LNOP	0.022397	0.057468	0.389734	0.0073
LNOP(-1)	-0.081042	0.058649	-1.381808	0.1693
C	-0.197638	0.431696	-0.457818	0.6478

Source: *Author's computation (2020)*.

Table 4.28 presents the ARDL estimates for the short-run relationship between exchange rates and the series that forecast it in Nigeria. A total of six independent variables, namely, inflation rates, interest rates, debts, GDP, money supply and oil prices are regressed against exchange rates adding up to seven variables. The findings from the analysis show that debts are not sufficiently statistically significant to impact exchange rates in the short run. The implication is that debts in Nigeria do not influence exchange rates in the short run. However, its coefficient suggests that a fall in debts will lead to currency appreciation (an increase in the value of the Naira). The Naira will appreciate by 1.2 percent. A region that is significantly indebted is expected to suffer exchange rates depreciation. Therefore, this study supports Eslamloueyan and Kia's (2015) finding that increases in debts may impede exchange rates appreciation. Interest rates show a negative relationship with exchange rates at 5 percent significance level. This implies that an increase in interest rates will cause a 1 percent appreciation in exchange rates. That is, higher interest rates in Nigeria tend to attract foreign investment, which is likely to increase demand for Naira. This finding is in line with Olomola (2011) who argues that higher interest rates will offer lenders in an economy higher returns relative to other countries. Consequently, a higher interest rate attracts foreign capital and causes the exchange rate to rise. The opposite relationship occurs when interest rates decrease; that is, lower interest rates tend to reduce exchange rates.

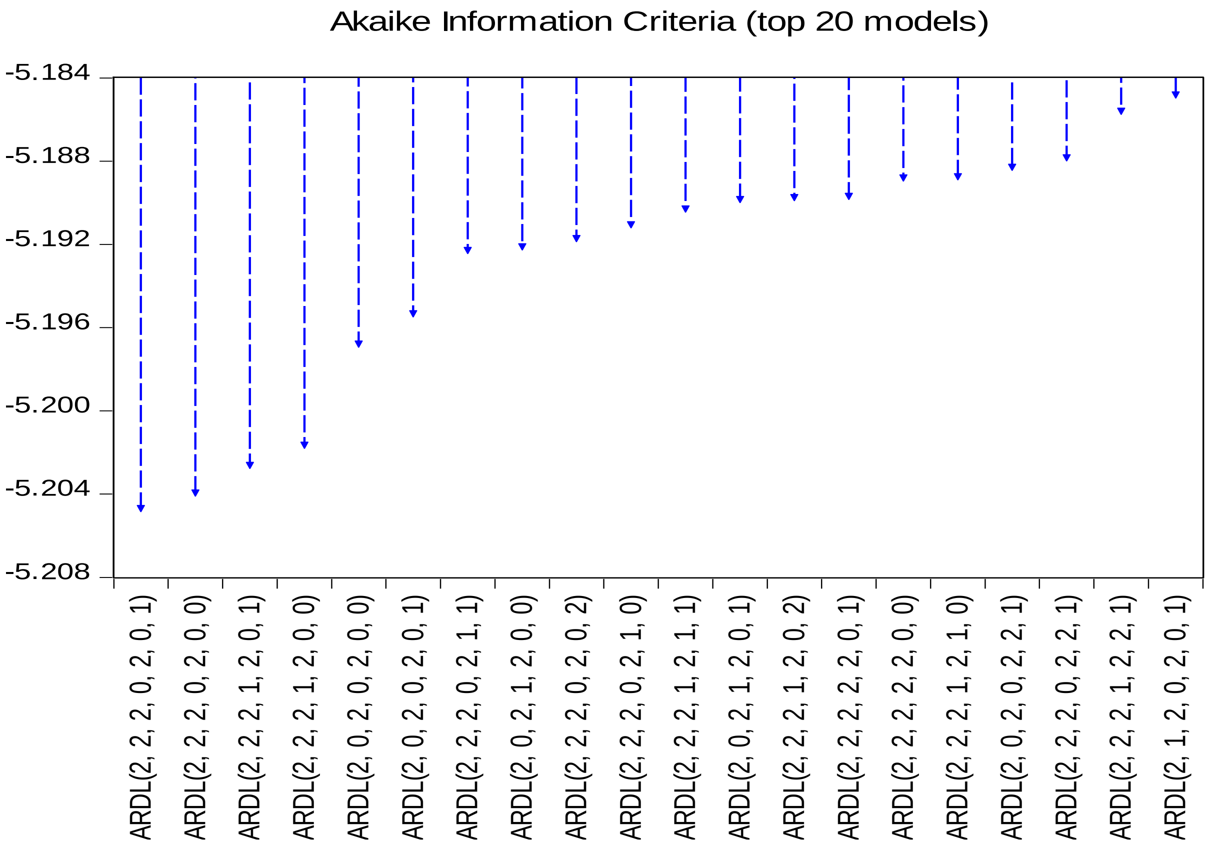
Money supply shows a positive relationship with exchange rates at 5 percent level of significance. This implies that an increase in money supply will lead to 3.3 percent depreciation in exchange rates. In other words, higher money supply in Nigeria tends to reduce interest rates, which may lead to a fall in demand for Naira. In addition, an increase in money supply can cause depreciation in exchange rates because there will be decreased demand for the currency and its value will tend to decrease in exchange rate markets. This finding validates earlier studies (see Ushie *et al.*, 2013; Demary, 2010; Olomola, 2011) which argue that higher money supply accounts for lower interest rates and consequently currency depreciation. The opposite relationship occurs when the money supply decreases. Inflation rates are sufficiently statistically significant to influence exchange rates in the short run. The findings show that inflation rates negatively impact exchange rates. This suggests that an increase in inflation rates leads to a 0.1 percent depreciation in Nigerian Naira. This study supports Iwayemi and Fowowe (2011) who contend that a very low rate of inflation does not guarantee favourable exchange rates for a country, but that an extremely high inflation rate is very likely to negatively impact the country's exchange rates with other nations.

Oil prices show a positive relationship with exchange rates at 5 percent level of significance. The implication is that rises in oil prices lead to 8.1 percent appreciation in exchange rates. That is, higher oil prices account for appreciation of the Nigerian Naira. This finding validates earlier studies that assert that an increase in oil prices Granger causes the currency of oil-exporting countries (Iwayemi and Fowowe, 2011; Ahmed, 2017).

4.6.7.2 **Measuring the Strength of the Model Selection Criteria**

This section employs the criteria graph technique to establish the strength of the AIC model selection summary over other models such as the HQIC and the Schwarz criterion. The criteria graph is also engaged in the ARDL regression model to ascertain the short-run relationships in the ARDL model. Consequently, the criteria graph presented in figure 4.39 determines the top twenty ARDL models. The figure shows that the ARDL criteria graph having (2, 2, 2, 0, 2, 0, 1) and -5.205 AIC value is the most preferred because it has the lowest AIC value, followed by ARDL (2, 2, 2, 0, 2, 0, 0) with -5.204 AIC value. The ARDL (2, 1, 2, 0, 2, 0, 1) has the highest AIC value, -5.185 and is the least preferred.

Figure 4.39: **Strength of the ARDL Model Selection**



Source: *Author's Computation (2020), using data sourced from the WDI.*

4.6.7.3 **Wald Test**

This section tests if there is a short-run relationship moving from the independent variables to the dependent variables (exchange rates). The test is carried out using the Wald test with a null hypothesis of no short-run cointegration amongst the variables. The benchmark hypotheses of the Wald test are specified below:

$$H_0: \text{Short} - \text{run cointegration does not exist among the regressors and regressand}$$
$$H_1: \text{Short} - \text{run cointegration exists between the regressors and dependent variables}$$

Decision rule:

Accept H_0 when P-Value is higher than 5 percent or Reject H_1 when P-Value is smaller than 5 percent.

Table 4.29 presents the result of the Wald test, revealing the existence of a short-run relationship between the independent variables and exchange rates at the P-value of 1 percent. Therefore, the null hypothesis cannot be accepted.

Table 4.29: **Wald Test Result**

Test Statistic	Value	Df	Probability
F-statistic	1117.436	(6, 138)	0.0000
Chi-square	6704.615	6	0.0000

Source: *Author's Computation (2020), using data sourced from the WDI.*

4.6.7.4 **Serial Correlation Results**

Table 4.30 presents the results of serial correlation. There is no evidence of serial correlation because the probability of the F-statistics is 45 percent which is greater than 5 percent. This suggests that the null hypothesis cannot be rejected. As a result, the study suggests that the model is free from serial correlation. The results also support that the parameter estimates of the model do not suffer from the autocorrelation problem.

Table 4.30: **Breusch-Godfrey Serial Correlation LM Test**

F-statistic	1.155132	Prob. F(2,136)	0.3181
Obs*R-squared	2.572337	Prob. Chi-Square(2)	0.2763

Source: *Author's Computation (2020), using data sourced from the WDI.*

4.6.7.5 **Heteroskedasticity Result**

Table 4.7 presents the results for the heteroskedasticity test. The heteroskedasticity test demonstrates the robustness and suitability of the model. The benchmark null hypotheses that are tested for the heteroskedasticity tests are:

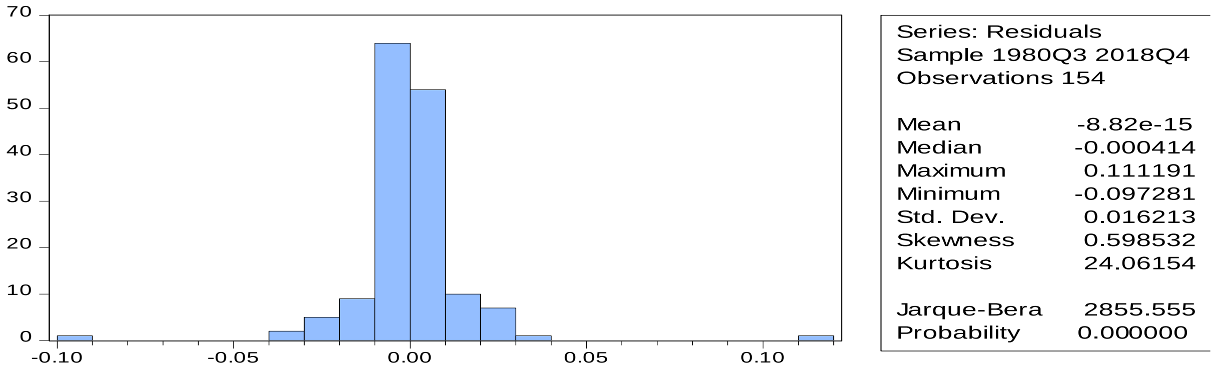
$$H_0\text{: there is no heteroskedasticity}$$
$$H_1\text{: there is heteroskedasticity}$$

Both the chi square and F-statistics are insignificant at 5 percent, implying that the null hypothesis of no heteroskedasticity cannot be rejected. Therefore, it is concluded that the estimated model is reliable and there is no problem of heteroskedasticity.

4.6.7.6 **Normality Test**

Figure 4.40 shows the normality test result. The test is conducted based on the three common tests in the literature, the skewness, Jarque-Bera and kurtosis tests. Ninety-eight percent of the variables in the model passed the normality test, both individually and jointly. This implies that the residuals of the model are normally distributed, and the data sets are appropriately modelled. In addition, the null hypothesis of "no normality of the residuals" cannot be rejected. Therefore, the result validates the model as consistent and favourable in forecasting exchange rates in Nigeria.

Figure 4.40: **Normality Test Results**

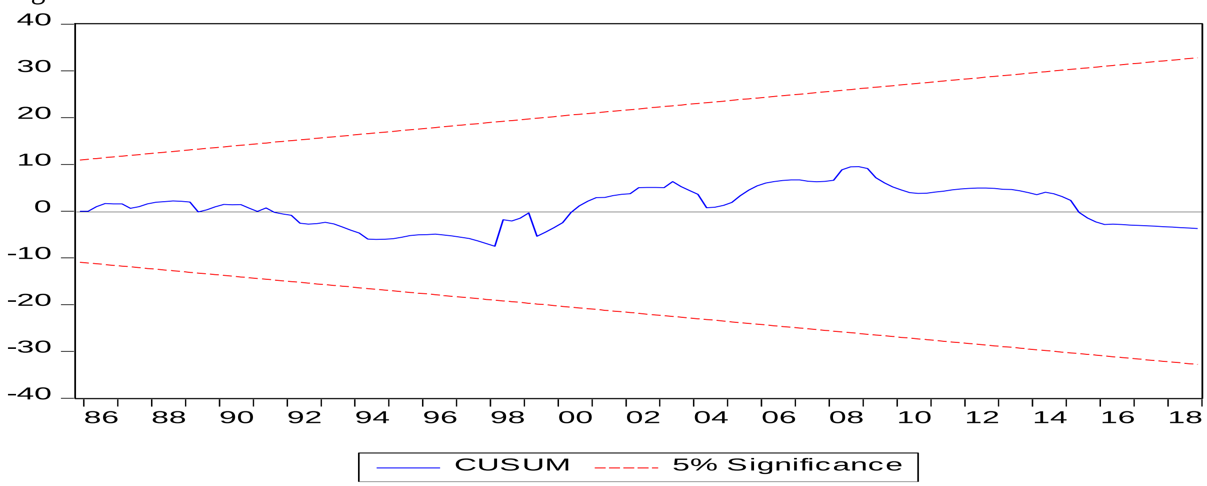


Source: *Author's Computation (2020)*, *using data sourced from the WDI.*

4.6.7.7 **CUSUM Stability Test**

The CUSUM test result is presented in figure 4.41, showing that the model is stable over time and could forecast exchange rates in Nigeria.

Figure 4.41: **CUSUM Test Result**

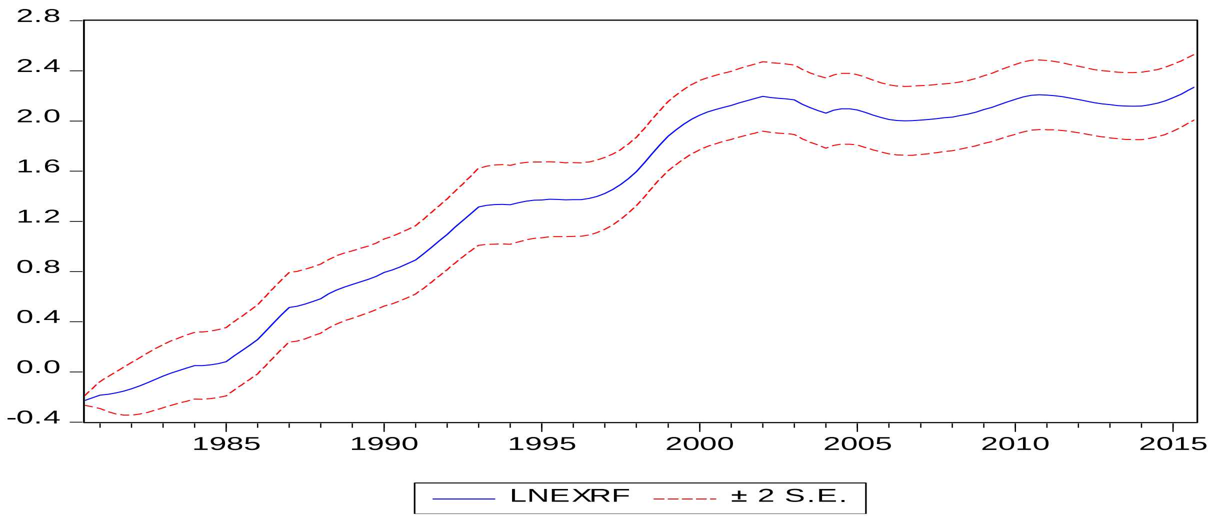


Source: *Author's computation (2020)*, *using data sourced from the WDI.*

4.6.7.8 **Forecasting Exchange Rates: Static and Dynamic Results**

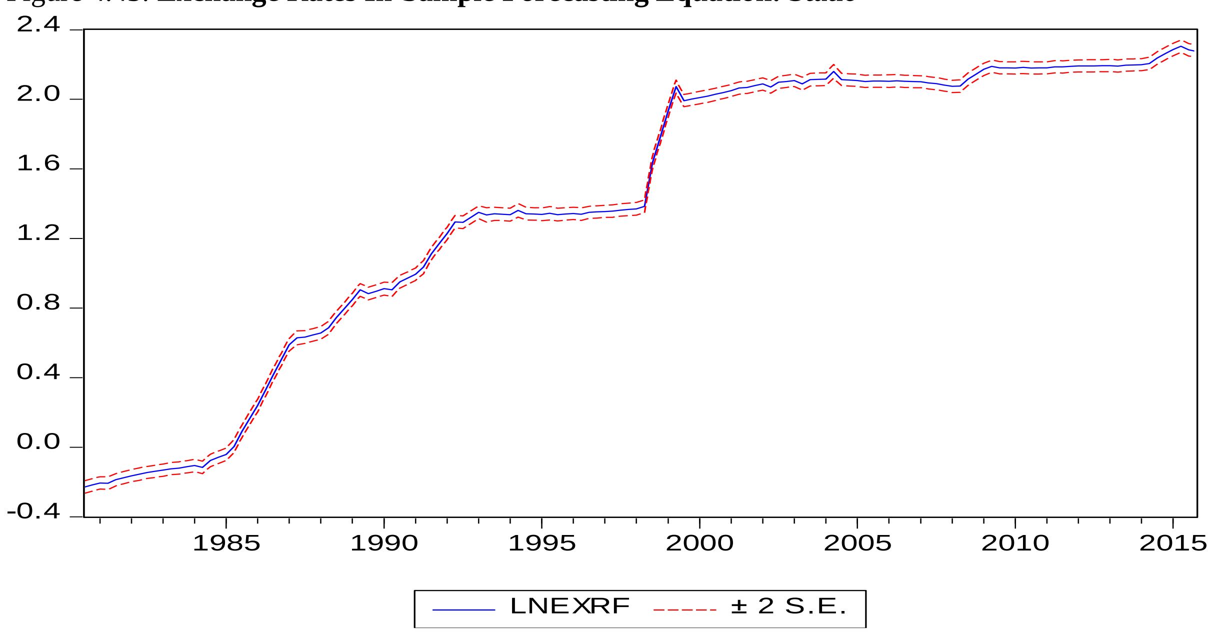
Having established that the estimated model is free from statistical errors and it is suitable to forecast exchange rates, the study forecasts exchange rates in this section. The estimated data for exchange rates ranges from 1980Q1 to 2018Q4. 1980Q1 to 2015Q4 is the period for the sample regression model for both the dynamic and static forecasts respectively, presented in figures 4.42 and 4.4. As revealed in the figures, the sample regressions are both significant at 95 percent confidence interval. This validates their robustness and appropriateness to make dynamic and static forecasts of exchange rates in Nigeria.

Figure 4.42: **Exchange Rates In-Sample Forecasting Equation: *Dynamic***



Source: *Author's computation (2020), using data sourced from the WDI.*

Figure 4.43: **Exchange Rates In-Sample Forecasting Equation: *Static***



Source: *Author's computation (2020), using data sourced from the WDI.*

The study employs the forecasting evaluation criteria utilized in the literature to determine the robustness and suitability of both the dynamic and static forecasts models (see Table 4.32). The evaluating coefficients for the dynamic forecast are 0.085197, 0.070959, 0.018975 and 0.026225 for the RMSE, MAE, MAPE and Theil coefficients, respectively. Likewise, the evaluating coefficients for the static forecast are 0.016812, 0.009637, 0.021657 and 0.005149 for the RMSE, MAE, MAPE and Theil coefficients, respectively. The outcomes of these coefficients are close to zero, satisfying the analysis benchmark for forecasting. These results support the reliability of the model to forecast exchange rates.

