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**Towards realisation of stable oil prices: an empirical
analysis of the impact of OPEC's oil price
band/stabilisation policies**

Mas'ud Usman Ibrahim

A thesis submitted in partial fulfilment of the
requirements of the Robert Gordon University,
Aberdeen, Scotland, degree of doctor of philosophy

December 2014

Declaration

I, Mas'ud Usman Ibrahim, hereby declare that this thesis is the product of my own effort and that no portion of it has been submitted for the application of another degree or qualification to another university or institute of learning. I can also confirm that where information from another source has been used in this research, it has been duly acknowledged.

Signed: _____

Date: _____

Mas'ud Usman Ibrahim

Dedication

This research dissertation is dedicated to my parents (Alhaji Abdulmumin Usman and Hajiya Salamatu Usman), my wife (Khadijah Muhammad Abdullahi), and my three lovely daughters (Hafsah Mas'ud Usman, Ruqayyah Mas'ud Usman, and Nafisah Mas'ud Usman) for their patience, support and prayers; and to the Late Muhammad Mustapha Isah (Mamman) who gave me the inspiration to climb the academic ladder and complete a PhD, but alas did not live long enough to witness and celebrate this achievement. May his gentle soul rest in perfect peace, amen!

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List of Abbreviations

ADF	Augmented Dickey-Fuller
BP	British Petroleum
CEC	Council of the European Communities
CEU	Council of the European Union
CFTC	Commodity Futures Trading Commission
EG	External Governance
EIA	Energy Information Administration
EMF	Energy Modelling Forum
ERSO	Elliot-Rthenberg-Stock Point-Optimal
EVT	Extreme Value Theory
FEVD	Forecast Error Variance Decompositions
GARCH	Generalized Autoregressive Conditional Heteroskedasticity
GER	Global Economic Recession
GRI	Global Reporting Initiative
IASB	International Accounting Standards Board
IEA	International Energy Agency
IEF	International Energy Forum
IG	Internal Governance
IMaGeS	Institute for Management, Governance and Society
IOCs	International Oil Companies
IOSC	International Organisation of Securities Commissions
IRF	Impulse Response Function
ISIS	Islamic State of Iraq and Syria
JODI	Joint Organisations Data Initiative
KPSS	Kwiatkowski-Phillips-Schmidt-Shin
LOMC	Logged Values of Oil Market Competition
LOOC	Logged Values of OECD Crude Oil Consumption
LOOS	Logged Values of OECD Crude Oil Stockpiling
LOPC	Logged Values of OPEC Production Cheating
LOPQ	Logged Values of OPEC Production Quota
LOPR	Logged Values of Oil Price
LOSC	Logged Values of OPEC Spare Capacity
MNCs	Multi-national Corporations
NP	Ng-Perron
OECD	Organisation for Economic Co-operation and Development
OLS	Ordinary Least Square
OMC	Oil Market Competition
OOC	OECD/IEA Crude Oil Consumption
OOS	OECD/IEA Crude Oil Stockpiling
OPB	Oil Price Band
OPC	OPEC Production Cheating
OPEC	Organisation of Petroleum Exporting Countries

OPQ	OPEC Production Quota
OPR	Oil Price
OSC	OPEC Spare Capacity
PP	Philips-Perron
SPR	Strategic Petroleum Reserve
STEO	Short Term Energy Outlook
TPZ	Target Price Zone
TZT	Target Zone Theory
U.N.	United Nations
U.S.	United States
VE	Vulnerability and Exploitability
VAR	Vector Autoregressive
VaR	Value at Risk
VD	Variance Decomposition
VECM	Vector Error Correction Models
WAR	War in Iraq
WTI	West Texas Intermediate
WTO	World Trade Organisation

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Abstract

This dissertation contributes to the literature on the role of the Organisation of Petroleum Exporting Countries (OPEC) in (de)stabilising oil prices by identifying and critically investigating a gap in the extant literature with respect to OPEC's actions in the oil markets, vis-à-vis its stabilisation policies. Two research questions were addressed, namely: to what extent could OPEC have stabilised global oil prices within a particular target price band; and to what extent were OPEC's stabilisation policies rendered ineffective by market forces? Consistent with the positivist's research paradigm, unrestricted vector autoregressive (VAR) models were applied to monthly data over the 13 year period 2000-2012 on a range of relevant variables identified from the literature. Granger causality tests, impulse response functions (IRFs) and forecast error variance decompositions (FEVDs) were obtained from the VAR estimates to enable a critical analysis to be undertaken of the complex dynamics at play between OPEC and other key market players.

The major contributions of the study are: it establishes that OPEC failed over the period 2000-2012 to operate as an effective cartel for controlling oil prices; it provides an innovative contribution to research methodology by utilising VAR impulse response functions and forecast error variance decompositions to describe the complex interactions between various players with diverse objectives in the markets; it contributes to the OPEC cartel literature in a novel way; it should enable regulators to better understand the political, social and economic interaction between key players in the oil markets, thereby increasing chances of policy embracement by all parties; it also makes a theoretical contribution by employing a framework based on target (price) zone theory; and finally it establishes that oil price band policy has the potential to be an important element of price stability in the oil market.

CHAPTER ONE: INTRODUCTION

Chapter One Introduction

1.1 Introduction

Volatility of oil prices and its effect on the oil market has been the subject of recent research interest (Kohl, 2002; Regnier, 2007; Al-Qahtani et al., 2008b). Many factors (such as supply-demand fundamental, speculation, geopolitical events, absence of market transparency and governance) have been proffered as causes of this volatility (see Kaufmann et al., 2008, Florini and Sovacool, 2009; Slaibi et al., 2010; Florini and Saleem, 2011; Martina et al., 2011). Perhaps the most frequently cited factor in the literature and Western media is the role played by (OPEC). Indeed, OPEC has been widely vilified as an international cartel of oil producers which coordinates its members' actions towards restricting crude oil production with a view to promoting high oil prices to the detriment of oil consumer nations, notably the Western economies (Simpson, 2008; Hyndman, 2008; Shaffer, 2009; Graefe, 2009; Sovacool, 2011). These allegations against OPEC date back to 1973 when the organisation placed an oil embargo on the U.S. and the Netherlands which led to oil prices quadrupling from \$3 to \$12 per barrel (Kisswani, 2014). No one would dispute the fact that OPEC took decisive action to increase oil prices in the early 1970s which brought an end to what is referred to as "the era of cheap oil" Tsoskounoglou et al. (2008).

The 1973 oil price shock, as it is popularly recognised, not only led to ill feeling against OPEC but also spawned a response from Western nations who, in 1974 established a consumer counter body to OPEC: the International Energy Agency (IEA). In addition to this, the price shock instigated the creation of a strategic petroleum reserve in 1975 by the U.S. as part of energy security measures. A second oil price shock occurred in 1979 following the Iranian revolution, which further increased the political pressure on OPEC as a cartel whose actions led to sharp and sustained high oil prices (see Al-Qahtani et al., 2008a). Furthermore, various energy policy acts were enacted in 1992, 2005, and 2007. Paradoxically, the allegations against OPEC completely contradict the provisions of OPEC's first resolution and official statute, which state that the organisation's responsibility is to promote price stability in the oil markets. Interestingly, a study by Kepplinger and Roth

(1979) concluded that the media created panic in the minds of the public by exaggerating OPEC's actions in order to achieve a predetermined motive. Kilian (2008) and Colgan (2014) partly lent support to the findings of Kepplinger and Roth (1979) by stressing that the crisis and effect of the embargo were mainly overstated. Kilian (2008) argued that production by Saudi Arabia and Kuwait was unusually high in September 1973, and that it would not have been so if the embargo had been effective as exaggerated by the media. However, it can be cogently argued that the impetus for OPEC's action came from what might be construed as an attempt to limit the exploitative harvesting of their oil reserves by the international oil companies (IOCs) (see Chalabi, 2010).

Furthermore, the last one and a half decades since 2000 have witnessed a rather more complex situation in the oil price history (Cifarelli and Paladino, 2010; Lombardi and Robays, 2011). Oil prices in both real and nominal terms exceed those prices in the previous three decades (see figure 1.1). A number of forecasts for low oil prices have not yielded any foreseeable positive results in favour of low international oil prices despite the extraction of shale oil reserves in the U.S.¹ and other parts of the Organisation for Economic Co-operation and Development (OECD) countries. Davidson (2008) noted that oil prices rose fivefold since 2001 to a level over \$130 per barrel in 2008. Part of the change from 2001 to 2005 involved an increase of nearly 103% making the event similar to that of 1970s (Campolmi, 2007). Another development resulting from increased positions in the futures oil market by the financial investment firms was observed to have been consistently growing over the remaining periods (see Cifarelli and Paladino, 2010; Alquist and Gervais, 2011; Lombardi and Robays, 2011). The permission to carry out this type of trading was granted since 1991 by the Commodity Futures Trading Commission (CFTC) to the firms just a year before the U.S. first Energy Policy Act in 1992. Over the last decade, the oil market has witnessed a fresh injection of investment funds totalling billions of dollars. From 2003 to 2008 alone, the financial holding in the futures markets rose from \$13billion to over \$260billion, which raised concerns on the effect this would have on oil

¹ It is important to know that shale revolution in the US has brought down energy prices domestically much lower than the Europe (see Haywood, 2014).

price volatility (Cifarelli and Paladino, 2010). Evidence of increasing speculation in oil markets is well documented in the literature², suggesting that oil prices are very high and volatile due to factors beyond oil market fundamentals. In its early reports in 2008, CFTC denied claims that investors are systematically engaged in promoting high oil prices³. However, new findings emerged suggesting evidence contrary to the earlier conclusions, which made the markets more complex (see Cifarelli and Paladino, 2010). Other international groups such as G20 (Group of 20), Joint Organisations Data Initiative (JODI)⁴ (Joint Organisation Data Initiative) have also acknowledged the effect of speculation in promoting high oil prices. Similarly, Aune et al. (2010) also noted that evidence of change in investment behaviour among the international oil companies was observed towards the end of the 20th century which further raised question about the real impact of OPEC in the price formation over the last decade; a period which coincided with many market developments⁵ (Russell and Ibrahim, 2013).

In this regard, the debate over the real cause of the sustained high oil prices has continued in the literature with a sizeable number of conflicting views about the role of OPEC in the oil market. Two prominent strands of opinion have emerged in this direction. The first strand believes that the imbalance between oil supply and demand (i.e. excess of oil demand over supply) as a result of OPEC operating as a cartel is the major cause for the high oil prices (see Adelman, 2002, Morris and Meiners, 2013). Therefore, this strand, mainly popularised by the Western politicians and media, argues that OPEC deliberately attempts to punish the Western economies by limiting the amount of oil those economies need to satisfy their demand for industrialisation. This has led to OPEC being challenged or sued before international courts or attempts to invoke antitrust laws against the organisation and sometimes calls on U.S. Congress's intervention to force OPEC to act in the Western interest (see Waller, 2002; Doggett, 2008 and

² See Büyüksahin and Robe (2014) for evidence based on both publically available and privileged data.

³ See CFTC Task Force report released on 22/07/2008

⁴ JODI has acknowledged that absence of accurate, reliable, and timely data were responsible for the speculative activities and that collective effort of the relevant stakeholders would make a clear difference in stabilising oil prices (JODI, 2013)

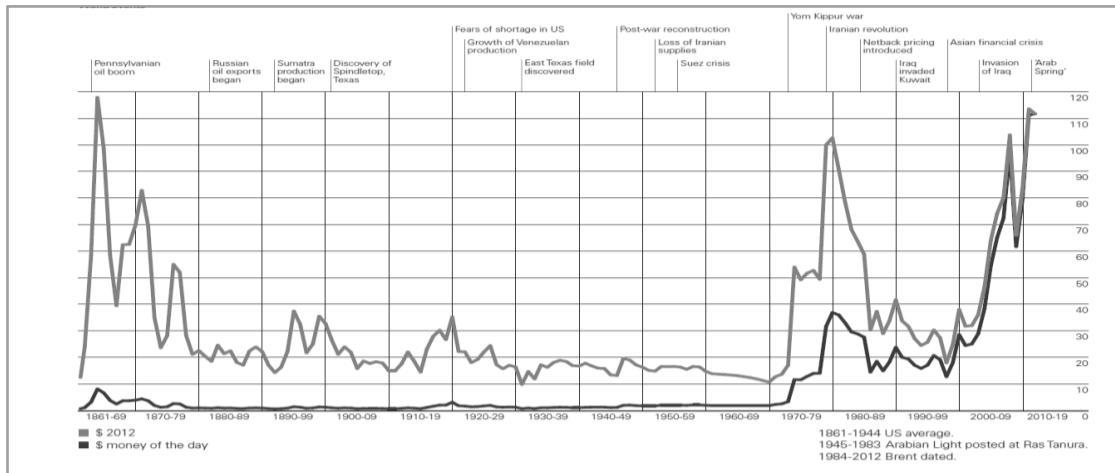
⁵ Some of the market developments include discovery and investments in unconventional energy and renewable sources and sand oil in Canada.

Lautenberg, 2004; Saxton, 2005). For example, Saxton's 2005 report clearly accused OPEC of not only restricting production, but also of absence of transparency and corruption as mentioned below:

"OPEC also aggravates price volatility. It cannot manipulate its rate of output to match changing market conditions precisely and thus causes or magnifies swings in the supply and the price of oil. OPEC conceals important industry information and is not forthright in sharing its output plans and price objectives. Transparency International ranks most OPEC members near the bottom of its worldwide corruption index. Given the capital intensity of oil operations, the cartel's behavior increases risk and uncertainty for non-member investors and slows their market responses."(Saxton, 2005:1)

In contrast, the other strand believes that speculation and geopolitical tensions, and not oil market fundamentals are responsible for the high oil prices observed in the last decade (see Yousefi and Wirjanto, 2004; Bina and Vo, 2007; Chung, 2008; Bina, 2008; Juhasz, 2008; Blas, 2009; Cifarelli and Paladino, 2010; Slaibi et al., 2010). This view is closer to that of OPEC stated in most of its reports. Kaufmann et al. (2009) were of the opinion that although market fundamentals have contributed to the volatility in oil prices, speculation exacerbated the prices above what fundamentals could have achieved. Similarly, Miller and Ratti (2009) examined the long-run dynamics between oil prices and stock prices in six OECD nations using cointegrating and error correcting models in different periods segregated with breaks. The results found strong evidence of a relationship between the stock prices and oil prices over the last decade suggesting evidence of market bubbles. Despite a sizeable review of literature on OPEC and its influence on oil prices, the conclusions still remain mixed (De Santis, 2003; Kaufmann, 2011; and Schmidbauer, and Rösch, 2012).

Figure 1.1: Crude Oil Prices 1861-2012 U.S. Dollars per Barrel and World Events



Source: BP Statistical Review of World Energy June 2013

Figure 1.1 gives an overview of the major historical events that influenced crude oil prices from 1861 to 2012 in both money of the day and 2012 real money terms. Oil prices were stable and low for ninety years prior to the establishment of OPEC in 1960. This is because, prices were mainly constant for the period (i.e.1959 to 1964) given that they were posted in bulletins issued by the IOCs where the nominal price per barrel never exceeded \$2.97 (Ballinger and Dwyer, 2004; Hammad, 2011). They were also comparably stable during the first 12 years of OPEC’s existence. This is consistent with Dvir and Rogoff (2009) who reviewed oil price evolution from 1861 to 2008 by spitting the entire sample periods into sub-periods. The study empirically finds similarities between 1861-1878 and 1972-2008 when industrialisation growth was faced by uncertainty surrounding oil supply in which Texas Railroads and OPEC played important roles as monopolies.

Furthermore, the prices rose dramatically between 1973-1979 due to 1st and 2nd oil price shocks and then steadily declined to relatively low levels in 1986 (due to oil price fall of 1986) through 1998. Prices began to rise towards the end of the 1999. Due to adverse consumer nations’ reaction to such high oil prices, OPEC responded in March 2000 by introducing oil price band (OPB⁶)

⁶ The OPB mechanism was set between \$22 and \$28 per barrel for the OPEC basket price. Beyond the upper limit, the consumption of OPEC oil is likely to be discouraged; and below the lower limit investments by OPEC nations, non-OPEC and IOCs is likely going to be discouraged.

policy aimed at stabilising oil prices within a given target range (Farrell et al., 2001) which is also consistent with the mission statement⁷ of the organisation. Following OPB premature suspension in 2005 due to a number of factors highlighted in OPEC's reports and bulletins (see, for example, OPEC bulletin 09, 2010⁸), volatility in oil prices continued with a sharp rise and decline in oil prices in 2008 as a result of speculation and global economic recession (see Sonnete et al., 2009).

Furthermore, no one will dispute the fact that, despite technological advancements in the renewables and shale energy developments; the costs of renewable and shale extraction remain more expensive when compared with the fossil fuels, most particularly OPEC oil (see, for example, Bull, 2001; Chalabi, 2010). The U.S. shale revolution has reduced energy prices domestically⁹ when its consumption of the OPEC oil has significantly declined¹⁰. Figure 1.2 presents the U.S. shale gas production in billion cubic feet day from 2000 to 2012. Has the international oil price come down in the light of these developments?

The policy was designed to automatically get triggered with increases (cuts) of 500 000 barrels per day should the oil prices exceed (or fall below) the target range for 20 (10) consecutive trading days.

⁷ OPEC's mission statement is *"..to coordinate and unify the petroleum policies of its Member Countries and ensure the stabilization of oil markets in order to secure an efficient, economic and regular supply of petroleum to consumers, a steady income to producers and a fair return on capital for those investing in the petroleum industry"*.

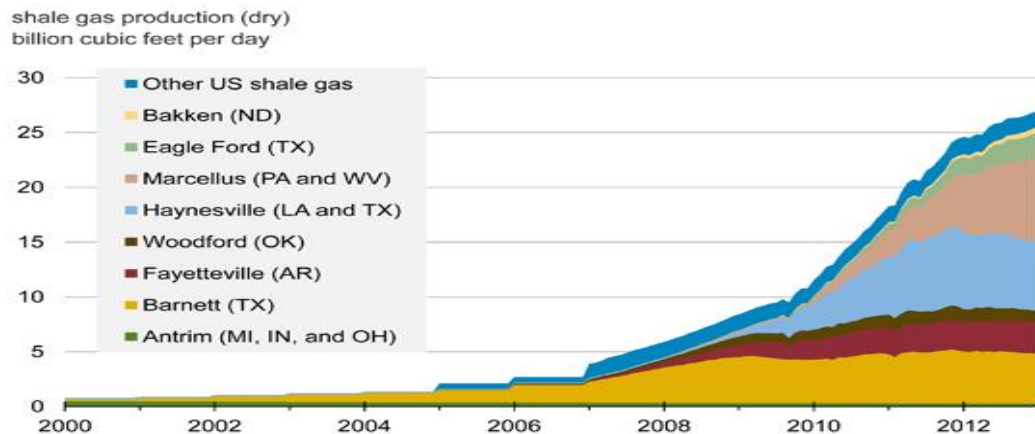
⁸ The information on some of the reasons that led to the suspension of the OPB can be found from the link below:

http://www.opec.org/opec_web/static_files_project/media/downloads/publications/OB092010.pdf

⁹ See Haywood (2014).

¹⁰ The decline in the US oil consumption is shown in figure 3.2 in Chapter 3 of this study.

Figure 1.2: U.S. Shale gas production by play 2000-2012



Sources: LCI Energy Insight gross withdrawal estimates as of January 2013 and converted to dry production estimates with EIA-calculated average gross-to-dry shrinkage factors by state and/or shale play.

Figure 1.2 shows the U.S. shale gas energy production by play from 2000 to 2012. The different components grew dramatically with some of them commencing from zero to a level high. Most of the increase took place during the second half of the total periods.

In the light of the background issues, it can be observed that the literature about the role of OPEC is not conclusive; a position consistent with Brémond et al. (2012). Furthermore, the market developments suggest there is a need for a new perspective with which to study the effectiveness of OPEC stabilisation policies. In response, this research empirically and critically assesses the effectiveness of OPEC's stabilisation policies vis-à-vis changes in the oil prices and the collective actions of other key market players.

1.2 Statement of the Research Problem

In today's world, the term "cartel" is widely considered synonymous with OPEC, most particularly in the allegation for oil price instability (see Adelman, 2002, 2004; Morris and Meiners, 2013); although such allegations run diametrically contrary to the objectives¹¹ claimed by OPEC for establishing the organisation in 1960. This self-assigned responsibility has led OPEC to

¹¹ In its first resolution in 1960, it was clearly defined "...that Members shall study and formulate a system to ensure the stabilisation of prices by, among other means, the regulation of production, with due regard to the interests of the producing and of the consuming nations." Although OPEC was established to coordinate and unify its members' policies towards identifying best means to safeguard their interests, one of the organisation's aspirations is to ensure stability in oil prices.

undertake some actions in addition to adjustments of its members' production quotas in an attempt to achieve oil price stability (Ghouri, 2006). One of these actions is the introduction of the oil price band (OPB) policy introduced in March, 2000 as part of the response to the increasing pressure from the oil consuming nations. In the light of the policy and OPEC commitment to achieve oil price stability, a repeated increase in oil production was observed in the early periods following the policy introduction (Farrell et al., 2001 and Russell and Ibrahim, 2013). Furthermore, in 2001, the Joint Organisations Data Initiative (JODI) was established by six global energy stakeholders under the International Energy Forum (IEF) to enhance and promote data transparency in the markets which was expected to reduce speculation with the sole aim of stabilising oil prices (JODI, 2013). Despite the attempts to stabilise oil prices, figure 1.2 shows that the prices exceeded the target set by OPEC in 2003 shortly following Iraq's invasion. The prices have continued to rise above the upper limit of the band and in February 2005, OPEC made an official withdrawal due to reasons it claimed were beyond its control (Russell and Ibrahim, 2013). Subsequently, prices sharply rose to about \$148 per barrel at the beginning of 2008 for nearly half a year before falling to less than \$40 just a few weeks after July 2008, which had raised further puzzle between the interest groups in the oil markets (Hache and Lantz, 2013).

The debate which has been heating up about the nature of OPEC since the 1973 oil price shock still remains inconclusive (Brémond et al., 2012). This could be partially attributable to the following factors: First, most of the literature on OPEC and oil price has mainly concentrated on the supply-side in modelling the oil market vis-à-vis OPEC's structure (see Benchekroun and Withagen, 2012). By so doing, many of the prominent incentives for the high oil prices originating from the actions of the major oil consumers might remain concealed, making it difficult to figure out the real cause of increased oil prices in the market. Second, most of the important media channels disseminating information to the oil market participants are owned and controlled by the U.S. and evidence showing consolidation of these media channels is still emerging (Chomsky, 2002, CEC, 2007). In the same connection, it has been cogently argued that the U.S. media often engaged in

some analysis based on wrong or misleading figures in the energy sector (see, for example, Koomey et al. 2002; Khadduri, 2005) and conflicting figures in the reporting of OPEC in the international markets (Sornette et al., 2009; Russell and Ibrahim, 2013).

Thirdly, the previous studies have considered the incentives for the actors in the oil market to behave politically in pursuing their economic objectives (Chalabi, 2010; Slaibi et al., 2010; Radetzki, 2012). In this regard, some useful philosophical concepts are crucial in a framework to underpin any complexity (see, for example, Goldthau and Sovacool, 2012 who introduced energy justice as well as other concepts, and Slaibi et al., 2010 who considered the effect of military strategies/activities and politics in achieving economic objectives within the target zone theoretical framework).

In the light of the general background which identifies evidence of lack of consensus about the specific role of OPEC (Brémond et al., 2012) and the market developments (e.g. the role of speculative activities, changes in the balance of power with discoveries in shale and other forms of energy), and the growing accusations against OPEC as a villain in the oil market, there is an emerging question about the specific role of OPEC's stabilisation policies in keeping the oil prices within a target price band given the growing complexities of the oil market. Therefore, this gap needs to be filled for the role of OPEC in the oil market to be established, thereby contributing to the general long debate about whether OPEC is a cartel or not.

1.3 Justifications for and Significance of the Study

It has been established from the preliminary review, and the problem statement that a gap exists in the literature about the actual role of OPEC in the oil market (Brémond et al., 2012), with most reviews concluding that OPEC is the stumbling block in the oil market (Morris and Meiners, 2013). The wide allegations and criticisms against OPEC (mostly by Western politicians and media) have sparked a range of energy policies in the Western nations and proposals for a tight regulatory framework aimed at making OPEC powerless (Lautenberg, 2004; Saxton, 2005). A successful implementation of such actions as proposed by the reports above will not only be detrimental to OPEC but further raises complexities in the structure of oil markets given that

the literature has remained without any consensus to date (see Schmidbauer, and Rösch, 2012). Evidence supporting this inconclusive nature of OPEC's study can be observed in many studies and the type of research questions they addressed. For example, "Does OPEC still exist as a cartel?" (Brémond et al., 2012); "Does OPEC act as a residual producer?" (Bandyopadhyay, 2009); "Does OPEC influence crude oil prices? Testing for co-movements and causality between regional crude oil prices" (Bentzen, 2007); "Does OPEC matter?" (Kaufmann et al., 2004); "Does OPEC Matter After 9/11?" (Demirer and Kutan, 2006).

In view of the development in the oil markets (e.g. shift in the balance of power, new oil discoveries from unconventional and renewable sources, technological advancements), a need arises for a critical review of the role of OPEC in stabilising oil prices within a given target band consistent with its objectives and policies. The issues addressed by this study are of economic importance to both OPEC and non-OPEC policy makers as well as the international agencies responsible for the regulation of the oil markets. Consequently, the study will make a potential contribution to the existing body of literature on the role of OPEC in general and its specific policies in the stability of oil prices. In addition to this, the study will contribute to the literature by enhancing our understanding of the factors that influence oil prices. More than that, it will also connect evidence of perceived demise in the previously powerful position played by OPEC with the factors that led to the high oil prices in the light of the shift in the balance of power from OPEC to non-OPEC producers and the increasing allegations against OPEC. The contribution will be made through.

1.4 Main Research Questions

In the light of the issues raised in sections 1.1 and 1.2, two research questions of interest are identified as follows:

1. To what extent could OPEC have stabilised global oil prices within a particular target price band?
2. To what extent have OPEC's stabilisation policies been obstructed by the actions of other key players in the oil market?

Based on the above research questions the following research aim, and objectives are developed in subsection 1.5.

1.5 Research Aim and Objectives

The main aim of this study is to critically review OPEC's oil price band policy and to analyse the barriers that may have impeded its success. To achieve this aim, the following objectives are developed:

- i. to critically examine the extent to which OPEC's stabilisation policies were/are able to keep oil prices within a given target band; and
- ii. to critically examine the effect of the actions of key market players in obstructing OPEC's ability to stabilise oil prices within a target band.

1.6 Theoretical Framework Introduced

To address the key question raised by this study in section 1.5 two different approaches are adopted to the investigation, namely: assessment of the extent to which OPEC stabilisation policies ensure oil price stability within a given target price band, and also assessing the factors that might obstruct such policies to achieve the desired targets. Therefore, the study focuses on the empirical examination of the effectiveness of OPEC stabilisation policies in stabilising oil prices within a target oil price band and the role of the other market players' actions on OPEC's ability to achieve such a stated objective- which is consistent with its first resolution and mission statement as enshrined in the official OPEC statute. Target price zone theory is employed to underpin this study given its compatibility with the econometric models applied in this research. Some important moral philosophies that are found useful in describing the individuals who make up institutions are also employed in the framework to aid in the interpretation of the results obtained from the analysis in Chapters 6 and 7 of the study.

1.7 Research Methodology Introduced

The study adopts a quantitative approach to the analysis of monthly data for a 13-year period (from 2000 to 2012). The main sources of data were four important and credible databases, namely: OPEC, Energy Information Administration (EIA), International Energy Agency (IEA), and British Petroleum (BP). Unrestricted vector autoregressive (VAR) models were

estimated for two models consistent with the two research questions. VAR models have multivariate forms that can capture the complex dynamics in terms of the association between OPEC's stabilisation policies and interaction of the key market players in the oil market institution. Prior to building the VAR models, a series of tests was considered in an effort towards building BLUE (Best Linear Unbiased Estimates) models. These tests include unit root (parametric and non-parametric – Augmented Dickey Fuller and Philips Perron respectively). Johansen system cointegration tests are also considered to establish the long-run relationships. In view of the sensitivity of the VAR models to the included lag, various lag length selection criteria were evaluated with a view to establishing the optimal lag for the estimation of the VAR. In addition, Granger causality tests were also carried out to explore additional evidence about the nature of the relationships between variables. Finally, some diagnostic tests were applied to avoid any possible misspecifications and enhance the validity of the results.

1.8 Summary and Conclusion

Studies on OPEC have received significant interest since the first oil price shock of 1973. A large proportion of the literature has concluded that OPEC had operated as an effective cartel since the early 1970s (see Morris and Meiners, 2013). However, other studies (for example, Kiswani, 2014) failed to agree with the fact that OPEC had operated as an effective cartel. Brémond et al. (2012) who applied cointegration and panel data approach concluded that OPEC's market power was gradually influenced by the oil pricing system evolution over time indicating that its behaviour is not static and major events have accounted for such changes. Splitting the members into two groups (savers and spenders), they noted that cartel behaviour was applicable in only sub-groups, but OPEC operated in most periods as a price taker.

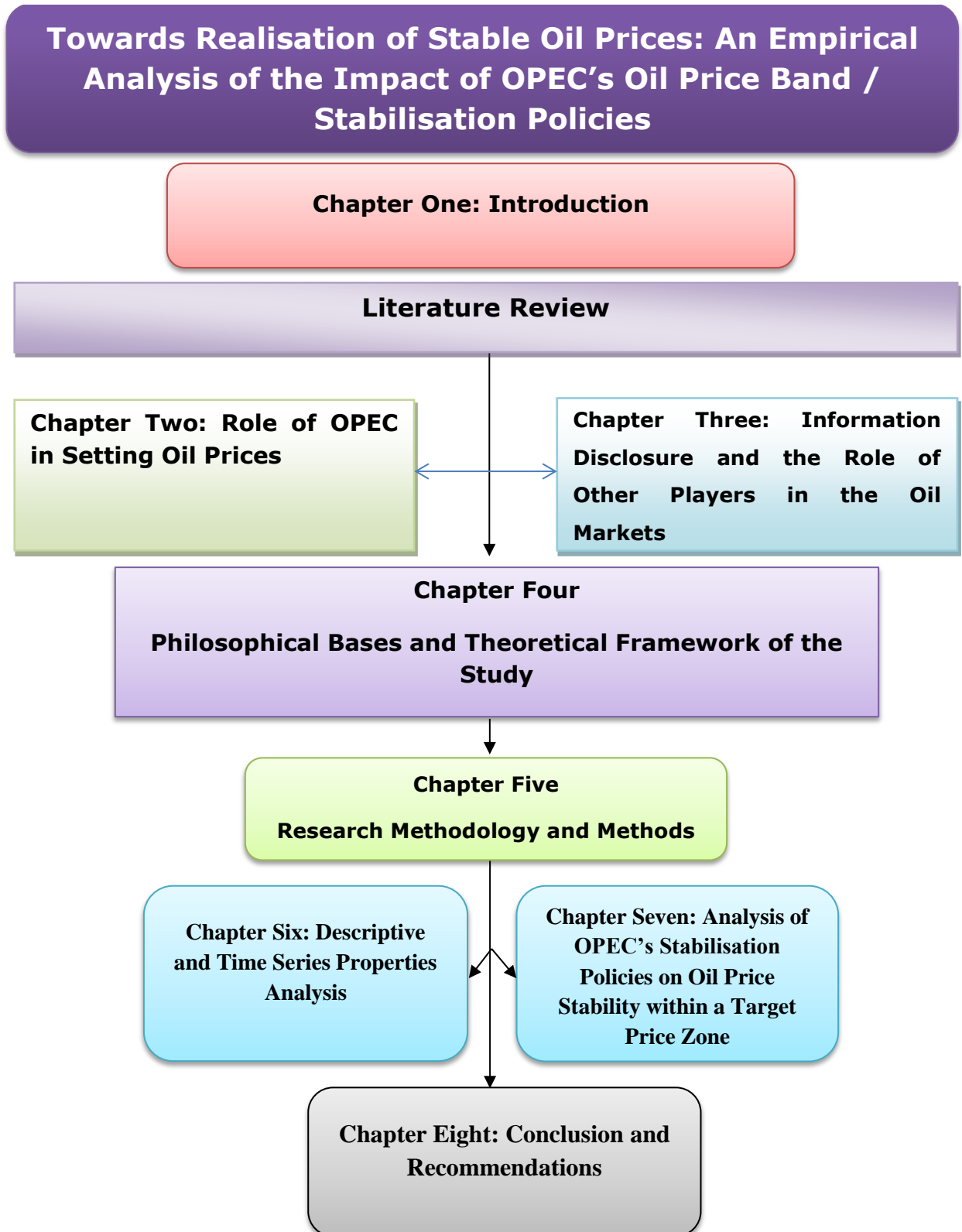
Furthermore, OPEC had a declared policy to maintain oil prices within a specific price range by introducing oil price band policy in the year 2000. The inconclusive nature of research findings in this area and the fact that OPEC had received wide media criticism for its inability to keep oil prices within its set target require further research. In this regard, a target price zone theory was introduced as a theoretical basis and within econometric modelling

framework to test the extent to which OPEC had attempted to stabilise oil prices within the band and why it had failed in pursuing its self-imposed OPB policy.

To summarise the entire chapter, section 1.1 provided a background to the study, followed by the statement of the research problem and justification of the study in sections 1.2 and 1.3 respectively. Section 1.4 presented the main research questions this study set to address. Section 1.5 discussed the research aim and objectives. Theoretical framework and the research methodology used in this research project were introduced in sections 1.6 and 1.7 respectively. Finally, figure 1.3 presented a diagrammatical structure of the entire thesis.

STRUCTURE OF THE THESIS

Figure 1.3: Structure of the Thesis



**CHAPTER TWO: ROLE OF OPEC IN SETTING
OIL PRICES**

Chapter Two Role of OPEC in Setting Oil prices

2.1 Introduction

Understanding the role OPEC plays in setting oil prices is a fundamental step in unravelling the complexities in the oil market. According to recent OPEC data¹², almost 80% of global proven oil reserves lie within the boundaries of OPEC members. However, only 40% of world production is from OPEC (Forbes, 2013). One interpretation of this mismatch between the ownership of the world's reserves of oil and the actual production of oil is that OPEC must be holding back production, presumably to keep prices high, and consequently, OPEC must be acting as a producers' cartel which is responsible for most oil price volatility in the oil market (see Russell and Ibrahim, 2013). This claim which is strongly supported by the Western media is totally contrary to the proclamations of price stability as contained in OPEC's first resolution and its objective statements (i.e. articles 2(a-c)). One of this study's objectives is to contribute in a significant way to the literature on whether or not OPEC is an effective cartel. The starting point for this analysis is to carry out a critical review of the extant literature on this topic, and this review is reported below. In preparation for the review, an overview of the role of OPEC in the oil markets is presented.

2.2 Origin of Oil and Emergence of OPEC

Oil plays an influential role in the current energy mix and, for the foreseeable future, will continue to play such a role in generating energy for the industrialised nations (EIA, 2013). Oil and gas play a central role in driving the economies of both oil consuming and producing nations (Bastianoni et al., 2005; Bastianoni et al., 2009; Mauro and Peri, 2011). Fan et al. (2008) summarised oil as the blood of industries across the globe. In this regard, oil and gas cannot be disconnected from the countries' and global politics. Therefore, to understand this role in relation to OPEC's actions, the following questions should be borne in mind as the history of oil and OPEC is explored in the subsequent sub-sections: What was happening to oil prices prior to the establishment of OPEC? What led to the emergence of OPEC? What is the historical perception of OPEC's role in oil price formation? The answers to the

¹² See OPEC Annual Statistical Bulletin, 2013.

above questions should aid in the process of understanding and describing specific roles and complexities of the evolution of oil, OPEC, oil prices, and the oil markets from a wider perspective. Additionally, it will contribute to the establishment of the underlying assumptions in the study of OPEC and oil markets. As argued by Painter (2012: 24), understanding this recorded trend will be an essential step towards understanding the 'consequences of U.S. global dominance'. Based on this, the section is split into two with the first sub-section discussing the historical development of oil and nature of oil prices before OPEC, while the second sub-section reviews the emergence of OPEC and its historical role in the oil price formation.

2.2.1 The Origin of Crude Oil

Prior to August 1859, lubricants and other solvents used to be generated from different sources; e.g. ".....from lard or whale, alcohol from agricultural products, and turpentine from wood" (Hamilton, 2011:2). Colonel Drake's innovative activity resulted in the substance first recognised as today's commercial crude oil from a 69-foot well at Titusville in Pennsylvania. However, Drake never imagined the complexity of the industry and the markets as it is today (Bockem, 2004). The first large oil reservoir was found when the drilling technology used in searching for water was applied on shallow fields. Crude oil is an important energy source usually derived from a complex mixture of hydrocarbons and other biological particles and liquid compounds resulting from some geological formations (i.e. usually from intensive heat) far down beneath the Earth. According to organic theory, crude oil is believed to have been formed long ago from the remains of animals and plants that lived millions of years ago (Rahimi and Gentzis, 2005; Wright and Gallun, 2008). Oil and gas discovery has had an important impact on the industrial revolution of the consuming nations as most transportation systems are based on oil (Mauro and Peri, 2011).

The U.S. took the initiative in oil production in the early days and was the leading nation in possession of the technological know-how which made it the universal prime producer for almost 70% of the twentieth century (Painter, 2012). Historically, the International Oil Companies known as "seven sisters" (with each company having its own vibrant history) have developed the international petroleum industry as the demand for the U.S. oil became

global between 1920s and 1970s (Sampson, 1980; Parra, 2004). While the global demand increased with industrialisation, the search for the precious commodity spread across the globe. However, the massive quantity of such resources was proved to be concentrated in the Middle Eastern and Latin American countries and again was much cheaper than not only the other sources of energy in the resource-rich countries but also with the oil with the U.S. origin (Parra, 2004; Chalabi, 2010). After the fall of the Ottoman Empire in the early 1920s, Middle East oil was regarded as the “spoils of war” with Britain, France, and the U.S. being the recipients of the spoils (Parra, 2004:8). It is not too difficult to see the significance to the industrialised nations of having powerful oil companies with close connections to the governments of these nations (Parra, 2004; Cortese, 2006). As the development of more reserves grew with the demand for industrialisation, major oil companies by the name of “Seven Sisters” emerged and were strategically in control of oil prices between 1920s and the early 1970s (except for the 1964 OPEC intervention¹³).

The system of operation by the “Seven Sisters” was long-term concession agreements (whose legal framework had been designed prior to 1950) between those corporations and the government of those resource-rich nations (Parra, 2004 and Chalabi, 2010). Parra (2004) noted that, from the historical perspective, the now discarded foundation and the implementation processes of the concessionary system are crucial in understanding the nature of the current international petroleum industry. Notably, as poor nations as they were, five to six core developing nations (i.e. Indonesia, Iran, Iraq, Kuwait, Saudi Arabia and Venezuela) that later made up the existing OPEC membership provided the raw crude oil needed for the global industrial growth in the 1950s; and about ten of them did the same in the 1960s (Parra, 2004). The nationalisation process of the oil companies which started from Mexico, Russia and Romania prior to the 1930s, appear to have made a significant impact on the nationalisation process in the current OPEC nations following the Second World War (see Chalabi, 2010).

¹³ OPEC’s intervention in early 1964 succeeded in achieving a constant level (\$1.80 per barrel) of posted prices which were originally falling; as well as influencing taxation rules and practice that improve the revenue accruing to the nations who possess those natural resources (see Fattouh, 2010 and Chalabi, 2010).

It is important to note that the U.S. oil reserves reached a peak in the early 1970s as predicted by Hubbert¹⁴ in 1956 (Stoft, 2008). With the political event in 1973, following OPEC's decision to enforce an oil embargo on the U.S. and its allies who supported Israel during the Arab-Israel war; oil prices quadrupled in response to a shortage in the supply from OPEC. The period between 1970 and 1973 marked a significant change in the balance of power from the international oil companies (IOCs) to OPEC in relation to oil price formation (Fattouh, 2010). This change in control led to the break of the then existing horizontal and vertical integration and control in the oil market by the renowned "Seven Sisters." However, this control was limited due to the lack of technical skills and capacity (due to the capital intensive nature of oil business) of the oil-producing nations to develop the resources and transport it to the final consumers. Given the extent of technical know-how possessed by the IOCs (mainly owned by the Western countries) and the perceived threat of OPEC's action on their national securities, it will be of interest to find answers to some questions, particularly where commitments in alternative energy are made by the International Energy Agency (IEA) group. Could the IOCs or Western countries (most particularly the U.S.) have invested in such areas considered high, costly and risky (e.g. Gulf of Mexico, Alaska, North Sea) without exerting pressure on the oil prices to rise to the level at which oil extraction from those areas becomes profitable?

As a journalist while analysing some political speeches during the 1973 oil price crisis, Sampson (1980:5) raised some important questions in fear of what the outlook for the oil market would be in the future. First, he considered what the consequence would be with a switch of pricing control from oil consuming nations to oil-producing nations. Another important question raised was "would the old powers of the companies and the consumers reassert their role, to divide and to rule?" Fattouh (2010) described the origin of OPEC as similar to that of a 'trade union'. The only great distinction between the major IOCs and OPEC was the ownership of the resources in question. While the "seven sisters" were fully in possession of the know-how and control of the prices, OPEC was in possession of the

¹⁴ Marion King Hubbert was a Shell researcher who predicted America's oil reaching its peak between 1965 and 1970 in a presentation at American Petroleum Institute (API) located in Texas.

resources and was agitating for higher revenue they considered fair for such resources.

2.2.2 Historical Development of OPEC's Control of Oil Prices

The Organization of the Petroleum Exporting Countries (OPEC) came into existence following the Baghdad Conference in September 1960 by five-member-countries namely: Iran, Iraq, Kuwait, Saudi Arabia and Venezuela. Other countries joined the organisation in the subsequent years are as follows: Qatar (1961), Indonesia (1962), Libya (1962), United Arab Emirates (1967), Algeria (1969), Nigeria (1971), Ecuador (1973), and Gabon (1975). Ecuador and Gabon later withdrew from the organization in 1992 and 1994 respectively for various reasons. The major source of revenue to sustain the organisation comes from the dues receivable from member nations. As part of their obligations to the organisation, genuine members are required to pay their regular and compulsory annual dues amounting to \$1,000,000.00, which confirms additional rights to them as against the rights attributable to "shadow members." Shadow members are allowed to participate in the discussions during debates relating to quantity controls but do not have any voting rights on any proposals (see Mason and Polaski, 2005 for details on this). The structure of OPEC was intended by the members to be similar to the Texas Railroad Commission (Colgan, 2014).

Among the members of OPEC, Venezuela first made a breakthrough in 1943 in its effort to benefit from a significant chunk of oil revenue when it signed a 50-50 profits-sharing contract, with a major IOC (Chalabi, 2010). Venezuela revised its tax system to accrue more revenue from its oil resources in the late 1940s. Subsequently, other producers took participation in a similar arrangement in the 1950s. When the IOCs staged an effort to retaliate against Venezuela's tax decision, a significant shift was noticed in demand from Venezuelan oil to other Arab nations' oil. Venezuela tactically responded by convincing and seeking cooperation of other producer nations to make similar tax changes.

Whilst the origin of OPEC was indeed similar to a "trade union" (Fattouh, 2010) the primary motive for coming together under a single umbrella was to harmonise production policies of the member nations with a view to

influencing oil prices. This coalition became determined to resist the making of unilateral decisions by the "Seven Sisters" via the "posted prices" (see Parra, 2004; and Chalabi, 2010). Chouri (1980) summarised three basic motivations for establishment of OPEC. 1 Fear of price-cuts by the IOCs which had powers over oil prices through a system of "posted prices"; 2 Perception that new entry of participants with lower production prices could threaten the existing developed markets; and 3 Possession of the technical know-how that increased the confidence of the producers to risk an attempt towards control of the market against the exploitative interests of the oil consuming nations and the IOCs. OPEC took the first step towards systematically influencing the post price when Libya first increased the tax rate to 55% from the initial 50%.

Subsequently, the implementation by Iran and Kuwait consolidated a move by OPEC in Caracas (in December, 1970) to adopt the same policy and further demanded that posted price should reflect any changes in foreign exchange rates. The non-compliance or rejection of OPEC's proposal by some of the IOCs resulted in a total sanction/embargo from the OPEC. OPEC's strategic approach was carrot and stick, which could be seen as a combination of negotiation and sanction. The outcome was favourable to OPEC. Chouri (1980) noted that, historically oil companies had been exerting significant political and economic influence in the pricing of oil, which led to intense pressure within the host nations. For example, an 8% price cut was followed by a further 6% unilateral cut in the posted price by the international oil companies (Chouri, 1980). The objective of OPEC to attain higher but fair oil prices initially appeared impossible given the evidence that the establishment of the organisation in September 1960 recorded little or no impact on oil prices (see Colgan, 2014).

The period between 1970 and 1973 marked a significant change in the balance of power to determine oil prices from the IOCs to the members of OPEC (Fattouh, 2010). Prior to the establishment of the Organisation of Petroleum Exporting Countries (OPEC) in 1960, oil prices were fundamentally cheap¹⁵ and hardly fluctuated beyond a range of \$2.50 and \$3 per barrel

¹⁵ Tsoskounoglou et al. (2008) attempted to analyse factors responsible for oil price changes with a view to answer whether the era of cheap oil has past. A good background of what

(Williams, 2010) or less than 1% volatility (Regnier, 2007). Oil prices more than quadrupled in 1973 generally due to OPEC's policy and actions resulting from Arab-Israel war. Opinion is divided with the majority attributing this sharp increase to the restricted oil supply by OPEC, which brought about shortage of oil (Adelman, 1992 and 2004; Pirog, 2007; Dvir and Rogoff, 2009). Another strand of opinion cast doubt on OPEC's ability to raise oil prices four-fold (see Kepplinger and Roth, 1979). Other studies such as Kilian (2008) and Colgan (2014) supported the view of Kepplinger and Roth (1979) that the action of OPEC was deliberately exaggerated by the media. As mentioned earlier, it is important to note that the beginning of the 1973 oil price shock coincided with the period when the U.S. oil had already reached its own peak.

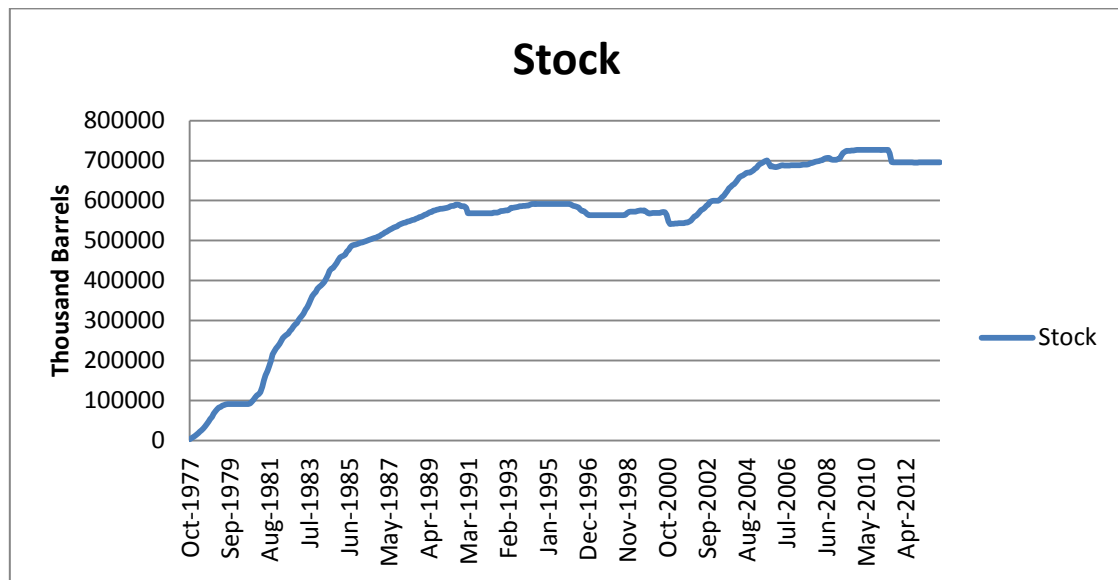
As mentioned in the introductory chapter of this study, a range of policy measures were introduced in response to the 1973 oil price shock which included: establishment of the U.S.-SPR in 1974 and the creation of the IEA in 1975. Furthermore, investments were seen to be growing into the high costly areas such as Alaska, Gulf of Mexico, North Sea. (Chalabi, 2010). This evidence conforms to the earlier argument that volatile oil prices have implications on OPEC's revenue in the long run (see Byzalov, 2002; Horn, 2004). While approaching the end of the first oil price shock, when oil prices began to decline towards the pre-price shock period, the crisis in Iran in which the U.S. government was involved indirectly, led to what was considered the second global oil price shock in 1979, which lasted until 1982 (see Gately, 1986).

Furthermore, the 1979 second oil-price-shock ended in 1986 and there was a subsequent oil price fall for over a decade until the end of the 1990s. No one will dispute that Saudi Arabia is one of the America's friends in the Middle East. Cheating by OPEC members (members ignoring the output limits set by OPEC) has been evident since the day OPEC first introduced the first quota system in the early 1980s (Chalabi, 2010). In 1986, Saudi Arabia and its allies within OPEC took a decisive action to consistently increase their oil

makes up cheap oil can be found in their paper titled: - The end of cheap oil: Current status and prospects.

supply (Gately, 1986). Evidence of increased stockpiling can be observed from figure 2.1 below:

Figure 2.1: U.S. Monthly Oil Closing Stock in Strategic Petroleum Reserve (SPR) from October, 1977 to December, 2013



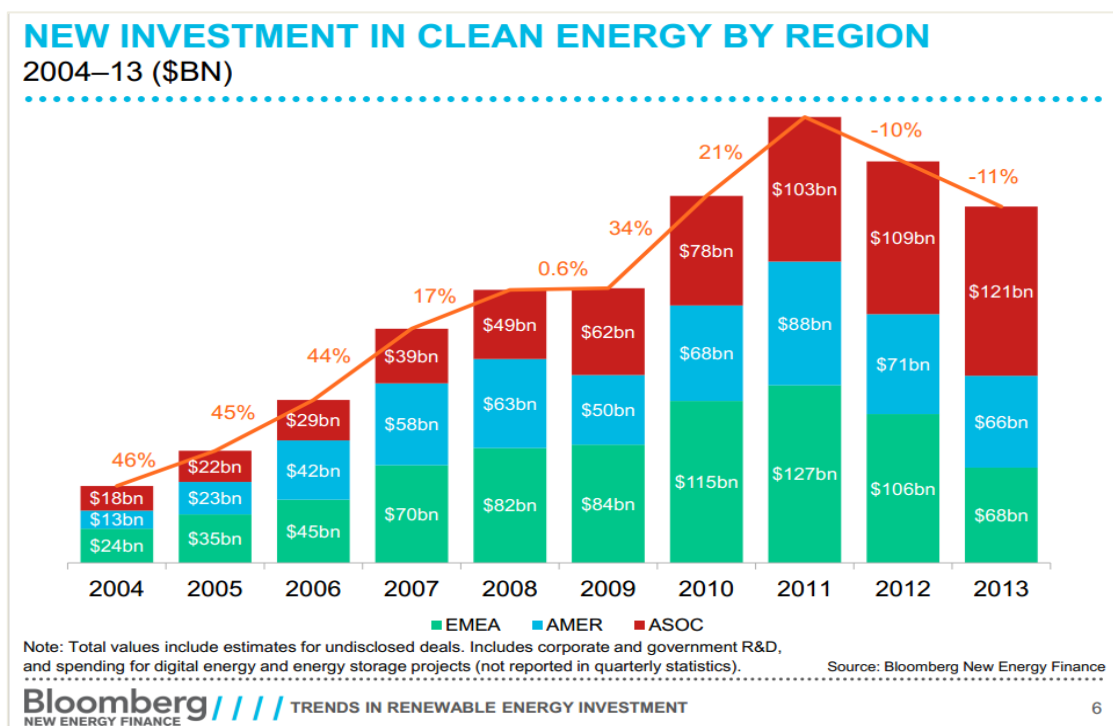
Source: U.S.-EIA, 2013

As shown in figure 2.1, the U.S. increased its stockpile of oil as the oil prices declined in the early 1980s following the second oil price shock. Demand for OPEC oil fell by more than 40% since 1982 (as prices went down) and remained low even after the price fall (Gately, 1986). In August 1985, more than half of the OPEC's 4 million bpd increase in output came from Saudi Arabia, and this finally led to the oil price collapse of 1986 (Gately, 1986).

However, high oil prices were observed towards the end of the 20th century and grew into the new century to what resembles the oil price surge in the 1970s. This period equally witnessed growing investment into the alternative energy sources, most particularly from the renewable sources due to the perceived effects of greenhouse carbon emissions on the environment or global climate change. Although increased oil prices during this period are allegedly attributed to the actions of OPEC in the oil market, the high costs of substitute sources of energy might not be ruled out easily; although it is often attributed to measures being taken by the IEA members for energy security. However, a more promising source of energy in terms of consistent

supply exists but costly in the short-run (see Sioshansi, 2006). Shale energy revolution is taking place in the U.S. that might potentially restore its status as the global energy producer consistent with EIA (2014) U.S. energy projection under three cases scenarios as highlighted earlier in Chapter 1 of the thesis. For the high scenario (which implies highest energy production) to be achieved, one of the key assumptions being that understanding is achieved between the U.S. government and the public who often end up becoming the major burden bearers of high costly energy policies. It remains an important challenge to reconcile the conflicting policies; one from cleaner sources of renewables and the other from a riskier process of fracking but, which potentially guarantees energy independence from OPEC members. In almost a decade since 2004, investments in the renewables have seemed to be on the decline (see figure 2.2 below).

Figure 2.2: Trend in Renewable-Energy Investments



Source: McCrone 2014, Bloomberg New Energy Finance

Figure 2.2 presents trends in the investments in renewable which seem to be on the consistent increase since 2004, slowed by the 2008 global economic recession and reached the peak in 2011. Thereafter, it begins to decline by 10% in 2012 and 11% in 2013. The increased investments by the OECD/IEA

members in the alternative energy have led to significant decline in consumption of OPEC oil as discussed later in the chapter. However, this important move by the OECD/IEA accords them some degree of energy independence. The questions remain: Is the decision to be less dependent on OPEC that is naturally endowed with low extraction cost resources helping the affordability objective by OECD/IEA members in the short-run? Is it plausible that the increased investment in the alternative sources of energy is the main driver for sustaining high oil prices or vice versa? Most EIA projections (e.g. EIA, 2013) often look into the prospects of the long-run in pursuing energy security objectives. Oil as a major source of energy provides nearly two-third of energy demand and is likely to fuel the energy demand of the industrialised nations over the next decades (Alvarez-Ramirez et al., 2003; Bernabe et al., 2004; OPEC, 2010; EIA, 2009). The real as against the nominal average crude oil price has exceeded \$41 per barrel from 1986 to 2003 and has witnessed a consistent annual increase (e.g. by average of 23% annually and to more than \$145 in the first half of the 2008) from 2003 to 2008 (Ji-Hyang and Lee, 2012; King et al., 2012).

2.3 OPEC Structure in the Oil Market

Many studies have been carried out on the role of OPEC in the international oil price formation. The pattern of relationships between different variables has been considered with a view to generating evidence on whether the organisation operated or still operates as a cartel or not. In this regard, the review of the literature attempts to explore the objective, nature and behaviour of OPEC and its members as well as how those characteristics influence the oil market in general and oil prices in particular. A very good start for this review is the study by Allsopp and Fattouh (2011) where they highlighted various models about alternating from classic cartel, "clumsy" cartel, dominant firm model, oligopolistic, monopolistic, and bureaucratic cartel. These different structures have been investigated against OPEC, and the outcomes are crucial in understanding why OPEC is generally regarded as a cartel in most literature as highlighted by Morris and Meiners (2013).

2.3.1 OPEC Models in the Oil Market

There is much debate about whether the organisation of petroleum exporting countries (OPEC) is, in essence, a cartel of producer nations that restricts oil production with a view to influencing international oil prices at the expense of oil consuming nations. This cartel allegation often linked to OPEC has its origin from 1973 when oil prices quadrupled in what is perceived to be the initial oil price shock. The name "OPEC" was rarely known by many since inception until the events in the 1973 which was perceived to be the first oil price shock when oil prices quadrupled (Chalabi, 2010). However, since then the organisation has been directly or indirectly alleged to be responsible for most sharp and sustained high oil prices over the last four decades (Adelman, 2004; Saxton, 2005; Morris and Meiners, 2013). Although the literature does not conclusively support this viewpoint, the media and politicians in the Western world invariably describe OPEC as a "cartel" (Bina and Vo, 2007; Chalabi, 2010; Russell and Ibrahim, 2013). OPEC's objectives as clearly contained in its statute include: ensuring fair prices while stabilising oil prices in the global oil market in the general interest of its members (OPEC, 2008). This objective is perceived to be inconsistent with cartel structure (Noguera and Pecchecchino, 2007). OPEC meets regularly to discuss issues associated with oil prices and the output of its members. In this direction, different models/theories were tested on OPEC market behaviour in relation to changes in oil prices.

The current OPEC data shows that about 80% of global proved conventional reserves are owned by its members which ostensibly make the organisation (i.e. OPEC) the leading global corporate oil producer which contributes more than 40% of the world's oil supply. OPEC's status of being the key decision maker with respect to oil production is, however, open to challenge as current disclosure of reserves of shale energy made by the EIA implies there has been a shift in the balance of power and control from OPEC to non-OPEC producers (Russell and Ibrahim, 2013). Nevertheless, the sizeable reserves held by OPEC's members should, *ceteris paribus*, enable OPEC to be in a position to exert pressures and control on the oil prices globally (Cairns and Calfucura, 2012; Coleman, 2012). However, OPEC leaders have been reiterating their position that events such as those in the 1970s would not

repeat themselves in the future. A view supporting this assertion has two strands in the literature. Some oil market analysts and researchers (e.g. Sodhi, 2008) believed that OPEC market power has diminished with time given the development in the shale energy which has spawned new dimension and shift in the balance of power from OPEC to non-OPEC (Omondude, 2002; Russell and Ibrahim, 2013). Similarly, Bernabe et al. (2004) argued that, changes in the OPEC reserves since the oil price shocks in the 1970s have already resulted in OPEC losing the power to dictate oil prices to the other market forces.

Similarly, other studies carried out to assess the fact about 'cartel' claims against OPEC (Kepplinger and Roth, 1979; Splimbergo, 2001; De Santis, 2003; Bina and Vo, 2007; Fattouh and Mahadeva, 2013; Colgan, 2014) have expressed varying results but mainly doubt OPEC's ability to stabilise prices. Is this reputation still valid? Kepplinger and Roth (1979) perceived the OPEC's action as being exaggerated. Bina and Vo (2007) also examined the effects of OPEC's output decisions using event's studies and find no evidence that OPEC operates as a cartel or holds any market power of promoting high oil prices. This finding is consistent with Alhajji and Huettner (2000a) who also argued that 40% of the market share to OPEC does not give OPEC the market power to operate as a cartel to control oil prices. In his attempt to highlight the weak nature of OPEC in the oil price formation and the oil market, Colgan (2014) believed that OPEC's action during the 1973 oil price crisis was hugely misunderstood but such actions could not have triggered the high prices. If OPEC had noted its capacity limitation to control the prices, should it have introduced the OPB policy in the first place?

Prior to the establishment of OPEC, the international cartel¹⁶ of most powerful oil companies popularly known as "Seven Sisters¹⁷" were in absolute control of global oil prices through a system of "posted prices¹⁸" which have remained stable (see figure 1.1) for a considerable period known as "era of cheap oil" (Tsoskounoglou et al., 2008). Following the 1973 and 1979 first

¹⁶ Seven Sisters are considered international cartel because they comprised of multinational corporations with the monopoly of know-how and capital strengths in both upstream and downstream activities for oil resources.

and second oil price shocks respectively, OPEC becomes the central mainframe for reference as villain obstructing oil price stability in the oil market. The oil price surged in the last decade, which in nominal value resembles that of the 1973 (see figure 1), is directly or indirectly linked to OPEC's action or inactions in relation by the IEA and most of the mass media. A number of attempts have been made seeking antitrust laws to enforce (see Waller, 2002; and Doggett, 2008) against OPEC's actions or seeking the U.S. Congress's intervention to force OPEC to act in the Western interest (see reports- Lautenberg, 2004; Saxton, 2005). However, this claim clearly contradicts the primary mission¹⁹ for creating the organisation. Furthermore, the cartel behaviour is incompatible with the organisation's disclosed efforts for oil price stability (Alhajji and Huettner, 2000a) and that previous models provided insufficient evidence distinguishing between cartel practice and competitive firm (Smith, 2005). Most often, OPEC leaders reiterated their commitments to avoid the recurrence of events similar to that of 1973 oil price crisis due to its effects to both oil consuming and producing nations.

2.4 Cartel and Non-Cartel Debate

Theoretically, the basic belief of the pure capitalist economic system is that businesses are usually out to make profits. How businesses achieve such a motive is subject to different interpretations. This is a foundation built in the classical study of cartel behaviour. According to Al-Qahtani et al. (2008b), cartel hypothesis assumes a firm or influential part of the firm to operate as "a monolithic wealth-maximizing monopolist." It is behaviour where a firm places a constraint on production/supply of resources with the sole intention of maximising its profits by pushing the prices as high as possible. Several studies were conducted to examine the OPEC's or its members' incentive to produce; and whether OPEC (individually or collectively) operates as a cartel or not (Allsopp and Fattouh, 2011). However, some studies (e.g. Moran, 1981; Gately, 1984; Bockem, 2004) doubted the ability of the classical theoretical models of a firm to offer comprehensive explanations as to the

¹⁹ OPEC's mission statement is "... to coordinate and unify the petroleum policies of its Member Countries and ensure the stabilization of oil markets in order to secure an efficient, economic and regular supply of petroleum to consumers, a steady income to producers and a fair return on capital for those investing in the petroleum industry". More information could be about OPEC's mission can be found from the following link: http://www.opec.org/opec_web/en/about_us/23.htm

actual role of OPEC in the oil market. For example, Moran (1981) believed that oil market and OPEC structure are unpredictable from the economics perspective. Gately (1984) further noted the challenge by describing it as still an open question for OPEC behaviour to be best modelled. Bockem (2004) acknowledged that from both theoretical and econometric modelling perspective, designing the optimal model capable of describing OPEC behaviour will be highly challenging. Furthermore, Smith (2005) acknowledged such fact that studies about OPEC behaviour in the oil market still remained largely inconclusive.

It should be noted that, the differences in approaches and assumptions of these studies on OPEC have impacted on the results- classifications and explanations of OPEC behaviour as a cartel or non-cartel (as noted by Smith, 2005). This sub-section reviews evidence by previous literature in classifying OPEC as a cartel.

2.4.2.1 OPEC as a Cartel

As earlier mentioned, the term "cartel" has become synonymous with the name of OPEC in the literature on OPEC. A sizeable proportion of the literature portrays OPEC as an evil cartel. The evidence cuts across studies such as Osborne (1976); Adelman (1982, 1986, 1990, 1993, 2001 2002, 2003, 2004); Salant (1976); Cremer and Weitzman (1976); Pindyck (1979, 2001); Newbery (1981); Morrison (1987); Greene (1991); Griffin (1992); Berg et al. (1997); Dahl and Celta (2000); Byzalov (2002); Thompson (2010). In most cases, the studies applied cartel models and reached such a conclusion that OPEC deliberately took actions to promote high oil prices at the expense of the Western nations.

Most of these studies adopted sophisticated theoretical assumptions (such as game theory where it is difficult if not impossible for the equilibrium position to reflect some moral and ethical considerations) in their analysis. For example, Salant (1976) first introduced a market system where OPEC (as a cartel) is modelled as a dominant producer while the remaining non-OPEC producers are price takers (i.e. a fringe). In his analysis, certain crucial assumptions were set for the results to be obtained in this direction. One of these critical assumptions is "zero extraction costs" to the cartel which,

arguably, is unrealistic. Assuming OPEC cartel to operate in a "dominant extractor" model as a limiting case of 'asymmetric Cournot oligopoly,' it was found that the competitive fringe acts more like Nash players²⁰ rather than price takers. Ulph and Folie (1980) re-examined the model by introducing positive and constant marginal extraction costs as against the zero extraction costs by Salant (1976) but still applied the open-loop Nash equilibrium concept. Following improvement to Salant's model, it was generalised by Ulph and Folie (1980). However, the model suffered from the same criticism in its assumption relating to cost of extraction. More crucially, inventory costs of spare crude oil capacity and also environmental costs of such extraction were overlooked.

Some weaknesses in the open-loop Nash equilibrium approach were identified (see Polasky, 1990). Subsequent studies (such as Groot et al., 2003 and Benchekroun and Withagen, 2012) used closed-loop assumptions of game theory. Benchekroun and Withagen (2012) explored further the price-taking behaviour in the oil market between the cartel and the fringe under imperfect competition within "open-loop" and "closed-loop" cartel-fringe games. Their study concluded that OPEC operated as a cartel over the time horizon by setting production quotas that helped determine the price paths.

Griffin (1985) attempted to empirically investigate a cartel hypothesis on OPEC and its members by establishing any "market-sharing behaviour"²¹ using different strategies. His attempts to test various models on both OPEC and non-OPEC producers concluded that the competitive model only fitted non-OPEC producers. Although, Gülen (1996) employed a relatively different approach (i.e. cointegration and Granger causality in the time series), and found evidence of causality (between 1982 and 1993) and cartel behaviour by OPEC, while the subsequent period showed an absence of causality. In the same vein, Adelman (1982, 1986, 1990, 1993, and 2002)

²⁰ Nash condition or equilibrium is an assumption in game theory based on rational choice model (i.e. that an action is chosen by a player while forming a belief about other market player's action profile in a correct manner with some degree of certainty). For details, see Osborne (2002).

²¹ Griffin (1985) believed that by correlating productions values between OPEC individual members and the entire OPEC's, the correlation coefficient could say a lot about market-sharing behaviour to justify the entire OPEC's behaviour as a cartel or non-cartel in the oil market. Jones (1990) extended Griffin's (1985) study and produces invariably similar position. For a detailed review of their findings, see Al-Qahtani et al. (2008b).

found that scarcity never existed in the oil market, over the last three decades, rather OPEC (which according to him holds the oil market power) deliberately restricted supply, despite their low production costs, while non-OPEC producers attempted to maximise their production. Rejecting application of a cartel model to OPEC, Dahl and Yücel (1991) found interesting variation in the pattern of behaviour by the members of OPEC. For instance, they documented evidence of target-revenue and swing producer goals among some members. However, Loderer (1985) could not reject the null hypothesis that OPEC did not operate as a cartel during the 1980s, although he established the absence of a significant effect of OPEC decision's announcements upon the oil prices.

Furthermore, other research of a similar nature was also carried out (see Griffin, 1985; Jones , 1990; Youhanna, 1994; Dahl and Yücel, 1991; Gülen, 1996; Byzalov, 2002; Almoguera et al., 2011; Brémond et al., 2012; Coleman, 2012; Lin, 2013). Perhaps of most interest to this thesis the work of Byzalov (2002) highlighted challenges facing OPEC members regarding their cartel habit as the consumers (most particularly the West) tailor their activities in forward-looking behaviour aimed at demand-reducing investment. In his dynamic model, which was adopted from Fershtman and Pakes (2000)²², Byzalov (2002) argued that from the evidence of collusive behaviour of OPEC in the spot market, which increased the tendency of moving the substitution-effect outward as the consumer nations intensified their search for an alternative energy, such activity made OPEC worse-off in the long run. However, the study did not incorporate new demands from the emerging economies such as China and India, as well as the increasing energy demands as the world's population grows higher.

Almoguera et al. (2011) used estimates obtained from a simultaneous equation switching regression model to test OPEC cartel behaviour based on data over a 30-year period (from 1974 to 2004). Their study found evidence of a switch between collusive and non-collusive behaviour and they concluded that OPEC behaved as a cartel in some periods but in most some periods, it

²² Fershtman and Pakes (2000)'s dynamic collusive framework based on Pakes and McGuire (1994) and Ericson and Pakes (1995) with numerical analysis to demonstrate how price wars are generated and consumer surplus achieved.

was not effective in raising oil prices systematically beyond Cournot competition levels. OPEC is therefore constrained with limited power by competition to actively operate as a cartel. In an attempt to understand how power is exercised in the oil market. Lin (2013) examined collusion in OPEC and oligopolistic behaviour in non-OPEC producers over a 35 year period (from 1970 to 2004) using dynamic models. The study found evidence of collusion among OPEC members, while non-OPEC producers collectively exhibited the characteristics of an oligopolistic fringe. On this basis, the study concluded that OPEC operated as a cartel over the period considered while non-OPEC operated as a fringe. However, in an effort to model the structure of the oil market, both studies were mainly supply-driven studies and also silent about the policies of oil consuming nations, which might also affect oil markets.

Brémond et al. (2012) introduced cointegration and panel data approach to the same issue in an attempt to provide an answer to whether OPEC still operated as a cartel and found partially similar results. Furthermore, Brémond et al. (2012)'s study concluded that OPEC's market power was gradually influenced by the oil pricing system evolution with time indicating that its behaviour is not static and major events have accounted for change. Splitting the members into two groups (savers and spenders), they note that cartel behaviour is applicable in the sub-groups, but OPEC operated in most periods as a price taker. Coleman (2012) investigated the relative influence of speculation in the futures markets in relation to oil prices, security threats in some OPEC members' region, and other shocks by employing monthly data over a period 25-year period (1984–2007). The study concluded that the oil market is dominated by OPEC as a cartel of producers, and that volatility in prices was usually due to its ability to leverage such dominance.

In an effort to answer the cartel question on OPEC, Brémond et al. (2012) investigated the coordination in production policies amongst OPEC members using "cointegration and Granger causality tests" on monthly data between 1973 and 2009. Their results indicated that OPEC is a price-taker, although a cartel-like action was observed in a subgroup within OPEC. Yousefi and Wirjanto (2005) moreover, documented evidence of Saudi Arabia's behaviour resembled that of the market leaders. In search for factors relating to OPEC

that influence oil prices, Kaufmann et al. (2004) employed a unit root test²³ (augmented Dickey Fuller test and Dickey Fuller), cointegration test, and HEGY²⁴ test statistics to investigate causality between independent variables²⁵ and dependent variable (oil prices) on the other side. The study concluded that the independent variables granger-cause the oil prices and not in the reverse form. Sankey et al. (2010) also noted that OPEC operated as a cartel and that depletion decisions left in the hands of the nationalists' governments of OPEC nations have not only led to a restriction of oil production but also investments into the new capacity.

2.4.2.2 Non-Cartel Hypothesis

Despite the sizeable literature in support of OPEC operating as a cartel, other studies have failed to find convincing evidence that the organisation is a cartel (see, for example, Kepplinger and Roth, 1979; Plaut, 1981; Loderer, 1985; Griffin, 1985; Dahl and Yücel, 1991; Al-Saif, 1997; Morse, 1997; Alhajji and Huettner, 2000a; Bentzen, 2007; Kaufmann et al., 2008; Reynolds and Pippenger, 2010; Colgan, 2014; Cairns and Calfucura, 2012). In developing arguments against a cartel hypothesis, Plaut (1981) highlighted that OPEC does possess the market power to influence oil prices higher than what should have been obtainable competitively if OPEC had not restricted its oil production. Loderer (1985) found evidence of collusion after 1980 by OPEC members' production behaviour but did not find any evidence that OPEC operated as a cartel in the 1970s.

Among the studies which rejected the cartel hypothesis on OPEC or its cores are: Alhajji and Huettner (2000a, 2000b); Kaufmann et al. (2004); and Brémond et al. (2012). Brémond et al. (2012) attempted to study whether OPEC acted as a cartel in the periods considered. The study used a panel data setting, co-integration, and Granger causality tests over production decision data (of all the 11 OPEC member nations and 4 key non-OPEC producers). The study found that OPEC operated as a price taker in most periods except the period after the oil counter- shock when it acted as a price setter, mostly

²³ The unit root tests are discussed in Chapter 5 of this study.

²⁴ HEGY stands for initials in the study conducted by Hylleberg, S., Engle, R. F., Granger, L. W. J. and Yo, B. S. (1990).