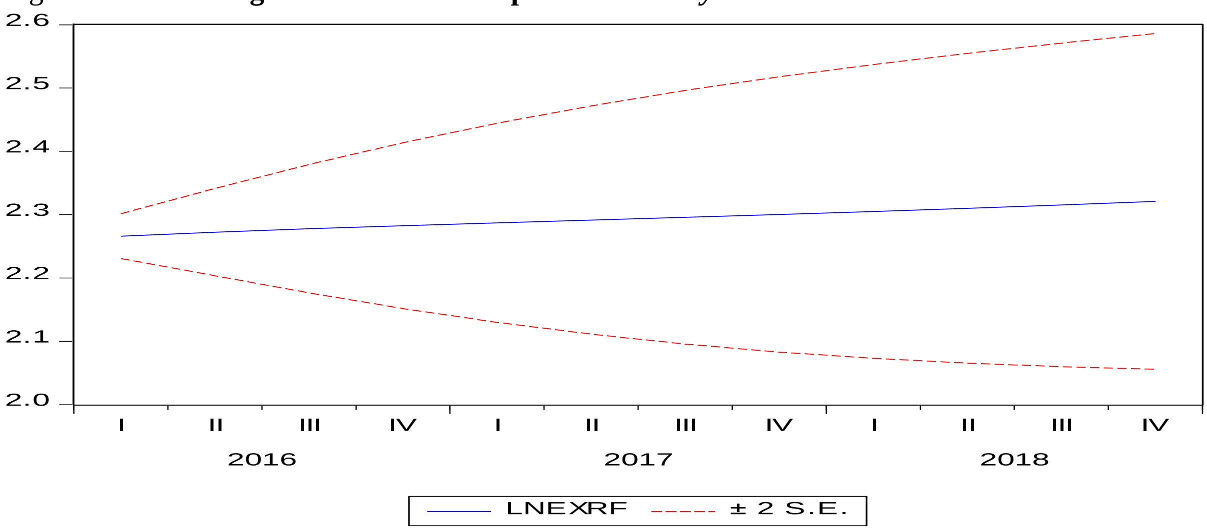
Table 4.32: **Exchange Rates In-Sample Forecast Equation 1980Q1-2015Q4**

	EVALUATION COEFFICIENTS			
	RMSE	**MAE**	**MAPE**	**THEIL**
Dynamic	0.085197	0.070959	0.018975	0.026225
Static	0.016812	0.009637	0.021657	0.005149

Source: *Author's computation (2020), using data sourced from the WDI.*

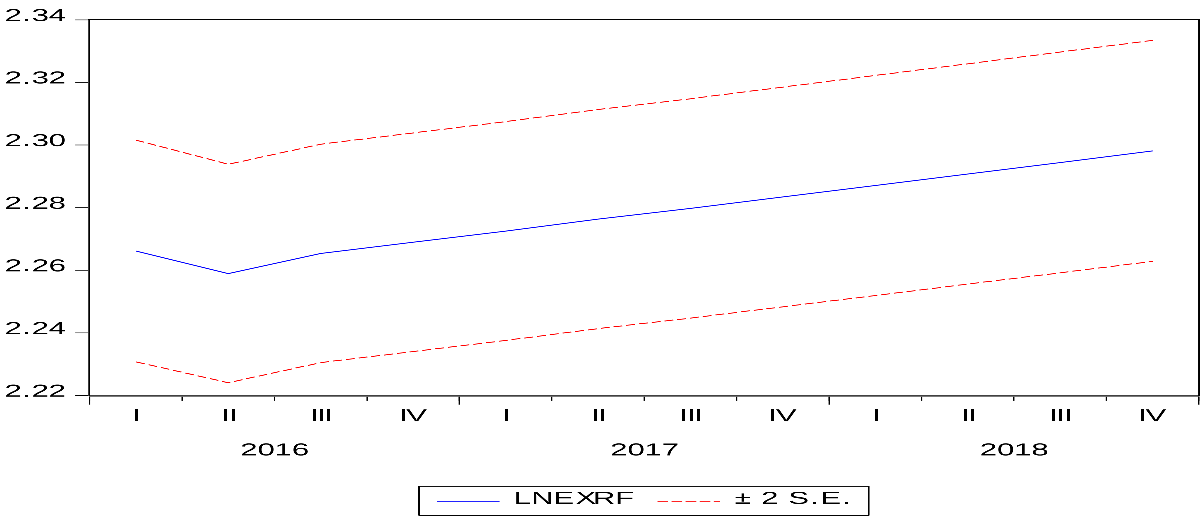
The out-of-sample forecasting horizon runs from 2016Q1 to 2018Q4 (see Figures 4.44 and 4.45). The results reveal that the forecasts are statistically significant at 95 percent confidence interval within the two (± 2) standard deviation error lines. These results support the suitability of the sample regression models to forecast exchange rates.

Figure 4.44: **Exchange Rates Out-of-Sample Forecast: *Dynamic***



Source: *Author's computation (2020), using data sourced from the WDI.*

Figure 4.45: **Exchange Rates Out-of-Sample Forecast: *Static***



Source: *Author's computation (2020), using data sourced from the WDI.*

The forecasting evaluation criteria for the out-of-sample dynamic forecast are respectively revealed as 0.017183, 0.016570, 0.072664 and 0.003759 for the RMSE, MAE, MAPE and Theil coefficients (see Table 4.33). Likewise, the forecasting evaluation criteria for the out-of-sample static forecast are respectively estimated as 0.002676, 0.001762, 0.077586 and 0.000587 for the RMSE, MAE, MAPE and Theil coefficients. The goodness of these criteria offers support for the appropriateness of the forecasting models for both the dynamic and static out-of-sample forecasts models.

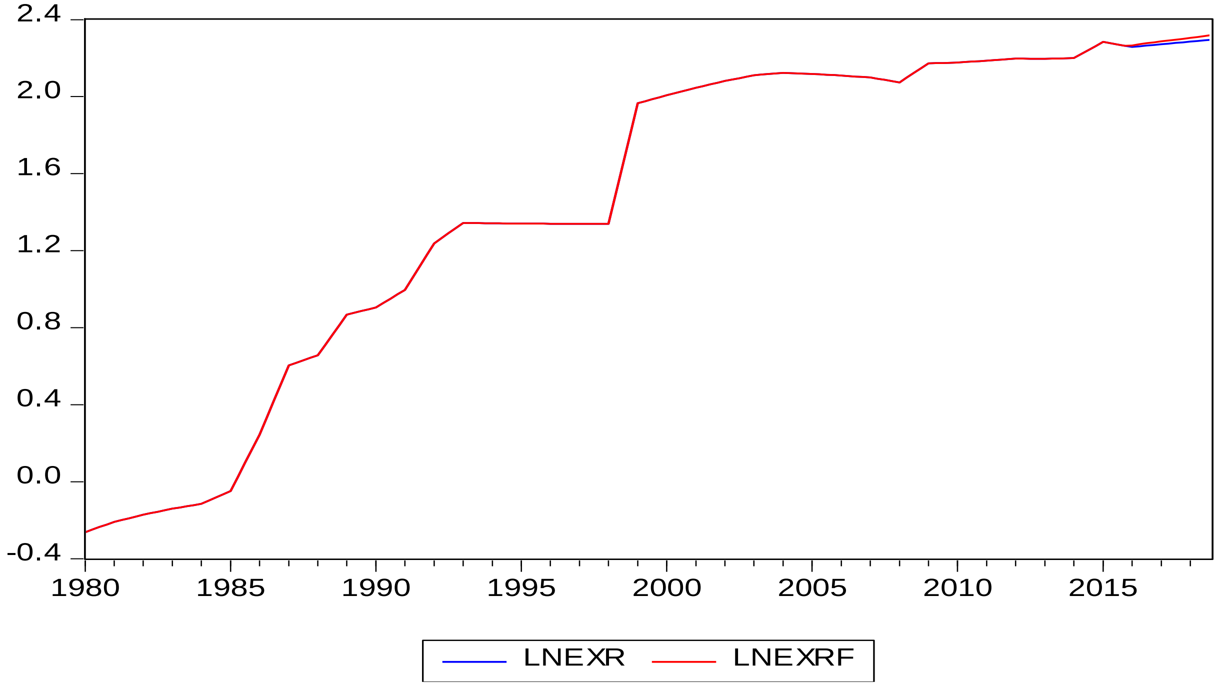
Table 4.33**: Exchange Rates Out-of-Sample Forecast lines: 1980Q1-2015Q4**

	EVALUATION COEFFICIENTS			
	RMSE	**MAE**	**MAPE**	**THEIL**
Dynamic	0.017183	0.016570	0.072664	0.003759
Static	0.002676	0.001762	0.077586	0.000587

Source: *Author's computation (2020), using data sourced from the WDI.*

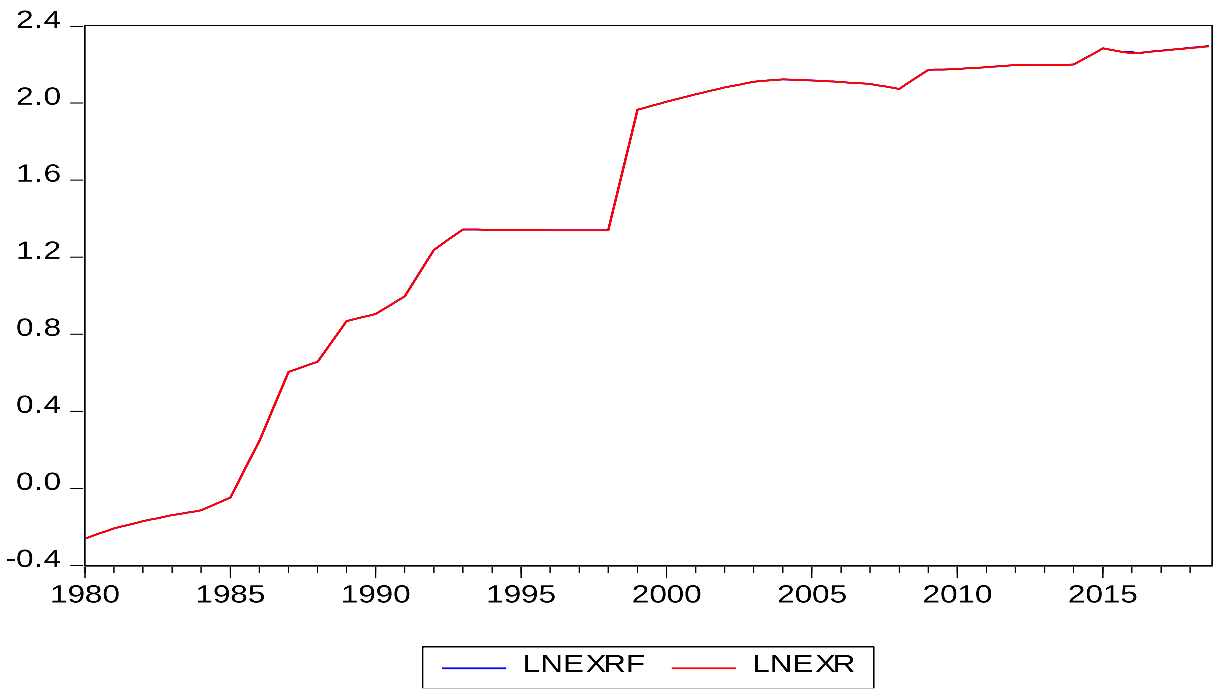
The actual and forecasted exchange rates are presented in figures 4.46 and 4.47, respectively. The findings reveal co-movement in the actual and forecasted models. This displays a strong co-movement in the actual and forecasted exchange rates, implying that the model is appropriate. The closeness in the actual and forecasted exchange rates in the dynamic and static forecasts reflects the Theil coefficient nearing zero. The actual and forecasted exchange rates show a co-movement with negligible variance. This could serve as a guide to policymakers when making decisions on how to stabilize exchange rates in Nigeria.

Figure 4.46**: Dynamic forecast**



Source: *Author's computation (2020), using data sourced from the WDI.*

Figure 4.47: **Static forecast**



Source: *Author's computation (2020), using data sourced from the WDI.*

4.6.7.9 **Discussions and Inferences**

This study forecasts an exchange rates model for Nigeria as a guide to exchange rates determination to aid decision making. Sample variables covering 1980Q1-2015Q4 are employed and out-of-sample variables cover 2016Q1-2018Q4. The model is found appropriate to forecast exchange rates following the various evaluation coefficients estimated to complement the statistical significance of our various tests of significance for the regressions and forecasting lines for both the dynamic and static forecasts. The various evaluation coefficients comprising the RMSE, MAE, MAPE and the Theil coefficients are nearing zero. This validates the appropriateness of the model. It is in line with the stretch of the benchmark for the suitability of a forecasting model. By implication, the satisfactory outcomes of the sample model and the significant results obtained in both the dynamic and static forecasts strongly support the claim that the selected explanatory variables are suitable to forecast the exchange rates of the Nigerian Naira. This finding aligns with Eslamloueyan and Kia (2015), Kao (1999) and Kia (2015). The study concludes that future exchange rates can be forecasted with INF, INT, LNDBT, LNGDP, and LNMS in addition to LNOP which is reported as significant and highly correlating with exchange rates. This finding contributes to knowledge that exchange rates forecasting in Nigeria strongly depends on these factors. Therefore, to overcome the possibility of an exchange rates surge arising from oil price shocks causing economic imbalances as noted in Gali and Monacelli (2005) and emphasized in Hameed *et al.* (2012), which Etuk *et al*. (2016) conclude is a major issue in the global economy, this study provides information to international economic agents who are continuously seeking guidelines to address uncertainties and unforeseen fluctuations.

4.6.8. **Summary and Conclusions**

This chapter forecasts exchange rates in selected AOECs using time series methods. The exchange rates of five national currencies (the Algeria Dinar, Egyptian Pound, Gabon Franc, Libyan Dinar and Nigerian Naira, against the USD) are investigated. An extensive examination of the ARDL is performed to forecast the exchange rates. The RMSE, MAE, MAPE and Theil coefficients are used to evaluate the accuracy of the forecasts obtained from the time series models. The Theil evaluating coefficient typically generates better forecasts. A fundamental aim of this study was to confirm whether oil price shocks impact the exchange rates of the selected countries. The findings reveal that, except for Libya, oil prices are sufficiently statistically significant to forecast exchange rates. The model is found stable over time. Therefore, we conclude that the oil price shocks concept has distinct significance in the currency exchange rates framework in the AOECs. Moreover, oil prices perform significantly in the frontier markets exchange rates series. These results are expected, since the AOECs are prone to oil price oscillations which in turn affect their output, consumption, and interest rates (see Hausmann *et al.*, 2006).

The findings presented in this chapter validate earlier findings in the exchange rates literature that the ARDL model generates superior exchange rates forecasts. In addition, our findings reveal that the Dynamic Forecasting Model (DFM) and Static Forecasting Model (SFM) appear to provide more reliable forecasts than classical exchange rates models and the naive random walk forecasting model of Cheung *et al.* (2009). The findings validate previous studies that argue that DFM and SFM are superior and suitable to forecast macroeconomic variables (Ferraro *et al.*, 2015; Beneki and Yarmohammadi, 2005). The DFM and SFM not only capture the time-varying property of the variables but could also automatically select the optimum model. This is considered as a new finding, which is novel to the literature. These results thus add knowledge to the growing body of literature on exchange rates.

Furthermore, the study's findings serve as a guide to policy makers. Accurate exchange rates forecasts will enable policy makers to obtain early signals of future crises. With globalization, the findings of this study are important to both importers and exporters since exchange rates instability has different effects on their decision making on matters relating to international transactions. For instance, if stability in exchange rates is high in each country, risk-averse traders may choose to reduce their transactions with these countries due to a high degree of profit unpredictability. In contrast, risk-seeking traders may benefit from seeking out hedging opportunities. In addition, risk managers and international investors could minimize their level of risk by assessing the extent of fluctuations in the currencies that they are dealing with. One of the policy implications of this analysis is that the government should be sensitive to its monetary variables and ensure stabilisation of the variables to guarantee policy consistency which could assist in curtailing the declining trend in the value of the AOECs.

CHAPTER 5

ASYMMETRIC BEHAVIOR OF OIL PRICE SHOCKS AND OUTPUT PERFORMANCE IN AFRICA'S OIL EXPORTING COUNTRIES

5.1 Introduction

The previous chapters, specifically Chapter Three, examine some key macroeconomic variables to show the transmission mechanism of oil price shocks and estimate the IRFs of the selected variables. The findings reveal that the exchange rate is the medium through which oil price shocks affect other macroeconomic variables. This leads to forecasting exchange rates as carried out in Chapter Four. However, several empirical studies on the relationship between oil price shocks and the economies of oil-exporting countries have assumed a homogeneous response (see Lagalo and Wada, 2011; Gachara, 2015; Boheman and Maxen, 2015). Furthermore, these studies assume a linear relationship between oil price shocks and macroeconomic variables, offering no insight into the dynamics of different categories of shocks (see Moshiri, 2015).

Policy makers and scholars have argued that the impact of positive and negative oil price shocks on the macroeconomy may vary both in magnitude and signs as well as across regions, hence causing economic imbalances (see Apergis *et al*., 2015; Narayan and Sharma, 2011; Narayan and Gupta, 2015). The few studies that have been carried out on oil-exporting countries have used linear estimating techniques, focusing on positive oil price shocks and disregarding the likely consequences of negative oil price shocks (see Damechi, 2012; Gachara, 2015). According to Damechi (2012) and Gachara (2015), this may lead to faulty policy decision making which may be counterproductive and misleading. Furthermore, it may result in the inability of the governments of oil-exporting countries to tackle the prolonged effects of oil price shocks on output. Some of the linear techniques such as OLS and Fully Modified OLS employed in the literature have been critiqued as unsuitable to estimate the relationship between oil price behavior and output performance (see Gachara, 2015; Damechi, 2012; Elbourne, 2008). In addition, Damechi (2012) and Gachara (2015) argue that the SVARs estimating technique which has frequently been used in the literature to estimate the relationship between oil price behavior and ouput performance is inadequate and could only be suitable for positive oil price shocks and country specific studies. An asymmetric relationship between oil price shocks and output performance may have vital consequences for policy responses and guidelines in the macroeconomic environment of oil-exporting countries (see Damechi, 2012; Gachara, 2015).

Considering the possible threat of the recent fall in oil prices and the vital role that variations in crude oil prices play in the conduct of fiscal and monetary policies in AOECs, it is necessary to investigate the asymmetric impacts of negative oil price shocks. This is an important issue for policy makers in oil-dependent countries, as it will assist them in making decisions that may have serious implications for output growth and the behavior of other macroeconomic variables. While there is evidence on how industrialized countries, mainly developed net oil-importing countries respond to positive oil price shocks, which are believed to hamper their economic growth (see Hamilton, 2013; Blanchard and Gali, 2007; Bjornland, 2000; Aastveit, Bjornland and Thorsrud, 2014), we are not aware of such a study having been carried out to establish how negative oil price shocks impact the AOECs, where such shocks are similarly believed to hamper output growth. Therefore, this study explicitly estimates a measure of oil price shocks in order to determine the response of output performance within the context of the AOECs.

Oil is an essential input in the global production process and will continue to be relevant and impactful in both oil-exporting and importing economies (Narayan and Gupta, 2015). It is likely to remain the most prominent source of energy for several decades to come, even under the most optimistic assumptions about the growth in alternative energy sources (see Wang, Zhu, and Wu, 2017; Kilian and Vigfusson, 2011, 2009). While oil prices are expected to have various impacts on the output growth of both oil-exporting and importing countries, there is a paucity of research on the asymmetric response of AOECs that captures the recent decline in oil prices compared to the differential impacts of oil shocks on oil-exporters (see Wang, Zhu and Wu, 2017; Kim *et al*., 2017).

Furthermore, the few empirical studies on the effects of oil price shocks on the economies of oil-exporting countries have assumed a linear relationship between oil price uncertainties and macroeconomic variables, offering no insight into the dynamics of different types of shocks. The literature also assumes a homogeneous response to oil price shocks by oil-exporting countries (see Hamilton, 2003). There is thus a need for deeper understanding of how oil price shocks impact oil-exporting countries' output. This chapter contributes to knowledge by empirically investigating the non-linear effects of oil price shocks on the macroeconomy of the AOECs, using the panel VAR estimating technique.

The chapter focuses on the asymmetry or non-linearity of the relationship between oil price shocks and output performance in the AOECs. It is structured as follows: Section 5.2 reviews related literature, comprising both the theoretical and empirical framework. Section 5.3 presents the methodology employed and the description of variables. The empirical results and interpretation of results are presented in section 5.4. Section 5.5 discusses the findings and their implications and section 5.6 summarizes and concludes the chapter.