²⁵ Kaufmann et al. (2004) identified the key variables as "OPEC capacity utilisation, OPEC quotas, the degree to which OPEC exceeds these production quotas, and OECD stocks of crude oil."

within a subgroup of its members distinguished as either 'savers' or 'spenders' depending upon the cheating incentives (Brémond et al., 2012). Reynolds and Pippenger (2010) failed to accept the cartel hypothesis on OPEC after applying a case study approach to the study of Venezuelan oil production relative to OPEC.

Furthermore, Brémond et al. (2012) did not find evidence that OPEC operated as a cartel during most of the periods they considered, and they concluded that OPEC is best described as a price taker. A study of some significance is that of Fan and Xu (2011) who studied relative factors that have affected oil prices from 2000 to 2008 by splitting the periods into two, i.e. 2000-2005 ("Relative Calm Market") and 2004-2008 ("Bubble Accumulation"). In both periods, the study documented evidence that speculation played a key role in driving oil prices high.

2.4.2.3 Other Models of OPEC in the Oil Markets

The pricing policy of OPEC has received particular attention from the model builders following the major oil price shocks of the 1970's and 1980s. From 1975, there has been much modeling attempts to explain the economic reasons behind the first jump in prices, October 1973 – January 1974. Following the 1973 oil price shocks, a significant review of literature (Fischer et al, 1975; Ezzati, 1976; Loderer, 1985; Geroski et al., 1987, Green, 1988; Jones, 1990; Dahl and Yücel, 1991; Griffin and Nielson, 1994; Gülen, 1996; Gault, et al., 1990, and Gault et al., 1999; Alhajji and Huettnner, 2000a and 2000b; Spilimbergo, 2001; and Ramcharran, 2001 and 2002; De Santis, 2003) has been developed to model the structure of OPEC behaviour in the light of volatile oil prices in the oil market. As noted above, most of the model assumptions on OPEC were examinations of cartel behaviour in an attempt to explain the price shock. After the second jump in oil prices 1979, the modelers tried to link the two price increases in the hope of giving a plausible economic explanation for OPEC's conduct. The dominant firm models assume both cartel and price leadership on OPEC or OPEC core.

In this direction, a number of scholarly studies have been carried out using different approaches to produce empirical evidence of the structure of OPEC and how it influences the oil market. Various models partially linked to cartel

or non-cartel are therefore identified to include: Low discount theory (Johany, 1980); monopolistic structure (Cremer and Weitzman, 1976; Dong and Whalley, 2012); oligopolistic structure (Stackleberg oligopoly²⁶ Nogueraa and Pecchechnino, 2007); collusive behaviour (Adelman, 1982; Danielsen and Kim, 1988; Al-Sultan, 1995); dominant producer (Mabro, 1975; Erickson, 1980; Plaut, 1981; Griffin and Teece, 1982; Wirl, 2009); swing producer (Dahl and Yücel, 1991); competitive firm (MacAvoy, 1982; Alhajji and Huettner, 2000a), revenue targets²⁷ (Ezzati, 1976, 1978; Cremer and Salehi-Isfahani, 1980; Teece, 1982; Coleman, 2012); bureaucratic syndicate (Smith, 2005); changes in ownership model in OPEC (Johany, 1979); political models (Ezzati, 1976); property right models (Johany, 1979 and 1980; Odell and Rosing, 1983; Gülen, 1996; Hansen and Lindholt, 2008) and others (e.g. Slaibi et al., 2010) target capacity and target price models.

2.5 OPEC Quota System, Cheating and Oil Prices

One of the major problems faced by OPEC has been the ability to coordinate effectively the actions of its members (i.e. "collective action problem") in accordance with its policy statements and objectives (Rousseau, 1998; Chalabi, 2010). This is what has been termed in the OPEC literature as "cheating behaviour" in OPEC (Dibooglu and AlGudhea, 2007). Cheating emerges as a result of the self-imposed quota system introduced by OPEC in 1982 as a stabilisation measure, although the agreement to unify their policy has been in the Statute of the organisation as far back as 1960 when the organisation was established. In analysing OPEC's incentives for higher production among members, Gately (2004) perceived two groups emerging from OPEC that is embarked in a "constant sum game," namely: the one which initiates a move and the other that responds, which poses a challenge in coordinating the overall objectives of the cartel. Cheating emerges where the members produce and supply oil beyond the officially allocated quotas.

Logically, one would expect the cheating to be beneficial to the market considering the allegation that oil market is undersupplied due to restriction exercised by OPEC. If this position holds true, then a negative association

²⁶ This is a market structure where the cartel (i.e. OPEC) takes the leadership position even in the oligopoly while other players follow (see Nogueraa and Pecchechnino, 2007).

²⁷ Alhajji and Huettner (2000b) could not reject the model on certain OPEC members such as Algeria, Libya and Nigeria.

should be expected, which translates that increased OPEC cheating should lower oil prices (see Abraham, 2000). Reduced cheating in OPEC, however, might result in higher oil prices because OPEC official production is not sufficient to accommodate the global oil demand. Furthermore, the Granger causality between OPEC cheating behaviour and the oil prices should flow in a bi-directional form as follows: OPEC cheating, whether positive or negative might influence oil prices; and that change in oil prices is likely to dictate the level of OPEC cheating in accordance with the theory of demand and supply. In the light of the findings in some previous studies, OPEC was found to be a non-cartel but other core of OPEC were believed to have operated as price leaders or dominant sub group of OPEC. This action, according to Yousefi and Wirjanto (2004), resulted in greater disagreements by creating segmentation within the organisation.

A sizeable literature is documented on cheating behaviour in OPEC. For example, Rousseau (1998) noted that incentive to cheat on OPEC exists in each member by producing in excess of its official allocation. He further notes that "However, all members have a similar incentive to increase production – i.e.; they all want to free ride on the collective good. The incentive to cheat implies that cartels are traditionally short-lived enterprises." Individual members were studied, and some interesting characteristics about them are documented in the OPEC literature. As an illustration, a case study approach was utilised to examine if OPEC operated as a cartel with particular reference to Venezuela's production decisions using Granger's causality. It was found that bidirectional causality occurs between Venezuela's production and OPEC production in different times in the short run indicating cheating by Venezuela after cuts, which ultimately suggest a 'tit-for-tat oligopoly game'²⁸ but far from anti-competitive behaviour Reynolds and Pippenger (2010:6045). However, the study found a unidirectional causality running from Venezuela's production to OPEC in the long run, suggesting that weakness in OPEC's output coordination as against the way it reacts to such output. A further examination using VECM suggested that no evidence of Venezuela's production converging towards OPECs quota assigned to Venezuela. Hamilton

²⁸ Tit-for-tat simply goes beyond a simple English meaning of "equivalent retaliation" to include a highly sophisticated strategy considered effective by a particular player in a game theory.

(2011), who studied events that led to the volatility in oil prices since the first oil price shock to 2010, concluded that Saudi Arabia had engaged on "cheating behaviour" by unilaterally taking a deliberate decision to alter production with a view to influencing oil prices, considering its reserves advantage. This finding is consistent with that of Dibooglu and AlGudhea (2007).

Kaufmann et al. (2008) modelled the relationship between variables in OPEC nations and oil prices using time-series analysis. Quotas and cheating were examined and found to be crucial determinants of elasticity of production response by OPEC nations. The study concluded that OPEC does not control oil prices as often proclaimed but evidence suggests that it can influence the prices in a sense. In an earlier study, Kaufmann et al. (2007) also documented evidence of competitive elements in OPEC behaviours. Finally, the study concludes that all nations other than Saudi Arabia show some form of production sharing behaviour, which may imply that OPEC shares "mismatches" between the call for OPEC production and OPEC quotas.

Some studies (such as Mabro, 1989; Gault et al., 1990; Bakhtiari, 1992; Alsalem et al., 1997, Morse, 1997; Al-Saif, 1997; Kaufmann et al., 2004) have attempted to analyse OPEC quota decisions. Gault et al. (1999) evaluated OPEC's quota allocation to members in their quest to understand OPEC behaviour. Gault et al. (1999) believed that OPEC's imposition of production cuts since February 1998 has been mainly arbitrary, and the bases of such allocations were not disclosed. Quota violations among the OPEC members have been attributed to what members perceived as "unfair" distribution of allocation quotas (see Ait-Laoussine, 1997; Salman, 1997). Gault et al. (1999) added that an 'explicit allocation formula' would increase what constitutes "fairness" to member nations.

Mazraati and Jazayeri (2004) studied the relationship between OPEC's compliance with the pre-set production agreements and the global oil price volatility on monthly historical data for a seven-year period (1995-2002) using compliance techniques, intervention analysis and econometric models. The study concluded that, a compliance level within the range of 94-99%

achieved higher oil prices while a less compliance level attracted a lower oil price and more volatility.

Kaufmann et al. (2004) attributed the oil price rise in the early beginning of the last decade to four reasons as follows: (1) OPEC capacity utilisation; (2) OPEC production quotas; (3) excess of OPEC production to the announced quotas; (4) OECD private inventories. Cheating increases with a decrease in oil prices and presence of "soft market"²⁹ and vice versa. There is a perceived or implied price band in the OPEC pricing strategy even in the period when it was not officially declared by OPEC. The importance of having a lower limit became apparent with OPEC's experience of oil price collapse in the 1980s. The methodology of this research is based on the target pricing zone to evaluate the success or otherwise of OPEC policies in stabilising oil prices. The target price zone (TPZ) theory is chosen for this work due to its unique quality to explain the situation.

OPEC leaders (such as Lukman and El-Badri) have often made reference to OPEC statute (2008) and reiterated the commitment of OPEC to oil price stability while ensuring steady and fair return streams for their members and external investors in the industry (Lukman, 2000 and El-Badri 2004). Noguera and Pecchechino (2007) stated that OPEC's goals can be classified into two, namely: microeconomic (which seeks to lower the price volatility in the oil markets) and macroeconomic (which seeks to promote the interest of the members by enhancing their economic development). This perception is contrary to the belief and understanding of some participants in the oil markets. Furthermore, Noguera and Pecchechino (2007) observed that the goals had been creating chaos since the cartel's tools of achieving those objectives are output quotas. Gault et al. (1999) attempted to model how quotas are allocated within the OPEC members with a view to understanding the organisational set production-ceiling. However, according to Business Week (2008), members have been defaulting quota policies without severe measures being taken by OPEC to punish or end such practice. Studies (e.g. Reinfenberg, 1996; Belton, 1998; Colitt, 1998; Cortzine 1998; Checci, 2007) documented evidence of OPEC members engaging in 'black market activities'

²⁹ Soft market refers to the period and state when oil prices are stagnant and reasonably low due to high or excess supply and low demand.

and the outcome of such activities have led to over-production by the members in the OPEC allocated quotas. According to Fritseh (1997) and Belton (1998), this made the organization ineffective and less powerful in the view of the major players in the oil market.

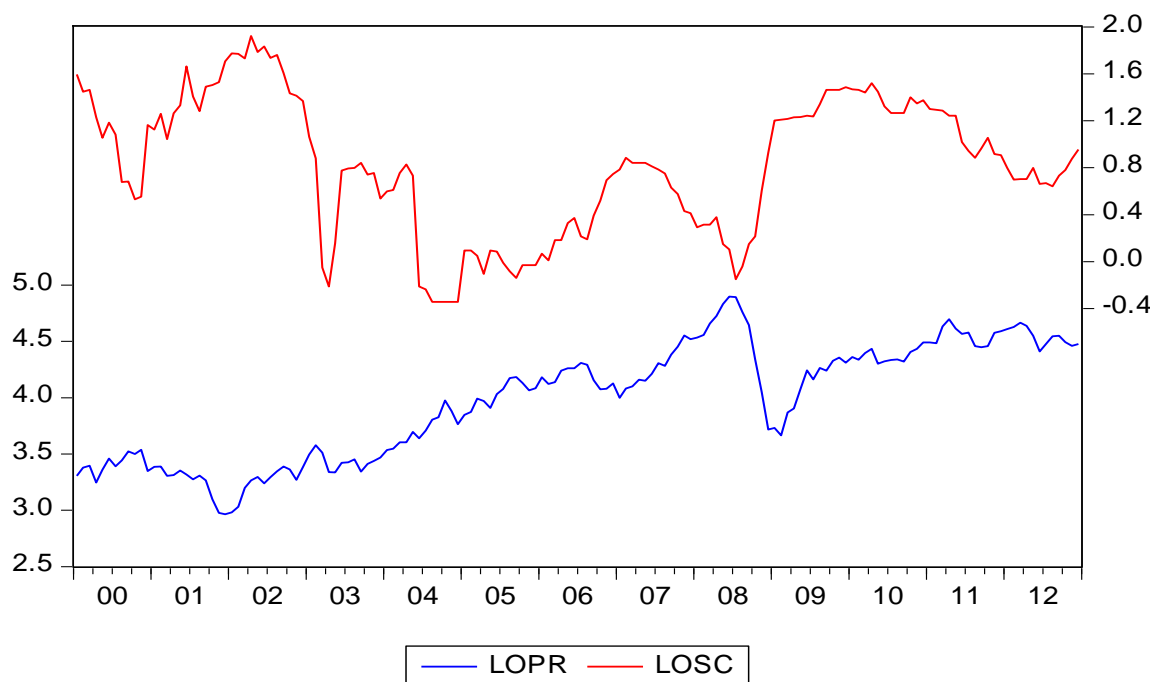
In conclusion, the effect of the OPEC quota system has been weakened by cheating behaviour in the organisation. Therefore, in this regard, the clear assessment of OPEC's quota system is often incomplete and confusing depending on how cheating has been incorporated in the OPEC allocation decisions.

2.6 OPEC Crude Oil Spare Capacity and Price Stability

Many studies have argued that OPEC spare capacity has a long term implication on the global oil market (see Gately, 2011). Consistent with this, IEA has often reiterated that the basis for their oil price projection is the low OPEC spare capacity observable in OPEC (see Simenski, 2013). Crude oil capacity is usually set by OPEC to accommodate any unanticipated future disruption to oil supply. Arguably, the purpose of reserves held by most OECD/IEA members (for example, U.S., UK, and Japan) is meant, in principle, to support similar disruption in order to avoid any potential serious harm to their economies. However, as noted earlier, maintaining reserves of oil for this type of reason requires some diligence. The literature on the actual role played by OPEC spare capacity on the oil price is mixed but with the majority contending that speculation around the capacity might be a key to influencing high oil prices. More importantly is the cost that is involved in maintaining these capacities and reserves from an accounting perspective. Although, relatively few studies (e.g. Hedenus et al., 2010) made attempts to model the cost of disruption in the oil supply, this review did not find any study that empirically analysed and compared such costs of disruption with the accounting cost of keeping inventory. However, a trade-off between the above decisions is needed somehow.

Figure 2.3 Presents WTI oil prices and OPEC spare capacity from January, 2000 to December, 2012.

Figure 2.3: WTI Oil Prices and OPEC Spare Capacity



Source: EIA, 2013

Key

LOPR: Logged values of oil prices

LOSC: Logged values of OPEC spare capacity

Figure 2.3 presents data about OPEC spare capacity and oil prices over 13-year period from 2000 to 2012 (i.e. on the horizontal axis). The logged values of oil prices are presented on the left vertical axis of the graph. Right vertical axis presents the monthly spare capacity of OPEC based on EIA dataset. The trend shows rather a mixed conclusion about the nature of the relationship between OPEC spare capacity and oil prices. While in some periods, such as 2003 to 2004 when oil spare capacity was increased despite ignoring Iraq's spare capacity by OPEC-10, oil prices continued to rise showing a positive association. However, evidence suggests that earlier periods such as the year 2000 to 2002 produced a relatively negative relationship, indicating that high spare capacity is associated with low oil prices in accordance with the claim by EIA and IEA when making oil price forecast. In 2008, high spare capacity is associated with low oil prices. One of the possible reasons could be that low oil demand during recession might allow OPEC members to accumulate the required excess capacity. The period

after, from 2009 up to 2010, increasing spare capacity could not result in low oil prices despite a consistent decrease in the OECD/IEA consumption of OPEC's oil (see, for example, figure 3.2 for the U.S. consumption). Research shows that private companies struggle to create spare capacity (see Wood, 2002), which indicates a potential problem with respect to the OPEC's ability to create any sufficient spare capacity.

More specifically, the war in Iraq has impeded OPEC's ability to maintain the expected spare capacity in view of the fact that Iraq was a major contributor in creating OPEC's capacity prior to the war (Chalabi, 2010). Although many other geopolitical events took place during the period considered in this study, only the effect of Iraq war was measured due to the following reasons. The impact of dramatic rise in oil prices when the war was at its peak demonstrated how important OPEC was during the last decade. Over this period, evidence suggested that Iraq war was well planned by the U.S. and its allies (see Chomsky, 2002; McChesney, 2004; Kramer and Michalowski, 2005; Chalabi, 2010). It was a war that led U.S. to utilise its Strategic Petroleum Reserve (SPR) to make up the shortfall in the global oil supply (see Bamberger, 2010). However, it is really challenging to distinguish between the effects of other geopolitical events such as Iran nuclear crisis, which was on and off for a period of time and other factors such as Arab spring. Similarly, it is challenging to isolate the impact of war in Libya from the the Arab spring.

Furthermore, Chalabi (2010) had documented evidence of long and historical Western rivalry for the control of Iraq's oil. A narrative historical analysis of Iraq's oil invasion and the U.S. aggression has also been documented in Kramer and Michalowski (2005) and Chalabi (2010). The views of other scholars such as Chomsky (2002), McChesney (2004) are that, the U.S. media was used to plan the invasion which targeted Iraq's oil. U.S. and its allies received wide criticisms for the war which in the U.N. Kofi Annan's viewpoint was an offence against the Iraq's sovereignty (Kramer and Michalowski, 2005). The effect of the U.S. led war against Iraq has been widely documented in the literature (see Kramer and Michalowski, 2005; Guidi et al., 2007). A sizeable review of the literature (see Chomsky, 2002;

McChesney, 2004; Kramer and Michalowski, 2005) concluded that the U.S. and its allies had made their way out of Iraq with huge barrels of crude oil which remained unaccounted for. Understanding key motivation for such an invasion is very crucial in this type of study. For example, the official period marking the end of the war witnessed a consistent rise in the production of shale energy which later gave the U.S. strategic ability to significantly reduce its production costs of energy while international oil prices continued to rise in the markets³⁰.

2.7 OPEC Oil Price Band Policy and Price Volatility

There are several questions raised in relation to the above decision. First, should OPEC have introduced the OPB system in the initial instance? Why the policy was temporarily suspended in both 1992 and 2005? Does the OPB policy address the initial objective? Should OPEC have declined to introduce the policy knowing the forces in the oil markets were beyond its control? Was there any change in the market developments such as a shift in the balance of power that might have motivated OPEC to withdraw the policy? A number of arguments were advanced to address the issues in the literature. A point worthy of note is that, OPEC never made any official documentation about the OPB policy. However, some statements were made by key OPEC officials³¹, which were assumed to be formal in the OPEC pricing strategy. Therefore, identifying determinants of OPEC OPB will go a long way in interpreting the situation better. Although it is beyond the scope of this study to detail and model factors responsible for oil prices, effort should be specifically made to highlight appropriate evidence surrounding OPEC's attempt to stabilise the oil prices within a target. This is consistent with the policy, whether it is officially in force or implied.

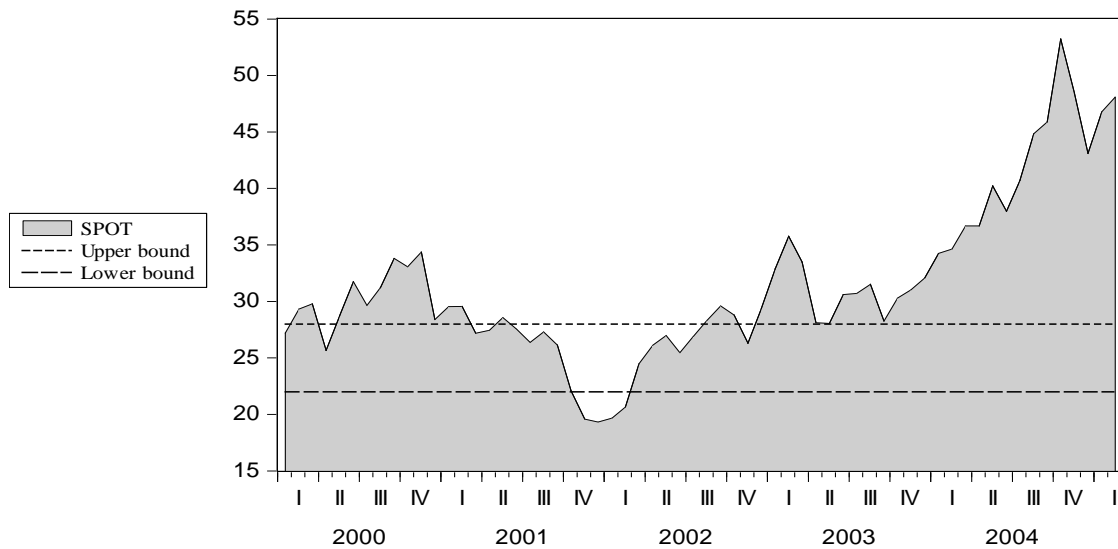
Understanding the determinants of the OPB will help in addressing whether the framework in the first place considers the most essential components (e.g. market realities) that address the objective the system is out to achieve (oil price volatility). Therefore, this will address the following concern about whether the policy is reflective of the market realities; whether it considers

³⁰ See evidence in figure 1.2 in Chapter 1.

³¹ Example of this is the announcement by former OPEC head- Ali Rodriguez of an unofficial establishment of \$22-\$28 band.

special timing; whether it is mounted with built-in dynamics that allows for flexibility when market conditions change; whether the views of the participants are considered in the process; whether the concept of cost plays any important role; whether the revenue stream is incorporated in the decisions and many other things. Hoffman (2000) noted that, effectiveness of an organisation is dependent upon its ability to adapt to developing changes in its environment (external factors). Understanding a clear nature of volatility, OPEC structure and the markets in which it operates are necessary in any attempt to examine whether OPEC policies are effective in addressing the price stability in the target band. It should be noted, however, that the primary objective of OPB is to dampen volatility by preventing sharp swings in oil prices as against volatility (see Fattouh and Allsopp, 2009). In another study, Fattouh and Scaramozzino (2011) highlighted that OPEC's actions can be interpreted to prevent oil prices falling below an unacceptable level as perceived by the members. Figure 2.1 presents for the period of the official OPB period, relationship between West Texas Intermediate (WTI) spot oil prices and OPEC oil price band in U.S. dollar per barrel.

Figure 2.4: Relationship between Spot Price and OPEC Oil Price Band in U.S. Dollar per Barrel



Sources: EIA Spot prices and OPEC OPB Policy

From figure 2.4, it can be observed that oil prices have been volatile over the duration when official OPB was in operation. Sharp swings in oil prices can also be observed over the period, but they are less skewed to the former part of the period than the latter part. The sharp rise and fall of prices were mainly contained in the former period. However, the pungent rise became permanent and remained high in the latter part of the period considered. Attouh and Allsopp (2009) noted huge tendencies for a sharp inter/intra-day volatility to be apparent within a specifically set oil price band. This type of volatility should not fall within the framework within which the success of the OPB policy should be assessed.

Despite the challenges faced by OPEC in pursuing OPB policy, some studies acknowledge the attempt as positive steps to stabilising oil prices from sharp fluctuation (see Tang and Hammoudeh, 2002) and was greatly welcomed by the Western powers (see Fattouh and Allsopp, 2009); others believed that OPEC lacks such an ability (Sodhi, 2008; Alhajji, 2009); while others still believed if OPEC had operated competitively in the oil markets, oil price could have been lower and even more stable than they were (see Hedenus et al., 2010). For example, based on their computations, estimated oil prices should have been between \$7-\$15/barrel had the oil market behaved competitively.

In line with the above, Alhajji (2009) argued that OPEC should never have even thought of introducing the OPB policy because it lacked the power to control the variables that infuse/trigger actions when any of the market conditions change. The answer to whether or not OPEC can influence oil price can be found in the framework of target pricing zone theory in which oil prices are allowed to float within a specified band with the expectation that both upper and lower limits are defended to ensure stability. The question is, is OPEC able to defend the boundaries in order to stabilise oil prices within the band, or it is beyond OPEC control (via policies) to actually address the instability in the oil market.

Dreher and Voigt (2008) classified credibility to be an asset which determines a country's investment and growth resulting from 'real interest rate'. They investigated the credibility derivable to a nation by joining membership of international organizations. According to Bharati et al. (2008) as argued in their model, it can be conceived that OPEC credibility = OPEC's overproduction relative to quota + world refining capacity utilization + OPEC capacity utilization + policy transparency (price + investment (production) transparency) – speculations (reduced speculations). In a competitive market with stochastic demand and supply shocks, the expectation is that, price clustering will not exist in the "least-significant integer digit," given a trend of an observed price range over time (Bharati et al., 2008).

2.7.1 OPEC Announcement on Oil Price Volatility

Guidi et al. (2007) examined the efficiency of the oil market in relation to its ability to incorporate the U.S. announcements in conflict and non-conflicts periods. Dermier and Kutan (2010) believed announcements surrounding the U.S. SPR relative to OPEC production decisions are equally important in understanding oil price volatility. They covered a 25 year-period (i.e. 1983-2008) to examine evidence of market reaction around the announcements periods for consistency with the "efficient market hypothesis" based on event-study's methodology. The study found no significant evidence of market reaction during "production increases announcements" but found significant positive returns during "production cut announcements." Furthermore, evidence is documented that SPR announcements also have the tendency of igniting a "short-run market reaction" for almost a week during

the post announcement period. Subsequently, they concluded after testing the cumulative abnormal return differences that SPR proves to be an ineffective means of achieving market stability. The implications of this finding lend support to the earlier claim that OPEC's action is often exaggerated by the media. While reduction is a means of attributing blame to OPEC, increased oil production by OPEC attracts little or no support from the market or the media.

Demirer and Kutan's (2010) finding lent support to the position reached by Deaves and Krinsky (1992) which found that announcements surrounding OPEC traders is systematically under-reacted by the traders in the markets, most particularly where bullish news is conveyed, which implies an abnormal return to certain investors. Brunetti et al. (2013) assessed the "fair price" pronouncements made by OPEC officials on the crude oil prices using two methodologies (event studies and autoregressive distributed lag models) on data from 2000 to 2012. The study concluded that the influence of the announcements in terms of provision of new news to players in the oil futures market is nearly "zero."

Graefe (2009) noted that despite OPEC's withholding of oil supply, international oil prices had been found to be "exceptionally inelastic" to most announcements in respect of the supply decisions. Schmidbauer and Rösch (2012) examined associations between OPEC production policies, particularly the informational aspect arising from OPEC conferences and the global oil price volatility computed in combination with Generalized Autoregressive Conditional Heteroskedasticity (GARCH) models on data (87 announcement) between 1986 and 2009 and extended regression models. The study documented evidence of positive effects/ relationship of OPEC announcements on expected returns and crude oil prices depending on the strength of the intended decision.

2.8 Review of Attempts to Challenge OPEC's Actions in the Oil Market

Hedenus et al. (2010) argued that oil prices were charged higher than the competitive level due to OPEC's restriction of production, which implies evidence of a transfer of wealth from the oil consuming countries to the oil-

producing nations. Greene (2010) computed over \$500 billion in 2008 as the lost/cost to the U.S. created by OPEC due to the market failures created from its production restriction. Given the provision of the Sherman Antitrust Act, one of the possible legal actions against OPEC, if established to be so, is that they could face some legal consequences before the U.S. courts. In this regard, in the recent periods, a body of evidence suggesting harsh sanctions against OPEC are reviewed below. The petroleum and public relations industries were primarily pioneered in the U.S. (Chomsky, 2002; Parra, 2004), and effort to protect its interest and their interests as well, should be well expected in any attempt to design a framework for the operation of the energy markets. There has been growing environmental concern over the amount of carbon emission associated with the consumption of crude oil, peoples' life-styles, and aggressiveness toward industrialisation and oil spills (Kolk and Pinkse, 2007). On this basis, the oil importing nations raised their doubt on the continuous dependence on a politically unstable group of nations by the name of OPEC for their supplies of energy (Parra, 2004).

Finally, it should be noted that many committees have been inaugurated and charged with different responsibilities aimed at challenging OPEC's actions since inception ranging from the U.S. Senate on Committee on Interior and Insular Affairs in 1975 to more recent reports such as the one on "the U.S. trade deficit, the dollar, and the price of oil" by Jackson (2011) as part of the U.S. congressional research series. For more on the review of the conclusions of most of these committees, see Grossack (1986); Ryngaert (2010); Morris and Meiners (2013). In most conclusions, if not all, the reports of the committees (as perceived by the above authors) proposed harsh measures to be taken against OPEC for its engagement in an illegal trade practice (i.e. anti-competitive behaviour).

2.9 Summary and Conclusion

OPEC has been identified as a major global oil producer with the highest proven conventional oil reserves since its inception in 1960. OPEC had emerged through a complex process propelled by members' desire to exercise control over their oil resources which they believed were under priced (see Chalabi, 2010). The movement for the establishment of OPEC had increased oil prices to the level desired by OPEC (Parra, 2004). However,

OPEC became well known globally as an effective cartel following its decisive action to restrict crude oil export to the U.S. and Netherland for their support to Israel during Arab-Israel war in the early 1970s. This major event had portrayed OPEC as a cartel that coordinated its actions with a view to promoting sustained high oil prices at the detriment of the Western economies (Adelman, 2001). The majority of the review of literature showed that OPEC operated as an effective cartel which deliberately restricted oil production and rarely invested in new crude oil capacity for its own ends (see Adelman, 2001 and Morris and Meiners, 2013). On the contrary, quite a few other studies (such as Bentzen, 2007; Cairns and Calfucura, 2012; Colgan, 2014; Kiswani, 2014) disputed the claim that OPEC had operated as an effective cartel.

Although the literature about OPEC's general and specific roles of OPEC in the oil market and its influence on oil prices still remained inconclusive (Schmidbauer and Rösch, 2012), the majority of the literature reviewed portrayed the actions of OPEC as an effective cartel (see Morris and Meiners, 2013). The implication of this dichotomy warranted further research to investigate why OPEC should introduce a policy (i.e. OPB policy) which presumably placed the organisation as an effective cartel that had control over oil prices but failed to adhere to such policy as it was accused by the Western media and politicians. Another interesting aspect relates to the fact that other factors might have hindered its ability to achieve that prime objective which only an effective cartel could achieve. Explaining these complex dynamics with a view to linking to the debate about whether or not OPEC had existed as an effective cartel from the year 2000 onward would be of academic interest.

**CHAPTER THREE: INFORMATION DISCLOSURE
AND THE ROLE OF OTHER MARKET PLAYERS IN
THE OIL MARKETS**

Chapter Three Information Disclosure and the Role of Other Market Players in the Oil Markets

3.1 Introduction

This chapter presents the global structure of the oil market, developments in new reserves (both conventional and unconventional) across the globe, trends in the renewable energy, and the potential impact on oil prices. Similarly, it presents a review of the empirical studies on information flow across the market, issues regarding transparency and the role of speculation on the prices.

3.2 An Overview of Global Oil Market and Price Volatility

The complexity of the oil prices is often explained in the context of "oil" being a non-renewable and exhaustible resource (see Hotelling, 1931). In economic theory, the price of a commodity is usually defined as the marginal cost of that commodity for an ordinary competitive market. However, one unique nature of the price for exhaustible resources is that it is often higher than its marginal cost when compared with other commodities (Hamilton, 2012). Oil market is often described as a very complex institution dominated by politics. The increasing oil prices which appear to be affecting or affected by other energy prices have been of increasing concern to various stakeholders ranging from consumers, analysts, international institutions and governments as well as the media (see Marimoutou et al., 2006). This leads to adoption of various complex approaches to its study. Modelling the global oil market would mean how decisions of various stakeholders or market agents (such as OPEC, non-OPEC, oil consumers) are modelled by the modeller (Powell, 1990).

Furthermore, the literature on the oil market modelling is divided into two broad categories, namely: optimisation and simulation (Powell, 1990; Baldwin and Prosser, 1988) although subsequent studies (see Cremer and Salehi-Isfahani, 1991; Alhajji and Huettner, 2000a) view the models from monopolistic and competitive perspectives (see Al-Qahtani et al., 2008b). Each modelling approach is guided by certain assumptions. Proponents of the optimisation approach to modelling oil market suggest an ideal situation where the intention of the decision-makers is a wealth optimisation over time

(Powell, 1990). Although, optimisation or inter-temporal optimisation modelling of oil markets (as suggested in Baldwin and Prosser, 1988) considers the extreme interest of a market player or set of players, there is no consideration of the social aspect of the markets in the most previous literature. Therefore, they suffered some degree of criticisms for being model-driven studies with many tendencies of arriving at wrong conclusions (see Smith, 2005).

In the same way, simulation models have been widely applied or tested in the oil market with a fundamental assumption that players are behaving competitively and/or operating towards a particular target price and take action to set a price path which is influenced by others depending on market developments (see Gately, 1984; Baldwin and Prosser, 1988; Al-Qahtani et al., 2008b). In other words, the second approach assumes a partial monopolistic set up. However, both approaches do not appear to be satisfactorily comprehensive in describing the events in the oil markets and the role of OPEC in influencing oil prices (see Slaibi et al., 2010). In this regard, Slaibi et al. (2010) proposed a framework considered cooperative as it encompassed the role of political and military influences connected with economic motives of both oil producers and consumers to keep price definition within a target zone. The econometric modelling of oil markets and prices based on Slaibi et al. (2010)'s approach has some degree of flexibility in the theoretical propositions. On this basis, the dynamic behaviour of the market players can best be described.

Oil price volatility has become a global concern given its effects on the macroeconomics of both developed and developing nations across centuries (Darby, 1982 and Hamilton, 1996, 2003, 2009 and Carlstrom and Fuerst, 2005). Oil, being one of the most important resources on the planet, has made the industry not only the largest but also the most international among other industries (Parra, 2004; Cortese, 2013; Lin, 2011). The opinions on the real causes of oil price volatility are divided across researchers and oil market analysts as much as opinions on the role of OPEC. The internationalisation of the oil companies and their approach to handling events that relate to environment, prices and technology transfer have been widely studied and debated from different perspectives and disciplines, which raise important

questions such as: Why oil and how does it influence power? Why are the oil prices volatile? How does the balance of power change over time? What are oil price volatility receiving important concerns to the market participants?

Historically, shifts in the balance of power in the oil markets have been established over time and from one player to another (see Fattouh, 2012; Russell and Ibrahim, 2013). Initially, during the early discovery periods of oil in the 1870s, the power of pricing was mainly determined by the market forces informed by demand and increased desire to produce more oil found in large quantities relative to the then-existing demands (see Hamilton, 2011). In the later periods when demand for high-related investments increased, the power to fix oil prices mostly moved to the hands of the major oil companies which provided the capital because the nature of the companies in those days did not accord much regards to any other parties apart from concern over the shareholders' wealth (see Parra, 2004; Chalabi, 2010). Yang et al. (2002) considered the demand side of the oil market to the OPEC supply using error correction models and simulation analysis in the light of the shift in demand and recession.

Furthermore, Marimoutou et al. (2006) showed inevitable connection between the sensitivity of oil prices and negative volatility and protective measures against market risk. In this regard, assuming such actions might pose a high risk to market players, their study applied both conditional and unconventional Extreme Value Theory (EVT) in assessing the risk-management strategies within the concept of Value at Risk (VaR) in the oil market. Over the last four decades, a growing literature has been well documented on the global oil market. More than thirty (30) models on the oil market were made publicly known by the Energy Modelling Forum (EMF) in the late 1970s alone (Powel, 1990). Jaffee and Soligo (2007) in their review of events and the role of the IOCs in the transformation of the international market found that oil markets are highly competitive. In all the OPEC nations, production of oil is largely carried out by the IOCs in partnership with the national oil companies. In the recent Forbes analysis of the top twenty five oil companies (i.e. both national and private international) based on their daily production capacity, national companies belonging to OPEC are competing

hand-in-hand with the national and privately-owned companies in the non-OPEC nations. Table 3.1 presents a summary of this ranking.

Table 3:1: Forbes Ranking of the World's Biggest Oil Companies

The World's 25 Biggest Oil Companies Based on Daily Production Capacity		
Ranking	Corporations	Million barrels per day
1	Saudi Aramco - OPEC (Saudi Arabia)	12.5
2	Gazprom - Non-OPEC (Russia)	9.7
3	National Iranian Oil Co. - OPEC (Iran)	6.4
4	ExxonMobil - OECD (USA)	5.3
5	PetroChina - Non-OPEC (China)	4.4
6	British Petroleum (BP) - OECD (United Kingdom)	4.1
7	Royal Dutch Shell - OECD (Netherlands)	3.9
8	Pemex - OECD (Mexico)	3.6
9	Chevron - OECD (USA)	3.5
10	Kuwait Petroleum Corp. - OPEC (Kuwait)	3.2
11	Abu Dhabi National Oil Co. - OPEC (UAE)	2.9
12	Sonatrach - OPEC (Algeria)	2.7
13	Total - OECD (France)	2.7
14	Petrobras - Non-OPEC (Brazil)	2.6
15	Rosneft - Non-OPEC (Russia)	2.6
16	Iraqi Oil Ministry - OPEC (Iraq)	2.3
17	Qatar Petroleum - OPEC (Qatar)	2.3
18	Lukoil - Non-OPEC (Russia)	2.2
19	Eni - OECD (Italy)	2.2
20	Statoil - OECD (Norway)	2.1
21	ConocoPhillips - OECD (US)	2
22	Petroleos de Venezuela - OPEC (Venezuela)	1.9
23	Sinopec - Non-OPEC (China)	1.6
24	Nigerian National Petroleum - OPEC (Nigeria)	1.4
25	Petronas - Non-OPEC (Malaysia)	1.4
	Total Contribution per 25 Biggest Companies	89.5
	Approximate Daily Global Average Oil Production	90
	Percentage Contribution of the World's Biggest 25 to World Oil Production	99.44%

Source: Forbes, 2013

Note: 2012 working interest production volumes calculated by Wood Mackenzie reflects oil plus the energy equivalent in natural gas.

In this regard, OPEC, non-OPEC and the OECD are summarised in table 3.2.

Table 3:2: Classification of the World's 25 Biggest Oil Companies Based on Country Group

<i>Classification of the World's 25 Biggest Oil Companies Based on Country Group</i>				
<i>Ranking</i>	<i>Corporations (National and International)</i>	<i>OPEC Million barrels per day</i>	<i>Non- OPEC Million barrels per day</i>	<i>OECD Million barrels per day</i>
1	<i>Saudi Aramco - OPEC (Saudi Arabia)</i>	12.5		
2	<i>Gazprom - Non-OPEC (Russia)</i>		9.7	
3	<i>National Iranian Oil Co. - OPEC (Iran)</i>	6.4		
4	<i>ExxonMobil - OECD (USA)</i>			5.3
5	<i>PetroChina - Non-OPEC (China)</i>		4.4	
6	<i>British Petroleum (BP) - OECD (United Kingdom)</i>			4.1
7	<i>Royal Dutch Shell - OECD (Netherlands)</i>			3.9
8	<i>Pemex - OECD (Mexico)</i>			3.6
9	<i>Chevron - OECD (USA)</i>			3.5
10	<i>Kuwait Petroleum Corp. - OPEC (Kuwait)</i>	3.2		
11	<i>Abu Dhabi National Oil Co. - OPEC (UAE)</i>	2.9		
12	<i>Sonatrach - OPEC (Algeria)</i>	2.7		
13	<i>Total - OECD (France)</i>	2.7		
14	<i>Petrobras - Non-OPEC (Brazil)</i>			2.6
15	<i>Rosneft - Non-OPEC (Russia)</i>		2.6	
16	<i>Iraqi Oil Ministry - OPEC (Iraq)</i>	2.3		
17	<i>Qatar Petroleum - OPEC (Qatar)</i>	2.3		
18	<i>Lukoil - Non-OPEC (Russia)</i>		2.2	
19	<i>Eni - OECD (Italy)</i>			2.2
20	<i>Statoil - OECD (Norway)</i>			2.1
21	<i>ConocoPhillips - OECD (US)</i>			2
22	<i>Petroleos de Venezuela - OPEC (Venezuela)</i>	1.9		
23	<i>Sinopec - Non-OPEC (China)</i>		1.6	
24	<i>Nigerian National Petroleum - OPEC (Nigeria)</i>	1.4		
25	<i>Petronas - Non-OPEC (Malaysia)</i>		1.4	
	<i>Average Daily Production (ADP) in Million Barrels per Country Group</i>	38.3	21.9	29.3
	<i>Percentage of ADP in Million Barrels per Country Group</i>	42.79%	24.47%	32.74%
	<i>Number of Corporations in Each Country Group</i>	10	6	9

Source: Forbes, 2013

According to the International Energy Agency (IEA) data, approximately 89 million barrels of oil and liquid fuels were produced and consumed per day globally in 2012. This is equivalent to around 32 billion barrels per annum. Non-OPEC production based on table 3.2 is nearly 60% despite the fact that they hold almost 1/4th of the global proved oil reserves. This has been consistently similar to the practice a decade ago (see Farrell et al., 2001). Although, OPEC has recorded a significant increase in its proved reserves over the last couple of decades, non-OPEC countries such as Canada, Norway and Russia have made huge discoveries in the conventional oil and gas which make them become important players in the market (see Farrell et al., 2001; Chalabi, 2010; and Russell and Ibrahim, 2013). Consumptions of the nations based on country-groups are presented in table 3.3

Table 3:3: Comparison of World Production and Consumption per Country Group

	OPEC	Non-OPEC (Excluding OECD)	OECD
Average Daily Production Per Country Group	38.3	21.9	29.3
Percentage Production Contribution to World Production Per Country Group	42.79%	24.47%	32.74%
Average Daily Consumption Per Country Group	8.36	34.92	45.99
Percentage Average Daily Consumption Per Country Group	9.37%	39.12%	51.51%
Conventional Oil & Gas Reserves Figures in 2012**			
Shale Oil and Gas Reserves Figures in 2012**			

Source: Forbes, 2013

** The conventional and shale energy figures above are based on the EIA data.

From Table 3.3, it can be observed that OPEC members consume less than 10% of the world oil production. Given the level of the OPEC consumption and corruption in the world corruption perception index, it can be argued that higher sales of oil beyond the current level by OPEC are likely to promote further corruption. It should be noted that non-disclosure of reserve figures relating to shale energy might have a potential impact on oil prices. Furthermore, recent development in the shale reserves is contributing to additional debates about the role of the new source of energy on the oil prices. Table 3.4 presents summary of the top ten countries in terms of shale oil and gas reserves from EIA data.

Table 3:4: Ranking of Countries According to Shale Reserves

<i>Ranks</i>	<i>Rankings in shale gas</i>		<i>Rankings in shale oil</i>	
	<i>Countries</i>	<i>trillion cubic feet</i>	<i>Countries</i>	<i>Billion barrels</i>
<i>1st</i>	<i>China</i>	<i>1,115</i>	<i>Russia</i>	<i>75</i>
<i>2nd</i>	<i>Argentina</i>	<i>802</i>	<i>U.S.</i>	<i>58</i>
<i>3rd</i>	<i>Algeria</i>	<i>707</i>	<i>China</i>	<i>32</i>
<i>4th</i>	<i>U.S.</i>	<i>665</i>	<i>Argentina</i>	<i>27</i>
<i>5th</i>	<i>Canada</i>	<i>573</i>	<i>Libya</i>	<i>26</i>
<i>6th</i>	<i>Mexico</i>	<i>545</i>	<i>Australia</i>	<i>18</i>
<i>7th</i>	<i>Australia</i>	<i>437</i>	<i>Venezuela</i>	<i>13</i>
<i>8th</i>	<i>South Africa</i>	<i>390</i>	<i>Mexico</i>	<i>13</i>
<i>9th</i>	<i>Russia</i>	<i>285</i>	<i>Pakistan</i>	<i>9</i>
<i>10th</i>	<i>Brazil</i>	<i>245</i>	<i>Canada</i>	<i>9</i>
	<i>World Total</i>	<i>7,299</i>		<i>345</i>

Source: EIA, 2013

Table 3.4 presents new discoveries in the shale oil and gas for the top ten countries; the only OPEC country in the list is Algeria.

3.3 Data Transparency in the Oil Market

This sub-section of the literature reviews studies about general framework for energy institutions and the extent to which transparency has been promoted with a view to enhancing oil price stability. In view of the fact that governance has been theoretically classified as internal governance (IG) or external governance (EG) (see Filatotchev and Nakajima, 2010), both

streams of the literature about OPEC's internal governance mechanism as well as the global mechanism through which its action is being managed and controlled externally are critically reviewed at this juncture. Internal governance concerns hierarchical governance (Lavanex and Schimmelfennig, 2009) while external governance concerns relationships with the external parties as reflected in the global energy governance (Florini and Sovacool, 2009). OPEC's actions therefore must have to be evaluated and judged against the effectiveness of both governance mechanisms in place.

To be effective in the IG, each organisation is expected to harness the resources at its disposal effectively by exercising significant control over its different units in the best interest of the organisational objectives. This section of the literature reviews governance. Therefore, transparency and compliance with the laid down rules are crucial in resolving internal challenges an organisation might face. This will consequently enhance the credibility and reputation of such organisation to be legitimately recognised and helps to reduce political pressures of operations within any community.

Similarly, effective external governance which relates to how the organisation deals with external forces and relationship with the community is highly crucial in uplifting the credibility of an organisation (Jensen, 2003, Hall, 2008). In this regard, OPEC was partly criticised by Saxton (2005) for being an isolated organisation well distanced from the discharge of duties to the Western society, and its governance is not clear to the public. As mentioned earlier, OPEC has suffered many allegations regarding both its internal and external governance, which has allegedly led to an ineffective and imperfect oil market (see Byzalov, 2002; Saxton, 2005; Greene, 2010). OPEC extends to its ability to manage effectively the relationship with other stakeholders without which the objectives of OPEC will never be achievable.

Therefore, effective governance and reputation of OPEC are associated with leadership of OPEC member nations (Doran, 1980 and Saxton, 2005) and effective management of relationship with non-OPEC members and with oil consumer nations by promoting policies that would not jeopardise their economies. The latter is enshrined in OPEC statute (2008) and made an important objective being pursued by OPEC today. The challenges facing

energy markets in general and oil³² markets, in particular, are enormous. Some of the key challenges linked to OPEC are widely documented in the literature. However, non-OPEC producers and oil consumers are rarely blamed for their actions that might potentially influence the market negatively. This has an implication for the functioning of the oil markets and the industry as a whole (see Cortese, 2006; Russell and Ibrahim, 2013).

Energy security remains a key concern to both oil consumers and producers given the scale of its perception and impact on actions of the affected market players. A more classical example that can be found in monthly oil reports from both organisations (i.e. OPEC and IEA) is the game of a blame shift between the two organisations. In most cases, OPEC claims that oil market is well supplied with the required volume of oil based on OPEC management's perception and evaluation of the market. Instead, OPEC often attributes the less impact of such overproduction to 'stockpiling' practice by the name of strategic oil reserves kept by most OECD countries. Similarly, if indeed, the issue of energy security is about the increase and regular supply of oil, investment in new capacity is not only considered as OPEC's sole responsibility but a similar step is expected from the oil consumer nations (Lukman, 2000).

However, a doubt was raised as why such investment has not been on the regular increase previously. One of the simple reasons could be the investment environment is not conducive (environmental, technical, political, economic, social problems) and the risk has become very high. A number of studies (Dalton et al., 1998; Agrawal and Knoeber, 1996 and 1999; and Sanda et al., 2005) found a positive relationship between effective governance and increase in shareholding of a firm, which impliedly means an increase in performance. Therefore, corporate governance plays a significant role in this direction, and this research views it as a key to enhancing global energy security for market stability. This view is consistent with that of Mazraati and Jazayeri (2004) who documented a need for coming together (through good governance) of parties or stakeholders in the oil market in order to address oil price volatility. On this basis, stakeholder theory has

³² The importance of oil as 'life blood' of the industries and human development is stressed by Schumacher and Kirk (1977); and Goldthau and Sovacool (2012).

been adopted in this study to explain the governance level that promotes understanding.

The study by Goldthau and Sovacool (2012) highlighted four key areas named 'dimensions of difference' in relation to governance issues in the oil industry for policy makers as compared with other fields. An interesting aspect of the study is the framework employed³³ to describe the differences.

Furthermore, another governance-related challenge to the oil markets revolves around data and transparency in the oil market; and it has received attention of the policy makers over the last decade and a half (see CEU, 2005; JODI, 2013). As highlighted earlier, JODI was mainly established to contain six members under the leadership of International Energy Forum (IEF) to voluntarily govern the data issues affecting the oil markets which have been linked to the frequent price volatility and speculative activities since 2000. Despite the fact that the market needs to be fed with more accurate, relevant, timely and handy data to aid users in their various decisions, the information dissemination in the oil market is not strictly or compulsorily governed with power of enforcement by any international regulatory body (Florini and Saleem, 2011). In this connection, incomplete data (Koomey et al., 2002), discrepancies in the data supply by reputable organisations such as IEA and EIA (Sornette et al., 2009), and climate-change challenges are important issues that remain unaddressed currently despite various initiatives such as the JODI and the Global Reporting Initiative (GRI) which were put in place to improve governance of information and enhancement of transparency. For any meaningful stability to be actualised, cooperation is necessary for the major global oil market players who begin to identify common goals as far as the challenges are concerned (Bressand, 2009).

3.4 A Review of Factors Responsible for Oil Price Volatility

There is a wide claim that oil prices have been volatile since the establishment of OPEC; a statement confirmed by empirical evidence.

³³ The framework uses three key concepts namely: energy security, justice and transition to low carbon energy.

However, it remains a puzzle whether OPEC has been the main cause of this high volatility as this allegation contradicts its objectives enshrined in the OPEC statute (2008). With the increasing shift of blame between consumer and producer nations, establishing the real cause of high volatility in oil prices will be important. The oil market is indeed regarded a complex institution where price formation is not limited to the action of a single player but a consortium of many forces (see Martina et al., 2011). Events that unfolded in the decades after OPEC was established showed that numerous factors ranging from economic incentives, geo-political events, quest for market leadership and control in the industry to be interpreted as possible factors responsible for volatile oil prices. The oil market is predominantly influenced by political factors, which often promote speculation about information regarding oil fundamentals. Over the last decade, there has been evidence of portfolio shift and increased activities of financial firms in the oil futures market which has made some observers conclude that the surge in oil prices observed during such decade was caused by financial speculation (Alquist and Gervais, 2011). For example, Richardson (2000) called for a combined responsibility among the oil stakeholders to enhance market data transparency with a view to achieving global oil price stability.

The failure of oil market fundamentals to explain the volatility in oil prices, which was observed in the last decade since early 2000s raised a question of whether speculation has played a key role in driving oil prices (Alquist and Gervais, 2011; Kaufmann, 2011). Beikalizadeh (2008) noted that most OPEC countries were dependent on the revenue from the exported crude oil for their economic growth and developments; and volatility in oil prices affects the economies of both oil consuming and producing nations. Many factors have been linked to oil price volatility and complexity of the oil markets from both consumer and producer perspectives and also market events that might be invisible in terms of the responsibility. Fattouh (2010) identified two views in relation to the key drivers of oil price volatility (during the first decade of the millennium) as follows: i "structural formation" in the oil market forces (demands and supplies) and changes in such fundamentals; and ii speculative activities. For instance, the speculation in oil prices and how they work in the oil market has been widely debated but with a mixed conclusion.

Gholtz and Press (2007) insisted that OPEC's role as a cartel remains largely a key factor influencing the market forces and thereby resulting in market imperfection and subsequent price increase due to supply fall. However, the study also acknowledges the crack in OPEC due to disagreement in the quota that often leads to cheating.

3.4.1 Relationship between Oil Price Volatility and Other Commodity Markets

Filis et al. (2011) examined the dynamics between oil prices and stock market prices for both oil-consuming and oil-producing nations using DCC-GARCH-GJR³⁴ methodology. However, the nations considered in the producing category were Canada, Mexico, and Brazil while the consumer nations were the U.S., Germany, and Netherlands. The study concluded based on the time-varying correlation coefficients that no difference exists between the two groups; the correlation responds (positively/negatively) to precautionary demand oil price shocks; which are the results of "global business cycle's fluctuations or world turmoil (i.e. wars)" (Filis et al. 2011: 152). However, it was found that the relationship between the two markets was not affected by oil price shock from the supply-side, but the lagged correlation values indicated that oil prices lead to a negative effect in the stock markets irrespective the shock's origin except for the 2008 global financial crisis.

3.5 Information Disclosure and Extent of Transparency in the Oil Market

The relevance of information to the oil market cannot be overemphasised. This can be well appreciated based on the framework and the primary motive for setting up the JODI. Although, compliance with JODI is on a voluntary basis, its ability to extend the concept of disclosure to the country by country level is of tremendous importance. It is always an established fact that more information is much preferable than less information to the investors (Wagenhofer, 2005) except if a particular group of investors have access to privileged information from the management, and that would result in an

³⁴ DCC-GARCH-GJR stands for dynamic conditional correlation GARCH based on a model estimation technique developed by Glosten, Jagannathan, and Runkle's (1993).

imperfect market (allegedly OPEC, see Saxton, 2005; Greene, 2010). More specifically, OPEC has been alleged by the U.S. Congress, Joint Economic Committee of concealing "...important industry information and is not forthright in sharing its output plans and price objectives".

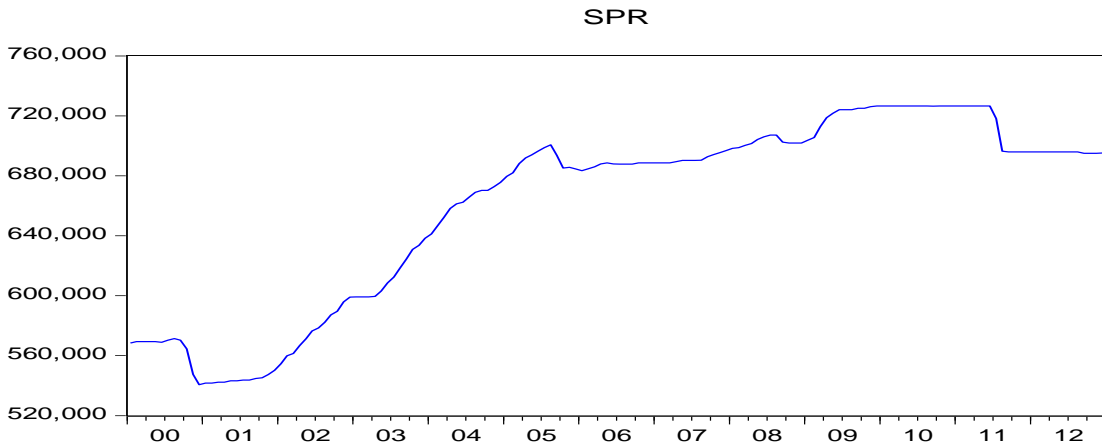
3.6 U.S. Stockpiling and Oil Price Volatility

The debate on the justification for maintaining oil stockpiles by the government, and the ideal volume of such oil stockpiles to be kept and/or released is still ongoing (Vatter, 2008). Although, most of the literature in this regards is in support of government maintaining such oil stockpiles, few studies have been conducted exploring the potential effects associated with the costs of maintaining such stocks in relation to appropriate level that might stabilise³⁵ oil prices.

The release from oil stockpiles proved effective in stabilising oil prices in the short run only during the 1991 Gulf war (Ghouri, 2006; and Vatter, 2008). Whether the use of oil stockpiles during this period was meant to generate support for the U.S. first intervention in Iraq by reducing the impact on the tax payers (both the U.S. and its allies) or a purposive attempt to stabilise oil prices, remains a difficult question to answer. If meant for stabilising oil prices and not politically motivated, a similar condition that warranted such response should be able to receive a similar response in the subsequent periods. This, however, was not the case when oil prices hit a high level in the beginning of the new millennium when evidence of speculation was evident. Ghouri (2006) emphasised that the U.S. SPR is only meant to accommodate shocks disruptive to supply in the long run. The uncertainty surrounding the release from SPR is expected to promote this speculative moment in the oil market. Figure 3.1 below shows how the U.S. stockpiling behaviour continues despite increasing oil prices.

³⁵ See Vatter (2008) for detailed review.

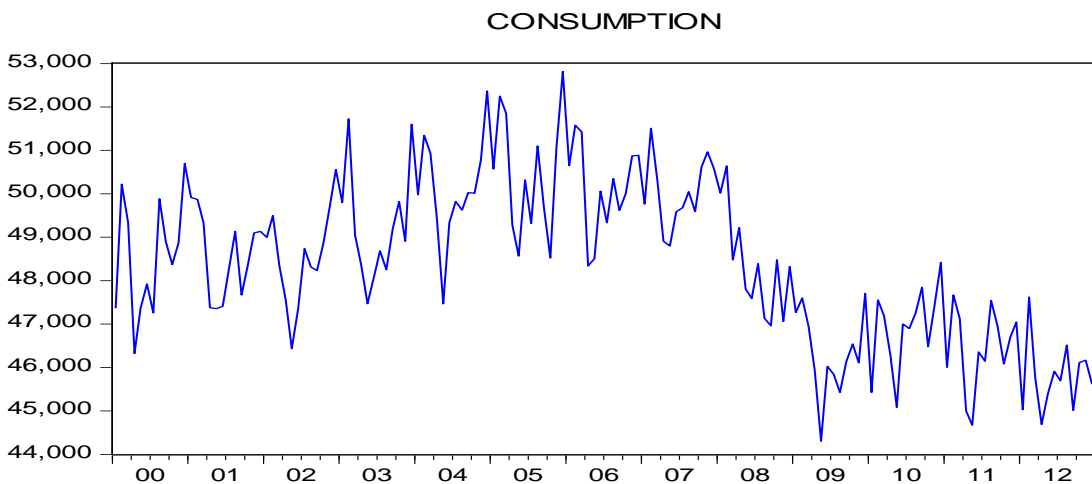
Figure 3.1: U.S. Strategic Petroleum Reserve in Thousand Barrels (2000 – 2012)



Source: EIA, 2013

Similarly, figure 3.2 presents the decline of U.S. consumption of OPEC oil from 2000 to 2012.

Figure 3.2: U.S. Crude Oil Consumption in Thousand Barrels per Day (2000 - 2012)



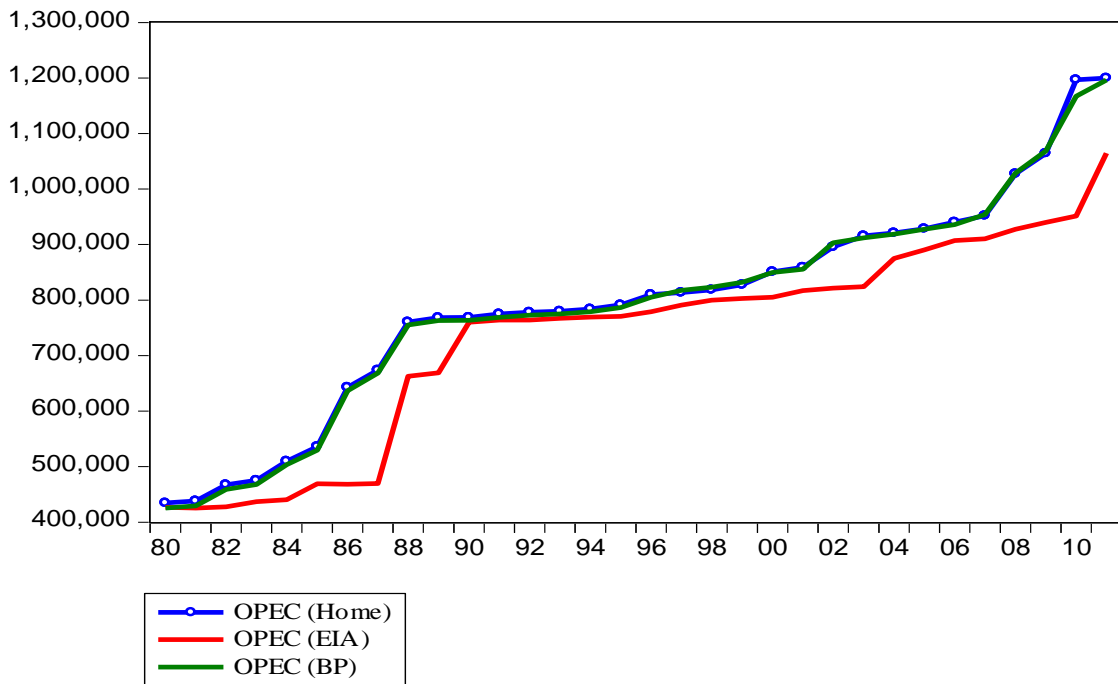
Oil prices have exceptionally grown high since the late 2003 exceeding the set target range set by OPEC. One of the key factors responsible for that was an increase in demand not only from the emerging economies such as China, India, and Brazil, but also due to the remarkable increase since 2003 in the U.S. consumption for filling up its Strategic Petroleum Reserves (SPR). The increase in SPR from 2001, January to 2004, April accounted for more than 122 million; however, within the eighteen (18) months between 2003 and

2004 alone, such inventories grew by 64 million to 663 million barrels from the earlier 599 million barrels at the beginning of the year 2003 (Ghouri, 2006; see also figure 3.2). During this period, OPEC's consistent efforts to stabilise oil prices within the target band (i.e. \$22 - \$28) was unsuccessful.

3.7 Analysis of the U.S. Disclosure Policies about OPEC and Implication on Oil Market Volatility

In an attempt to discuss the implications of OPEC disclosure policies about OPEC and its potential implication on the oil markets, we specifically analyse how the U.S. discloses not only the activities of OPEC, but also the resources in terms of reserves and operations in terms of oil supply to the oil markets. In order to achieve this objective, this subsection begins with OPEC's reserves and oil supply disclosure by the U.S. in relation to other credible Western databases (e.g. the BP, IEA) with a view to identifying any potential motive for the actions of the U.S. to promote speculation or obstruct OPEC's market power. In this connection, figure 3.3 presents graphical analysis of OPEC's reserves as disclosed by the U.S. and other parties.

Figure 3.3: OPEC's Oil Reserves (1980 - 2011) Three Databases



Key:

OPEC (Home): OPEC reserves as disclosed by OPEC database

OPEC (EIA): OPEC reserves as disclosed by Energy Information Administration

OPEC (BP): OPEC reserves as disclosed by British Petroleum

Figure 3.3 presents data used by the oil market analysts where BP and OPEC data seem to be closer to each other but with minor discrepancies, while the gap between disclosure from the two sources and that of the U.S. disclosure of OPEC reserves is very wide. There are various implications associated with the material gap in disclosure depending on the potential interpretation given for the motive. One possible interpretation of this behaviour, where the U.S. is assumed to deliberately understate OPEC's oil reserves might be that, the U.S. aspires for the leading position in the global energy markets. However, with the development in shale (see table 3.5) and renewable energy resources (despite their high costs) which could give the country some significant degree of energy independence, understating OPEC's reserves might be a possible way to achieve this objective. Therefore, it will be a way to portray OPEC as politically irrelevant.

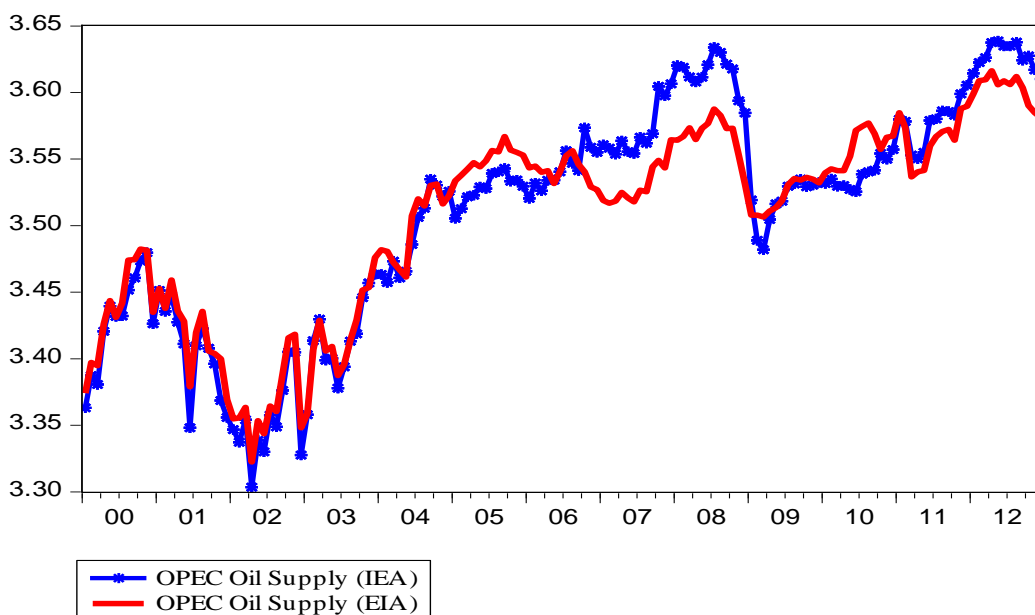
TABLE 3:5: Ranking of Countries According to Shale Reserves

Ranks	Rankings in shale gas		Rankings in shale oil	
	Countries	trillion cubic feet	Countries	Billion barrels
1 st	China	1,115	Russia	75
2 nd	Argentina	802	U.S.	58
3 rd	Algeria	707	China	32
4 th	U.S.	665	Argentina	27
5 th	Canada	573	Libya	26
6 th	Mexico	545	Australia	18
7 th	Australia	437	Venezuela	13
8 th	South Africa	390	Mexico	13
9 th	Russia	285	Pakistan	9
10 th	Brazil	245	Canada	9
	World Total	7,299		345

Source: EIA, 2013

A wide discrepancy can be observed from figures 3.4 and 3.5 in the disclosures between two important data bases that are considered reliable in the oil markets.

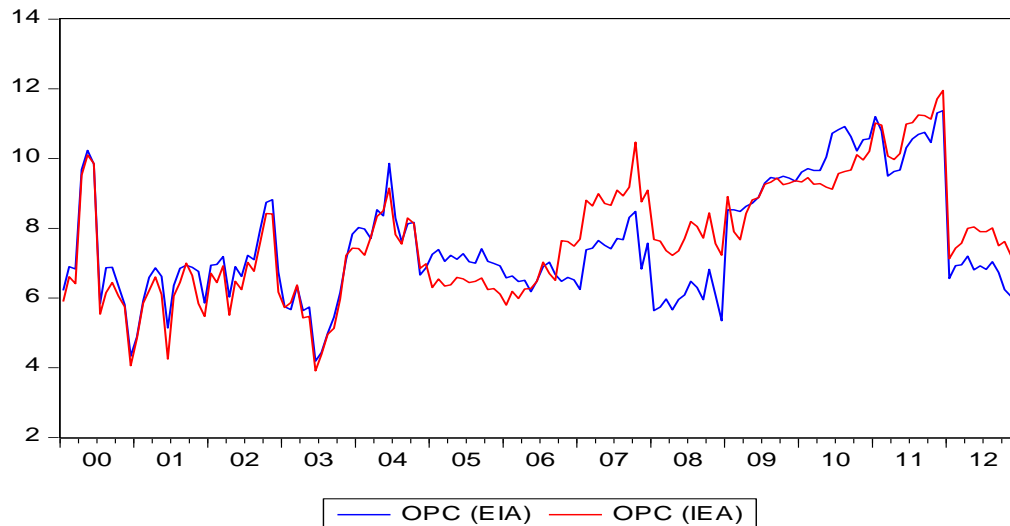
Figure 3.4: Discrepancy between IEA and EIA in Disclosure of OPEC Supply to Oil Market



From figure 3.4, the left vertical axis shows scale from 3.30 3.65 of logged values of OPEC'S oil supply according to IEA and EIA data, the horizontal axis presents the periods from January 2000 to December 2012 over which the disclosure was made. the initial four years (from 2000 to 2003), which coincide with the relatively low oil price regime and official OPB period, discrepancy in disclosure of OPEC'S oil supply is observed to be minimal when compared with the remaining subsequent periods. In periods 4 to 12, which are found to be highly volatile and when implied OPB was in force, there is inconsistent variation in the disclosure between the two databases with two years from 2006 to 2008 experiencing widest variation. Within the two years, IEA data reported higher figures than the EIA data source.

Furthermore, to highlight closer effect of the discrepancies, data for a variable used in this study (i.e. OPEC production cheating) is plotted in figure 3.5.

Figure 3.5: Discrepancy between IEA and EIA in Disclosure of OPEC Production Cheating



Key

OPC (EIA): OPEC Production Cheating (Energy Information Administration)

OPC (IEA): OPEC Production Cheating (International Energy Agency)

Figure 3.5 presents the discrepancy in the same variable employed in this study (i.e. OPC). The interpretations are almost similar to figure 3.4. The implications of these types of disclosure discrepancies are many, one of which

is speculative behaviour in the oil market. This evidence implies that the diverse views of the reporting might also misguide the market analysts' decisions, and that absence of a unified and authentic reporting framework for the market could be a basis for speculation. This finding lends support to Sornette et al. (2009). It could also result in arriving at different conclusions depending on the data source employed by a particular study. For example, from IEA view-point, OPEC might be concluded to have performed fairly well at above logged value of 10 (i.e. in the last quarter of year 7) as shown in figure 3.5, while EIA might conclude that OPEC restricted production cheating or excess production to logged value less than 8 on the vertical axis. Therefore, this might lead to a wrong conclusion that OPEC operated as a cartel in a period by a study using EIA data, while opposite conclusion might be reached by another study that employed the IEA database.

The implication of the entire disclosure of OPEC's reserves and oil supply might promote speculation about OPEC and oil prices. By understating OPEC's supply, the U.S. might be attempting to portray OPEC as a cartel responsible for the high oil prices. The growing evidence of anti-trust laws might have implication for OPEC in the long run. OPEC is accused of being a monopoly/cartel engaged in wealth transfer by punishing the Western economies. Given the provision of the Sherman Antitrust Act, one of the possible legal actions against OPEC will be detrimental to the members' objectives in the event the Act becomes successful. Therefore, there is a high risk of portraying OPEC as an effective cartel coordinating high oil prices while the reality of the matter remains the opposite.

3.8 Summary and Conclusion

In this chapter, events affecting the operation of the oil market and prices were reviewed. The structure of the international oil market in relation to the developments in new reserves (both conventional and unconventional) and trends in the renewable energy were highlighted. Information disclosure literature and its effect on the oil prices in the light of the role played by various international organisations were also discussed with a view to assessing the degree of the transparency in oil markets. Whilst identifying the role of oil market speculation on oil prices, this chapter also reviewed empirical studies on speculative trading in oil futures markets and its

influence on other markets and prices. In this connection, the need to conceptualise energy security and governance was also highlighted.

Furthermore, major factors influencing oil prices in addition to the role of OPEC were also reviewed. Although growing oil demand from the emerging economies such as China, India and Brazil has contributed to high oil prices, there was sufficient evidence to believe that U.S. led war had impeded OPEC's ability to create adequate spare capacity to the satisfaction of increasing oil markets. Based on the review of energy governance issues relating to oil markets, many studies (e.g. Winzer, 2012; Goldthau and Sovacool, 2012) established strong need to conceptual important factors such as energy security, governance framework and many more other issues in the global oil market for stability in energy prices including oil and gas. Classical examples establishing the potential effects of poor data and discrepancies in such data have been documented by JODI and Sornette et al. (2009) respectively. U.S. stockpiling policy has been established to be another important area that requires a critical review for effective global energy regulatory framework to be achieved. An effective regulatory framework in the global energy requires actions from the relevant international regulatory authorities such as International Organisation of Securities Commissions (IOSCO), International Accounting Standards Board (IASB), JODI, United Nations, and WTO.

**CHAPTER FOUR:
PHILOSOPHICAL BASES AND THEORETICAL
FRAMEWORK OF THE STUDY**

Chapter Four Philosophical Bases and Theoretical Framework of the Study

4.1 Introduction

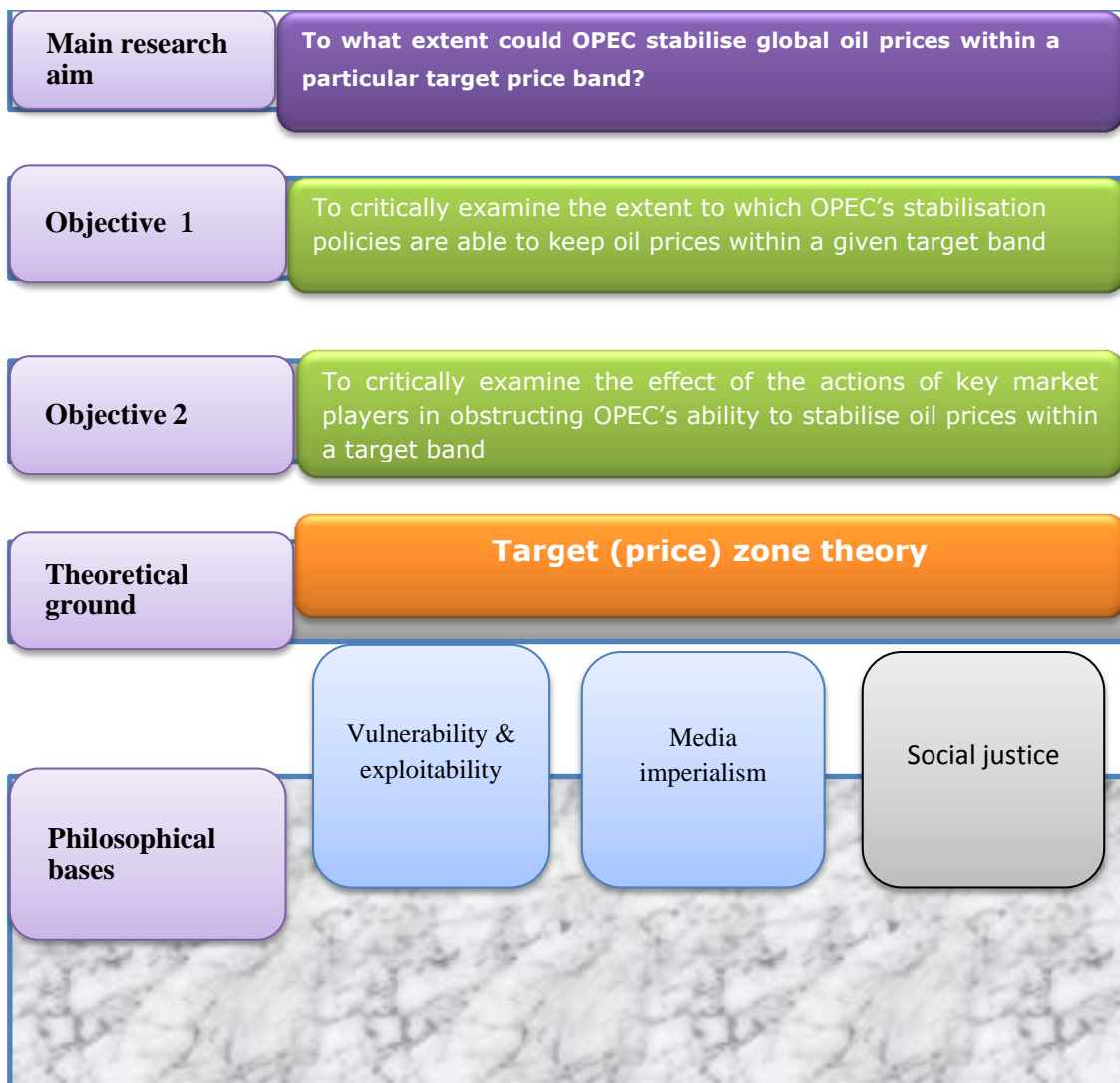
Theory in any piece of research plays an important role by shaping understanding of the relationships that exist between concepts (i.e. practice) and also the reasons why they exist in such directions (Downing, 1996; and Blaikie, 2010). The connection between concepts and social theory are well embedded in the positivist research paradigm (see Blumer, 1969). In highlighting the meaning of a theory, Blaikie (2010) gave a general description based on Inkeles' (1964) and Turner's (1991) definitions. It is perceived as "a heuristic device for organizing what we know, or think we know, at a particular time about some more or less explicitly posed question or issue" (Inkeles, 1964: 28). Turner (1991) perceived a theory to tell a story about the occurrence of events and why they should happen. This suggests that there might be some circumstances where a single established theory is insufficient to tell the story, therefore combining multiple theories become inevitable in such a situation. It is very possible that a theory is supported with certain philosophies that might brighten the understanding of how such theory works in the practical world. This is very much compatible with the research paradigm of positivists, which is mainly guided by deductive reasoning³⁶. In the light of the literature reviewed on OPEC, many studies including Bernabe et al. (2004) concluded that a single model is found insufficient to describe events in the oil markets, particularly the role of OPEC.

The philosophical bases tend to provide a good ground for a comprehensive understanding of the moral reasoning issues associated with the actions or conditions of the players that might influence the outcome of results in a way not possibly anticipated. North (1991) produced an important argument in this regard by highlighting the role of individuals' motives and interests in influencing the market operation as an institution. This same strategy has been found useful in many studies while developing a theoretical framework

³⁶ This aspect is dealt with in the next chapter that specifically focuses on the research design, approach and strategies for the conduct of this study.

based on multiple or single theoretical framework to underpin their studies. Costese (2006) employed some philosophical concepts adapted from institutional theory to integrate two prominent theories, namely: Lukes' conception of power theory and Mitnick's theory of regulatory capture. Hassan (2012) also used two environmental philosophies, namely: 'consequentialism' and 'deontology' to support integration three compatible theories (environmental Kuznets curve theory, legitimacy theory, and voluntary disclosure theory). This can be much appreciated in the structuration theory developed by Giddens (1976) and extended in 1984. Giddens' effort to establish a link between social theory tradition and social actors' experience in the light of the various structures (social totalities) informed what is captured in today's Structuration Theory (Blaike, 2010). Slaibi et al. (2010) also considered the effect of the military and politics towards achieving economic objectives of the key players in an attempt to keep oil prices within a target by applying target zone theory. In this regard, the chapter specifically deals with the philosophical bases embedded in the target (price) zone theory to build the research framework. Figure 4.5 presents a summary of the strategy to answer the research questions in the light of the theory and the philosophies (which are discussed in detail in the following sub-sections).

Figure 4.1: Theoretical Framework



As shown in figure 4.1, the main research question is highlighted with two objectives formulated to achieve the main aim of the study. In the light of the literature reviewed, a theoretical framework is developed. Three philosophies are discussed, which form ground for developing the theoretical framework based on target (price) zone theory (TPZ or TZT).

4.2 Philosophical Bases

Philosophical bases guide a researcher in analysing a theory or bodies of theories with a view to learning more about moral reasoning aspects associated with actors’ behaviour (see Fox and De Marco, 2001). Philosophical assumption provides basis or logical ground to understanding why a particular action that happens might likely produce a desirable or undesirable impact that impacts on a theory. This will provide an

environment in the deductive reasoning approach which ensures a contribution and improvement in a theoretical proposition in social science (see Blaikie, 2010). In this study, the theory adopted, as will be discussed extensively in the subsequent sections, is target (price) zone theory. It is consistent with the theoretical bases of the unrestricted VAR models, the TPZ theory can be employed to underpin the dynamics produced by VAR in describing the actions of the key players in the oil market as an institution. However, since the theoretical framework underpins the entire study, the philosophical concepts might well express the degree to which one actor in the institution is superior to the other or vulnerability of the other to the action of the other. Oil markets are characterised with high politics (Cortese, 2006; Selivanova, 2007; Slaibi et al., 2010). The concept of vulnerability and exploitability (VE) as proposed by Belal et al. (2013), the concept of the media imperialism, and the concept of energy (social) justice, are combined in the framework to underpin the entire study with a view to lending support to inferences in the analysis of the study.

4.2.1 The Concept of Vulnerability and Exploitability-OPEC Members

Although the concept of vulnerability is very old, it has generated keen interests among scholars with the publication of the World Development Reports (2001 and 2010) by the World Bank which emphasised the risk exposure of the various resource-rich developing and under developed nations in the more complex globalised markets and environments. Since then researchers have been exploring implications of various indices for vulnerability to economic shocks among others (see Echevin, 2013). Furthermore, the economies of some nations that are much stronger than others in the same group might be much larger compared with others. The difference was highlighted in Belal et al. (2013) in which a few powerful economies (e.g. Brazil, China, India, Mexico and Russia) account for 57.3% of the GDP contribution of the 150 countries. All OPEC nations fall into the world definition of emerging economies.

Previous studies (such as Morduch, 1994; Blaikie et al., 1994; Glewwe and Hall, 1998; Dercon and Krishnan, 2000; Ligon and Schechter, 2003; Suryahadi and Sumarto, 2003; Amin et al., 2003; Calvo and Dercon, 2008; Calvo and Dercon, 2013; Gallardo, 2013) have established a long relationship

between poverty and vulnerability. Other studies are interested in the vulnerability of the emerging economies to risk exposure of environmental hazards due to the actions of the multi-national corporations (MNCs). These developments extend to the international markets where the risk exposure is likely to be much higher. This relationship is evident in a number of measures of vulnerability that include "Vulnerability to Expected Poverty" and "Vulnerability as Threat of Future Poverty" (Montalbano, 2011) despite the effect of globalisation where the local markets of the less-developed nations are to compete with the economies of developed nations. This type of vulnerability in terms of competition with the multinationals due to weak technical know-how to handle the industry in their respective nations is well documented in many studies (see Hitt et al., 2000).

Three main risk management approaches to vulnerability are raised in the less-developed countries' literature based on the World Bank's classification of vulnerability, which includes: risk exposure; responsiveness capacity; and a lowest relevant event consequence (Montalbano, 2011). Distinguishing these approaches from the one defined by the UNDP, Montalbano (2011:1492) highlights "Sustainable Livelihood Vulnerability" approach as effective given its consideration for the incorporation of negative shocks sensitivities of key macroeconomic variables that are good indicators of livelihood and resilience. By virtue of the vulnerability exposure to poverty and inability of the less-developed countries to provide the appropriate 'adaptive capacity'; places some countries at disadvantage and risk of being exploited. Subsequently, in designing any global policy framework, such vulnerability exposure and country-differences need to be incorporated otherwise the less-developed nations could be prone to any exploitation (Belal et al., 2013). This is due to the fact that lower risk and higher resilience and 'adaptive capacity' are attributable to the developed countries (Ward and Shively, 2012).

Most of these less developed or emerging economies, including OPEC nations heavily rely on export of natural resources for foreign reserves or national income (Aulakh et al., 2000; Yiu et al., 2007; Beikalizadeh, 2008). Internationalisation of these economies measured by the foreign direct investments (FDI) brings about economic growth where industrialisation

process is strengthened with development in the “financial and informational infrastructure” (Belal et al., 2013; Gaur et al., 2014). However, the tendency for the nations to compete favourably in the modern markets dominated by the Western capitalist system is impulsive. Other studies (such as Luo and Tung, 2007; Gaur et al., 2014) further noted that those economies that perform better than others have in addition to export, FDIs of those developed nations significantly improved.

This may suggest that depending on the Western or U.S. interest, some nations might be placed at advantage over others. Resource curse theories (see Shaxson, 2005; Baggio and Papyrakis, 2006) are other means to explain the effect of poor governance and massive unemployment, and low economic growth and development in those nations. In a longitudinal study which employs data from 1989-2005, Gaur et al. (2014) examined factors responsible for such a strategic shift from export to increased FDI from resource- and institution-based perspectives. Conceptualising the idea of the vulnerability of these nations due to their heavy dependency on the Western markets for the revenues (e.g. oil revenue as argued by Beikalizadeh, 2008), assuming that these nations should be engaged in practices that might deter the revenue inflow might not be sound. The developed nations have the advantage of exploring some alternative sources, though they might be expensive, as against the developing nations that are heavily dependents on the big economies for their survival. The tendency for exploitation, therefore, from the developed nations to the under-developed or developing economies is more to be expected than the other way round.

4.2.2 The Concept of Energy Social Justice

Social justice demands for fairness in distribution of resources and disclosure of information from the institutional perspective to those who deserve them (see Fox and Marco, 2001; Belkaoui, 2007). In reality, some resources are unevenly distributed in the nations across the globe. While some have a competitive advantage in the light of Adams Smith’s economic arguments, trading between nations over the resources in which they have competitive advantages will create wealth and make both nations better off. In the modern markets, social justice is meaningful when resources are fairly valued in the market system irrespective of where they originate from. Energy is

considered an important driver of industrialisation for the developed nations as earlier stressed. As discussed in Chapter 3, despite the fact that OPEC nations own over 75% of the global proved conventional oil, their consumption remains less than 10%, which shows evidence of the level of industrialisation in those nations. Evidence presented in the vulnerability and exploitability concept of the level of poverty also portrays the level of risk exposure associated with the injustice in the resource and capital allocation of the international markets in terms of value. Yet the countries still suffer from the problems of electricity, which affect the industrialisation processes, economic growth and corruption. Corruption and poor governance are the consequences.

Goldthau and Sovacool (2012) identified energy justice as an important element for addressing the increasing governance problem in the international perspective. The study distinguished energy justice from two perspectives of demand and supply. Energy injustice according to the study revolves around a global energy system which denies billions of humans access to electricity, or, alternatively, they become dependent on the local source of energy that heavily pollutes not only the environment alone but also leads them to become susceptible to health-related risks. In highlighting such types of energy injustice based on the IEA, UNDP, and UNIDO reports in 2009, Goldthau and Sovacool (2012) stated a figure of 1.4 billion people that are without electricity and 85% that are based in rural areas, despite the fact that most of the countries are rich in resources. Goldthau and Sovacool (2012) also noted the disparity in the access to energy in the OECD nations is very wide, which indicates more evidence of energy injustice. Different approaches to social justice exist. For example, Rawls' theory of justice approaches social justice from the principle-based perspective which is applicable in developing the basic structure of society derived from social contract theory. The theory poses a huge challenge to the normative approach to ethics based on utilitarianism³⁷. Other perspectives of social justice have emerged based on Nozick's and Rawls' theory of justice.

³⁷ Utilitarianism within the normative theoretical approach is about the ethics of undertaking actions that best maximise the utility.

In this direction, multi-national corporations operating in most of these resource-rich nations have not helped in transforming the lives of the people despite the increasing contribution of the companies to the environmental pollution and degradation as documented in many UN and many other independent studies. This problem can be summarised in the social and environmental accountability context of the MNCs operating in the resources rich nations. For example, Afifi and Jager (2010) wrote extensively about how migration of the residents in the resource-rich nations is forced due to degrading environment and social vulnerability resulting from the actions of the MNCs. However, there is still no clear definition of the dimension of justice in the international context as well as its mandatory regulatory enforcement (Goldthau and Sovacool, 2012). Similar conditions apply to the international energy industry and markets where governance is lacking (see Costese, 2006; Goldthau and Sovacool, 2012).

4.2.3 The Concept of Media Imperialism

It has been observed that the Western media portrays OPEC (and its members) in an adverse light Chomski (2002). In this study, this concept is employed as a framework against which the Western media engages in depicting OPEC as a cartel behind most energy crises in the west. This is possible where in an attempt to legitimise a particular energy transition by way of expensive policies in the short-run, the media might be engaged in disseminating analysis to make people believe in a particular cause. A number of studies have been carried out on the role of the media in transforming public perceptions about the pictures of events surrounding them (see Bennett, 1982; Zaller, 1999; Koomey et al., 2002; Bennett, 2004; Coyne and Lesson, 2009; Oates, 2008; Stockmann and Gallagher, 2011) This is due to the concentration of ownership and control of the media in the hands of only a few individuals. In this regard, there is high likelihood for OPEC's image to be misrepresented most particularly where such misrepresentation could earn some positive results to the Western energy policies. Thus, for example, production quota allocations by OPEC may be under-publicised or over-publicised depending on the impact such reporting would have on the reputation of OPEC (see Colgan, 2014). This could be an indication of use of media in manipulating information for oil market players

to achieve a political or economic objective. Evidence of this behaviour has been mentioned in many studies (e.g. Kepplinger and Roth, 1979; Chalabi, 2010; Colgan, 2014).

As mentioned earlier, oil market imperfection has been attributed to OPEC's actions. Media plays a key important role in this regard by portraying OPEC's imperfection as the basis for the crisis in the oil markets (e.g. Morris and Meiners, 2013). Also, the media is important in portraying the risk the OECD nations, particularly the U.S., are exposed to by their reliance on the OPEC oil. It can be cogently argued that the way these events are packaged and presented by the media might influence the level of the energy transition³⁸ of the OECD nations.

Kalyango and Vultee (2012) highlighted the impact of media in orchestrating conflict between nations in developing economies. Thus, Chomsky (2002) articulated reasons behind the U.S. led war in Iraq believing that the media was employed by politicians to manipulate peoples' perceptions so that economic and political objectives could be achieved via military action. Few people would disagree that Iraq is an important member of OPEC, and possibly the U.S.-led war could be an attempt to weaken OPEC by promoting high oil prices due to the crisis and also in view of the projected energy opportunities as witnessed in the U.S. shale energy revolution that sparked into life just after the war was formerly ended in 2005 as shown in figure 1.2. It is also possible that OPEC statements (i.e. expressed by its leaders in many forums) or its position (i.e. expressed in periodic reports such as monthly and annual reports) might be accurate, in which case it has been making attempt to stabilise oil prices, but the media effect which is outside OPEC's control could make OPEC's action ineffective. This is true where two conflicting parties give evidence, and the weaker one is blamed for the consequence regardless of the facts. Some empirical evidence is consistent with this view such as Bharati et al. (2013) who found that OPEC's official 'fair price pronouncements' have no effect on oil prices for data covering almost the period considered in this study.

³⁸ Energy transition is a conceptual term used to describe a shift from one form of energy to a portfolio of other sources usually due to security, environment. It is also backed up by several policies and strategies designed to achieve such purpose.

4.3 Theoretical Ground

The oil market is characterised as a complex institution where it is difficult, if not impossible, for a single model to describe events surrounding interaction of the players and their influence on international oil prices. The oil market works as a system with various institutions seeking seemingly different objectives. For example, despite OPEC's continuous commitment to stability of oil prices as reiterated by its leaders, other users/players strongly accuse it of being a villain and performing actions contrary to its stated objective (see Saxton, 2005). Furthermore, IEA/OECD members also claim a strong commitment to oil price stability. In contrast, the actions of the other market players might have caused OPEC's action to be less effective in achieving desired objectives (Russell and Ibrahim, 2013). Whichever way, the economic value and benefit derivable or enjoyed over time might be a good yardstick to evaluate critically an incentive of any institution (whether OPEC, non-OPEC and IEA/OECD).

Many theories, as highlighted in Chapter 2, have been advanced in previous studies attempting to underpin the influence of OPEC in the oil market vis-à-vis the actions of the market players. However, the major weaknesses of the theories are; 1. They view OPEC in isolation of the role simultaneously played by other players in the market who could influence OPEC decisions. 2. In view of the fact that so many studies rely on a single theory to underpin understanding of OPEC, the benefits of connecting the theory with any moral philosophy is lost. In this context, target (price) zone theory is used in building the framework for this study. Fox and Marco (2001:351) noted that "much political action is aimed at amending the existing laws by introducing new legislation." In this regard, there is a view that strongly believe that OPEC's establishment in 1960 was politically motivated to address issues surrounding the pricing of oil which the founding members believed was not competitively sold to IOCs (Parra, 2004; Chalabi, 2010). As argued earlier, there is high an incentive for OPEC to maintain stable oil prices within a target band in the light of the three philosophical concepts identified in the previous sections of this chapter. Below the lower band, investments will be discouraged, while above the upper band, it will encourage investments in the alternative energy sources. A natural question at this point is: What will

happen in the event where investment in alternative energy has been committed by the Western politicians initially due to high oil prices instigated by OPEC? Should the Western world sustain such high oil prices for the viability of their investments or choose to incur loss on the committed investments? If the answer to the above question is yes, therefore, the IEA or the U.S. might engage in preserving a target price other than that of OPEC in an effort to safeguard the return for the committed investments and systematically charge it to OPEC.

In providing answer to the question above, Colgan (2014) noted that it is possible for OPEC to know that the market power it is portrayed or purported to have possessed to drive high oil prices are not real, however, given the fact that they benefit from the resulting high revenues they tend to be silent. This might not be unconnected with the concept of vulnerability and demand for high oil revenue to sustain their economies as discussed above. In the last decade, OPEC has produced a number of measures (including new reviews such as 'who gets what from imported oil')³⁹ aimed at promoting public awareness about how oil revenue from the imported OPEC's oil (presumably in the high oil price regime, e.g. 2008-2014) is usually shared between OPEC and other key players. This includes additional analysis for tax imposed by the Western countries to arrive the pump price in the petrol and gas stations (see OPEC, 2014)⁴⁰. Perhaps, this analogy fits the example of the strategy adopted by Japan (which had high energy costs) to enforce innovative transition to energy-efficient products that placed the country at a highly competitive level internationally in the electronic industry (see Porter, 1980). If the Western nations are faced with high energy cost, a potential option could be consistent with Porter's. It remains an interesting side of a story to understand that such issues are seldom discussed by the western media in analysing the causes of high oil prices.

4.3.1 Target (Price) Zone Theory

The target (price) zone theory (TPZ or TZT) is discussed at this stage to enable first, the linkage with the philosophies and second, the discussion of

³⁹ The review was initially introduced in 2008 and has been consistent to date

⁴⁰ Check the link below for the latest (i.e. 2014) review:
http://www.opec.org/opec_web/en/publications/341.htm

logical processes of developing the framework that underpins the research. The idea of target (price) zone theory is not new in the OPEC and oil market literature as it has been applied and found useful in describing the movements of oil prices in oil markets (see, for example, Tang and Hammoudeh, 2002; Slaibi et al., 2010; Bharati et al., 2012). It was originally borrowed from the monetary economic (particularly exchange rate economic) literature to experiment OPEC's ability to stabilise oil prices within a particular target band with upper and lower limits (Hammoudeh and Madan, 1995; Tang and Hammoudeh, 2002; Flandreau and Komlos, 2006; Al-Qahtani et al., 2008b; Bharati et al., 2012). Although not explicitly described in the Keynes' (1930) economics, Svensson (1991 and 1992) noted that proclamation championing the modern TZT can be attributed to Keynes (1930). The first empirical analysis examining structure of the currency bands vis-à-vis the behaviour of the exchange rate was made by Krugman (1991) in a seminal presentation on "exchange rate target zone" (see Kempa et al. 1999).

Furthermore, the theory has subsequently been applied and improved by modification to capture important behavioural elements in an attempt to prove the movement of oil prices within a given target band, following a series of studies carried out in this regard. For example, Flandreau and Komlos (2006) believed that improvement in the theory is achievable by deriving a target zone model based on a combination of nested hypotheses in relation to 'Austro-Hungarian'. In this connection, evidence for policy credibility as well as efficiency of the market produces an inference for the workability of the theory. Similarly, evidence for price clustering in a volatile oil market is believed to produce support for OPEC's actions and ability to stabilise oil prices within a target price band (see Bharati et al. 2012).

Furthermore, by introducing philosophical reasoning in the structure of the interaction between the key market players, effectiveness or otherwise of the OPB policy could properly be evaluated. For example, historically, oil market players have been at different levels in terms of skills, infrastructure and tools while operating at various stages of the market, industry and price evolution (see Parra, 2004; Chalabi, 2010) for review of the historical gaps between the market players). This is partly one of the possible reasons for the failure of game theory models to provide comprehensive underpinning of

the nature of OPEC and its influence in the oil markets. Guttman (1996) highlighted the weaknesses of early evolutionary economic models⁴¹ by highlighting the missing link of 'rationality' in the players' optimisation decisions which the models were unable to capture and describe. In this regard, the three philosophical concepts supporting the theoretical proposition are discussed in the subsequent sections (i.e. sections 4.2.1-4.2.3). Considering this study's approach and emphasis on the social action theory, applying TZT should greatly improve the social aspect of the market interactions associated with the activities of the key market players. Examining the interactions between various players and any likely inferences given the philosophical foundation built in the study, will provide a better framework to understand and improve the existing theory consistent with the deductive reasoning approach⁴² to research.

However, earlier theoretical attempts for target behaviour models⁴³ on OPEC comprise of target capacity utilisation (Griffin, 1984); target revenue (Alhajji and Huettner, 2000a and 2000b); and target price zone (Slaibi et al., 2010). Although, these theoretical concepts were earlier reviewed in Chapter 2 of this thesis, an attempt is made to highlight the relevant aspect of the review to the theory adopted for the conduct of this study. It has been mentioned earlier that it is never an overstatement to conclude that, given the structure of the OPEC nations (in terms of reserves ownership, production/ratio, low oil consumption, vulnerability), all OPEC nations mainly depend on oil revenue for the sustenance and development of their economies. In this regard, volatility in oil price and other related issues of energy security is of tremendous concern to them as much as it is to the OECD and non-OPEC nations (see Lukman, 2000). In this regard, high oil prices may results in damage to OPEC in two ways: first in the volatility of budgets and other macroeconomic activities of OPEC members (Farzanegan and Markwardt, 2009); and second in promoting investment in alternative sources of energy

⁴¹ Some of the evolutionary economic models (such as Axelrod, 1981 and 1984; Hirshleifer, 1982) were widely criticised in Guttman (1996) for neglecting rationality and maximisation in behaviour.

⁴² This approach is discussed in Chapter 5 of this study. However, it should be noted that it is a research approach where conceptual and theoretical framework is designed with the intention of testing for empirical evidence to be generated and general inferences to be deduced in the light such established structure/framework (Collis and Hussey, 2009).

⁴³ An attempt was made by Al-Qatani et al. (2008) who reviewed the large literature on target behaviour by OPEC.

by non-OPEC countries (Bazalov, 2002). This will obviously translate into the long-run decline or loss in the stability and revenue streams of OPEC nations.

Similarly, low oil prices are likely to discourage not only investment in the new reserves of OPEC oil by the both OPEC national companies and the IOCs. They will also translate into low national revenue, foreign reserves earnings to the OPEC nations who mainly depend on oil for their incomes (Noguera and Pecchecchino, 2007). Consequently, it will be difficult for them to service their debts and other costs of governance, which might potentially lead to a failed state. Logically, IOCs are likely to lose their revenues as well in view of the fact that most exploration activities in the OPEC nations are being carried out by the well-established IOCs. Stabilising oil prices in line with the OPEC's stated objectives is the key to a win-win strategy for OPEC and IOCs. However, what might seem to matter in this regard revolves around the control of the prices in the light of the market forces (including potential roles of key players with different objectives in the market institution). One of the possible propositions of the TZT, as highlighted by Slaibi et al. (2010), is that the market players might struggle to apply different strategies to keep oil prices at a different target zone considered more suitable for achieving their energy policies and national interests. In this connection, Slaibi et al. (2010) stressed the role of interaction between the political, military and economic forces for both oil producers and consumers in defining a cooperative framework towards a target price zone.

This suggests that empirical review of various economic, political and military measures, gains and strategies could be useful in obtaining evidence and deducing inference about how a target price zone is achieved by players in the oil market. Therefore, exploring economic incentives behind key factors that drive high oil prices such as speculation (Davidson, 2008), discoveries in shale and other unconventional forms of energy (Russell and Ibrahim, 2013), development in renewables energy, as discussed above, are some the important arrears where such evidence could be generated. These developments, coupled with the energy diversification of the OECD nations which resulted in consistent decline of OPEC's oil consumption in the OECD nations (see Russell and Ibrahim, 2013), oil stockpiling behaviour and role of information dissemination to oil market players, might raise further

challenges to OPEC in its attempt to stabilise oil prices within a desired target band and TZT might be informative in underpinning the various interactions in this regard. More of the relevant aspect of the theory is discussed in the light of the literature reviewed in both Chapters 2 and 3.

4.5 Summary and Conclusion

In this chapter, four main sections were used from introduction to conclusion with a view to discussing the philosophical assumption employed for this study. The first section introduced the chapter. The second section discussed the relevant philosophical bases. Three philosophical concepts were used, which included vulnerability and exploitability, social justice and media imperialism. Section three presented the theoretical underpinning of the study and finally section four summarised and concluded the chapter. A target (price) zone (TPZ) theory was used to form the theoretical ground and in the light of the philosophical bases to underpin this study. This strategy was adopted following the North (1991) argument about understanding market as an institution. In an attempt to understand political economy of institutional decisions and changes, North (1991) argued that oil market should better be understood as an institution based on a comprehensive framework. Many other studies such as Giddens (1976); Cortese (2006); Hassan (2012) employed a similar strategy to aid the understanding of the main theories discussed in their theoretical frameworks. Designing an effective framework is crucial in understanding events in the oil market most particularly in relation to the OPEC's actions (policies) in the oil markets and the political economy of the OECD/IEA energy transition which was grossly understudied (see Goldthau and Sovacool, 2012).

Furthermore, the theoretical underpinning for this study was used to understand the extent to which OPEC's actions targeted to control oil prices within a particular band set by OPEC. Besides, the theory would form the basis for understanding why OPEC could not control oil prices within the band it set given the assumption it had such a capability similar to an effective cartel. In view of the criticisms and allegations made against OPEC, this theory would help in interpreting some important events in the international oil markets and how regulators should better be informed of complex dynamics in the markets based on available empirical evidence. TPZ theory

has has been widely used in many economics studies that aimed at understanding effectiveness of government interventions/policies in controlling interest rates within a particular range withi both lower and upper boundaries (see Kaugman, 1991). Recently in the last decade, the theory has been widely advocated in relation to OPEC (see Tang and Hammoudeh, 2002 and Slaibi et al., 2010).

**CHAPTER FIVE: RESEARCH METHODOLOGY
AND METHODS**

Chapter Five Research Methodology and Methods

5.1 Introduction

The previous chapter discussed the theoretical framework that underpins this study. This chapter discusses the research method, methodology and assumptions that guide the philosophical and statistical framework employed in this study. It has been widely argued that a researcher's philosophical framework, which includes assumptions about the nature of reality and how it should be approached, largely influence the choice of the research methods which are inevitably influenced by the research design (Burrell and Morgan, 1979; Blaikie, 1993; 2007; and 2010; Symon and Cassell, 2012; and Saunders et al., 2012). A rigorous and successful harmonisation of such a philosophical stand and appropriate statistical tools are likely to enhance the methodological fit⁴⁴ (Edmondson and McManus, 2007) which impacts on the quality of the research results. For this reason, this chapter is technically regarded as the steering wheel of the entire research as it identifies and discusses the research paradigms and presents justification for the choice of the research methodology and methods.

Consistent with the above view, each research project must ensure that proper "internal consistency"—for various elements within the research project—is achieved for a meaningful theoretical and practical impact to be made. Edmondson and McManus (2007) identified the following important elements: research question; prior literature on the subject area; proper research design; and the "theoretical contribution." In line with the above argument, this chapter connects the various research elements in an effort to ensure appropriate methodological fit. Besides, the success of the entire strategy of the research depends upon how the research philosophical and methodological underpinnings (such as ontology, epistemology, axiology, methodology, and methods) are identified and designed to provide convincing answers to the research questions (see Grix, 2002; Blaikie, 2007; Collis and Hussey, 2009; and Saunders et al., 2012).

⁴⁴ Methodological fit is defined by Edmondson and McManus (2007: 1155) as the "internal consistency among elements of a research project." This definition is consistent with the definition given by Saunders et al. (2012: 158) on methodological coherence covered in the term they refer to as "research onion".

5.2 Philosophical Assumptions in Accounting Research

To ensure proper understanding of a social reality within the parlance of social sciences, appropriate research paradigm must be stipulated. 'Paradigm' refers to the philosophical framework identified by the researcher to guide the conduct of the research in line with conventional wisdom relating to the application of philosophies as well as the assumptions and ideas regarding the nature of knowledge and the entire universe (Collis and Hussey, 2009). This section presents the literature on the philosophical issues in research and how they are identified for the purpose of the study. Historically, a paradigm is developed when it is discovered that the older or existing one could not provide a comprehensive explanation about a phenomenon as people's perceptions of reality progress (Kuhn, 1962; Burrell and Morgan, 1979; Chambers, 1994; Pretty et al., 1995; Ryan et al., 2002; Blaikie, 2007; Collis and Hussey, 2009). For example, the drawbacks observed in using questionnaire-based surveys (e.g. time-consuming, costly, and inability to provide in-depth understanding of the social reality) prompted the use of qualitative surveys in the 1980s (Chambers, 1983 and 1994; Pretty et al., 1995).

It is pertinent to highlight the characteristics of the assumptions that underpin the research paradigm and how they are linked to this study. Blaikie (2007) identified ontological and epistemological assumptions as the core assumptions. In order to discuss and relate the various assumptions to different research paradigms, it is important to note that all the research paradigms highlight different approaches of establishing connections between three important elements about the nature of reality in social sciences (i.e. "ideas, social experience, and social reality"⁴⁵ as explained in Blaikie, 2007). Crotty (1998) argued that discovery of a "meaning" was not made but rather established via interaction between the world and our consciousness. Three prominently established research paradigms (positivist; interpretivist and pragmatist) are worthy of introduction at this juncture with a view to justifying the most appropriate one for this study.

⁴⁵ For detailed explanation about the three concepts refer to footnote 3 above.

To relate the above elements to, and enhance the understanding of the assumptions of this research work, the following specific questions are raised:

1. What are the appropriate philosophical assumptions relating to the nature of reality that enable analysis to be undertaken on the effect of OPEC policies on oil price volatility?
2. What constitutes valid 'knowledge' with respect to the relationship between OPEC policies and oil price volatility?
3. How can the relationship between OPEC policies and oil price volatility be explored?
4. What specific strategies, methods and techniques can be put in place to derive knowledge about the various relationships between OPEC policies and oil price volatility?

Generally, the research philosophy chosen and its associated paradigm helps locate the contribution of the research in the social science discipline (see Burrell and Morgan, 1979; Falconer and Mackay, 1999; Ryan et al., 2002; Ryan, 2006; Morgan, 2007; Denscombe, 2008; Modell, 2009; Bryman and Bell, 2007, 2011). In this connection, Grix (2002) highlighted five chronological processes (often referred to as a research building block⁴⁶ as described below), to enhance the understanding of the methodological framework for this study:

- i. Ontology: This is concerned with the assumption made about the nature of reality; this assumption sets the framework for the research.
- ii. Epistemology: This is the assumption about what constitutes valid knowledge.
- iii. Methodology: How can we go about acquiring the knowledge to address the research question being investigated?
- iv. Source: This element defines the type of data to be collected for such knowledge to be known?
- v. Methods: This stage involves procedures, models, tools and techniques designed to acquire such knowledge.

⁴⁶ See also Hassan (2012a)

Furthermore, Schratz and Walker (1995) and Ryan (2006) argued that research techniques are often miserable procedures in the absence of knowledge of philosophy or context in a research process. This is because philosophy enhances such meaning of a phenomenon with guiding principles that cannot be offered by "procedural advice" in a particular technique. Therefore, a structured methodology will not only enhance the understanding of the phenomenon, but will likely take a step further in facilitating replication, which is a critical issue about reliability in research (Gill and Johnson, 2010).

However, Blaikie (2007) observed that the major philosophical challenge posed to a researcher is the ability to establish a connection between "ideas, social experience and social reality." Therefore, for a proper understanding of the research strategies and the philosophies, Grix's (2002) building blocks are discussed in the subsequent sections of this chapter in a more relevant context to this study starting with the philosophical assumptions; data sources, population definition and sampling selection procedures; variables definition and measurement strategies; and data analyses - tools and methods. Consistent with the above philosophical design, Saunders et al. (2012) noted that researcher's methodological choice, strategy employed, and the time scope of the research (collectively referred to as "three layers of research onion") are influenced by the selection of research philosophy and approach given the primary role they play in the research design process⁴⁷. In the subsequent sections and subsections, attempt is made to discuss the various theories behind such four elements and how this research will specifically fit into the parlance of the social sciences and preceded by the methods.

5.2.1 Ontological Assumptions

Ontology deals with the question of "what" is the nature of the existing social reality which needs to be known (Burrell and Morgan, 1979 and 2002; Guba, 1990; Grix, 2002; Ryan et al., 2002; Sale et al., 2002; Crossan, 2003;

⁴⁷ According to Saunders et al. (2012), the research design process enhances the transformation of the researcher's research question in to a research project. Research design has to be integrated into other elements to achieve methodological fit (Edmondson and McManus, 2007; Saunders et al., 2012). Edmondson and McManus (2007) highlight the components of methodological fit to include each of the four elements, namely: "research questions, prior work or state of current theory, research design and theoretical contribution".

Blaikie, 2007 and 2010; Collis and Hussey, 2009; Saunders et al., 2012). It is a concept concerned with the study of being about knowledge otherwise known as "what is" (Crotty, 1998; Sunders et al., 2011; Scotland, 2012). Existing literature often summarises ontological theories into two most prominent (but "opposed and mutually exclusives") groups, namely: "idealism" and "realism" (Blaikie, 2007). The divisions exist due to the different positions of the researchers informed by different perceptions of how things are and work. Idealism is the ontological position of interpretivism which believes that what we need to know appears there and is inseparable from our thoughts, experiences, conscious, and senses (see Blaikie, 2007; Scotland, 2012).

In contrast, realist theory views objects as having existence independent of the researcher investigating them (Blaikie, 2007; Cohen et al., 2007; and Collis and Hussey, 2009). The realist approaches a social world with assumptions similar to that of the natural sciences about what knowledge exists and how it can be explored (Cohen et al., 2007; Scotland, 2012). Realism believes that knowledge about an object exists independent of the researcher (Pring, 2000; Blaikie, 2007; Collis and Hussey, 2009). The clear distinction between the theories is that, while realists strongly believe in the singularity of the nature of reality, its independence with the researcher and the objectivity in approach, idealists' on the contrary believe in the multiplicity and "relativism"⁴⁸ in approaching such object (Collis and Hussey, 2009).

In the same direction, the dichotomy between the philosophies in idealist (interpretivist) and realist (positivist) theories (paradigms) has a long established standing history in the literature (Blaikie, 2007). In an effort to enhance the distinction between the two theories, various studies present a

⁴⁸ Relativism attaches a subjective view to reality and believes this view differs across the individual researchers studying it (Guba and Lincoln, 1994; Blaikie, 2007; Scotland, 2012). This contrast between the relativism and idealism recently emerges from the literature in an attempt to understand the underlying basis of different paradigms (Blaikie, 2007).

number of useful sets of categories, which are able to define where the researcher falls in his quest to discover "knowledge." It should be noted that these categories are non-exhaustive and non-universal in the research literature. This is the main reason why Burrell and Morgan (1979)'s attempt to standardise paradigms model receives criticisms relative to "paradigm incommensurability" (see Hassard, 1991; Parker and McHugh, 1991; Willmott, 1993; Weaver and Gioia, 1994; DeCock and Rickards, 1995; Deetz, 1996; Blaikie, 2007).

Supporting the distinction between the two prominent paradigms within the ontological context, Bryan and Bell (2007) highlighted the questions of whether research objects under study are social entities whose nature of reality is such that can or cannot be influenced by the perceptions and actions of the social actors. The answers to the questions pose a position of objectivism and the subjectivism (or constructionism/rationalism). Objectivism in the social sciences has long been established in the literature due to its connection with the natural science process of enquiry. However, the constructionists are out to challenge the scientific process application to discover social phenomenon or reality (Bryman and Bell, 2007; Hassan, 2012).

5.2.2 Epistemological Assumptions

Epistemological assumptions deal with what is considered and accepted as valid knowledge to social scientist (Collis and Hussey, 2009). Epistemology is a "theory of knowledge" or simply a science of how knowledge is validly acquired about the social reality in a social entity (Blaikie, 2007). It is a philosophical assumption which provides a framework for judging how knowledge is validly established within a social entity. Therefore, it deals with the philosophical basis for selecting what can be known. While the interpretivist's assumption is that reality is usually mediated by human senses, conscience and/or experiences. Positivists believe entirely in the opposite stance because according to their school, independence and objectivity of the researcher in getting to know about the social reality are fundamentally necessary as against the experience which might be highly biased (Pring, 2000; Balikie, 2007; Scotland, 2012).

Positivism was mainly popularised by Comte (1798-1857) in his attempt to apply scientific procedures for finding reality in the social world (see Crotty, 1998; Scotland, 2012). In his effort to give an example of the independence of the knowledge and the social being, Scotland (2012) extended the example given by Crotty (1998)⁴⁹ and noted that a meaning of a social object remains firmly as it is and is not influenced by the researcher's conscience but rather his strategy to acquire such meaning⁵⁰. Positivists also believe in descriptive and factual statements, which are founded by sound data (House, 1991; Scotland, 2012).

Furthermore, epistemology is concerned with the philosophical assumption that having believed that a particular knowledge exists, how does a social scientist obtain such knowledge about social reality? Ryan et al. (2002) added that, it entails dealing with challenges when deciding on how knowledge should be acquired. It has two important groups, namely: 'positivism' and 'interpretivism'. In view of the above and the empirical nature of the study, positivism which advocates objectivity and views objects (being researched) as independent of the researcher and his/her research activities is adopted as the research philosophy supporting the study. Basically, the strategy in this study is based on positivist's research paradigm and employs a deductive reasoning approach where a relevant theoretical framework is developed and relevant data are subjected to robust statistical testing that are expected to produce empirical evidence either or not consistent with such framework (see Hassan, 2012).

The emergence of post-positivists from the positivism in the 20th century was another scientific paradigm mainly motivated by the belief that knowledge is created within the various social movements and the relationships aimed at aspiring a global change and contribution to "social justice" (Ryan, 2006). He further summarises the features of the post-positivists as i it is broad in scope as against the positivists which remains specialised; ii theory and practice are two inseparable yardsticks that provide a context for acquiring

⁴⁹ In his precise words, Crotty (1998: 8) notes that "a tree in the forest is a tree, regardless of whether anyone is aware of its existence or not. As an object of that kind, it carries the intrinsic meaning of treeness. When human beings recognize it as a tree, they are simply discovering a meaning that has been lying in wait for them all along."

⁵⁰ See also (Schratz and Walker, 1995) which lends a similar support.

knowledge; and iii enterprise is directly dependent upon the researcher's motivations and his commitment to the conduct of research.

To understand the post-positivism very well, a summary of the school's characteristics is highlighted below in contrast with positivists:

1. In the post-positivists school, research seems broad (due to various relationships that exist in the social phenomenon) rather than specialism thought in positivism (Ryan, 2006);
2. There is strong connection between theoretical and the practical nature of phenomena in post-positivism as against the positivists which might rely on 'just the facts' (see Ryan, 2006); and
3. Post-positivism implores the idea of richness of data collection and categorisation techniques (due to the broad nature of research) above the positivists' school for a meaningful, objective and certain outcome to be observed and make the research processes more rigorous (see Scotland, 2012).

The epistemological assumption for interpretivists is based upon subjectivism in approaching a social reality (Blaikie, 2010). Therefore, this establishes a demarcation between what we know (which is often subjective) and what is out there to be known (Grix, 2004 and Blaikie, 2010). The experience of the researcher is very crucial in generating new knowledge as consciousness of the researcher interacts with particular social reality (Heron and Reason, 1997; Crotty, 1998; Creswell, 2009; and Scotland, 2012). This is the main reason in interpretive school why disparities could exist in perception of a social phenomenon given such human differences in constructing meaning (Cohen et al., 2007). The methodology of the interpretivists might involve the use of "case studies" (which involves in-depth examination of a social reality over a long span of period); "phenomenology" (which involves personal and direct experience of the researcher while avoiding any personal prejudice); "hermeneutics" (which involves meaning derivation from a language); and "ethnography" (which involves longitudinal study of cultural groups) (see Scotland, 2012).

Interpreivist's epistemological assumption strongly believes in individual constructs which Guba and Lincon (1994) noted are best stimulated by a

researcher based on his interaction with the research participants, whose responses should be credible enough (Creswell, 2009). Scotland (2012) noted the challenges with interpretation of events surrounding such constructs which open up new horizon of understanding as more efforts are made to describe phenomena. Grint (2000) argued in relation to the concept of 'leadership' (e.g. Richard Branson) that the meaning is subjective depending on how the followers perceive their leader (i.e. the constructs). This explains the reason 'fun' superseded 'reward' for respondents to recognise a good leader. Alternative approach as Grint (2000) argued would have been difficult to describe and find answers to the phenomena.

Interpretive methods yield insight and understandings of behaviour, explain actions from the participant's perspective, and do not dominate the participants. Examples include: open-ended interviews, focus groups, open-ended questionnaires, open-ended observations, think aloud protocol and role-playing. These methods usually generate qualitative data. Analyses are the researchers' interpretations; consequently, researchers need to make their agenda and value- system explicit from the outset. Internal and external validity in research complement the ability to replicate (i.e. replicability of) a project and make it be accepted as good research within the academic community. Any knowledge must have a well-defined filtering process to qualify as knowledge capable of producing meaningful contribution (see Richie and Lewis, 2003; Cohen et al, 2007).

5.2.3 Methodological Assumptions

Methodology is referred to as the actual approach taken in the process of research, which entails the body of different methods (Burns, 2000; Collis and Hussey, 2009). This subsection on methodology deals with the specific procedures taken for the conduct of the entire research. More specifically, methodology in this context simply involves all the theoretical explanations and analysis adopted in relation to the methods and principles for the conduct of a research in a particular discipline (Burns, 2000; Saunders et al., 2012). It encompasses laid-down procedures, tools, approaches, methods, and system, which guide how a particular problem will be solved in research (Irny and Rose, 2005; Collis and Hussey, 2009). Methodological assumptions and

philosophical assumptions are concepts often used by many scholars interchangeably (see Collis and Hussey, 2009).

In this regards, research methodology covers multiple methods, which could be linked together sequentially, combined or rather divided in to sub-processes (Katsicas, 2009). Therefore, as the name implies, it involves clear definition and identification of the entire and specific procedure(s) in relation to research population, sample, data categorisation, variable measurement, and design as well as strategies for analysis. Although each of the above processes is independent, cohesion and proper justification must be achieved within and between them for the enhancement of methodological rigour⁵¹ (Paley, 1997; Giorgi, 2000a, 2000b; Collis and Hussey, 2009). For a study successfully to address or generate its research questions, it must be firmly grounded within a methodological approach (Allen et al. 1986).

Furthermore, studies find a methodological misuse⁵² in much academic research which failed to portray a clear linkage between the major research concepts highlighted above (Giorgi, 2000a; Edmundson and MacManus, 2007). For instance, (Giorgi, 2000a, 2000b) established among others absence of relationship between research questions and methodological choice, as well as the impact of such choice on the selected sample size, and tools of analysis employed. Maggs-Rapport (2001) observed that, the consequence of the absence of the rigour has the tendency of yielding increased criticism and dismissal of research findings. Blaikie (2007) further highlighted that identifying proper methodological assumptions are crucial in the choice of a methodology which makes the entire research task easier. Maggs-Rapport (2001) concluded that 'best research practice' remains unachievable unless researchers are able properly comprehend the existing methodological precepts as well as the relationship between research method and research methodology.

The methodological assumption under positivists entails examination of relationships and factors that might influence the outcomes of such

⁵¹ Collis and Hussey (2009:337) defined the methodological rigour as "the appropriateness and intellectual soundness of the research design and the systematic application of the research methods".

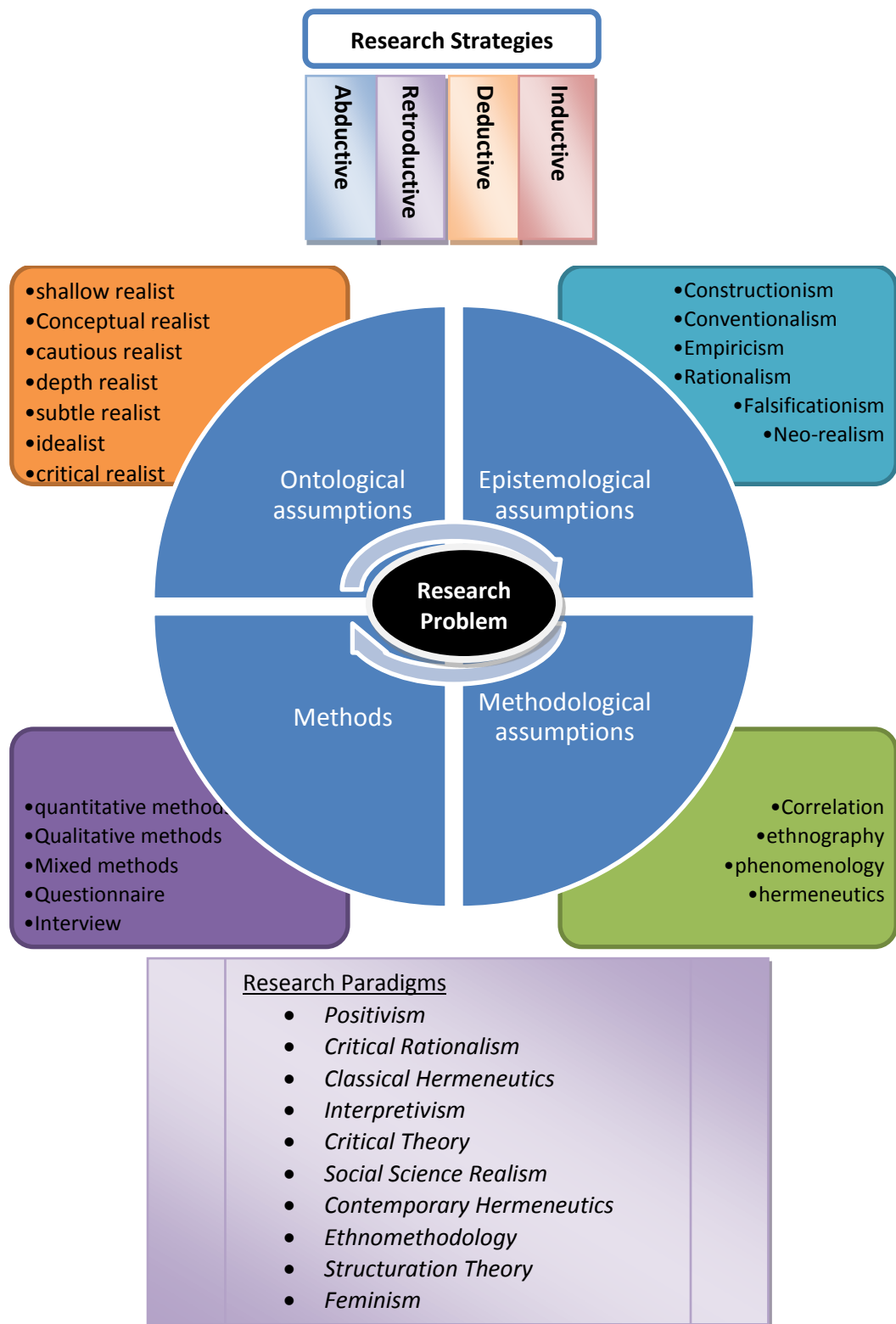
⁵² See Cohen et al. (1998); SmithBattle and Leonard (1998); Edmondson and McManus (2007); and Saunders et al. (2012).

relationship (Creswell, 2009). Similarly, in order to closely examine the various complex relationships existing between variables within the social reality, techniques (such as correlation and experimentation) are employed by positivists. Therefore, for knowledge to be acquired, the ultimate outcome must be supported with empirical pieces of evidence, though not restricted to quantitative (Pring, 2000; Saunders et al., 2012). Knowledge generated about the social reality is considered 'value neutral' due to the nature of methodological assumption of 'value neutrality' in the positivists' school of thought (Scotland, 2012). The same pattern of correlation and experimentation exists in post-positivism but with some improvements based on the sophistication they believed to exist in examining what should be knowledge (see Creswell, 2009; and Scotland, 2012). Furthermore, Creswell (2009) noted that participant's perception is often added to the empirical data to enhance the research rigour.

5.3 Linking Research Paradigm with Research Methodology and Methods

Considering the chosen paradigm (i.e. positivist), figure 5.1 below presents a structural summary of the research paradigms in order to justify the main basis for not adapting the alternative strategies.

Figure 5.1: Summary of Paradigm Choice in Research



Source: Adapted from research authors (Creswell, 1994 and 1998; Collis and Husseys, 2009 and Blaikie, 2007 and 2010).

5.4 Research Strategy: Approaches and Methods

The success of the entire strategy of the research depends upon how the research philosophical and methodological underpinnings (such as ontology, epistemology, axiology, methodology, and methods) are identified, designed and linked together (Schratz and Walker, 1995; Ryan, 2006; Blaikie, 2007; and Scotland, 2012). It is well established in the field of research that the degree to which a researcher becomes clear about a theory prior to conducting a particular study has an important bearing in the choice of a research design⁵³ or approach to a specific study (Saunders et al., 2012). Therefore, two prominent approaches in the literature are deductive and inductive reasoning. The approaches are detailed in the following paragraphs with a view to highlighting the approach as well as the justification for the purpose of this study. Similarly, the research philosophies and their associated paradigms provide proper guidance on how this research will fit in the parlance of the social sciences as a discipline.

Furthermore, methods are considered as the techniques for collecting and analysing data in a particular research and the nature of the data (i.e. whether qualitative or quantitative) generally dictates the choice of the data analysis techniques or methods in every research; and this is informed by the philosophical stance of a researcher (see Collis and Hussey, 2009). In order to properly define the position of this study in relation to the approach and strategies applied on various research elements, this section highlights the population identification and definition processes; sample and sampling selection procedures; variable measurement strategies, data collection and analysis techniques.

5.4.1 Research Approach

In line with the introduction of the research approaches in the previous paragraph, the following approaches are identified from the literature: inductive, deductive, retroductive, and abductive.

⁵³ Research design is defined as a technical and detailed plan, including the private working papers often prepared by the researcher or his team prior to commencement of a research project (Saunders et al., 2012). It is "an integrated statement of and justification for the technical decisions involved in planning a research project" (Blaikie, 2010).

5.4.1.1 Inductive Reasoning Approach

Inductive reasoning occurs where a researcher develops a new theory in a research effort to bridge an existing gap between 'conclusion'⁵⁴ and 'observed premises'⁵⁵ with a view to providing answers to the research questions. In this research approach, the purpose of the research emanates from the quest of the researcher to gain a feel for the happenings about a particular phenomenon with a view to understanding its nature and patterns to enable development of a theory. Therefore, it is "a study in which theory is developed from the observation of empirical reality; thus general inferences are induced from particular instances" (Collis and Hussey, 2009: 8).

Consistent with Collis and Hussey (2009), Blaikie (2010) and Saunders et al. (2012) noted that studies carried out using an inductive approach usually involve collecting data to explore an existing phenomenon, understand its nature and pattern by operationalising concepts (i.e. conceptual framework) with a view to developing a theory. Although the conclusions drawn via inductive reasoning are not tested, the established framework could be tested to later become a theory upon subsequent confirmation by follow-up studies.

5.4.1.2 Deductive Reasoning Approach

The deductive approach involves the use of established theoretical propositions to proffer explanation, understanding, and sometimes prediction of a particular research phenomenon (Collis and Hussey, 2009). With a theory in place as a guide to the conduct of the research, deductive reasoning is inclined to what can be referred to as much of scientific research (Saunders, 2012). Therefore, the basis of explanations and prediction is the theory which must have been earlier developed in the previous studies and adopted in the theoretical framework to underpin the current study.

More specifically, deductive research involves "a study in which a conceptual and theoretical structure is developed and then tested by empirical observation; thus, particular instances are deduced from general inferences" (Collis and Hussey, 2009:8). Data are collected to enable the researcher to

⁵⁴ Conclusion here refers to the finding of other studies in relation to a similar research problem upon which the researcher sets to provide more convincing explanations.

⁵⁵ Observed premises are those established ideas/relationships/questions/hypothetical statements made by the researcher based on experiences/ review of literature or observation of the social phenomenon.

evaluate some research questions or hypotheses formulated within the context of a particular theory. In this regard, the outcome of the study might agree with the theory or disagree with it. In any case, the approach enhances the understanding of the nature of the reality by relating the phenomenon against a particular theory.

Blaikie (2010) identified six important steps for conducting deductive research, which were also summarised in Saunders et al. (2012) as follows:

Set in place a tentative and testable proposition, idea, premise, or hypothesis (which highlights a relationship between two or more variables) or set of hypotheses that form theoretical proposition(s).

Deduce from the existing literature a conceptual position, testable proposition or more by identifying and defining different conditions under which assumptions of a particular chosen theory are likely to hold.

Carry out evaluation of the premises as well as the argument behind the logic and compare such argument against existing theories in order to judge the extent to which explanation is produced until the best understanding is achieved.

Obtain the relevant and appropriate data in order to measure, test, and analyse the variables or such concepts or relationships;

A failure of the outcome of the analysis to agree with the premises results in a "tests fail!" which indicates theory falsification. In that regard, it will lead to rejection, modification or even restarting the entire process.

Consistency of the researcher's conclusions with the premises indicates that a theory is therefore corroborated.

5.4.1.3 Retroductive Reasoning Approach

Consistent with the previous approaches, this approach sets to begin with "an observed regularity" and attempts to generate various successions of explanations (evidence) by identifying those "structure(s)" and the "mechanism(s)" causing such regularity (Blaikie, 2007). By this attempt, retroductive strategy provides strong reasons for a hypothesis to be pursued but unable to convincingly produce reasons for the hypothesis to be believed.

The probability of the explanations becoming true is never “1” but could rather be split 50/50, which means a 50% chance of being true. However, in each case, further augmentation is developed empirically to provide a rationale behind believing in a particular hypothesis (Ward and Gimbel, 2010).

Alongside the above development, retroduction strategy has gained momentum and application in the social science literature⁵⁶. For example, Downward and Mearman (2007) evaluated the logic of retroduction within the context of economic research in which a mixed methods strategy is adopted. Using this approach it was found useful and logically consistent within the social science discipline in general and economics in particular. Its ability to unite various economic and social thoughts in providing useful insights into a phenomenon is an important finding of their study. Consistent with Lawson’s (2003) study, Downward and Mearman (2007) noted that effectiveness of combining different methods and strategies in addressing specific economic and social phenomena using triangulation, retroduction appears the most appropriate logical basis of defining the conduct of such type of study.

Furthermore, abduction and retroduction approaches are identified to have a synergy effect when combined in social science studies (Danermark et al., 2002). Retroduction on its own might not be without certain limitations. Although, retroduction attempts to provide explanations to an observed regularity, the inference does not lead to a movement by the researcher from a hypothesis to drawing conclusion (Danermark et al., 2002). Therefore, combining this approach with another in social science has some advantages.

5.4.1.4 Abductive Reasoning Approach

The abductive reasoning approach originated from the early work of Aristotle, but later developed into an established approach and theory of inference by an American philosopher called Charles S. Peirce (1839-1914) (Svennevig 2001). In this approach to research or reasoning, a researcher formulates explanatory hypotheses or ideas and evaluates such based on meanings and accounts from the social actors’ everyday activities (see Blaikie, 2010). The

⁵⁶ See for example, Ayim (1974); White (1997); Tsang and Kwan (1999); Mir and Watson (2001); Danermark et al. (2002); Ward (2006); Downward and Mearman (2007); Meyer and Lunnay 2013 for empirical studies involving retroduction strategy.

approach has its roots from combination of the renowned deductive and inductive approaches (Suddaby, 2006). Its strategy or logic is based on establishing premises with a view to arriving at logical conclusions. In so doing, relevant data are collected to explore a particular phenomenon by constructing themes which form a conceptual framework of the study. The framework is subjected to further test by obtaining new data until theory is generated or modified (Saunders et al., 2012). Meyer and Lunney (2013) found that, many studies in social sciences often employed abductive or retroductive inference without them knowing or realising doing so. An important distinction between abductive and retroductive inferences is that while the latter demands conceptualisation of circumstances without which no concept can exist, the former simply examines data which is even outside the initial premise, chosen theory or developed theoretical framework.

In view of the above discussions about the various research approaches, deductive reasoning approach is applied by this study to achieve methodological fit as highlighted by Edmundson and MacManus (2007). All the research ideas, questions and the relationships amongst variables are formulated in the light of the chosen theoretical framework. Based on this methodology, quantitative or quantifiable data were collected and analysed based on unrestricted VAR models (more about VAR is detailed in section 5.5.3) which allowed the results about the various dynamics to be obtained and helped in answering the research questions within a context of the theoretical framework (see Blaikie, 2010: i.e. six steps in deductive approach).

This approach is consistent with the research paradigm chosen for this study. Considering the fact that various relationships between variables are highlighted, the deductive approach is suited to providing explanations and predicting social phenomenon on the basis of a given theory or bodies of theories (Creswell, 2009 and Saunders et al., 2012). Saunders et al. (2012) further noted that in testing the propositions using a deductive approach, a researcher collects quantitative data but that does not rule out the use of qualitative data. Consistent with the above view, Blaikie (2010) earlier highlighted that deductive reasoning is in conformity with studies that are scientifically inclined (natural or social sciences).

Table 5:1: Reasoning/Approach to Research

	Inductive	Deductive	Retroductive	Abductive
Logic	Inference is induced when existing premises serve as the basis for generating untested conclusions	Inference is deduced when the premises hold true, the conclusions must equally be true.	Inference is retroduced when an observed regularity serves as a basis for generating testable pieces of evidence (critical realism).	Inference is abduced when known premises serve as a basis for generating some testable conclusions
Generalisability	It flows from general to specific.	It flows from specific to general.	It flows from the combination between specific and general.	It flows from the interactions between specific and general.
Data usage	It collects data to explore a phenomenon by identifying and constructing themes with a view to creating a conceptual framework within which the research is explained.	It collects data to enable hypotheses tests against an existing theory or body of theories (theoretical framework).	It collects data with a view to exploring a phenomenon by devising various strategies to generate evidence-based explanations regarding an observed regularity.	It collects data with a view to exploring a phenomenon by identifying and constructing themes to enable identification of conceptual framework and thereafter test the established theory by another data collection procedure.
Use of Models	It is formed by "abstract descriptions" and via conceptual frameworks.	It is formed by "theoretical models" and via diagrammatic and mathematical representations.	It is formed by "abstract description" and entails use of analogies.	It is formed by "abstract description" and discovering everyday meanings and motives.
Theory	It generates a theory.	It enables test against a theory with a view to falsifying or verifying.	It generates and modifies a theory by investigating data often outside the initial theoretical framework.	It generates and possibly modifies a theory

Source: Adapted from Blaikie (2010) and Saunders et al. (2012)

5.5 Research Methodology

Methods are considered as the techniques for collecting and analysing data in a particular research (Collis and Hussey, 2009). The nature of the data to be collected (i.e. whether qualitative or quantitative) generally dictates the choice of the data analysis techniques or methods in every research; and this is informed by the philosophical stance of a researcher (see Blaikie, 2007; and 2010; Collis and Hussey, 2009; Scotland, 2012). This section discusses the methods used in collecting data for this study and the empirical methodology for analysing the data.

Table 5:2: Sample Period Selection for the Study

Classification for OPEC [Fattouh's (2012) approach]	Phase I era (1960-1985) (Trade union and Price setter)	Phase II era (1986-2006) (Residual Producer and spare capacity holder)	Phase II era (2007 to 2010) (Inventory Manager and Signaller)
1960-2012 (52 years)	1960-1985 (25 years)	1986-2006 (21 years)	2007-2012 (6 years)
Population	100%	100%	100%
Sample - 2000 to 2012 (13 years)	NA (Based on Brémond et al., 2012)	29% (06/21*100) equivalent to 01/01/2000 - 31/12/2006.	100 % equivalent to 01/01/2007 - 31/12/2012

Source: Developed by the researcher from the literature.

Based on table 5.2, it can be observed that OPEC's behaviour changed over time from the inception in 1960 to 2012 (Fattouh, 2012). The period in which OPEC acted more like a trade union and price setter (phase 1) has not been considered in this research, although reference was made to such literature to gain an insight that will enable understanding of reasons for the current dynamics in OPEC behaviour or in that of other key oil market players. This is consistent with the view of Brémond et al. (2012) who argued that reference to phase 1 is an important guide to understanding OPEC's subsequent actions. In phase II, 40% of the period formed part of the sample used in this research in consideration of data limitation, while the entire period (i.e. 100%) of phase III when OPEC acted as signaller and inventory manager was also considered.

5.5.1 Methods of Data Collection

Considering the focus of this study is to empirically assess OPEC's oil price band/stabilisation policies vis-à-vis its ability to control oil prices within a target price band, the appropriate research method employed to achieve the stated research objectives is quantitative methods based on analysis of secondary data. Secondary data are employed for two important reasons. Firstly, since the 1973 oil price shock, there has been an exchange of political statements and shift of blame between OPEC (as a cartel) and IEA or the U.S. on who has been responsible for the sustained high oil prices. Besides the challenge of identifying respondents that represent the interests of players/organisations in the oil markets, another potential challenge is that the views to be generated from any primary data collection instrument might end up reflecting the diverse views of such organisations. Therefore, in the light of positivists' paradigm which assumes singularity and objectivity of a social reality, knowledge could still be established in a process not influenced "by the act of investigating it" (Collis and Hussey, 2009: 56). Given the developments in the internet reporting, the responses of both organisations always remain that all necessary information reflecting their energy position and policies could be found on their websites and various periodic reports.

Consequently, secondary data are used to explore the complex relationships and dynamics between various oil market players' actions to provide answers to the research questions raised in this study. In view of the fact that this study solely relies on the secondary sources of data, it becomes crucial to highlight detailed structure of the data for the modelling purposes. Huisman (2009) highlighted the crucial importance of understanding data before applying any modelling technique. Data were obtained for a period of 13 years (equivalent to 156 monthly data points) from 2000 and 2012 from the energy archival sources of OPEC, EIA, BP, and IEA. Other variables included in the model were expressed as dummies for war in Iraq; economic events (i.e. global economic recession); and OPEC official and implied oil price band policies.

5.5.2 Definition of Variables and Measurement Strategies

This section defines the variables used in this study. Variables representing OPEC stabilisation policies were included in the models to examine how the policies influenced oil prices and how they are influenced by changes in other variables. Consistent with VAR model's classification of variables, data collected were split into endogenous and exogenous variables. In this connection, data in relation to OPEC's actions were collected for i) OPEC production quota policy; ii) OPEC oil price band policy; iii) OPEC spare capacity policy; and iv) OPEC production cheating. To critically investigate the effect of the actions of other key market players, data were collected for three variables namely: OECD/IEA crude oil consumption, OECD/IEA crude oil stockpiling, and non-OPEC production. The three variables are considered important due to the following reasons. First, OECD/IEA members' crude oil consumption and stockpiling are two prominent ways of implementing IEA's policies. Managing the two variables by the member nations, IEA is able to respond to disruption in the oil market⁵⁷. Furthermore, stockpiling behaviour has been established as an important factor that explain the variation in oil prices, therefore it has been used in many studies (see Pyndick, 2001; Considine and Larson, 2001; Ye et al., 2002; Déés et al., 2003; Kaufmann et al., 2004; Zamany, 2004; Ghouri, 2006; Kings et al., 2012). OECD/IEA stocks level at a particular period is likely to be influenced by the crude oil consumed. In order for the OECD/IEA members to comply with the IEA policy, there is a tendency to increase consumption by OECD/IEA members to meet up with the minimum stock level even when oil prices keep rising.

Secondly, non-OPEC producers are considered important because they are the only competitors in the oil market to OPEC. There is a general belief in the oil market literature that non-OPEC group behaves competitively (Allsopp and Fattouh, 2011), therefore, their actions are largely described or assumed to be like that of a fringe (Horn, 2001; Sankey et al. 2010). In this connection, their relative contribution towards high oil prices is rarely investigated. A sizeable review of literature on oil market could not provide sufficient empirical support that non-OPEC played not significantly in

⁵⁷ See more on how IEA responds to major disruptions in oil prices via the weblink below: <https://www.iea.org/topics/energysecurity/respondingtomajorsupplydisruptions/>

promoting high oil prices. Including this variable is believed to yield some findings that might be in support or against this conclusion.

Oil Price (OPR): West Texas Intermediate (WTI) futures contract crude oil prices are most commonly used in this type of study (see Hammad, 2011). The crude oil contracts which are usually traded on the New York Market Exchange (NYMEX) were found to be the world's most liquid futures contract (Büyüksahin et al., 2009), most widely traded for futures contracts (Sadorsky, 2006 and 2008; Brunetti et al., 2013). WTI has been used by many other studies because it quickly reflects the information about projected value of oil in the current contract prices (see for example Hammoudeh et al., 2003; Ye et al., 2005; Ye et al., 2006; Villar and Joutz, 2006). WTI spot prices are commonly used as the reference prices that guide futures contracts (see Horn, 2001) and as a benchmark against which the OPEC reference basket is compared in the oil markets. To further justify our choice for WTI spot prices, a number of robustness checks were carried out on futures oil prices against other forms of prices including spot oil prices and the OPEC basket prices. No significant differences were found between futures and spot oil prices which are consistent with the findings from other studies (see Silvério and Szklo, 2012, and the covariance and correlation analysis result reported in Appendix XXV). The monthly oil prices data were obtained from U.S. Energy Information Administration database for the sample period (i.e. from year 2000 to 2012), which produces 156 periods or observations.

OPEC Production Quota (OPQ): OPEC production figures have been employed by previous studies⁵⁸ (e.g. Kaufmann, et al., 2008; Barros et al., 2011) to examine OPEC behaviour/strategy in influencing oil prices in the global markets. OPQ is defined in this context as the raw production levels OPEC often set periodically as part of its strategy to protect members' interests with a view to attaining "fair prices"⁵⁹. Quota might be initially

⁵⁸ For more and extensive review about these studies refer to Chapter 2 of this study on OPEC structure in the global oil market.

⁵⁹ "Fair price" has no any universally accepted general definition. However, for the purpose of this study, fair prices are considered just and acceptable prices to OPEC which will not set the members at disadvantage. It is such a price the OPEC would be happy to witness it prevailing

allocated to a member, but due to factors⁶⁰ beyond the members' control, another member with the excess capacity (usually Saudi Arabia) is often invited to make up the initial allocation made to that country. This variable is included because; it is established to be the most effective tool for OPEC to influence oil prices (see Mazraati and Jazayeri, 2004; Kaufmann et al., 2004). In this regard, monthly OPEC production quota from January 2000 to December 2012 (equivalent to 13 year period and 156 observations) were taken from OPEC database.

OPEC Production Cheating (OPC): This variable is a proxy for cheating by members of OPEC (see Chapters 2 and 4 for detailed literature on OPEC cheating behaviour). It is derived from two major variables. First is the actual OPEC production obtained from the EIA database and second, OPEC production quota described above. This proxy is used due to the fact that it is difficult, if not impossible, to obtain accurate and reliable data about how much crude oil and gas products that sold in the market outside OPEC official allocation. The variables are monthly variables obtained as difference between OPEC actual production supply to the market and officially allocated quota. This variable was defined in a similar way in the previous OPEC literature (see Kaufmann et al., 2004: 67) who defined it as "the degree to which OPEC exceeds" their allocated "production quota". There is no unanimous agreement as to the effect of this behaviour in the oil market. Therefore, while a view exists arguing that increased OPEC cheating is a sign of inefficiency on the part of OPEC which increases uncertainty, another strand believes that the action helps the market by pumping in more oil and helps keeps demand-supply balance (see Abraham, 2000, Kaufmann et al. 2004). The monthly cheating were obtained based on both U.S.-EIA and OPEC datasets for the sample period (i.e. from year January, 2000 to December, 2012), which produced 156 periods or observations.

OPEC Spare Production Capacity (OSC): Monthly data were generated from the U.S.-EIA database for OPEC spare capacity. Spare capacity is the

in the oil market. For more about various aspects of "fair prices" see Markham (2005); Brewer (2007); and Brunetti et al. (2013).

⁶⁰ Some of the factors are natural disaster (King et al., 2012), or social and political insecurities in the member state (King et al., 2012), and incentive for a member to cheat (Dibooglu and AlGudhea, 2007; Chalabi, 2010).

excess crude oil provision made to cushion the oil market in the event of any disruption or any unanticipated contingencies. Due to the effect of the war in Iraq, accurate data on this variable for the entire OPEC was not obtainable. Therefore in most periods, OPEC-10 data were relied upon for the entire OPEC's capacity. This variable is important because it is often a basis for the U.S. and OECD/IEA's projection of oil prices (see Siemenski, 2013). High spare capacity in OPEC members indicates low oil price projection, while low spare capacity in OPEC members means projection of high oil prices. It will be of interest to examine the specific role of this variable on oil prices. Furthermore, understanding factors responsible for high or low spare capacity will show the importance of this variable in the model. Kaufmann et al. (2004) employed almost similar variable (i.e. capacity utilisation as against the available capacity) based on quarterly data to assess the claim that OPEC's power had diminished.