5.2 **Literature Review**

A substantial body of both theoretical and empirical evidence has been documented on the relationship between oil price shocks and the response of the economy around the world. However, the specific literature on the AOEC bloc appears inadequate. The notion of a nexus between oil price shocks and output aligns with a few studies that assert that a proportional change in oil price shocks is similar to the proportion of change in output (see Catik and Onder, 2013; Iwayemi and Fowowe, 2011). However, some scholars argue that the proportion of oil price shocks may not necessarily account for the same proportional change in output. Although it is clear that oil price movement affects output, the asymmetric response of output to oil price shocks remains unclear (see Catik and Onder, 2013). While many studies on this issue have been carried out in developed oil-importing countries, the experience in oil-exporting economies remains equivocal, calling for an empirical study like the current one.

5.2.1 **Theoretical Perspectives**

Several developing oil-exporters largely rely on proceeds from oil exports, causing their economic activities to oscillate with variations in oil prices (Aastveit, Bjornland, and Thorsrud, 2014; Ahmed, 2017). The literature reveals that most developing oil-exporting countries are lagging behind their non-resource-based contemporaries (see Smith, 2004; Sachs and Warner, 2001; Subramanian and Sala-i-Martin, 2003). This is explained within the context of poor economic performance in oil-exporting economies, and by the adverse effects of oil windfalls on government policies, institutions, and investment in human capital. It is argued that, comparatively, oil-abundant economies accumulate less human capital than their oil-poor counterparts because oil is characterized by a capital-intensive enclave, government has little incentive to invest in skilled workers (Hjort, 2006), and returns on education and the quality of education are low (Birdsall, Pinckney and Sabot, 2001). This suggests that oil prices might have had asymmetric effects on the economies of developing oil-exporting countries, implying that they may not only have suffered from low oil prices because of falling proceeds, but have also not benefited fully from increases in oil prices, which account for massive foreign reserves inflows that are critical for their economic growth.

The traditional technique to describe the effect of oil price changes on output growth in oil-exporting countries is the Dutch Disease theory (see Corden and Neary, 1982; Van Wijnbergen, 1984). Rising oil prices have adverse effects on oil-exporting countries' economic activities because they change the structure of the economy through resource movement in favour of the booming oil and non-traded sectors and against the traded sectors, especially manufacturing. Furthermore, increased oil revenue during an oil boom leads to appreciation of the domestic currency, reducing net exports and undermining the traded sectors. Since the manufacturing sector is characterized by economies of scale and learning-by-doing, its weakening will seriously compromise long-run growth (Krugman, 1988). Therefore, a temporary boom in the oil market may have a long-run detrimental effect on the economy. The Dutch Disease theory focuses on the effect of higher oil prices, but it implies that the same transmission mechanism will be in place in the opposite direction when the oil price falls. Empirical evidence on the Dutch Disease theory is rather mixed. For example, Mikesell (1997) shows that the Dutch Disease mechanism is not responsible for poor economic performance in half of the countries investigated. Fardmanesh (1991) argues that the tradable manufacturing sector did not necessarily contract in some oil-exporting countries after the oil booms of 1970 and the 1980s. Korhonen and Mehrotra (2009) report mixed results for real exchange rates appreciation following oil price hikes in four oil-producing countries and argue that supply shocks and not oil price shocks are important factors in explaining output movement in these countries. Some scholars have also suggested that oil price volatility, rather than its trend, causes subdued economic performance in oil-exporting countries (Poelhekke and Van der Ploeg, 2007). They add that high volatility is detrimental to economic performance because it leads to higher rates of unemployment. During periods of negative economic growth, workers are displaced and they struggle to find new jobs when the economy expands (Baldwin and Brown, 2004). In addition, these scholars argue that the volatility of oil prices is due to low-price elasticity of demand and supply in the short run. This means that a small change in either demand or supply will require a large change in prices to restore the equilibrium.

Another theory on the oil price shocks and output performance relationship is premised on the fact that variations in oil prices impact real economic activities from both the demand and supply sides (see Lescaroux and Mignon, 2008; Serletis and Istiaks, 2013; Jimenez-Rodriguez and Sanchez, 2005). According to Brown and Yucel (2002) and Serletis and Istiaks (2013), increases in the prices of oil are mirrored in higher production costs, exerting adverse effects on supply. These studies posit that, higher production costs reduce the return on investment, which tends to negatively affect demand for investment. Similarly, Rafiq *et al*. (2016) point out that, increased volatility in oil prices impacts on investment and causes growing uncertainty on future price movements. Rafiq *et al*. (2016) also note that consumer demand is influenced by changes in oil prices as they affect product prices by changing the production cost. Since oil has a direct linkage with the process of production, it could have a significant effect on employment, output, and inflation.

This implies that oil price shocks may trigger inflation, increasing the cost of production factor inputs, as inflationary pressure may lead to a fall in demand which in turn, is expected to lead to a cut in production, contributing to higher unemployment (Lescaroux and Mignon, 2008; Loungani, 1986).

Similarly, Inflation could lead to high levels of unemployment. When inflation is high, firms are uncertain of whether investment will be profitable or not. Therefore, investments drop resulting in redundancies or labour loss arising from a fall in the labour input needed for production. On the other hand, countries with low inflation rates attract relatively more investments and more jobs. Buttressing this claim, Iwayemi and Fowowe (2011), Mountain and Wu (2016) have argued that countries with higher inflation rates tend to have lower investments and thus lower economic growth. Therefore, if there are low levels of investment, this could lead to higher unemployment in the long term. According to these studies, the employment-oil price connection holds true not only for industrial production but also for agricultural employment. Oil price shocks also affect the implementation of monetary policy through their effect on inflation. Furthermore, for oil-importing countries, increases in oil prices may lead to a rise in the cost of imports (see Dohner, 1981), which in turn may lead to inflation in the domestic economy. For oil-exporting countries, increase in prices lead to currency appreciation (see Kim *et al*., 2017; Wang *et al*., 2017).

According to Rafiq *et al.* (2016), the asymmetric impact of oil price variations on trade may be classified into the impact of positive oil shocks on net oil-exporting economies and the impact of negative oil shocks on these economies. The effects of positive oil price shocks have been relatively well documented in the literature, specifically in relation to oil-importing countries (see Huang, Hwang and Peng, 2005). These studies argue that oil price increases may have a positive impact on net oil-exporting economies. This direct impact can be termed a revenue effect, asserting that increases in oil prices are likely to improve the terms of trade in net oil-exporting countries, which in turn, may lead to increases in oil revenue, an improved trade balance, and increases in both consumption and investment (see Korhonen and Ledyaeva, 2010). Such direct positive shocks could be refuted using different indirect effects (Le and Chang, 2013). For instance, increases in oil prices may result in inflationary pressure on global markets, which may eventually increase the prices of imports in both oil-exporting and oil-importing countries. Therefore, for any country to curb inflationary pressure, the monetary authorities across all trading partners may react by increasing interest rates, leading to falling investment and consumption and thus, reducing the growth rate among the partner countries. In addition, this could result in a fall in demand for oil and ultimately leading to a fall in oil exports, while affecting the trade balance in oil-exporting countries[24]. On the other hand, a rise in oil prices may create negative supply shocks to the production processes of the importing countries, which in turn, may result in an economic slowdown in these countries, causing

[24] Demand effect.

their imports to drop on the one hand and on the other, exerting a negative impact on the trade balances of oil-exporting economies.[25] Overall, the gain from a rise in oil prices for an oil-exporting nation is completely dependent on the degrees of three effects, namely demand, supply, and revenue effects. In addition, even if the general impact is positive, Le and Chang (2013) point out that, there are other concerns, like the presence of volatility, Dutch Disease and the exhaustibility of the positive impact and dependence on trade partners.

Increased oil prices are negative terms-of-trade shocks for oil importers. Therefore, they are assumed to be unfavourably affected by positive shocks (Backus and Crucini, 2000; Kim and Loungani, 1992). Due to this terms-of-trade effect, net oil-importing countries are expected to be left with less production and exports, causing downward pressure on their trade balances. Kilian and Vigfusson (2011) question this transmission channel of the negative effect, illustrating that the negative cost shock may not always be large enough, as the cost portion of oil could be very small in the domestic production process for some oil exporters[26]. Given the increased availability of alternative energy sources, it may not be difficult for net oil-importing countries to reduce the cost portion of oil in their domestic production process. Furthermore, net oil-importing countries may reduce the contrary effect of oil price shocks by increasing non-oil exports to their oil-exporting counterparts, thus, improving their trade balance[27]. Hence, both the sign and magnitude of the overall impact resulting from positive oil shocks for oil-importing countries, are ultimately determined by the cross interaction of all these effects. While declines in the oil price may reduce oil proceeds in the case of oil-exporting countries (the revenue effect), the same could have a direct impact in increasing exports, because of increased demand from oil importers (the demand effect). Due to rapid trade liberalization and globalization, countries and corporates are now flexible in varying their fuel mix in their production process, thus, instantly affecting import allocation.

A fall in oil prices may improve a net oil importer's terms-of-trade situation because of lower demand for the currencies of oil-exporting countries. This may also come with negative consequences. As oil becomes a cheaper resource, oil importers may increase oil imports and put further pressure on external balances (both the cost-share and the trade composition effect). In due course, this may cause both efficiency and production in non-oil sectors to rise, thus, increasing exports of non-oil goods and

[25] Supply effect.

[26] Cost share effect.

[27] Trade composition effect.

resulting in a positive effect on non-oil output and trade balances. The trend in exchange rates across trading partners therefore affects trade (see Le and Chang, 2013; Chin, 2004; Singh, 2002).

5.2.2 **Empirical Review**

There are several studies on the asymmetric effect of oil price shocks on oil-importing countries (see Herrera, Lagalo and Wada, 2011; Hamilton, 2008; Mork, 1989; Mory, 1993; Lee *et al*., 1995). These studies have generally revealed that increases in the price of oil have adverse impacts, but the effects of drops in oil prices on the economic activities of the US and some developed oil-importing countries (e.g. the OECD) are not significant. Some studies have also investigated the transmission mechanism of oil price shocks, seeking to identify the causes of non-linearity (Ferderer, 1996; Hamilton, 1996; Bernanke *et al*., 1997; Huntington, 1998; Atkeson and Kehoe, 1999). The transmission mechanism and the nature of the asymmetric effects of oil price shocks in oil-exporting countries are likely to be different from those in oil-importing countries. Oil price shocks have demand-side effects in oil-exporting countries, and a possible reason for non-linearity in demand-effects in these countries may be the size of the government and its excessive role in their economies.

According to Husain *et al*. (2008) and Frankel (2010), in most developing oil-exporting countries, oil revenue accrues to the government, making it the main economic player with a lion's share of employment, total investment, and other economic activities. Furthermore, these studies note that fiscal policy in these countries is often procyclical rather than countercyclical (Husain *et al*., 2008; Frankel, 2010). Following an oil price increase, the governments of these countries launch large social programs and investment projects, which may not contribute much to economic growth because they often exceed the economy's absorptive capacity, leading to higher inflation (see Moshiri, 2015). Moshiri (2015) adds that, when oil prices decrease sharply, most state-backed economic activities are shut down, and many large investment projects are left unfinished, putting additional pressure on the economy. To fulfill recurrent cost commitments and to avoid social and political unrest, governments run a huge budget deficit, which is usually financed by borrowing from central banks or abroad.

The non-linear association between oil prices and output performance has been explained in various ways. For example, Davis (1987) and Loungani's (1986) studies, which are the leading works on this nexus, argue that oil price shocks could cause sectoral swings and expensive reallocation of resources. Mork (1989) reveals that, in separately estimating the coefficients on rises and falls in oil prices, the coefficient on falls is not statistically different from zero. Lee *et al.* (1995) show that a better prediction of GDP could be obtained by adjusting the oil price rise using standard deviation of price volatility. Taking this investigation further, Hamilton (2003) examines the non-linear relationship using an elastic parametric model and finds support for Lee *et al.*'s (1995) results. Various studies offer evidence of a non-linear relationship between oil prices and output performance for OECD countries (see Mork, 1989; Cunado and de Gracia, 2003; Jimenez-Rodriguez and Sanchez, 2005).

A new strand of studies has come up with an alternative explanation to the identification of oil price shocks used by Lee *et al.* (1995) and Hamilton (2003). These include Kilian and Vigfusson (2009), and Kilian (2009, 2008), who point to potential endogeneity in the estimation of the effects of oil shocks on the US economy and employ a measure of oil price shocks based on a structural near-VAR model of the real price of crude oil. In Kilian (2009), the methodology used to identify structural shocks to the real price of oil depends on delay restrictions that, according to Kilian (2009), are economically reasonable only at the monthly frequency. He develops a technique that permits the separation of innovations on oil prices into three fragments: oil-specific demand shocks, oil supply shocks, and aggregate demand shocks. Separating the source of oil price shocks in these three fragments, he concludes that, most of the shocks in the prices of oil are accountable for oil-specific demand shocks and aggregate demand shocks.

Studies on oil-exporting countries including Baldini (2005), Husain, *et al.* (2008) and more recently Ahmed (2017) and Kose and Baimaganbeto (2015) find that oil shocks mainly affect the economic cycle in oil-exporting economies through their own fiscal policy. Using a VAR model on a panel of oil-exporting countries, Husain *et al.* (2008) estimate fiscal impulses, capturing transmission of oil price shocks to the economy. This study considers a sample of AOECs, comprising of Algeria, Egypt, Gabon, Libya and Nigeria which Husain *et al.* (2008) do not consider in their sample. This focus offers a better ground to estimate the oil price shocks and output performance nexus. In addition, it provides informed understanding to policy makers of the effects of unexpected fluctuations in the oil price on output performance within the symmetry or asymmetry context.

In contrast to studies in the US, which focus on the asymmetric relationship between oil price shocks and output performance, Mork's (1989) conclusion that there is a strong association between oil price variations and the GNP growth rate in the US continues to hold when the sample period is extended to the oil price collapse in 1986. The consequences of oil price shocks on output were corrected using the oil price control technique. His findings show that a negative correlation persists between oil price increases and the GNP growth rate. However, the real effects of oil price decreases are different from those of oil price increases, with oil price decreases not showing a statistically significant effect on the US economy.

Similarly, Elder and Serletis (2008) study the direct impacts of unexpected oil price changes on real economic activity in the US over the modern OPEC period within the context of a structural VAR, modified to accommodate GARCH-in-Mean errors. As a measure of uncertainty about impending oil prices, they use the conditional standard deviation of the forecast error for the change in the prices of oil. Their study reveals that uncertainty about the price of oil has had a negative and significant effect on real economic activity in the post-1975 period, even after controlling for lagged oil prices and lagged real output. Furthermore, the results reveal that oil price uncertainty tends to reinforce the decline in real GDP in response to higher oil prices while moderating the short-run response of real GDP to lower oil prices. Similar studies on asymmetry relating to these earlier studies include Hooker (1996), who examines the asymmetric effects of oil price shocks on GNP by analyzing the response of interest rates to oil price shocks. Sadorsky (2000) investigates the dynamic interaction between oil prices and other economic variables using an unrestricted VAR with US data on industrial production, the interest rate of a three-month Treasury bill, the oil price and real stock returns.

In examining the impact of oil price shocks on the real GDP growth of a few OECD countries, Jimenez-Rodriguez and Sanchez (2005) differentiate between net oil-exporting and importing countries. They analyse the relationship between oil prices shocks and GDP growth using four VAR-specifications, namely, a linear model and three leading non-linear specifications. Their study reveals evidence of non-linear impacts of the oil price on real economic activity, with oil prices (or transformation thereof) having different impacts on real output when they increase and when they fall. This finding contrasts with the linear technique where oil prices are assumed to have symmetrical impacts on real economic activity. The VAR results are largely consistent with the expectation that the real GDP growth of oil-importing economies suffers from increases in oil prices in both linear and non-linear models. These conflicting results for oil-exporting nations are traceable to sharper real exchange rates appreciation. In the case of net oil-importing countries, the results obtained using the optimal order of the model (i.e., four lags) indicates a positive association between oil prices and real performance.

Davis and Haltiwanger (2001) employ a VAR estimating technique to estimate the response of employment creation and destruction in order to separately define positive and negative oil price shocks using plant-level census data from 1972Q2 to 1988Q4 on employment, capital per employee, energy use, the age and size of a plant, and product durability, at the four-digit SIC level. Examining job creation and destruction between aggregate and allocative transmission mechanisms, their results show that the aggregate channel would increase job destruction and reduce job creation in response to an oil price increase, while an oil price decrease reduces job destruction and increases job creation symmetrically. The findings suggest that allocative channels would increase both job creation and destruction asymmetrically in response to both price increases and decreases.

Van der Ploeg and Venables (2011) explore the possibility of a non-linear relationship between oil prices and Norwegian exchange rates. Contrary to findings from related studies, their results show that the oil price was negatively related to the value of Norwegian exchange rates when the oil price fall was below $14. In a similar study, Bjornland's (2008) research in Norway incorporated stock returns in a structural VAR model. His findings show that a 10 percent rise in oil prices leads to a 2.5 percent increase in stock returns with a robust outcome for non-linear and linear measures of oil prices. The author concludes that the Norwegian economy responds to rising oil prices by increasing aggregate demand and wealth.

Park and Ratti (2007) use a multivariate VAR technique for a monthly sample from 1986 to 2005 in Norway to analyze the relationship between oil prices and output. They find that oil price fluctuation is responsible for about 6 percent of volatility in real stock returns. In contrast, in most European economies increased volatility of oil prices has been found to significantly depress real stock returns. For the US, research reveals that oil price shocks, rather than interest rates, explain more of the fluctuations in real stock market returns. This conforms to Sadorsky (2000) and Nora's (2017) studies that concluded that oil prices explain a larger fraction of the forecast error variance in real stock returns than interest rates after 1986. In a similar study, Miller and Ratti (2009) examine the long-run relationship between global crude oil prices and international stock markets for the period 1971:1-2008:3 using a co-integrated Vector Error Correction Model. They conclude that international stock market indices respond negatively to increases in oil prices in the long run. They also establish the existence of long-run co-movement between the crude oil price and the stock market from 1971:1-1980.5 and 1988:2-1999.9 with evidence of a breakdown in the relationship after this period. The authors note that this suggests that the relationship between real oil prices and real stock prices has changed in the more recent period compared to the earlier period.

Rahman and Serletis (2011) examine the asymmetric impacts of oil price shocks on output growth. Using a general bivariate framework in a modified VAR framework, the study employs simulation methods to estimate Generalized Impulse Response Functions (GIRFs) and Volatility Impulse Response Functions (VIRFs) to trace the effects of independent shocks on the conditional means and the conditional variances, respectively. Their result reveals that the conditional variance-covariance process underlying output growth and the change in the real price of oil exhibits significant non-diagonality and asymmetry. It also shows evidence that increased uncertainty about changes in the real price of oil is associated with a lower average growth rate in real economic activity.

Papapetrou (2001) investigates the linkages among oil prices, real stock prices, interest rates, real economic activity and employment for Greece, using a multivariate VAR approach. The empirical results suggest that while oil prices are important in explaining stock price movements, stock market returns do not lead to changes in real activity and employment. Therefore, the author observes that variations in oil prices affect real economic activity and employment.

Using daily data, Eryigit (2009) examines the impacts of oil price changes on the sectoral indices of the Turkish stock exchange. Adopting an OLS model, he estimates an extended market model which includes market return, oil prices (in Turkish Lira), oil prices in dollars and exchange rates (USD/TL) to determine the effects of oil price (USD) variations on the Istanbul Stock Exchange's (ISE) market indices for the period 2000-2008. The results show that changes in oil prices have statistically significant impacts on electricity, retail trade, insurance, wholesale and holdings, investment, wood, paper, printing, basic metal, metal and non-metal products, machinery and mineral products. In addition, changes in the oil price (USD) have a significant positive effect on the wood, paper, printing, insurance, and electricity subsector indices.

Lippi and Nobili (2008) assert that the sources of oil price shocks may affect economic performance in different ways. For instance, they observe that oil price increases due to an increase in oil demand shocks affect output differently from oil price rises associated with lower world oil supply shocks. Furthermore, they claim that positive oil supply shocks reduce domestic production. To assess the impacts of oil supply shocks, they employ the sign-restrictions approach pioneered by Canova and De Nicolo (2002) and Uhlig (2005). They set up a three-variable VAR model that includes world crude oil production, real price changes, and domestic growth rates. Following Lippi and Nobili (2008) and Nora (2017), they define positive oil supply price shocks such that oil production falls, but oil prices increase at the contemporaneous period where no additional restrictions are imposed for additional periods as well as for their effect on output.

The asymmetric relationship between oil prices and output performance in Nigeria has also been investigated. For instance, Aliyu (2009) uses a multivariate VAR model to empirically examine (linear and non-linear specification) the impacts of oil price shocks on real macroeconomic behavior in this country. Among other things, his findings offer evidence that oil price shocks have both linear and non-linear impacts on real GDP. In the non-linear models, asymmetric oil price increases are found to have a positive impact on real GDP growth of larger magnitude than asymmetric oil price decreases' adverse effect on real GDP. The non-linear estimation shows significant improvement over the linear estimation and the one reported earlier by Aliyu (2009).

Olomola and Adejumo (2006) examine the relationship between oil price shocks and aggregate economic activity using output, money supply, real exchange rates, and inflation as proxies. The study uses quarterly data spanning 1970 to 2003. The findings reveal that, contrary to earlier empirical studies, oil price shocks do not significantly affect inflation and output in Nigeria, but do significantly impact real exchange rates. The authors thus argue that oil price shocks may give rise to a wealth effect that appreciates real exchange rates and may squeeze the tradable sector, giving rise to the Dutch Disease.

Akpan (2009) investigates the dynamic relationship among oil price shocks and economic activities. He finds that major oil price shocks lead to a significant rise in inflation and directly result in a rise in real national income through higher export earnings. However, part of this gain is by way of losses from lower demand for exports generally due to economic recessions suffered by trading partners. The study also shows that there is a strong positive nexus between real government expenditure and positive oil price variations.

Nora (2017) examines the impacts of oil price shocks on economic activity in Jordan, proxied by industrial production growth. The study accommodates non-linearity by employing various measures for oil price shocks. His results show that positive oil shocks negatively and significantly impact growth, while a decrease in oil prices has no impact on growth. These findings suggest that decreases in oil prices do not necessarily trigger industrial growth in oil-importing economies. Consequently, the symmetry specifications of oil price shocks and growth are found to correlate negatively. Furthermore, he asserts that oil is directly linked to the production process and it may therefore have a significant impact on inflation, employment and output in the case of oil-importing countries. Variations in oil prices may affect an economy's interest rates and price level (see Cologni and Manera, 2008); exchange rates (see Chen and Chen, 2007); unemployment (Keane and Prasad, 1996) and stock prices (see Jones and Leiby, 1996; Huang *et al.,* 1996; Papapetrou, 2001; Sadorsky, 2000; Huang *et al*., 2005; Nora, 2017). Another strand of the literature, including Lee *et al*. (1995), Ferderer (1996), Guo and Kliesen (2005), and Rafiq *et al. (*2016) examines the impact of uncertainties evolving from oil price shocks. These studies conclude that oil price shocks have important impacts on aggregate macroeconomic indicators like interest rates, unemployment and exchange rates, GDP, investment and inflation. However, they find an asymmetric relationship between oil price variations and the economy, implying that the negative effect of oil prices increases is not the same as the positive effects of oil price drops. These studies were conducted in the context of developed oil-importing nations in Europe and North America. Few academic endeavors have been undertaken to analyze the impact of oil price shocks on external balances (see Backus and Crucini, 2000; Bodenstein, Guerrieri and Gust, 2013).

Oomes and Kalcheva (2007) investigate the asymmetric effect of crude oil prices and exchange rates on the prices of petroleum products in selected sets of northern Mediterranean countries. They find that crude oil prices increase the price of petroleum products more than exchange rates in the long run. However, in the short run, exchange rates were observed to increase the prices of petroleum products more than crude oil prices. According to the authors, the effect of crude oil prices on petroleum products is regionally based. They also observe that prices in regional markets reflect the balance between supply and demand in each market as well as the relative quantity of each commodity. Thus, crude oil prices are typically the largest determinants of the global prices of petroleum products which are processed or refined from crude oil. This explains why the authors find the lowest short-run asymmetric effect of exchange rates (relative to crude oil prices) in Turkey rather than in Greece.

Korhonen and Juurikkala's (2007) investigation of the effects of oil price shocks on oil-exporting countries' economic growth reveals that oil price shocks have asymmetric effects on these nations' economic growth. The adverse effects of higher oil prices are greater than the stimulating effects of lower prices. The study further shows that the effects of oil price shocks on economic performance and their transmission mechanism in oil-exporting countries are different from those of oil-importing countries. It concludes that in developing oil-exporting countries, lower oil prices would lead to major fall in revenue and economic stagnation. However, higher oil prices and accompanying higher revenue do not translate into sustained economic growth (see Korhonen and Juurikkala, 2007).

The Dutch Disease theory has also been employed to explain the impact of oil price variation on output growth in oil-exporting countries. Empirical evidence on the Dutch Disease is somewhat mixed. While some studies offer evidence of this disease in some oil-exporting countries, others do not support it. The Dutch Disease mechanism is not responsible for poor economic performance in half the countries investigated (see Berumet *et al.,* 2013). It has also been argued that the tradable manufacturing sector did not necessarily contract in some oil-exporting countries after the oil booms of the 1970s and the 1980s (see Moshiri, 2015).

According to Moshiri (2015), the immediate effect of positive oil price shocks is increased costs of production for oil-importing countries. This is likely to decrease output, with its magnitude depending on the shape of the aggregate demand curve. Higher oil prices reduce disposable income and thus decrease consumption. Once oil price increases are perceived as permanent, private investment also shrinks. If the shocks are perceived as persistent, oil is used less in production, capital and labour productivity decrease and potential output falls (Berument *et al.*, 2010). Using a structural VAR model, Le and Chang (2013) empirically demonstrate that the impact of oil price shocks on output and prices is asymmetric in nature, with the impact of an oil price decrease significantly greater than that of an oil price increase.

Aliyu (2009) investigates the role of country specific and global factors, particularly the oil price, on the real exchange rate in selected Commonwealth of Independent States (CIS) nations, namely, Azerbaijan, Kazakhstan, Kyrgyzstan, Moldova, Russia, Turkmenistan, Ukraine, and Uzbekistan for the period spanning 2000 to 2011. The study uses a panel smooth transition autoregressive (PSTAR) model, which takes into account the nonlinear dynamic adjustment of real exchange rates towards equilibrium. It reveals asymmetric behavior by real exchange rates in the face of either overvaluation or undervaluation of the domestic currency. Furthermore, the study reveals that oil prices have significant impacts on appreciation of domestic currencies, particularly in oil and gas-exporting, relatively richer countries, and that the CIS countries have become vulnerable to global shocks.

Berumet *et al.* (2009), employ the unrestricted VAR estimating technique to determine the asymmetric and symmetric effects of oil exports shocks on the non-tradable sector of the Iranian economy. The findings from their non-linear model show that oil export movement leads to an asymmetric reaction in construction, services and other variables employed in the study. The results of the impulse response function reveal that shocks in oil export growth significantly increase construction, imports, manufacturing, services and real effective exchange rates. The variance decomposition suggests that negative oil price shocks play a stronger role in the economy than a positive one in construction. On the whole, the oil rich country of Iran suffered from a weak and undiversified economy, which leads to the Dutch Disease.

A few studies have suggested that volatility of oil prices is inelastic in the short run (see Fardmanesh, 1991). Hence, a small change in either demand or supply requires a large change in price to restore the equilibrium. Demand is inelastic since a change in energy consumption requires a change in capital stock, which would take time to occur. Energy supply has low elasticity since energy production is capital intensive and producers need time to expand production when prices rise. Indeed, oil price volatility has led some countries to establish an oil reserve fund to alleviate the negative impact of volatility on their economic activities.

Frankel (2010) employs a VAR model using quarterly data from 1970 to 2003 to examine the impact of oil price shocks on aggregate economic activity in Nigeria. The results reveal that while oil prices significantly influenced exchange rates, it did not have significant effect on inflation and output in the country. The study concludes that an increase in the price of oil results in wealth effects which appreciate exchange rates and increase the demand for non-tradable goods, a situation that would result in the Dutch Disease. Extensive debate on the impact of oil price shocks on real exchange rates prompted Poelhekke and Van der Ploeg (2007) to examine the relationship between oil prices and real exchange rates in Russia. They employed the VAR model and the cointegration technique and found that fluctuations in oil prices and real exchange rates significantly influence the Russian economy in both the long-run equilibrium condition and short-run direct impacts.

In response to rapid globalization, a few studies have analyzed the trade channels through which oil can affect the macroeconomy. These include Backus and Crucini (2000), Kilian *et al*. (2009), Bodenstein *et al*. (2011), and Le and Chang (2013). While Le and Chang (2013) and Kilian *et al.* (2009) employ impulse responses time series to examine the relationship between oil prices and trade performance in oil-importing countries, Backus and Crucini (2000) and Bodenstein *et al*. (2011) use the dynamic general equilibrium technique to carry out a similar analysis. Backus and Crucini (2000) focus on technology shocks and oil supply as probable drivers of oil price variations, while Kilian *et al*. (2009) and Bodenstein *et al*. (2011) also consider oil demand shocks. The primary focus of these three studies is a developed oil-importing country (i.e., the US economy). More recent studies investigate this nexus between oil price variations and economic growth. For instance, Le and Chang (2013) examine the impacts of oil prices on trade balances, along with its oil and non-oil components for Malaysia as an oil exporter, Singapore as an oil refiner, and Japan as an oil importer. These studies share similar views and concur on the divergent impacts associated with oil demand and supply shocks, and on the changing effects of oil shocks on exporters and importers. However, the literature has paid little attention to the asymmetric impacts of these shocks, as well as their variant behavior on oil exporters.

Furthermore, while these studies use time series estimating techniques, it is essential to identify these linkages within a panel framework. This is necessary to comprehend the oil exporting group dynamics arising from these impact channels. More importantly, regional economic performance is attracting scholarly interest in order to advance appropriate policy guidelines for oil resources. This is the focus of this study. In addition, it adds to the existing literature on the non-linear relationship between oil prices and output performance. This is achieved by adopting a non-linear estimating technique that ascertains the asymmetric effect of oil price shocks in a panel of countries within the context of the AOECs.

5.3 **Methodology**

This section presents the methodology employed for this study. It includes the model specification, the estimating technique, data, and the description of variables.

5.3.1 **Panel-VAR (PVAR) Technique**

Following several studies on natural resources, this study is carried out using the PVAR estimating technique (see Canova and Ciccarelli, 2004; Holtz-Eakin, Newey and Rosen, 1988; Antonakakis, Cunado and Filis Perez de Gracia, 2015; Cavalcanti *et al.*, 2011; Andarov, 2019; Tazhibayeva, Ter-Martirosyan and Husain, 2008; Boubtane *et al.*, 2013; Tazhibayeva *et al.*, 2000; Ter-Martirosyan and Husain, 2008; Magazzino, 2016; Lee and Chang, 2008; Yildirim, Aslan and Ozturk, 2014; Kum, 2012). This technique is employed to generate impulse-response functions to analyze the impact of oil price shocks on the output of the AOECs.

According to Canova and Ciccarelli (2012), the PVAR is built on the VAR framework. Apart from the fact that the PVAR is considered as an appropriate technique, focusing on the multivariate correlation among variables, it supports the creation of several lags because the effects of oil price shocks may not be instantaneous.

Nikolas *et al.* (2001) identify several advantages of using a panel VAR methodology compared with the methods (the OLS model) previously used to investigate the oil price shocks and macroeconomy nexus. Firstly, in contrast to cross country methods, panel data techniques permit the control of unobservable time-invariant country characteristics, and minimize concerns relating to omitted variable bias. Secondly, time fixed effects can be added to account for any global (macroeconomic) shocks that may affect all countries in the same way.

Thirdly, the inclusion of lags of the variables in a PVAR model helps to analyze the dynamic relationship between the different variables. Thus, IRFs based on PVARs can account for any delayed effects on and of the variables under consideration and thus determine whether or not the effects between the variables of interest are short-lived. Such dynamic effects would not have been captured by panel regressions.

Fourthly, treating all variables as potentially endogenous, PVARs explicitly address the endogeneity problem, which is one of the major challenges of empirical research on oil prices. Fifthly, PVARs can be effectively employed with relatively short time series due to the efficiency gained from the cross-sectional dimension. Sixthly, PVAR pools data over time and across the section. This helps the study to overcome the problem of shortage of degrees of freedom which analysis with limited data using a country-specific or single VAR may compromise (see Boubtane *et al.*, 2013; Magazzino, 2016; Andarov, 2019). In addition, Andarov (2019) and Gravier-Rymaszewska (2012) assert that, unlike the SVAR model, the PVAR model does not require the imposition of a structural relationship, although theory is involved to select the appropriate normalisation and to interpret the results. Furthermore, PVAR requires only a minimal set of assumptions to interpret the effects of shocks on each variable of the PVAR system (Gravier-Rymaszewska, 2012).

Cruz Zuniga (2011) observes that the PVAR model offers advantages over other estimating techniques because it accounts for dynamics in the system. Therefore, this technique presents the impulse-response functions of output consequent to orthogonal shocks from oil prices and the monetary variables of interest. This procedure permits the impact of one shock at a time to be recognized. The IRFs resulting from the PVAR also offer more understanding of the impact of monetary policy than the statistical results (Bernanke and Gertler, 1995). Furthermore, the choice of this technique is informed by the identical yet idiosyncratic characteristics of Africa's oil-producing economies. These economies are net oil exporters, and are open, developing economies that rely on oil as a major source of revenue and a budgetary base. The countries are also characterized by mutual peculiarities such as oil importation, corrupt practices, high exchange rates, inadequate refineries, poverty and susceptibility to external oil price shocks which may have a degrading impact on their economies if they are unfavourable (see WDI, 2018).

The VAR estimating technique developed by Sims (1980), which is widely hailed by macroeconomists, only handles time-series data which usually constrains its application to analyses involving one economy. In contrast, the PVAR is suitable for analyses involving more than one economy. This overcomes the weaknesses and limitations associated with the VAR technique. This methodological option is suitable for this study, which, among other things, contributes to knowledge in this regard.

Several scholars have used the PVAR estimating technique in their empirical studies (Boubtane *et al.,* 2013; Andarove, 2019; Kum, 2012). Similarly, oil-related studies have employed the PVAR model in their analyses (see Cunado and De Gracia, 2003; Rafiq, Agro and Apergis, 2016; Kum, 2012; Magazzino, 2016; Yildirim *et al.,* 2014; Lee and Chang 2008). Studies relating to banking and finance have also applied it (see Love and Zicchino, 2006).

5.3.1.1 **Various Applications of Panel VARs**

Various macroeconomists and policy makers have found the Panel VARs estimating technique useful to address different issues of interest. For instance, within the context of the business cycle literature, Canova *et al.* (2004) employ a panel VARs to study the similarities and convergences among the G7 countries' cycles. Similarly, Canova and Ciccarelli (2012) employ the panel VARs to examine the cross-sectional dynamics of Mediterranean business cycles. Canova and Ciccarelli (2012) also find the PVARs suitable to construct coincident or leading indicators of economic activity or to forecast out-of-sample such as output and inflation. This procedure takes into account potential cross-unit spillover effects. According to Canova and Ciccarelli (2012), cyclical indicators of both a coincident and leading nature can easily be constructed from a Panel VAR and (density) forecasts can be constructed with straightforward Monte Carlo methods. In addition, they highlight that Panel VARs are mainly appropriate to analyze the transmission of idiosyncratic shocks across various units and time. For instance, Canova and Ciccarelli (2012) examined how shocks to US interest rates are propagated to ten European economies, seven in the Euro area and three outside of it, and how German shocks, defined as shocks which concurrently increase domestic output, employment, consumption, and investment are transmitted to the other economies. Ciccarelli *et al.* (2012) examine the heterogeneity in macro-financial association cutting across developed economies and compare the transmission of real and financial shocks with a focus on the most recent recession. Caivano (2006) examines how disturbances generated in the Euro area are transmitted to the US and vice versa when these two units are included in a world economy. Beetsma and Giuliadori (2011) investigate the transmission of government spending shocks and how immigration shocks are transmitted in a variety of countries. Finally, Love and Zicchino (2006) measure the effect of shocks on the financial factors of a cross-section of firms in the US.

The Panel VARs technique has also been frequently used in the literature to construct the average effects across heterogeneous groups of units and to characterize unit specific differences relative to the average (see Canova and Pappa, 2005, 2007; Canova, 2005; Rebucci, 2010). Furthermore, the Panel VAR is used to analyze the importance of interdependencies, and to ascertain whether feedbacks are generalized or only involve certain pairs of units. Thus, one may want to use a Panel VAR to test the small open economy assumption or to evaluate certain homogeneity assumptions that are often made in the international economics literature.

It is against this background that our empirical strategy employs a panel-data VAR methodology. This procedure combines the traditional VAR technique, which assumes all variables in the VAR system as endogenous, with the panel data procedure. It allows for unobserved individual heterogeneity, following a similar strategy as Magazzino (2016).

5.3.1.2 **Rationale for Panel Data Technique**

The study employs a panel data estimating technique, following Eslamloueyan and Kia (2015), Hasio (2014), Mahembe (2014), Baltagi (2008) and Kia (2006). For purposes of clarity, Baltagi (2008) and

Gujarati (2004) highlight the following reasons to support the choice of the panel estimating approach, which is found suitable for our study: panel regulates for heterogeneity in specific data; is appropriate for the study of dynamic adjustments; ascertains and evaluates the impact that is not noticeable in pure cross-sectional analysis or time-series data; provides additional variability, more explanatory power and less collinearity among variables in the model; offers more degrees of freedom (DoF) and is more efficient when compared to cross-sectional data or time-series; allows for the creation and analysis of more complex behavioral models like economies of scale and technological change; and removes the problem of non-standard distributions that characterizes the test for variable stationarity in a time series analysis.

Supporting this rationale, Andrew, Golsch and Schmidt (2013) advance the following reasons for adopting the panel estimating technique: panel data provides an efficient means to measure changing behaviors over time; the temporal order of cause and effect is known when using panel data; it controls for sample selectivity and biases arising from omitted variables; and recurring observations of the same individuals over time demonstrate the processes of variation.

Various studies have come up with different lines of argument regarding the extent to which panel data could be used in the analysis. For example, in addition to learning about individual variation, Andrew *et al.* (2013) argue that the panel data technique evaluates the levels and trends of variables over time in a similar manner to cross-sectional data analyses (although it is noted that cross-sectional analyses do not provide information about change at the individual level). According to Andrew, Golsch and Schmidt (2013), a panel data estimating technique is a rich source of information on trends and levels, as cross-sectional surveys often don't capture certain variables of interest. However, other scholars contend that panel data should purely be used to analyze change, as the challenge of "panel attrition" (i.e., individuals falling off the observation/survey) can arise when it is used to examine long-term trends (see Hasio, 2014; Mahembe, 2014).

5.3.1.3 **Oil Price Change Derivation: *Decomposition***

Many earlier studies focus on positive shocks, postulating that negative shocks will have a symmetric impact (see Hamilton, 1983). In contrast, recent studies have claimed that negative and positive oil price shocks might have asymmetric effects (See Kose and Baimaganbetov, 2015; Aliyu, 2009; Rafiq *et al.,* 2016). To critically investigate the asymmetric effect, this study decomposes the oil price shocks (see Mork, 1989; Lee *et al*., 1999; Hamilton, 2003). This procedure helps us to examine output responses within a short-run horizon. Furthermore, it allows us to explain the policy response and obtain policy direction on variations in global oil prices (increases and decreases) over time. An unprecedented variation in oil prices may have serious implications for economies that are reliant on oil, such as the AOECs. These asymmetric estimation techniques have been found suitable to measure movements in oil prices (see Kose and Baimaganbetov, 2015). As a result, this study employs three main non-linear transformations accounting for asymmetry of oil prices to examine the presence of an asymmetric relationship. These transformations have been widely used in related studies and are thus relevant to this study (see Herrera *et al*., 2011; Kose and Baimaganbetov, 2015). The specifications are the asymmetric specification (Mork, 1989), scaled specification (Lee *et al.*, 1995), and net specification (Hamilton, 1996, 2003).