Oil Market Competition (OMC): This is non-OPEC monthly crude oil production which stands as a proxy for competition in the global oil market. The variable was obtained from the U.S.-EIA database. The essence of using this variable is to observe dynamics (similarities or differences) between OPEC reaction to that of its competitors in an effort to evaluate whether the actions of OPEC resemble a cartel as often claimed by the Western politicians and media. In the same way, understanding non-OPEC producers (who are responsible for nearly 60% of the market share) will be useful to understanding the shift in the balance of power in the light of developments in other energy sources, such as shale energy (see Russell and Ibrahim, 2013).

OECD/IEA Crude Oil Consumption (OOC): IEA has set up a policy regarding strategic reduction in the consumption of OPEC's oil while pursuing an energy policy that is considered efficient, affordable and sustainable within the framework of energy security. As presented in panel 6 of figures 6.1 and 6.2, during the implied OPB period, this variable has been declining consistently in response of the policy. In this regard, this study attempts to examine the effect of this policy not only on the oil prices, but also in obstructing OPEC's attempt to achieve stable and reasonable oil prices in

accordance with its stated objectives. More on the reason for including this variable was discussed at the beginning of this subsection.

OECD/IEA Crude Oil Stockpiling (OOS): Crude oil stockpiling is yet another OECD/IEA policy where each of the 28 members is expected to maintain stocks at least not less than 90 days of its prior year's net imports (IEA, 2013). However, any of the member nations is not restricted to stockpile more than the minimum level. This explains why the U.S. and Japan can set up strategic reserves holding hundreds of thousands of crude oil. The essence of the policy is to provide a cushion if future crude oil disruption arises; it was introduced as part of the IEA policy response to the OPEC oil embargo in the 1970s.

OPEC Oil Price Band (OPB) policy: OPEC OPB policy was aimed at achieving crude oil price stability as part of the specific OPEC intervention policies introduced in the early 2000s to respond to rising oil prices that started in the latter part of the 1990s (see Farrell et al., 2001). The policy was also considered a commitment from OPEC to actualise one of its primary objectives of oil price stability (see Fattouh and Allsopp, 2009). OPB is usually seen as the consensus price range which OPEC was happy to witness prevailing in the oil market. It was widely welcome by non-OPEC producers as well⁶¹. This definition is similar to the "fair price" concept except that OPB operates two boundaries (upper and lower bounds) that are crucial to both oil consumers as well as producers (e.g. \$22 and \$28). Kobayashi (2010) believed that a fair price regime would not only guarantee a balanced oil supply and demand regime, but must equally promote a balanced regime in the flow of information. For the purpose of this study, OPB policy was included as an exogenous variable to test for its effect on the oil price stability and also impact on the model⁶². On this basis, OPB policy was

⁶¹ When oil prices fell during 2008, a delegation from India at the Jeddah Meeting of OPEC in July 2008, presented a new proposal for reviving its OPB policy. The new proposal was welcomed by most IEA countries' political leaders (for example, the US president George Bush, the French president Nicolas Sarkozy and the UK Prime Minister Gordon Brown)⁶¹. The support also extended to the other non-OPEC producer countries such as Russia and Norway. Hence, the OPB policy idea was earlier supported by the IEA members in their general struggle to stabilise the oil prices.

⁶² Having carried out tests relating to the OPB policy, it was established that although it does have an effect on oil prices, it does not produce any significant difference between the model with and without OPB policy as an exogenous variable.

classified into two broad categories, namely: (a) an official OPB policy (which lasted between 2000 and 2005) announced by OPEC as an entity, and (b) an implied OPB policy based on unofficial announcements often made by senior government officials. Suitable coding was introduced to the model to evaluate the effect of the official policy introduction and withdrawal.

Global Economic Recession (GER): Economic events are found to be important factors influencing oil prices. Those economic events in this context do not include those economic events that might be politically motivated. The recent 2008 recession which originated from the banking crisis in U.S. affected the globe including both oil consuming and producing nations. This trend in the economic cycle usually results in low oil prices and low consumption. This variable was considered to control for this effect. King et al. (2012: 25) employed a dummy variable to control for the effect of economic events in examining factors responsible for volatility in daily oil prices between 2007 and 2008. In their approach, economic events included monetary policy actions, news about financial trading relating to oil market and events leading to economic instability (European crisis, global economic recession and Asian crisis). On the basis of this assessment, dummy variables were employed to represent the duration when the impact of the recession was felt globally as defined in Eaton et al. (2011)⁶³. The sharp structural break during the sample period led to this variable being considered as a major explanation for such sharp change. Therefore, the period of the recession is represented with a dummy variable where "1" denotes presence of economic recession while the other period with no recession is represented with "0".

War in Iraq (WAR): A number of geopolitical events that affected the oil market have been observed since 2000 onward (see Parra, 2004; Radetzki, 2012). One of the most important events which affected OPEC during the last decade was the war in Iraq. Recognising conflict periods in oil market related studies enhances the analysis as noted by Rigobon and Sack (2005). However, it is often very difficult to establish pre, during and post event

⁶³ The study considers the actual impact period for the recession to commence from the 1st quarter of 2008 to the end of the 1st quarter of 2009.

effects with a high degree of certainty. And this decision about the span of the period or the variable measurement to be considered has important impact on the modelling process (see Stock and Watson, 2001; Brooks, 2008; Wit et al., 2012). To remove any ambiguity in the measurement process of this important event, the EIA definition of this event period was adopted with a view to enhancing the validity of the results. This covered a period from March 2003 to December 2005. The same definition was employed by Guidi et al. (2007) when examining the oil market efficiency to incorporate U.S. policies during both conflict and non-conflict periods. The period when the war was formally taking place was represented by "1" while its absence was represented by "0". This variable was considered as the major event to be included as an exogenous variable for the following reasons. First, it was the major political event that took place during the period when official OPEC OPB was in operation (see Chalabi, 2010). Second, its use was well established in the previous studies (see for example King et al., 2012). Third, no other event was established in the literature whose effect could be reliably ascertained during the sample period. Furthermore, the Iraq war was identified as the only political war that many commentators and columnists and even politicians could have termed as an oil war (Mabro, 2003; Kramer and Michalowski, 2005).

5.5.3 Methods of Data Analysis

This section highlights the various techniques employed for analysing the entire data collected to answer the research questions. Considering the choice for the research paradigm in this study, a number of techniques will be employed in the analysis of data in order to achieve the above stated objectives. Therefore, it starts with the preliminary analysis as well as further or more complex analysis with a view to understanding the nature of relationships existing between the existing premises.

5.5.3.1 Descriptive Statistics

Descriptive statistics are usually applied to enable the researcher to deduce appropriate and "accurate profile of events, persons or situations" within the context of descriptive and exploratory research (see Saunders et al., 2012). They enable description of data using diagrams for measurements on central tendencies and dispersions. Descriptive statistics are compatible with both

qualitative and quantitative methods, therefore the analysis will pave way for understanding and describing the nature of the data, but are not able to test or examine relationships, differences and other behavioural pattern of the data. In this regard, the summary statistics of the dataset are presented and discussed. Furthermore, diagrammatical representation in graphs and charts are employed to view the pattern of the distribution. Other forms of normality tests (which include formal tests) are used to explore the nature of the distribution for further statistical analysis.

5.5.3.2 Econometric Analysis

To empirically examine the impact of OPEC stabilisation policies and OPEC's ability to control oil prices within a target oil price band, three Vector Autoregressive models are utilised. The first model enables a critical examination to be undertaken of the effectiveness of OPEC stabilisation and OPB policies assuming no intervention of any other endogenous factors. The second model considers the scenario where other market forces such as competition in the oil markets and OECD/IEA consumption and stockpiling policies influence OPEC's ability to achieve their price stabilisation goals. The third model considers the impact on oil prices, while controlling for the effect of its consumption from OPEC nations, of U.S. stockpiling behaviour via its establishment of strategic petroleum reserves.

Econometric analysis enjoys widespread application in the field of applied economics, finance, politics and accounting in the sense that it can effectively be used in forecasting economic, social, or political behaviours of individuals or entities (Wooldridge, 2009; Hansen, 2013). In the light of the time series variables defined in subsection 5.5.2, the philosophical basis for this study, and the theoretical framework discussed earlier, this subsection discusses the empirical methodology adopted to examine various dynamics/relationships between variables with a view to achieving the stated research objectives. The presence of the quantitative data (e.g. time series variables) suggests the appropriateness of utilising econometrics⁶⁴ for this research. Therefore, in an effort to investigate the response of OPEC policies

⁶⁴ Econometrics involves application of statistical methods to enable estimation of various economic relationships between variables, or testing economic theories (Wooldridge, 2009).

to oil price volatility, this study employs the use of an unrestricted⁶⁵ VAR as opposed to simply using ordinary simple regression for analysis.

The use of VAR in time series analysis to study complex dynamics enjoys wide application (Brooks, 2008; Zuniga, 2005; Park and Ratti, 2008; King et al., 2012). Developments in time series econometrics have enabled a framework to be established for modelling both short and long-term dynamics in the economic and financial series with a view to highlighting various relationships (Zuniga, 2005; and Brooks, 2008). In view of this development, this section presents various time-series property tests and specifies how the VAR model works in evaluation of relationships and in predicting dynamics in variables. It is important to bear in mind when dealing with time series data that future occurrences of events are assumed to solely depend on the past series data but not vice-versa (Wooldridge, 2009). In this case, properties of time-series might not allow application of classical ordinary least square (OLS) regression procedures⁶⁶

5.5.3.3 Vector Autoregressive (VAR) Models

VAR is considered a systems regression model which is more reliable where there is more than one dependent variable of interest to the researcher (for example oil price volatility and OPEC disclosure). A multivariate time series (like VAR) is a modelling technique which is a hybrid between the univariate time series and simultaneous equations models⁶⁷, and can effectively capture complex dynamics due to the following reasons:

- i. In a VAR model, information can be extracted from a variable by capturing and examining dynamics from itself or its own lag in both univariate and multivariate time series (Asteriou and Hall, 2007).
- ii. It gives flexibility where a variable can be influenced by the time lag of another variable. In VAR, the dynamics in variables can be

⁶⁵ Brooks (2008) noted that for any VAR to be unrestricted, it must preserve the same level or number of lags for the entire variables used in the VAR equation.

⁶⁶ Given the nature of the time series data in this study, it is believed that a simple regression model cannot fit the methodology for this study. This is because, time series data have unique properties; and when classical regression models are applied, that will end up producing spurious results, e.g. high R^2 . Also, one might be tempted to conclude that relationship exists between variables, while in the real sense, the variables are not related to each other (see Asteriou and Hall, 2007).

⁶⁷ For such details, see Brooks (2008).

comprehensively understood by exploring how lags of other variables can influence another variable and vice versa. This is because VAR model work as a system with room to accommodate various equations within a single system. In this connection, it can measure changes in one variable in relation to its own lags and also in relation to the other variables as well as their own lags (Asteriou and Hall, 2007; Brooks, 2008; Farzanegan and Markwardt, 2009; Farzanegan, 2011; Hansen, 2013).

- iii. In VAR analysis, one does not need to specify the independent and dependent variables as all the variables are endogenously selected for the examination of relationships (see Brooks, 2008).
- iv. One of the important issues in time series regressions is the test on data for stationarity which is performed to deal with a problem of spurious regression due to non-stationarity. VAR enables these processes to be examined in order for the estimates to be free from bias and to enable consistency of the coefficients.
- v. Because VAR considers variables as vectors, it enables the relationships between variables to be considered simultaneously and in multivariate form. Therefore, considering oil market as an institution where different market players participate with presumably different objectives, VAR can model the dynamics in terms of the interaction of the various policies in the system.

Before specifying the VAR model, a series of tests, known as time-series properties are required. In this regard, the tests are carried out in the next chapter (i.e. Chapter 6) alongside all the descriptive statistics. More specifically, the stationarity tests for unit roots and cointegration tests⁶⁸ are carried out.

5.5.3.4 Unit Root Tests

Due to the stochastic nature of time series variables (i.e. the tendencies of the mean of the series to oscillate in a seemingly unpredictable "random

⁶⁸ The cointegration test adopted for the purpose of this study is Johansen (1988) cointegration test.

walk" over time (Dougherty, 1992), the use of a unit root test becomes inevitable within the context of the theory of unit-root econometrics (Asteriou and Hall, 2007). As a condition for a univariate analysis, a series must be stationary⁶⁹ for unique dynamics to be properly explored. Unit root test is carried out on each of the included variables in VAR for any joint significance tests to be observed on the lags of such variables (Brooks, 2008). In the event a non-stationary series (i.e. with the presence of unit roots) exists, the outcome from ordinary classical regression analysis will remain invalid, therefore resulting in "spurious regressions"⁷⁰ (Asteriou and Hall, 2007; Brooks, 2008). As part of the tests on the properties of time series, a unit root test is carried out in order to establish stationarity or non-stationarity in the series (Brooks, 2008; Asteriou and Hall, 2007). Therefore, the null hypothesis test is carried out to establish whether each series is integrated of order one (i.e. $Y_t = I(1)$) which simply implies that there is a presence of a unit root in each of the series.

Furthermore, Brooks (2008) noted two major important reasons why the stationarity checks should be carried out on a series: First, there is a clear distinction on the effect of 'shocks' between stationary and non-stationary data. Whereas in stationary series, 'shocks' during time t will continue to have a reduced effect as time changes from one period to another (t to $t + 1$, and from $t + 1$ to $t + 2$, and so on); but the persistence of the shocks in non-stationary series moves towards infinity, which interprets that the 'shocks' in period t will not have a lower effect in $t + 1$, and subsequent $t + 2$ and so on. Second, relates much to the fear of spurious regressions as a result of applying classical regressions to non-stationary data, which might produce a very high R^2 and significant coefficient estimates, therefore producing invalid results.

Therefore, depending on "the order of integration of a series"⁷¹, various tests are applicable in the course of examining stability in the series in relation to

⁶⁹ Stationary series is such series "...with a constant mean, constant variance and constant autocovariances for each given lag." (see, Brooks, 2008).

⁷⁰ Spurious regression is such which employs classical regression analysis on series that appears to be non-stationary, therefore producing invalid results (Asteriou and Hall, 2007).

⁷¹ According to Asteriou and Hall (2007), "the order of integration of a series" is assumed as a general rule to be the size a series is differenced for it to become a stationary one. In this regard, it is similar to the number of unit roots.

constant mean and variance (popularly known as 'stationary series'). A series Y_t integrated of order d is denoted by $Y_t = I(d)$. Therefore, a series with unit-root problem, which is integrated of order 1 [i.e. denoted $I(1)$], can be filtered at a first-difference (i.e. $\Delta Y_t = Y_t - Y_{t-1}$) to generate a stationary series with a constant mean and variance. This is one of the crucial property test for time series model such as VAR to be estimated. The various approaches to investigating stationarity properties (i.e. performing the unit-root tests) include Augmented Dickey-Fuller (ADF); Dickey-Fuller GLS (ERS); Phillips-Perron (PP); Kwiatkowski-Phillips-Schmidt-Shin (KPSS); Elliot-Rthenberg-Stock Point-Optimal (ERSO); and Ng-Perron (NP) test. However, the most famous among them are usually two (i.e. the Augmented Dickey-Fuller (ADF), the Phillips-Perron) which have enjoyed widespread application⁷² in the fields of Economics, Accounting and Finance.

Similarly, in line with the previous studies' practices, this study employs Augmented Dickey and Fuller and Phillips and Perron for unit roots tests in an effort to ensure consistency and allow for comparison with the previous studies. Furthermore, it allows for comparison between parametric and non-parametric tools in time series analysis and other various unit – root tests⁷³.

5.5.3.5 Cointegration Tests

Cointegration,⁷⁴ being a statistical tool through which co-movement of non-stationary economic variables or series can be described, has been employed in the previous literature to test long term relationships between variables in Accounting, Finance and Economics disciplines most particularly where oil prices are involved. For example, cointegration was used to test long run relationship between oil prices and global economic activity (Lardic and Mignon, 2008; He et al., 2010), other commodity prices such as gold (Zhang and Wei, 2010), evidence of collusion and cartel behaviour (Gülen, 1996). Two or more non-stationary time series data are considered to be cointegrated "if a linear combination of the terms results in a stationary time

⁷² Some of the studies that employ or propagate the popularity of the two tests include but not limited to the followings: Zuniga (2005); Asteriou and Hall (2007); Farzanegan (2011); Brooks (2008);

⁷³ For further references about the tests, refer to Gülen (1996), Zuniga (2005).

⁷⁴ This is a process through which long-run comovement of non-stationary variables are evaluated and described. It has been used in many OPEC studies (see Gülen, 1996; Kaufmann et al., 2004).

series" (Zuniga, 2005). It is important to note that for cointegration to take effect, all the included variables in VAR models must be of the same order of integration. Evidence of cointegration between variables has been interpreted as presence of long run relationship which enables the estimation of VECM (see Gülen, 1996).

A number of approaches are available in the economic literature which includes: Engle-Granger (Engle and Granger, 1987) two-step test, the Johansen cointegration test and Phillips-Ouliaris cointegration test. However, despite the shortcomings of each of the approaches, the most popular one in social sciences⁷⁵ is the one developed by Johansen (1988). Johansen's system cointegration method introduces two tests statistics, namely the Trace and Lambda Max tests. The null hypothesis usually states there is no cointegrating equation in the system. Under both trace and Max statistics, the null hypothesis can be rejected or fail to reject on two bases, namely: excess of the trace or Max statistics over the critical values or simply the significance level. In view of the fact that evidence of cointegration might suggest application of the vector error correction models (VECM), the long run dynamics existing within the variables might be observed subject to any restriction in the model.

5.5.3.6 Lag Length Identification and Selection

The choice of the appropriate lag order in VAR models is the most critical aspect considering the fact that the success of the inferences drawn are directly dependent upon the correct specification of the model (Gutierrez et al., 2009; Zuniga, 2005; Hatemi, 2003; Hacker and Hatemi, 2008; King et al. 2012). Due to tendencies of human bias if individuals' subjective reasoning is allowed to dictate the orders of the lags, a wide difference must be expected in results given the sensitivity of lag order to the R^2 values in the regressions. In this regard, the order is statistically arrived. Zuniga (2005)

⁷⁵ Among the empirical studies that apply the Johansen (1988) in the field of Accounting and Finance and Economics disciplines include but not limited to the followings: Zuniga (2005); Li (2007).

noted the various elements upon which a need exists to achieve trade-offs; which include best fitness⁷⁶, less residuals, and loss of degrees of freedom⁷⁷.

The approaches to the selection⁷⁸ of lag structure which are famous in the previous literature included but were not limited to the following: Likelihood ratio test (LRT), Final prediction error (FPE), Akaike information criterion (AIC), Schwarz information criterion (SIC), Bayer information criterion (BIC) and Hannan-Quinn information criterion (HQIC). Hatemi (2003) after experimenting with Monte Carlo simulation, found that the optimal selection of lag order is achieved when the two criteria (namely: Schwarz (1978) and Hannan and Quinn (1979)) are combined.

A number of studies highlighted the danger of wrong selection of lag in VAR model (for example see Gutierrez et al., 2009; Hatemi, 2003; Hacker and Hatemi, 2008; Brooks, 2008; Asteriou and Hall, 2008; Lütkepohl, 1993). It is unanimously agreed that "overfitting"⁷⁹ or "underfitting" might result in an increased "mean-square forecast errors" and "autocorrelated errors" respectively. AIC, BIC and LRT are evaluated in most studies that apply VAR models because it is standard practice to include them (see Zuniga, 2005). Five criteria were evaluated for the purpose of selecting the appropriate lag for estimating the VAR. To ensure the appropriateness of the selection, further tests to justify the stability of the VAR at the selected lag level were carried out using both roots of characteristic polynomial and inverse roots of AR characteristic polynomial.

5.5.4 VAR Models Specifications

To examine the complex dynamics between, OPEC stabilisation/OPB policies, other market players' policies and the international oil prices, unrestricted vector autoregressive (VAR) models were estimated and the resulting impulse response (IR) and variance decomposition (VD) analysed. Impulse responses traces out over time the responsiveness of current and future values of each

⁷⁶ The best fit model is the ability of a particular criterion to minimise the information criterion function (otherwise known as the overall sum of squared residuals) or maximizes the LR (see Zuniga, 2005).

⁷⁷ This is the loss arising as a result of a size of estimated parameters (see Zuniga, 2005)

⁷⁸ The approaches can be classified as traditional information criterion (AIC, SIC and HQIC) and modern or alternative information criterion (IC(p, s)).

⁷⁹ Overfitting exists where a "higher order lag length" is selected against what should be the "true lag length"

of the variables to a shock in one of the VAR equations. While, variance decompositions measured the proportion of the movements in the dependent variables that are due to their own shocks, and also the shocks of the other variables (see Brooks, 2008).

Two models were estimated, the first model assumes that OPEC has control over the oil market and attempt is made to examine its influence holding other factors constant in order to observe the degree to which oil prices will be stabilised within a target range.

5.5.3.1 First VAR Model Specification

Consider a VAR of order P:

$$Y_t = C + A_1 Y_{t-1} + A_2 Y_{t-2} + \dots + A_p Y_{t-p} + BZ_t + e_t \quad \mathbf{5.1}$$

Where Y_t is a $(n \times 1)$ vector of endogenous variables, A_i is a $(n \times n)$ vector of deterministic variables, and A_i and B are coefficients matrices, C is the $(n \times 1)$ intercept vector of the VAR, Z_t stands for the vector of exogenous variables, and e_t is the $(n \times 1)$ generalisation of a white noise process.

Brooks (2008:290) identified "compactness" as one of the important features of VAR. In other words, equation 5.1 can be rewritten or expanded to include the number of variables in the models (i.e. all the four series (Y_t) of endogenous variables (for example $y_{1t}, y_{2t}, \dots, y_{nt}$).

$$\text{Therefore, } Y_t = [\text{LOPR}_t, \text{LOPQ}_t, \text{LOPC}_t, \text{LOSC}_t] \quad \mathbf{5.2}$$

Note that: LOPR stands for logged values of oil prices; LOPQ stands for logged values of OPEC production quota; LOPC stands for Logged values of OPEC production cheating; and LOSC stands for logged values of OPEC spare capacity.

The remaining three exogenous⁸⁰ variables standing for OPEC oil price band policy (OPB), war in Iraq (WAR), and global economic recession (GER) are presented in equation 5.3 where Z_t is considered a vector of exogenous variables:

$$Z_t = [\text{OPB}_t \text{ WAR}_t \text{ GER}_t] \quad \mathbf{5.3}$$

By implication, equation 5.1 above can be further broken down into the following block of equations (5.4) to make it much clearer (assuming $p=1$):

$$\begin{aligned} \text{LOPR}_t = & \alpha_{0,1} + \beta_{1,1}\text{LOPR}_{t-1} + \beta_{1,2}\text{LOPQ}_{t-1} + \beta_{1,3}\text{LOPC}_{t-1} + \beta_{1,4}\text{LOSC}_{t-1} + \beta_{1,5}\text{OPB}_{t-1} + \beta_{1,6}\text{WAR}_{t-1} \\ & + \beta_{1,7}\text{GER}_{t-1} + e_{1,t} \end{aligned}$$

$$\begin{aligned} \text{LOPQ}_t = & \alpha_{0,2} + \beta_{2,1}\text{LOPQ}_{t-1} + \beta_{2,2}\text{LOPR}_{t-1} + \beta_{2,3}\text{LOPC}_{t-1} + \beta_{2,4}\text{LOSC}_{t-1} + \beta_{2,5}\text{OPB}_{t-1} + \beta_{2,6}\text{WAR}_{t-1} \\ & + \beta_{2,7}\text{GER}_{t-1} + e_{2,t} \end{aligned}$$

$$\begin{aligned} \text{LOPC}_t = & \alpha_{0,3} + \beta_{3,1}\text{LOPC}_{t-1} + \beta_{3,2}\text{LOPR}_{t-1} + \beta_{3,3}\text{LOPQ}_{t-1} + \beta_{3,4}\text{LOSC}_{t-1} + \beta_{3,5}\text{OPB}_{t-1} + \beta_{3,6}\text{WAR}_{t-1} \\ & + \beta_{3,7}\text{GER}_{t-1} + e_{3,t} \end{aligned}$$

$$\begin{aligned} \text{LOSC}_t = & \alpha_{0,4} + \beta_{4,1}\text{LOSC}_{t-1} + \beta_{4,2}\text{LOPR}_{t-1} + \beta_{4,3}\text{LOPQ}_{t-1} + \beta_{4,4}\text{LOPC}_{t-1} + \beta_{4,5}\text{OPB}_{t-1} + \beta_{4,6}\text{WAR}_{t-1} \\ & + \beta_{4,7}\text{GER}_{t-1} + e_{4,t} \end{aligned}$$

As mentioned earlier, VAR is a systems regression model (which signifies there could be more than one dependent variable at different times). Interestingly, the equations (5.4) could be rewritten where the A_i 's are 4 x 4 coefficient matrix to produce the following vector (5.5):

$$\begin{aligned} \begin{bmatrix} \text{LOPR}_t \\ \text{LOPQ}_t \\ \text{LOPC}_t \\ \text{LOSC}_t \end{bmatrix} = & \begin{bmatrix} \alpha_{0,1} \\ \alpha_{0,2} \\ \alpha_{0,3} \\ \alpha_{0,4} \end{bmatrix} + \begin{bmatrix} \beta_{11,1} & \beta_{12,1} & \beta_{13,1} & \beta_{14,1} \\ \beta_{21,1} & \beta_{22,1} & \beta_{23,1} & \beta_{24,1} \\ \beta_{31,1} & \beta_{32,1} & \beta_{33,1} & \beta_{34,1} \\ \beta_{41,1} & \beta_{42,1} & \beta_{43,1} & \beta_{44,1} \end{bmatrix} \begin{bmatrix} \text{LOPR}_{t-1} \\ \text{LOPQ}_{t-1} \\ \text{LOPC}_{t-1} \\ \text{LOSC}_{t-1} \end{bmatrix} + \dots \\ & + \begin{bmatrix} \beta_{11,p} & \beta_{12,p} & \beta_{13,p} & \beta_{14,p} \\ \beta_{21,p} & \beta_{22,p} & \beta_{23,p} & \beta_{24,p} \\ \beta_{31,p} & \beta_{32,p} & \beta_{33,p} & \beta_{34,p} \\ \beta_{41,p} & \beta_{42,p} & \beta_{43,p} & \beta_{44,p} \end{bmatrix} \begin{bmatrix} \text{LOPR}_{t-p} \\ \text{LOPQ}_{t-p} \\ \text{LOPC}_{t-p} \\ \text{LOSC}_{t-p} \end{bmatrix} + \begin{bmatrix} e_{1,t} \\ e_{2,t} \\ e_{3,t} \\ e_{4,t} \end{bmatrix} \end{aligned}$$

⁸⁰ Exogeneity for a variable x is defined by Leamer (1985) in relation to y , "if the conditional distribution of y given x does not change with modifications of the process generating x ." (see Brooks, 2008:273). In this regard, a major distinction was between "predetermined" and "strictly exogenous" variables (Brooks, 2008). While the former relates to a variable which is independent of the current and future errors in an equation, the latter describes variable independent of the past, contemporary, and future errors in an equation.

5.5.3.2 Second VAR Model Specification

The second model however assumes that OPEC is no longer solely responsible for setting oil prices, and that other market players are introduced with different policies based on objectives different from OPEC. Therefore, in the initial VAR model based on equation 5.1, the Y_t has been modified to reflect the new players' policies as follows:

$$Y_t = [LOPR_t, LOPQ_t, LOPC_t, LOSC_t, LOMC_t, LOOC_t, LOOS_t] \quad \mathbf{5.6}$$

Note that: $LOPR_t$ stands for logged values of oil prices; $LOPQ_t$ stands for logged values of OPEC production quota; $LOPC_t$ stands for logged values of OPEC production cheating; $LOSC_t$ stands for logged values of OPEC spare capacity; $LOMC_t$ stands for logged values of oil market competition; $LOOC_t$ stands for logged values of OECD/IEA crude oil consumption; and $LOOS_t$ stands for logged values of OECD/IEA crude oil stockpiling.

However, the exogenous variables remain as in equation 5.6. In this regard, the following block of equations (5.10) is developed based on equation 5.4.

$$LOPR_t = \alpha_{0,1} + \beta_{1,1}LOPR_{t-1} + \beta_{1,2}LOPQ_{t-1} + \beta_{1,3}LOPC_{t-1} + \beta_{1,4}LOSC_{t-1} + \beta_{1,5}LOMC_{t-1} + \beta_{1,6}LOOC_{t-1} \\ + \beta_{1,7}LOOS_{t-1} + \beta_{1,8}OPB_{t-1} + \beta_{1,9}WAR_{t-1} + \beta_{1,10}GER_{t-1} + e_{1,t}$$

$$LOPQ_t = \alpha_{0,2} + \beta_{2,1}LOPQ_{t-1} + \beta_{2,2}LOPR_{t-1} + \beta_{2,3}LOPC_{t-1} + \beta_{2,4}LOSC_{t-1} + \beta_{2,5}LOMC_{t-1} + \beta_{2,6}LOOC_{t-1} \\ + \beta_{2,7}LOOS_{t-1} + \beta_{2,8}OPB_{t-1} + \beta_{2,9}WAR_{t-1} + \beta_{2,10}GER_{t-1} + e_{2,t}$$

$$LOPC_t = \alpha_{0,3} + \beta_{3,1}LOPC_{t-1} + \beta_{3,2}LOPR_{t-1} + \beta_{3,3}LOPQ_{t-1} + \beta_{3,4}LOSC_{t-1} + \beta_{3,5}LOMC_{t-1} + \beta_{3,6}LOOC_{t-1} \\ + \beta_{3,7}LOOS_{t-1} + \beta_{3,8}OPB_{t-1} + \beta_{3,9}WAR_{t-1} + \beta_{3,10}GER_{t-1} + e_{3,t}$$

$$LOSC_t = \alpha_{0,4} + \beta_{4,1}LOSC_{t-1} + \beta_{4,2}LOPR_{t-1} + \beta_{4,3}LOPQ_{t-1} + \beta_{4,4}LOPC_{t-1} + \beta_{4,5}LOMC_{t-1} + \beta_{4,6}LOOC_{t-1} \\ + \beta_{4,7}LOOS_{t-1} + \beta_{4,8}OPB_{t-1} + \beta_{4,9}WAR_{t-1} + \beta_{4,10}GER_{t-1} + e_{4,t}$$

$$LOMC_t = \alpha_{0,5} + \beta_{5,1}LOMC_{t-1} + \beta_{5,2}LOPR_{t-1} + \beta_{5,3}LOPQ_{t-1} + \beta_{5,4}LOPC_{t-1} + \beta_{5,5}LOSC_{t-1} + \beta_{5,6}LOOC_{t-1} \\ + \beta_{5,7}LOOS_{t-1} + \beta_{5,8}OPB_{t-1} + \beta_{5,9}WAR_{t-1} + \beta_{5,10}GER_{t-1} + e_{5,t}$$

$$LOOC_t = \alpha_{0,6} + \beta_{6,1}LOOC_{t-1} + \beta_{6,2}LOPR_{t-1} + \beta_{6,3}LOPQ_{t-1} + \beta_{6,4}LOPC_{t-1} + \beta_{6,5}LOSC_{t-1} \\ + \beta_{6,6}LOMC_{t-1} + \beta_{6,7}LOOS_{t-1} + \beta_{6,8}OPB_{t-1} + \beta_{6,9}WAR_{t-1} + \beta_{6,10}GER_{t-1} + e_{6,t}$$

$$LOOS_t = \alpha_{0,7} + \beta_{7,1}LOOS_{t-1} + \beta_{7,2}LOPR_{t-1} + \beta_{7,3}LOPQ_{t-1} + \beta_{7,4}LOPC_{t-1} + \beta_{7,5}LOSC_{t-1} + \beta_{7,6}LOMC_{t-1} \\ + \beta_{7,7}LOOC_{t-1} + \beta_{7,8}OPB_{t-1} + \beta_{7,9}WAR_{t-1} + \beta_{7,10}GER_{t-1} + e_{7,t}$$

In the second model the VAR specification in equation 5.1 which has been broken down to produce the block of equations in 5.7, is further transformed

into a 7X7 matrix. In this regard, equation 5.11, in matrix form, produces the following:

$$\begin{bmatrix} LOPR_t \\ LOPQ_t \\ LOPC_t \\ LOSC_t \\ LOMC_t \\ LOOC_t \\ LOOS_t \end{bmatrix} = \begin{bmatrix} \alpha_{0,1} \\ \alpha_{0,2} \\ \alpha_{0,3} \\ \alpha_{0,4} \\ \alpha_{0,5} \\ \alpha_{0,6} \\ \alpha_{0,7} \end{bmatrix} + \begin{bmatrix} \beta_{11,1} & \beta_{12,1} & \beta_{13,1} & \beta_{14,1} & \beta_{15,1} & \beta_{16,1} & \beta_{17,1} \\ \beta_{21,1} & \beta_{22,1} & \beta_{23,1} & \beta_{24,1} & \beta_{25,1} & \beta_{26,1} & \beta_{27,1} \\ \beta_{31,1} & \beta_{32,1} & \beta_{33,1} & \beta_{34,1} & \beta_{35,1} & \beta_{36,1} & \beta_{37,1} \\ \beta_{41,1} & \beta_{42,1} & \beta_{43,1} & \beta_{44,1} & \beta_{45,1} & \beta_{46,1} & \beta_{47,1} \\ \beta_{51,1} & \beta_{52,1} & \beta_{53,1} & \beta_{54,1} & \beta_{55,1} & \beta_{56,1} & \beta_{57,1} \\ \beta_{61,1} & \beta_{62,1} & \beta_{63,1} & \beta_{64,1} & \beta_{65,1} & \beta_{66,1} & \beta_{67,1} \\ \beta_{71,1} & \beta_{72,1} & \beta_{73,1} & \beta_{74,1} & \beta_{75,1} & \beta_{76,1} & \beta_{77,1} \end{bmatrix} \begin{bmatrix} LOPR_{t-1} \\ LOPQ_{t-1} \\ LOPC_{t-1} \\ LOSC_{t-1} \\ LOMC_{t-1} \\ LOOC_{t-1} \\ LOOS_{t-1} \end{bmatrix} + \dots \\
 + \begin{bmatrix} \beta_{11,p} & \beta_{12,p} & \beta_{13,p} & \beta_{14,p} & \beta_{15,p} & \beta_{16,p} & \beta_{17,p} \\ \beta_{21,p} & \beta_{22,p} & \beta_{23,p} & \beta_{24,p} & \beta_{25,p} & \beta_{26,p} & \beta_{27,p} \\ \beta_{31,p} & \beta_{32,p} & \beta_{33,p} & \beta_{34,p} & \beta_{35,p} & \beta_{36,p} & \beta_{37,p} \\ \beta_{41,p} & \beta_{42,p} & \beta_{43,p} & \beta_{44,p} & \beta_{45,p} & \beta_{46,p} & \beta_{47,p} \\ \beta_{51,p} & \beta_{52,p} & \beta_{53,p} & \beta_{54,p} & \beta_{55,p} & \beta_{56,p} & \beta_{57,p} \\ \beta_{61,p} & \beta_{62,p} & \beta_{63,p} & \beta_{64,p} & \beta_{65,p} & \beta_{66,p} & \beta_{67,p} \\ \beta_{71,p} & \beta_{72,p} & \beta_{73,p} & \beta_{74,p} & \beta_{75,p} & \beta_{76,p} & \beta_{77,p} \end{bmatrix} \begin{bmatrix} LOPR_{t-p} \\ LOPQ_{t-p} \\ LOPC_{t-p} \\ LOSC_{t-p} \\ LOMC_{t-p} \\ LOOC_{t-p} \\ LOOS_{t-p} \end{bmatrix} + \begin{bmatrix} e_{1,t} \\ e_{2,t} \\ e_{3,t} \\ e_{4,t} \\ e_{5,t} \\ e_{6,t} \\ e_{7,t} \end{bmatrix}$$

The main essence of VAR is to analyse the impulse response and variance decomposition of variables. The model specification in VAR is very important in the sense that validity of the diagnostic tests solely depend on the successful accurate specification of the model (Dougherty, 2011).

5.5.5 Granger Causality

Granger causality technique was originally developed and improved by Granger (1969) and Sims (1972 and 1980) respectively. A unidirectional Granger causality exists for a variable when its lagged values influence other variable, in which case the reverse does not hold true (Dougherty, 2011). In a stationary bivariate data (X_t, Y_t) , Diks and Panchenko (2006: 1648) intuitively defined Granger causality that “ $\{X_t\}$ is a Granger cause of $\{Y_t\}$ if past and current values of X contain additional information on future values of Y that is not contained in past and current Y-values alone”. It has enjoyed widespread application by many researchers in empirical economics, finance and accounting. It should be noted however that Granger causality, as the name implies, does not in real sense mean a literal, physical, structural causal relationship that binds the variables in question (Brooks, 2008; Wooldridge, 2009; Dougherty, 2011; King et al., 2012). It is called Granger causality because it is a “chronological ordering of movements in the series” which measures, statistically if dynamics (movements) in a variable correlate

(appear to lead) with the dynamics (movements) in the other variables and does not translate that movement of variable causes movements in the other variables (Brooks, 2008: 312).

In this study, maximum likelihood estimate approach which has enjoyed large support in related studies⁸¹ is employed. Due to the inability of the parametric Granger causality to detect and measure nonlinear causal relationships among various variables, it is recommended to carry out nonparametric Granger causality tests alongside the parametric ones (King, et al., 2012). Non-parametric tests are extensively advocated in the literature because of the difficulty for normality assumption to hold on most time series data. In this regard, different approaches are well documented depending on the nature of the sample (see Robinson, 1989; Bierens and Ploberger, 1997; Chen and Fan, 1999; Hidalgo, 2000; Diks and Panchenko, 2006; Nishiyama et al., 2011; King et al., 2012).

5.5.6 Diagnostic Tests

One of the few challenges often encountered when using OLS in VAR is the appropriateness of the model specification. To minimise or avoid the effect of model misspecification, diagnostic tests were carried out (see Chapter 7 for the results and discussion). These diagnostic tests are considered at different stages of analysis in this study. Various tests (which include unit root test, cointegration and lag length test) were initially carried out prior to building the final VAR models. Diagnostic reports under each VAR estimates were also considered for analysis. Consistent with the previous studies (Zanuga, 2005; Farzanegan and Markwardt, 2009; Kumar et al., 2012), this research employed the most commonly used tests after VAR models have been estimated. These include: Autocorrelation LM tests, Jarque-Bera tests and VAR Residual Heteroskedasticity Tests.

⁸¹ Some of the studies that consider MLE include but not limited to the followings: Toda and Phillips, (1993); Dolado and Lutkepohl, (1996); Zapata and Rambaldi, (1997); Giles and Mirza, (1999); King et al., (2012).

5.6 Justification of the Use of VAR Models in Answering Research Questions

Prior to the 1970s' crises (including both first and second oil price shocks), a macro-economic framework based on various techniques⁸² was used by macro-economists to describe and forecast data, obtain structural inferences and make suggestion for policy-making. This framework was deemed inappropriate in the post 1970s' chaos (Stock and Watson, 2001). However, Sims (1980) provided a new framework based on VAR models that work as a system and promise to provide a more rigorous, coherent and credible methodology to describe and forecast data as well as provide structural inferences and policy analysis (see Stock and Watson, 2001). In view of the fact that this study aimed at describing actions and events to establish whether or not OPEC had operated as an effective cartel to control oil prices from year 2000 to 2012, VAR models were deemed to be an appropriate method of describing and forecasting the future as they have been established as "powerful and reliable tools" in everyday use (see Stock and Watson, 2001; Brooks, 2008). Stock and Watson (2001) further highlighted some difficulties with the application of VAR models in addressing structural inferences and policy analysis due to "identification problem"⁸³. They noted that additional procedures involving "economic theory or institutional knowledge" were useful in overcoming issues associated with such purely statistical tools such as VAR.

VAR models in the context of this study were used for description and forecasting purposes. Various dynamics observed were used to describe the behaviour of institutions and predict future behaviour based on the available data with a view to providing answers to the research questions rather than just testing a particular hypothesis.

⁸² These techniques according to Stock and Watson (2001) ranged from large models involving many equations to the use of a single equation exploring interactions between variables, and to univariate time series analysis which involved modelling a single variable.

⁸³ Identification problem relates to the difficulties when differentiating between correlation and causation.

5.7 Limitation of Statistical Models

This section discusses the general and specific limitations of statistical models, particularly the VAR models employed for this study. Over recent decades, efforts were made, theoretically and empirically, towards validating various models including VAR models with a view to investigating the nature of the dynamics existing in a multi-variate framework. A major strength of VAR models over univariate and bivariate models relates to the fact that VAR models integrate current and lagged values of multivariate time series to show the complex dynamics that take place between variables. In this regard, the co-movements between the time series can be captured and each variable in the model can become a dependent variable at some point. A sizeable literature (for example: Bierens, 2004; Zanuga, 2005; Brooks, 2008; Genton, 2009; Farzanegan and Markwardt, 2009; Kumar et al., 2012) highlighted that VAR makes a useful contribution in describing the complex dynamics between variables of interest. However, despite the wide use of this innovative approach to analysing data, it suffers from limitations just like other statistical models (Stock and Watson, 2001). An important limitation relates to the framework used for making statistical inference. For example, there is a tendency for highly persistent time-series to produce misleading results based on the methods for statistical inference (Stock and Watson, 2001). Also without modification, standard VARs may fail to detect nonlinearities, conditional heteroskedasticity, and drifts or breaks in parameters. Another limitation is that it is often very difficult to interpret the parameters estimated in VAR based on OLS methods (Brooks, 2008). Consequently, interpretation and comparability of parameters become very challenging when VAR models are employed against ordinary regression results.

Furthermore, the concept of model uncertainty is paramount to understanding foundational issues, the general framework and weaknesses of statistical models⁸⁴ (see Wit et al., 2012). Different models may depend on

⁸⁴ A statistical model is defined as "a collection of probability measures on some outcome space" (Wit et al., 2012:218).

different assumptions in trying to achieve fitness⁸⁵. Sometimes, model building might require certain strong assumptions to be made on particular types of data (such as having strictly exogenous predictors, homoscedastic model errors, serial uncorrelation and normal distribution - see Clark and McCracken, 2012).

Although unrestricted VAR models are effective in data description and forecasting, they have another limitation relating to structural inference and policy analysis (Stock and Watson, 2001). This specific limitation relates to differentiating correlation from causality even in simpler and straight forward models. They concluded that despite such limitations of VAR models, wise use based on a well constructed economic reasoning and proper institutional familiarity would make the models fit the data and provide additional meaning about the estimates and causal relationships.

5.8 Summary and Conclusion

Having introduced the various research paradigms in social sciences in general and Accounting in particular, this chapter identified positivist research paradigm to best fit the study because it relied on quantitative methods approach to analysing the data. Similarly, a number of other strategies (such as variable definition and measurement, research approach) have been highlighted with a view to enhancing the internal validity and methodological fit as pointed out by Edmondson and McManus (2007) and Collis and Hussey (2009). In addition to the above, various methodologies in line with the chosen research paradigms have been described as part of the strategy to achieve the research objectives and provide more convincing answers to the research questions.

Therefore, the chapter identified and discussed general methodological approaches and specifically linked it to this study. Different tools for determining the empirical relationships about the nature of OPEC stabilisation policies and oil price volatility were highlighted with a view to situating the study in the general body of research about OPEC behaviour in the oil market. On the basis of such general discussion, it has been established

⁸⁵ Fitness of a model relates to the degree of closeness/goodness of the regression line to the actual set of data/observations.

above that objectivism is the study's ontological stance. In view of the experience generated from the literature, positivism has been identified as the epistemological paradigm and the most appropriate strategy for this research. In line with the assumptions under positivists' school of thought, deductive research approach was adopted.

Specifically in relation to the time series analysis, EViews 7 was used because it is considered as a powerful econometric tool used by many studies for analysing time series data (Brooks, 2008). To test the stochastic properties of the time series variables, Augmented Dickey-Fuller (ADF) test and Philips-Perron test are applied. Where the test finds evidence of cointegration, it will be concluded that there is a long term relationship between variables; therefore vector error correction models (VECM) could be estimated to explore long-term dynamics between variables. Unrestricted Vector Autoregressive (VAR) models can still be estimated where there is no cointegration found. Therefore, unrestricted VAR models were specified with variables for the purpose of achieving two research objectives and consequently providing answers to the research questions as highlighted in Chapter 1 of this study.

Consistent with the theoretical framework developed for this study; which considers energy social justice, media imperialism and vulnerability and exploitability dimensions, OPEC's ability to control oil prices within a target oil price band was examined within the context of a policy introduced by the organisation in year 2000. VAR models are employed to reveal how various dynamics based on how OPEC and non-OPEC countries autoed their actions in responding to changes in oil prices and vice versa. The period covered in the study represent both periods when OPEC belived it was an effective cartel that could control oil prices and those period when the organisation finally conceded that stability of oil prices was beyond its control. Although specific hypotheses were not generated this methodology is set to explore various complex dynamics with a view to describing the extent to which OPEC had attempted to control oil prices within the target price zone and also understanding factors that impeded such ability. Consequently, considering the size of the numerous dynamics within the variables considered in this

study, developing a hypothesis for each complex dynamic relationship might be pre-emptive and complex.

**CHAPTER SIX: DESCRIPTIVE AND TIME
SERIES PROPERTIES ANALYSIS**

Chapter Six Descriptive and Time Series Properties Analysis (Summary)

6.1 Introduction

This chapter is aimed providing detailed descriptive analysis and other preliminary analysis deemed necessary for the modelling analysis carried out in Chapter 7. Please note that the detailed underlying analysis relating to this chapter is moved to appendix for ease of understanding. However, this chapter summary is intended to provide summary of the findings, relevance of the chapter findings to Chapter 7 and justification for analysis in the thesis. The main reason for introducing this summary is to ease reading of the thesis. Therefore, numbering in this three-page summary chapter are ignored because the main Chapter 6 (see appendix 1) has numbering system appearing as if it were inserted in place of this summary.

6.2 Summary of the Chapter Findings

The main chapter (see appendix 1) presented and described 156 observations for each of the seven variables used in this study namely: oil price in U.S. dollar (denoted by OPR); OPEC production quota in million barrels per day (denoted by OPQ); OPEC production cheating in million barrels per day (denoted by OPC); OPEC spare capacity in million barrels per day (denoted by OSC); oil market competition (OMC); OECD/IEA crude oil consumption (OOC); and OECD/IEA crude oil stockpiling (OOS). The chapter started by analysing descriptive statistics (particularly central tendencies and normality distribution of the datasets). In addition to providing proper understanding of the pattern of each variable used in the model (see Chapter 7), descriptive analysis would help in detecting some missing and inconsistent observations or outliers. The descriptive results showed no missing data. While some variables were found to be normally distributed, others exhibited leptokurtic distribution.

Furthermore, in an attempt to carry out the modelling, the chapter examined unit root tests based on Augmented Dickey-Fuller (ADF) under parametric assumption and Phillips-Perron (PP) tests under non-parametric assumption. Having satisfied this condition, cointegration tests based on Johansen tests

were carried out to examine the long-run relationship. This was explored to assess the need to extend this study to capture the long-run dynamics between the key oil market players. Two cointegrating equations were found by both Trace and Max-Eigen statistics. In addition, analysis relating to the number of lags to be included in the models (see Chapter 7) was carried out at this juncture where 1 lag proved to be most recommended based on five criteria considered.

These initial tests are necessary to building the models in Chapter 7 in addition to the useful information relating to different patterns of the variables that could provide support to some findings from the models and other diagnostic tests as explained in Chapter 7.

**CHAPTER SEVEN: ANALYSIS OF OPEC'S
STABILISATION POLICIES AND OIL PRICES
USING VAR**

Chapter Seven Analysis of OPEC's Stabilisation Policies and Oil Prices Using VAR

7.1 Introduction

In the last chapter, various analyses were conducted to understand the properties of the data which was achieved by combining descriptive statistics, normality tests, and other time series tests (e.g. unit root test, cointegration test, and lag length test). This chapter analyses the effect of OPEC's stabilisation policies on oil price stability within a target band. Drawing upon the rationale that OPEC, as the major reserve holder (i.e. 80%) with almost 40% of the market share, its policies (namely: production quota, OPEC cheating, spare capacity, and OPB policies) should be able to stabilise oil prices within its desired target price band if it acted as effective cartel. Therefore, the 1st model is set to achieve the first objective of the study with a view to answering the first research question. The 2nd model is also estimated by introducing additional factors that could not only influence oil prices, but could also exert some degree of influence on OPEC's ability to stabilise oil prices within its desired target. This analysis is carried out with a view to achieving objective 2, thereby leading to answers for the second research question. In this regard, the next subsection presents the analysis for OPEC's stabilisation policies and oil prices.

7.2 Analysis of the Impact of OPEC's Stabilisation Policies on Oil Price Stability within a Target Price Band

In an attempt to critically examine the impact of OPEC stabilisation policies on the oil prices within a target price band, the complex dynamics between OPEC policies and oil prices using unrestricted VAR are explored as described in equation 7.1 below.

$$Y_t = C + A_1 Y_{t-1} + A_2 Y_{t-2} + \dots + A_p Y_{t-p} + B Z_t + e_t \quad \mathbf{7.1}$$

Where Y_t is a $(n \times 1)$ vector of endogenous variables, A_1 is a $(n \times n)$ vector of deterministic variables, and A_i and B are coefficients matrices, C is the $(n \times 1)$ intercept vector of the VAR, Z_t stands for the vector of exogenous variables, and e_t is the $(n \times 1)$ generalisation of a white noise process.

The series (Y_t) of four endogenous and three exogenous variables, mainly has three policies of OPEC considered within its immediate control, while the last variable stands for oil price.

Therefore, $Y_t = [OPR_t, OPQ_t, OPC_t, OSC_t]$ **7.2**

The remaining three exogenous variables standing for OPEC oil price band policy (OPB), war in Iraq (WAR), and global economic recession (GER):

$Z_t = [OPB_t, WAR_t, GER_t]$ **7.3**

7.2.1 Granger Causality Analysis

Having carried out various preliminary tests (in Chapter 6) for VAR model estimation, Granger causality tests for the four series are considered at this stage. In its simplest definition, Granger causality test seeks to provide answer to the question whether changes in one variable Granger cause changes in other variable or set of variables. Besides, Granger causality test also guides on whether the endogenously selected variables in the VAR model could be exogenously treated in the model based on the joint significance. The null hypothesis for each pair of variables assumes that, one independent variable (appearing in column) does not Granger-cause the dependent variable indicated on the row. This hypothesis can be rejected in the strongest form, moderate form, and weakest form at 1%, 5%, and 10% respectively. Block exogeneity test using chi-square (Wald) statistics for the joint significance of the lagged variables are used for Granger causality test. The reported estimates are asymptotic Wald statistics and the values in parentheses are the p-values.

Table 7:1: Granger Causality/Block Exogeneity Tests

Dependent	LOPC	LOPQ	LOPR	LOSC	Joint
LOPC		0.5542 [0.4566]	0.1878 [0.6647]	8.3393 [0.0039]*	12.1878 [0.0068]*
LOPQ	0.1632 [.0.6863]		9.9755 [0.0016]*	15.7332 [0.0001]*	32.7001 [0.0000]*
LOPR	0.9764 [0.3231]	0.3782 [0.5386]		0.6476 [0.4210]	6.6338 [0.0845]***
LOSC	4.6578 [0.0309]**	8.033 [0.0046]*	12.3885 [0.0004]*		13.9916 [0.0029]*

Notes: *, **and *** represent significance at the 1%, 5% and 10% levels respectively. Significance implies that the column variable Granger causes the row variable except for the joint column.

Key:

LOPR: Logged values of oil prices

LOPQ: Logged values of OPEC production quota

LOPC: Logged values of OPEC production cheating

LOSC: Logged values of OPEC spare capacity

From table 7.1, a unidirectional causation running from oil prices (LOPR) to OPEC production quotas (LOPQ) can be observed, implying that changes in the values of oil price cause changes in the values of OPEC production quota, but that changes in the value of OPEC production quota does not necessarily cause changes in oil prices as often alleged against OPEC. This suggests that although OPEC restricts output, such restriction does not Granger-cause changes in oil prices (see Gülen, 1996 and Bina and Vo, 2007 for support to this empirical finding). Similarly, a unidirectional causality is running from LOPR to LOSC which suggests that, changes in OPEC spare capacity do not Granger-cause changes in oil price but changes in oil prices could cause changes in the level of the capacity. Based on the nature of OPEC members (high population and urgent demand for infrastructure e.g. Nigeria, Angola, Iran) the above result is expected in the sense that pressure might be exerted on the spare capacity by increasing "cheating" behaviour by OPEC members to benefit from high oil prices. International oil companies (IOCs) are strongly accused of this type of practice when oil prices are high (see Wood, 2002). Furthermore, bidirectional causality running between OPEC

spare capacity to cheating behaviour and OPEC quota lend support to the position established above. This confirms that changes in either OPEC production quota or cheating Granger-cause changes in OPEC spare capacity, and also vice versa.

However, based on the results, causality between cheating in OPEC and its quota could not be established; and likewise between cheating and oil prices as might be expected logically. This could be due to: 1. Under-reporting of OPEC's actual oil supply by the EIA in relation to other databases (Sornette et al., 2009); and also 2. The fact that most data on "cheating" practices cannot be accurately ascertained although various evidence proved that they exist. Furthermore, causation between OPB (as dependent variable) and spare capacity and oil prices (as independent variables) could not be established, a unidirectional causality running from OPB to OPEC quota and cheating behaviour is revealed in Granger-causality results. Finally, evidence of joint significance of causality of lagged sets of variables to each of the dependent variables was found.

Consistent with the Granger causality tests, the results of the first VAR model are presented in table 7.2 to explore further dynamics from the impulse response and variance decomposition.

Table 7:2: Vector Autoregressive Estimates of the Series

	LOPR	LOPQ	LOPC	LOSC
LOPR(-1)	0.946827 (0.03820) [24.7848]	0.036805 (0.01221) [3.01368]	0.008769 (0.04737) [0.18510]	-0.312450 (0.07509) [-4.16085]
LOPQ(-1)	-0.163027 (0.22799) [-0.71505]	0.718711 (0.07289) [9.86077]	0.272896 (0.28271) [0.96527]	1.253746 (0.44816) [2.79752]
LOPC(-1)	0.033256 (0.06592) [0.50451]	-0.010685 (0.02107) [-0.50703]	0.789870 (0.08174) [9.66333]	0.349774 (0.12957) [2.69942]
LOSC(-1)	-0.008606 (0.02366) [-0.36369]	-0.032766 (0.00756) [-4.33127]	0.131352 (0.02934) [4.47638]	0.915099 (0.04652) [19.6730]
C	0.715199 (0.78297) [0.91345]	0.817855 (0.25030) [3.26747]	-0.615708 (0.97089) [-0.63417]	-3.416179 (1.53906) [-2.21965]
OPB	-0.068190 (0.03110) [-2.19283]	0.009943 (0.00994) [1.00015]	-0.045165 (0.03856) [-1.17128]	-0.052959 (0.06113) [-0.86639]
WAR	0.013431 (0.02573) [0.52200]	-0.015601 (0.00823) [-1.89666]	0.110938 (0.03190) [3.47715]	-0.143823 (0.05058) [-2.84371]
GER	-0.033630 (0.02713) [-1.23951]	-0.011289 (0.00867) [-1.30160]	0.004650 (0.03364) [0.13821]	0.033735 (0.05333) [0.63254]
R-squared	0.972481	0.917363	0.762502	0.918587
Adj. R-squared	0.971171	0.913428	0.751192	0.914711
Sum sq. residuals	1.082554	0.110635	1.664562	4.182884
S.E. equation	0.085816	0.027434	0.106412	0.168686
F-statistic	742.1113	233.1245	67.42163	236.9451
Log likelihood	164.7825	341.5478	131.4389	60.02740
Akaike AIC	-2.022999	-4.303843	-1.592760	-0.671321
Schwarz SC	-1.865919	-4.146763	-1.435680	-0.514241
Mean dependent	3.977490	3.248703	2.000818	0.815652
S.D. dependent	0.505416	0.093239	0.213334	0.577606
Determinant residual covariance (dof adj.)		4.68E-10		
Determinant residual covariance		3.79E-10		
Log likelihood		801.5813		
Akaike information criterion		-9.930082		
Schwarz criterion		-9.301762		

Key:

LOPR: Logged values of oil prices
LOPQ: Logged values of OPEC production quota
LOPC: Logged values of OPEC Production cheating
LOSC: Logged values of OPEC spare capacity
OPB: Oil price band policy
WAR: War in Iraq
GER: Global Economic Recession

On the basis of the VAR estimates obtained and presented in table 7.2, the following discussions are relevant to understanding the dynamics although VAR estimates are very difficult to interpret (Zuniga, 2005; Brooks, 2008). VAR estimates could reveal the nature of the influence of the independent variable on the dependent variable. In this connection, an attempt was made to infer some meaning from the estimates to enable interpretation of the VAR impulse responses and variance decompositions.

7.2.2 Analysis of OPEC's Stabilisation Policies and Oil Prices Stability within a Target Band

This section begins by examining the nature of oil price and how it is influenced by both endogenous and exogenous variables as shown in equation 7.2. Evidence generated from the Granger Causality analysis in table 7.1, VAR coefficients in table 7.2, and complementary analysis of impulse responses and variance decompositions based on the VAR estimates.

$$LOPR_t = \alpha_{0,1} + \beta_{1,1}LOPR_t + \beta_{1,2}LOPQ_{t-1} + \beta_{1,3}LOPC_{t-1} + \beta_{1,4}LOSC_{t-1} + \beta_{1,5}OPB_{t-1} + \beta_{1,6}WAR_{t-1} + \beta_{1,7}GER_{t-1} + e_{1t} \quad \mathbf{7.4}$$

Based on the Granger causality results in table 4.3, it can be observed that none of the three policies of OPEC (namely: OPEC production quota, OPEC cheating, and OPEC spare capacity) individually Granger caused oil prices over the sample periods. However, there is weak evidence at 10% significant level (i.e. 0.0845) that the collective policies Granger caused oil prices as shown by the joint chi-square values of 6.6338 (which is significant at 10% level). On this basis, the Granger causality result revealed first evidence about OPEC's coordinated action to stabilise oil prices within a target band which might be weak considering the fact that each policy individually was not significant in Granger causing oil prices. The results partly lend support to Gately (1996) who relied on Granger causality and cointegration to examine claims whether OPEC acted as a cartel during the sample considered in the study. In this regard, the complex dynamics of the variables are investigated for the purpose of generating further evidence from the VAR equation 7.2.

From the VAR results in table 7.2, it can be observed that in addition to the positive influence by its lagged value, oil price is negatively influenced by the lagged values of OPEC quota, positively influenced by the lagged values of

OPEC cheating, and negatively influenced by the lagged values of OPEC spare capacity. For the exogenous variables, the results reveal that oil price is negatively influenced by OPEC OPB policy, positively influenced by the war in Iraq, and negatively influenced by the global economic recession. The above results can be interpreted in relation to oil price as follows. The major influential variable on the current oil price is the status of the previous period oil price (i.e. LOPR (-1) with up to 0.946827). This suggests that the current oil price is conditional on the previous period oil prices plus or minus other associated relevant events. There is a high tendency for the current oil price to increase if there has been a historical increase in the previous period except one of the policies indicating a negative relationship with oil prices is activated (e.g. increased OPEC production quota, reduced crude oil consumption and stockpiling by OECD – see the second VAR model in table 7.9 for a detailed description of this relationship). However, a unit change (increase) in the previous period production quota by OPEC (i.e. LOPQ (-1)) lowers the oil price by about 0.163027 (as suggested by the negative coefficient -0.163027). This result is confirmed by the impulse response of OPEC production quota to oil prices.

In the same direction, the negative coefficient of oil price (LOPR) to the lagged value of the OPEC spare capacity (i.e. LOSC (-1)) implies that a unit increase in the OPEC spare capacity reduces oil price by up to 0.0086 (i.e. -0.008606). Furthermore, a positive relationship between the lagged values of OPEC cheating and the current oil prices was found. This implies that a unit increase in the previous period OPEC cheating leads to an increase in the current oil price by up to 0.033256. The literature on the effect of OPEC cheating on oil price is mixed. Therefore, this result does not come as a surprise. Alongside the above results, the absence of accurate and formal data on OPEC cheating might contribute to this finding. An alternative interpretation might be that the cheating in OPEC is highly motivated by the high oil prices as suggested by the positive VAR coefficient of LOPC to LOPR (-1).

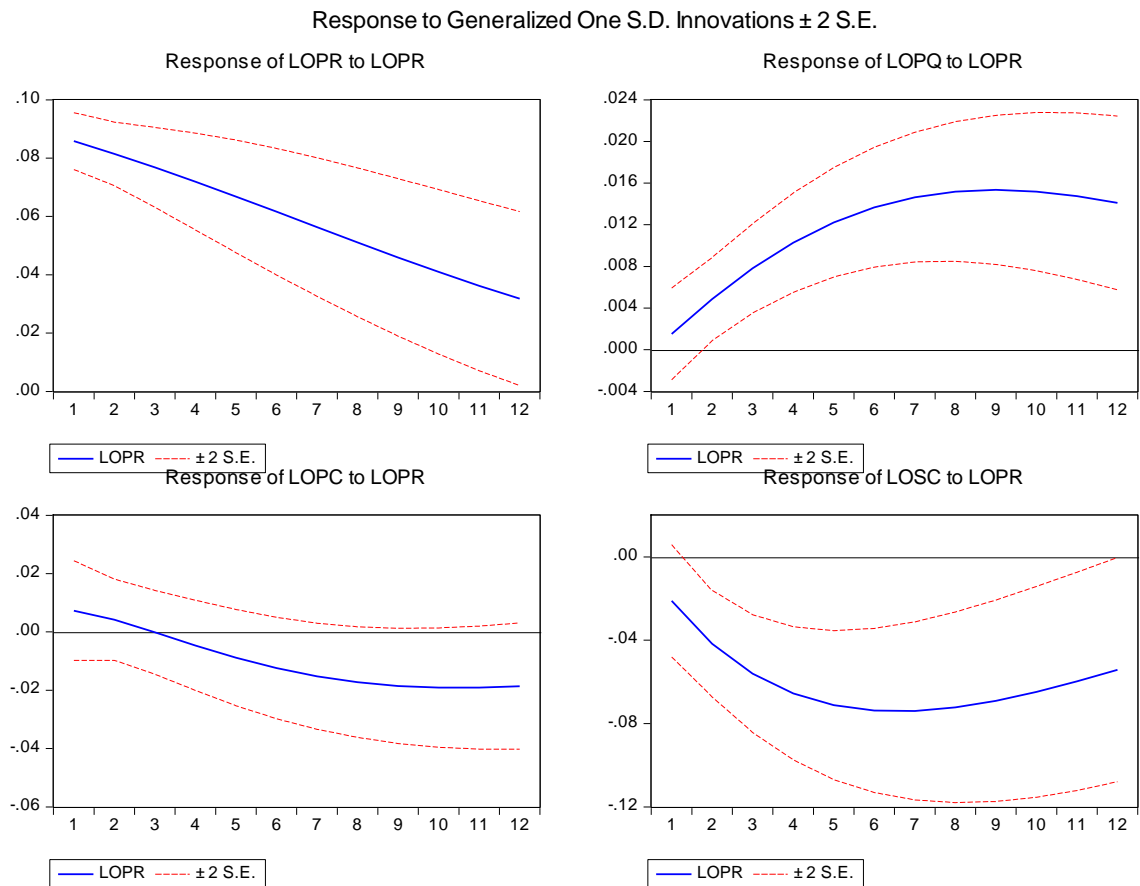
Similarly, the results reveal a negative association between OPEC OPB policy and oil price (LOPR) with a VAR coefficient of -0.068190. This reveals that introduction of the OPEC OPB policy reduces the oil price in the light of OPEC

compliance with the OPB policy. Also of interest is the U.S.-led war on Iraq. The results show a positive VAR coefficient of 0.013431 (i.e. LOPR to WAR). This shows that the war impacts positively on oil prices as shown by the coefficient of 0.013431. In the same direction, nature of the influence of the global economic recession on the oil prices can be investigated. As indicated by the results, a negative coefficient can be observed for LOPR to GER (i.e. -0.033630). Possible interpretation of this finding is that oil price is affected negatively by the presence of economic recession. The 2008 economic recession influenced a reduction of oil price of up to 0.033630.

Generalized impulse response functions (GIRF) are utilised (based on Koop et al., 1996 and Pesaran and Shin, 1998) for the purpose of this study as against the Choleski decomposition. GIRFs are recommended by Dibooglu and AlGudhea (2007) where a variable is affected by another and vice versa. As highlighted earlier, an impulse response function (IRF⁸⁶) is a mechanism that measures the effects of one standard deviation shock to an innovation of another variable holding other variables constant in a system and this is measured over time. Thus, it is often interpreted as "effects of a one-time shock to one of the innovations on current and future values of the endogenous variables" (Farzanegan and Markwardt, 2009: 139). Figure 7.1 presents the IRFs for a unit standard innovation in the oil price.

⁸⁶ More specifically, by imposing a unit standard deviation shock on a dependent variable, the reaction on the residuals of other explanatory variable is observed holding other factors constant.

Figure 7.1: Impulse Response Functions for One Standard Deviation Innovation in Oil Price (LOPR)



Key:

- LOPR: Logged values of oil prices
- LOPQ: Logged values of OPEC production quota
- LOPC: Logged values of OPEC production cheating
- LOSC: Logged values of OPEC spare capacity

Figure 7.1 presents four panels of the impulse response functions for one standard deviation innovation in oil prices to the shocks on all four endogenous variables over 12 periods. The blue line in the middle of the two red-dotted lines indicates the response of each of the four endogenous variables to the shocks in the dependent variable (i.e. logged values of oil prices). The two red-dotted lines indicate standard error bar/band which is similar to t-statistic used for reporting coefficients in regression analysis (Runkle, 1987). The error band as indicated in the key boxes under each panel is measured at ± 2 standard errors. The horizontal axis shows the periods in month over which the IRFs are computed. The vertical axis

represents the response of each of the explanatory variables to the unit change in the standard deviation shock. The values represent innovations (in percentages based on logged values) when unit-time standard deviation shock⁸⁷ is imposed on the LOPR. Based on the first panel (i.e. response of LOPR to LOPR), response of crude oil price to the initial shock in the oil price to be positive and permanent throughout the periods considered can be viewed. The shocks in the oil price significantly increase OPEC production quota as indicated by the second panel (i.e. response of LOPQ to LOPR), but decreases OPEC spare capacity (as shown by panel four (i.e. response of LOSC to LOPR)). The positive response of OPEC production quota starts in period 1 and progressively moves through the remaining periods before reaching its peak in period 8 from where it stays constant over the 9th period and thereafter begins to decline over the remaining three periods.

Similarly, OPEC spare capacity responds negatively to the shock in oil price and reaches its minimum level in the end of period 7, coincidentally when the response of OPEC quota to the oil price shock is at its maximum positive position. This nature of the relationship is somehow suggested by the VAR coefficient of lagged OPEC spare capacity to OPEC production quota (i.e. LOSC (-1) to LOPQ -0.032766). This can be interpreted to mean that rapid positive response of OPEC production quota exerts much pressure on the OPEC spare capacity. The pressure on OPEC spare capacity reduces as response of OPEC quota to oil price reduces from period 9 to 12 as shown in panel 2 of figure 7.1. However, OPEC production cheating responds positively from period 1 to period 3 before it begins to respond negatively at declining state from period 4 to period 9 and remains constant throughout the remaining periods (i.e. period 9 to period 12). The impulse response of OPEC production quota suggests that, in the short-run, it reacts to a

⁸⁷ A unit standard deviation shock in this case may be interpreted to be a 1% standard deviation on the error term of LOPR since the series was considered based on its logged values. Then an impulse response function with one unit shock (for example in the second panel titled "Response of LOPQ to LOPR" should be interpreted as: response of LOPQ to 1% shock of LOPR. The third panel titled "Response of LOPC to LOPR" therefore shows that a unit S.D. shock on the error term of the dependent variable (in this case LOPR) will result in the reactions plotted by the blue line over the period considered in the IRFs analysis. This is also applicable to the LOSC presented in the fourth panel titled "Response of LOSC to LOPR". A unit S.D. innovation/impulse/shock on the dependent variable (in this case the LOPR) is used in order to observe the response of the independent variable (i.e. LOSC). This is repeated over the periods considered in the IRFs analysis to plot the blue line in the panel.

symmetric shock in oil price by increasing. Although, the increase has remained positive throughout the periods, other variables' reaction to this response may exercise some level of influence OPEC production quota. Table 7.3 presents the results for the variance decomposition of oil prices.

Table 7:3: Variance Decomposition of Oil Price (LOPR)

Period	S.E.	LOPR	LOPQ	LOPC	LOSC
1	0.085874	100.0000	0.000000	0.000000	0.000000
2	0.118400	99.16398	0.561949	0.245750	0.028323
3	0.141637	97.75606	1.551686	0.632470	0.059784
4	0.159774	96.14797	2.729032	1.044860	0.078135
5	0.174398	94.54507	3.945581	1.427943	0.081406
6	0.186327	93.04984	5.114817	1.760261	0.075078
7	0.196083	91.70529	6.189368	2.037463	0.067881
8	0.204041	90.52164	7.145886	2.263110	0.069367
9	0.210503	89.49202	7.975612	2.443836	0.088534
10	0.215721	88.60136	8.678661	2.586935	0.133049

Cholesky Ordering: LOPR LOPQ LOPC LOSC

Key:

LOPR: Logged values of oil prices

LOPQ: Logged values of OPEC production quota

LOPC: Logged values of OPEC production cheating

LOSC: Logged values of OPEC spare capacity

Table 7.3 presents the variance decomposition of oil price which analyses the contribution of OPEC policies towards explaining the variation in oil prices. This source of evidence is important in the sense that if OPEC's stabilisation policies were effective, they should be able to collectively account for a significant variation in oil prices. From table 7.3, other than the oil price which accounts for 99.16%, OPEC production quota, production cheating, and spare capacity account for 0.56%, 0.25%, and 0.03% respectively. OPEC production quota is the variable that accounts for the largest variation during the entire periods with variations of 3.95%, 7.15%, and 8.68% in periods 5, 8, and 10 respectively. This finding is consistent with previous literature (e.g. Mabro, 2005; Kaufmann et al. 2008) that concluded OPEC production quota as the most important weapon for OPEC to influence oil prices.

The second most important variable accounting for the variation is OPEC production cheating which accounts for 1.43%, 2.26%, and 2.59% for period 5, 8, and 10 respectively. The last but not the least is the OPEC spare capacity which accounts for less than 0.5% throughout the periods considered. This result might be expected based on the empirical findings. However, the literature is supportive that this policy is sensitive to oil price changes. For example, consistent with the claim made by the EIA chief Adam Sieminski, EIA projected high oil prices in its short term energy outlook (STEO) whenever OPEC spare capacity was low (see STEO, 2006 and 2014; Sieminski, 2013). This result does not necessarily mean that OPEC production quota was not adjusted to appropriately accommodate the demand shocks during the period. This finding suggests that OPEC spare capacity does not appear to be an important role that would account for oil price shock. However, the interpretation of the policy by other key players might be that low OPEC capacity indicates a signal from OPEC for high oil prices because increase in OPEC production quota and cheating would depend on the available excess capacity created by OPEC. This finding lends support to Brémond et al. (2012) who found that OPEC acted as signaller during the sample period. An important question that might produce a different answer at this stage is whether OPEC's ability to create spare capacity was solely dependent on the member's decision or a product of other factors outside members' control. In other words, valid conclusions cannot be reached at this juncture without having further consideration of the determinants for changes in the OPEC spare capacity from within and outside the organisation. In the subsequent analysis, the real dynamic of this variable emerges as the other variables are introduced in the model (see second model).