The first of these transformation measures was propounded by Mork (1989). The asymmetric specification decomposes quarterly oil prices into and differentiates between a positive rate of change (OP_t^+) and negative rate of change (OP_t^-), which are expressed as:

$$OP_t^+ = \{OP_t if\ OP_t > 0, 0\ otherwise$$

$$OP_t^- = \{OP_t if\ OP_t < 0, 0\ otherwise$$

where OP_t represents the rate of change in oil prices. However, OP_t^+ quotes the net increase in oil prices and OP_t^- quotes the net fall in oil prices in a directly opposite manner.

Mork (1989) proposes the censoring of the oil price series after the 1985-86 drop in the prices of oil.

Lee *et al*. (1995) propose the second of these transformation measures, PVAR:

$$OP_t^+ = 0\ if\ \frac{OP_t}{\sqrt{\delta_t}} > 0$$

$$OP_t^- = 0\ if\ \frac{OP_t}{\sqrt{\delta_t}} < 0$$

where, $OP_t$is a measure of changes (increase/decrease) in oil prices.

Hamilton (2003) proposes the third transformation procedure to measure the effect of oil price shocks. In addition, the transformation proposes the benchmark model given by:

$$Q_{i,t} = \delta_{\mathrm{i,t}} + \sum_{i=1}^{n} \beta_{t-i}\, Q_{t-i} + \sum_{i=1}^{n} \partial_{t-i}\, OP_{t-1}^{shocks} + \varepsilon_{\mathrm{i,t}}$$

where OP_{t-1}^{shocks} denotes an alternative measure of shocks (positive/negative); $Q_t$is output.

According to Hamilton (2003), considering the various available metrics of oil price shocks, the following test can help to determine the appropriate measure of such shocks. He further argues that although the measures of shocks could be non-linear functions of oil prices, they are linear functions of the parameter estimates of $Q_{i,t}$ above. Therefore, the benchmark model can be expressly reduced as follows:

$$Q_{i,t} = \delta_{\mathrm{i,t-j}} + \partial' \rho_{i,t-j} + \varepsilon_{\mathrm{i,t-j}}$$

Where $\rho_{i,t}$, is defined as $[Q_{t-1}, Q_{t-2};\ OP_{t-1}^{shocks}, OP_{t-2}^{shocks}]$.

5.3.1.4 **Model Specification and PVAR set up**

This study employs data from five AOECs for the period 1980-2018. It uses the Hatemi-J (2012) PVAR methodological technique, which is similar to Hamilton (1989). The technique extends the traditional VAR model introduced by Sims (1980), which assumes that all variables in the system are endogenous, with the panel-data approach, which allows for unobserved individual heterogeneity. Therefore, the PVAR model can be expressed as follows in the general form:

$$Q_{\mathrm{i,t}} = \delta_{\mathrm{i,t}} + \psi_{\mathrm{n,i,}} OP_{i,t-j}^{shocks} + \varepsilon_{\mathrm{i,t-j}} \quad (5.1)$$

where, Q is the output growth and OP is the oil prices expressed in USD; $i = 1, 2, \ldots, 5$ denoting the oil-exporting countries; $t = 1980, 1981, \ldots, 2018$; $n = 1\ and\ 2$, showing movement in the oil price or the cumulative amount of movement in the oil price, which could either be positive or negative and j is the lag element.

Following Hatemi-J (2012), the study decomposes the prices of oil into their cumulative amounts of positive $(+)$ and negative $(-)$ shocks. This is in response to Hooker (1996) who argues that the linear relationship of oil price and output growth proposed by Hamilton (1983) which was based on the oil price increase alone, is not dependable, especially given observed output growth performance realities. In addition, the decomposition of oil prices into positive and negative shocks in this study is a departure from what is common in the literature which considers only positive oil price shocks rather than the fluctuating movement in oil prices (see Backus and Crucini, 2000; Huang, Hwang and Peng, 2005; Nora, 2017).

$$OP_{\mathrm{i,t}} = \psi_{\mathrm{i,t}} OP_{i,t}^{+} + \vartheta_{\mathrm{i,t}} OP_{i,t}^{-} \quad (5.1.1)$$

Deviating from previous studies that employed Western Texas Intermediate, Brent Sweet Light Crude, Forties Crude and Oseberg Crude (see OPEC, 2016), this study examines the impacts of Brent

Crude oil price shocks on AOECs, based on the asymmetric specification framework in equation (5.1.1) which is substituted into equation (5.1) to derive equation (5.2):

$$Q_{\mathrm{i,t}} = \delta_{\mathrm{i,t}} + \psi_{\mathrm{i,t}} OP^{+}_{i,t-j} + \vartheta_{\mathrm{i,t}} OP^{-}_{i,t-j} + \varepsilon_{\mathrm{i,t}} \tag{5.2}$$

As shown in equation (5.1), our benchmark specification is a bivariate PVAR, containing output growth and oil prices. Nevertheless, the study extends the model to a quad-variate PVAR with the inclusion of two policy control variables, namely, inflation and exchange rates. Exchange rates (EXCH) measure the currency of each country expressed in the currency of another country. The study uses the USD exchange rate as a benchmark because of its wide acceptability and the fact that it is the most traded currency in the foreign exchange market (see Ibrahim and Amin, 2005; Rafiq *et al.,* 2016). Its inclusion follows Rafiq *et al*. (2016) in investigating how variations in the value of the USD affect the variables selected in the AOECs. This also assesses the degree of interaction between business cycles and the process through which it stimulates output growth. Exchange rates assist in examining how changes in the value of the USD affect oil prices and consequently output (Rafiq *et al.,* 2016). Furthermore, the inclusion of the inflation rate helps in assessing how the general price level may affect output growth when oil prices vary.

$$Q_{\mathrm{i,t}} = \delta_{\mathrm{i,t}} + \psi_{\mathrm{i,t}} OP^{+}_{i,t} + \vartheta_{\mathrm{i,t}} OP^{-}_{i,t} + \mu_{\mathrm{i,t}} \xi_{\mathrm{i,t}} + \omega_{\mathrm{i,t}} \zeta_{\mathrm{i,t}} + \varepsilon_{\mathrm{i,t}} \tag{5.3}$$

where Q is output growth; OP^{+} is positive oil price shocks; OP^{-} is negative oil price shocks; ξ is exchange rates. $\delta_{\mathrm{i,t}}, \psi_{\mathrm{i,t}}, \vartheta_{\mathrm{i,t}}, \mu_{\mathrm{i,t}}$ and $\omega_{\mathrm{i,t}}$ are parameters for intercept, positive oil price shocks, negative oil price shocks, exchange rates and inflation rate, respectively; $\varepsilon_{\mathrm{it}}$ is error term.

The oil price shocks decomposition procedure used in this study is a clear departure from previous studies that considered the oil price trend over time rather than oil price behavior (shocks). Ojo and Alege (2012) consider this approach a vital variable to determine output in oil-exporting countries. The exchange rates and inflation rate variables are considered here as policy variables to offer direction to policy makers.

OP_{t}(oil price at time t) is assumed to follow a random walk process given by:

$$OP_{\mathrm{t}} = OP_{\mathrm{t-1}} + \varepsilon_{\mathrm{i,t-1}} \tag{5.4}$$

Such that, the positive shocks from the white noise can be expressed as $\varepsilon^{+}_{1it} = max(\varepsilon_{1\mathrm{it}}, 0)$ and negative shocks as $\varepsilon^{-}_{1it} = min(\varepsilon_{1\mathrm{it}}, 0)$. Hence, it is defined as $\varepsilon_{\mathrm{it}} = \sum_{t=1}^{1} \varepsilon^{+}_{it} + \sum_{t=1}^{1} \varepsilon^{-}_{it}$, such that,

$$OP_{\mathrm{t}} = OP_0 + \sum_{t=1}^{1} \varepsilon_{it}^{+} + \sum_{t=1}^{1} \varepsilon_{it}^{-} \tag{5.5}$$

where OP_0 is the initial value of oil prices and $\varepsilon_{\mathrm{it}}$ is a white noise disturbance term.

Thus, this study employs a non-linear panel estimation technique to establish the relationship between oil price shocks and output performance. To carry out this estimation, it utilizes the recent non-linear panel estimation technique of Kapetanios *et al*. (2014), which allows for cross-sectional dependence, and is appropriate for panel heterogeneity (see Rafiq *et al.*, 2016; Gravier-Rymaszewska, 2012; Sadorsky, 2000).

The standard PVAR technique that captures the variables, output (Q_{t}), positive oil price shocks (OP_t^{+}), negative oil price shocks (OP_t^{-}), exchange rates (ξ_{t}), and inflation (ζ_{t})) employed in this study is made up of five system-equation given as equations (5.6.1) to (5.6.5).

$$Q_{i,t} = \delta_{1,t} + \sum\nolimits_{i=1}^{n} \eta_i Q_{i,t-1} + \sum\nolimits_{i=1}^{n} \psi_i OP_{i,t-1}^{0+} + \sum\nolimits_{i=1}^{n} \vartheta_{\,i} OP_{i,t-1}^{-} + \sum\nolimits_{i=1}^{n} \mu_{1,i} \xi_{i,t-1} + \sum\nolimits_{i=1}^{n} \omega_i \zeta_{i,t-1} + \varepsilon_{1,t} \tag{5.6.1}$$

$$OP_{i,t}^{+} = \delta_{2,t} + \sum\nolimits_{i=1}^{n} \eta_i Q_{i,t-1} + \sum\nolimits_{i=1}^{n} \psi_i OP_{i,t-1}^{+} + \sum\nolimits_{i=1}^{n} \vartheta_i OP_{i,t-1}^{-} + \sum\nolimits_{i=1}^{n} \mu_i \xi_{i,t-1} + \sum\nolimits_{i=1}^{n} \omega_i \zeta_{i,t-1} + \varepsilon_{2,t} \tag{5.6.2}$$

$$OP_{i,t}^{-} = \delta_{3,t} + \sum\nolimits_{i=1}^{n} \eta_i Q_{i,t-1} + \sum\nolimits_{i=1}^{n} \psi_i OP_{i,t-1}^{+} + \sum\nolimits_{i=1}^{n} \vartheta_i OP_{i,t-1}^{-} + \sum\nolimits_{i=1}^{n} \mu_i \xi_{i,t-1} + \sum\nolimits_{i=1}^{n} \omega_t \zeta_{i,t-1} + \varepsilon_{3,t} \tag{5.6.3}$$

$$\xi_{i,t} = \delta_{4,t} + \sum\nolimits_{i=1}^{n} \eta_i Q_{i,t-1} + \sum\nolimits_{i=1}^{n} \psi_i OP_{i,t-1}^{+} + \sum\nolimits_{i=1}^{n} \vartheta_i OP_{i,t-1}^{-} + \sum\nolimits_{i=1}^{n} \mu_i \xi_{i,t-1} + \sum\nolimits_{i=1}^{n} \omega_4 \zeta_{i,t-1} + \varepsilon_{4,t} \tag{5.6.4}$$

$$\zeta_{i,t} = \delta_{5,t} + \sum\nolimits_{i=1}^{n} \eta_i Q_{i,t-1} + \sum\nolimits_{i=1}^{n} \psi_i OP_{i,t-1}^{+} + \sum\nolimits_{i=1}^{n} \vartheta_i OP_{i,t-1}^{-} + \sum\nolimits_{i=1}^{n} \mu_i \xi_{i,t-1} + \sum\nolimits_{i=1}^{n} \omega_5 \zeta_{i,t-1} + \varepsilon_{5,t} \tag{5.6.5}$$

The standard PVAR model made up of equations 5.6.1 to 5.6.5 can be concisely put in matrix notation. Therefore, the reduced form of a relationship between the endogenous variables (output, positive oil price shocks, negative oil price shocks, exchange rates, and inflation) is given as:

$$Q_{\mathrm{i,t}} = A_0\beta_{i,t} + \alpha_1\phi_{\mathrm{i,t-1}} + \ldots + \alpha_{\mathrm{n}}\phi_{\mathrm{i,t-n}} + \nu_{\mathrm{i,t}} \tag{5.7}$$

where $Q_{\mathrm{i,t}}$ denotes a 5x1 vector of k system-variables (output, positive oil prices, negative oil prices, exchange rates, and inflation); A_0 is the associated parameter matrix; $\beta_{i,t}$ is a vector of deterministic terms such as trend and a constant; d i is a cross-sectional identifier such that, $i = 1, \ldots, l$; $\alpha_{1,2,\ldots,n}$ represents a 5x5 matrix of slope/coefficient estimates attached to the lagged variables $\phi_{\mathrm{i,t}}$; ν represents a 5x1 vector of system innovations or the stochastic error terms often called impulse innovations or shocks; and the optimal lag length (VAR order) is denoted by n for each variable selected in accordance with the SIC and AIC. The study adopts lag length two, which is found superior to the others in terms of performance (see table 5.6).

The reduced form PVAR in equation (5.7), once the unknown parameters are estimated, allows for the implementation of dynamic simulations. According to Gravier-Rymaszewska (2012), this procedure only permits the analysis of short-run adjustment effects and not structural long-run effects. The result takes the form of IRFs and their coefficient analysis, as well as forecast error variance decompositions that enable one to evaluate the impact of shocks on any particular variable in the PVAR system.

The error process $\nu_{\mathrm{t}} = \gamma_{\mathrm{i}} + u_{\mathrm{t}} + e_{\mathrm{i,t}}$ (5.7.1)

where γ_{i} is the country specific effect, u_{t} captures the annual effect, and $e_{\mathrm{i,t}}$ the disturbance term. The error term ν_{t} is assumed to have zero mean, i.e., $E(\nu_{\mathrm{t}}) = 0$. The time invariant covariance matrix and ν_{t}s are independent.

Following Canova and Ciccarelli (2004), this study imposes two restrictions on the specifications in equation (5.7) and (5.7.1). Firstly, the study assumes common slope coefficients, and it does not allow for interdependencies across units. With this restriction, the estimated matrices α are interpreted as average dynamics. The interpretation is in response to shocks. Secondly, given the standard VAR model, the study assumes that variables depend on the past behavior of the variables in the PVAR system, with the main difference being the presence of the individual country-specific term $\gamma_{\mathrm{i.}}$

5.3.2 **Data**

Quarterly data spanning 1980Q1 to 2018Q4 is employed in this study. The commencement date captures the period of major oil price shocks that are assumed to cause an imbalance in the global economy and the exchange rates of oil-exporting countries. Data paucity dictates the cut-off date. It should be noted that the cut-off date accounts for the period of continuous decline in oil prices. The data were sourced from the OPEC and Federal Reserve Economic Database (FRED), maintained by the Federal Reserve Bank of St. Louis, over the period 1980:1 to 2018:4 on three variables. These variables are oil price (OP), output (Q) and exchange rates (EXR). The choice of Brent Blend, also known as Brent Crude follows the literature that notes that Brent Blend is the principal oil export in the AOECs among many major classifications (OPEC, 2016). The cutoff date is also informed by the belief that the period coincides with a time of continuous variations in global crude oil prices, with these prices lately showing a more sustained drop than in any other period.

Following Rafiq *et al*. (2016), Le and Youngho (2013), Korhonen and Ledyaeva (2010), and Backus and Crucini (2000), this study considers the terms of trade as a measure of output growth performance. It should be noted that the terms of trade reflect these countries' openness which is predominantly influenced by oil; and that oil accounts significantly for their foreign exchange earnings. In 2018, for instance, oil accounted for about 87 percent of foreign exchange earnings in Nigeria and approximately 95 percent in Libya. It made up around 80 percent of foreign exchange earnings in Gabon from 2010 to 2016 (WDI, 2019). Similarly, the terms of trade capture economic activity that is likely to be directly affected by oil prices and uncertainty about such prices (see Rafiq *et al.*, 2016). Theory and empirical studies dictate the choice of these variables (see Rafiq *et al.*, 2016) that are modeled into a PVAR estimating technique. Due to the requirement for using the panel VAR estimating technique, the variables employed here are subject to the stationarity test before proceeding to estimate the panel VAR model.

5.3.2.1 **Brief Description of Variables**

5.3.2.1.1 ***Output (Q)***

The *terms of trade (TOT)* which proxies for output expresses the relationship between import prices and export prices. The TOT is said to improve if it rises above 100 percent. It refers to the relative price of imports in terms of exports and is defined as the ratio of export prices to import prices. It may also be interpreted as the number of imported goods that an economy can purchase per unit of exported goods. Following Rafiq *et al*. (2016), and Rafiq and Sgro (2017), this study employs the TOT to analyze the asymmetric relationship between oil price shocks behavior and output performance in AOECs. The choice of the TOT is informed by the understanding that the crude oil exports of these countries account significantly for their revenue and more importantly that, variations in the prices of crude exports affect their exchange rates.

5.3.2.1.2 ***Oil Prices (OP)***

The oil price is measured per barrel and is the amount at which oil is sold each day on the international market (see Rafiq *et al.*, 2016; Hamilton, 2013; Iwayemi and Fowowe, 2011). It is usually invoiced in dollars. This study uses the prices of Brent Blend, also known as Brent Crude because it is the principal oil export in the AOECs among many major classifications of oil consisting of Brent Sweet Light Crude, Brent Crude, Forties Crude and Oseberg Crude (OPEC, 2016). However, following Hatemi-J (2012), the study decomposes oil price shocks behavior into positive oil price shocks (OP^{+}) and negative oil price shocks (OP^{-}), to capture how output responds to this behavior. The OP^{+} and OP^{-} are usually seen as good news for oil-exporting and importing countries, respectively. Oil prices are externally determined.

5.3.2.1.3 ***Exchange Rates (EXCH)***

Exchange rates express each country's currency in another country's currency. USD exchange rates are selected as a benchmark in this study due to their wide acceptability and the fact that US dollars are the most traded currency on the foreign exchange market (Eslamloueyan and Kia, 2015; Kia, 2006). The choice of nominal exchange rates in this study is premised on various studies such as Korhonen and Mehrotra (2009), Ngalawa and Kutu (2016) and Rafiq *et al.* (2016). These studies support the claim that underdeveloped and developing countries may have no power to determine exchange rates due to the fragility and non-competitive nature of their economies. This is unlike developed economies such as the US, which has the most traded currency in the foreign exchange market (see Ngalawa and Kutu, 2016). In addition, oil is invoiced in dollars and the AOECs cannot influence the price due to their output volume, among other factors that are exogenously determined.

5.3.2.1.4 ***Inflation Rate (INF)***

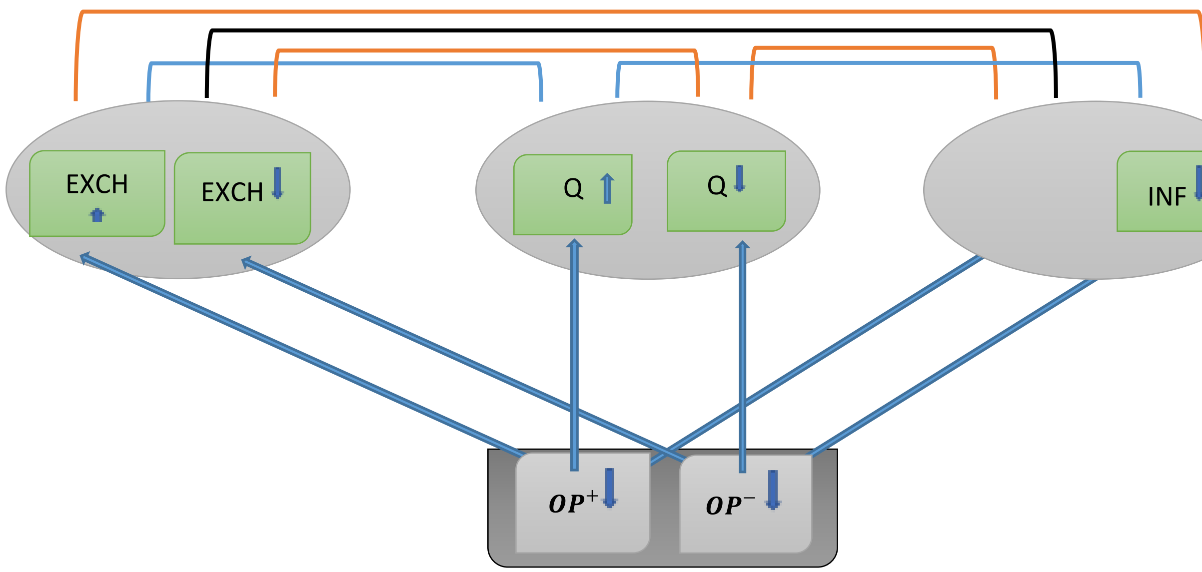
Inflation measures the general rise in prices and a decrease in the purchasing power of money over time. It is measured using a quarter by quarter national composite consumer price index with 2010 as the base year. Inflation is a fundamental monetary policy variable and it reacts when oil price shocks occur (see Hamilton, 2013). Therefore, it is introduced into the PVAR model as a monetary policy variable to serve as a control variable with a link to monetary policy decisions, especially exchange rates. For instance, Cologni and Manera (2008) note that when the exchange rate increases, there will be an increase in the overall level of prices because oil serves as a factor of production. When the exchange rate falls, that is, when the domestic currency appreciates, prices are expected to fall and by implication, output increases.

Table 5.1: Description of Variables

Variables	Abbreviation	Description
Quantity	Q	Quarterly average units
Oil Price *(Positive)*	OP^+	Quarterly average price, UU$ per barrel
Oil Price *(Negative)*	OP^-	Quarterly average price, US$ per barrel
Exchange Rates	EXCH	Quarterly average rate
Inflation	INF	Quarterly average rate

Source*: Author's computation (2020), using data sourced from the WDI.*

Figure 5.1: **Macroeconomic-Opi Price Shocks Behavior Model**



Source: Author's compilation (2020).

Figure 5.1 presents a model showing the relationship among the various macroeconomic variables considered in this study. More specifically, the model shows how the decomposed oil price shocks interact with output, exchange rates and inflation. For the AOECs, positive oil price shocks cause exchange rates to appreciate as a result of higher demand for their currencies. However, positive oil price shocks may cause an increase in inflation because the AOECs rely on importation of refined oil and other refined petroleum products due to their low refinery capacity. Inversely, production factors' prices may fall following negative oil price shocks. Output, which is the focus of this study, may respond negatively to oil price shocks and this may lead to a fall in revenue. Furthermore, a fall in oil prices may hamper economic growth and consequently lead to an unfavourable trade balance.

5.3.3 **Estimating Technique**

5.3.3.1 **Panel Unit Root Tests**

Various studies have emphasized the concept of unit root tests (see Bornhorst and Baum, 2006; Moon *et al.*2007, Im *et al.*, 2003). To conduct PVAR analysis, it is required that the properties of the variables estimated are examined. This is necessary because if the variables are non-stationary as well as non-cointegrated, this may lead to wrong specification of the model, which may ultimately give misleading values of R-square, F-statistic and t-statistic (see Al-Yousef, 2005; Hamid and Shabri, 2017) and hence, spurious results. The study implements tests developed by Im *et al*. (2003), Levin *et al*. (2002) and Breitung and Pesaran (2008) to examine whether the variables follow a unit root process, using both the Akaike and Schwarz Information criteria. The choice of the various criteria is informed by the need to confirm the validity and reliability of our results as well as their consistency (see Moon and Perron, 2004; Frimpong and Oteng-Abayie, 2006).

To test whether a series, say ψ_t, is integrated or equivalent to testing for the significance of a series, the study employs the regression equation given in equation (5.8.1). This procedure follows the Augmented Dickey-Fuller technique which suggests that the Dickey-Fuller test creates an autocorrelation problem. An Augmented Dickey-Fuller test is suggested to tackle this problem (see Frimpong and Oteng-Abayie 2006).

$$\Delta\psi_t = \phi_0 + \beta\psi_{1t-1} + \alpha_{1i} + \varepsilon_{1t} \qquad 5.8.1$$

$$\Delta\psi 2_t = \phi_0 + \phi_{1t} + \beta\psi_{2t-1} + \alpha_{2i} + \varepsilon_{2t} \qquad 5.8.2$$

Regression equations (5.8.1) and (5.8.2), respectively represent ADF with intercept only and ADF with trend and intercept. The hypotheses are specified below:

Null Hypothesis (H_0: $Variables\ are\ not\ stationary\ or\ have\ unit\ roots$)

Alternative Hypothesis (H_1: $Variables\ are\ stationary\ or\ have\ no\ unit\ roots$)

5.3.3.2 **Panel lag length**

The lag length shows the number of times between which output action responds to oil price shocks. It refers to how many times back down the Autoregressive (AR) process one examines for serial correlation. In this respect, the study uses a recent non-linear unit root test developed by Emirmahmutoglu and Omay (2014) because it is suitable for examining unit roots in non-linear asymmetric heterogeneous panels. According to Lutkepohl (2006), the information criteria for optimal lag length is contingent on the number of observations. While the AIC and FPE are more suitable when there are less than sixty observations, the Hannan-Quin is more appropriate when there are more than a hundred and twenty observations (see Lutkepohl, 2006). Since the series for this study are quarterly, the study tests for various orders of lag selection criteria to allow for adjustments in the model and the attainment of well-behaved residuals.

5.4 **Interpretation of Empirical Results**

5.4.1 **Panel Unit Root Results**

The first stage of our analysis is to examine the properties of our series. To achieve this, the study follows Levin *et al.* (2002) and Im *et al.* (2003) and carries out stationary tests to check for the presence of unit-roots. The results presented in tables 5.2a and 5.2b reveal that output and negative oil price shocks under all the criteria considered are stationary in their first difference and no variable is found to be stationary following the second differences I(2).

Table 5.2a: Levin *et al.* Im *et al*. and Fisher-ADF unit root tests: Individual Intercept

Var	Levin *et al.* (Individual Intercept)			Im *et al.* (Individual Intercept)			ADF- Fisher-Chi Square (Individual Intercept)		
	Integ Order	t-stat (t*)	Prob Value	Integ Order	t-stat (t*)	Prob Value	Integ Order	t-stat (t*)	Prob Value
Q	I(1)	-3.43894	0.0001***	I(1)	-3.3199	0.0000***	I(1)	8.19228	0.0001***
OP(-)	I(1)	-11.9081	0.0000***	I(1)	-12.9788	0.0000***	I(1)	11.2142	0.0000***
OP(+)	I(1)	-13.2155	0.0040***	I(1)	-10.6106	0.0000***	I(1)	14.2063	0.0020***
EXCH	I(1)	-9.12571	0.0023***	I(1)	-5.18969	0.0000***	I(1)	71.1402	0.0000***
INF	I(1)	-5.32421	0.0011***	I(1)	-5.24554	0.0000***	I(1)	25.1480	0.0100***

"***", "**" and "*" respectively represent statistical significance at 1 per cent, 5 per cent and 10 per cent.
Source*: Author's computation (2020), using data sourced from the WDI.*

Table 5.2b: Levin *et al.* Im *et al*. and Fisher-ADF unit root tests: Individual Intercept and trend

Varia	Levin *et al.* (Individual Intercept and trend)			I'm *et al.* (Individual Intercept and trend)			Fisher-ADF (Individual Intercept and trend)		
	Integ Order	t-stat (t*)	Prob Value	Integ Order	t-stat (t*)	Prob Value	Integ Order	t-stat (t*)	Prob Value
Q	I(1)	-2.31527	0.0054***	I(1)	-2.11106	0.0410***	I(1)	22.2875	0.0009***
OP(-)	I(1)	-9.41454	0.0000***	I(1)	-11.3011	0.0010***	I(1)	120.147	0.0000***
OP(+)	I(1)	-16.6126	0.0000***	I(1)	-14.1268	0.0000***	I(1)	172.767	0.0000***
EXCH	I(1)	-13.0597	0.0000***	I(1)	-8.14352	0.0050***	I(1)	69.7551	0.0000***
INF	I(1)	-6.24174	0.0104***	I(1)	-4.24306	0.0000***	I(1)	39.7626	0.0000***

"***", "**" and "*" respectively represent statistical significance at 1 per cent, 5 per cent and 10 per cent.
Source*: Author's computation (2020), using data sourced from the WDI.*

5.4.2 **Summary Statistics of Variables**

Table 5.3 presents the summary statistics for the series employed in this study for the period under consideration, namely, output, positive and negative oil price shocks, exchange rates and inflation rates. Exchange rates are expressed in their log forms, showing their elasticities. The mean is the average value of the data series. The study focuses on decomposed oil prices and output because they are variables of interest, as the aim is to establish if oil prices have an asymmetric relationship with output. The maximum and minimum values of output are 357.58 and 43.88, respectively. The mean value of output is 141.18, suggesting that the mean falls at the lower side of the distribution. The range of the series and its mean distribution are relatively close to the minimum output, suggesting that oil prices might not have been significantly impactful on output but rather are considered low.

This further suggests that the various positive oil price shocks experienced during the period under review may not have significantly impacted output, or the negative shocks could have retarded the economies of the oil-exporting countries. The means of the positive and negative oil price shocks are 2.27 and -2.09, respectively. The minimum negative oil price shocks and maximum positive oil price shocks are -59.8 and 25.59, respectively. The standard deviation for output stands at 56.85.

Table 5.3 presents the normality test carried out based on three known tests, namely, kurtosis, Jarque-Bera, and skewness. For the countries under examination, the findings reveal that all the variables in the model passed the normality test, both individually and jointly. This is shown by the probability values which indicate that they all passed the test at a one percent significance level. The inference of this result is that the residual of our model is normally distributed.

Table 5.3 Summary statistic of variables

	Q	**OP^-**	**OP^+**	**EXCH**	**INF**
Mean	141.1824	-2.096655	2.274537	1.651184	1.166200
Median	134.2700	0.000000	0.415000	1.838750	0.947500
Maximum	357.5800	1.877262	25.59460	2.410000	2.870000
Minimum	43.88000	-59.82567	0.000000	-0.360000	-0.550000
Std. Dev.	56.85417	5.945696	3.916720	0.549886	1.135036
Skewness	0.943263	-6.688887	2.693203	-1.673476	0.010600
Kurtosis	4.220013	59.87563	12.22507	5.569516	1.497017
Jarque-Bera	164.0408	110948.6	3708.749	578.6463	73.43076
Probability	0.000000	0.000000	0.000000	0.000000	0.000000
Sum	110122.2	-1635.391	1774.139	1287.924	909.6360
Sum Sq. Dev.	2518037.	27538.66	11950.40	235.5494	1003.592
Observations	780	780	780	780	780

***Source**: Author's computation (2020), using data sourced from the WDI.*

5.4.3 **Panel Correlation Matrix**

To ascertain that the multi-collinearity problem is averted in the estimation of this study, this section presents the extent of the relationship among the series under consideration. These include output, oil price (positive and negative), exchange rates and inflation rates. Table 5.4 presents the association of these series.

Table 5.4: Panel Correlation Matrix

Variables	**Q**	**OP^-**	**OP^+**	**EXCH**	**INF**
Q	1.000000	-0.076609	0.204135	0.253283	0.217768
OP^-	-0.076609	1.000000	0.204418	-0.062467	-0.120420
OP^+	0.204135	0.204418	1.000000	0.139023	0.235335
EXCH	0.253283	-0.062467	0.139023	1.000000	0.400155
INF	0.217768	-0.120420	0.235335	0.400155	1.000000

***Source**: Author's computation (2020), using data sourced from the WDI.*

A close look at the correlation matrix shows that the sign of connecting coefficients is consistent. For instance, the connecting coefficient of Q and OP^- is negative while that of Q and OP^+ is positive, indicating an improvement in output and fall in output. Nonetheless, the positive shocks coefficient (0.02) does not suggest an asymmetric relationship with negative shocks (-0.07). Similarly, negative oil price shocks reveal a weak association between oil prices and output, and positive oil price shocks reveal a relatively strong relationship between oil prices and output. These findings validate the "*oil revenue effect"* on the oil-exporting economies. The association between negative oil price shocks and output presents an inverse relationship, while positive oil price shocks show otherwise. This validates our earlier results that positive oil price shocks are good news for oil-exporting countries (see Rafiq *et al.,* 2016; Catik and Onder, 2013; Hamilton, 2008).

This study also takes into account the association between monetary variables and the various oil price shocks. In particular, it considers the association between inflation and positive oil price shocks as well as negative oil price shocks. The positive sign between inflation and negative oil price shocks reveals that a fall in oil prices reduces inflation but a rise in oil prices has the tendency to increase inflation.

Apart from output and exchange rates that record a slightly weak coefficient with oil price shocks, other variables record strong correlations with such shocks. Nevertheless, the overall correlation among the various paired variables presents a negative and positive mix.

5.4.4 **Panel Cointegration**

After the variables have been tested and found stationary, a panel cointegration test is conducted using the Pedroni-Engle-Granger based procedure (1999). This is conducted to establish if there is a cointegrations relationship among the variables. Tables 5.5a and 5.5b show that there is no cointegrations relationship. The presence of a cointegrations relationship among variables may call for structural VAR analysis of long-run effects (see Baltagi and Kao, 2001).

Table 5.5a: Panel Cointegration- Individual Intercept

Criteria	Statistic	Prob.	Weighted Statistic	Prob.
Panel v-Statistic	-1.448872	0.9263	-1.540788	0.9383
Panel rho-Statistic	1.531916	0.9372	1.613725	0.9467
Panel PP-Statistic	1.336873	0.9094	1.424279	0.9228
Panel ADF-Statistic	1.914493	0.9722	2.086855	0.9815

Source*: Author's computation (2020), using data sourced from the WDI.*

Table 5.5b: Panel Cointegration- Individual Intercept and Trend

Criteria	Statistic	Prob.	Weighted Statistic	Prob.
Panel v-Statistic	-2.199932	0.9861	-2.163561	0.9848
Panel rho-Statistic	2.775702	0.9972	2.748835	0.9970
Panel PP-Statistic	3.219331	0.9994	3.215085	0.9993
Panel ADF-Statistic	3.238242	0.9994	3.269647	0.9995

Source*: Author's computation (2020), using data sourced from the WDI.*

5.4.5 Panel optimal Lag Selection

This study carries out a panel optimal lag length test following Canova (2011) who argues that it is necessary to select an appropriate lag length when estimating a VAR model to avoid error of lag length in the form of under specification or over specification. According to him, over specification of lag length could increase error in forecasts and waste degrees of freedom. Under specification of lag length could omit relevant information, rendering the equations spurious, with the possibility of creating the problem of autocorrelation in residuals (Stock and Watson, 2007). Therefore, appropriate lag length selection is vital for the panel VAR model. Furthermore, if VARs have lags that are too short, they may fail to capture the system's dynamics, resulting in omitted variable bias. On the other hand, if they have too many lags, they may result in loss of degrees of freedom, leading to over-parameterization of the model. In considering appropriate selection of the lag length, the study is guided by the established criteria in the literature, which suggests that the lag with the lowest AIC is most suitable (see Lutkepohl, 2006). In addition, the procedure suggests that the smaller the value of the AIC, the more reliable the model. Therefore, regression equations are separately estimated to find the most appropriate lag length following Suzuki (2004) and Sharifi-Renani (2010). The parameters to carry out the lag length test are the sequential modified LR test statistic (LR), FPE, AIC, and SIC. Based on the Lagrangian Multiplier (LM) test for residual autocorrelation, table 5.6 reveals that lag length 2 is the optimal lag length. This aligns with the optimal lag length employed in Raza *et al*. (2015).

Table 5.6: The Panel ARDL Optimum Lag Selection Criteria

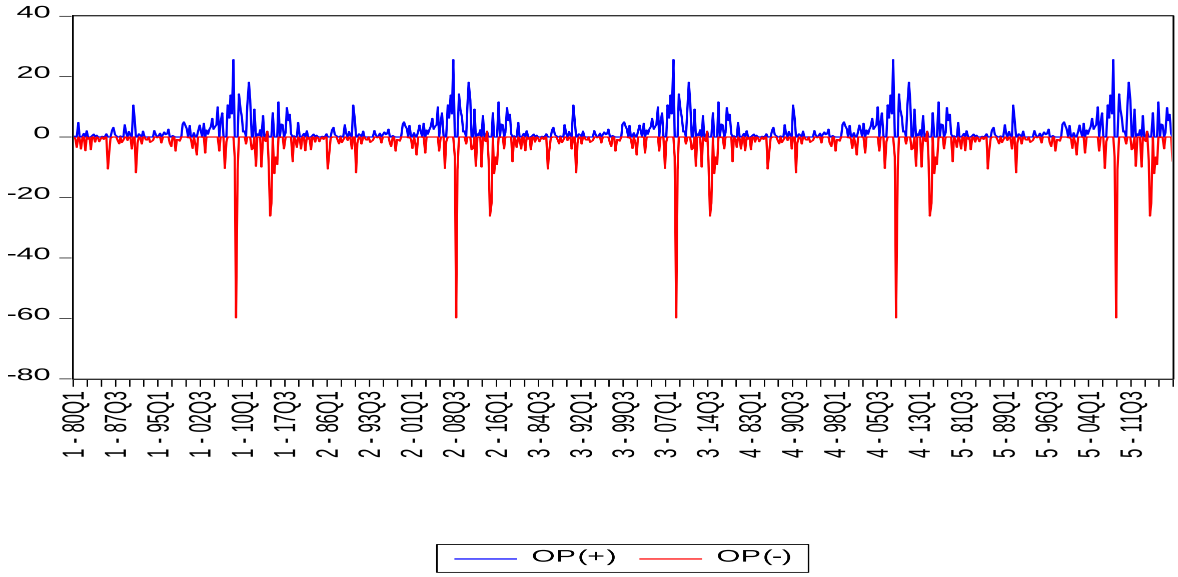
Lag	LogL	LR	FPE	AIC	SC	HQ
0	-649.9163	290.9888	6.06e-06	2.175449	3.140356	2.547482*
1	-626.0697	78.65847	6.08e-06	2.178567	3.299103	2.610604
2	-584.4336	45.37297*	5.81e-06*	2.133604*	3.109771*	2.625647
3	-564.5175	101.9111	6.16e-05	2.223020	3.321037	3.015037
4	-450.1018	99.3375	9.09e-06	2.281356	3.235003	2.833378
5	-401.7723	93.26296	8.54e-06	2.218303	3.327580	2.830330

Source: Author's computation (2020), using data sourced from the WDI.

5.4.6 Panel VAR Estimation Results

The panel data procedure employed in this study follows Holtz-Eakin *et al.*'s (1988) claim that PVAR addresses unobserved heterogeneity in a model. To explain the cause-effect association amidst the explained and explanatory variables, two perspectives of oil prices are considered, via the OP_t^+ and OP_t^- to investigate the impact of oil price behavior on the output performance of the AOECs. These perspectives are presented in figure 5.2, showing the graphical demonstration of various oil price shocks' behavior. In this distinction, positive oil price shocks are referred to as a rise in oil prices as shown above line zero (0) in figure 5.2 and negative oil prices are referred to as a fall in oil prices as shown below line zero (0).

Figure 5.2: Oil Price Shocks (Positive and Negative)



***Source**: Author's computation (2020), using data sourced from the WDI.*

The following section presents the results of the PVAR model. The study focuses on the relationship between various oil price shocks and output. Therefore, it tracks the dynamic paths of oil prices and how they impact on output over time. In this regard, the study relies on the IRFs obtained from the VAR technique, since it treats all the variables as endogenous. Sims (1980) introduced impulse response function analysis in the VAR estimating technique. The technique highlights the state of an economic system in the future if variation occurs in any of its components. This procedure provides an answer to the question of how the future of a system is affected by variation in one of its variables. The impulse response technique helps to trace the time path response of the current and future values of each variable to a one-unit increase in the current value of one of the VAR innovations (see Amisano and Giannini, 1997; Stock and Watson, 2001). Bernanke and Mihov (1998) confirm that the impulse response technique provides a quantitative measure of the reaction of each variable to shocks in the differential equations of the system. In addition, the impulse response generates the expected future path of variables following particular shocks. It is also interesting to determine how important particular shocks are in explaining fluctuations of variables in the PVAR system, which is achieved through variance decomposition. Given these objectives, we decided to rely on an atheoretical PVAR model, rather than a regression-based panel data approach, which was likely to be more grounded in theory but would come at the cost of its inability to track the dynamics of output over time, following oil price shocks. We distinguish between positive and negative oil price shocks which are respectively captured by the positive and negative values of oil price changes.