In this regard, both impulse response functions in figure 1 and forecast error variance decompositions of oil price indicate a very interesting trend. While OPEC attempts to consistently increase oil production (i.e. period 1 to 9) due to shock in the oil price, continuous decline in the OPEC's spare capacity which could be influenced by a number of reasons seems to persist from period 1 to 7 before recovering in the subsequent periods (8 to 12). Linking this trend in the impulse response functions to that of the variance decomposition, it further confirms that despite such consistent increase

production, the production quota appears to be the major contributing variable explaining variation in the oil price. Despite the perceived effect of declining spare capacity of OPEC as shown by the trend in the 4th panel of figure 7.1, variance decomposition shows OPEC spare capacity has no huge impact on oil price. Given the fact that non-OPEC producers interpret OPEC's low spare capacity as a signal for high oil prices, it would be important understand what actually led to such declining state of spare capacity in OPEC. Further evidence of OPEC's inability to sustain production with a view to reducing shock in oil prices is revealed in response of OPEC production cheating to shocks in oil prices. This was initially positive in the first three period but later declined over the remaining 9 periods. Considering this trend in relation to the contribution of OPEC production cheating to variation in oil price, it is clear that OPEC production cheating accounts for less variation in oil prices when there was positive response between LOPC and LOPR in figure 7.1. Thereafter contribution of OPEC production cheating to variation in oil price started to increase because of the low spare capacity and negative response of OPEC production cheating to shock in oil price.

7.2.2.1 Analysis of the OPEC Production Quota

Furthermore, the nature of the influence of the lagged values of all the endogenous and exogenous variables is examined for OPEC production quota policy as captured by equation **7.5** below:

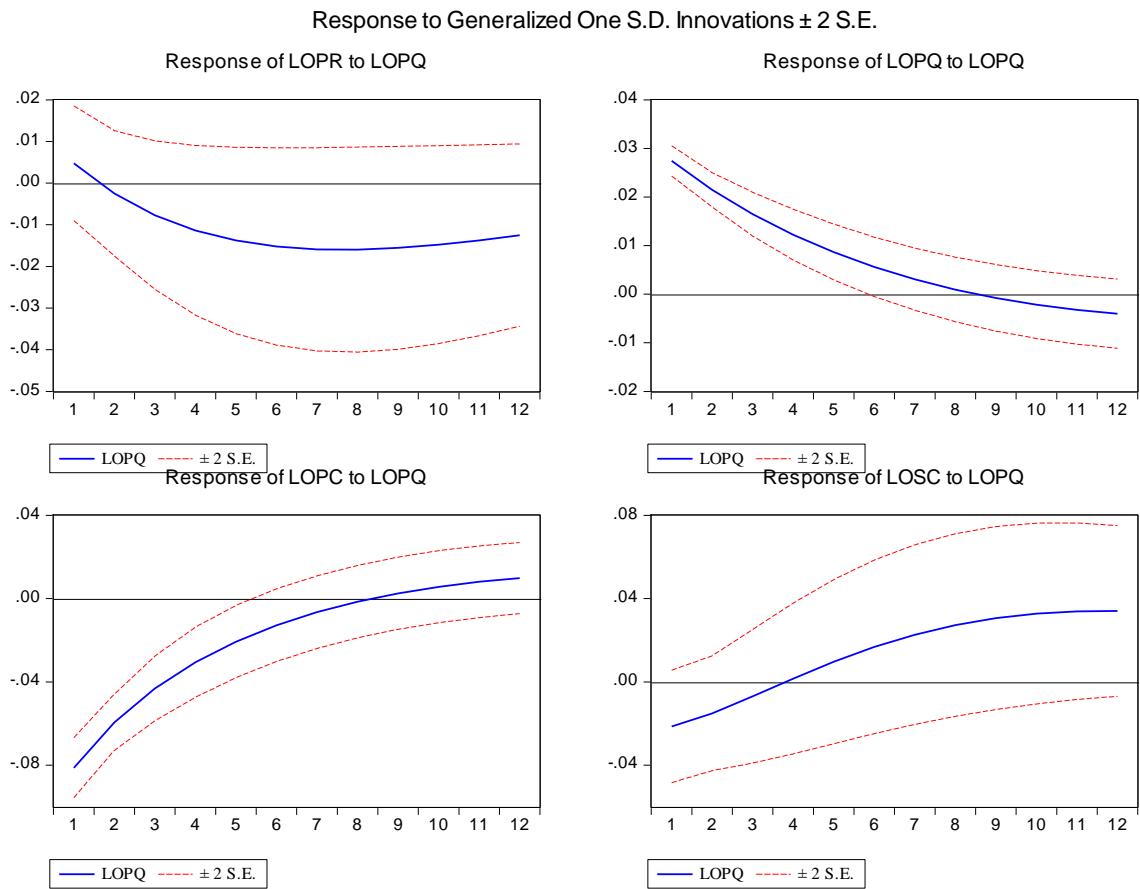
$$LOPQ_t = \alpha_{0,2} + \beta_{2,1}LOPQ_{t-1} + \beta_{2,2}LOPR_{t-1} + \beta_{2,3}LOPC_{t-1} + \beta_{2,4}LOSC_{t-1} + \beta_{2,5}OPB_{t-1} + \beta_{2,6}WAR_{t-1} + \beta_{2,7}GER_{t-1} + e_{2,t} \quad \mathbf{7.5}$$

The objective at this stage is to evaluate how the OPEC quota system has been affected by other variables. This will clearly spell out how capable OPEC might be in influencing future oil prices. From table 7.2 above, OPEC production quota policy has been largely and positively influenced by the lagged values of its production quota policy, positively influenced by the lagged values of oil prices, negatively influenced by the lagged values of OPEC cheating practices, and negatively influenced by the lagged values of OPEC spare capacity.

It can be observed from our results that the war had a negative repercussion on OPEC production, considering the proportion of Iraq reserves in OPEC (see table 2.0000), as indicated by the VAR coefficient of WAR on LOPQ (i.e. -0.0113). Consequently, the war has impacted on the market by increasing the oil prices as revealed by the VAR coefficient of WAR on LOPR (i.e. 0.0134). The impact of WAR on oil prices (LOPR) is slightly greater than that of OPEC production quota (i.e. by 0.0021), this is likely to increase when the effect of the market reaction (usually from both speculators and crude oil importing nations) is considered in the model. In the same vein, WAR (i.e. the U.S.-led Iraq war) shows a positive relationship with OPEC cheating (i.e. 0.1109) which could take any two possible interpretations. First, it indicates a positive OPEC's response by increasing its oil production during the war as oil prices rose due to lost production from OPEC. Second, OPEC cheating might have increased due to the fact that some OPEC members saw the war as an opportunity to raise their production to gain from the rising oil prices given some of the members' vulnerability and quest for high revenue to develop their infrastructure.

More specifically, the impulse response functions (IRF) of all the four variables to the shocks in OPEC production quota are explored as indicated by figure 7.2 below:

Figure 7.2: Impulse Response Functions for One Standard Deviation Innovation in OPEC Production Quota (LOPQ)



Key:

- LOPR: Logged values of oil prices
- LOPQ: Logged values of OPEC production quota
- LOPC: Logged values of OPEC production cheating
- LOSC: Logged values of OPEC spare capacity

Figure 7.2 presents four panels of the response of all the four endogenous variables to the shock in OPEC production quota. The blue line in the middle of the two red-dotted lines indicates the response for each of the four endogenous variables to the shocks in the dependent variable (i.e. logged values of OPEC production quota). Supplementing the findings from the VAR estimates discussed under subsection 7.2.3, response of oil price to OPEC production quota is initially positive up to the middle of period 2, but later becomes negative throughout the periods (periods 2 to 12). This finding suggests that oil prices are reduced by increased OPEC production. However, magnitude of the impact might not be commensurate with response of OPEC

production quota to the shock in the oil prices (i.e. the peak of the response of LOPQ to LOPR is much more than the response of LOPR to LOPQ). OPEC production quota response to the shock in OPEC production quota is initially positive and continues until the end of period 9 when it becomes negative over the remaining periods considered.

The response of OPEC cheating to the shock in OPEC production quota begins as negative from period 1 to period 8 and later turns to be positive for the remaining periods. OPEC spare capacity also responds negatively to the shock in OPEC production quota at the beginning (specifically from period 1 up to period 3). Later the response becomes positive and permanent throughout the remaining periods (i.e. periods 4 to 12). This suggests that as OPEC production quota increases, OPEC cheating decreases which slightly affects the spare capacity of the organisation in the early stages of the periods considered in the impulse response analysis. However, the cheating increases and becomes positive lately towards the 8th period as the shock in OPEC quota to OPEC quota becomes negative (see the second panel of response of LOPQ to LOPQ). As the response of OPEC spare capacity increases from period 3, it can be observed the response of oil price to OPEC production quota already becomes negative and gradually remains so in the remaining periods when the spare capacity remains positive and permanent throughout the remaining periods.

In the same manner, the variance decompositions of the OPEC production quota are explored as shown in table 7.4 below.

Table 7:4: Variance Decomposition of OPEC Production Quota (LOPQ)

Period	S.E.	LOPR	LOPQ	LOPC	LOSC
1	0.027655	0.311131	99.68887	0.000000	0.000000
2	0.035473	2.063812	96.87883	0.262771	0.794582
3	0.040151	5.156615	91.46556	0.793064	2.584759
4	0.043669	9.296580	84.09969	1.473265	5.130464
5	0.046783	13.97339	75.80229	2.176967	8.047355
6	0.049796	18.65380	67.59070	2.806352	10.94914
7	0.052797	22.94024	60.19249	3.309729	13.55755
8	0.055773	26.62264	53.96775	3.676333	15.73328
9	0.058673	29.64656	48.98462	3.920499	17.44832
10	0.061440	32.05290	45.13983	4.066808	18.74046

Cholesky Ordering: LOPR LOPQ LOPC LOSC

Key:

LOPR: Logged values of oil prices

LOPQ: Logged values of OPEC production quota

LOPC: Logged values of OPEC production cheating

LOSC: Logged values of OPEC spare capacity

From table 7.4, it can be observed that OPEC production quota accounts for the major variation in the second period with up to 96.88%, while oil price, OPEC cheating and spare capacity account for only 2.06%, 0.26%, and 0.79% respectively in the same period. These variations change in the 5th period where OPEC production quota accounts for 75.80% while the corresponding figures for oil price, OPEC cheating and spare capacity account for 13.97%, 2.18%, and 8.05% respectively. For the 8th and 10th periods, another remarkable change has taken place. OPEC production quota accounts for 53.97% and 45.14% in the 8th and 10th periods respectively. The reduction in the variation from OPEC production quota is largely split between oil price and OPEC spare capacity where oil price accounts for 26.62% and 32.05% in period 8 and 10 respectively. For the corresponding periods, OPEC spare capacity accounts for 15.73% and 18.74%. Although, OPEC production quota does not account for any tangible variation in the oil prices as shown by table 7.2 above, it is established in table 7.4 (consistent with the Granger causality results) that OPEC production quota is motivated by the prevailing crude oil prices and also the available spare capacity in the member countries. As can be observed, OPEC cheating does not account for any much

variation presumably because increase in the members' quota usually offsets the amount of cheating that would have been embarked upon.

7.2.2.2 Analysis of the OPEC Production Cheating

Similarly, this subsection examines the nature of OPEC cheating practice and how it is influenced by its lagged values and the lagged values of other variables and the exogenous variables as captured by equation **7.6**:

$$LOPC_t = \alpha_{0,3} + \beta_{3,1}LOPC_{t-1} + \beta_{3,2}LOPR_{t-1} + \beta_{3,3}LOPQ_{t-1} + \beta_{3,4}LOSC_{t-1} + \beta_{3,5}OPB_{t-1} + \beta_{3,6}WAR_{t-1} + \beta_{3,7}GER_{t-1} + e_{3,t} \quad \mathbf{7.6}$$

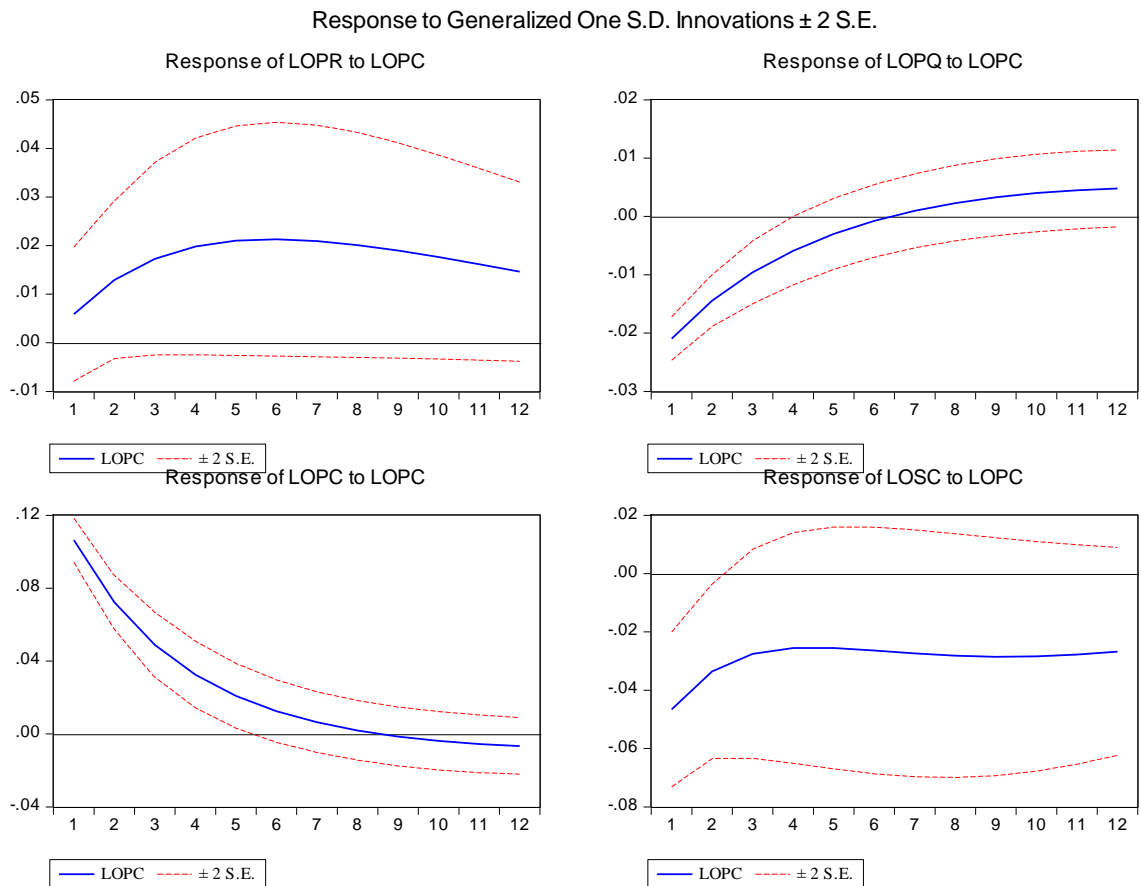
Based on the results presented in table 7.2, consistent with equation 7.6, OPEC cheating is largely and positively influenced by its lagged values (i.e. 0.789870). In the same direction, it is positively influenced by the lagged values of oil price (LOPR), positively influenced by the lagged values of OPEC production quota (LOPQ), positively influenced by the lagged values of OPEC spare capacity. It can also be observed from the results that OPEC cheating is negatively influenced by OPEC OPB policy, and positively influenced by both war in Iraq and the global economic recession. Therefore, the results can be interpreted as follows, starting with lagged values of the OPEC cheating ($LOPC_{t-1}$) which produces a VAR coefficient of 0.789870. This suggests that increase in the current OPEC cheating is explained (0.789870) by the previous period cheating. Also, the positive influence of OPEC cheating to the lagged value of the OPEC production quota ($LOPQ_{t-1}$) reveals an interesting positive VAR coefficient (i.e. 0.272896). This can be interpreted as a unit increase in the OPEC quota in the previous period results in an increase in the cheating in OPEC. As earlier mentioned, the cheating practice could possibly be motivated by high oil prices when OPEC quota is increased, or perhaps a deliberate effort to cheat because of the grievances of a member feeling cheated in the official OPEC allocation quota (see Chalabi, 2010).

Moreover, OPEC cheating is positively influenced by increase in the lagged values of OPEC spare capacity. This suggests that, given the fact that there exists a negative VAR coefficient of lagged value of oil price (i.e. LOPR), to the OPEC spare capacity (LOSC), increased oil price is accompanied by reduction in the capacity largely due to the pressure not only on the production but also from the cheating observed in the member nations.

Similarly, the effect of the OPB policy on the OPEC cheating can be viewed which yields a VAR coefficient of -0.0045165 . This implies that introduction of the policy was able to reduce cheating in OPEC. Consistently, war in Iraq (WAR) and global economic recession (GER) both have positive effect on the OPEC cheating (i.e. 0.110938 and 0.004650 respectively). The possible interpretation for such positive coefficients could not be unrelated to the structure of OPEC as an organisation. The war in Iraq has increased oil prices which then served as possibly motivation for some OPEC members to increase their production to benefit from the rising oil prices.

Similarly, global economic recession (GER) reveals a positive coefficient with OPEC cheating (LOPC) of 0.004650 which means that despite the decrease in oil prices due to global economic recession, OPEC cheating has continued with the recession. This could be due to one of the two possible reasons mentioned in the last paragraph: that is, some OPEC members exceed their allocated quota to boost their economies. It should be noted that cheating is usually higher during a war than a recession because a war era is likely to lead to speculation about likely increases in oil prices whereas the reverse is true during a recession. In fact, usually during recession prices fall and consumption is reduced. Consistent with the VAR estimates above, VAR impulse responses for a 12 year period were calculated with a view to understanding the nature of the policy responses to the shocks in the dependent variables (i.e. OPEC production cheating). Figure 7.3 shows the impulse responses of all the variables to OPEC cheating using four panels.

Figure 7.3: Impulse Response Functions for One Standard Deviation Innovation in OPEC Production Cheating (LOPC)



Key:

- LOPR: Logged values of oil prices
- LOPQ: Logged values of OPEC production quota
- LOPC: Logged values of OPEC production cheating
- LOSC: Logged values of OPEC spare capacity

Panel one of figure 7.3 (i.e. response of LOPR to LOPC) shows a positive and permanent response of oil price to OPEC production cheating. The blue line in the middle of the two red-dotted lines indicates the response for each of the four endogenous variables to the shocks in the dependent variable (i.e. logged values of OPEC production cheating). Consistent with the VAR coefficients in tables 7.2, this result lends support to the fact that OPEC cheating is motivated by high oil prices. However, the near bumpy IRF in panel 1 of figure 7.4 suggests that the response starts as positive from a

lower level and reaches its maximum in period 5 before declining towards the remaining periods considered. The second panel (i.e. response of LOPQ to LOPC) shows a negative response of OPEC production quota to its production cheating from period 1 to period 6. Thereafter the response becomes positive and lasts for the remaining part of the periods considered. This result suggests that initially when oil price responds positively to the shock in OPEC cheating up to its maximum level in the periods considered, OPEC quota which responds negatively up to such period (i.e. period 6) turns to produce a positive response. Panel 3 shows the response of OPEC production cheating to the shock in OPEC production cheating which is positive from period 1 to period 8 and later turns to be negative from period 9 to the remaining periods considered. In this direction, OPEC spare capacity responds negatively to the shock in OPEC production cheating. This explains why OPEC maintains low spare capacity in the short run in some periods based on the sample. Implications of the results on OPEC behaviour are: OPEC behaviour changes with time depending on the nature of the shock in any of the variables. Shock in OPEC production behaviour receives a negative response from OPEC spare capacity due to the pressure created by such shock.

Furthermore, table 7.5 presents how all the independent endogenous variables in the VAR can explain variation in OPEC production cheating as the dependent variable in the VAR equation.

Table 7:5: Variance Decomposition of OPEC Production Cheating (LOPC)

Period	S.E.	LOPR	LOPQ	LOPC	LOSC
1	0.110102	0.689333	58.77903	40.53164	0.000000
2	0.137935	0.544360	59.52270	39.49115	0.441783
3	0.151758	0.449931	59.56073	38.50351	1.485833
4	0.159612	0.454757	58.92834	37.51847	3.098429
5	0.164696	0.590693	57.73685	36.50196	5.170500
6	0.168522	0.865792	56.14927	35.44206	7.542877
7	0.171824	1.265105	54.34522	34.34764	10.04204
8	0.174937	1.757585	52.48828	33.24165	12.51248
9	0.177986	2.305251	50.70560	32.15267	14.83648
10	0.180989	2.871129	49.08130	31.10797	16.93960

Cholesky Ordering: LOPR LOPQ LOPC LOSC

Key:

LOPR: Logged values of oil prices

LOPQ: Logged values of OPEC production quota

LOPC: Logged values of OPEC production cheating

LOSC: Logged values of OPEC spare capacity

From table 7.5, variation in OPEC production cheating is accounted by 58.78% and 0.69% from OPEC production quota and oil price respectively in addition to the effect of OPEC production quota itself which accounts for 40.53% in the first period where OPEC spare capacity accounts for nil. This variation in the 5th period is accounted by 0.59%, 57.74%, 36.50%, and 5.17% from oil price, OPEC production quota, OPEC production cheating, and spare capacity respectively. It can be observed that OPEC spare capacity gathering momentum with time as important factor accounting for variation in OPEC production cheating after OPEC production quota and cheating. In the 8th period, this trend is maintained. Oil price, OPEC production quota, OPEC cheating, and OPEC spare capacity account for 1.76%, 52.49%, 33.24%, and 12.51% respectively. In the final period considered (i.e. period 10), the results show that oil price, OPEC quota, OPEC cheating, and spare capacity account for 2.87%, 49.08%, 31.11%, and 16.94% respectively. The results suggest that OPEC production quota is the major variable accounting for the variation in OPEC cheating, implying the effect of quota system in the behaviour of OPEC members towards oil market and oil price stability. Second

major variable accounting for variation is OPEC spare capacity which started from 0 to almost 17%.

7.2.2.3 Analysis of the OPEC Crude Oil Spare Capacity

Furthermore, the 4th equation in an attempt to understand the nature of the dynamics between OPEC spare capacity and its lagged values as well as the lagged values of other variables and the exogenous variables as shown by equation **7.7** below:

$$LOSC_t = \alpha_{0,4} + \beta_{4,1}LOSC_{t-1} + \beta_{4,2}LOPR_{t-1} + \beta_{4,3}LOPQ_{t-1} + \beta_{4,4}LOPC_{t-1} + \beta_{4,5}OPB_{t-1} + \beta_{4,6}WAR_{t-1} + \beta_{4,7}GER_{t-1} + e_{4,t} \quad \mathbf{7.7}$$

In this regard, the results reveal that the current OPEC spare capacity is largely and positively influenced by the lagged values of the spare capacity (i.e. $LOSC_{t-1}$) by 0.915099, negatively influenced by the lagged values of oil prices (i.e. $LOPR_{t-1}$) by -0.312450, positively influenced by lagged values of OPEC production quota (i.e. $LOPQ_{t-1}$) by 1.253746, and positively influenced by the lagged values of OPEC cheating (i.e. $LOPC_{t-1}$) by 0.349774. Also, OPEC spare capacity is negatively influenced by the OPEC OPB by -0.052959 and the war in Iraq (WAR) by -0.143823, but positively influenced by the global economic recession (GER) by 0.033735.

From the results described above, the following interpretations could be useful in understanding OPEC behaviour and how it responds with its spare capacity. The positive VAR coefficient of $LOSC$ to $LOSC_{t-1}$ can be interpreted as the current OPEC spare capacity is influenced by the position of the previous period capacity level by up to 0.915099. This suggests that a unit increase in the previous spare capacity is likely to increase the current period spare capacity by the VAR coefficient of 0.915099. This result is highly expected. However, OPEC spare capacity is negatively influenced by oil prices which suggests that a unit increase in previous period oil price, OPEC increases its current production quota (i.e. $LOPQ$ to $LOPR_{t-1}$ at 0.036805) and also current cheating (i.e. $LOPC$ to $LOPR_{t-1}$ at 0.008769). The resultant increase in the above couple of variables will therefore exert more pressure on the existing spare capacity therefore leading to a decrease as revealed by the negative VAR coefficient of -0.312450. This behaviour is very well expected considering the lag between investments and actual crude oil

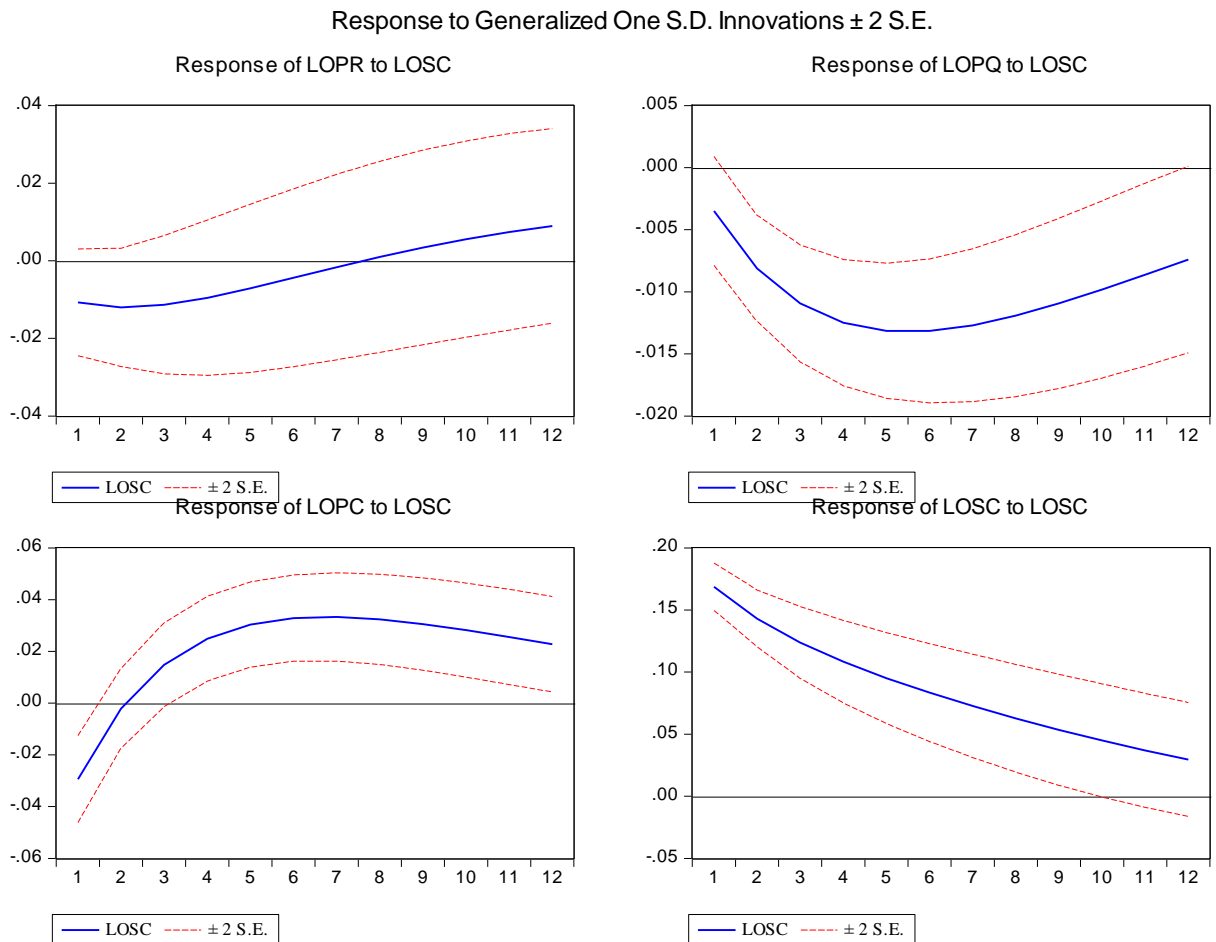
production output for the oil market which might have spill over effect over the subsequent periods. This behaviour might not be expected for a cartel pursuing sustained high oil prices due to restricted crude oil production.

In a similar manner, it can be observed that there is a positive influence of the lagged values of OPEC quota ($LOPQ_{t-1}$) on the current OPEC spare capacity (LOSC). A unit increase in the OPEC production in the previous period (i.e. $LOPQ_{t-1}$) usually increases current spare capacity (LOSC) by 1.253746. This result is expected because it is believed that increase in OPEC production quota will improve the amount of spare capacity *ceteris paribus*. Also, the same pattern of relationship is revealed for OPEC spare capacity to the lagged values of OPEC cheating (i.e. $LOPC_{t-1}$). The same analogy is applicable in the interpretation of OPEC spare capacity to the lagged values of OPEC production quota. Production increase by OPEC from cheating usually originates from the existing spare capacity. That means there is high motivation for cheating to increase when spare capacity is available (see VAR coefficient for $LOPC$ to $LOSC_{t-1}$). Likewise, when cheating is high in the short run, that could be taken as an indication for existence of high spare capacity.

Consistently, introduction of OPB policy has negative influence on the spare capacity presumably due the need for compliance by members with the policy any time oil prices increased for consecutive days as stipulated by the policy. That means for members to compliance with the provision of the policy, pressure is exerted on the capacity which makes it to reduce as events that might bring about such policy response usually appeared unanticipated. In the same vein, the spare capacity is negatively influenced by the war (i.e. WAR with VAR coefficient of -0.143823). The result makes a logical interpretation that war has negative effect on the spare capacity. The in Iraq might have exerted a high pressure on the existing capacity which changes easily in the short run. OPEC production quota usually decreases with the presence of global recession (see VAR coefficient of $LOPQ$ to GER in table 7.4: i.e. -0.011289) presumably due to decreased oil prices (see VAR coefficient of $LOPR$ to GER, i.e. -0.033630). Despite the increased production by the OPEC members resulting from cheating during global recession (e.g. see VAR coefficients for $LOPC$ to GER, i.e. 0.004650), spare capacity appears to be positive. This means that, with the advent of global economic recession,

demand is reduced due to lost purchasing power from the oil consumer nations. Consequently, the stocks available would have to continue to build capacity despite the reduction of member's quota (i.e. LOPQ to GER VAR coefficient of -0.011289).

Figure 7.4: Impulse Response Functions for One Standard Deviation Innovation in OPEC Spare Capacity (LOSC)



Key:

LOPR: Logged values of oil prices

LOPQ: Logged values of OPEC production quota

LOPC: Logged values of OPEC production cheating

LOSC: Logged values of OPEC spare capacity

Figure 7.4 presents four panels of impulse responses of the four endogenous variables to the shock in the OPEC spare capacity. The blue line in the middle of the two red-dotted lines indicates the response for each of the four

endogenous variables to the shocks in the dependent variable (i.e. logged values of OPEC cheating). In the first panel (i.e. response of LOPR to LOSC), it can be observed a negative response of oil price to OPEC spare capacity from period 1 to the end of 7th period. From the 8th period, the shock becomes positive as expected. This interprets that at the beginning when there is a shock in OPEC spare capacity, oil prices reduces up to period 7. Thereafter a positive response of oil price to the capacity means that price increases as the capacity increases. This is due to declining positive response of OPEC spare capacity to OPEC spare capacity (as shown by panel four), which suggests the nature of the shock decreases with time and that pressure from OPEC cheating (see panel three of response of LOPC to LOSC) will further force the capacity down. The positive response of OPEC cheating to the spare capacity indicates that cheating increases with shock in capacity. However, the shock which starts as negative from period 1 up to the middle of period 2 becomes positive thereafter and remains permanent throughout the remaining periods. The impulse response reaches its peak in the 7th period and begins to decline though positive. Panel two shows that OPEC production quota has a negative response to the shock in OPEC spare capacity.

In this connection, it can be concluded that most of the above responses are consistent with what was earlier reviewed and projected in the literature. In the same direction, table 7.6 presents analysis of the variance decomposition of OPEC spare capacity with a view to discussing the most important variable(s) that account for the variation in the excess capacity.

Table 7:6: Variance Decomposition of OPEC Spare Capacity (LOSC)

Period	S.E.	LOPR	LOPQ	LOPC	LOSC
1	0.173025	2.009340	0.740698	35.40693	61.84303
2	0.238871	4.208889	0.397723	30.75406	64.63932
3	0.287895	6.670495	0.392395	26.79206	66.14505
4	0.328730	9.106040	0.713872	23.49767	66.68242
5	0.364338	11.34273	1.305585	20.79813	66.55355
6	0.395961	13.29840	2.095358	18.60351	66.00273
7	0.424178	14.95040	3.013400	16.82554	65.21066
8	0.449297	16.31015	4.000391	15.38621	64.30325
9	0.471524	17.40577	5.009575	14.22032	63.36434
10	0.491033	18.27167	6.005947	13.27497	62.44741

Cholesky Ordering: LOPR LOPQ LOPC LOSC

Key:

LOPR: Logged values of oil prices

LOPQ: Logged values of OPEC production quota

LOPC: Logged values of OPEC production cheating

LOSC: Logged values of OPEC spare capacity

From table 7.6, the major contributing variable to the variation is OPEC spare capacity, followed by OPEC cheating, oil price and then lastly OPEC production quota. On the basis of the results, the proportion of the variation contributed by oil price and OPEC production quota grow steadily while that of OPEC cheating diminishes. It can be observed that in period 1, other than OPEC spare capacity which accounts for 61.84% of the variation in the spare capacity, oil price, OPEC production quota, and OPEC production cheating account for 2.01%, 0.74%, and 35.41% respectively. In the 5th, 8th, and 10th periods, oil price accounts for 11.34%, 16.31%, and 18.27% respectively. The variation accounted by the OPEC production quota does not exceed more than 6%. It starts from less than 1% from period 1 to 4 and increases in multiple of 1 from period 5 to 12. OPEC cheating which contributes the highest next to OPEC spare capacity, accounts for 20.80%, 15.39%, and 13.28% for periods 5th, 8th, and 10th respectively.

Having carried out the analysis above, it is important at this point to predict how the coordinated OPEC's action can predict the subsequent year (i.e. 2013) based on the calculated VAR 1st model coefficients. Table 7.7 such results.

Table 7:7: Out of Sample Forecast for 2013 Based on VAR – 1st Model

<i>Period</i>	1	2	3	4	5	6	7	8	9	10	11	12	
Actual Oil Price	87.86	92.94	92.02	94.51	95.77	104.67	106.57	106.29	100.54	93.86	97.63	94.62	
Forecasted Oil Price	90.96	92.80	96.55	93.87	85.66	73.96	79.26	85.17	85.51	80.74	77.93	79.19	
Prediction Error	-3.10	0.14	-4.53	0.64	10.11	30.71	27.31	21.12	15.02	13.12	19.70	15.43	
LOPR_{t-1}	100.27	102.2	106.16	103.32	94.66	82.3	87.9	94.13	94.51	89.49	86.53	87.86	
	0.946827	94.93834	96.76572	100.5152	97.82617	89.62664	77.92386	83.22609	89.12483	89.48462	84.73155	81.92894	83.18822
LOPQ_{t-1}	30	30	30	30	30	30	30	30	30	30	30	30	
	-0.16303	-4.89081	-4.89081	-4.89081	-4.89081	-4.89081	-4.89081	-4.89081	-4.89081	-4.89081	-4.89081	-4.89081	
LOPC_{t-1}	6.56	6.93	6.95	7.20	6.81	6.92	6.82	7.04	6.73	6.24	6.05	5.91	
	0.033256	0.218159	0.230464	0.231129	0.239443	0.226473	0.230132	0.226806	0.234122	0.223813	0.207517	0.201199	0.196543
LOSC_{t-1}	2.22	2.01	2.02	2.02	2.22	1.94	1.95	1.90	2.08	2.18	2.40	2.60	
	-0.00861	-0.01911	-0.0173	-0.01738	-0.01738	-0.01911	-0.0167	-0.01678	-0.01635	-0.0179	-0.01876	-0.02065	-0.02238
C													
	0.715199	0.715199	0.715199	0.715199	0.715199	0.715199	0.715199	0.715199	0.715199	0.715199	0.715199	0.715199	
OPB	0	0	0	0	0	0	0	0	0	0	0	0	
	-0.06819												
WAR	0	0	0	0	0	0	0	0	0	0	0	0	
	0.013431												
GER	0	0	0	0	0	0	0	0	0	0	0	0	
	-0.03363												
Standard Error	1.10029	1.10029	1.10029	1.10029	1.10029	1.10029	1.10029	1.10029	1.10029	1.10029	1.10029	1.10029	

From table 7.7, it can be observed that using equation 7.3 which is restated after estimating the appropriate VAR coefficients (see equation 7.8), twelve months-period forecast is obtained for the year 2013 on the basis of VAR model 1. The forecasted results are therefore compared with actual results.

$$LOPR_t = 0.715199 + (0.946827)LOPR_{t-1} + (-0.16303)LOPQ_{t-1} + (0.033256)LOPC_{t-1} + (-0.00861)LOSC_{t-1} + (-0.06819)OPB_{t-1} + (0.013431)WAR_{t-1} + (-0.03363)GER_{t-1} + e_{1t}$$

7.8

As indicated by the results obtained from the first model, OPEC made an attempt to stabilise oil prices within its target band. More specifically, the out of the sample forecast showed that OPEC's coordinated policies were able to stabilise oil prices within the range between \$87.86 and \$106.57 in the forecasted year (2013) based on the model. This was clear in the first 5-6 months of the year as there was no much variation from the original prices. However, the attempt to achieve this stability was hindered by factors outside OPEC control which have not been considered in this model. Some of these factors were described as speculation (Büyüksahin and Robe, 2014), geopolitical (Slaibi et al., 2010). For the entire 12 periods (i.e. January, 2013 to December, 2013), oil prices based on OPEC's stabilisation policies should have maintained the following trends: January-\$90.96, February-\$92.80, March-\$96.55, April-\$93.87, May-\$85.66, June-\$73.96, July-\$79.26, August-\$85.17, September-\$85.51, October-\$80.74, November-\$77.93 and December-\$79.19 against the actual data. This result may imply that while OPEC does take actions to stabilise oil prices, the market power to stabilise oil prices at the level it might have been unrealistically given to OPEC alone. This finding is consistent with Khan (2009) who concluded that oil prices in 2008 should have been within the range of \$80-\$90 as against \$147 which was due to the market speculation.

As can be observed from equation 7.4, and table 7.2, above, a multivariate model based on the estimated VAR results in table 7.2, was used. The forecasted results were compared with the actual to evaluate the power of the VAR model in predicting the future dynamics. Interestingly, it was found that our model shows what can be achieved by the combined OPEC policies towards oil price stability. The model was able to project movement in oil

prices from 1st to the 5th periods. The model shows that other factors presumably not included in this model contribute to the discrepancies in the subsequent periods. This is due to the fact that the model shows how much oil prices should have been achievable had those events not taken place. We can therefore note at this juncture that OPEC attempts to act as a cartel by unifying its members' oil production policies in order to stabilise oil prices within a target band in accordance with its objective statement. In fact when oil prices begin to surge high, OPEC stabilisation policies usually attempt to stabilise such prices within the band.

However, factors that appeared to be beyond OPEC's control might be important in explaining the volatility in oil prices. In this regard, the 2nd model is estimated by introducing new variables (see the next section) with a view to providing explanation for high oil prices beyond what OPEC might have set as target price band. In addition, it will add to understanding of how OPEC stabilisation policies are influenced by those additional variables in OPEC's attempt to achieve the target objective of price stability within either official band or implied. This study finds evidence that unrestricted VAR models reveal good forecast ability in both sample and out-of-sample forecast as against the Cabbibo and Fiorenzani (2004) and Chantziara and Skiadopoulos (2008) who documented evidence of low forecast power of VAR models in their study which compared principal components analysis, univariate and VAR models in the futures oil markets, although the approach for the out-of-sample tests differ. This could be attributable to the fact that the basis of comparison is not similar, for example, no any formal tests for predictive ability of the models such as Hensen tests, root mean squared prediction error (RMSE), Theil's inequality coefficient, were used to conclude the forecast power of the VAR model employed in this study.

7.3 Impact of Non-OPEC and OECD Inventory Policies of Oil Price Stability

In the previous sections, attempt was made to understand how OPEC policies work to stabilise oil prices within a given target (whether official or implied OPB). To examine the effects of non-OPEC and OECD inventory policies, the 2nd VAR model is estimated. In this regard, the effect of actions of other key market players on oil price is analysed in addition to that of OPEC. By

introducing the new variables, VAR estimate diagnostic results at the bottom of table 7.4 can be compared with the ones obtained in table 7.9 in relation to some key elements such as R-squared, F-statistics.

Having carried out all the tests for unit root and cointegration in Chapter 6 of this project, the next subsection analyses the Granger causality results presented in table 7.8 below. It should be recalled that "1" lag is chosen as optimal lag for estimating the VAR (see subsection 6.4.3 for the lag selection tests and criteria).

7.3.1 Granger Causality Analysis

Granger causality tests are also carried out for the second model and the results are however presented in table 7.8.

Table 7:8: Granger Causality/Block Exogeneity Tests

Dependent Variables	Excluded variables							
	LOPR	LOPQ	LOPC	LOSC	LOMC	LOOC	LOOS	Joint
LOPR		0.3993 [0.5275]	0.369196 [0.5434]	0.00574 [0.9396]	5.672912 [0.0172]**	1.411599 [0.2348]	1.547812 [0.2135]	14.53289 [0.0242]**
LOPQ	4.424315 [0.0354]**		0.034556 [0.8525]	15.21972 [0.0001]*	1.78127 [0.1820]	1.76737 [0.1837]	3.749231 [0.0528]**	40.92099 [0.0000]*
LOPC	0.813623 [0.3671]	0.924407 [0.3363]		18.08085 [0.0000]*	2.121893 [0.1452]	2.208102 [0.1373]	2.439717 [0.1183]	28.72019 [0.0001]*
LOSC	19.55967 [0.0000]*	2.279366 [0.1311]	1.340223 [0.2470]		0.05884 [0.8083]	2.223217 [0.1359]	8.052409 [0.0045]**	34.00463 [0.0000]*
LOMC	0.432297 [0.5109]	1.129172 [0.2880]	0.586038 [0.4440]	2.415092 [0.1202]		0.111576 [0.7384]	4.327015 [0.0375]**	11.04307 [0.0871]***
LOOC	0.766511 [0.3813]	2.101742 [0.1471]	3.12989 [0.0769]***	6.925184 [0.0085]*	1.230237 [0.2674]		6.246755 [0.0124]*	18.34012 [0.0054]*
LOOS	0.091991 [0.7617]	0.007335 [0.9318]	0.357791 [0.5497]	0.298972 [0.5845]	2.00E-05 [0.9964]	3.443649 [0.0635]***		5.069483 [0.5349]

Notes: * ,**and *** represent significance at the 1%, 5% and 10% levels respectively. Significance implies that the column variable Granger causes the row variable except for the joint column.

Key:

LOPR: Logged values of oil price

LOPQ: Logged values of OPEC production quota

LOPC: Logged values of OPEC production cheating

LOSC: Logged values of OPEC spare capacity

LOOS: Logged values of OECD crude oil stockpiling

LOOC: Logged values of OECD crude oil consumption

LOMC: Logged values of oil market competition

Table 7.8 presents the Granger causality results with the variables on the row representing dependent variables. A unidirectional causality running from different variables to other variables can be observed. For example, causation from oil market competition (LOMC) to oil prices (LOPR); oil prices (LOPR), OPEC spare capacity (LOSC), and OECD stock policy to OPEC production quotas (LOPQ); OPEC spare capacity (LOSC) to OPEC production cheating (LOPC); OECD/IEA crude oil stockpiling and oil prices to OPEC spare capacity (LOSC); OECD/IEA crude oil stockpiling (LOOS) to oil market competition (LOMC); and finally from OPEC production cheating (LOPC) and OPEC spare capacity (LOSC) to OECD/IEA crude oil consumption (LOOC) can be observed. Besides, a bidirectional causality running between OECD/IEA crude oil stockpiling and OECD/IEA crude oil consumption is also found.

Based on the results from table 7.8, it can be noted that introducing new variables into the second VAR models has yielded some interesting findings as described below. After introducing three other variables into the earlier model, it can be observed that oil prices and OPEC spare capacity remain very significant in Granger causing OPEC production quota (at 5% and 1% respectively). However, OECD/IEA crude oil stockpiling becomes another significant factor Granger causing OPEC production quota. Also in the earlier model, all the three OPEC stabilisation policies were not found significant at even 10% in Granger causing oil prices. The results in the second model basically remain as in the previous model, however, it can be established that oil market competition from non-OPEC is significant in Granger causing oil prices at 5% (i.e. 0.0172). In the same vein, OPEC spare capacity also remains very significant in Granger causing OPEC production cheating as in the previous model. An interesting finding with respect to OPEC spare capacity is observed. While oil prices remains an important variable Granger causing OPEC spare capacity, OPEC production quota and OPEC production cheating become not very significant at 13% and 25% respectively. However, OECD/IEA becomes another important significant variable Granger causing the OPEC spare capacity (at 1% significant value).

Furthermore, it can be observed that of the entire variables, only OECD/IEA crude oil stockpiling is significant in Granger causing oil market competition. However, OPEC production cheating and OPEC spare capacity are found to be

significant in Granger causing OECD/IEA crude oil consumption. Bidirectional causality between LOOS and LOOC indicates that each one causes the other and given existence of a uniform policy in all the member countries, some relationships of interest might be found. Finally, evidence of joint significance of all joint logged values of variables in Granger causing each of the dependent variables except OECD/IEA crude oil stockpiling were found. In this regard, the VAR estimates (in table 7.9) were explored to understand the nature of the relationships between variables prior to computing the impulse response functions and the variance decompositions.

Table 7:9: Vector Autoregressive Model Estimates

	LOPRS	LOPQ	LOPC	LOSC	LOMC	LOOC	LOOS
LOPR(-1)	0.931232 (0.04100) [22.7129]	0.028095 (0.01336) [2.10341]	0.046815 (0.05190) [0.90201]	-0.351216 (0.07941) [-4.42263]	0.002764 (0.00420) [0.65749]	-0.010022 (0.01145) [-0.87551]	-0.001186 (0.00391) [-0.30330]
LOPQ(-1)	-0.149607 (0.23676) [-0.63190]	0.728328 (0.07713) [9.44274]	0.288152 (0.29970) [0.96146]	0.692339 (0.45858) [1.50976]	0.025792 (0.02427) [1.06262]	-0.095835 (0.06610) [-1.44974]	0.001934 (0.02258) [0.08564]
LOPC(-1)	0.042423 (0.06982) [0.60762]	-0.004228 (0.02275) [-0.18589]	0.782754 (0.08838) [8.85663]	0.156555 (0.13523) [1.15768]	0.005479 (0.00716) [0.76553]	-0.034488 (0.01949) [-1.76915]	0.003983 (0.00666) [0.59816]
LOSC(-1)	-0.002168 (0.02861) [-0.07576]	-0.036365 (0.00932) [-3.90125]	0.154010 (0.03622) [4.25216]	0.818587 (0.05542) [14.7708]	0.004558 (0.00293) [1.55406]	-0.021023 (0.00799) [-2.63157]	-0.001492 (0.00273) [-0.54678]
LOMC(-1)	1.282601 (0.53850) [2.38179]	0.234142 (0.17543) [1.33464]	-0.992971 (0.68167) [-1.45667]	0.253007 (1.04303) [0.24257]	0.782969 (0.05521) [14.1825]	-0.166768 (0.15036) [-1.10916]	-0.000230 (0.05135) [-0.00447]
LOOC(-1)	0.302247 (0.25439) [1.18811]	-0.110178 (0.08288) [-1.32942]	0.478522 (0.32203) [1.48597]	-0.734693 (0.49274) [-1.49105]	0.008711 (0.02608) [0.33403]	0.647196 (0.07103) [9.11170]	-0.045020 (0.02426) [-1.85571]
LOOS(-1)	-0.533327 (0.42868) [-1.24411]	-0.270415 (0.13966) [-1.93629]	0.847599 (0.54265) [1.56196]	2.356167 (0.83032) [2.83768]	0.091418 (0.04395) [2.08015]	0.299152 (0.11969) [2.49935]	0.881844 (0.04088) [21.5708]
C	-4.482425 (1.90022) [-2.35890]	0.752819 (0.61906) [1.21608]	-0.191328 (2.40541) [-0.07954]	-2.406567 (3.68054) [-0.65386]	0.534580 (0.19481) [2.74415]	2.005833 (0.53056) [3.78060]	0.335865 (0.18122) [1.85341]
OPB	-0.077321 (0.03681) [-2.10061]	-0.003492 (0.01199) [-0.29123]	-0.001691 (0.04659) [-0.03630]	0.040159 (0.07130) [0.56328]	0.004004 (0.00377) [1.06095]	0.003201 (0.01028) [0.31147]	-0.006876 (0.00351) [-1.95880]
WAR	0.017925 (0.03036) [-0.59037]	-0.020164 (0.00989) [-2.03852]	0.135103 (0.03843) [3.51514]	-0.196222 (0.05881) [-3.33659]	0.006910 (0.00311) [2.22005]	-0.000611 (0.00848) [-0.07204]	0.003162 (0.00290) [1.09209]
GER	-0.016167 (0.02717) [-0.59509]	-0.008743 (0.00885) [-0.98779]	-0.005257 (0.03439) [-0.15286]	0.025098 (0.05262) [0.47696]	-0.001418 (0.00279) [-0.50911]	-0.009953 (0.00759) [-1.31210]	0.003078 (0.00259) [1.18798]
R-squared	0.974319	0.919912	0.769023	0.926232	0.877056	0.658552	0.961400
Adj. R-squared	0.972535	0.914350	0.752983	0.921109	0.868519	0.634840	0.958719
Sum sq. residuals	1.010264	0.107223	1.618852	3.790114	0.010618	0.078758	0.009188
S.E. equation	0.083760	0.027287	0.106028	0.162235	0.008587	0.023387	0.007988
F-statistic	546.3195	165.4021	47.94400	180.8064	102.7269	27.77330	358.6567
Log likelihood	170.1386	343.9756	133.5969	67.66928	523.1840	367.8865	534.3946
Akaike AIC	-2.053401	-4.296460	-1.581895	-0.731217	-6.608826	-4.604987	-6.753479
Schwarz SC	-1.837416	-4.080475	-1.365910	-0.515232	-6.392841	-4.389002	-6.537494
Mean dependent	3.977490	3.248703	2.000818	0.815652	3.726920	3.879248	1.408347
S.D. dependent	0.505416	0.093239	0.213334	0.577606	0.023681	0.038701	0.039315

Determinant resid. covariance (dof adj.)	5.21E-22
Determinant resid. Covariance	3.11E-22
Log likelihood	2298.384
Akaike information criterion	-28.66302
Schwarz criterion	-27.15113

Key:

LOPR: Logged values of oil price

LOPQ: Logged values of OPEC production quota

LOPC: Logged values of OPEC production cheating

LOSC: Logged values of OPEC spare capacity

LOOS: Logged values of OECD/IEA crude oil stockpiling

LOOC: Logged values of OECD/IEA crude oil consumption

LOMC: Logged values of oil market competition

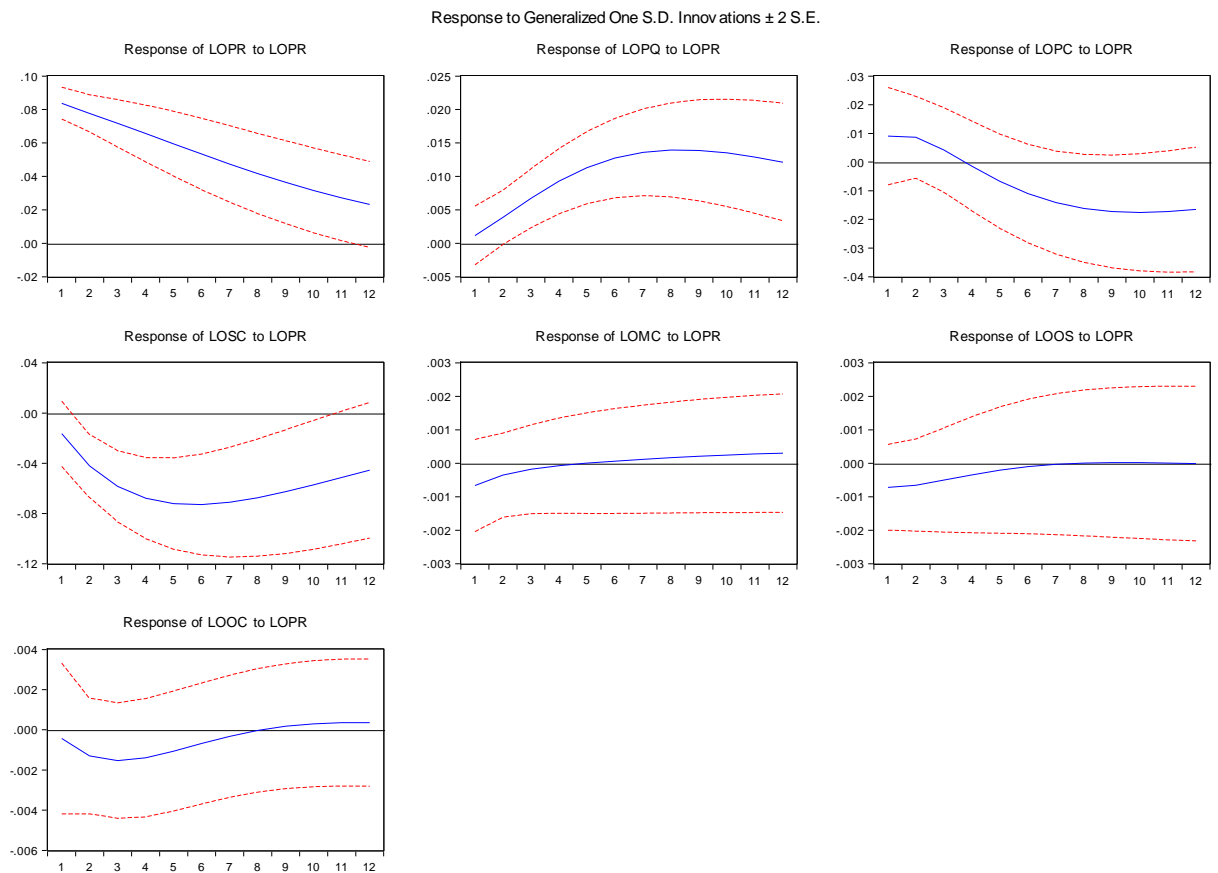
7.3.2 Analysis of the Impact of OECD/IEA Crude Oil Consumption and Stockpiling on the Oil Prices and OPEC Stabilisation Policies

$$LOPR_t = \alpha_{0,1} + \beta_{1,1}LOPR_{t-1} + \beta_{1,2}LOPQ_{t-1} + \beta_{1,3}LOPC_{t-1} + \beta_{1,4}LOSC_{t-1} + \beta_{1,5}LOOS_{t-1} + \beta_{1,6}LOOC_{t-1} + \beta_{1,7}LOMC_{t-1} + \beta_{1,8}OPB_{t-1} + \beta_{1,9}WAR_{t-1} + \beta_{1,10}GER_{t-1} + e_{1t} \quad \mathbf{7.9}$$

On the basis of the VAR estimates (in table 7.9) and more specifically in relation to the equation 7.9, the nature of relationship between various policies of the key oil market players can be described. Based on optimal “1” lag selected to estimate the model, a positive relationship between OECD/IEA crude oil consumption and oil prices (i.e. 0.302247) is found. This implies that the current oil price is influenced positively by OECD crude oil consumption. Similarly, the result reveals that the current oil price is negatively influenced OECD/IEA crude oil stockpiling is negatively related with oil prices, suggesting that a unit change (increase) in the previous period crude oil stockpiling by OECD/IEA (i.e. LOOS_{t-1}) lowers the oil price by about -0.533327. However, based on the physical and graphical representation of the two variables, a mixed nature of relationship was earlier observed. In this regard, impulse response functions and variance decompositions would be useful in describing the nature of the complex dynamics.

Oil prices are positively influenced by lagged values of oil market competition (i.e. 1.282601), which means that oil prices are increased by the increase in the lagged values of competition faced by OPEC in the oil market.

Figure 7.5: Impulse Response Functions for One Standard Deviation Innovation in Oil Price (LOPR)



Key:

- LOPR: Logged values of oil price
- LOPQ: Logged values of OPEC production quota
- LOPC: Logged values of OPEC production cheating
- LOSC: Logged values of OPEC spare capacity
- LOOS: Logged values of OECD crude oil stockpiling
- LOOC: Logged values of OECD crude oil consumption
- LOMC: Logged values of oil market competition

Figure 7.5 presents seven panels of impulse responses of all the endogenous variables to the shocks in oil price. Starting with the first panel (i.e. response of LOPR to LOPR), response of the oil price to the shock in oil price is positive and permanent throughout the period. It starts very high and positively in the beginning period before it declines with time as it can be observed from the panel. The second panel (i.e. response of LOPQ to LOPR) remains positive throughout the period as it was found in the first model. The interpretation is not different from the one earlier made in the first model. Therefore, this suggests that despite the actions of various other market players, OPEC

responds positively to the shocks in oil prices by increasing its quota. Therefore, given the inverse nature of the relationship as suggested by the VAR coefficients in tables 7.2 and 7.9, the response (by way of production increase) should be able to bring oil prices back to the band. The positive response starts in period 1 and grows consistently up to period 7. It remains constant from period 7 until the end of period 9. Thereafter, it begins to decline the end of the 12th period approaches, though it remains positive over the entire period. The third panel (i.e. response of LOPC to LOPR) shows that OPEC production cheating responds to the shock in oil prices positively in period 1. This response remains positive and constant up to the middle of the 2nd period before it begins to decline. As the response of LOPC to LOPR descends towards negative from middle of the 2nd period to period 4, we can observe from the third panel (i.e. response of LOSC to LOPR) which responds negatively; that it is already approaching its minimum in period 6.

In the same way, it can be observed from panel four that oil market competition from non-OPEC responds negatively to the shocks in oil prices from period 1 to period 4, and thereafter it becomes positive over the remaining periods and remains permanent. This suggests that in the first four periods after a shock, non-OPEC begins to gather momentum from a reduced but growing supply possibly due to their low reserves and time lag between the investments and production. Similarly, OECD/IEA crude oil stockpiling (LOOS) responds negatively to oil price shock from period 1 up to 6th period and remains positive just above the "0" level over the remaining periods. However, OECD/IEA consumption responds negatively to the oil price shock from the period 1 and reaches its minimum in the 4th period before moving towards positive and crosses the "0" line in period 8. It remains positive from the 8th period to the 12th period.

In this regard, the variance decomposition of oil prices is computed and presented in table 7.10 to seek further explanation on how the variation in the oil price was accounted for.

Table 7:10: Variance Decomposition of Oil Prices (LOPR)

Period	S.E.	LOPR	LOPQ	LOPC	LOSC	LOMC	LOOS	LOOC
1	0.083760	100.0000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2	0.115528	97.73122	0.270983	0.078669	0.038755	1.114656	0.569858	0.195857
3	0.138800	94.37667	0.662336	0.147390	0.054860	2.811638	1.361076	0.586025
4	0.157121	91.09327	1.049074	0.183822	0.049598	4.562046	2.005158	1.057035
5	0.171663	88.31638	1.390755	0.197305	0.041670	6.156161	2.377718	1.520013
6	0.183101	86.11737	1.681581	0.199162	0.046278	7.534358	2.497744	1.923504
7	0.191995	84.41851	1.926290	0.196599	0.073109	8.694716	2.445788	2.244986
8	0.198857	83.09680	2.131026	0.193251	0.128012	9.653216	2.317287	2.480411
9	0.204150	82.02930	2.300730	0.190675	0.214392	10.42937	2.199090	2.636448
10	0.208271	81.11140	2.438949	0.189440	0.333889	11.04225	2.158694	2.725375
11	0.211550	80.26291	2.548355	0.189733	0.486607	11.51015	2.240502	2.761748
12	0.214244	79.42837	2.631308	0.191632	0.671197	11.85097	2.466297	2.760226

Cholesky Ordering: LOPR LOPQ LOPC LO SC LOMC LOOS LOOC

Key:

- LOPR: Logged values of oil price
- LOPQ: Logged values of OPEC production quota
- LOPC: Logged values of OPEC production cheating
- LOSC: Logged values of OPEC spare capacity
- LOOS: Logged values of OECD crude oil stockpiling
- LOOC: Logged values of OECD crude oil consumption
- LOMC: Logged values of oil market competition

Table 7.10 presents the variance decomposition of oil prices where in period 2, oil price accounts for 97.73% of the variation in the current oil price movement. Despite the response from OPEC and OECD/IEA organisations, OPEC quota, OECD/IEA crude oil stockpiling and consumption all account for less than 1% (i.e. 0.27%, 0.57%, and 0.20% respectively). However for the entire periods, oil market competition from non-OPEC is the second factor that accounts for the variation in the oil prices other than oil price itself. The effect of the oil price reduces in periods 5, 10 and 12 to 88.32%, 81.11%, and 79.43 respectively. OPEC production quota accounts for 1.39%, 2.44%, and 2.6%. This variation resembles the one observed in the OECD/IEA crude oil consumption. This suggests that the production activities of OPEC as the major global oil producer and the consumption of the OECD/IEA as the major oil consumer do not vary much in accounting for variation in the oil prices. These findings may lend support to the claim by OPEC that it attempts to ensure supply-demand balance on monthly basis as disclosed in most OPEC monthly oil market reports. OPEC spare capacity and OPEC production cheating account for less than 1% throughout the periods considered. This suggests that the variables on their own might not strongly account for the variation in the oil prices but perhaps the associated speculation could be responsible. During the periods considered, OECD/IEA crude oil stockpiling accounts for 0.57%, 2.38%, 2.15%, and 2.47% for the 2nd, 5th, 10th, and the 12th periods respectively. The variable accounting for the major variation in the oil prices next to oil price, is oil market competition from non-OPEC that accounts for 1.12%, 6.15%, 11.04%, and 11.85% in periods 2, 5, 10, and 12 respectively.

7.3.3 Analysis of the Impact of Non-OPEC Policies on the Oil Prices and OPEC Stabilisation Policies

To understand the effect of oil market competition and the role of OECD/IEA crude oil stockpiling and consumption on the activities of OPEC, OPEC production quota, OPEC production cheating, and OPEC spare capacity are examined after the actions of the new players are introduced.

In general, relying on the evidence from the Granger causality, VAR impulse response functions and the variance decomposition, it is found that OECD/IEA and non-OPEC behaviour do have some degree of influence of oil prices and

OPEC' stabilisation policies. Pressure on the organisation often generates some reactions that have potential implications on oil prices. The results lend empirical support to the conclusion of Amano (1987).

7.4 Analysis of the Impact of Actions of Other Market Players on OPEC Stabilisation Policies

To understand these dynamics, OPEC's stabilisation policies are revisited one after the other in the following sub-sections while taking into consideration the effect of the actions of external players on OPEC's ability to stabilise the oil prices.

7.4.1 Analysis of OPEC Production Quota and Actions of Other Market Players

From table 7.9, and on the basis of equation 7.10 below, it can be observed that the current OPEC production quota is positively influenced by the lagged valued oil price, lagged values of OPEC production quota, and lagged values of oil market completion from non-OPEC. It is also negatively influenced by lagged values of OPEC production cheating, lagged values of OPEC spare capacity, lagged values of OECD/IEA crude oil consumption and stockpiling.

$$LOPQ_t = \alpha_{0,2} + \beta_{2,1}LOPQ_{t-1} + \beta_{2,2}LOPR_{t-1} + \beta_{2,3}LOPC_{t-1} + \beta_{2,4}LOSC_{t-1} + \beta_{2,5}LOOS_{t-1} + \beta_{2,6}LOOC_{t-1} + \beta_{2,7}LOMC_{t-1} + \beta_{2,8}OPB_{t-1} + \beta_{2,9}WAR_{t-1} + \beta_{2,10}GER_{t-1}e_{2,t} \quad \mathbf{7.10}$$

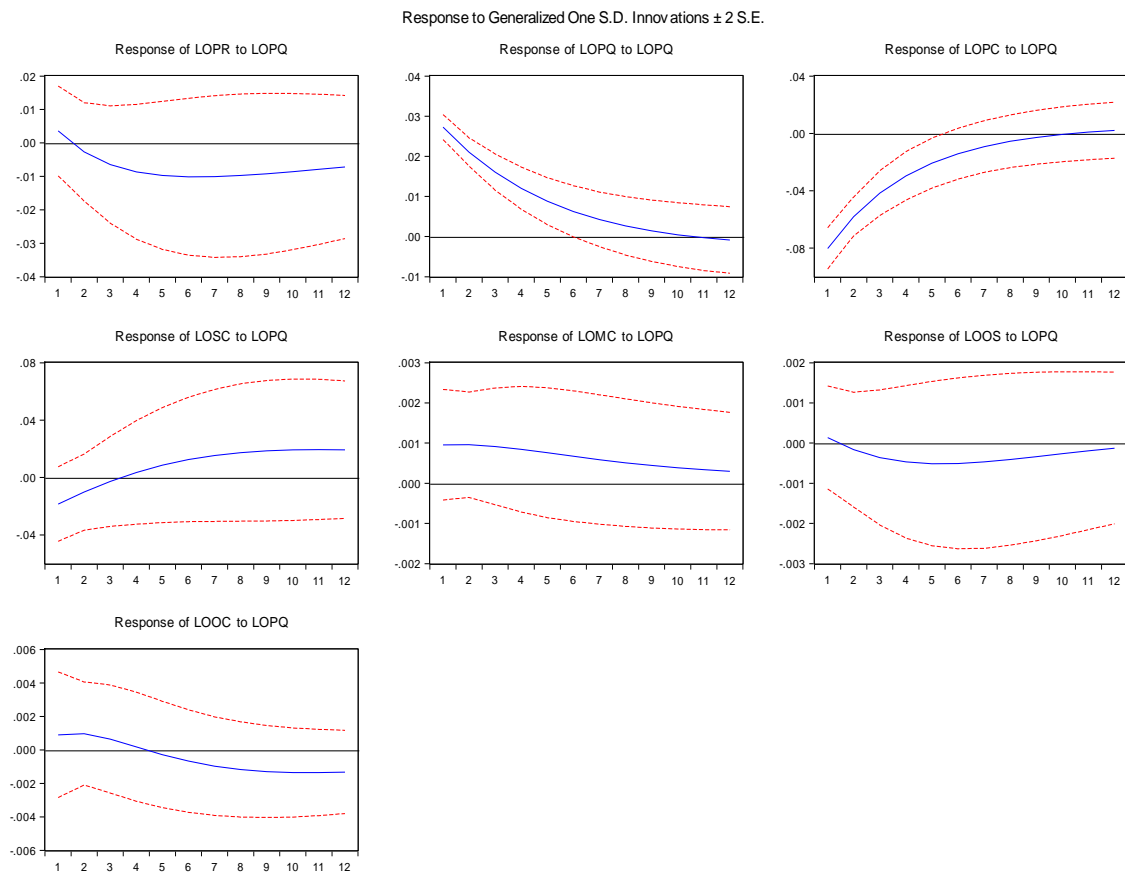
OPEC production quota is positively influenced by lagged values of oil price (0.028095) and OPEC production quota (0.728328). This implies that (change) increase in the previous period oil prices increases the current OPEC quota. This action is expected from OPEC but could potentially have two different interpretations. First, oil price shock could have been triggered by any factor not probably mentioned in this study and to understand OPEC's response we might imply positive relationship of oil prices to OPEC quota to mean that; OPEC increases quota, given the increased oil prices in an attempt to ensure higher production with a view to forcing oil prices down again. The second interpretation might be that OPEC increases production quota consistent with its objective, but going by the theory of markets, it does that in order to benefit from such increased oil prices. Also, OPEC quota is negatively influenced by the lagged values of OPEC production cheating.

This is expected in the light of earlier findings and logical argument that production cheating is reduced by increased quota allocation to members. In the same connection, OPEC production quota is negatively influenced (i.e. -0.110178) by lagged values of OPEC spare capacity consistent with the findings in sub-section 7.2.3. However, oil market competition from non-OPEC affects OPEC production quota positively (i.e. 0.234142). This result is expected because high oil prices are usually followed by increased OPEC production quota and also increased oil market competition from non-OPEC. Therefore, it is logical to expect positive effects between the two variables.

OPEC production quota is negatively influenced by the OECD/IEA crude oil consumption and stockpiling. This implies that the quota is reduced by increase in the two variables as expected. In the same direction, we find some interesting dynamics from the effects of the exogenous variables as expected. For example, we find in the first model (see table 7.4), we find that OPEC production quota is increased by the introduction of OPEC oil price band policy (0.009943). However, the result in table 7.9 shows a slightly different effect as a result of the introduction of new variables in the model. This might be expected given the nature of the policy demands increase and decrease at some points depending on the need for a situation. However, we find that OPEC production quota is negatively affected by war in Iraq, and global economic recession. In a simple interpretation, OPEC production quota is reduced by the presence or increase in any of the two exogenous events. This is expected in the light of economic theory. Recession usually reduces purchasing power, exports, demand, and GDP of nations (IMF, 2012 and Haughton, 2013). War might also affect economic activities in the nation involved in war, which potentially affects the overall OPEC production quota.

In this regard, the impulse response function of OPEC production quota is analysed and results presented in figure 7.6 with a view to understanding how other players respond to shock in OPEC production quota.

Figure 7.6: Impulse Response Functions for One Standard Deviation Innovation in Opec Production Quota (Lopq)



Key:

- LOPR: Logged values of oil price*
- LOPQ: Logged values of OPEC production quota*
- LOPC: Logged values of OPEC production cheating*
- LOSC: Logged values of OPEC spare capacity*
- LOOS: Logged values of OECD crude oil stockpiling*
- LOOC: Logged values of OECD crude oil consumption*
- LOMC: Logged values of oil market competition*

Figure 7.6 presents seven panels of the VAR impulse responses of all the endogenous variables to the shock in OPEC production quota. From the first panel (i.e. response of LOPR to LOPQ), oil price responds positively to the shock in OPEC production but only in the 1st period. It changes in the 2nd period by responding negatively over the remaining periods (2-12). OPEC quota responds positively to OPEC quota (in the second panel of response of LOPQ to LOPQ) from period 1 until period 11. It begins to respond negatively only in the 12th period. The third panel (i.e. response of LOPC to LOPQ) shows that OPEC production cheating responds negatively to the shock in OPEC

production quota from period 1 up to period 10 before it emerges positive in period 11 and remains positive over the end of the 12th period. This implies that increased OPEC production quota is usually received by reduced cheating. The cheating gains momentum with time over the given periods and becomes positive as the response of OPEC quota to the shock in OPEC quota becomes negative (see panel 2 of figure 7.7). The fourth panel of response of LOSC to LOPQ shows that OPEC spare capacity initially responds negatively to the shock in OPEC production quota only from period 1 to 3. It turns to be positive from the 3rd period as the response of the LOPQ to LOPQ declines towards negative (see panel 2). OPEC spare capacity gradually increases and remains positive and permanent throughout the subsequent periods.

Similarly, the fifth panel shows that oil market competition from non-OPEC responds positively to the shock in OPEC production quota. This remains positive throughout the periods considered but at a gradually declining state. Usually, OPEC production is often increased when oil prices are high in order to calm the prices low and within the target band. This finding shows that non-OPEC members also react to that OPEC decision at the beginning but as the shock in the OPEC production declines, non-OPEC response also declines with time. The decline in non-OPEC response might be due to the low reserves compared to OPEC or possibly they appear within this critical moment of high prices to grab their market share. In the sixth panel (i.e. response of LOOS to LOPQ), we observe OECD/IEA crude oil stockpiling responds positively in the 1st period, and subsequently turns to be negative as the shocks in both oil prices and OPEC quota decline (see 2nd panel, fig. 7.8, and 7.9). The impulse response continuously declines and reaches its minimum in the fifth period. Thereafter, it begins to grow towards the positive region as it approaches the end of the period considered. Finally, we observe from the last panel (panel 7) in figure 7.9 that OECD/IEA crude oil consumption responds positively to the shock in OPEC production quota from period 1 up to period 4 before changing pattern in period 5 to be negative and permanent throughout the remaining periods. This implies that OECD/IEA crude oil consumption is increased by the increase in the OPEC production quota and is reduced accordingly as the shock reduces.

However, we compute the variance decomposition of OPEC production quota in table 7.11 to examine the contribution of each independent variable towards explaining variation in the OPEC production quota.