To order the variables used in our model, the study follows Demary (2010) and Musso, Neri and Stracca's (2011) studies that address the wealth effect in time-series based VAR models for individual countries. According to these studies, the VAR approach is essentially an atheoretical one, and hence, proper identification of the structural shocks is a field of on-going research in time-series econometrics. Therefore, the possible shocks in the system are identified based on slow (ordered before) and fast-moving (ordered after) variables relative to specific shocks.

5.4.7 Impulse Response Functions Analyses

Sims (1980) pioneered the application of the impulse response function technique (IRFT) in VAR modeling, to demonstrate the position of an economic system in the future when a variation occurs in a component of the system. The IRFT answers the question: How is the future of a system affected by a change in one of its variables? It thus shows the extent to which variables of the VAR system react to one another at a time.

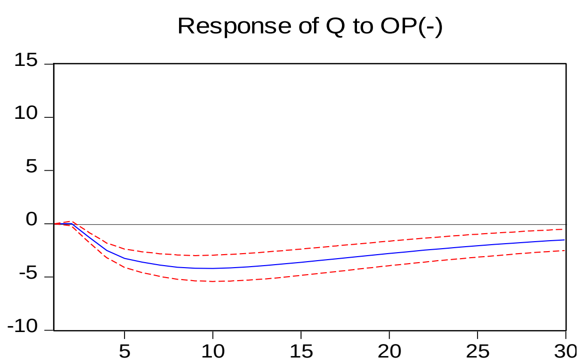
Given that the impulse response function accounts for the extent to which the endogenous (dependent) variables react to one another as variations occur over time, the study constructs impulse responses for all the variables considered in the model. This allows us to recognize how the economy reacts to various oil price shocks. For suitable analysis to be achieved, the IRFs analyses are divided into a thirty-period horizon, as shown on the horizontal axis (see figures 5.3 and 5.4). This is done to highlight the economy's response to the various oil price shocks. Since the stability of the VAR framework has been achieved, this study examines the economic system of the AOECs' impulse response to various oil price shocks (i.e., negative and positive oil price shocks) via output, exchange rates, and inflation rate. In the impulse responses depicted in figures 5.3 and 5.4, the x-axis represents the periods that the analysis covers. Generally, the unit root results of these macroeconomic variables reveal that the variables are stationary (see tables 5.2a and 5.2b for details).

5.4.7.1 *Impulse responses of output and other selected macroeconomic variables to negative oil price shocks*

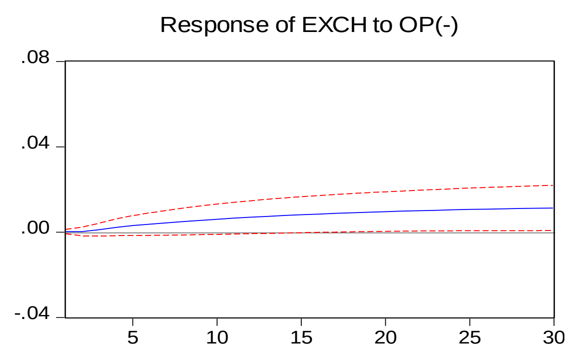
The key focus of this study is to analyze how various oil price shocks impact output, with the aim of establishing whether or not there is an asymmetric relationship. The response of each variable to negative oil price shocks is analyzed. Figure 5.3 depicts the impulse responses of output, exchange rates, and inflation to a one percent standard deviation in negative oil price shocks, as dictated by the international oil market, covering thirty periods. More specifically, the impulse response in figure 5.3(a) captures output's responses to negative oil prices during the periods under investigation. Output is negative and significant in explaining the impact of negative oil price shocks. One standard deviation in negative oil price shocks leads to a negative response in output. Following the negative oil price shocks' behavior, it is evident that output continuously declines from the beginning through period five to nine and bottoms at period ten. As it proceeds into future periods, it begins to rise until period thirty. This suggests recovery or improved output among the AOECs and also implies that negative oil price shocks may not necessarily dictate a continuous fall in output over time.

Figure 5.3: Responses of Output to Negative Oil Price, Exchange Rates to Negative Oil Priceand Inflation Rates to Negative Oil Price

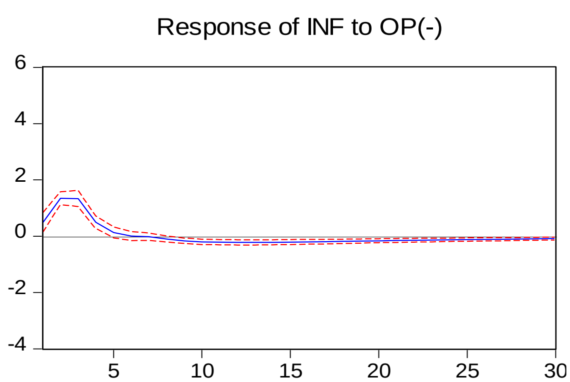
(a)



(b)



(c)



where Q is output, INF: inflation, EXCH: Exchange Rates and OP(-): Negative Oil Price

***Source**: Author's computation (2020), using data sourced from the WDI.*

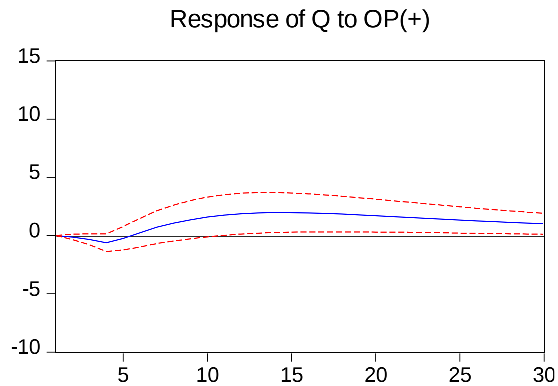
The attendant impact of a one percent variation in negative oil price shocks is also reflected in a positive and significant reaction in exchange rates from periods fifteen to thirty. Prior to this, the exchange rates trend is positive but not significant, suggesting that the impact of negative oil price shocks is not felt instantaneously in exchange rates variations. Furthermore, the response shows that unanticipated negative oil price shocks from the external environment reduce the value of the domestic currency, as more units of domestic currency exchange for fewer units of dollars and this situation may relatively persist in the future period. This finding is in line with Kose and Baimaganbetov (2015) and Rafiq *et al*. (2016), who argue that the impact of oil price shocks on the currency of oil-exporting countries leads to currency appreciation or depreciation if the shocks are positive or negative, respectively. Figure 5.3c shows a slight, significant decline in inflation over a relatively long period, specifically from the eighth to the thirtieth period, consequent to a one percent standard deviation in negative oil price shocks. More precisely, inflation rises sharply within periods one and two, peaks in period three and begins to decline continuously from period four as it moves towards period five, bottoming at period ten. It stabilizes steadily and flattens at period ten and continues up until period thirty with a negligible increase. These findings align with our expectations that, negative oil price shocks reduce output and cause a decline in oil revenue (revenue effects). However, external shocks have a spillover impact on economic output. For instance, negative oil price shocks could lead to a fall in production arising from an increase in the prices of production factor inputs. Following Di Giovanni and Shambaugh (2008) who assert that various economies are affected by external conditions, this is reflected in inflation that initially trends upward within the first three periods and later declines significantly until period thirty.

5.4.7.2 ***Impulse responses of output and other selected macroeconomic variables to positive oil price shocks***

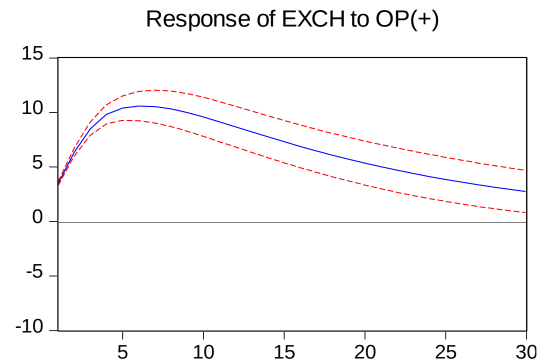
Figure 5.4 presents the impulse responses of output and other macroeconomic variables to a one percent standard deviation in positive oil price shocks. More specifically, figure 5.4(a) shows that positive oil price shocks reduce output in periods one and three, bottoming out in period four. Thereafter, they become positive and significant, rising over a relatively long period and peaking at about period fifteen. Output responds positively to one standard deviation in positive oil price shocks. This may result in a rise in oil proceeds accruing to domestic oil-exporting economies and may consequently lead to domestic currency appreciation. This finding is in line with theory and also supports the findings of Rafiq *et al*. (2016) and Iwayemi and Fowowe (2011) who report a positive relationship between output and one standard deviation in positive oil price shocks. Despite this observed similarity, there is a slight difference in output behavior in response to positive oil price shocks. For example, this study finds a positive and significantly prolonged rise in output among the AOECs.

Figure 5.4: Responses of Output to Positive Oil Price, Exchange Rates to Positive Oil Priceand Inflation Rates to Positive Oil Price

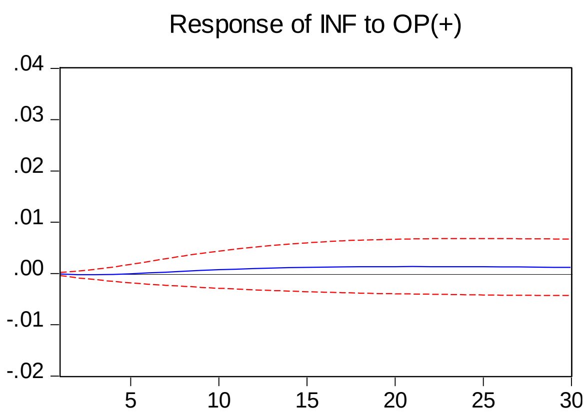
(a)



(b)



(c)



Source*: Author's computation (2020), using data sourced from the WDI.*

The impulse responses of exchange rates to a one percent standard deviation in positive oil price shocks are presented in figure 5.4(b) that shows that exchange rates rise, peaking in the fourth period and begin to decline significantly and continuously as it moves to period thirty. This suggests appreciation in the domestic currency of the AOECs, as less of their domestic currency will be required in exchange for foreign currencies. This is in line with the literature and the standard theory of exchange rate determination, suggesting that, positive oil price shocks cause the value of the currency of an oil-exporting country to appreciate and vice versa. As demand for its currency increases in the foreign exchange market, the value of domestic currency appreciates. In contrast to negative oil price shocks, the inflation rate depicted in figure 5.3(c) does not significantly respond to one standard deviation in positive oil price shocks. This suggests that positive oil price shocks may not necessarily trigger inflation in the AOECs.

5.4.8 **Variance Decomposition**

Variance decomposition shows the proportion of shocks to a specific variable that relates to either its own innovations or innovation from other endogenous variables over a specified or forecasted time frame in a given model (see Raghavan and Silvapulle, 2008). Furthermore, variance decomposition accounts for the information about the percentage of movements in a sequence of a given variable due to its own shocks or shocks arising from other variables in a model (see Adarov, 2019). It analyses the relative importance of shocks in explaining changes among the variables in a given model. For the purpose of this study, variance decomposition is used to determine the relative fraction of shocks to variables in our model; basically, to assess the impact of the various oil price shocks on the AOECs' output.

In order to determine the comparative importance of each structural innovation in explaining fluctuations of the variables in our model, tables 5.7-5.9 present variance decompositions for the variables output, exchange rates, and inflation for period thirty. The analyses thus cover a six-year forecast horizon.

Table 5.7 shows that the difference in the number of variations in output specifically ascribed to positive and negative oil price shocks is relatively pronounced compared to inflation and exchange rates. Negative oil price shocks account for more than five times the proportion of the fluctuations in output that positive oil price shocks account for during the periods under examination. The degree of fluctuations associated with negative oil price shocks rose consistently over the period. It is zero percent in the first period, jumps to 6.6 percent, rises steadily through period twenty and peaks at 14.1 percent in period thirty. Similarly, positive oil price shocks gently appreciate within these periods. For example, it starts at 0.31 percent in the sixth period, jumps to 2.2 percent, more than quadruples in period eighteen and peaks at 3.1 percent in period thirty.

Table 5.7 reveals that exchange rates are relatively more influential in accounting for fluctuations in output than inflation.

Table 5.7: **Variance Decomposition of Output**

Period	S.E.	Q	OP^{-}	OP^{+}	EXCH	INF
1	3.471490	100.0000	0.000000	0.000000	0.000000	0.000000
6	21.77491	93.19200	6.646211	0.131175	0.017879	0.012735
12	34.03277	87.27542	11.38841	1.144590	0.181550	0.010027
18	39.61210	84.03319	13.20269	2.267500	0.426801	0.069810
24	42.16138	82.32790	13.90002	2.864421	0.678381	0.229279
30	43.35975	81.31243	14.16148	3.145823	0.916510	0.463755

Source*: Author's Computation (2020), using data sourced from the WDI.*

Comparatively, the results show that negative oil price shocks and exchange rates, respectively account for more fluctuations in output than positive oil prices shocks and inflation rates. On the whole, the fluctuations in output ascribed to positive oil price shocks are greater than those arising from either exchange rates or inflation rates. Similarly, the fluctuations in output that are ascribed to negative oil price shocks exceed those arising from positive oil price shocks, exchange rates and inflation rates. The result reveals that negative oil price shocks, that measure a net fall in oil prices, have the most influence on output behavior. The inference is that, of the two decomposed oil price shocks used to measure the attendant impacts of shocks on output, OP^{-} is higher than OP^{+}. Similarly, the outcome shows that positive and negative oil price shocks are disproportionate, suggesting the existence of asymmetry.

In addition, this finding reveals that negative oil price shocks account for the largest proportion of the fluctuations in output from the beginning to the end of the period. This clearly suggests that caution should be exercised, and appropriate policy measures should be applied to cushion the impact of negative oil price shocks.

Table 5.8 presents the variance decomposition of exchange rates, showing the different contributions of each innovation to exchange rates fluctuations. Exchange rates have been observed to have a large effect on output. As table 5.8 shows, inflation rate shocks have a marginal impact on exchange rates, accounting for less than 0.1 percent of fluctuations in exchange rates in period six, increasing to 1.3 percent in period eighteen and peaking at 3 percent in period thirty. Negative oil price shocks have a somewhat greater impact on exchange rates fluctuations than positive oil price shocks. The table shows that negative oil price shocks account for about 0.02 percent of the fluctuations in exchange rates in the first period. This jumps to 0.82 percent, and rises to 1.24 percent, 1.62 percent, and 1.94 percent at the end of the third, fourth, fifth and sixth periods, respectively. It can thus be concluded that the effect of negative oil price shocks is more pronounced than that of positive oil price shocks that stand at 0.06 percent, 0.02 percent, 0.05 percent, and 0.09 percent at the end of periods six, eighteen and thirty, respectively.

Table 5.8: **Variance Decomposition of Exchange Rates**

Period	**S.E.**	**Q**	OP^{-}	OP^{+}	**EXCH**	**INF**
1	0.014158	0.873938	0.027485	0.008834	99.08974	0.000000
6	0.090328	2.304548	0.359204	0.060999	97.12223	0.153015
12	0.167000	3.530559	0.823751	0.025064	94.97388	0.646748
18	0.226481	4.699531	1.249025	0.026697	92.67757	1.347175
24	0.275300	5.728002	1.623586	0.054779	90.44387	2.149760
30	0.317316	6.576038	1.940153	0.093401	88.38858	3.001827

Source*: Author's Computation (2020), using data sourced from the WDI.*

The results show that, during the period under examination, output increasingly accounts for fluctuations in exchange rates. This is in line with the exchange rates theory that posits that increases in output cause exchange rates to appreciate. It suggests that governments should focus on output enhancing policy to stabilize exchange rates. Table 5.8 also shows that output has a significant effect on exchange rate fluctuations compared with positive and negative oil price shocks, and inflation rates. Furthermore, positive oil price shocks, is directly proportionate to output. Therefore, output increases during positive oil price shocks and vice versa.

Considering the variance decomposition in Table 5.9, the study reveals that positive oil price shocks account for a marginal impact of 0.07 percent on the inflation rate. It rises progressively to 0.06 percent at the end of the twelfth period and at the end of periods eighteen, twenty-four and thirty, positive oil price shocks account for 0.12 percent, 0.15 percent and 0.16 percent of the fluctuations in inflation, respectively.

Table 5.9: **Variance Decomposition of Inflation Rates**

Period	S.E.	Q	OP^{-}	OP^{+}	EXCH	INF
1	0.004283	0.001255	0.007145	0.070211	0.230658	99.69073
6	0.032102	0.013164	0.070212	0.017710	0.399657	99.49926
12	0.066706	0.116352	0.121356	0.065540	0.585704	99.11105
18	0.096033	0.297678	0.118513	0.125580	0.733111	98.72512
24	0.119652	0.520491	0.099052	0.154753	0.850107	98.37560
30	0.138463	0.758024	0.079717	0.163500	0.947730	98.05103

Source*: Author's Computation (2020), using data sourced from the WDI.*

In contrast, negative oil price shocks' impact on the inflation rate changes within the first ten periods, peaks at the end of period twelve and continuously declines to 0.07 percent at period thirty. The implication is that negative oil price shocks might result in an unstable inflation rate in AOECs. Shocks to exchange rates largely account for fluctuations in inflation from period one through to period thirty. For example, exchange rates account for 0.23 percent of the fluctuations in inflation in the first period. They account for 0.03 percent of fluctuations in inflation after six periods and 0.58 percent after twelve periods, peaking at 0.94 percent in period thirteen. Output shocks account for a negligible 0.01 percent of the fluctuations in inflation after the sixth period, 0.11 percent after twelve periods and progressively rise to 0.75 percent after period thirty.

5.5 Discussion and Inferences

The primary objective of this study is to establish the existence of asymmetry in the various oil price shocks in AOECs. Its findings may thus lead to vital conclusions in the debate concerning oil price asymmetry. As discussed earlier, there are several views in the literature on oil price shocks and output asymmetry. Furthermore, oil price shocks might not exclusively capture the impact oil price movements have on the output performance of AOECs. Therefore, this study's findings contribute to knowledge and the debate relating to oil price shocks' behavior and AOECs' output performance.

Firstly, the study finds evidence to support Rafiq *et al.*'s (2016) conclusion that the relationship between oil price shocks and output is asymmetric, implying that output performance is different when positive oil price shocks are used, compared with when negative oil price shocks are employed. This is also evident from the impulse response analyses results (see figures 5.3a and 5.4a). As indicated, positive oil price shocks clearly present a disproportionate pattern from negative oil price shocks. Consequently, output performance responds to various oil price shocks in a disproportionate way. In addition, the study presents evidence that increased uncertainty with regard to variations in oil prices is associated with lower output. The generalized impulse response function shows the asymmetric effects of positive and negative oil price shocks on output performance. The IRFs reveal that the effect of positive oil price shocks on output over time differs in size and persistence from that of negative oil price shocks (bad news). This further assists in explaining the asymmetric response of output performance to oil price shocks.

Secondly, the study's findings offer a contrary opinion to the earlier claim that positive oil price shocks may trigger inflation (see figure 5.4b). This suggests that positive oil price shocks might not account for inflation, but changes in other factors may lead to inflation. Inflation responds negatively to negative oil price shocks and is significant. This is in line with theory and earlier studies on oil-producing economies (see Olomola and Adejumo, 2011). Based on this premise, it can be asserted that positive oil prices have not accounted for inflation.

5.6 **Summary and Conclusions**

This study employs a comprehensive cross-country dataset to examine the impact of oil price shocks and its asymmetry on output performance in AOECs. Previous studies on the relationship between oil price shocks and the macroeconomy focused on how oil price uncertainty affected output in developed oil-importing countries but neglected the asymmetric relationship between oil price shocks and economic activities (see Elder and Serletis, 2008). This study specifically examines this relationship using decomposed oil price shocks and output in the AOECs. It relies on a panel VAR model to study this relationship which allows us to account for impulse-response analysis to examine the effects of oil price shocks on output. In addition, through the panel VAR technique, variance decomposition is performed to assess the importance of those effects and guidelines are offered for policy formation. The study, which focuses specifically on the asymmetric effects of oil shocks by testing for the different effects of positive and negative shocks on output, holds that positive and negative oil price shocks generate asymmetric and heterogeneous effects on output across the AOECs.