Table 7:11: Variance Decomposition of OPEC Production Quota (LOPQ)

Period	S.E.	LOPR	LOPQ	LOPC	LOSC	LOMC	LOOS	LOOC
1	0.083760	0.183254	99.81675	0.000000	0.000000	0.000000	0.000000	0.000000
2	0.115528	1.315906	95.94923	0.618942	1.566777	0.246805	0.020195	0.282145
3	0.138800	3.814212	88.84597	1.489543	4.054348	0.881326	0.505986	0.408614
4	0.157121	7.501778	79.58192	2.201175	6.509455	1.849070	1.997056	0.359548
5	0.171663	11.71540	69.54452	2.590546	8.384762	2.988413	4.454924	0.321434
6	0.183101	15.75856	60.06422	2.686773	9.550281	4.128889	7.382119	0.429153
7	0.191995	19.22105	51.93869	2.597824	10.13408	5.163523	10.24231	0.702527
8	0.198857	21.99347	45.39586	2.424902	10.33523	6.054587	12.70256	1.093392
9	0.204150	24.13867	40.31855	2.233288	10.32112	6.805973	14.64233	1.540060
10	0.208271	25.77762	36.45919	2.056100	10.20291	7.437430	16.07336	1.993393
11	0.211550	27.03003	33.55964	1.906161	10.04508	7.970581	17.06668	2.421824
12	0.214244	27.99374	31.39759	1.785678	9.881502	8.423693	17.70966	2.808138

Cholesky Ordering: LOPR LOPQ LOPC LO SC LOMC LOOS LOOC

Key:

LOPR: Logged values of oil price

LOPQ: Logged values of OPEC production quota

LOPC: Logged values of OPEC production cheating

LOSC: Logged values of OPEC spare capacity

LOOS: Logged values of OECD crude oil stockpiling

LOOC: Logged values of OECD crude oil consumption

LOMC: Logged values of oil market competition

From table 7.11, it can be observed that the major variation in the OPEC production quota is accounted by OPEC production quota itself, followed by oil prices, OECD/IEA crude oil stockpiling, OPEC spare capacity, oil market competition from non-OPEC, and OECD/IEA crude oil consumption. In the 2nd, 5th, 10th, and the 12th periods, variations in OPEC production quota are 95.95% , 69.54%, 36.56%, and 31.40% accounted by OPEC production quota. It can be observed that the variation rapidly moved from nearly 100% in period 1 to less than 70% in period 5 and also around 30% in the 12th period. Oil price accounts for 1.32%, 11.72%, 25.78%, and 27.99% in the 2nd, 5th, 10th, and 12th periods. It shows how rapidly important oil price accounts for changes in OPEC production decision. This is also important evidence that OPEC responds to oil price changes in line with the results found from VAR estimates and impulse responses. In the same vein, we find evidence that OECD/IEA stockpiling is responsible for variation in OPEC production quota in the following order: 0.02%, 4.46%, 16.07%, and 17.71% for the 2nd, 5th, 10th, and 12th respectively. OPEC production quota also depends partly on its spare capacity as it accounts for 1.57%, 8.38%, 10.20%, and 9.88% in periods 2, 5, 10, and 12 respectively. Oil market competition also accounts for 0.24% in the 2nd period, and grows to 2.99% in the 5th period. In the 10th and the 12th period, it only accounts for 7.44% and 8.42% respectively. The other two variables that do not seem to have much important information in driving variation in OPEC production are OPEC production cheating and OECD/IEA consumption. The cheating accounts for less than 1% (i.e. 0.62%) in the 2nd period and remains slightly above 2% from the 4th period to the 10th period before coming down to less than 2% in the remaining 2 periods. However, OECD/IEA accounts for less than 1% from period 1 to 7. It accounts for between 1.09% and 1.99% in the subsequent 3 periods (i.e. period 8 to 10), and less than 3% in the last 2 periods.

7.4.2 Analysis of OPEC Production Cheating and Actions of Other Market Players

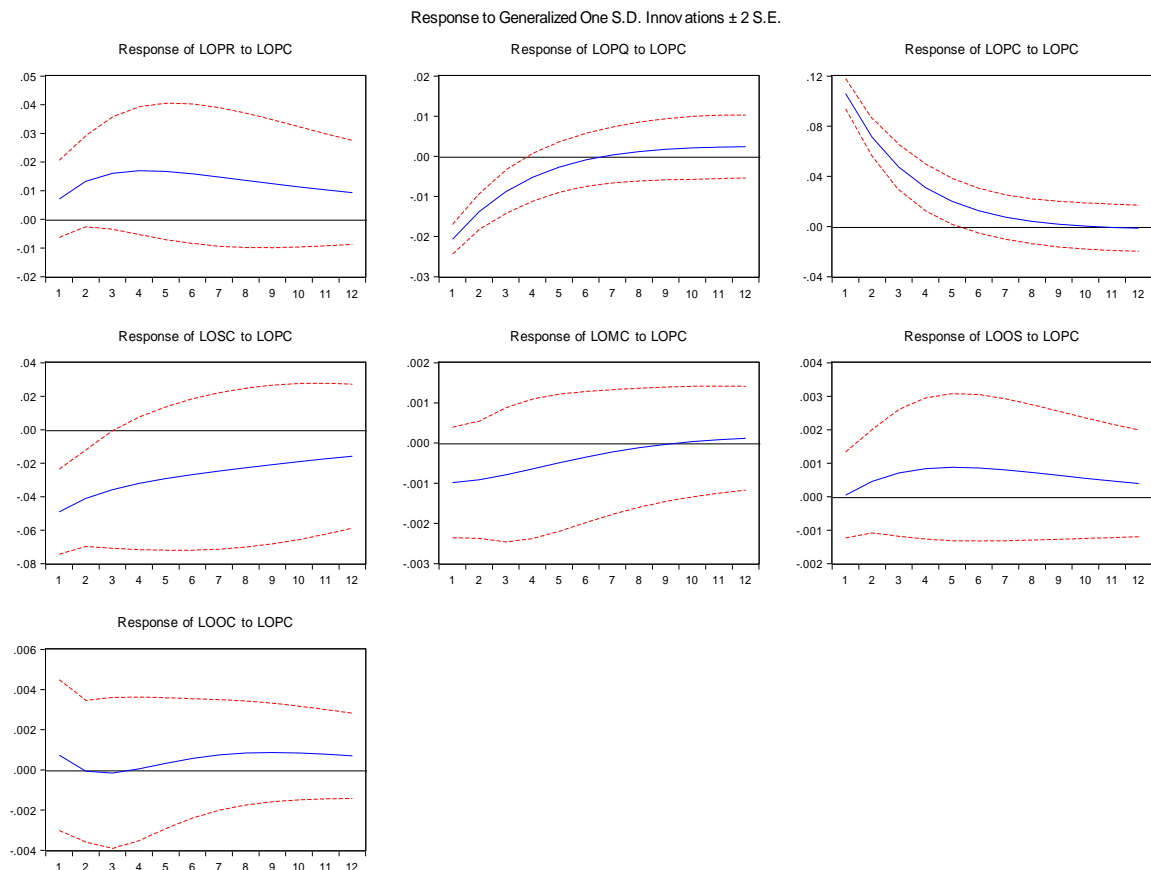
To understand the behaviour of OPEC production cheating when effect of other variables (i.e. oil market competition from non-OPEC, OECD/IEA crude oil consumption and stockpiling) are considered, equation 7.11 is analysed below:

$$LOPC_t = \alpha_{0,3} + \beta_{3,1}LOPC_{t-1} + \beta_{3,2}LOPR_{t-1} + \beta_{3,3}LOPQ_{t-1} + \beta_{3,4}LOSC_{t-1} + \beta_{3,5}LOOS_{t-1} + \beta_{3,6}LOOC_{t-1} + \beta_{3,7}LOMC_{t-1} + \beta_{3,8}OPB_{t-1} + \beta_{3,9}WAR_{t-1} + \beta_{3,10}GER_{t-1} + e_{3,t} \quad \mathbf{7.11}$$

In this regard, table 7.9 presents the results of equation 7.11 where the var estimates are discussed. OPEC production cheating (LOPC) is positively influenced by the lagged values of oil price ($lopr_{t-1}$) as shown by the coefficient (0.046815). This implies that current increase in OPEC production is 0.046815 influenced by a unit increase in the previous period oil price. In the same vein, the cheating is positively influenced by the lagged values of OPEC production quota (i.e. 0.288152), and its own lagged values (0.782754). Similarly, the effect remains positive for the lagged values of the remaining exogenous variables except oil market competition (i.e. 0.154010, -0.992971, 0.478522, 0.847599 for lagged values of OPEC spare capacity, oil market competition, OECD/IEA consumption and stockpiling respectively). It can be observed that the exogenous variables show a similar pattern with the OPEC production quota except for the effect of the war. Therefore, it can be implied that OPEC production cheating is negatively affected by the introduction of the OPEC opb policy and effect of global economic recession. However, the cheating is positively influenced by the war in Iraq. This means that OPEC cheating is increased by the effect of the war. this might be interpreted as increase in production by members to either benefit from the high oil prices as a result of deficiency created by the affected war country (i.e. Iraq) or possibly an attempt by a member (e.g. Saudi Arabia) to increase production with a view to bring oil prices down. However, despite the effect and effort shown by the results, oil prices continue to surge.

Attempt is therefore made (see figure 7.7) to describe how other OPEC policies alongside other non-OPEC usually respond to the cheating in OPEC.

Figure 7.7: Impulse Response Functions for One Standard Deviation Innovation in OPEC Production Cheating (LOPC)



Key:

- LOPR: Logged values of oil price
- LOPQ: Logged values of OPEC production quota
- LOPC: Logged values of OPEC production cheating
- LOSC: Logged values of OPEC spare capacity
- LOOS: Logged values of OECD crude oil stockpiling
- LOOC: Logged values of OECD crude oil consumption
- LOMC: Logged values of oil market competition

Figure 7.7 presents seven panels of impulse responses of all the seven endogenous variables to the shock in OPEC cheating behaviour. From the first panel (i.e. response of LOPR to LOPC), it can be observed that oil price responds positively to OPEC cheating. The positive response (in panel two) which begins from period 1 grows to its maximum in period 4 before beginning to decline but still remains positive over the remaining periods considered. OPEC production quota initially responds negatively to the shock in the cheating from period 1 up to period 6 before it turns to be positive and remains permanent over the remaining periods. OPEC production cheating (i.e. LOPC), responds positively to OPEC production cheating (LOPC) as

shown by panel three of figure 7.8 (i.e. response of LOPC to LOPC). However, the response which begins from period 1 declines to its minimum in period 10 and remains constant along the "0" line for the remaining periods. Panel four (i.e. response of LOSC to LOPC) shows that OPEC spare capacity responds negatively to OPEC cheating. This is expected because increased cheating exerts pressure on the existing capacity.

Furthermore, oil market competition responds negatively in period up to period 8 and thereafter becomes positive for the remaining periods (periods 9-12) as shown by panel five (i.e. response of LOMC to LOPC). However, for the OECD/IEA crude oil stockpiling and consumption show positive response to OPEC production cheating (i.e. LOPC). From panel six (i.e. response of LOOS to LOPC), stockpiling responds positively in period 1 and grows to its peak in period 5 and continuous at declining state, though still positive over the remaining periods. Panel seven (i.e. response of LOOC to LOPC) shows that OECD/IEA crude oil consumption initially responds positively in period 1 to 2 before temporarily declining and producing negative response in period 3 and later plunges into positive again. It remains positive over the remaining periods considered. The implication of the result is that, OECD/IEA increases its member crude stockpiling and consumption as the OPEC production cheating increases.

Similarly, the variance decomposition of the OPEC production cheating is computed to understand how all the endogenous variables contribute to variation in the cheating (see table 7.12).

Table 7:12: Variance Decomposition of OPEC Production Cheating (LOPC)

Period	S.E.	LOPR	LOPQ	LOPC	LOSC	LOMC	LOOS	LOOC
1	0.083760	0.724908	58.01878	41.25632	0.000000	0.000000	0.000000	0.000000
2	0.115528	0.927331	59.12517	37.23732	2.010780	0.308794	0.001051	0.389554
3	0.138800	0.861054	58.11670	33.81928	5.404162	0.923591	0.184951	0.690261
4	0.157121	0.776493	55.67720	30.93334	9.072920	1.702981	1.085217	0.751855
5	0.171663	0.887361	52.31442	28.36768	12.29114	2.503770	2.944450	0.691180
6	0.183101	1.258125	48.52990	26.02392	14.73907	3.221069	5.567532	0.660388
7	0.191995	1.831138	44.76985	23.90980	16.40996	3.805323	8.533686	0.740241
8	0.198857	2.503745	41.33830	22.06223	17.45871	4.252383	11.44811	0.936528
9	0.204150	3.184987	38.38168	20.49953	18.07543	4.582109	14.06030	1.215970
10	0.208271	3.815709	35.92986	19.21249	18.42046	4.820934	16.26306	1.537483
11	0.211550	4.366330	33.94744	18.17318	18.60740	4.992841	18.04546	1.867351
12	0.214244	4.827632	32.37184	17.34585	18.70869	5.116518	19.44655	2.182921
Cholesky Ordering: LOPR LOPQ LOPC LOSC LOMC LOOS LOOC								

Key:

LOPR: Logged values of oil price

LOPQ: Logged values of OPEC production quota

LOPC: Logged values of OPEC production cheating

LOSC: Logged values of OPEC spare capacity

LOOS: Logged values of OECD crude oil stockpiling

LOOC: Logged values of OECD crude oil consumption

LOMC: Logged values of oil market competition

Table 7.12 presents the variance decomposition of OPEC production cheating in order to have insight on how other endogenous variables usually account for variation in the dependent variable (LOPC). It can be observed that, OPEC production cheating accounts for less than 50% of the variation in itself (with 41.26%, and 37.24% in the 1st and 2nd periods respectively). This shows the relative importance of OPEC production quota which accounts for 58.02% and 59.12% in the 1st and 2nd periods respectively, in influencing how and why members should cheat in OPEC. This finding is consistent with some insider observation that OPEC production quota is the main driver for the organisational members to engage in cheating (see Chalabi, 2010). In the 5th, 10th, and the 12th periods, OPEC production cheating already accounts for 28.37%, 19.21%, and 17.35% respectively. In the same vein, OPEC production quota accounts for 52.31%, 35.93%, and 32.37% in the 5th, 10th, and 12th periods respectively. Although OPEC production cheating responds positively to the shock in oil price and vice versa, its impact in accounting for variation is not as expected.

In the same vein, oil price accounts for variation in OPEC quota in the 2nd, 5th, 8th, 10th, and 12th periods at 0.92%, 0.89%, 2.50%, 3.82%, and 4.83% respectively. However, another two important factors that account for the variation in OPEC cheating behaviour are OPEC spare capacity and the OECD/IEA crude oil stockpiling which initially account for 2.01% and 0.00% in the 2nd periods respectively. For OPEC spare capacity, it grows to account for 12.29%, 17.46%, 18.42%, and 18.71% in periods 5, 8, 10, and 12 respectively. Similarly, crude oil stockpiling by OECD/IEA accounts for 2.94%, 11.45%, 16.26%, and 19.45% in the 5th, 8th, 10th, and 12th periods respectively. OECD/IEA crude oil consumption does not seem to account for much variation given that it produces less than 1% from periods 1 to 8, less than 2% from periods 9 – 11, and less than 3% in the last period. However, oil market competition is slightly higher as it accounts for less than 1% in the first 3 periods, less than 4% in the next 4 periods up to period 7, less than 5% in the subsequent 4 periods, and just 5.12% in the last period.

7.4.3 Analysis of OPEC Spare Capacity and Actions of Other Market Players

In this regard, the dynamics in OPEC spare capacity are analysed in the same manner as OPEC production cheating in order to understand its peculiarities and how it is influenced by other variables. On the basis of VAR estimates in table 7.9 from which results of equation 7.12 are extracted and discussed.

$$LOSC_t = \alpha_{0,4} + \beta_{4,1}LOSC_{t-1} + \beta_{4,2}LOPR_{t-1} + \beta_{4,3}LOPQ_{t-1} + \beta_{4,4}LOPC_{t-1} + \beta_{4,5}LOOS_{t-1} + \beta_{4,6}LOOC_{t-1} + \beta_{4,7}LOMC_{t-1} + \beta_{4,8}OPB_{t-1} + \beta_{4,9}WAR_{t-1} + \beta_{4,10}GER_{t-1} + e_{4,t} \quad \mathbf{7.12}$$

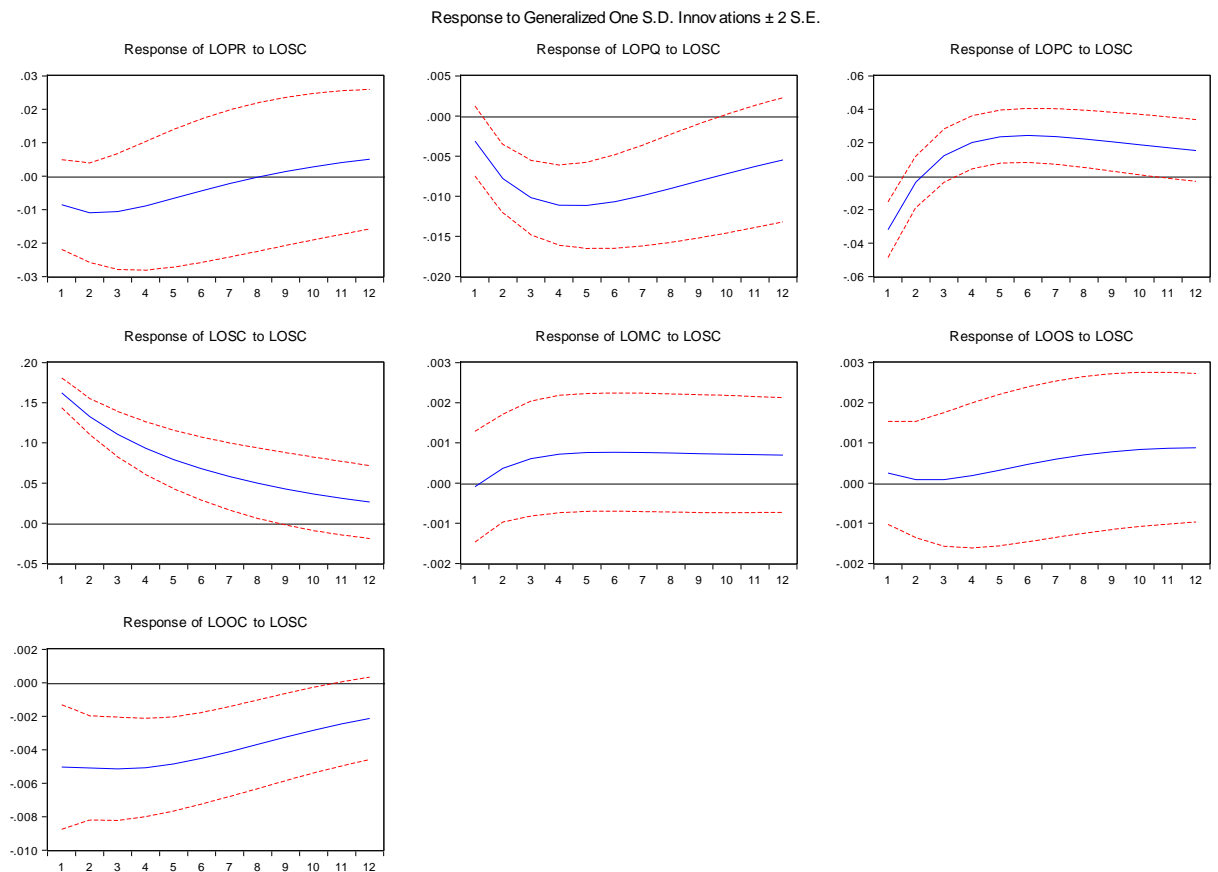
From table 7.9, OPEC spare capacity is negatively affected by the lagged values of oil price (-0.351216), positively affected by the lagged values of OPEC production quota (0.692339), positively influenced by the lagged values of OPEC production cheating (0.156555), positively influenced by spare capacity (0.818587), positively influenced by oil market competition from non-opec (0.253007), negatively influenced by OECD/IEA crude oil consumption (-0.734693) but positively influenced by OECD/IEA crude oil stockpiling (2.356167). In the same order, we expect high capacity to be maintained when oil prices are presumably low, and similarly when opec production quota is maintained, although with time such pressure resulting from increased quota might force the opec spare capacity to go low. Positive relationship should be expected between OPEC spare capacity and lagged values of the spare capacity. The capacity is usually expected to grow as the oil competition increases, given evidence of the response of non-opec to the shock in oil prices. It can also be observed that a unit increase in the OECD/IEA consumption influences the capacity by (-0.734693) whereas the spare capacity is positively influenced by a positive change in the lagged value of stockpiling.

However, the capacity is positively influenced by the introduction of OPEC OPB policy which indicates a possible compliance by the members to the policy. This is further confirmed by the negative relationship of OPB to OPEC production cheating implying that the introduction of the policy reduces cheating in OPEC among its members. It can be observed that OPEC spare capacity is negatively influenced by the war, which implies that the war in Iraq reduces OPEC spare capacity. Finally we observe a positive relationship

running between OPEC spare capacity and global economic recession. This implies that OPEC spare capacity is increased by the presence of global economic recession. This result is expected given the fact that economic recession reduces demand which in turn reduces OPEC supply. The implication is that a large reserve would be held by the members due to limited buyers or reduced demand.

Therefore, the impulse response of all the endogenous variables considered in the model to the shock in OPEC spare capacity are analysed as indicated by the seven panels of figure 7.8.

Figure 7.8: Impulse Response Functions for One Standard Deviation Innovation in OPEC Spare Capacity (LOSC)



Key:

- LOPR: Logged values of oil price
- LOPQ: Logged values of OPEC production quota
- LOPC: Logged values of OPEC production cheating
- LOSC: Logged values of OPEC spare capacity
- LOOS: Logged values of OECD crude oil stockpiling
- LOOC: Logged values of OECD crude oil consumption
- LOMC: Logged values of oil market competition

From the first panel of figure 7.8 (i.e. response of LOPR to LOSC), it can be observed that OPEC spare capacity is negatively influenced by oil price from period 1 to period 8. Thereafter, it turns to be positive in the middle of period 8 and remains so over the remaining periods (i.e. period 8 – 12). This means initially when shock occurs in the OPEC spare capacity, oil price is reduced and later begins to grow as the shock in OPEC spare capacity reduces (see panel 4). In the second panel (i.e. response of LOPQ to LOSC), we can observe that throughout the periods considered, OPEC production quota responds negatively to the shock in OPEC spare capacity. The response of OPEC cheating to spare capacity exhibits a comparably different behaviour. Initially, OPEC production cheating responds negatively to its spare capacity from period 1 to the middle of the 2nd period before it crosses to the positive region over the remaining periods (i.e. periods 2 – 12).

As already highlighted, panel 4 shows that OPEC spare capacity is positively influenced by the spare capacity; the response which starts in period 1 gradually reduces with time up to period 12, though it remains positive throughout. In panel 5, we can observe that the oil market competition from non-OPEC responds positively to the spare capacity. The response which begins in period 1 grows up to period 3 and remains permanent over the remaining periods. In this regard, OECD/IEA crude oil stockpiling responds positively to the OPEC spare capacity (see panel 6, i.e. response of LOOS to LOSC). It begins as positive from period 1 and slightly goes down and remains constant throughout period 2 from where it gathers momentum from period 3 to the remaining periods. Finally (in panel 7, response of LOOC to LOSC), OECD/IEA crude oil consumption responds negatively to OPEC spare capacity. In the same direction we investigate how each of the independent endogenous variables account for variation in the OPEC spare capacity from the results presented in table 7.13.

Table 7:13: Variance Decomposition of OPEC Spare Capacity (LOSC)

Period	S.E.	LOPR	LOPQ	LOPC	LOSC	LOMC	LOOS	LOOC
1	0.083760	1.031419	1.203839	34.46393	63.30081	0.000000	0.000000	0.000000
2	0.115528	4.469295	0.841027	29.82482	62.62114	0.005105	1.902808	0.335804
3	0.138800	8.557763	0.604328	25.05897	59.41034	0.053622	5.331881	0.983097
4	0.157121	12.29216	0.522227	20.90498	55.16084	0.177071	9.170824	1.771892
5	0.171663	15.26930	0.564044	17.60280	50.90880	0.373269	12.70629	2.575501
6	0.183101	17.47194	0.686017	15.10215	47.15065	0.619504	15.64420	3.325545
7	0.191995	19.03404	0.852426	13.25294	44.03512	0.889229	17.94205	3.994187
8	0.198857	20.11360	1.039276	11.90023	41.54338	1.160420	19.66793	4.575165
9	0.204150	20.84571	1.231828	10.91577	39.59405	1.417619	20.92309	5.071937
10	0.208271	21.33327	1.421371	10.20188	38.09254	1.651265	21.80800	5.491674
11	0.211550	21.65080	1.602806	9.686465	36.95075	1.856337	22.41027	5.842576
12	0.214244	21.85105	1.773117	9.316838	36.09310	2.031061	22.80205	6.132784
Cholesky Ordering: LOPR LOPQ LOPC LOSC LOMC LOOS LOOC								

Key:

LOPR: Logged values of oil price

LOPQ: Logged values of OPEC production quota

LOPC: Logged values of OPEC production cheating

LOSC: Logged values of OPEC spare capacity

LOOS: Logged values of OECD crude oil stockpiling

LOOC: Logged values of OECD crude oil consumption

LOMC: Logged values of oil market competition

Table 7.13 above presents the results of the variance decompositions of OPEC spare capacity. OPEC spare capacity accounts for 63.30% variation in the spare capacity in the beginning period. At the same time, OPEC production cheating accounts nearly for 34.46% while both oil price and OPEC production quota account for less than 2% each. In the 2nd, 5th, 8th, 10th, and 12th periods, OPEC spare capacity accounts for 62.62%, 50.91%, 41.54%, 38.09%, and 36.09% respectively. Also, the second major contributor (i.e. OPEC production cheating) exhibits similar pattern. It accounts for 29.82%, 17.60%, 11.90%, 10.20%, and 9.32% in periods 2, 5, 8, 10, and 12. Both variables start from their highest values to the lowest (i.e. descending order). For the third most important variable accounting for variation in OPEC spare capacity (i.e. OECD/IEA crude oil stockpiling), it starts from the lowest value (i.e. 1.90% in the 2nd period) and ascend to the highest value in the 12th period (i.e. 22.80%). In the 5th, 8th, and the 10th periods, OECD/IEA accounts for 12.71%, 19.67%, 21.81% respectively.

A similar pattern is exhibited by the oil price, which accounts for 4.47%, 15.27%, 20.11%, 21.33%, and 21.85% in the 2nd, 5th, 8th, 10th, and the 12th periods. This implies that OECD/IEA crude oil stockpiling and oil price go in the same direction in influencing OPEC spare capacity. Oil market competition accounts for less than 1% from period 1 to period 7, accounts for less than 2% from period 8 to period 11, and slightly above 2% (i.e. 2.03%) in the 12th period. OPEC production quota starts from 1.20% and plunges to less than 1% from the 2nd period to period 7. Thereafter, it increases to less than 2% for the entire remaining periods considered. OECD/IEA crude oil consumption accounts for less than 1% in the first 3 periods. In the 5th, 8th, 10th, and the 12th periods, OECD/IEA crude oil accounts for 2.56%, 4.58%, 5.84%, and 6.13% respectively.

7.4.4 Analysis of OECD/IEA Crude Oil Stockpiling

To understand how OPEC stabilisation policies and other related factors influence OECD/IEA crude oil stockpiling, 7.12 is solved in table 7.14 to analyse the various dynamics between the variables.

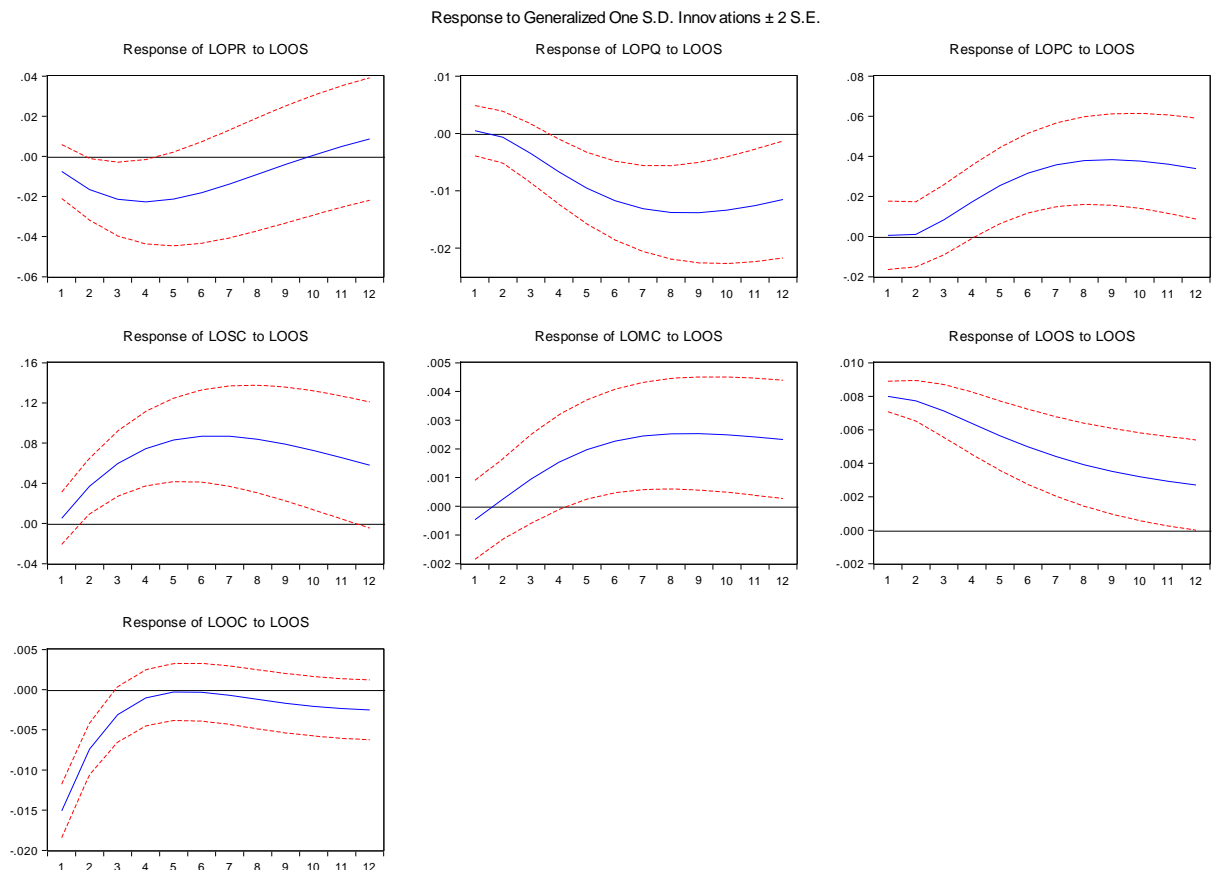
$$LOOS_t = \alpha_{0,5} + \beta_{5,1}LOOS_{t-1} + \beta_{5,2}LOPR_{t-1} + \beta_{5,3}LOPQ_{t-1} + \beta_{5,4}LOPC_{t-1} + \beta_{5,5}LOSC_{t-1} + \beta_{5,6}LOOC_{t-1} + \beta_{5,7}LOMC_{t-1} + \beta_{5,8}OPB_{-1} + \beta_{5,9}WAR_{t-1} + \beta_{5,10}GER_{t-1} + e_{5,t} \quad \mathbf{7.13}$$

On the basis of the coefficients estimated from equation 7.13 and presented in table 7.14, we can observe that OECD/IEA crude oil stockpiling is negatively influenced by the lagged values of oil prices (i.e. -0.001186), lagged values of OPEC spare capacity (i.e. -0.001492), lagged values of oil market competition (-0.000230), lagged values of OECD/IEA crude oil consumption (i.e. -0.045020). Furthermore, OECD/IEA crude oil stockpiling is positively influenced by OPEC production quota and cheating (i.e. 0.001934 and 0.003983 respectively), as well as OECD/IEA crude oil stockpiling (i.e. 0.881844). This implies that the stockpiling is reduced increase in the oil prices but increased by increased OPEC production quota and cheating. Therefore, the just described relationship is very important in the sense that the stockpiled oil from accounting perspective are valued on average, first in first out, or last in first out. The implication of this type of behaviour has not been explored to the bottom in this study.

OECD/IEA crude stockpiling is negatively influenced by OPEC OPB policy. This implies that the stockpiling behaviour is reduced with the existence of OPB policy by OPEC. The war in Iraq contributes positively to building stock in the OECD/IEA. Global economic recession also influences the stockpiling positively. This means that due to reduced economic activities in the consumer nations due to recession, a sizeable amount of stocks might be expected.

In the same way, the response of various endogenous variables to the shock in the OECD/IEA crude oil stockpiling are examined the results are presented based on seven panels of figure 7.9.

Figure 7.9: Impulse Response Functions for One Standard Deviation Innovation in OECD/IEA Crude Oil Stockpiling (LOOS)



Key:

- LOPR: Logged values of oil price
- LOPQ: Logged values of OPEC production quota
- LOPC: Logged values of OPEC production cheating
- LOSC: Logged values of OPEC spare capacity
- LOOS: Logged values of OECD crude oil stockpiling
- LOOC: Logged values of OECD crude oil consumption
- LOMC: Logged values of oil market competition

Panel 1 (i.e. Response of LOPR to LOOS) of figure 7.9 presents the response of oil price to the shock in OECD/IEA crude oil stockpiling. The response initially begins as negative in period 1 and reduces to its lowest level in period four and begins a steady movement up towards positive region. It turns into positive in the 10th period and remains positive throughout the period considered. In the 2nd panel (i.e. Response of LOPQ to LOOS), we can observe that opec production quota responds positively to the shock in OECD/IEA stockpiling in the 1st period but turns to be negative and permanent throughout the remaining periods. However, OPEC production cheating exhibits rather opposite pattern with OPEC production cheating. The

response of opec cheating starts from period 1 as positive and steadily grows to the maximum in period 8 before declining during the remaining periods though it has still remained positive.

Furthermore, panels 4 (i.e. Response of losc to loos) and 5 (i.e. Response of LOMC to LOOS) show some similarities. In panel 4, OPEC spare capacity responds positively in period 1 and increases up to 6 where it stays constant for the subsequent period up to period 7. Thereafter, it begins to decline in the remaining periods considered. Panel 5 shows that the response of oil market competition to the shock in OECD/IEA crude oil stockpiling (i.e. LOMC to LOOS), is negative in the 1st period but turns out to be a positive over the entire remaining periods. In the 6th panel, OECD/IEA crude oil stockpiling responds positively to the OECD/IEA stockpiling throughout the periods considered. In the 7th panel, we can observe a negative response of oecd/iea consumption to the shock in the stockpiling. The response initially increases toward the positive region but remains constant along the "0" line from period 5 to period 7 before falling back to negative region and remains permanent over the subsequent periods.

The contribution of all the endogenous variables in accounting for variation in the OECD/IEA crude oil stockpiling as presented in table 7.14.

Table 7:14: Variance Decomposition OF OECD/IEA Crude Oil Stockpiling (LOOS)

Period	S.E.	LOPR	LOPQ	LOPC	LOSC	LOMC	LOOS	LOOC
1	0.083760	0.820818	0.044681	0.216801	0.429362	0.377449	98.11089	0.000000
2	0.115528	0.766587	0.037584	0.439478	0.401946	0.473296	97.41452	0.466586
3	0.138800	0.684370	0.091214	0.644023	0.465610	0.529073	96.54320	1.042505
4	0.157121	0.604649	0.167669	0.816454	0.613903	0.556280	95.69035	1.550693
5	0.171663	0.539411	0.244801	0.955163	0.847821	0.564725	94.89170	1.956380
6	0.183101	0.490509	0.310448	1.063427	1.162835	0.561748	94.14267	2.268359
7	0.191995	0.455255	0.359380	1.146320	1.546897	0.552485	93.43354	2.506119
8	0.198857	0.429795	0.391063	1.209203	1.982599	0.540304	92.75821	2.688826
9	0.204150	0.410781	0.407780	1.256949	2.450427	0.527257	92.11471	2.832095
10	0.208271	0.395909	0.413109	1.293624	2.931632	0.514484	91.50363	2.947607
11	0.211550	0.383835	0.410844	1.322420	3.410114	0.502548	90.92657	3.043673
12	0.214244	0.373857	0.404356	1.345742	3.873299	0.491669	90.38508	3.126000
Cholesky Ordering: LOPR LOPQ LOPC LOSC LOMC LOOS LOOC								

Key:

LOPR: Logged values of oil price

LOPQ: Logged values of OPEC production quota

LOPC: Logged values of OPEC production cheating

LOSC: Logged values of OPEC spare capacity

LOOS: Logged values of OECD crude oil stockpiling

LOOC: Logged values of OECD crude oil consumption

LOMC: Logged values of oil market competition

From table 7.14, some evidence that most of the variation in the OECD/IEA crude oil stockpiling is guided by a fixed OECD/IEA stockpiling policy can be observed. OECD/IEA crude oil stockpiling accounts for 97.42%, 94.89%, 92.76%, 91.50%, and 90.38% in the 2nd, 5th, 8th, 10th, and 12th periods respectively. Therefore, it is not possible to project accurately the OECD/IEA stockpile. This potentially poses challenge to identifying association with most other variables because irrespective of the prevailing oil prices, OECD/IEA members are expected to comply with the given policy. In this regard, we find that oil price (LOPR), OPEC production quota (LOPQ), and oil market competition (LOMC) account for less than 1% of the variation in the stockpiling throughout the periods considered. The only two important variables are OPEC spare capacity and OECD/IEA crude oil consumption. The spare capacity (represented by LOSC) accounts for less than 1% in the beginning 5 periods and less than 2% in the next 3 periods (i.e. periods 6 to 8). However, it accounts for less than 4% in the remaining periods. OECD/IEA crude oil consumption accounts for 0.47%, 1.96%, 2.69%, 2.95%, and 3.13% for the 2nd, 5th, 8th, 10th, and the 12th periods respectively. OPEC production cheating (i.e. LOPC) accounts for less than 1% in the first 5 periods and less than 2% in the remaining periods.

7.4.5 Analysis of OECD/IEA Crude Oil Consumption

Similarly the behaviour of the OECD/IEA consumption are analysed by looking into dynamics of all endogenous and exogenous variables as captured in equation 7.14.

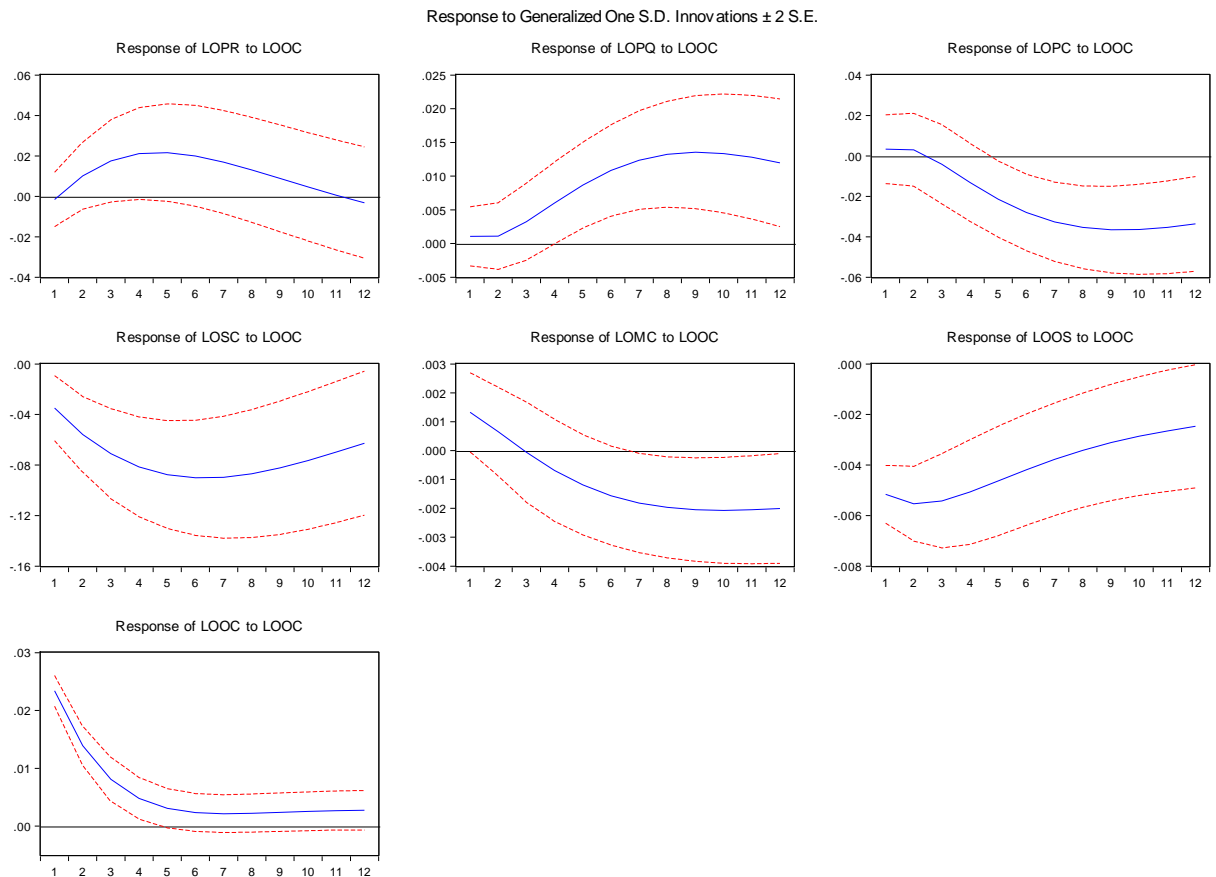
$$\begin{aligned}
 LOOC_t = & \alpha_{0,6} + \beta_{6,1}LOOC_{t-1} + \beta_{6,2}LOPR_{t-1} + \beta_{6,3}LOPQ_{t-1} + \beta_{6,4}LOPC_{t-1} + \beta_{6,5}LOSC_{t-1} + \\
 & \beta_{6,6}LOOS_{t-1} + \beta_{6,7}LOMC_{t-1} + \beta_{6,8}OPB_{t-1} + \beta_{6,9}WAR_{t-1} + \beta_{6,10}GER_{t-1} + e_{6,t}
 \end{aligned}
 \tag{7.14}$$

Equation 7.14 presents the coefficients of the above variables in relation to the dependent variable OECD/IEA crude oil consumption. Consumption is negatively influenced by the lagged values of oil price (i.e. -0.010022) as expected which indicates that OECD/IEA consumption is reduced by the increase in oil price. It can also be observed that there is a negative relationship between lagged values of OPEC production quota and OECD/IEA crude oil consumption (i.e. -0.095835). This result is not expected partly, however if OPEC production quota increase is induced by surge in oil price,

OECD/IEA consumption could be reduced by such change in the production. The same relationship is observed running between the lagged values of OPEC production cheating and OECD/IEA crude oil consumption (-0.03488). Also, OPEC spare capacity exhibits similar effect in its relationship with the OECD/IEA crude oil consumption. In fact the entire OPEC stabilisation policies, oil market competition, and oil prices are negatively related to the OECD/IEA crude oil consumption. However as expected, OECD/IEA crude oil consumption is positively influenced by the lagged value of OECD/IEA crude oil consumption (i.e. 0.647195) and stockpiling (i.e. 0.299152). This implies that the current oil stockpiling by the OECD/IEA is increased with additional crude oil consumption in the previous period.

With regards to the exogenous variables, it can be observed that there is a positive relationship between OECD/IEA consumption with OPEC OPB policy. For the war in Iraq and general economic recession, it was established that both are negatively related to OECD/IEA crude oil consumption. War reduces the consumption presumably due to reduced OPEC quota. Recession is very likely to discourage demand as mentioned earlier. Therefore, more of the dynamics are explored by computing the impulse response functions in seven panels of figure 7.10 below.

Figure 7.10: Impulse Response Functions for One Standard Deviation Innovation in OECD/IEA Crude Oil Consumption (LOOC)



Key:

- LOPR: Logged values of oil price
- LOPQ: Logged values of OPEC production quota
- LOPC: Logged values of OPEC production cheating
- LOSC: Logged values of OPEC spare capacity
- LOOS: Logged values of OECD crude oil stockpiling
- LOOC: Logged values of OECD crude oil consumption
- LOMC: Logged values of oil market competition

Figure 7.10 presents seven panels of the impulse response functions in an attempt to describe response of various variables to the shock in the OECD/IEA crude oil consumption. Therefore, we begin with the first panel (i.e. response of LOPR to LOOC) where response of oil price to the shock in OECD/IEA crude oil consumption is found to be positive in period 1 after starting up with a negative for a little short while. The response increases from period 1 and reaches the maximum between periods 4 and 5 before slashing down to period 11 where it becomes negative thereafter. We can observe from panel 2 (i.e. response of LOPQ to LOOC) that OPEC production quota responds positively to the shock in OECD/IEA crude oil consumption.

The response is positive and constant for the first 2 periods. It increases and reaches its maximum between periods 5 to 10 and later begins a downward movement toward the remaining periods. Panel 3 shows that OPEC production cheating begins with positive response from periods 1 – 3 and later turns to be negative for the remaining periods. This might imply that OPEC members respond positively to the shock in the OECD/IEA crude oil consumption for a limited period. However, absence of adequate reserve might hinder their ability to sustain the supply for a long time. OPEC spare capacity responds positively to the shock in OECD/IEA crude oil consumption (see panel 4: i.e. response of LOSC to LOOC). The response which starts from period 1 reduces to its minimum level in period 6 and subsequently gathers momentum and increases over the remaining periods. Oil market competition responds positively in the initial periods (i.e. periods 1 – 3) before turning to be negative (see panel 5: i.e. response of LOMC to LOOC). The same interpretation as that of OPEC cheating can be applied at this point. The low reserve and capacity might be constraint which hinders such positive response to be achieved from non-OPEC. However, we can observe from panel 6 (i.e. response of LOOS to LOOC), that there is a positive response between OECD/IEA crude oil stockpiling and the consumption. This is expected given that the amount of consumption greatly determines the amount to be stockpiled. The last panel (i.e. panel 7) presents the response of OECD/IEA crude oil consumption to the shock in OECD/IEA crude oil consumption (i.e. response of LOOC to LOOC). The response is positive throughout the periods considered.

In the same direction, the variance decomposition of OECD/IEA crude oil consumption is computed and the results are presented in table 7.15.

Table 7:15: Variance Decomposition of OECD/IEA Crude Oil Consumption (LOOC)

Period	S.E.	LOPR	LOPQ	LOPC	LOSC	LOMC	LOOS	LOOC
1	0.083760	0.034204	0.153349	0.950972	3.827992	2.160496	40.55441	52.31858
2	0.115528	0.249221	0.250554	0.908510	6.748190	1.624103	36.40717	53.81225
3	0.138800	0.497649	0.280958	0.881118	10.16999	1.526569	33.30628	53.33744
4	0.157121	0.675571	0.267991	0.853849	13.57422	1.702537	31.12408	51.80175
5	0.171663	0.758611	0.260337	0.824828	16.62394	1.974403	29.55020	50.00768
6	0.183101	0.773963	0.291595	0.796004	19.19017	2.231833	28.35647	48.35996
7	0.191995	0.758345	0.371104	0.769956	21.26307	2.430063	27.43955	46.96791
8	0.198857	0.737329	0.491192	0.749304	22.88357	2.562789	26.76442	45.81140
9	0.204150	0.722352	0.636684	0.736317	24.11283	2.640404	26.31144	44.83997
10	0.208271	0.715031	0.791777	0.732424	25.01944	2.677849	26.05261	44.01088
11	0.211550	0.712472	0.943706	0.737923	25.67170	2.689011	25.94918	43.29601
12	0.214244	0.711072	1.083939	0.752044	26.13191	2.684730	25.95822	42.67809

Cholesky Ordering: LOPR LOPQ LOPC LOSC LOMC LOOS LOOC

Key:

LOPR: Logged values of oil price

LOPQ: Logged values of OPEC production quota

LOPC: Logged values of OPEC production cheating

LOSC: Logged values of OPEC spare capacity

LOOS: Logged values of OECD crude oil stockpiling

LOOC: Logged values of OECD crude oil consumption

LOMC: Logged values of oil market competition

Table 7.15 presents the variance decomposition of OECD/IEA crude oil consumption where OECD/IEA crude oil stockpiling is the main driver explaining the variation in the consumption other than the consumption itself. In the 2nd, 5th, 8th, 10th and 12th periods, OECD/IEA crude oil consumption accounts for 53.81%, 50.01%, 45.81%, 44.01%, and 42.68% respectively. The next variable that contributes more after the consumption is the OECD/IEA crude oil stockpiling which accounts for 36.41%, 29.55%, 26.76%, 26.05%, and 25.96% in periods 2, 5, 8, 10, and 12 respectively. It is also found that OPEC spare capacity is another influential factor that account for variation in the OECD/IEA crude oil consumption. It accounts for 6.75%, 16.62%, 22.88%, 25.02%, and 26.13% in the 2nd, 5th, 8th, 10th, and 12th periods respectively. However, oil price, OPEC production quota, and cheating do not seem to account for any variation over 1% except the 12th period of OPEC production quota which accounts for 1.08%. Oil market competition accounts for 2.16% in period 1 but reduces to 1.62% in the 2nd period. It accounts for less than 2% for the subsequent 4 periods up to period 5. In the remaining periods, it only accounts for less than 3%.

7.4.6 Analysis of Oil Market Competition from Non-OPEC

Given the allegation that OPEC operates as a cartel of oil producers that restricts crude oil with a view to pushing oil prices high, analysing oil market competition becomes useful. Therefore, equation 7.14 is used to demonstrate the complex dynamics surrounding the oil market competition and the role of OPEC stabilisation policies.

$$LOMC_t = \alpha_{0,7} + \beta_{7,1}LOMC_{t-1} + \beta_{7,2}LOPR_{t-1} + \beta_{7,3}LOPQ_{t-1} + \beta_{7,4}LOPC_{t-1} + \beta_{7,5}LOSC_{t-1} + \beta_{7,6}LOOC_{t-1} + \beta_{7,7}LOMC_{t-1} + \beta_{7,8}OPB_{t-1} + \beta_{7,9}WAR_{t-1} + \beta_{7,10}GER_{t-1} + e_{5,t} \quad \mathbf{7.15}$$

The results are obtained from table 7.15 where all the lagged values of independent variables are positively related to the oil market competition. Oil market is positively influenced by the lagged values of oil price which implies increase in the oil price drives oil market (i.e. 0.002764). This is not coming as a surprise when the results in table 7.10 show that oil market competition is the main driver explaining variation in the oil prices with an account of between 1.12% and 11.85%. Also, the results in table 7.14 show that oil

market competition is positively influenced by the OPEC production quota (i.e. at 0.025792). Oil market competition is usually increased by the increase in OPEC production quota. As explained earlier, this situation is very possible where oil price rise is the main motivation for OPEC to increase its quota in an attempt to cushion oil prices down within the target band. Oil market competition responds to either assist with the cause of calming oil prices or penetrating to grab their own market share from the rising oil prices.

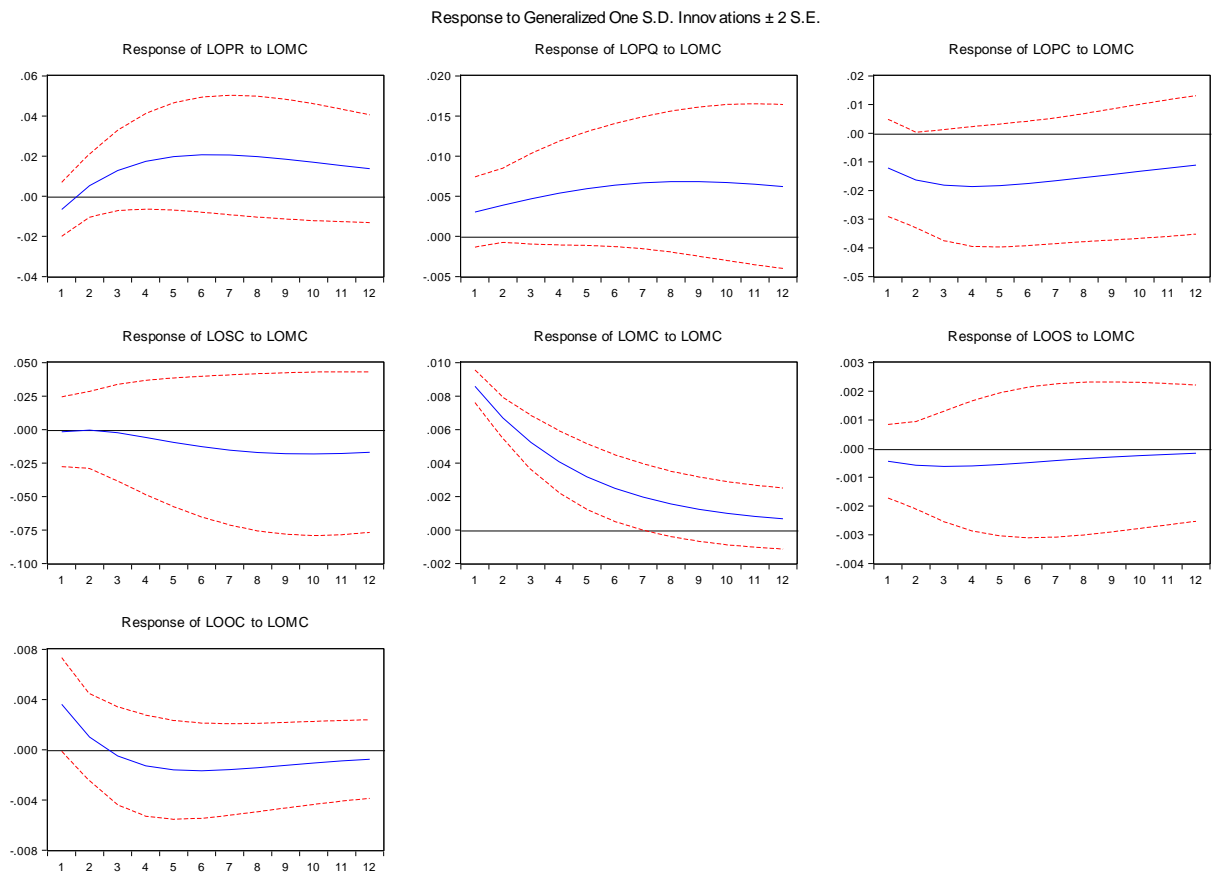
In the same manner, we read the influence of the lagged values of OPEC production cheating on the oil market competition (i.e. 0.005479) which might also take a similar interpretation as that of OPEC production quota. For the OPEC spare capacity, we earlier had a logical argument that low capacity for OPEC might drive oil market competition high most particularly where high oil prices are projected. This evidence is supplemented by the Granger causality results running from OPEC spare capacity to the market competition. The results based equation 7.15 and table 7.9, a positive relationship is found between OPEC spare capacity and oil market competition (i.e. 0.004558).

Furthermore, oil market competition is positively influenced by its lagged values (i.e. 0.782969) and the lagged values of OECD/IEA crude oil consumption (0.008711) and stockpiling (i.e. 0.091418) as earlier expected. This implies that increased OECD/IEA demands for consumption and stockpiling in the previous period become important driver to increase the current supply from non-OPEC. Other exogenous variables are found to have influence on the oil market competition in the following ways. OPEC OPB policy is found to have a positive relationship with the market competition (i.e. 0.004004). This implies that the introduction of the policy attracts more production from non-OPEC given that the policy was specific as to what should be expected in the event of changes in the market conditions. Also, we document evidence of some degree of compliance by OPEC members that might be a motivation for non-OPEC to see an advantage to increase the oil production and supply. War in Iraq is found to be positively related with the market competition (i.e. 0.006910). This result is also expected given the fact that if the motivation of the non-OPEC is to take advantage of the war by

increasing supply to accrue the benefits from the high oil prices just like explained in the case of OPEC production cheating during the war periods. However, the economic recession as earlier discussed affects demand which forcefully reduces supply. Therefore, the negative relationship between global economic recession and the market competition (i.e. -0.001418) is not coming in as a surprise.

In order to generate more evidence about the dynamics, the impulse responses of the variables to the shock in the oil market competition are analysed and presented by seven panels in figure 7.11.

Figure 7.11: Impulse Response Functions for One Standard Deviation Innovation in Oil Market Competition (LOMC)



Key:

- LOPR: Logged values of oil price
- LOPQ: Logged values of OPEC production quota
- LOPC: Logged values of OPEC production cheating
- LOSC: Logged values of OPEC spare capacity
- LOOS: Logged values of OECD crude oil stockpiling
- LOOC: Logged values of OECD crude oil consumption
- LOMC: Logged values of oil market competition

From panel 1 of figure 7.11 above (i.e. response of LOPR to LOMC), it can be observed that the response of oil price begins with being negative in period 1 but it crosses to positive from the 2nd period up to the end of the 12th period considered in the computation. The response of OPEC production quota to the shock in the oil market competition (i.e. response of LOPQ to LOMC) is presented in panel 2. The response is positive throughout the periods considered. It begins from period 1 and steadily increases to reach its maximum from periods 7 to 10 and later begins to gradually decline towards the remaining 2 periods. The 3rd panel presents the response of OPEC production cheating to the oil market competition (i.e. response of LOPC to LOMC). The response is negative and begins from period 1 and to its lowest level in period 4. Thereafter, it begins a gradual move towards positive region from period 5 to period 12. OPEC spare capacity responds negatively at the start of period 1 but immediately move and stays constant along the "0" line up to the 3rd period. Thereafter it moves to respond negatively to the shock in the oil market competition and remains constant over remaining periods. In panel 4, oil market competition responds positively to the shock in the oil market competition. It starts highly positive and begins to gradually reduce with time, but stays positive throughout the periods considered. In the 6th panel, we observe that OECD/IEA crude oil stockpiling responds negatively to the shock in the oil market competition (see response of LOOS to LOMC). The response which begins from period 1 reaches its lowest level in period 3 before it begins to steadily move towards positive region. The closeness to the positive region can be seen in period 12. This implies that OECD/IEA stockpiling responds to the shock in the oil market and if additional periods were added, the positive response could have been possible. In the last panel, a positive response of OECD/IEA crude oil consumption to the shock is observed in the oil market competition in the first 2½ periods before turning to be negative in period 3 up to the remaining periods considered.

Table 7:16: Variance Decomposition of Oil Market Competition (LOMC)

Period	S.E.	LOPR	LOPQ	LOPC	LOSC	LOMC	LOOS	LOOC
1	0.083760	0.606740	1.320349	0.098813	0.091082	97.88301	0.000000	0.000000
2	0.115528	0.481672	1.611747	0.100962	0.185855	97.30661	0.294969	0.018181
3	0.138800	0.407840	1.863065	0.089083	0.564105	95.86059	1.194729	0.020585
4	0.157121	0.360702	2.056039	0.078191	1.108974	93.62029	2.756821	0.018978
5	0.171663	0.329032	2.185635	0.081318	1.736621	90.77750	4.852731	0.037160
6	0.183101	0.308233	2.258096	0.105112	2.390878	87.59101	7.257699	0.088974
7	0.191995	0.296702	2.285839	0.149734	3.037963	84.31059	9.744442	0.174736
8	0.198857	0.293863	2.282493	0.211116	3.660211	81.12734	12.13890	0.286082
9	0.204150	0.299192	2.259858	0.283545	4.250002	78.16065	14.33487	0.411886
10	0.208271	0.311831	2.226785	0.361465	4.805089	75.46866	16.28406	0.542110
11	0.211550	0.330563	2.189281	0.440379	5.325632	73.06674	17.97803	0.669377
12	0.214244	0.353946	2.151095	0.517083	5.812622	70.94463	19.43154	0.789088
Cholesky Ordering: LOPR LOPQ LOPC LOSC LOMC LOOS LOOC								

Key:

LOPR: Logged values of oil price

LOPQ: Logged values of OPEC production quota

LOPC: Logged values of OPEC production cheating

LOSC: Logged values of OPEC spare capacity

LOOS: Logged values of OECD crude oil stockpiling

LOOC: Logged values of OECD crude oil consumption

LOMC: Logged values of oil market competition

In the same way, table 7.16 presents the analysis obtained from the variance decompositions of the oil market competition. It can be observed that oil market remains the major variable accounting for variation in itself 97.88% in the first period to about 70.94% in the 12th period. The second major variable that accounts for the variation is the OECD/IEA crude oil stockpiling which in the first period accounts for nothing but grows to be responsible for up to 19.43% in the 12th period.

7.5 Diagnostic Tests of the VAR Models

Diagnostic tests otherwise known as misspecification/robustness tests are usually conducted on the basis of test statistic. Diagnostics are usually carried out to avoid or minimise the risk of misspecification of the models by proper examination of the residuals. In other words, by diagnostics or robustness checks, we are concerned with examining the appropriateness of the VAR estimates within the framework of BLUE (best linear unbiased estimators). Applying Q-Statistics, the autocorrelations/partial autocorrelations of the residuals for the VAR equations up to the specified number of lags within the context of Ljung-Box Q-statistics can be viewed. The main essence of testing for the correlograms of the squared residuals is to examine the degree of 'autoregressive conditional heteroskedasticity' (i.e. ARCH) from the model residuals. The simple interpretation of the results is that, absence of the ARCH in the model equations residuals indicates "0" in all the specified lags which is not expected to be significant at each level. In this connection, the results for the above tests are presented in appendix XV-XXIV.

There are basically two most popular approaches that are fully integrated in most statistical packages, namely: the Wald test and the LM test (Brooks, 2008). It should be noted that the diagnostics of LM test statistics take a χ^2 (chi-squared) distribution where the degrees of freedom are equal to the number of restrictions on the model (m). However, the Wald test takes on F -distribution with $(m, T - k)$ degrees of freedom. Brooks (2008) notes that the results are usually not different from each other in the real large samples (i.e. when sample size increases towards infinity);

however some differences might be found between the two if small samples are used. For this purpose, as mentioned in the fifth chapter of the study, LM test statistics is employed. More specifically, we carried out tests for autocorrelation LM test on both models. After normality test on the residuals⁸⁸, the white heteroskedasticity test⁸⁹ was also analysed. However, prior to the tests, it is worth noting that important steps below were taken to enhance the results of the models.

A number of procedures were applied to ensure the model is free from mis-specification by examining some diagnostic tests at different stages of building and estimating the model (i.e. before and after). The process involved subjecting all the variables to unit root tests (see section 6.4.1 of Chapter 6 for more details). Two stationarity tests (for parametric and non-parametric) are applied on the series after the results of the descriptive statistics revealed that the datasets were not normally distributed (see section 6.3 of Chapter 6). Augmented Dickey Fuller tests for the parametric and Philips Perron for the non-parametric were carried out but no significant difference between the two sets of results at both level and first difference.

Furthermore, cointegration test was carried out based on Johansen (1988) system cointegration where both Trace and Max Eigen statistics were considered for choosing the number of cointegrating equations. Also, due to sensitivity of VAR estimates to included lag, appropriate lag selection procedures were applied and followed by a check based on inverse roots of

⁸⁸ As part of the description of the data for modelling processes, effort is made in Chapter 6 to analyse the descriptive statistics and properties which includes the graphical pattern, histogram and normality assumptions, on the raw data. In this part of diagnostics, we revisit the normality tests but this time around on the residuals to view evidence of any normal distribution in the residuals and including the Jarque-Bera statistics. In this case, it is assumed a normally distributed row data or residuals should be bell-shaped when presented in histogram. Second, the Jarque-Bera statistics are not expected to be any significant.

⁸⁹ As part of effort to minimise or remove the heteroscedasticity, there is need for the data to be rescaled for the potential extreme values to be "pulled in" (Brooks, 2008). This was achieved where the raw data were transformed by considering their natural logs. In this research, all the variables were transformed to their natural logs except for the dummies as "logarithms of a variable cannot be taken in situations where the variable can take on zero or negative values, for the log will not be defined in such cases" (Brooks, 2008: 138).

AR characteristic polynomial to ensure that the VAR has satisfied the stability condition.

On the basis of the generated R-squared⁹⁰ (R^2), the degree of variability for the two models can be viewed and analysed to obtain evidence about the fitness of the model. Starting with the first model, each of the equations in the model has its corresponding R-squared as shown in table 7.4. Each of the dependent variables namely: LOPR (logged values of the oil price), LOPQ (logged values of OPEC production quota), and LOPC (logged values of OPEC production cheating), and LOSC (logged values of OPEC spare capacity) have the corresponding R-squared as 0.972481, 0.917363, 0.762502, and 0.918587 respectively. They showed high R^2 which is additional indication of evidence for the fitness of the model. Consistent with the results from the first model, the second model showed R-squared of 0.974319, 0.919912, 0.769023, 0.926232, 0.877056, 0.658552, and 0.961400 for LOPR, LOPQ, LOPC, LOSC, LOMC, LOOC, and LOOS respectively. These results are impressive in terms of the high R-squared they produced couple with low standard errors as can be observed from both model outputs in tables 7.2 and 7.9.

Furthermore, the diagnostic tests were carried out on the residuals in order to obtain further evidence about the models. Part of the diagnostic procedures involved evaluation of serial autocorrelation, heteroskedasticity, and normality tests for the residuals. The results of the diagnostic tests for the two models are discussed under sub-sections 7.5.1 and 7.5.2. However, detailed figures of the tests are presented in Appendix XV through Appendix XXIV. The results showed evidence of non-normality for the residuals in line with the initial findings in Chapter 6 under normality test. The LM serial correlation tests showed not much correlation to worry about regarding the two models.

⁹⁰ **R-squared** (otherwise known as coefficient of multiple determination) is a statistical measurement of closeness of data to the fitted regression line. It explains the percentage of variability of the response data in relation to its mean based on the computed model.

7.5.1 First Model Diagnostics

As mentioned earlier, various tests for lag length selection were carried out to ensure that the estimated VAR is stable at the selected lag. VAR has been estimated in the first instance for such analysis on the basis of which the appropriate lag was computed and applied in estimating the VAR output produced in table 7.2. Having computed the model in this category based on the recommended VAR lag, some improvements were observed on the R-squared, standard errors, and the VAR coefficients. Prior to the above tests, the variables were subjected to normality tests based on their logged as recommended by Brooks (2008) but were mostly found to be not normally distributed. In addition, logging the variables often minimises or removes the heteroskedasticity as argued by Brooks (2008). However, the residuals were also subjected to various tests. Full graphical picture of the residuals are produced in appendix XV. The LM serial correlation test shows averagely good results as most of the null hypotheses of serial correlation were rejected at 5% level of significance for most of the lags (see appendix XVI). The results therefore confirm the absence of problem for missing variables as earlier established from the descriptive analysis in Chapter 6. Also for test of heteroskedasticity (see Appendix XVIII), nearly 50% of the null hypotheses were rejected implying no residual heteroskedasticity. For the normality tests, the skewness, kurtosis and Jarque-Bera are presented in appendix XIX. However, we fail to reject in any case the null hypotheses.

7.5.2 Second Model Diagnostics

This analysis begins with the normality tests on the residuals by applying three different tests of Skewness, Kurtosis, and Jarque-Bera. The null hypothesis states that the residuals are normally distributed which is rejected at 5% level of significance. The results are presented in appendix XXIII. Further tests for LM serial correlation reveal some good results (see Appendix XXII). In this regard, the p-values above 5% render confirmation for accepting null hypothesis there is no serial correlation. For the most of the LM-Stats, the p-values are beyond 5% acceptance level except only for the 1st, 5th, 6th, the 12th lags. On the overall, we can conclude that there is

no much to worry about on the serial correlation. Similarly, the most of the results from the residual heteroskedasticity are fairly ok as revealed in appendix XXIV.