Furthermore, the study finds that, on average, positive oil price shocks positively impact output and this effect remains significant for more than fifteen periods. The reverse is observed with regard to negative oil price shocks. Negative oil price shocks result in a fall in output. This implies that revenue from output will also fall. In terms of magnitude, the study finds that negative oil price shocks impact output more than positive oil price shocks. For instance, fourteen percent of the fluctuations in output are associated with a change in negative oil price shocks, while only a three percent change in output is explained by a change in positive oil price shocks. This finding validates the claim that the relationship between oil price shocks and output is asymmetric. In addition, the results offer additional support for the institutional view of output performance that, with lower negative oil price shocks, output could be enhanced. Similar to output, fluctuations in exchange rates arising from negative oil price shocks are higher than those ascribed to positive oil price shocks. This suggests that the AOECs are more affected by negative oil price shocks than positive oil price shocks. The net impact of positive and negative oil price shocks on output in the AOECs may therefore be unfavourable. Since this study established that the AOECs rely on proceeds from oil, and that, many of these countries rely on importation of refined oil due to their weak refinery capacity to meet local consumption, they need to mitigate against negative oil price shocks which may have serious consequences for their economies, and cause a decrease in oil revenue.

The findings reveal the prevalence of Dutch Disease[28] among the AOECs that is evident in the effects of negative oil price shocks on both output and exchange rates. The attendant effect of this phenomenon on the AOECs' tradable sectors is that it affects the domestic factors' prices, thus, squeezing out the tradable sector, portending further negative consequences for their macroeconomic performance. Previous studies agree that higher oil prices bring in extensive capital which may result in higher investment in physical and human capital in oil-exporting countries. On the other hand, a windfall from oil could lead to exchange rates appreciation and deindustrialization which are detrimental to growth. Therefore, negative oil price shocks would also lead to investment projects undertaken during the oil boom being put on ice and stagnation in economic activities, a monetized budget deficit, and inflation.

[28] Dutch Disease is a situation where a rise in oil revenue does not result in increased domestic growth.

In view of this, policies need to be formulated to minimize the impact of oil price shocks on output, especially negative oil price shocks which have been found to adversely affect oil revenue (e.g., policies aimed at strengthening economic activities through diversification, so as to enhance the export mix). This will reduce the AOECs' on-going reliance on large revenues from oil arising from positive oil price shocks which the literature argues has had a negative and retarding impact on the economy, mainly because it affects the non-oil sector. Therefore, it is recommended that governments should provide public goods to support diversification.

It would also be beneficial for the AOECs to adopt economic stabilization policies that could reduce the level of risk attached to oil price shocks. This could include a more flexible exchange rates policy, which, to a reasonable degree, would increase the extent to which the economy can make the necessary adjustments without hindering output growth in the long run. In addition, a counter-cyclical fiscal policy is recommended. This aims to reduce spending and raise taxes during a boom, and increase spending and cut taxes during a recession to improve output and exchange rates. It could also mitigate the effects of oil price shocks on the economies of the AOECs via active management of the government budget over the business cycles. This approach will demand that funds are reserved and a mechanism instituted through which assets are accumulated during oil booms and drawn during busts. This serves as a cushion fund that government can rely on without having to secure external borrowing to finance domestic investment. While it is noted that developed oil-exporting and oil-importing countries have some type of oil reserve fund and other internal mechanisms to stabilize their economies during unfavourable oil price shocks or in case of any uncertainties, the reverse is the case for most developing oil-exporting countries. This scenario is still somewhat new to them, and they confront challenges like corruption, accountability, governance, transparency, insecurity, inequality, and high mortality rates.

It is also recommended that oil proceeds, windfalls and excess crude oil revenue are transformed into physical amenities and capital instead of being redistributed to municipal and regional governments that may not use it prudently to finance productive ventures. Funding business support projects will go a long way in encouraging production of additional tradable goods for export, and will strengthen the industrial base of the economy, and increase output. In addition, since oil resources are characterized as a generational resource, it is recommended that tax policy is introduced to transform today's oil revenue into social infrastructure and physical capital that will benefit future generations.

In conclusion and for the purpose of further research, the optimal size and management of oil proceeds within the oil-exporting regions are vital and this may be an interesting area for future research. On the whole, governance of the AOECs should always be proactive and provide public goods without having to rely on revenue from oil .

While our data sample for the countries under consideration is assumed adequate, a larger sample size, and more high-frequency variables, especially for the estimation of the panel VAR model, would be more appropriate. This is due to the fact that the assumption underlying the identification of the VAR model, where the data is on a quarterly or annual basis, could be too strong, because variables do not contemporaneously respond (within one year) to changes in other variables. Hence, data on monthly or daily frequency might offer more reliable results. Unfortunately, monthly and weekly data on national income accounts are unavailable for the countries included in our sample. The Mixed Data Sampling (MIDAS) estimating technique is recommended to handle this problem in further research.

Finally, it is recommended that future studies focus on oil revenue shocks rather than oil price shocks which might confound demand and supply shocks. This will offer opportunities to discern the nature of oil price shocks which could be an interesting subject for investigation.

CHAPTER 6

SUMMARY, CONCLUSIONS, RECOMMENDATIONS AND AREAS FOR FURTHER RESEARCH

6.1 Summary and Conclusions

This study examined three distinct but interrelated topics relating to the energy-macroeconomic behavior of AOECs (Algeria, Egypt, Gabon, Libya, and Nigeria), for the period spanning 1980-2018. The study consisted of six chapters, classified into three sections. The first section comprised Chapters One and Two, which presented the motivation and justification for the study that aimed to understand oil price shocks and the macroeconomy of the AOECs. The second section comprised of Chapters Three, Four and Five. In Chapter Three, the study employed the PSVAR estimating technique with short-run restrictions to examine the oil price shocks transmission mechanism in AOECs. Using quarterly data for the period spanning 1980 to 2018, it emphasized the interrelationship among domestic macroeconomic variables and the oil price which was treated as an exogenous variable to establish the countries' transmission process. Within the same framework, the study examined the trend of output growth and oil prices and established that oil price shocks have statistically significant impacts on output and exchange rates in AOECs. While positive oil price shocks increase output, negative oil price shocks lead to a fall in output. The study demonstrated that exchange rates contain additional information that is vital in the transmission mechanism of oil price shocks. This finding validates earlier studies which conclude that positive oil price shocks lead to exchange rates appreciation and vice versa in oil-exporting countries. It is contrary to the conclusion reached by previous studies that increases in oil prices may not trigger inflation in oil-exporting countries. The study revealed that an increase in oil prices results in increased inflation. This finding is associated with the AOECs' inadequate refining capacity that means that refined oil has to be imported at a high cost, increasing the cost of production. Consequently, an increase in inflation arising from an increase in oil prices may lead to increased unemployment because possible job opportunities associated with the refining process would have been forfeited to countries that are active in oil refining.

The study also examined how oil price shocks impact macroeconomic variables and how these shocks spread to other prices over time. This leads to variations in the overall price level within the economy. The attendant effect of positive oil price shocks on GDP is reflected in a positive and significant response in output. This implies that an unanticipated change from the external milieu increases the AOECs' output over time. Furthermore, it was found that positive oil price shocks lead to exchange rates appreciation which has a significant impact on GDP, money supply and interest rates. This supports the claim that exchange rates serve as a transmission medium through which oil price shocks impact the macroeconomic behavior of the AOECs.

Chapter Four focused on the study's second objective. An ARDL model was developed using domestic macroeconomic time-series data from the AOECs in addition to international oil prices. The model incorporates dynamic and static forecasts of exchange rates. This is motivated against the background that dynamic and static exchange rates forecasts include sample and out-of-sample forecast models.

Using four evaluation criteria, namely, Mean Absolute Error (MAE), Root Mean Square Error (RMSE), Theil coefficient and Mean Absolute Percentage Error (MAPE) to evaluate the accuracy of the dynamic and static forecasts, the study demonstrates that the selected macroeconomic variables (money supply, interest rates, GDP, oil price, inflation rates and debt) are appropriate to forecast exchange rates. The RMSE, MAE, MAPE and Theil coefficients that are commonly used as measures for error magnitude demonstrate that the exchange rates forecasting model is accurate and appropriate (Baumeister and Kilian, 2014; Beneki and Yarmohammadi, 2014). Furthermore, this finding suggests that forecast combination methods may have good application in the field of exchange rates modelling and also forms the basis to conclude that a combination of the static and dynamic exchange forecasting models may offer better performance than a single exchange rates forecasting model.

A fundamental aim of this study is to confirm whether oil price shocks forecast exchange rates. Our findings reveal that, except for Libya, oil prices are statistically significant to forecast exchange rates in AOECs. Therefore, we conclude that oil price shocks have distinct significance in the currency exchange rates framework in the AOECs. Furthermore, oil prices perform significantly in the frontier markets exchange rates series. Another important finding is that the ARDL model generates superior exchange rates forecasts. Therefore, the incorporated dynamic forecasting and static models appear to forecast exchange rates appropriately. This may offer a better outcome than the classical exchange rates model and the naïve random walk model critiqued in Clarida *et al.* (2003).

Chapter Five focused on the study's third objective. Employing the PVAR model, it investigates the asymmetric relationship between output and oil price shocks in AOECs. Using quarterly data from 1980 to 2018, the study decomposes oil prices into positive and negative. Within the same framework, it examines output's response to variations in the decomposed oil prices.

The study finds that the relationship between oil price shocks and output is asymmetric. This implies that output performance responds differently to variations in positive oil price shocks when compared with negative oil price shocks. For instance, while positive oil price accounts for 0.13 percent of the variation in output in period six, negative oil price accounts for 6.6 percent (see Table 5.7). Similarly, in period thirty, positive oil price accounts for 3.1 percent of the variation in output, while negative oil price accounts for 14.1 percent, about four times the variation associated with a positive oil price. Buttressing this claim, figures 5.3a and 5.4a reveal that positive oil price shocks present a different pattern from negative oil price shocks. Consequently, output performance responds to various oil price shocks disproportionately. Furthermore, the study finds that, on average, positive oil price shocks positively impact output and this effect remains significant for more than fifteen periods. The reverse is observed with negative oil price shocks, which result in a fall in output. This implies that revenue from output will also fall. In terms of magnitude, the study finds that negative oil price shocks impact output more than positive oil price shocks.

The study also finds that low output in AOECs is associated with uncertain variations in oil prices. The generalized impulse response function shows the asymmetric effects of positive and negative shocks on output performance. Thus, the IRFs reveal that the effect of positive oil price shocks on output over time differs in size and persistence from that of negative oil price shocks. This assists in further explaining the asymmetric response of output performance to oil price shocks.

The study shows strong evidence that inflation in AOECs responds positively to positive oil price shocks. This suggests that positive oil price shocks significantly account for a rise in inflation. Similarly, inflation rates respond significantly negatively to negative oil price shocks. This is in line with theory and earlier studies on oil-producing economies (see Olomola and Adejumo, 2011).

However, certain macroeconomic variables in our model, including output and exchange rates have a statistically significant asymmetric response to oil price shocks. Therefore, this study establishes that AOECs' economies are vulnerable to negative oil price shocks that affect exchange rates negatively, and positive oil price shocks that positively affect the cost of production.

In summary, this study concludes that oil price shocks play a significant role in influencing economic activity in the AOECs.

6.2 **Recommendations**

The study found that positive oil price shocks trigger inflation. Since it is established that AOECs rely on importation of refined oil due to their weak refining capacity to meet local consumption, it is recommended that these countries should mitigate against positive oil price shocks which may have serious consequences for their price level. In addition, the AOECs should pursue forward growth integration that will enable them to improve oil refining to boost refined oil output. Other associated end products from crude oil would serve as another source of income.

Although previous studies agree that higher oil prices bring extensive capital into oil-producing countries, leading to higher investment in physical and human capital, oil windfalls could lead to exchange rates appreciation and deindustrialization which are detrimental to economic growth. Negative oil price shocks would retard investment projects undertaken during an oil boom and stagnation in economic activities, a monetized budget deficit, and inflation in the economy. To overcome this, it is recommended that these countries should strengthen economic activities through diversification to enhance the export mix, especially when negative oil price shocks adversely affect oil revenue. This will reduce shocks that may arise from continuous reliance on revenue from oil. Governments should also provide public goods to support diversification. Reliance on oil proceeds as forecast in the preparation of annual budgets could result in budget deficits, especially during periods of severe oil revenue uncertainty.

Diversification is also believed to reduce dependence on oil and mono-economic practice; promote investment opportunities in tradable and non-tradable sectors of the economy; and encourage exports of non-oil goods. This policy option will also assist in reducing the economy's vulnerability to oil price shocks, especially when it is unfavourable. It would go a long way in reducing the economy's reliance on oil proceeds

It is also recommended that the AOECs should introduce economic stabilization policies that could help to reduce the level of risk relating to oil price shocks. This may include a more flexible exchange rates policy, which to a reasonable degree, would increase the extent to which the economy can make the necessary adjustments without negatively impacting output. In addition, a counter-cyclical fiscal policy that reduces spending and raises taxes during a boom, and increases spending and cuts taxes during a recession to improve output and stabilize exchange rates is recommended. This may also mitigate the effects of oil price shocks on the economic activities of the AOECs via active management of the government budget over the business cycles. To actualize this, funds and assets accumulated during the oil boom would have to be reserved, and a mechanism instituted through which the reserves and accumulated assets would be applied to lessen the burden on oil revenue. This would serve as a cushion fund that the government can rely on as an internal mechanism to stabilize the economy during unfavourable oil price shocks or in the case of any uncertainties without having to secure external borrowing to finance domestic expenditure.

It is also recommended that oil proceeds, windfalls and excess crude oil revenue are transformed into physical amenities and capital instead of being redistributed to municipal and regional governments that may not use these funds prudently to finance productive ventures. Funding business support projects will go a long way in encouraging the production of additional tradable goods for export, strengthening the industrial base of the economy, increasing output and consequently, stabilizing exchange rates. Accordingly, governments of AOECs will need to be cognizant of oil price fluctuations when pursuing their objectives of promoting employment and economic growth. That is, they should understand that positive oil price shocks trigger inflation which may cause an increase in unemployment rates.

6.3 **Areas for Further Research**

There is need for on-going research on oil price shocks and macroeconomic behavior. Arising from this study, possible areas for further research include profitable management of oil proceeds within the oil-exporting regions, which may include expenditure on building refineries.

While our data sample for the countries under consideration is assumed adequate for the current study, a larger sample size, and higher frequency data, especially for the estimation of the panel VAR model, would be more appropriate. This is due to the assumption underlying the identification of the VAR model when the data is quarterly or annual. Unlike quarterly and other high frequency data, it is assumed that variables may not contemporaneously respond, within one year, to changes in some other variables. Furthermore, variables on a monthly, weekly or even daily frequency are believed to offer more reliable results than their annual counterparts because high-frequency variables reveal dynamic changes in the variables. Unfortunately, monthly, weekly and daily data on national income accounts are unavailable for the countries included in our sample. To overcome this shortcoming, future research might consider the Mixed Data Sampling (MIDAS) framework proposed by Ghysels, Santa-Clara and Valkanov (2006) and used in Clements and Galvao (2008). This method is found suitable for forecast models without bias to data frequency, especially when the study aims to estimate and forecast a small number of hyper-parameters relative to a sampling rate of higher-frequency variables (see Ghysels, Santa-Clara and Valkanov, 2006; Clements and Galvao, 2008).

Since the study is cross-sectional in nature, it may also be interesting to capture vital monetary variables such as Federal Fund Rates (FFR) that could not be considered in the PSVAR estimating technique employed in this study. The FFR may offer a guide on how global monetary policy may impact the AOECs. More reliable results could be obtained if a study were to consider this monetary variable using an estimating technique like the Factor-Augmented Vector Autoregressive (FAVAR)[29] methodology proposed by Bernanke *et al.* (2004), which can accommodate more variables without necessarily running out of degrees of freedom.

[29] The FAVAR is believed to improve on the traditional PSVAR method by accommodating additional variables without having to entertain the danger of compromising the degrees of freedom.

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Appendices

A-0: Lag Length Selection

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-7261.863	NA	0.355622	18.83125	18.87341	18.84747
1	3541.083	21382.00	2.83e-13	-9.028712	-8.691480	-8.898945
2	4173.322	1239.910	6.24e-14	-10.53969	-9.521955	-9.848535
3	4187.446	27.44343	6.83e-14	-10.44934	-9.907385*	-10.09248
4	4216.176	55.30109	7.20e-14	-10.39683	-9.174363	-9.926425
5	4291.912	144.4076	6.72e-14	-10.46609	-8.948548	-9.882142
6	4371.768	81.64722*	6.21e-14*	-10.54603*	-8.733409	-10.29638*
7	4388.452	31.20686	6.75e-14	-10.46231	-8.354611	-9.651269
8	4432.530	150.8171	6.84e-14	-10.44956	-8.046782	-9.524972

A-1: Serial Correlation

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	0.028044	Prob. F(3,132)	0.9936
Obs*R-squared	0.096819	Prob. Chi-Square(3)	0.9922

A-2: Hetereoschedasticity

Heteroskedasticity Test: Breusch-Pagan-Godfrey

F-statistic	0.890128	Prob. F(16,135)	0.5817
Obs*R-squared	14.50524	Prob. Chi-Square(16)	0.5611
Scaled explained SS	32.22269	Prob. Chi-Square(16)	0.0094

A-3: Granger Causality

Null Hypothesis:	Obs	F-Statistic	Prob.
INT does not Granger Cause INF	153	0.80534	0.4928
INF does not Granger Cause INT		7.28007	0.0001
LEXR does not Granger Cause INF	153	2.30973	0.0788
INF does not Granger Cause LEXR		1.10620	0.3487
LMS does not Granger Cause INF	153	0.71901	0.5422
INF does not Granger Cause LMS		1.35114	0.2602
LNGDP does not Granger Cause INF	153	1.72660	0.1641
INF does not Granger Cause LNGDP		2.05806	0.1084
LOP does not Granger Cause INF	153	0.08777	0.9667
INF does not Granger Cause LOP		2.08639	0.1046
UNE does not Granger Cause INF	153	3.07374	0.0297

INF does not Granger Cause UNE		0.34757	0.7910
LEXR does not Granger Cause INT	153	3.25369	0.0235
INT does not Granger Cause LEXR		0.07469	0.9735
LMS does not Granger Cause INT	153	2.80422	0.0419
INT does not Granger Cause LMS		0.45960	0.7109
LNGDP does not Granger Cause INT	153	1.90606	0.1312
INT does not Granger Cause LNGDP		1.96604	0.1217
LOP does not Granger Cause INT	153	0.95822	0.4143
INT does not Granger Cause LOP		5.51653	0.0013
UNE does not Granger Cause INT	153	6.38162	0.0004
INT does not Granger Cause UNE		0.33875	0.7973
LMS does not Granger Cause LEXR	153	0.96944	0.4090
LEXR does not Granger Cause LMS		1.25246	0.2930
LNGDP does not Granger Cause LEXR	153	1.90284	0.1317
LEXR does not Granger Cause LNGDP		0.65203	0.5829
LOP does not Granger Cause LEXR	153	0.18935	0.9035
LEXR does not Granger Cause LOP		1.37418	0.2530
UNE does not Granger Cause LEXR	153	0.47967	0.6969
LEXR does not Granger Cause UNE		0.78792	0.5025
LNGDP does not Granger Cause LMS	153	0.27982	0.8399
LMS does not Granger Cause LNGDP		1.98355	0.1190
LOP does not Granger Cause LMS	153	0.27786	0.8413
LMS does not Granger Cause LOP		2.87651	0.0382
UNE does not Granger Cause LMS	153	0.59140	0.6216
LMS does not Granger Cause UNE		0.03660	0.9906
LOP does not Granger Cause LNGDP	153	0.18872	0.9039
LNGDP does not Granger Cause LOP		3.75744	0.0123
UNE does not Granger Cause LNGDP	153	1.81840	0.1464
LNGDP does not Granger Cause UNE		0.49451	0.6866
UNE does not Granger Cause LOP	153	0.80570	0.4926
LOP does not Granger Cause UNE		0.33840	0.7976