7.6 Summary and Conclusion

This chapter analysed the data based on two vector autoregressive models with a view to answering two main research questions as stated in section 1.4 of Chapter 1. For each of the research questions, Granger causality tests, impulse response functions, and forecast error variance decompositions were computed based on the estimated VAR coefficients results. In view of the fact that VAR property tests carried out in Chapter 6 revealed some interesting findings, attention was given to carry out some diagnostic tests on the model error terms to minimise any risk of model misspecifications (Brooks, 2008). Although the results disclosed very interesting dynamics between OPEC and non-OPEC players, evidence suggests that OPEC had taken various degrees of actions which aimed at oil price stability within a target price band. On the basis of impulse response functions, it responded positively to oil price shocks for reasonable period aiming to reduce the shocks over time. The main rationale for OPEC taking such an action was to bring down oil prices so that it would not lose demand from mainly the OECD/IEA nations who could redirect investments for alternative energy sources such as fracking, renewables and nuclear. OPEC cheating also responded positively to the shocks in oil prices. This result indicates how weak OPEC is in coordinating its members to achieve its objective of oil price stability. Further evidence suggests that OPEC spare capacity was affected by many factors including war in Iraq and global economic recession. These exogenous events have also affected OPEC's ability in many other ways. More concisely, the next paragraphs present summary of key findings of the chapter based on the above analysis.

a. OPEC responded positively to shocks in oil prices by increasing its production quota with the intention of bringing oil prices back within the target price band. OPEC's reaction to the shock was to increase its production quota however the evidence from the analysis shows that this

did not strongly Granger cause changes in oil prices. This implies that changes in OPEC production quota might not be a key factor in causing changes to oil prices. However, changes in the OPEC allocation of production quota accounted for less than 5% of the variation in oil price in the first five periods and less than 10% in the subsequent periods considered. It was found that OPEC production quota was Granger caused by changes in oil prices (significant at 1% level). This further evidence implies that OPEC had responded to changes in oil prices by an upward review of its quota to suit the market needs as often documented in its monthly oil market reports and also reiterated by its officials. This finding supports the view that OPEC could not have acted as an effective cartel over the last decade because of the relatively small change in oil price resulting from the OPEC action. Similarly, it is found that changes to OPEC production quota was Granger caused by the changes in OPEC spare capacity. This implies that the volume of OPEC production quota is dependent upon the existing members' crude oil excess capacity. Spare capacity of OPEC has, arguably, been hindered by many factors. For example, the U.S. led invasion/war in Iraq, Libya, and political sanctions on Iran as OPEC's major reserve holders next to Saudi Arabia clearly affected OPEC's access to oil reserves. However, the analysis showed that OPEC production cheating did not Granger cause changes in OPEC production quota at a statistically significant level. This implies that cheating behaviour of OPEC members does not necessarily partly determine the basis for setting OPEC's production quota.

b. OPEC production cheating responded to the shocks in the oil price in a slightly different way. It initially responded positively in the first three periods of the entire periods considered in the impulse response function but changed to respond negatively in the remaining nine periods. This is connected with the effect of reduced spare capacity during the periods. This is because when the spare capacity began to rise towards the positive region in the subsequent periods, OPEC cheating also became sensitive to that change over such periods. Despite this response, there was no significant evidence that OPEC cheating Granger caused changes to oil prices. Similarly, further evidence supported this position that less than

3% of the variation in the oil price was due to the changes in production cheating behaviour in OPEC. There is significant statistical evidence that OPEC production cheating was Granger caused by the amount of available spare capacity. This empirical finding lends support to opinions of some oil market analysts and commentators that high crude oil spare capacity often generates high cheating behaviour in OPEC (see Abraham, 2000). This is consistent with the positive response of OPEC cheating to the shock in OPEC crude oil spare capacity as noted by the impulse response functions in figure 7.14. Also evidence based on joint probability level (at 1%) implies that the entire OPEC policies and oil prices Granger caused changes in OPEC cheating behaviour. This implies that changes to: the allocation of OPEC production quota; OPEC spare capacity; and oil prices could cause changes in cheating by OPEC members.

c. OPEC crude oil spare capacity responded negatively to the shocks in oil prices. There is insufficient evidence to believe that such negative response was deliberate. Initial evidence showed that pressure from OPEC cheating played an important role in shrinking the spare capacity. Increase in positive response for cheating and for allocation of OPEC production quota should be capable in reducing oil prices significantly if OPEC operated as an effective cartel. Although it has been argued in the literature that investments in new capacity and high costs of maintaining such stocks/capacity have been responsible for the negative relationship, IEA in general and the U.S. in particular often capitalised upon this low capacity for any short-term projections of future high oil prices. It was also found that oil prices were not significantly Granger caused by changes in OPEC spare capacity. Further to this evidence, changes in the spare capacity contributed to less than 1% of the variation in the oil prices. There is evidence that OPEC's policies and the oil price Granger caused OPEC spare capacity individually and jointly. This might imply that although OPEC spare capacity might not influence high oil prices directly, the speculation surrounding such a situation might be critical as often noted by key energy consumers (e.g. IEA).

d. Given the above finding that OPEC's coordinated policies could exercise significant influence on high oil prices, oil prices for the year 2013 were forecast and compared with the actual results (as part of the out-of-sample test) to investigate how accurate OPEC's coordinated policies might predict oil prices. This is based on the general assumption that such policies could be controlled by OPEC leadership to a significant degree. On the bases of the OPEC stabilisation policies, oil prices should have been maintained within a band of \$73.96-\$96.87 (near the implied oil price band of \$80 - \$90) as against \$88-\$109 that actually prevailed. In the periods (i.e. month five to month twelve) when the actual oil prices exceeded \$95 per barrel, OPEC's policies were predicted to have maintained oil prices within a band of between \$73.96 and \$85.51. This finding implies that while OPEC does take coordinated actions to stabilise oil prices within a target price range, the market power to stabilise the prices at such desired level might be unrealistically outside the control of the organisation. This finding lends support to Khan (2009) who concluded that oil prices in 2008 should have been within the range of \$80-\$90 as against \$147 in the absence of the market speculation.

i. In the second model where the actions of other key market players were introduced into the system, almost similar responses from OPEC stabilisation policies were observed. Slight changes in the response of OPEC policies could be attributed to the reaction to other policies. For example, forecast error variance decompositions have changed to presumably allow the most important factor to take lead position in accounting for the variation in oil prices. It was noted that the effects of the actions of the newly introduced players into the market system on the oil prices have contributed in understanding some of the key answers that were not available in the first model. More specifically, the following points were found pertinent:

a. Non-OPEC production policies responded negatively to the shocks in the oil prices during the four periods in the entire twelve periods considered. In the remaining eight periods, non-OPEC production policy began to respond positively. Despite the fact that this group satisfy nearly

60% of the global oil demand and that there has been an apparent shift in the balance of power from the OPEC to non-OPEC producers based on developments in the new reserves (e.g. Canadian sand oil reserves and Norway's new oil reserves), their response to the initial shock in oil prices remains a debatable issue. This conclusion is based on the premise that non-OPEC producers appear to have had the capacity to respond positively to reduce oil prices during all 12 periods but failed to do so. This shows that the response of OPEC to the shocks in the oil prices appeared to be much higher than that of non-OPEC. One possible reason for this situation might be that OPEC possesses more reserves than the non-OPEC producers as claimed by OPEC (i.e. nearly 80% based on the Annual Statistical Bulletin, 2013). The important implication of this finding is that OPEC stabilisation policies might be rendered ineffective without support of the non-OPEC producers. If this is true then the responsibility for stable oil prices must be shared between OPEC and OPEC producers for meaningful stability of prices to be achieved. Also further evidence was found that non-OPEC production policy significantly Granger caused changes in the oil prices (i.e. 5% p.value). When all factors were considered in the forecast error variance decomposition of oil prices, non-OPEC production policy accounted for the highest variation in the oil prices (i.e. up to nearly 12% in the 12th period).

b. OECD/IEA crude oil consumption policy responded negatively to the oil price shocks in the initial periods (i.e. up to first eight periods) of oil price shock as expected under normal circumstances. Subsequently, the response became positive in the remaining four of the periods considered. This implies that, in the initial period of the shock, reduction in the OECD/IEA consumption due to high oil prices should be expected to bring prices down. This helps explain why less than 2% of the variation in the oil prices was accounted for by the changes in the OECD/IEA crude oil consumption policy in each of the initial six periods. In the remaining six periods, the consumption policy accounted for only less than 3% in each of the periods. Also, there was no significant evidence that OECD/IEA crude oil consumption Granger caused changes to the oil prices. Although, OECD/IEA crude oil consumption had declined over the sample period in

this study, it did not seem to produce any substantial impact on oil prices. This could be due to intervention of other consumers (such as China, India, Brazil) to consume what had not been fully consumed by OECD/IEA. This finding is consistent with that of Gallo et al. (2010) who also employed Granger causality and VAR for their analysis of supply-demand dynamics. OECD/IEA crude oil stockpiling policy also responded to the shock in the oil prices in almost similar pattern to the OECD/IEA crude oil consumption policy. However, it accounted for less than 2% of the variation in the oil prices in the first four periods. Thereafter the increase did not exceed 2.5% in each of the subsequent periods. Similarly, OECD/IEA crude oil stockpiling policy did not produce any significant evidence in Granger causing changes to oil prices. The main point of contention in this regard is similar to that in OPEC spare capacity. Although, there was insufficient evidence to linky this policy with high oil prices, it might be implied that speculation around the variable might be a basis for high oil prices.

ii. The study documented evidence that changes in the non-OPEC and OECD/IEA policies influenced OPEC stabilisation policies in different ways which might affect oil prices indirectly. Despite the introduction of the actions of the new players into the market system, the following findings are noted.

a. Evidence was established that oil prices and OPEC crude oil spare capacity Granger caused changes in OPEC production quota. It was also found that OECD/IEA crude oil stockpiling policy was significant in Granger causing changes in OPEC production quota. This might imply that OPEC's quota allocation could be altered when OPEC perceived that OECD/IEA is engaged in stockpiling rather than regular consumption. Evidence was also found that non-OPEC production policy responded positively to the shock in OPEC production quota in the early periods considered but gradually reduced and became negative as the periods increased. This implies that OPEC might have more reserves than the non-OPEC and that competition with OPEC in this regard might not seem economically viable presumably due to the low production costs in OPEC nations. Where the response of non-OPEC countries could be related to the claim of a shift in the balance

of power, this evidence might support the view that non-OPEC producers could have engaged in an action to promote high oil prices. This position was supported by evidence from the forecast variance decompositions.

As expected, both OECD/IEA crude oil consumption and stockpiling responded positively to the shock in the OPEC production quota in the initial stage of the shock before turning negative in the subsequent periods. While the positive response remained longer for the consumption policy, it was found to be very short for the stockpiling policy. This evidence is consistent with the theory that when OPEC released more oil than it might have currently supplied to the market, OECD/IEA consumption is likely to be high. This might happen because OECD/IEA stockpiling policy did not place any maximum limit on oil consumption that could be maintained. Similarly, the positive response of OECD/IEA crude oil consumption to the initial shock in the OPEC production quota might imply that OECD/IEA might respond positively to the shock even when the concern was to make up the shortfall created in the past. This might be justifiable considering OPEC's oil is a cheaper option than alternative sources. Oil prices, OECD/IEA crude oil stockpiling and OPEC spare capacity were the major variables accounting for variation in OPEC production quota based on the variance decomposition analysis.

b. Furthermore, there was insufficient evidence that OPEC production cheating was Granger caused by any of the newly introduced variables in the second model. However, there was evidence that non-OPEC production policy responded negatively to the shocks in OPEC production cheating in the initial periods but the response turned positive in the later periods. This could imply that, given low extraction costs of OPEC oil, competition from non-OPEC was often low if the cheating in OPEC was high. Alternatively, it could imply low availability of reserves and capacities in the non-OPEC nations. However, for the consumers (i.e. OECD/IEA), both consumption and stockpiling responded positively to the shocks in OPEC production cheating. This clearly implies that OECD/IEA members increased their consumption and stockpiling behaviour when OPEC cheating became high. This could possibly be part of a strategy to reduce the impact of any future

oil price increase. Further evidence on the variation in the OPEC production cheating showed how important OECD/IEA crude oil stockpiling and OPEC spare capacity were in promoting cheating in OPEC. This supported earlier findings that most of the oil consumption during increase in OPEC production cheating was being stockpiled rather than going regular consumption in the OECD/IEA nations. This action might increase pressure on the production cheating in OPEC and more pressure on OPEC crude oil spare capacity could be expected.

c. As noted in the previous findings, a clear connection from OPEC production quota and cheating to OPEC spare capacity was established. More specifically, the findings above were reinforced by analysing response of the three variables to the shocks in the OPEC spare capacity. Non-OPEC responded positively to the shocks in the spare capacity throughout the periods considered. Similarly, OECD/IEA crude oil stockpiling responded positively to the shocks in spare capacity. However, the OECD/IEA crude oil consumption responded negatively to the shocks in spare capacity. Evidence from the variance decomposition further confirmed that apart from the spare capacity itself, OECD/IEA crude oil stockpiling and oil prices appeared to be most important variables accounting for variation in OPEC spare capacity with up to nearly 22% in the last period for each variable.

It was also found that there existed a wide discrepancy between disclosures about OPEC reserves and oil supply in the oil market. While disclosure by BP and OPEC were nearly identical, with only immaterial differences, the U.S.-EIA's disclosure was hugely different in most of the periods compared to the two mentioned databases (i.e. OPEC and BP). In the same direction, OPEC crude oil supply to the oil market was under-reported by the U.S.-EIA compared with the IEA counterpart. This finding is consistent with Sornette et al. (2009). These variations might have promoted speculation based on potentially wrong/biased market analysis and often propagated by the media (see Koomey et al., 2002). For example, analysis using different datasets might potentially show different

results as suggested by the findings from the summary statistics in Chapter 6.

**CHAPTER EIGHT: CONCLUSION AND
RECOMMENDATIONS**

Chapter Eight Conclusion and Recommendations

8.1 Conclusion and Original Contributions to Knowledge

This study has extended the VAR methodology by applying Granger causality, VAR impulse response functions and forecast error variance decompositions to describe the complex dynamics between various players with diverse objectives in the oil markets. The evidence obtained is consistent with OPEC not being an effective cartel for controlling oil prices. This finding is an important contribution to the OPEC and oil price literature and is consistent with the elements of the prior literature which have been quoted previously (see Kepplinger and Roth, 1979; Botcheva and Martin, 2001; Bentzen, 2007; Reynolds and Pippenger, 2010; Cairns and Calfucura, 2012; Colgan, 2014).

The study has presented evidence that tensions between the implementation of the competing policies of IEA/OECD members and other non-OPEC producers may have neutralised the apparent power over oil prices that OPEC has allegedly had. On reflection I have formed the view that whilst this modelling analysis has made inroads into settling the OPEC cartel issue, it has also revealed the depth of complexity existing in the real world environment that helps determine oil prices. Human behaviour based on personal gain or on national interests interacts with basic economic issues relating to supply and demand. This research may well have raised many more issues requiring research than the ones it has solved. But since oil and gas energy access is central to most companies' economies I find this insight also to be a significant finding. It opens the door for future research.

I have also reflected on the reasons why most observers of OPEC behaviour have concluded that OPEC is an effective cartel. In essence, the answer is simple: OPEC has acted as if it were a cartel which could actually control oil prices; that was why it formulated an oil price band policy. The analysis in this thesis shows that OPEC was wrong to have held that belief. I further believe that the analysis presented calls into question the transparency and effective passing of information between countries which have signed up to the principles of the Joint Organisations Data Initiative

Therefore, a need to introduce a mandatory disclosure framework for information providers is a crucial step towards enhancing transparency of the market which Joint Organisations Data Initiative members generally believed could reduce the risk premiums arising from speculative activities in the oil markets.

My conclusion is that the VAR methodology is applicable for producing research that is useful for market regulators and accounting standard setters; this result arguably has significant economic and political consequences. This innovative contribution to the research methodology by utilising VAR impulse response functions and forecast error variance decompositions enables regulators to better understand the political, social and economic interaction between key players in the oil markets, thereby increasing chances of policy embracement by all parties. Hence this can result in establishing optimal solutions to issues that otherwise might present intractable difficulties.

8.2 Policy Implications

OPEC has failed to control oil prices within its target band policy set by the organisation in the year 2000. In view of this failure OPEC needs to be more proactive in engaging publically about its objectives and actions taken to achieve those objectives.

Consistently, evidence suggests that further actions need to be carried out by regulatory bodies on the data/information disclosure to international oil markets. Unless this important issue is well addressed, discrepancies in the information supplied by other players about OPEC and the information supplied by OPEC about itself would continue to promote speculative activities that could lead to higher oil prices. OPEC in this regard would need to do more to restore confidence in the quality of data it provides to the market.

8.3 Limitations of the Study

The study was based on analysis of historic data and any limitations inherent in the data are thus also a limitation of this research. Attempts were made to cross-check data sets and in this way any limitation due to inaccuracy of data has been minimised. The econometric analysis revealed

interesting outcomes; however there are limitations in interpreting these results. Although the explanations given are logical there may be other interpretations that are equally valid. Overcoming this limitation will be the subject of future research.

In retrospect, the study could perhaps have provided more detailed dynamics if panel data models had been used to explore the specific actions of some core nations in oil consuming and producing nations (for example Saudi Arabia (in OPEC) or the U.S. (in OECD/IEA) respectively). The model has limitations relating to its failure to capture the effect of important geo-political events. This reflects the approach taken was not primarily an events study approach. But, on reflection, some exogenous events such as the Syrian war had the potential to promote speculative activities around actions of the market players. Subsequent studies could improve the model's prediction by capturing these exogenous events.

The findings of the study may have been more persuasive if the interpretations of the findings based on the statistical models had been supplemented by some qualitative data. In view of the fact that some cointegration results were observed between variables, VEC models should have been estimated with a view to estimating long-term dynamics between the variables. This would have allowed this study to describe differences between short and long term dynamics in the variables. However, the main focus of this study is on the short-term dynamics which were adequately covered using unrestricted VAR. Extending the framework to examine the long-term dynamics would be an exciting area for further research.

8.4 Future Research Opportunities

As mentioned above my future research approach will adopt a more qualitative approach. Also a panel data approach will be applied to provide greater insight into the above findings. These methods will help overcome the limitations of VAR models.

The study has considered the short-run dynamics of some key actors in the oil market. The findings showed evidence of cointegration between oil prices and other cointegrating variables in the vectors which imply the

existence of a long run relationship between oil prices and the cointegrating variables of interest. Applying vector error correction models (VECM) in future studies might reveal these long-run dynamics between variables and provide a possible comparison with the results obtained in this study.

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Appendices

Appendix I: (Analysis and Graphs Relating to Chapter 6: Descriptive and Time Series Properties Analysis)

For ease of reading and to aid comprehension, the numbering system/pattern in this appendix will be as it would appear if it were appearing in the main body of the thesis. The results of the analysis are summarised in the actual Chapter 6 in the main body. The analysis and results in the summary justifies the model findings presented in Chapter 7.

Chapter Six Descriptive and Time Series Properties Analysis

6.1 Introduction

This chapter presents data, descriptive statistics and other preliminary empirical analysis that helped inform the additional empirical investigation that is reported in Chapter 7. The chapter starts by presenting the data and descriptive statistics which assists in understanding the properties of the data and the appropriateness of the tools for modelling the data (Huisman, 2009; Saunders et al., 2012). The subsequent analysis helps to identify adjustments and inferences prior to constructing the final models. Moreover, the issue of normality of the distribution of the datasets does not necessarily pose any challenge at this stage because VAR models (unrestricted VAR and VECM) are not usually based upon normality of data (see Brooks, 2008).

There are five sections in this chapter. The first section, deals with the summary descriptive statistics (mean, median, standard deviation). In the second section, various tests are carried out to understand how normally distributed the series used in this study are before being subjected to the modelling process. Therefore, graphical and other forms of formal tests of normality are performed. Similarly, graphical representations of data are made in the third section to identify the pattern of the data and observations are noted on the need to explore beyond ordinary descriptive statistics in order to understand the properties of the series. The time series properties tests (including both parametric and non-parametric tests) together with cointegration tests are outlined in the fourth section. The fifth section concludes the chapter with particular reference to how the results obtained are specifically linked to the next stage of analysis. In the process of examining the pattern of the data, an exploration is made of the differences (where applicable) from different datasets with a view to establishing any potential implications on further analysis.

6.2 Descriptive Statistics of the Sample Datasets

Descriptive analyses are provided in this section by exploring summary statistics with a view to describing the datasets and detecting any potential problems (such as inconsistencies, missing observations, outliers). Understanding and interpretation of the empirical analysis of data are enhanced when the natural pattern of the variables are well described. Descriptive statistics of the series obtained from the various databases (as discussed in Chapter 5) are summarised in tables 6.1 to 6.6 (i.e. summary statistics). Furthermore, two periods namely: official and implied oil price band periods, are identified and data in respect of each period and the entire sample period are analysed. Table 6.1 presents summary statistics for six variables (OPR [oil price], OPQ [OPEC production quota], OSC [OPEC spare capacity], OMC [Oil market competition], OOC [OECD/IEA crude oil consumption], and OOS [OECD/IEA crude oil stockpiling]).

Table 6:1: Summary Statistics for the Datasets [OPR, OPQ, OSC, OMC, OOC, and OOS]

	OPR	OPQ	OSC	OMC	OOC	OOS
Mean	59.95096	25.84942	2.652885	41.54854	48.41700	4.090288
Median	59.18000	25.30000	2.305000	41.72879	48.40466	4.133730
Maximum	133.8800	30.00000	6.830000	43.94868	52.81538	4.351867
Minimum	19.39000	21.07000	0.710000	39.15836	44.30346	3.734640
Std. Dev.	28.17862	2.403361	1.423432	0.988658	1.866524	0.160965
Skewness	0.384610	0.082526	0.655347	-0.627771	-0.013912	-0.390273
Kurtosis	2.166592	2.320392	2.716310	2.987292	2.293031	2.013430
Jarque-Bera	8.360742	3.179204	11.68961	10.24754	3.253762	10.28672
Probability	0.015293	0.204007	0.002895	0.005954	0.196542	0.005838
Sum	9352.350	4032.510	413.8500	6481.572	7553.052	638.0849
Sum Sq. Dev.	123075.4	895.3022	314.0548	151.5038	540.0065	4.016011
OBS	156	156	156	156	156	156

Key

OPR: Oil prices in U.S. dollar (\$)

OPQ: OPEC production quota in million barrels per day

OSC: OPEC spare capacity in million barrels per day

OMC: Oil market competition in million barrels per day

OOC: OECD/IEA crude oil consumption in million barrels per day

OOS: OECD/IEA crude oil stockpiling in million barrels per day

OBS: Observations

Table 6.1 presents the summary statistics for the entire series (except OPEC production cheating⁹¹ which receives further consideration in table 6.2 below). The six series (variables) appearing in the first row of table 6.1 are used for building the first and second models specified in Chapter 5 of this study. 156 observations are used for each of the series (representing monthly observations over a 13 year period [12 x13=156]). Over the entire sample period, it can be observed that the mean oil price is \$59.95. This is similar to the median value of \$59.18. The minimum and maximum values are however \$19.39 and \$133.88 respectively. The standard deviation of 28.18, as a measure of dispersion, shows how volatile the prices are from the average during the period (see Brorsen et al., 1989; Guidi et al., 2007). The skewness is a normality tool which assesses “the extent to which a frequency distribution is asymmetric” (Collis and Hussey, 2009: 248). The standard for a normally distributed data should be “0” (Bai and Ng, 2005). From the results above, the skewness for the oil prices is positive at 0.3846, which shows that the series slightly skews to the right.

Furthermore, the Kurtosis is another tool for measuring normality of a distribution which assesses “the extent to which frequency distribution is flatter or more peaked than a normal distribution” (Collis and Hussey, 249). Theoretically, “0” is also assumed for a normally distributed dataset. The Kurtosis for the oil price distribution in table 6.1 is 2.1666 which indicates that oil price distribution might be flatter than normally distributed data. Similarly, the Jarque-Bera (JB) statistic is expected not to be significant at 5% for a series to be normally distributed. In this case, the result is 8.3607 which is significant at 5% (i.e. 0.0152) indicating that the series are not normally distributed based on the JB test. In this case, further tests based on graphical representation/properties (i.e. histogram, boxplots) are carried out to explore more details (which are considered in the later part of this chapter, see normality tests section).

⁹¹ OPEC production cheating (i.e. OPC) receives separate analysis due to the discrepancy discovered in the data sources between IEA and EIA. Therefore, their implications are highlighted for oil markets.

Similarly, it can be observed that the mean distribution of OPEC production quota is 25.84942 (i.e. in million barrels per day). It is not also different in absolute value from the median of 25.30 mb/d over the period of the sample. The minimum and maximum values stand at 21.07 mb/d and 30.00 mb/d respectively. The standard deviation for the OPEC quota is 2.403361. The indicators of normality (i.e. skewness, Jarque-Bera) show that this series appears to be normally distributed with skewness of 0.082526 and Jarque-Bera statistic of 3.179204 which is not statistically significant at 5% (i.e. 0.204007).

OPEC spare capacity has a mean of 2.65 million barrels per day (mb/d) which is quite different from the median at 2.30 mb/d. With a high skewness of 0.6553 and Jarque-Bera statistics of 11.6896 (and significant at 1% [e.g. 0.002]), it can be concluded that the series does not appear to be normally distributed.

Oil market competition averages 41.5485 mb/d for mean, and 41.7288 mbd for median. Relating the means for the OPQ and OMC, it can be observed that on average OPEC's average market share is around 40% (i.e. 26 mb/d for OPEC over the total from both OPEC and non-OPEC [67 mbd]). The minimum and maximum values are 39.1584 and 43.9487 respectively. While OPEC quota's percentage change from mean to maximum value is 16%, the same value for OMC is just 6%. This shows that there is more volatility in OPEC quota than is non-OPEC.

Furthermore, the skewness (-0.6278) and Jarque-Bera statistics (10.2475) together with the probability value of 0.0060 also suggest that OMC series is skewed to the left and not normally distributed based on JB statistics. It can be observed that the mean of the distribution for OECD/IEA crude oil consumption, is 48.4170 mb/d slightly around same with the median value of 48.4047 mb/d. The mean value of OOC (i.e. 48.4170 mb/d) is over 70% of the global consumption based on average production from both OPEC and non-OPEC as summarised in table 6.1. The minimum and maximum values are 44.3035 mb/d and 52.8154 mb/d respectively. The skewness is slightly to the left (i.e. not far from "0" [-0.013912]), however, the Jarque-Bera statistic of 3.2538 is not significant at 5% (i.e. 0.1965). This

suggests strong closeness of the series to normality. In this regard, further evidence to normality is obtained based on the closeness of difference between mean average and median (i.e. 48.4170 mb/d and 48.4047 mb/d for mean and median respectively). Finally, the last column from table 6.1 reveals the summary statistics for OECD/IEA crude oil stockpiling. The mean and media are almost similar (i.e. at 4.09029 mb/d and 4.1337 mb/d respectively). The minimum and maximum values are 3.7346 mb/d and 4.3519 mb/d respectively. The standard deviation is 0.1610 which comparably indicates low variability. The series is skewed to the left with a value of -0.0139 and JB statistics of 3.2538 which is not significant at 5%. All observations considered in table 6.1 showed no evidence of missing data, and this is important for the serial correlation test discussed in Chapter 5 for which analysis is considered in Chapter 7.

The descriptive statistics for OPEC production cheating and OPEC oil supply are considered in table 6.2 based on two different databases namely: IEA and EIA as part of the robustness checks. It should be noted that EIA database is used based on section 5.5.2: definition of variables and measurement strategy. Analysing the discrepancies, if any, based on the two databases is crucial particularly when dealing with factors that influence oil prices from speculative activities (see Sornette, et al., 2009; Cifarelli and Paladino, 2010) and political motivation of oil market players (Mauro and Peri, 2011; Radetzki, 2012). Therefore, table 6.2 presents specifically OPEC production cheating and OPEC actual oil supply as reported by both organisations whose data are reputable sources for oil market analysis.

Table 6:2: Summary Statistics for OPEC Production Cheating and Opec Crude Oil Supply (EIA and IEA Data)

	OPC-EIA	OPC-IEA	OSS-EIA	OSS-IEA
Mean	7.556923	7.680769	33.40635	33.53019
Median	7.035000	7.555000	34.17500	34.12000
Maximum	11.37000	11.95000	37.20000	38.04000
Minimum	4.190000	3.910000	27.73000	27.21000
Std. Dev.	1.642911	1.672271	2.371312	2.789373
Skewness	0.592395	0.316012	-0.628740	-0.354761
Kurtosis	2.538024	2.624695	2.298752	2.181784
Jarque-Bera	10.51146	3.512005	13.47455	7.623830
Probability	0.005218	0.172734	0.001186	0.022106
Sum	1178.880	1198.200	5211.390	5230.710
Sum Sq. Dev.	418.3691	433.4559	871.5834	1205.994
Observations	156	156	156	156

Key

OPC-EIA: OPEC production cheating-Energy Information Administration mb/d

OPC-IEA: OPEC production quota-International Energy Agency mb/d

OSS-EIA: OPEC crude oil supply-Energy Information Administration mb/d

OSS-IEA: OPEC crude oil supply-International Energy Agency mb/d

It can be observed from table 6.2 that average OPEC production cheating for mean and median are quite different for both EIA and IEA. The mean for EIA is 7.5569 mb/d while that of IEA stands at 7.6808 mb/d. Furthermore, the medians are 7.0350 mb/d and 7.5550 mb/d for EIA and IEA respectively. The minimum and maximum values for EIA and IEA are 4.1900/11.3700 (mb/d) and 3.9100/11.9500 (mb/d) respectively. However, a more interesting difference emerges from skewness and Jacque-Bera results. EIA data source shows that OPEC production is over skewed to the right (i.e. 0.5924), and with a high Jacque-Bera statistics of 10.5115 which is significant at 1% (i.e. 0.0052). However, IEA data rather shows a skewness of 0.3160 which is much less than the one obtained from the EIA by almost a 100%. Also, the IEA indicates a Jacque-Bera

result of 3.5120 which does not appear to be significant at 5% (i.e. 0.1727).

In this regard, the entire period is divided into two namely: official and implied OPB periods with a view to comparing the sample by exploring similarities/variations in the periods. Table 6.3 presents summary statistics for the series, during the official OPB period, except OPC which is separately analysed in table 6.4.

Table 6:3: Summary Statistics for All Datasets except OPC in Official OPB Sample Period

	OPR	OPQ	OSC	OMC	OOC	OOS
Mean	31.51806	24.06048	3.083065	40.84532	49.07922	3.916414
Median	29.63500	24.35000	2.885000	40.90240	49.07473	3.931343
Maximum	53.28000	27.00000	6.830000	42.66872	52.36961	4.085536
Minimum	19.39000	21.07000	0.710000	39.15836	46.32043	3.734640
Std. Dev.	7.246080	1.785227	1.717106	1.025707	1.366910	0.083378
Skewness	1.009403	-0.092131	0.345453	0.001607	0.301740	-0.323485
Kurtosis	3.882468	1.905790	2.044249	1.843002	2.746510	2.300136
Jarque-Bera Probability	12.54034 0.001892	3.180724 0.203852	3.592930 0.165884	3.458192 0.177445	1.106815 0.574987	2.346646 0.309337
Sum	1954.120	1491.750	191.1500	2532.410	3042.911	242.8177
Sum Sq. Dev.	3202.846	194.4091	179.8557	64.17658	113.9750	0.424063
OBS	62	62	62	62	62	62

Key

OPR: Oil prices in U.S. dollar (\$)

OPQ: OPEC production quota in million barrels per day

OSC: OPEC spare capacity in million barrels per day

OMC: Oil market competition in million barrels per day

OOC: OECD/IEA crude oil consumption in million barrels per day

OOS: OECD/IEA crude oil stockpiling in million barrels per day

OBS: Observations

From table 6.3, the mean average for the oil prices stands at \$31.5181 during the official OPB period. The median (i.e. \$29.6350) however is different from the mean which indicates likelihood of non-normality of the series. The minimum and maximum values stand at \$19.3900 and \$53.2800 respectively. The standard deviation is \$7.2461 compared with that of the entire sample period in table 6.1 (i.e. \$28.1786). The series is skewed to the right (i.e. 1.0094) and has Jarque-Bera statistic of 12.5403 which is strongly significant at 1% (i.e. 0.00189). This is also a further

indication that the series is not normally distributed. OPEC production quota has mean average of 24.0605 mb/d with median of 24.35 mb/d. The minimum and maximum values are 21.07 mb/d and 27 mb/d respectively. Standard deviation is 1.7852 mb/d compared with 2.4034 mb/d for the entire sample period. As stated earlier, the Jacque-Bera statistic is not significant even at the weakest form of 10% (i.e. 0.2034).

OPEC spare capacity has a mean of 3.0831 mb/d for the sub sample period which is higher than that computed for the entire sample period (i.e. 2.6528 mb/d) in table 6.1. The median is 2.885 mb/d, while the minimum and maximum values stand at 0.71 mb/d and 6.83 mb/d respectively. The standard deviation is 1.7171 mb/d indicating that variation in the sub-period is much more than that of the entire period i.e. with standard deviation of 1.4234 mb/d as can be observed in the minimum-maximum values. However, the Jarque-Bera indicates the series is normally distributed (i.e. not significant at even 10%) as shown by the probability value of 16.59%. Oil market competition has average mean of 40.8453 mb/d and median of 40.9024 mb/d. Comparing the results with the entire period sample in table 6.1, it can be observed how static the oil market competition has been and improvement in the subsequent period which makes the entire sample period mean and median to be 41.5485 mb/d and 41.7288 mb/d respectively. This low variation is confirmed by the minimum-maximum values and standard deviation computed at 39.1584 mb/d - 42.6687 mb/d and 1.0257 mb/d respectively. On the basis of the Jarque-Bera statistic (3.4582) and probability level of 17.74%, it can be concluded that series is near to normality.

OECD/IEA crude oil consumption has average mean and median of 49.0792 mb/d and 49.0747 mb/d respectively and higher than the corresponding average mean and median for the entire sample period (i.e. 48.4170 mb/d and 48.4047 mb/d respectively). This is consistent with OECD/IEA crude oil consumption falling in the later sub- period. The minimum and maximum values are 46.3204 mb/d and 52.3696 mb/d respectively. The standard deviation for the sub-period is 1.3669. Consistent with the earlier statement, Jacque-Bera statistic (1.1068) and probability (57.50%) suggest that the series is close to normality.

Furthermore, OECD/IEA crude oil stockpiling is analysed based on the figures in table 6.4. The mean and median averages stand at 3.9164 mb/d and 3.9313 mb/d respectively. The minimum and maximum values for the sub-period are 3.7346 mb/d and 4.0855 mb/d respectively. The standard deviation is very low at 0.0834 which confirms the low difference between the minimum and maximum values. It is slightly skewed to the left (i.e. -0.3235) but Jarque-Bera statistic (2.3466) and probability (30.93%) indicate that the series is normally distributed. In the same manner, the summary statistics for OPEC production cheating and actual OPEC supply are computed and presented in table 6.4.

Table 6:4: Summary Statistics for OPEC Production Cheating and OPEC Crude Oil Supply in Official OPB Period (IEA vs EIA Datasets)

	OPC-IEA	OPC-EIA	OSS-EIA	OSS-IEA
Mean	6.630323	6.915645	30.97613	30.69081
Median	6.445000	6.870000	30.84500	30.62000
Maximum	10.10000	10.23000	34.39000	34.29000
Minimum	3.910000	4.190000	27.73000	27.21000
Std. Dev.	1.329930	1.314163	1.717963	1.758491
Skewness	0.456429	0.356809	0.277805	0.195731
Kurtosis	3.275434	3.207659	2.251804	2.312807
Jarque-Bera	2.348698	1.426960	2.243620	1.615813
Probability	0.309020	0.489936	0.325690	0.445790
Sum	411.0800	428.7700	1920.520	1902.830
Sum Sq. Dev.	107.8916	105.3485	180.0353	188.6297
Observations	62	62	62	62

Key

OPC-EIA: OPEC production cheating-Energy Information Administration mb/d

OPC-IEA: OPEC production quota-International Energy Agency mb/d

OSS-EIA: OPEC crude oil supply-Energy Information Administration mb/d

OSS-IEA: OPEC crude oil supply-International Energy Agency mb/d

It can be observed from table 6.4 that the mean and median averages stand at 6.6303 mb/d and 6.4450 mb/d respectively for the IEA data. However, corresponding mean and median for the EIA data show 6.9156 mb/d and 6.87 mb/d respectively. Unlike the statistics for the entire sample period, the sub-period Jarque-Bera results show that both IEA and EIA data are normally distributed with probability values of 30.90% and

48.99% respectively. For the OPEC oil supply from the EIA data, it can be observed that the average mean and median at 30.9761 mb/d and 30.8450 mb/d respectively. The corresponding figures for the IEA data stand at 30.6908 mb/d and 30.62 mb/d respectively. However, since our primary intention revolves around understanding how OPEC stabilisation policies work, particularly during the official and implied OPB periods, table 6.5 below presents the summary statistics for the implied OPB period except for the OPEC production cheating which is covered in table 6.5.

Table 6:5: Summary Statistics for all Series Except OPC (Implied OPB Period)

	OPR	OPQ	OSC	OMC	OOC	OOS
Mean	78.70457	27.02936	2.369149	42.01236	47.98022	4.204970
Median	76.35500	27.50000	2.190000	41.96407	47.61101	4.198266
Maximum	133.8800	30.00000	4.570000	43.94868	52.81538	4.351867
Minimum	39.09000	24.85000	0.860000	39.99631	44.30346	4.018896
Std. Dev.	19.86251	1.998931	1.112771	0.626001	2.023809	0.071937
Skewness	0.442092	0.185711	0.386976	0.133348	0.263330	-0.011239
Kurtosis	3.018623	1.519385	1.889983	3.879665	2.065954	2.415524
Jarque-Bera	3.063342	9.126524	7.171967	3.309337	4.503431	1.339960
Probability	0.216174	0.010428	0.027709	0.191155	0.105219	0.511719
Sum	7398.230	2540.760	222.7000	3949.162	4510.141	395.2672
Sum Sq. Dev.	36690.28	371.6024	115.1581	36.44453	380.9096	0.481267
OBS	94	94	94	94	94	94

Key

OPR: Oil prices in U.S. dollar (\$)

OPQ: OPEC production quota in million barrels per day

OPC: OPEC production cheating

OSC: OPEC spare capacity in million barrels per day

OMC: Oil market competition in million barrels per day

OOC: OECD/IEA crude oil consumption in million barrels per day

OOS: OECD/IEA crude oil stockpiling in million barrels per day

OBS: Observations

It can be observed from table 6.5 that for oil prices, the mean and median average are \$78.7146 and \$76.3550 respectively. It is clear that the averages during the implied OPB are much larger than the official OPB periods which stand at \$31.52 and \$29.64 for the mean and median respectively. This implies that during the implied OPB period average price exceeds that of official OPB by \$47.19 (i.e. \$78.71 - \$31.52). The prices

are also more volatile in the implied OPB period with standard deviation of \$19.8625 compared with official OPB which has standard deviation of \$7.2461. The maximum value for the implied OPB period is \$133.88 as against the \$53.28 in the official OPB period. However, official OPB appears to be more skewed to the right (i.e. 1.0094) than the implied OPB period (0.4421), which together with the Jarque-Bera statistics (3.0633) and probability of 21.62% indicates the normality of the series for the implied OPB period.

OPEC production quota in the implied OPB period (i.e. 27.0292 mb/d) is higher than official OPB period (i.e. 24.0605 mb/d). However the Jarque-Bera statistics is significant at 1% which suggests that the series during the sub-period is not normally distributed. OPEC spare capacity during the implied OPB sub-period has mean and median average of 2.3692 mb/d and 2.19 mb/d respectively. It also shows evidence that the series is not normally distributed as suggested by the Jarque-Bera statistics of 7.1720 significant at 5% (0.0277). Oil market competition averages 42.0124 mb/d in mean, and 41.9641 mb/d in median. These figures are slightly higher than official OPB period which stand at 40.8453 mb/d and 40.9024 mb/d for corresponding mean and median respectively. This evidence shows that there is little difference between average means for both periods (i.e. 41.9641 mb/d and 42.0124 mb/d for official and implied periods respectively). During this sub-period, the series appears to be normally distributed based on Jarque-Bera statistic of 3.3093 with probability of 19.12%.

Similarly, OECD/IEA crude oil consumption in the implied OPB period has mean average of 47.9802 mb/d which is less than 49.0792 mb/d in the official OPB period. The standard deviation in the implied OPB period is 2.0238 mb/d. As in the official OPB period, the Jarque-Bera statistic is 4.5034 which is not significant (i.e. 10.52%). For the same period, OECD/IEA crude oil stockpiling averages 4.2050 mb/d in mean and 4.1983 mb/d in median. The standard deviation for the implied OPB period is 0.07194 mb/d which is not greatly different from the official OPB period with 0.0834 mb/d. The series skews slightly to the left with skewness value at -0.0112. Jarque-Bera statistics is 1.3400 which is not significant

(i.e. probability value of 51.17%). This suggests that the crude oil stockpiling series is normally distributed. The difference between OPEC production cheating during the implied OPB period (in table 6.6) and that of the official OPB period are examined.

Table 6:6: Summary Statistics for OPEC Production Cheating and OPEC Crude Oil Supply in Implied OPB Period (IEA and EIA Datasets)

	OPC-IEA	OPC-EIA	OSS-EIA	OSS-IEA
Mean	8.373617	7.979894	35.00926	35.40298
Median	8.120000	7.325000	34.90000	35.00000
Maximum	11.95000	11.37000	37.20000	38.04000
Minimum	5.800000	5.350000	33.33000	32.52000
Std. Dev.	1.509923	1.706115	0.949607	1.421131
Skewness	0.324274	0.490386	0.397774	0.374298
Kurtosis	2.322636	1.865076	2.507900	1.965488
Jarque-Bera	3.444462	8.812358	3.427321	6.386568
Probability	0.178667	0.012202	0.180205	0.041037
Sum	787.1200	750.1100	3290.870	3327.880
Sum Sq. Dev.	212.0276	270.7069	83.86305	187.8242
Observations	94	94	94	94

Key

OPC: OPEC production cheating

OSS: OPEC crude oil supply

OPC-EIA: OPEC production cheating-Energy Information Administration mb/d

OPC-IEA: OPEC production quota-International Energy Agency mb/d

OSS-EIA: OPEC crude oil supply-Energy Information Administration mb/d

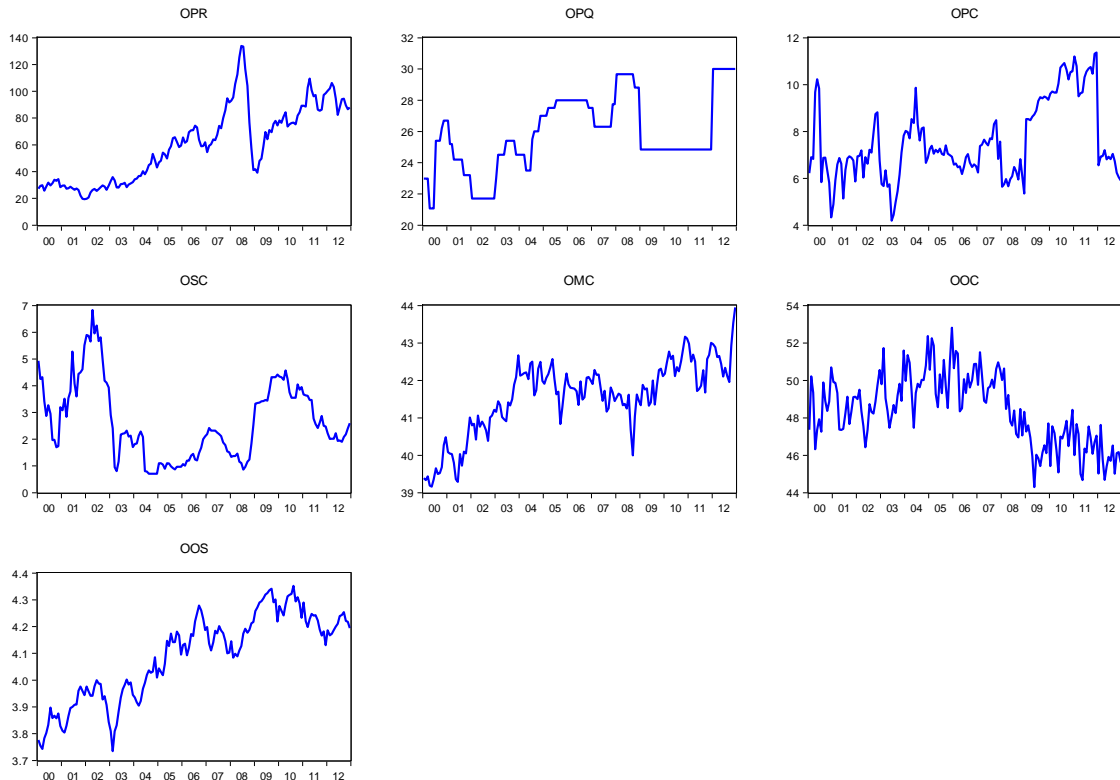
OSS-IEA: OPEC crude oil supply-International Energy Agency mb/d

From table 6.6, it can be observed that the mean and median values for both IEA and EIA are quite different (i.e. IEA-mean [8.3736 mb/d] median [8.1200 mb/d] and EIA-mean [7.9799 mb/d] median [7.3250 mb/d]). This difference is an indication of non-normality of a distribution. Similarly, the Jarque-Bera statistics are different for the two data sources. For the IEA, OPEC production cheating in the implied OPB period indicates that the series is normally distributed with probability value of 17.87%. EIA data

shows results contrary to that of IEA with a significant value at 1%. While average EIA data on OPC appears to be higher than the IEA during the official OPB period, it can therefore be observed that in the implied OPB period, the average IEA data exceeds that of the EIA. Similarly for the OPEC actual supply, this shows EIA data source to be normally distributed based on JB statistics which is not significant (i.e. 18%) as against the IEA with JB statistics significant at 5%.

Having examined the summary statistics of different series that made up the sample for this study, the graphical properties of the series are presented in figures 6.1 and 6.2. For this purpose, all the series are taken at the logged values in line with the reasons stated in Chapter 5 above. However, the raw data of the variables do not exhibit much physical difference with the logged values (although a few differences are found between the two sets of data) as shown in figure 6.1 and 6.2 respectively.

Figure 6.1: Graphical Representation of the Monthly Series for the Full Sample (Unlogged Values)

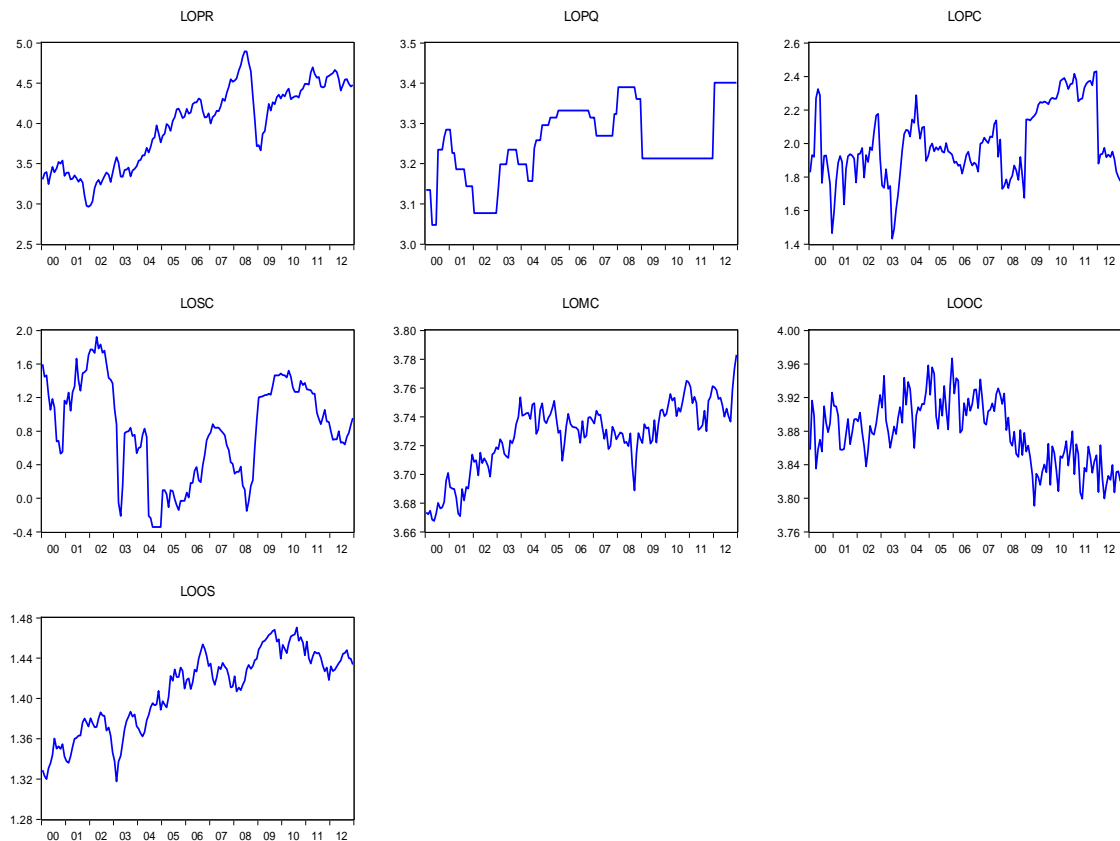


Key:
OPR: Oil price

OPQ: OPEC production quota
OPC: OPEC production cheating
OSC: OPEC spare capacity
OOC: OECD crude oil consumption
OMC: Oil market competition
OOS: OECD crude oil stockpiling
Horizontal axis stands for periods in years
Vertical axis stands for the units of measurement (i.e. U.S. dollar for OPR,
and million barrels per day for all other variables)

Figure 6.1 presents results based on the raw (i.e. unlogged) datasets. The sample period for each series starts from January, 2000 to December, 2012 (indicating 156 observations). Based on the graphical representation of the series in seven panels of figure 6.1, it can be observed that there are various trends in the variables that will be of interest in terms of pattern and direction of the series in relation to others. These dynamics in particular are set to be explored using VAR models in Chapter 7. Furthermore, figure 6.2 shows graphical representation of series in seven panels but after being transformed to their logged values.

Figure 6.2: Graphical Representation of the Series for the Full Sample (Logged Values)



Key:

LOPR: Logged values of oil price

LOPQ: Logged values of OPEC production quota

LOPC: Logged values of OPEC production cheating

LOSC: Logged values of OPEC spare capacity

LOOC: Logged values of OECD crude oil consumption

LOMC: Logged values of oil market competition

LOOS: Logged values of OECD crude oil stockpiling

Horizontal axis stands for periods in years

Vertical axis stands for unit of measurement for the logged values of the series

Figure 6.2 presents seven panels, one for each series, over the entire sample period (i.e. January, 2000 to December, 2012). Comparing the two figures (i.e. 6.1 and 6.2), it can be observed that in few cases such as in the first panel of figure 6.1 (i.e. OPR) and the last panel (OOS), taking the variables at logged values has minimised, to some extent, the outliers that can be observed from the graphical results for unlogged values (presented in figure 6.1).

Furthermore, it can be observed from panel 1 of figures 6.1 and 6.2 that oil prices were comparably lower in the official OPB period (i.e. 2000 to 2005). During same period, OPEC production quota was low at the beginning but rose up sharply in the subsequent two periods before falling in the end of second year. However, it can also be observed that, although the period showed low production quota, OPEC cheating in the 3rd panel increased sharply in the first period before falling at the end of the first year (i.e. 2000). It subsequently rose again in year 2 and 3 and later fell while OPEC production quota rose again at the end of the 3rd year. OPEC spare capacity appears to be at its peak during the period before it fell down sharply at the end year three. OPEC spare capacity was grossly weakened during the period which coincided with the U.S. invasion of Iraq (which happened to be one of the largest reserve holders after Saudi Arabia). The effect of the war still remains an important factor that might influence not only the capacity of OPEC, but also its production decisions. In this case, considering war as exogenous variable when estimating the model could yield important results and control based on the sharp changes that appeared in most variables which might be due to the war.

Interestingly, oil market competition in panel 4 appeared to be very low at the beginning of the period (when oil prices were lower as shown in the previous analysis of the official OPB period), but continued to rise with the oil prices in the latter period of the official OPB regime. At the same time, OECD/IEA crude oil consumption seemed to be swinging within a specific range but the stockpiling behaviour was building up with the growing oil prices. One of the interesting questions that might be raised at this stage is: what would have promoted high oil prices during this period when OPEC production quota, OPEC production cheating and oil market competition were increasing to compensate for OECD/IEA consumption? While discussing this issue in the review, two important answers were raised. First, some literature attributed the escalation of prices to the sharp rise in oil demand from emerging economies such as China, India, Brasil (see Campolmi, 2007; Hayat and Narayan, 2011). Others (such as Cigarelli and Pladino, 2010) believed that speculative activities surrounding events such

as war in Iraq, and the build-up of U.S. strategic reserves, were mainly some explanatory factors.

Furthermore, considering the regime of oil prices when implied OPB regime exists, it can be observed that oil prices are higher in the implied period than the official OPB period as mentioned earlier. Despite the fact that OPEC cheating was high from year 2009 to the early 2012 and also high spare capacity and oil market competition, oil prices remain higher than the implied OPB of \$70 - \$80 as suggested by Russian President Dmitry Medvedev during the G8 meeting which received supports from OPEC officials (see for example Fattouh, and Allsopp, 2009). Consistent with the earlier question raised in the previous paragraph, it can also be argued that if market fundamentals were responsible for the sustained high oil prices, the decreased OECD/IEA crude oil consumption (see panel 6) which is backed up by increased non-OPEC reserves discoveries (see, Russell and Ibrahim, 2013) should have forced the oil prices low within a target band despite the increased demand from the emerging economies. Instead, what the market experienced was increasing stockpiling in the subsequent periods (see panel 7) despite the rising oil prices (see panel 1). For instance, the U.S. alone has, by the provision of its Energy Policy Act of 2005 (EPACT, P.L. 109-158), increased its stockpiling to towards the 1 billion barrels per its SPR capacity; although the law authorises such behaviour only if it will not generate upward pressure on the oil prices (see Bamberger, 2010). As mentioned earlier, the normality tests are extended with sets of more formalised tests in an attempt to understand the category of the data for modelling which is important in the interpretation of the diagnostic results (which is discussed in Chapter 7).

6.3 Normality Tests

In the above descriptive analysis, attempt is made to test for some normality properties of the datasets. This subsection provides further tests to ascertain the position of our distribution as to normal (bell-curve) or leptokurtic (otherwise called 'fat tailed risk' is characterised with more peaked and thin curve than normally distributed observations)⁹². Kurtosis

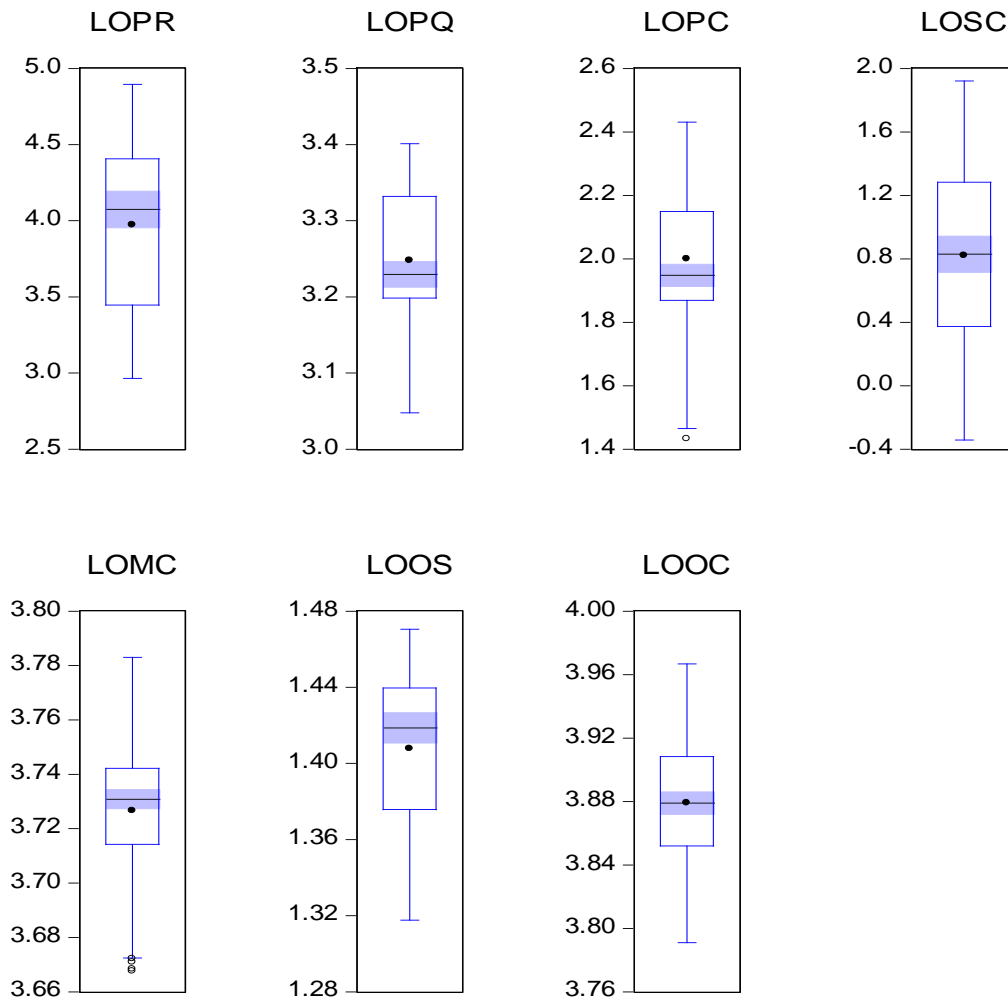
⁹² See Fraser et al. (2001) for more details about Leptokurtic distribution.

is used and described as a measure to assess the size of the tails of the based on their probability distribution with a view to ascertaining the peak or fat tails. A number of arguments have been advanced challenging Kurtosis ability to provide sound information to measuring normality of a particular distribution (see Hammad, 2011). Similarly, the Jarque-Bera tests is another important tool for measuring normality of the distribution as noted above, although the test does not suggest further information as to whether a variable found to be Leptokurtic should be used or not (see Huisman, 2009, Hammad, 2011). In this connection, studies (such as Lewis, 2005) recommend relaxing this assumption and employing Student's-t distribution assumption to address the fat-tails in most financial series. In this regard, histograms and quartiles are presented for each of the variables in order to give an important picture of the distributions by having a view of most of the results in terms of skewness of the distributions and the nature of the tails as shown by the histograms and the quartiles respectively (see appendices I to XIV).

Furthermore, visual representations of the series were made in figure 6.0 using histograms likely to provide additional explanations about the frequency and randomness of the data (Huisman, 2009). The wider the histograms the wider the uncertainties expected due to higher standard deviation. Low standard deviation coefficients indicate lower volatility and uncertainty which usually represent thinner histograms. The importance of skewness is to obtain relevant information relating to likelihood of results producing extreme events (positive and/or negative) from the sample data. Therefore a "0" skewness ($\text{skewness} = 0$) is an indication of a symmetric distribution of our sample data. Positive skewness is an indication that our sample carries large positive values relative to the negative ones (i.e. $\text{skewness} > 0$). The reverse is the case for negative skewness which indicates the likelihood of more negative values relative to the positive ones (i.e. $\text{skewness} < 0$). From appendices I to VII, histograms show that variables except LOPR, LOPC, LOMC, LOOS exhibit resemblance to normal distribution. Some scholars (such as Huisman, 2009) believed that within the statistical context, that the JB test is rich as a standalone test on data for normality assumption. However, for the

purpose of this research, the analysis of the series is extended to consider the Boxplot to highlight other descriptive properties of the data. In this regard, figure 6.3 provides results of the Boxplot to explain fat-tails as earlier described.

Figure 6.3: Boxplot for the Full Sample Dataset



From figure 6.3, it can be observed that only two variables have their plots located at the centre, while all other exhibit evidence of fat tails.

In order to enhance understanding of the dataset for empirical analysis, general grounds guiding statistical technique (whether parametric or non-parametric) are applied to ascertain the nature of the distribution. Some robust models such as unrestricted VAR or VECM do not necessarily depend upon an assumption of normality but the error terms need to be normally distributed (see Brooks, 2008). It should be noted, however, that

normal distribution tests might help in describing the data. It will also guide in explaining diagnostics of a model in terms of input and output. A more important consideration in relation to empirical analysis with regards to normality of the distribution in more robust models (such as VAR) is “whether the error components in the abstract theoretical model for the test are independent and identically distributed normal random variables” (Totton and White, 2011:1). In this connection, Totton and White (2011) noted that paying attention to normality of the data and not the residuals might be a bit deceptive.

6.4 Initial Empirical Analysis

Having carried out the descriptive analysis, the graphical results suggest further analysis be carried out for the purpose of examining relationships (short run or long run). On this basis, unit root tests, cointegration tests, lag length selection criteria are carried out as part of the initial empirical analysis to estimate VAR.

6.4.1 Stationarity/Unit Root Tests

Having discussed the various patterns (based on descriptive statistics and normality tests) and forms of graphical representations of the series in figures 6.1 and 6.2 above, the need to carefully examine the variables for modelling purposes becomes essential at this juncture. Considering the trend in the panels, it might be difficult to capture the dynamics under the unit root assumption (see section 5.5.3.4 in Chapter 5). It can be observed that the variables might not have constant mean and variance for any meaningful future forecast to be carried out. In this connection, the variables were subjected to stationarity tests using both parametric and non-parametric methods as mentioned in the fifth chapter of this study. More specifically, stationarity tests were carried out using Augmented Dickey-Fuller (ADF) under parametric assumption and Phillips-Perron (PP) tests under non-parametric assumption. The null hypothesis states that a particular series has a unit root present. The hypothesis is rejected at 5% level of significance. It should be noted that for the purpose of modelling, the logged values were considered in line with the reasons highlighted in Chapter 5. Furthermore, the tests were carried out at two different stages namely, intercept, and intercept & trend. More detailed summary of the

entire tests are presented in appendix XXV. Table 6.7 presents the ADF test on the full sample at both level and first difference with intercept.

Table 6:7: Augmented Dickey-Fuller Unit Root Tests at Level and 1st Difference (Full Sample)

ADF Unit root test with intercept				
	Level		1st difference	
Variables	t-Statistics	Prob.	t-Statistics	Prob.
LOPR	-1.456096	0.5532	-9.535024	0.0000*
LOPQ	-1.901745	0.3309	-11.87369	0.0000*
LOPC	-3.512900	0.0089	-13.74155	0.0000*
LOSC	-2.484358	0.1213	-10.29674	0.0000*
LOMC	-2.275863	0.1811	-13.76482	0.0000*
LOOC	-2.970695	0.0400	-13.48131	0.0000*
LOOS	-1.991889	0.2902	-12.94143	0.0000*

* indicates the probability level (which rejects the null hypothesis at 5% level of significance).

Key:

LOPR: Logged values of oil price

LOPQ: Logged values of OPEC production quota

LOPC: Logged values of OPEC production cheating

LOSC: Logged values of OPEC spare capacity

LOOS: Logged values of OECD crude oil stockpiling

LOOC: Logged values of OECD crude oil consumption

LOMC: Logged values of oil market competition

From table 6.7, the results indicate that all variables (except two – LOPC and LOOC) have the presence of unit root at level but become stationary after taking the first difference. In view of the fact that probability levels are greater than 5%, we fail to reject the hypothesis that each of the series has a unit root. For the other variables, the results are expected because first, LOPC is derived from the difference between OPEC’s actual production and its officially allocated quota for the given period. There exists a high tendency for the mean of the series to evolve around zero equilibrium level. Also, for the LOOC, it can be observed from the graph that OECD/IEA consumption over the sample period fluctuates around a particular range due to the existing policy. However, all the variables

(including LOPC and LOOC) become stationary at first difference with strong probability levels (0.0000).

Therefore, given the fact that ADF is a parametric test, similar tests using a non-parametric test were carried out (i.e. based on Philips Perron test) and presented in table 6.8.

Table 6:8: Philips Perron Unit Root Tests at Level and 1st Difference (Full Sample)

Philips Perron Unit root test with intercept				
	Level		1st difference	
Variables	t-Statistics	Prob.	t-Statistics	Prob.
LOPR	-1.475652	0.5434	-9.574391	0.0000*
LOPQ	-2.074605	0.2553	-11.88067	0.0000*
LOPC	-3.512900	0.0089	-14.96707	0.0000*
LOSC	-2.184315	0.2129	-10.20409	0.0000*
LOMC	-2.183271	0.2133	-14.06643	0.0000*
LOOC	-3.954558	0.0022	-13.13522	0.0001*
LOOS	-1.980740	0.2951	-12.94043	0.0000*

* indicates the probability level (which rejects the null hypothesis at 5% level of significance).

Key:

LOPR: Logged values of oil price

LOPQ: Logged values of OPEC production quota

LOPC: Logged values of OPEC production cheating

LOSC: Logged values of OPEC spare capacity

LOOS: Logged values of OECD crude oil stockpiling

LOOC: Logged values of OECD crude oil consumption

LOMC: Logged values of oil market competition

It can be observed from table 6.8 that near similar results were obtained when a non-parametric Philips Perron test was applied on the series. In this regard, the trend and intercept are considered as indicated by table 6.9.

Table 6:9: Augmented Dickey-Fuller Unit Root Tests at Level and 1st Difference (Full Sample)

ADF Unit root test with trend and intercept				
Variables	Level		1st difference	
	t-Statistics	Prob.	t-Statistics	Prob.
LOPR	-3.037166	0.1256	-9.503507	0.0000*
LOPQ	-2.326061	0.4171	-11.83686	0.0000*
LOPC	-3.717692	0.0240	-13.70890	0.0000*
LOSC	-2.456407	0.3494	-10.28237	0.0000*
LOMC	-3.644641	0.0293	-13.71906	0.0000*
LOOC	-3.755356	0.0216	-13.44839	0.0000*
LOOS	-2.522877	0.3168	-12.98932	0.0000*

* indicates the probability level (which rejects the null hypothesis at 5% level of significance).

Key:

LOPR: Logged values of oil price

LOPQ: Logged values of OPEC production quota

LOPC: Logged values of OPEC production cheating

LOSC: Logged values of OPEC spare capacity

LOOS: Logged values of OECD crude oil stockpiling

LOOC: Logged values of OECD crude oil consumption

LOMC: Logged values of oil market competition

Considering the trend and intercept in the computation of the unit root test, table 6.9 presents results for all the series based on the full sample period using ADF test. In this connection, we fail to reject the null hypothesis for four out of seven variables at a 95% confidence level. However, the null hypothesis at first difference for the entire variables is rejected which implies that the variables become stationary at first difference. Having established the stationarity of the series at first difference based on ADF test which is parametric, non-parametric (i.e. based on Philips Perron test) were carried out and the results are presented in table 6.10.

Table 6:10: Philips Perron Unit Root Tests at Level and 1st Difference (Full Sample)

Philips Perron Unit root test with trend and intercept				
Variables	Level		1st difference	
	t-Statistics	Prob.	t-Statistics	Prob.
LOPR	-2.858232	0.1792	-9.543404	0.0000*
LOPQ	-2.552305	0.3029	-11.84434	0.0000*
LOPC	-3.699602	0.0252	-14.94390	0.0000*
LOSC	-2.144177	0.5168	-10.18582	0.0000*
LOMC	-3.483394	0.0447	-14.01406	0.0000*
LOOC	-5.293559	0.0001	-31.12573	0.0001*
LOOS	-2.783600	0.2056	-12.98932	0.0000*

Key:

LOPR: Logged values of oil price

LOPQ: Logged values of OPEC production quota

LOPC: Logged values of OPEC production cheating

LOSC: Logged values of OPEC spare capacity

LOOS: Logged values of OECD crude oil stockpiling

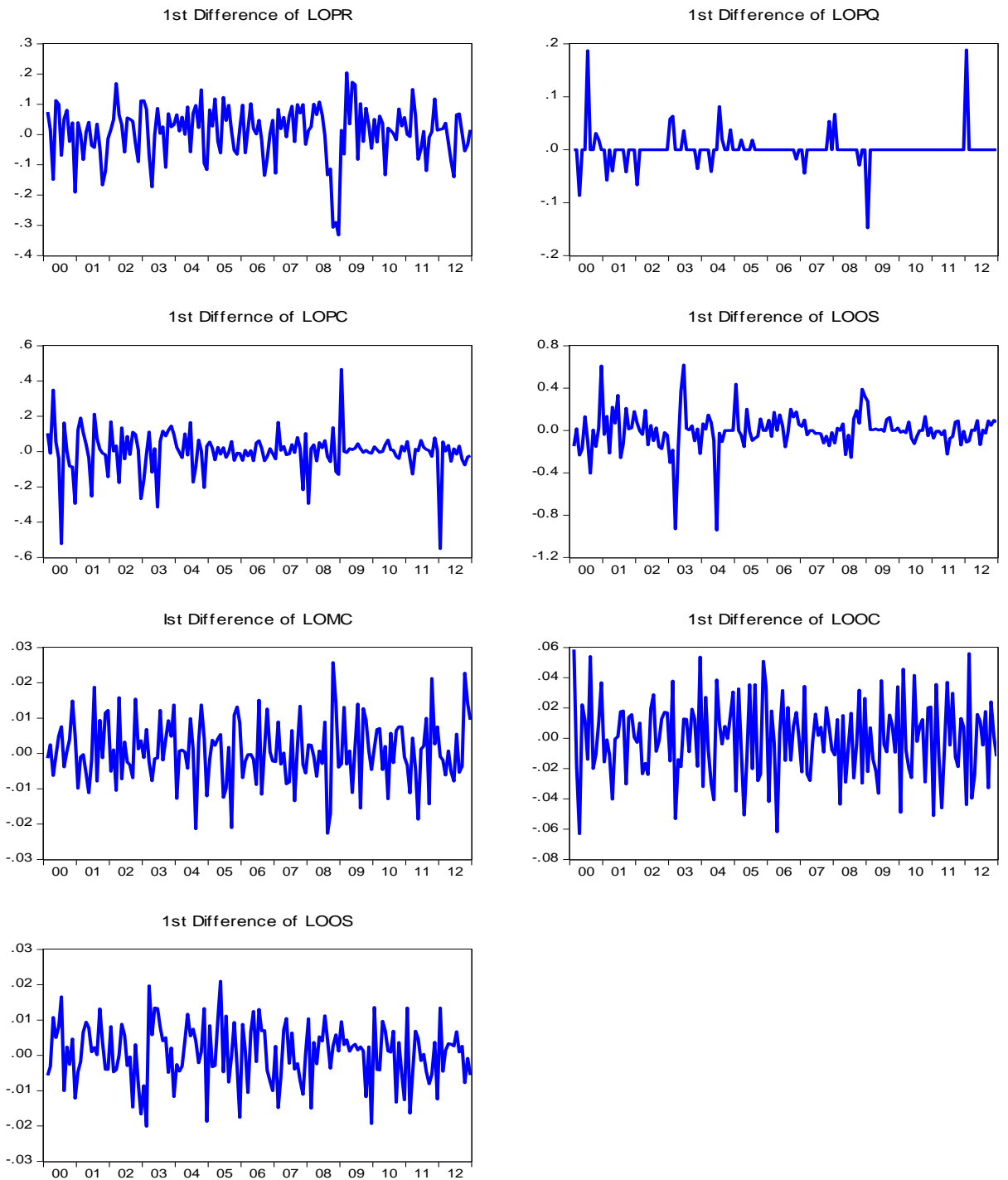
LOOC: Logged values of OECD crude oil consumption

LOMC: Logged values of oil market competition

From table 6.10 it can be observed that near similar results to ADF are obtained by PP. In other words, the outcome for the same variables under ADF test are reinforced by the results obtained from the PP test in table 6.11. All the variables (except LOPC, LOMC, and LOOC) have unit root in log level with significance level of 5%. However, the entire seven variables become stationary after taking the first difference.

Figure 6.4 presents seven panels for the seven series indicating based on the first difference with a view to observing the constant distance in mean and variance for modelling purpose.

Figure 6.4: 1st Difference of the Logged Values for the Full Sample



Key:

- LOPR: Logged Values of Oil Prices
- LOPQ: Logged Values of OPEC Production Quota
- LOPC: Logged Values of OPEC Production Cheating
- LOSC: Logged Values of OPEC Spare Capacity
- LOMC: Logged Values of Oil Market Competition
- LOOC: Logged Values of OECD/IEA Crude Oil Consumption
- LOOS: Logged Values of OECD/IEA Crude Oil Stockpiling

Based on figure 6.4 above, it can be observed that the entire seven panels exhibited evidence of constant mean and variance when first differences were considered. This makes it much easier for the dynamics to be captured by VAR models.

6.4.2 Cointegration Tests and Selection of Lag Length

Having satisfied the important condition of stationarity test for VAR, cointegration tests were carried out to investigate the long run relationship between the variables. The effect of the cointegration results is that it could establish the need to estimate the vector error correction models (VECM) for the series where the long run dynamics in the series are of interest. As mentioned earlier, Johansen system cointegration is used for this study. The results of Johansen system cointegration tests are presented in tables 6. 11 through 6.14 based on the two models identified in Chapter 5. The three exogenous variables (i.e. OPB, WAR and GER) are included in each of the models. For each of the two models, Trace and Max-Eigen statistics are analysed and reported.

6.4.2.1 Cointegration Tests (First Model)

Johansen cointegration test is carried out on the first model where four endogenous variables (namely: OPQ, OPC, OSC, and OPR) and three exogenous variables (i.e. OPB, WAR and GER) are computed and Trace and Max-Eigen statistics are presented in tables 6.11 and 6.12 respectively.

Table 6:11: Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.196313	72.64145	47.85613	0.0001
At most 1 *	0.134981	39.64112	29.79707	0.0027
At most 2 *	0.089894	17.74547	15.49471	0.0225
At most 3	0.023056	3.522225	3.841466	0.0605
Trace test indicates 3 cointegrating eqn(s) at the 0.05 level				
* denotes rejection of the hypothesis at the 0.05 level				
**MacKinnon-Haug-Michelis (1999) p-values				

Table 6.11 presents the results of the Johansen system cointegration test for Trace statistics where the long run relationships for three cointegrating equations are established. The null hypothesis states that there is no

cointegrating equation at different stages (namely: none, at most 1, and at most 2) which is rejected at 5% level of significance. A similar decision can be reached based on excess of Trace statistics over the critical values for the rejection of the null hypothesis.

From table 6.11 above, the hypothesised number of cointegrating equations for "none" is rejected at 5% and with the Trace statistics being greater than the critical values (i.e. $72.64 > 47.86$). Similarly, hypothesised "at most 1" and "at most 2" equations are cointegrated are also rejected at a 5% level. Also for both, the Trace stats are greater than the respective critical values ($39.64 > 29.80$ and $17.75 > 15.50$ respectively). Failure to reject the null hypothesis of hypothesised number of cointegrating equations of "at most 3", a decision can therefore be taken based on the earlier stage significant at 5% level, and indicating that three equations are cointegrated.

In addition to Trace statistics, table 6.12 below presents the Maximum-Eigenvalue which lends support to the Trace statistics in table 6.11 above but with slight difference in results. This is expected due to the conservative approach of Maximum-Eigenvalue over the trace statistics (see Bockem, 2004).

Table 6:12: Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.196313	33.00033	27.58434	0.0091
At most 1 *	0.134981	21.89565	21.13162	0.0390
At most 2	0.089894	14.22324	14.26460	0.0507
At most 3	0.023056	3.522225	3.841466	0.0605
Max-eigenvalue test indicates 2 cointegrating eqn(s) at the 0.05 level				
* denotes rejection of the hypothesis at the 0.05 level				
**MacKinnon-Haug-Michelis (1999) p-values				

Table 6.12 shows the Max-Eigen statistics are in agreement with Trace statistics. At 5% significant level, the null hypothesis of no cointegration is rejected with the Max-Eigen statistics greater than the critical value (i.e. $33.00 > 27.58$). Hypothesised number of cointegrating equations "at most 1" is rejected at 5% significance level and Max-Eigen statistics of 21.90 greater than the critical value of 21.13. On the basis of 5% significance level decision criteria, the hypothesised number of cointegrating equations of "at most 2" cannot be rejected. Therefore, decision can be made at "at most 1" level suggesting two cointegrating equations.

On the basis of tables 6.11 and 6.12, it can be concluded that at least 2 cointegrating equations exist. The implication of the results for this study is that VECMs, which are effective in exploring the long-run dynamics, can be estimated. However, the fact that this study is much interested in the short-run relationships to explore the impact of OPEC's stabilisation policies and the claim that OPEC acted as a signaller during the sample period (see Fattouh, 2012), VAR is considered more appropriate. In this regard, unrestricted VAR is considered superior to the restricted VECM in supplying the short run forecast variance (see Clements and Hendry, 1995; Hoffman and Rasche, 1996; Park and Ratti, 2008). Naka and Tufte (1997) also found that results from both unrestricted VARs and VECMs are almost identical over the short-run for impulse response analysis. In this regard, unrestricted VARs are employed in this study given their superiority in prediction over the VECM, where the interest of investigation is the short-term dynamics (see Park and Ratti, 2008).

6.4.2.2 Second Model (Cointegration Tests)

Similarly, Johansen system cointegration tests for the second model are analysed in the same way the first model was analysed. In the second model, other series are introduced to adjust for the effects of the policies of other oil market players (i.e. competition from non-OPEC and crude oil consumption and stockpiling from the OECD/IEA). Therefore, ten variables are considered for the test in total where seven are endogenous variables and three are exogenous variables. The Trace and Max-Eigen stats/results are summarised in tables 6.13 and 6.14 respectively.

Table 6:13: Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.323584	177.1443	125.6154	0.0000
At most 1 *	0.308345	118.1113	95.75366	0.0006
At most 2	0.203541	62.44245	69.81889	0.1682
At most 3	0.087711	28.07796	47.85613	0.8103
At most 4	0.062462	14.21640	29.79707	0.8283
At most 5	0.028998	4.477161	15.49471	0.8616
At most 6	0.000223	0.033719	3.841466	0.8543
Trace test indicates 2 cointegrating eqn(s) at the 0.05 level				
* denotes rejection of the hypothesis at the 0.05 level				
**MacKinnon-Haug-Michelis (1999) p-values				

The Trace statistics are presented in table 6.13 with recommendation for 2 cointegrating equations. In this regard, the null hypothesis that there is no cointegrating equations at "none", or "at most 1" stages is rejected. The Trace statistics also at both stages are greater than the corresponding critical values ($177.14 > 125.62$, and $118.11 > 95.75$ respectively), confirming the decision taken earlier. Since decision cannot be made where the probability value is beyond the 5% criteria, then the more appropriate stage based on table 6.13 is "at most 1" level which interprets that 2 cointegration equations exist.

Similarly, table 6.14 presents the results of Max Eigen statistics.

Table 6:14: Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.323584	59.03304	46.23142	0.0014
At most 1 *	0.308345	55.66881	40.07757	0.0004
At most 2 *	0.203541	34.36448	33.87687	0.0437
At most 3	0.087711	13.86156	27.58434	0.8321
At most 4	0.062462	9.739238	21.13162	0.7687
At most 5	0.028998	4.443442	14.26460	0.8098
At most 6	0.000223	0.033719	3.841466	0.8543

Max-eigenvalue test indicates 3 cointegrating eqn(s) at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis (1999) p-values

From table 6.14, the null hypotheses of no cointegration, at "none", "at most 1", and "at most 2" cointegrating equations are rejected at 5% significance levels. The Max-Eigen statistics shows that at the three stages the corresponding Max-Eigen values are greater than the critical values (59.03 > 46.23; 55.67 > 40.08; 34.36 > 33.88 respectively). Interpretation similar to the one made under Trace statistics is found useful to conclude that three cointegrating equations are present based on the results.

6.4.3 Lag Length Selection Criteria

Having carried out the unit roots and cointegration tests in the previous sections, another critical stage in VAR model estimation is the determination of appropriate lags selection that will optimise the values of the estimates. Consequently, as mentioned in Chapter 5 of this study, the series were subjected to lag selection process tests based on five approaches (namely: Sequential modified LR test statistic, Final prediction error, Akaike information criterion, Schwarz information criterion, and Hannan-Quinn information criterion). On this basis the roots of characteristic polynomial are viewed both in table and graph to confirm the

stability/stationarity of the VAR estimates. A separate VAR model is first estimated with a view to identifying various lag selection criteria appropriate for the estimation of the final VAR models (i.e. 1st and 2nd models) from which the impulse response and variance decompositions are estimated in Chapter 7. In this regard, table 6.15 presents lag length selection criteria.

Table 6:15: Lag Length Selection Criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	223.7562	NA	6.12e-07	-2.955564	-2.792079	-2.889137
1	766.5180	1040.913	4.50e-10*	-10.17148*	-9.681024*	-9.972196*
2	781.5523	28.00917	4.56e-10	-10.15825	-9.340825	-9.826112
3	793.8438	22.22562	4.80e-10	-10.10745	-8.963052	-9.642454
4	807.3068	23.60632	4.99e-10	-10.07270	-8.601328	-9.474845
5	815.3681	13.69328	5.58e-10	-9.963947	-8.165609	-9.233241
6	830.2785	24.51022	5.70e-10	-9.949021	-7.823712	-9.085459
7	847.6514	27.60616*	5.64e-10	-9.967827	-7.515547	-8.971410
8	859.5208	18.21059	6.04e-10	-9.911243	-7.131993	-8.781970
9	870.1125	15.66990	6.59e-10	-9.837157	-6.730936	-8.575028
10	881.0766	15.62014	7.19e-10	-9.768172	-6.334981	-8.373188

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

From table 6.15 above, the asterisk (*) indicates each of the selected criteria in relation to a given lag order. four criteria (namely: FPE, AIC, SC, and HQ) present results in support of "1" lag for estimating the final 1st VAR model for the purpose of analysis considered in Chapter 7. This finding is similar to similar to King et al. (2012). The four asterisks represent 80 percent of the total criteria while "7" lag is recommended by LR criterion. Based on the results, the majority of the criteria to apply one lag for the VAR estimation are considered more appropriate and objective. In this connection, the roots of characteristic polynomial are analysed for the stationarity of the VAR based on table 6.16 and figure 6.5 below.

Table 6:16: Roots of Characteristic Polynomial

Root	Modulus
0.939652	0.939652
0.904805 0.089715i	- 0.909242
0.904805 0.089715i	+ 0.909242
0.742019	0.742019

No root lies outside the unit circle.
VAR satisfies the stability condition.

From table 6.16, none of the roots is up to “1” in absolute value which indicates that the estimated VAR has satisfied the stability condition. This result can further be viewed using AR roots graph which confirms the results in table 6.16.

Figure 6.5: Inverse Roots of AR Characteristic Polynomial

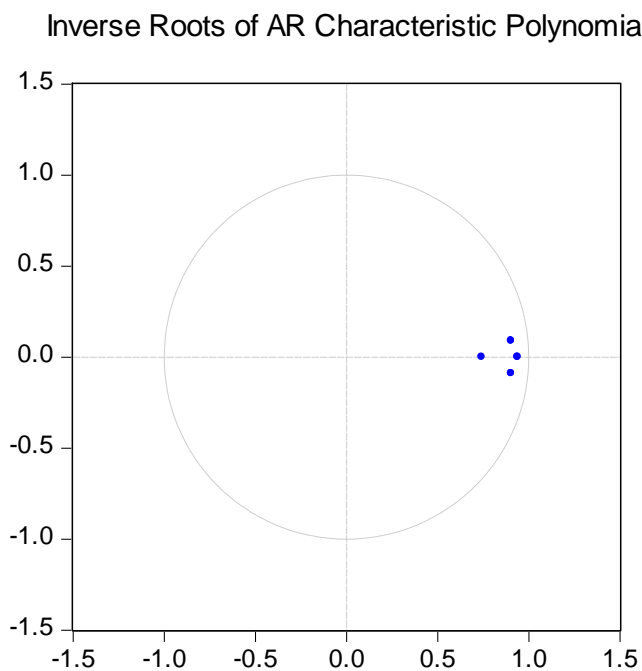


Figure 6.5 gives a graphical representation of results similar to those obtained in table 6.14. All the roots are located within the circle and all less than “1” which confirms that the estimated VAR with “1” lag has satisfied the stability condition.

Furthermore, a lag exclusion wald test was carried out to test the null hypothesis that inclusion of the selected lag (i.e. "1 lag" as recommended by the different criteria) is significant, and this is rejected on the basis of the p-values for each variable and for the joint variables as shown in table 6.17 below.

Table 6:17: VAR Lag Exclusion Wald Tests

Chi-squared test statistics for lag exclusion:					
Numbers in [] are p-values					
	LOPC	LOPQ	LOPR	LOSC	Joint
Lag 1	342.637	1886.85	4734.86	1840.04	12309.6
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
Df	5	5	5	5	25

Based on table 6.17, it can be concluded that selection of one "1" lag is supported for individual variables and the joint ones.

Furthermore, the results for the lag length selection criteria for the 2nd model are presented in the following table, 6.18.

Table 6:18: Lag Length Selection Criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	1467.315	NA	6.45e-18	-19.71665	-19.14445	-19.48415
1	2200.097	1355.143	5.53e-22	-29.08352	-27.50997*	-28.44415*
2	2259.502	104.1621	4.83e-22	-29.22605	-26.65115	-28.17981
3	2316.677	94.76980	4.38e-22*	-29.33804	-25.76180	-27.88493
4	2346.006	45.80151	5.89e-22	-29.06857	-24.49098	-27.20859
5	2394.113	70.51398	6.22e-22	-29.05635	-23.47741	-26.78950
6	2460.106	90.40021	5.25e-22	-29.28912	-22.70883	-26.61540
7	2518.629	74.55692*	5.03e-22	-29.41957	-21.83794	-26.33898
8	2573.329	64.44198	5.23e-22	-29.49766	-20.91469	-26.01020
9	2627.590	58.72025	5.70e-22	-29.56973	-19.98540	-25.67539
10	2680.755	52.43635	6.60e-22	-29.62678*	-19.04110	-25.32557

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

On the basis of the results presented in table 6.18, different positions are presented with SC and HQ agreeing on one lag as the best criterion to estimate the 2nd VAR model. At this stage the two criteria constitute the majority because all other criteria identified a single lag order not supported by any other. In this regard, further tests are carried out to ensure the stability of the VAR at the selected criterion (see table 6.19 and figure 6.6 below).

Table 6:19: Roots of Characteristic Polynomial

Root	Modulus
0.955552	0.955552
0.894720 - 0.084641i	0.898715
0.894720 + 0.084641i	0.898715
0.727663 - 0.074662i	0.731483
0.727663 + 0.074662i	0.731483
0.686296 - 0.082262i	0.691209
0.686296 + 0.082262i	0.691209

No root lies outside the unit circle.
VAR satisfies the stability condition.

Table 6.19 confirms the appropriateness of the lag selected for VAR estimation, given that no root is up to “1”. To find some supportive evidence for this test, figure 6.6 examines whether any of the roots lies outside the circle.

Figure 6.6: Inverse Roots of AR Characteristic Polynomial

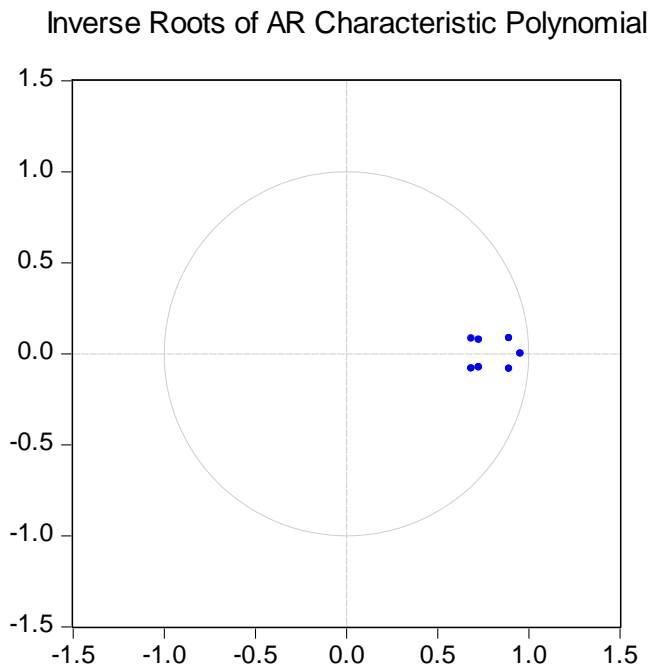


Figure 6.6 indicates that all the dots/roots are located within the circle confirming that the estimated var is stable at the selected lag (i.e. “1” lag) is appropriate. Therefore as mentioned in relation to the results noted in 1st model, the 2nd model is to be estimated using “1” also. Exploring the lag exclusion tests (in table 6.20), it can be concluded that the null hypothesis that “1” lag should be excluded for the estimation, is rejected for each of the variables and also jointly.

Table 6:20: VAR Lag Exclusion Wald Tests

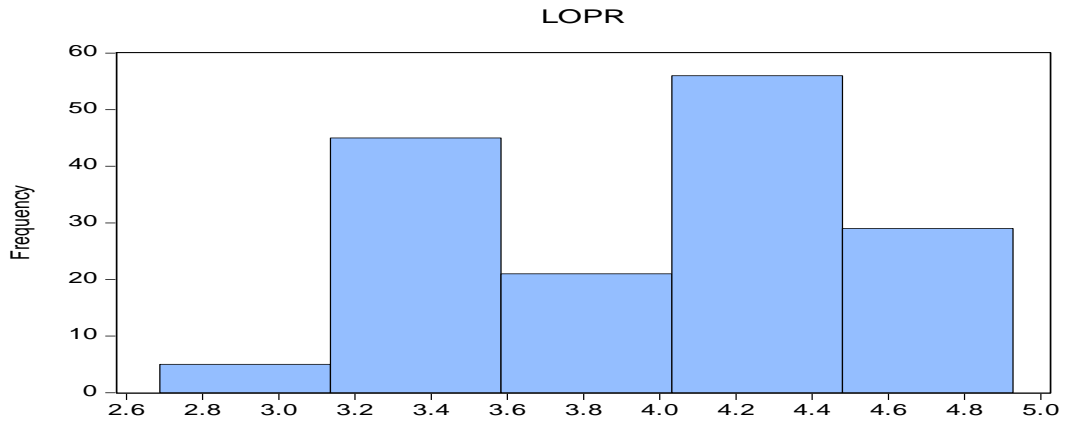
Chi-squared test statistics for lag exclusion: Numbers in [] are p-values								
	LOPR	LOPQ	LOPC	LOSC	LOMC	LOOC	LOOS	Joint
Lag 1	1240.642 [0.000000]	803.8628 [0.000000]	355.3420 [0.000000]	800.2103 [0.000000]	467.4382 [0.000000]	194.4840 [0.000000]	852.0101 [0.000000]	5498.034 [0.000000]
Df	7	7	7	7	7	7	7	49

6.5 Summary and Conclusion

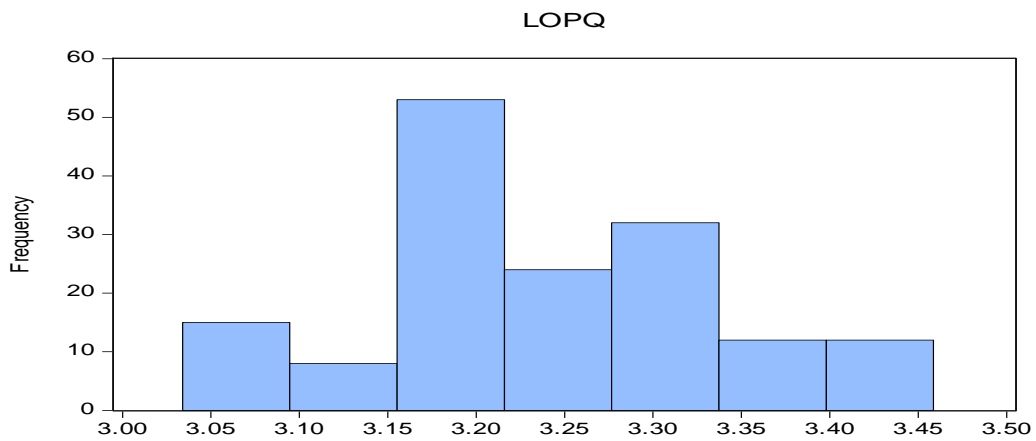
This chapter presented data with a view to carrying out initial analysis prior to VAR estimations. Descriptive statistics were considered with particular attention to measures of central tendencies (the mean and the median) and the measures of dispersion (i.e. standard deviation) of the datasets. Similarly, the Kurtosis, skewness, and Jarque-Bera statistic were evaluated alongside other normality test procedures with a view to determining the nature of the distribution before the VAR estimation. This finding enables easy comparisons to be made once VAR diagnostic results have been produced (see Chapter 7 for details). In some cases, series were found to be normally distributed while in other cases they were found to be exhibiting leptokurtic distribution. Consequently, the series were suitable for inclusion in the models the results of which are analysed in Chapter 7.

Furthermore, initial empirical analysis including stationarity tests using both parametric and non-parametric tests, cointegration tests, lag length selection criteria were considered with a view to estimating VAR models (considered in further empirical analysis chapter). Although, this chapter does not discuss the findings and their potential implications, it should be noted that our findings of evidence of cointegration between oil prices and other variables in both models are similar to the conclusion reached by Kaufmann et al. (2008).

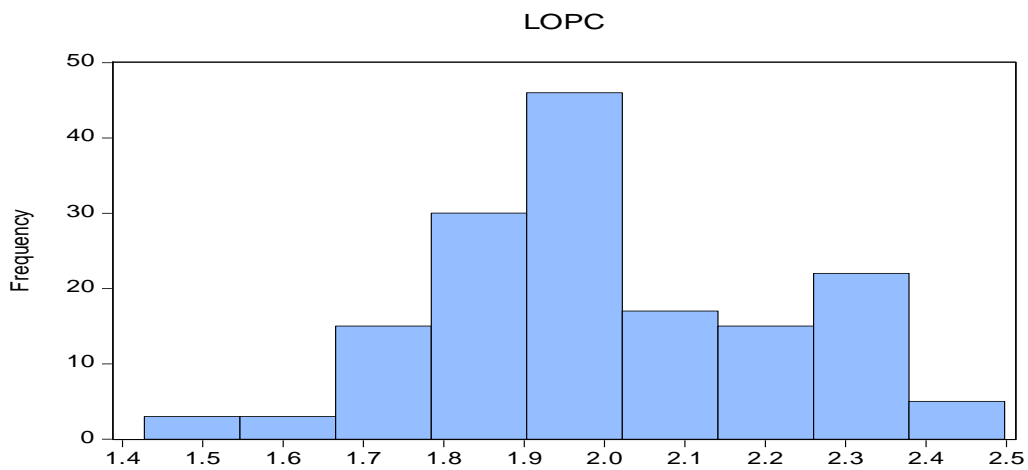
Appendix II: Histograms of the LOPR



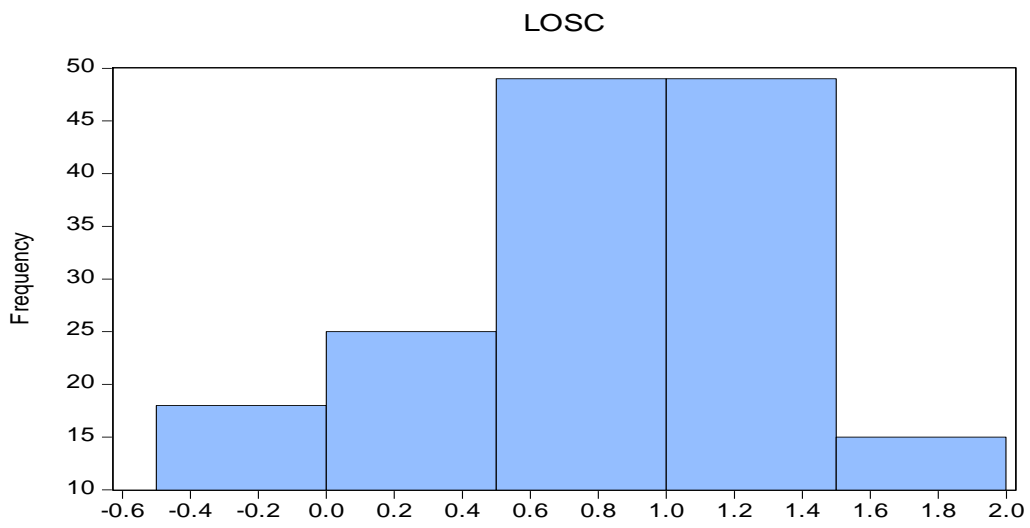
Appendix I: Histogram of the LOPQ



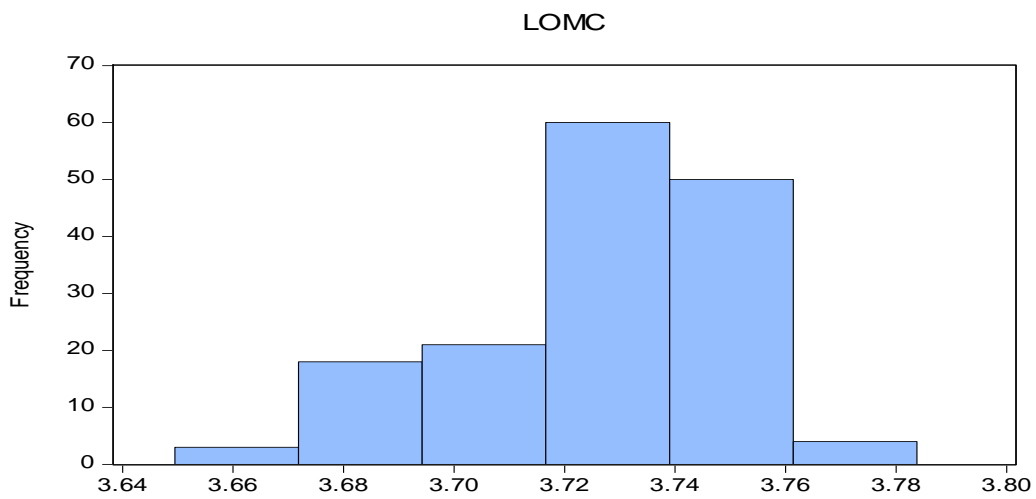
Appendix II: Histogram of the LOPC



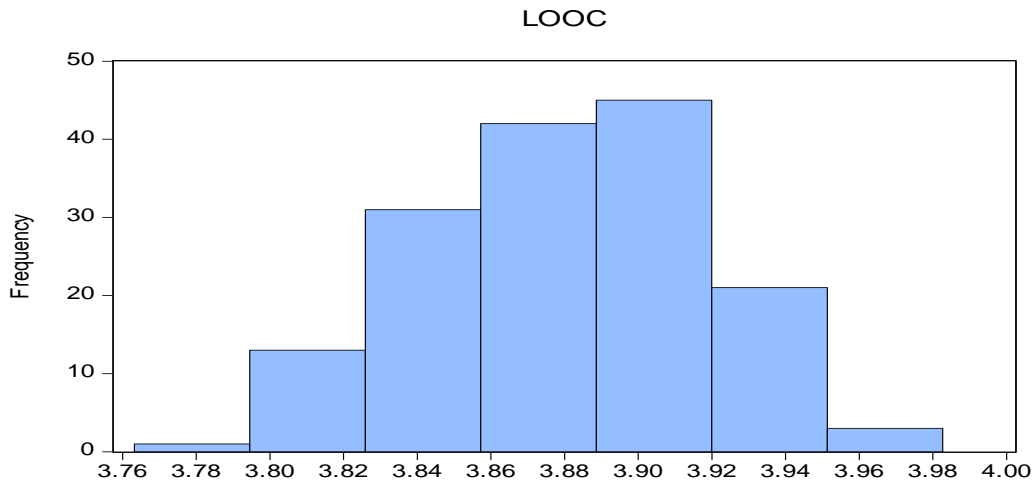
Appendix III: Histogram of the LOSC



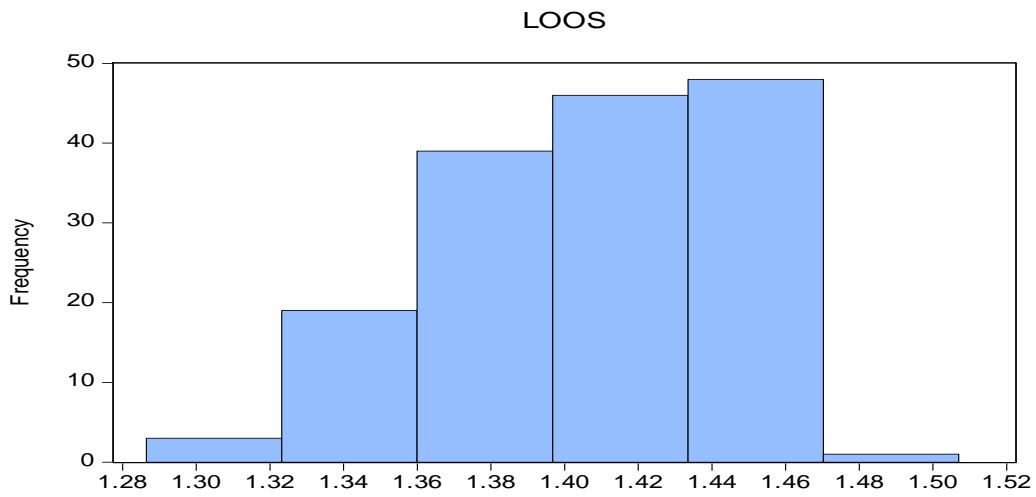
Appendix IV: Histogram of the LOMC



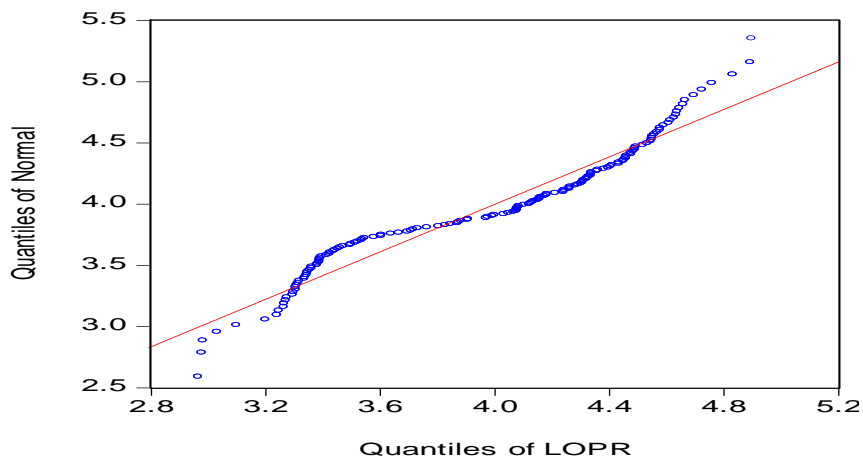
Appendix V: Histogram of the LOOC



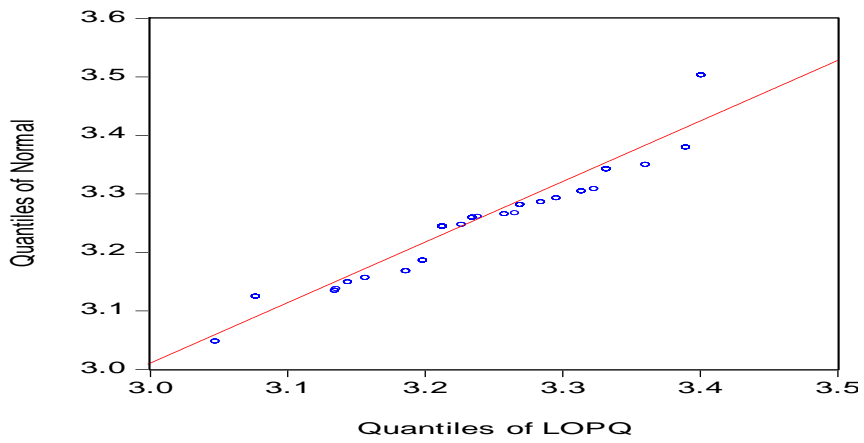
Appendix VI: Histogram of the LOOS



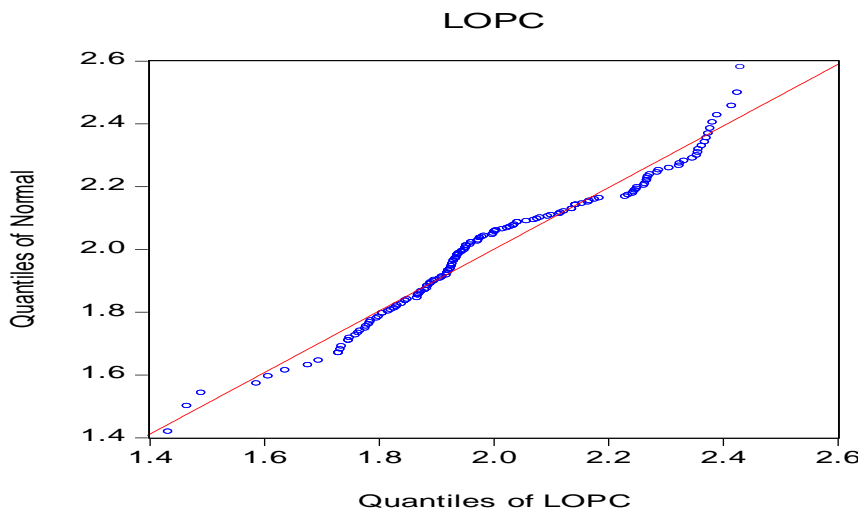
Appendix VII: Quantiles of the LOPR Series



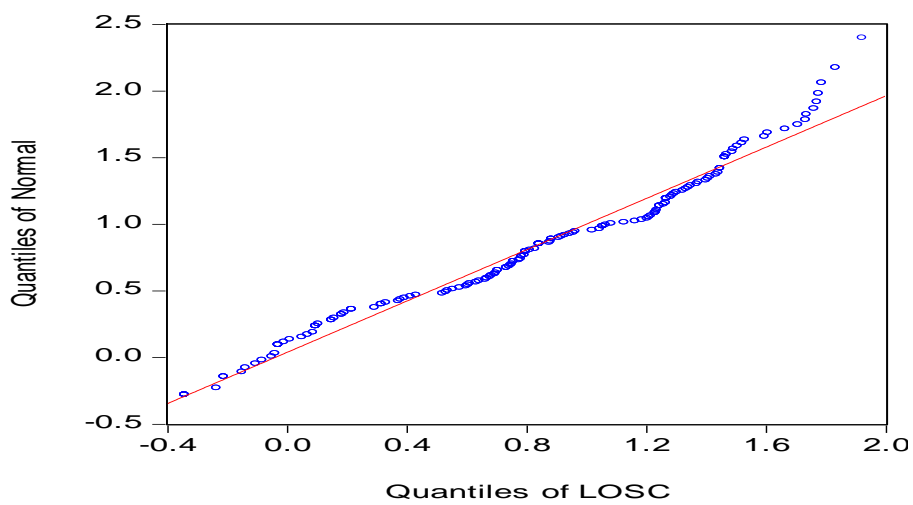
Appendix VIII: Quantiles of the LOPQ Series



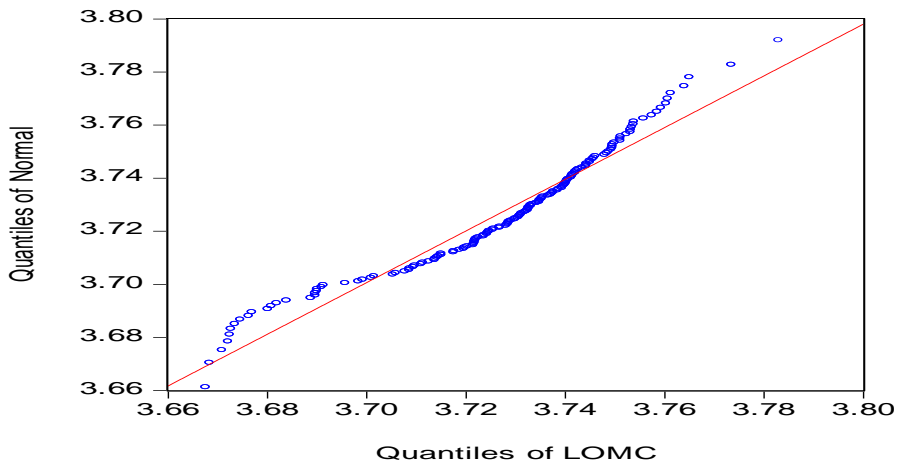
Appendix IX: Quantiles of the LOPC Series



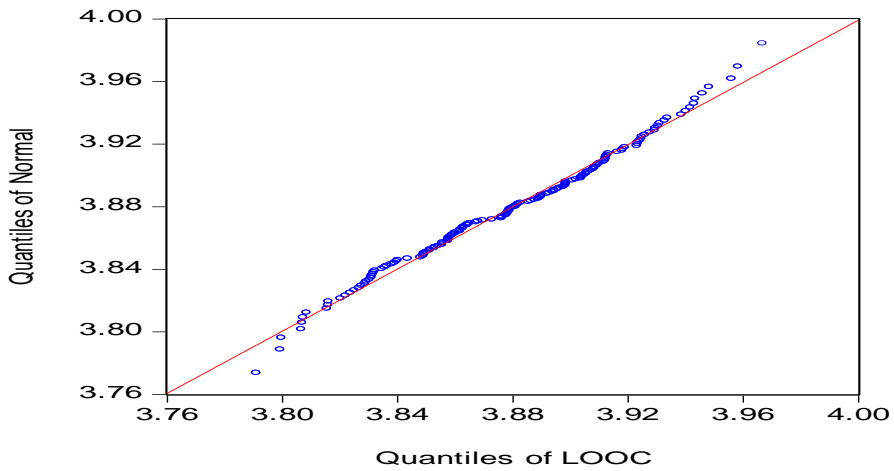
Appendix X: Quantiles of the LOSC Series



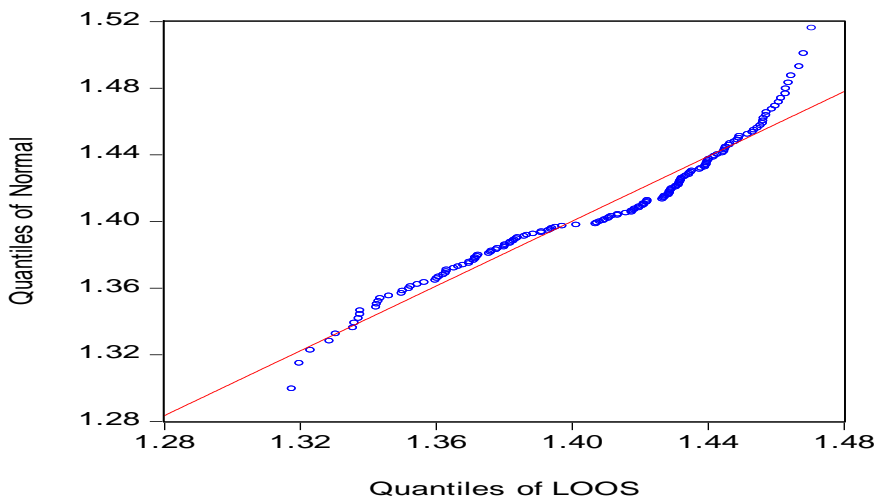
Appendix XI: Quantiles of the LOMC



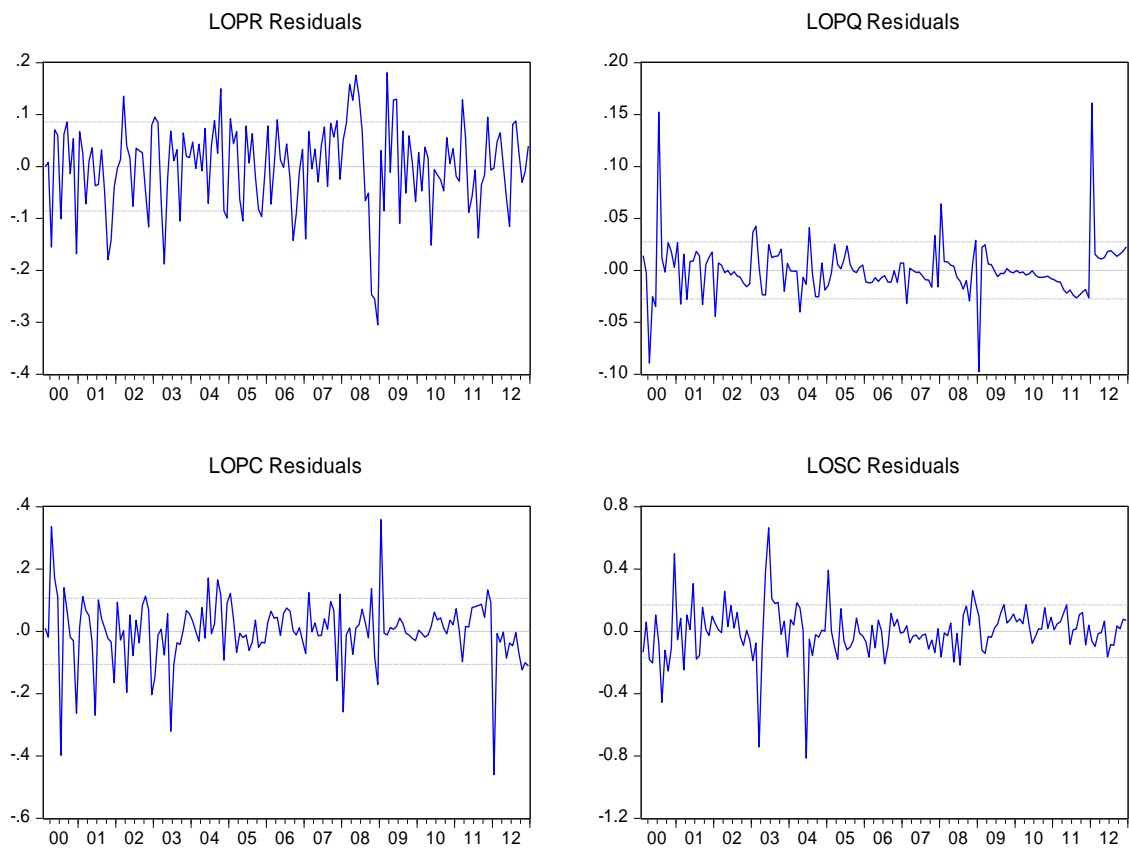
Appendix XII: Quantiles of the LOOC



Appendix XIII: Quantiles of the LOOS



Appendix XIV: Graphical Representation of VAR Residuals (1st Model)



Appendix XV: Correlation Matrix of the VAR Residuals (1st Model)

	LOPR	LOPQ	LOPC	LOSC
LOPR	1.000000	0.055225	0.068653	-0.125134
LOPQ	0.055225	1.000000	-0.763502	-0.127076
LOPC	0.068653	-0.763502	1.000000	-0.276215
LOSC	-0.125134	-0.127076	-0.276215	1.000000

Appendix XVI: VAR Residual Serial Correlation LM Tests (First Model)

Lags	LM-Stat	Prob
1	30.32684	0.0164
2	21.25848	0.1688
3	20.96508	0.1799
4	17.93356	0.3278
5	28.98746	0.0240
6	27.49153	0.0363
7	15.44945	0.4920
8	9.497233	0.8915
9	13.47773	0.6376
10	8.678488	0.9261
11	13.40837	0.6427
12	26.60972	0.0460

Probs from chi-square with 16 df.

Appendix XVII: VAR Residual Heteroskedasticity Tests: No Cross Terms (Only Levels and Squares) – First Model

Joint test:					
Chi-sq	df	Prob.			
189.7532	110	0.0000			
Individual components:					
Dependent	R-squared	F(11,143)	Prob.	Chi-sq(11)	Prob.
res1*res1	0.275722	4.948901	0.0000	42.73686	0.0000
res2*res2	0.159832	2.473092	0.0073	24.77393	0.0098
res3*res3	0.141723	2.146623	0.0206	21.96704	0.0246
res4*res4	0.189956	3.048514	0.0011	29.44320	0.0019
res2*res1	0.112999	1.656126	0.0894	17.51483	0.0935
res3*res1	0.108468	1.581645	0.1101	16.81257	0.1135
res3*res2	0.145480	2.213221	0.0167	22.54942	0.0204
res4*res1	0.165572	2.579538	0.0051	25.66369	0.0073
res4*res2	0.048167	0.657854	0.7761	7.465841	0.7602
res4*res3	0.081985	1.160994	0.3194	12.70773	0.3129

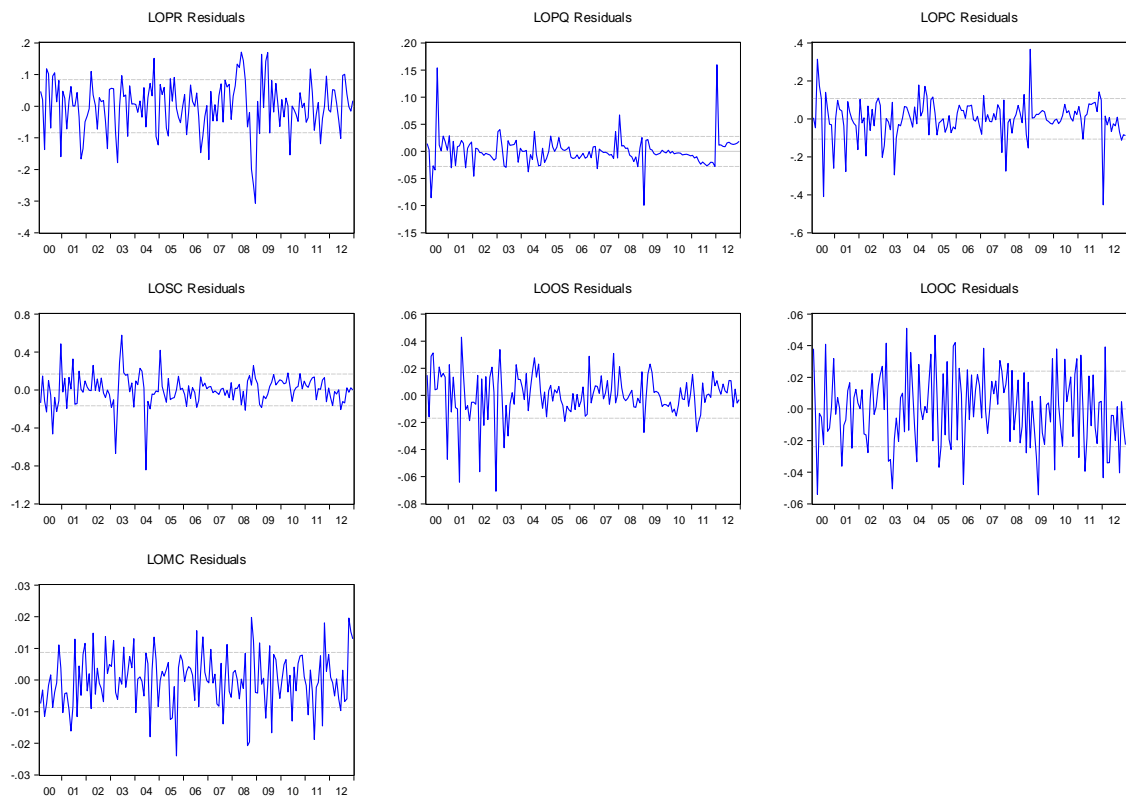
Appendix XVIII: VAR Residual Normality Tests (Lutkepohl) – 1st Model

Component	Skewness	Chi-sq	df	Prob.
1	-0.712651	13.12002	1	0.0003
2	2.163327	120.8996	1	0.0000
3	-1.227104	38.89943	1	0.0000
4	-1.536421	60.98186	1	0.0000
Joint		233.9009	4	0.0000

Component	Kurtosis	Chi-sq	df	Prob.
1	3.979544	6.196809	1	0.0128
2	18.25539	1503.028	1	0.0000
3	6.973188	101.9527	1	0.0000
4	12.34416	563.8988	1	0.0000
Joint		2175.076	4	0.0000

Component	Jarque-Bera	Df	Prob.
1	19.31683	2	0.0001
2	1623.927	2	0.0000
3	140.8521	2	0.0000
4	624.8807	2	0.0000
Joint	2408.977	8	0.0000

Appendix XIX: Graphical Representation of VAR Residuals



Appendix XX: Residual Correlation Matrix (Second Model)

	LOPR	LOPQ	LOPC	LOSC	LOMC	LOOC	LOOS
LOPR	1.000000	0.042808	0.085142	-0.101559	-0.077894	-0.018494	-0.090599
LOPQ	0.042808	1.000000	-0.757358	-0.113967	0.111467	0.038332	0.017240
LOPC	0.085142	-0.757358	1.000000	-0.302148	-0.114347	0.031234	0.006093
LOSC	-0.101559	-0.113967	-0.302148	1.000000	-0.010254	-0.215332	0.031681
LOMC	-0.077894	0.111467	-0.114347	-0.010254	1.000000	0.154202	-0.054738
LOOC	-0.018494	0.038332	0.031234	-0.215332	0.154202	1.000000	-0.645586
LOOS	-0.090599	0.017240	0.006093	0.031681	-0.054738	-0.645586	1.000000

Appendix XXI: VAR Residual Serial Correlation LM Tests (2nd Model)

Lags	LM-Stat	Prob
1	111.2667	0.0000
2	72.34477	0.0167
3	67.76071	0.0391
4	62.94273	0.0870
5	70.82683	0.0223
6	122.6807	0.0000
7	66.55062	0.0482
8	41.93099	0.7528
9	35.97449	0.9171
10	61.61076	0.1066
11	51.82012	0.3644
12	145.8113	0.0000

Probs from chi-square with 49 df.

Appendix XXII: VAR Residual Normality Tests

Component	Skewness	Chi-sq	df	Prob.
1	-0.621728	9.985766	1	0.0016
2	1.840063	87.46735	1	0.0000
3	-1.245963	40.10426	1	0.0000
4	-1.273558	41.90037	1	0.0000
5	-0.263073	1.787857	1	0.1812
6	0.093757	0.227083	1	0.6337
7	-0.014623	0.005524	1	0.9408
Joint		181.4782	7	0.0000

Component	Kurtosis	Chi-sq	df	Prob.
1	4.047699	7.089138	1	0.0078
2	16.98175	1262.535	1	0.0000
3	6.944421	100.4817	1	0.0000
4	10.60353	373.3796	1	0.0000
5	3.336599	0.731722	1	0.3923
6	2.754752	0.388447	1	0.5331
7	2.683907	0.645282	1	0.4218
Joint		1745.251	7	0.0000

Component	Jarque-Bera	Df	Prob.
1	17.07490	2	0.0002
2	1350.003	2	0.0000
3	140.5860	2	0.0000
4	415.2800	2	0.0000
5	2.519579	2	0.2837
6	0.615530	2	0.7351
7	0.650807	2	0.7222
Joint	1926.729	14	0.0000

Appendix XXIII: VAR Residual Heteroskedasticity Tests: No Cross Terms (Only Levels and Squares) – 2nd Model

Joint test:					
Chi-sq	df	Prob.			
581.6537	476	0.0006			
Individual components:					
Dependent	R-squared	F(17,137)	Prob.	Chi-sq(17)	Prob.
t					
res1*res1	0.286068	3.229119	0.0001	44.34053	0.0003
res2*res2	0.218468	2.252750	0.0052	33.86256	0.0087
res3*res3	0.210541	2.149205	0.0081	32.63381	0.0125
res4*res4	0.230454	2.413349	0.0026	35.72030	0.0050
res5*res5	0.128614	1.189461	0.2809	19.93520	0.2776
res6*res6	0.165770	1.601371	0.0717	25.69436	0.0802
res7*res7	0.153363	1.459804	0.1187	23.77125	0.1258
res2*res1	0.209889	2.140783	0.0084	32.53276	0.0129
res3*res1	0.169912	1.649579	0.0600	26.33644	0.0685
res3*res2	0.205414	2.083338	0.0107	31.83911	0.0158
res4*res1	0.199926	2.013771	0.0143	30.98849	0.0200
res4*res2	0.085949	0.757778	0.7380	13.32209	0.7144
res4*res3	0.177079	1.734125	0.0435	27.44723	0.0518
res5*res1	0.131843	1.223852	0.2540	20.43560	0.2526
res5*res2	0.145373	1.370809	0.1603	22.53274	0.1651
res5*res3	0.116139	1.058927	0.4003	18.00155	0.3887
res5*res4	0.090409	0.801010	0.6896	14.01342	0.6662
res6*res1	0.144793	1.364417	0.1637	22.44288	0.1683
res6*res2	0.225172	2.341963	0.0036	34.90161	0.0064
res6*res3	0.183152	1.806931	0.0328	28.38854	0.0406
res6*res4	0.145789	1.375408	0.1579	22.59730	0.1628
res6*res5	0.098271	0.878255	0.6004	15.23199	0.5788
res7*res1	0.126786	1.170096	0.2969	19.65180	0.2924
res7*res2	0.256546	2.780884	0.0005	39.76463	0.0014
res7*res3	0.181082	1.781991	0.0362	28.06765	0.0442
res7*res4	0.149698	1.418782	0.1366	23.20325	0.1427
res7*res5	0.120831	1.107583	0.3527	18.72875	0.3443
res7*res6	0.160844	1.544662	0.0881	24.93080	0.0963

Appendix XXV: Unit Root Tests-Augmented Dickey Fuller Tests at level (Intercept)

LOPR

Null Hypothesis: LOPR has a unit root

Exogenous: Constant

Lag Length: 1 (Automatic - based on SIC, maxlag=13)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-1.456096	0.5532
Test critical values:		
1% level	-3.473096	
5% level	-2.880211	
10% level	-2.576805	

*MacKinnon (1996) one-sided p-values.

LOPQ

Null Hypothesis: LOPQ has a unit root

Exogenous: Constant

Lag Length: 0 (Automatic - based on SIC, maxlag=13)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-1.901745	0.3309
Test critical values:		
1% level	-3.472813	
5% level	-2.880088	
10% level	-2.576739	

*MacKinnon (1996) one-sided p-values.

LOPC

Null Hypothesis: LOPC has a unit root

Exogenous: Constant

Lag Length: 0 (Automatic - based on SIC, maxlag=13)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-3.512900	0.0089
Test critical values:		
1% level	-3.472813	
5% level	-2.880088	
10% level	-2.576739	

*MacKinnon (1996) one-sided p-values.

LOSC

Null Hypothesis: LOSC has a unit root

Exogenous: Constant

Lag Length: 1 (Automatic - based on SIC, maxlag=13)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-2.484358	0.1213
Test critical values:		
1% level	-3.473096	
5% level	-2.880211	
10% level	-2.576805	

*MacKinnon (1996) one-sided p-values.

LOMC

Null Hypothesis: LOMC has a unit root

Exogenous: Constant

Lag Length: 0 (Automatic - based on SIC, maxlag=13)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-2.275863	0.1811
Test critical values: 1% level	-3.472813	
5% level	-2.880088	
10% level	-2.576739	

*MacKinnon (1996) one-sided p-values.

LOOC

Null Hypothesis: LOOC has a unit root

Exogenous: Constant

Lag Length: 1 (Fixed)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-2.970695	0.0400
Test critical values: 1% level	-3.473096	
5% level	-2.880211	
10% level	-2.576805	

*MacKinnon (1996) one-sided p-values.

LOOS

Null Hypothesis: LOOS has a unit root

Exogenous: Constant

Lag Length: 0 (Automatic - based on SIC, maxlag=13)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-1.991886	0.2902
Test critical values: 1% level	-3.472813	
5% level	-2.880088	
10% level	-2.576739	

*MacKinnon (1996) one-sided p-values.

Appendix XXVI: Unit Root Tests-Augmented Dickey Fuller Tests at 1st Difference (Intercept)

LOPR

Null Hypothesis: D(LOPR) has a unit root

Exogenous: Constant

Lag Length: 0 (Automatic - based on SIC, maxlag=13)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-9.535024	0.0000
Test critical values: 1% level	-3.473096	
5% level	-2.880211	
10% level	-2.576805	

*MacKinnon (1996) one-sided p-values.

LOPQ

Null Hypothesis: D(LOPQ) has a unit root

Exogenous: Constant

Lag Length: 0 (Automatic - based on SIC, maxlag=13)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-11.87369	0.0000
Test critical values: 1% level	-3.473096	
5% level	-2.880211	
10% level	-2.576805	

*MacKinnon (1996) one-sided p-values.

LOPC

Null Hypothesis: D(LOPC) has a unit root

Exogenous: Constant

Lag Length: 0 (Automatic - based on SIC, maxlag=13)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-13.74156	0.0000
Test critical values: 1% level	-3.473096	
5% level	-2.880211	
10% level	-2.576805	

*MacKinnon (1996) one-sided p-values.

LOSC

Null Hypothesis: D(LOSC) has a unit root

Exogenous: Constant

Lag Length: 0 (Automatic - based on SIC, maxlag=13)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-10.29674	0.0000
Test critical values: 1% level	-3.473096	
5% level	-2.880211	
10% level	-2.576805	

*MacKinnon (1996) one-sided p-values.

LOMC

Null Hypothesis: D(LOMC) has a unit root

Exogenous: Constant

Lag Length: 0 (Automatic - based on SIC, maxlag=13)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-13.76482	0.0000
Test critical values:		
1% level	-3.473096	
5% level	-2.880211	
10% level	-2.576805	

*MacKinnon (1996) one-sided p-values.

LOOC

Null Hypothesis: D(LOOC) has a unit root

Exogenous: Constant

Lag Length: 1 (Fixed)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-13.48131	0.0000
Test critical values:		
1% level	-3.473382	
5% level	-2.880336	
10% level	-2.576871	

*MacKinnon (1996) one-sided p-values.

LOOS

Null Hypothesis: D(LOOS) has a unit root

Exogenous: Constant

Lag Length: 0 (Automatic - based on SIC, maxlag=13)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-12.94143	0.0000
Test critical values:		
1% level	-3.473096	
5% level	-2.880211	
10% level	-2.576805	

*MacKinnon (1996) one-sided p-values.

Appendix XXVII: Augmented Dickey Fuller Tests at Level (Trend and Intercept)

LOPR

Null Hypothesis: LOPR has a unit root

Exogenous: Constant, Linear Trend

Lag Length: 1 (Automatic - based on SIC, maxlag=13)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-3.037166	0.1256
Test critical values:		
1% level	-4.018748	
5% level	-3.439267	
10% level	-3.143999	

*MacKinnon (1996) one-sided p-values.

LOPQ*Null Hypothesis: LOPQ has a unit root*

Exogenous: Constant, Linear Trend

Lag Length: 0 (Automatic - based on SIC, maxlag=13)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-2.326061	0.4171
Test critical values: 1% level	-4.018349	
5% level	-3.439075	
10% level	-3.143887	

*MacKinnon (1996) one-sided p-values.

LOPC*Null Hypothesis: LOPC has a unit root*

Exogenous: Constant, Linear Trend

Lag Length: 0 (Automatic - based on SIC, maxlag=13)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-3.717692	0.0240
Test critical values: 1% level	-4.018349	
5% level	-3.439075	
10% level	-3.143887	

*MacKinnon (1996) one-sided p-values.

LOSC*Null Hypothesis: LOSC has a unit root*

Exogenous: Constant, Linear Trend

Lag Length: 1 (Automatic - based on SIC, maxlag=13)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-2.456407	0.3494
Test critical values: 1% level	-4.018748	
5% level	-3.439267	
10% level	-3.143999	

*MacKinnon (1996) one-sided p-values.

LOMC*Null Hypothesis: LOMC has a unit root*

Exogenous: Constant, Linear Trend

Lag Length: 0 (Automatic - based on SIC, maxlag=13)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-3.644641	0.0293
Test critical values: 1% level	-4.018349	
5% level	-3.439075	
10% level	-3.143887	

*MacKinnon (1996) one-sided p-values.

LOOC

Null Hypothesis: LOOC has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 1 (Fixed)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-3.755356	0.0216
Test critical values:		
1% level	-4.018748	
5% level	-3.439267	
10% level	-3.143999	

*MacKinnon (1996) one-sided p-values.

LOOS

Null Hypothesis: LOOS has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic - based on SIC, maxlag=13)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-2.522877	0.3168
Test critical values:		
1% level	-4.018349	
5% level	-3.439075	
10% level	-3.143887	

*MacKinnon (1996) one-sided p-values.

Appendix XXVIII: Unit Root Tests-Augmented Dickey Fuller Tests at 1st Difference (Trend and Intercept)

LOPR

Null Hypothesis: $D(LOPR)$ has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic - based on SIC, maxlag=13)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-9.503507	0.0000
Test critical values:		
1% level	-4.018748	
5% level	-3.439267	
10% level	-3.143999	

*MacKinnon (1996) one-sided p-values.

LOPQ

Null Hypothesis: $D(LOPQ)$ has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic - based on SIC, maxlag=13)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-9.503507	0.0000
Test critical values:		
1% level	-4.018748	
5% level	-3.439267	
10% level	-3.143999	

*MacKinnon (1996) one-sided p-values.

LOPC

Null Hypothesis: D(LOPC) has a unit root

Exogenous: Constant, Linear Trend

Lag Length: 0 (Automatic - based on SIC, maxlag=13)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-13.70890	0.0000
Test critical values:		
1% level	-4.018748	
5% level	-3.439267	
10% level	-3.143999	

*MacKinnon (1996) one-sided p-values.

LOMC

Null Hypothesis: D(LOMC) has a unit root

Exogenous: Constant, Linear Trend

Lag Length: 0 (Automatic - based on SIC, maxlag=13)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-13.71906	0.0000
Test critical values:		
1% level	-4.018748	
5% level	-3.439267	
10% level	-3.143999	

*MacKinnon (1996) one-sided p-values.

LOOC

Null Hypothesis: D(LOOC) has a unit root

Exogenous: Constant, Linear Trend

Lag Length: 1 (Fixed)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-13.44839	0.0000
Test critical values:		
1% level	-4.019151	
5% level	-3.439461	
10% level	-3.144113	

*MacKinnon (1996) one-sided p-values.

LOOS

Null Hypothesis: D(LOOS) has a unit root

Exogenous: Constant, Linear Trend

Lag Length: 0 (Automatic - based on SIC, maxlag=13)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-12.98932	0.0000
Test critical values:		
1% level	-4.018748	
5% level	-3.439267	
10% level	-3.143999	

*MacKinnon (1996) one-sided p-values.

Appendix XXIX: Unit Root Tests-Philips Perron Tests at level (Intercept)

LOPR

Null Hypothesis: LOPR has a unit root
 Exogenous: Constant
 Bandwidth: 3 (Newey-West automatic) using Bartlett kernel

	Adj. t-Stat	Prob.*
Phillips-Perron test statistic	-1.475652	0.5434
Test critical values: 1% level	-3.472813	
5% level	-2.880088	
10% level	-2.576739	

*MacKinnon (1996) one-sided p-values.

Residual variance (no correction)	0.007603
HAC corrected variance (Bartlett kernel)	0.011641

LOPQ

Null Hypothesis: LOPQ has a unit root
 Exogenous: Constant
 Bandwidth: 4 (Newey-West automatic) using Bartlett kernel

	Adj. t-Stat	Prob.*
Phillips-Perron test statistic	-2.074605	0.2553
Test critical values: 1% level	-3.472813	
5% level	-2.880088	
10% level	-2.576739	

*MacKinnon (1996) one-sided p-values.

Residual variance (no correction)	0.000903
HAC corrected variance (Bartlett kernel)	0.001055

LOPC

Null Hypothesis: LOPC has a unit root
 Exogenous: Constant
 Bandwidth: 0 (Newey-West automatic) using Bartlett kernel

	Adj. t-Stat	Prob.*
Phillips-Perron test statistic	-3.512900	0.0089
Test critical values: 1% level	-3.472813	
5% level	-2.880088	
10% level	-2.576739	

*MacKinnon (1996) one-sided p-values.

Residual variance (no correction)	0.012697
HAC corrected variance (Bartlett kernel)	0.012697

LOSC

Null Hypothesis: LOSC has a unit root

Exogenous: Constant

Bandwidth: 0 (Newey-West automatic) using Bartlett kernel

	Adj. t-Stat	Prob.*
Phillips-Perron test statistic	-2.184315	0.2129
Test critical values:		
1% level	-3.472813	
5% level	-2.880088	
10% level	-2.576739	

*MacKinnon (1996) one-sided p-values.

Residual variance (no correction)	0.031574
HAC corrected variance (Bartlett kernel)	0.031574

LOMC

Null Hypothesis: LOMC has a unit root

Exogenous: Constant

Bandwidth: 1 (Newey-West automatic) using Bartlett kernel

	Adj. t-Stat	Prob.*
Phillips-Perron test statistic	-2.183271	0.2133
Test critical values:		
1% level	-3.472813	
5% level	-2.880088	
10% level	-2.576739	

*MacKinnon (1996) one-sided p-values.

Residual variance (no correction)	7.49E-05
HAC corrected variance (Bartlett kernel)	6.90E-05

LOOC

Null Hypothesis: LOOC has a unit root

Exogenous: Constant

Bandwidth: 4 (Newey-West automatic) using Bartlett kernel

	Adj. t-Stat	Prob.*
Phillips-Perron test statistic	-3.954558	0.0022
Test critical values:		
1% level	-3.472813	
5% level	-2.880088	
10% level	-2.576739	

*MacKinnon (1996) one-sided p-values.

Residual variance (no correction)	0.000595
HAC corrected variance (Bartlett kernel)	0.000493

LOOS

Null Hypothesis: LOOS has a unit root

Exogenous: Constant

Bandwidth: 1 (Newey-West automatic) using Bartlett kernel

	Adj. t-Stat	Prob.*
Phillips-Perron test statistic	-1.980740	0.2951
Test critical values:		
1% level	-3.472813	
5% level	-2.880088	
10% level	-2.576739	

*MacKinnon (1996) one-sided p-values.

Residual variance (no correction)	6.49E-05
HAC corrected variance (Bartlett kernel)	6.22E-05

Appendix XXX: Unit Root Tests-Philips Perron Tests at 1st Difference (Intercept)

LOPR

Null Hypothesis: D(LOPR) has a unit root

Exogenous: Constant

Bandwidth: 2 (Newey-West automatic) using Bartlett kernel

	Adj. t-Stat	Prob.*
Phillips-Perron test statistic	-9.574391	0.0000
Test critical values:		
1% level	-3.473096	
5% level	-2.880211	
10% level	-2.576805	

*MacKinnon (1996) one-sided p-values.

Residual variance (no correction)	0.007206
HAC corrected variance (Bartlett kernel)	0.007434

LOPQ

Null Hypothesis: D(LOPQ) has a unit root

Exogenous: Constant

Bandwidth: 2 (Newey-West automatic) using Bartlett kernel

	Adj. t-Stat	Prob.*
Phillips-Perron test statistic	-11.88067	0.0000
Test critical values:		
1% level	-3.473096	
5% level	-2.880211	
10% level	-2.576805	

*MacKinnon (1996) one-sided p-values.

Residual variance (no correction)	0.000929
HAC corrected variance (Bartlett kernel)	0.000951

LOPC

Null Hypothesis: D(LOPC) has a unit root

Exogenous: Constant

Bandwidth: 12 (Newey-West automatic) using Bartlett kernel

	Adj. t-Stat	Prob.*
Phillips-Perron test statistic	-14.96707	0.0000
Test critical values:		
1% level	-3.473096	
5% level	-2.880211	
10% level	-2.576805	

*MacKinnon (1996) one-sided p-values.

Residual variance (no correction)	0.013586
HAC corrected variance (Bartlett kernel)	0.007046

LOSC

Null Hypothesis: D(LOSC) has a unit root

Exogenous: Constant

Bandwidth: 5 (Newey-West automatic) using Bartlett kernel

	Adj. t-Stat	Prob.*
Phillips-Perron test statistic	-10.20409	0.0000
Test critical values:		
1% level	-3.473096	
5% level	-2.880211	
10% level	-2.576805	

*MacKinnon (1996) one-sided p-values.

Residual variance (no correction)	0.031578
HAC corrected variance (Bartlett kernel)	0.028117

LOMC

Null Hypothesis: D(LOMC) has a unit root

Exogenous: Constant

Bandwidth: 3 (Newey-West automatic) using Bartlett kernel

	Adj. t-Stat	Prob.*
Phillips-Perron test statistic	-14.06643	0.0000
Test critical values:		
1% level	-3.473096	
5% level	-2.880211	
10% level	-2.576805	

*MacKinnon (1996) one-sided p-values.

Residual variance (no correction)	7.69E-05
HAC corrected variance (Bartlett kernel)	5.92E-05

LOOC

Null Hypothesis: D(LOOC) has a unit root

Exogenous: Constant

Bandwidth: 21 (Newey-West automatic) using Bartlett kernel

	Adj. t-Stat	Prob.*
Phillips-Perron test statistic	-30.13522	0.0001
Test critical values:		
1% level	-3.473096	
5% level	-2.880211	
10% level	-2.576805	

*MacKinnon (1996) one-sided p-values.

Residual variance (no correction)	0.000573
HAC corrected variance (Bartlett kernel)	0.000109

LOOS

Null Hypothesis: D(LOOS) has a unit root

Exogenous: Constant

Bandwidth: 1 (Newey-West automatic) using Bartlett kernel

	Adj. t-Stat	Prob.*
Phillips-Perron test statistic	-12.94043	0.0000
Test critical values:		
1% level	-3.473096	
5% level	-2.880211	
10% level	-2.576805	

*MacKinnon (1996) one-sided p-values.

Residual variance (no correction)	6.66E-05
HAC corrected variance (Bartlett kernel)	6.69E-05

Appendix XXXI: Unit Root Tests-Philips Perron Tests at Level (Trend and Intercept)

LOPR

Null Hypothesis: LOPR has a unit root

Exogenous: Constant, Linear Trend

Bandwidth: 4 (Newey-West automatic) using Bartlett kernel

	Adj. t-Stat	Prob.*
Phillips-Perron test statistic	-2.858232	0.1792
Test critical values:		
1% level	-4.018349	
5% level	-3.439075	
10% level	-3.143887	

*MacKinnon (1996) one-sided p-values.

Residual variance (no correction)	0.007440
HAC corrected variance (Bartlett kernel)	0.012207

LOPQ

Null Hypothesis: LOPQ has a unit root

Exogenous: Constant, Linear Trend

Bandwidth: 4 (Newey-West automatic) using Bartlett kernel

	Adj. t-Stat	Prob.*
Phillips-Perron test statistic	-2.552305	0.3029
Test critical values:		
1% level	-4.018349	
5% level	-3.439075	
10% level	-3.143887	

*MacKinnon (1996) one-sided p-values.

Residual variance (no correction)	0.000892
HAC corrected variance (Bartlett kernel)	0.001073

LOPC

Null Hypothesis: LOPC has a unit root

Exogenous: Constant, Linear Trend

Bandwidth: 1 (Newey-West automatic) using Bartlett kernel

	Adj. t-Stat	Prob.*
Phillips-Perron test statistic	-3.699602	0.0252
Test critical values:		
1% level	-4.018349	
5% level	-3.439075	
10% level	-3.143887	

*MacKinnon (1996) one-sided p-values.

Residual variance (no correction)	0.012560
HAC corrected variance (Bartlett kernel)	0.012437

LOSC

Null Hypothesis: LOSC has a unit root

Exogenous: Constant, Linear Trend

Bandwidth: 0 (Newey-West automatic) using Bartlett kernel

	Adj. t-Stat	Prob.*
Phillips-Perron test statistic	-2.144177	0.5168
Test critical values:		
1% level	-4.018349	
5% level	-3.439075	
10% level	-3.143887	

*MacKinnon (1996) one-sided p-values.

Residual variance (no correction)	0.031501
HAC corrected variance (Bartlett kernel)	0.031501

LOMC*Null Hypothesis: LOMC has a unit root*

Exogenous: Constant, Linear Trend

Bandwidth: 4 (Newey-West automatic) using Bartlett kernel

	Adj. t-Stat	Prob.*
Phillips-Perron test statistic	-3.483394	0.0447
Test critical values:		
1% level	-4.018349	
5% level	-3.439075	
10% level	-3.143887	

*MacKinnon (1996) one-sided p-values.

Residual variance (no correction)	7.12E-05
HAC corrected variance (Bartlett kernel)	6.42E-05

LOOC*Null Hypothesis: LOOC has a unit root*

Exogenous: Constant, Linear Trend

Bandwidth: 5 (Newey-West automatic) using Bartlett kernel

	Adj. t-Stat	Prob.*
Phillips-Perron test statistic	-5.293559	0.0001
Test critical values:		
1% level	-4.018349	
5% level	-3.439075	
10% level	-3.143887	

*MacKinnon (1996) one-sided p-values.

Residual variance (no correction)	0.000559
HAC corrected variance (Bartlett kernel)	0.000532

LOOS*Null Hypothesis: LOOS has a unit root*

Exogenous: Constant, Linear Trend

Bandwidth: 3 (Newey-West automatic) using Bartlett kernel

	Adj. t-Stat	Prob.*
Phillips-Perron test statistic	-2.783600	0.2056
Test critical values:		
1% level	-4.018349	
5% level	-3.439075	
10% level	-3.143887	

*MacKinnon (1996) one-sided p-values.

Residual variance (no correction)	6.36E-05
HAC corrected variance (Bartlett kernel)	7.61E-05

Appendix XXXII: Unit Root Tests-Philips Perron Tests at 1st Difference (Trend and Intercept)

LOPR

Null Hypothesis: D(LOPR) has a unit root

Exogenous: Constant, Linear Trend

Bandwidth: 2 (Newey-West automatic) using Bartlett kernel

	Adj. t-Stat	Prob.*
Phillips-Perron test statistic	-9.543404	0.0000
Test critical values:		
1% level	-4.018748	
5% level	-3.439267	
10% level	-3.143999	

*MacKinnon (1996) one-sided p-values.

Residual variance (no correction)	0.007205
HAC corrected variance (Bartlett kernel)	0.007434

LOPQ

Null Hypothesis: D(LOPQ) has a unit root

Exogenous: Constant, Linear Trend

Bandwidth: 2 (Newey-West automatic) using Bartlett kernel

	Adj. t-Stat	Prob.*
Phillips-Perron test statistic	-11.84434	0.0000
Test critical values:		
1% level	-4.018748	
5% level	-3.439267	
10% level	-3.143999	

*MacKinnon (1996) one-sided p-values.

Residual variance (no correction)	0.000929
HAC corrected variance (Bartlett kernel)	0.000951

LOPC

Null Hypothesis: D(LOPC) has a unit root

Exogenous: Constant, Linear Trend

Bandwidth: 12 (Newey-West automatic) using Bartlett kernel

	Adj. t-Stat	Prob.*
Phillips-Perron test statistic	-14.94390	0.0000
Test critical values:		
1% level	-4.018748	
5% level	-3.439267	
10% level	-3.143999	

*MacKinnon (1996) one-sided p-values.

Residual variance (no correction)	0.013571
HAC corrected variance (Bartlett kernel)	0.006987

LOMC

Null Hypothesis: D(LOMC) has a unit root

Exogenous: Constant, Linear Trend

Bandwidth: 3 (Newey-West automatic) using Bartlett kernel

	Adj. t-Stat	Prob.*
Phillips-Perron test statistic	-14.01406	0.0000
Test critical values:		
1% level	-4.018748	
5% level	-3.439267	
10% level	-3.143999	

*MacKinnon (1996) one-sided p-values.

Residual variance (no correction)	7.69E-05
HAC corrected variance (Bartlett kernel)	5.92E-05

LOOC

Null Hypothesis: D(LOOC) has a unit root

Exogenous: Constant, Linear Trend

Bandwidth: 21 (Newey-West automatic) using Bartlett kernel

	Adj. t-Stat	Prob.*
Phillips-Perron test statistic	-31.12573	0.0001
Test critical values:		
1% level	-4.018748	
5% level	-3.439267	
10% level	-3.143999	

*MacKinnon (1996) one-sided p-values.

Residual variance (no correction)	0.000572
HAC corrected variance (Bartlett kernel)	0.000100

LOOS

Null Hypothesis: D(LOOS) has a unit root

Exogenous: Constant, Linear Trend

Bandwidth: 0 (Newey-West automatic) using Bartlett kernel

	Adj. t-Stat	Prob.*
Phillips-Perron test statistic	-12.98932	0.0000
Test critical values:		
1% level	-4.018748	
5% level	-3.439267	
10% level	-3.143999	

*MacKinnon (1996) one-sided p-values.

Residual variance (no correction)	6.61E-05
HAC corrected variance (Bartlett kernel)	6.61E-05

APPENDIX XXIVIII: COVARIANCE ANALYSIS (ORDINARY)

Covariance	OPRFUTURES	OPRSPOT
Correlation	OPRFUTURES	OPRSPOT
OPRFUTURES	792.1444 1.000000	
OPRSPOT	790.5250 0.999977	788.9447 1.000000
