FACTORS DETERMINING CRUDE OIL PRICE

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ABSTRAK

Punca kenaikan harga minyak telah menjadi satu subjek yang diberi perhatian dan kajian mengenai kepentingan minyak sebagai sumber tenaga utama dunia. Dalam tempoh dua dekad yang lalu, harga minyak mentah telah turun-naik dengan pantas sekali dan adakalanya secara drastik. Namun, faktor yang menyebabkan kenaikan ini masih menjadi kontroversi. Kajian literatur mempunyai dua pandangan. Kumpulan pertama menghujahkan bahawa perubahan harga minyak adalah disebabkan oleh faktor asas iaitu permintaan dan penawaran. Pihak yang lain mendakwa bahawa pemboleh ubah kewangan (spekulasi dan pasaran hadapan) memainkan peranan penting dalam perubahan harga minyak. Tujuan kajian ini adalah untuk menentukan penyebab utama perubahan harga minyak mentah dengan menggunakan Model Vektor Pembetulan Ralat. Kajian ini juga untuk menentukan kesan pemboleh ubah baharu dalam pasaran minyak seperti hari penawaran hadapan dan hasil mudah terhadap perubahan harga minyak. Kajian ini memeriksa empat faktor utama yang mempengaruhi harga minyak mentah iaitu pemboleh ubah penawaran, pemboleh ubah permintaan, geopolitik dan spekulasi. Dapatan kajian menunjukkan bahawa harga minyak dalam tempoh dua dekad yang lalu terutamanya selepas krisis 2008 ditentukan oleh pemboleh ubah asas iaitu jumlah pelantar minyak, hari penawaran hadapan dan hasil mudah. Di samping itu, analisis Komponen Utama menunjukkan bahawa hari penawaran hadapan merupakan faktor terdekat sistem koordinat yang menjelaskan perubahan harga minyak mentah.

Kata kunci : harga minyak mentah, fundamental, spekulasi, model MVPR, analisis komponen utama.

ABSTRACT

Causes of oil price increase have been a subject of much interest and numerous studies given the importance of oil as the main source of energy of the world. In the last two decades, the price of crude oil has been fluctuating rapidly and at times drastically. But the causes of the rise in the price of crude oil still remained a controversy. Literature has two views. The first group argues that the changes in oil prices are due to supply and demand. The other claims that financial variables (speculation and future markets) play a big role in crude oil price changes. The objectives of this study to determine the main determinants of crude oil price changes by using the VECM model and examine the effect of the new variables in the oil market such as; days of forward supply and convenience yield on oil price changes. This study examines four main factors that affect crude oil prices which are; supply variables, demand variables, geopolitics and speculation. The results of this study indicate that oil prices in the last two decades especially after the crisis in 2008 are determined by fundamental variables which are total oil rigs, days of forward supply and convenience yield. Moreover, principal component analysis indicates that days of forward supply is the nearest factor in the PCA coordinate system which explains the changes in crude oil prices.

Keywords: crude oil prices, fundamentals, speculation, VECM, principal component analysis.

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GLOSSARY OF TERMS

Crude Oil (Including Lease Condensate)	A mixture of hydrocarbons that exists in liquid phase in underground reservoirs and remains liquid at atmospheric pressure after passing through surface separating facilities. Included are lease condensate and liquid hydrocarbons produced from tar sands and oil shale.
Federal Energy Administration (FEA):	A predecessor of the U.S. Energy Information Administration.
Gross Domestic Product (GDP)	The total value of goods and services produced by labor and property located in the United States.
API gravity	The American Petroleum Institute gravity, or API gravity, is a measure of how heavy or light petroleum liquid is compared to water.
Organization for Economic Cooperation and Development (OECD)	An international organization helping governments tackle the economic, social and governance challenges of a globalized economy. Its membership comprises about 30 member countries.
Organization of the Petroleum Exporting Countries (OPEC)	An intergovernmental organization whose stated objective is to "coordinate and unify the petroleum policies of member countries." It was created at the Baghdad conference on September 10–14, 1960.
Real Price	A price that has been adjusted to remove the effect of changes in the purchasing power of the dollar. Real prices, which are expressed in constant dollars, usually reflect buying power relative to a base year.
Refinery (Petroleum)	An installation that manufactures finished petroleum products from crude oil, unfinished oils, natural gas liquids, other hydrocarbons, and alcohol.
Strategic Petroleum Reserve (SPR)	Petroleum stocks maintained by the Federal Government for use during periods of major supply interruption.
West Texas Intermediate (WTI)	Also known as Texas light sweet, is a grade of crude oil used as a benchmark in oil pricing.

LIST OF ABBREVIATIONS

CPI	Consumer Price Index
CVAR	Cointegrated Vector Auto regression
C.Y	Convenience yield
DUMMY04	Dummy variable for war
EIA	Energy Information Administration
FOB	Free On Board
FRED	Federal Reserve Economic Data
GDP	Gross Domestic Product
G-20	The greatest twenty industrialized countries
ICE	International Petroleum Exchange in
IEA	International Energy Agency
L	Logarithm
LFUT4	Log for future oil contracts for four months
LOECDDAYS	Log for OECD days
LOPCAPUTIL	Log for OPEC capacity utilization
LCY	Log for convenience yield
LRIGS	Log for total oil rigs
mb/d	Million barrels daily
NYMEX	New York Mercantile Exchange
OECD	Organization for Economic Cooperation and Development
OLS	Ordinary Least Squares
OPEC	Organization of Petroleum Exporting Countries
p/b	Per barrel
SBC	Schwarz Bayesian Criterion
S&P	Standard & Poor's
SPR	Strategic Petroleum Reserve
SRP	Sulphate Removal Package
UK	United Kingdom
UNCTAD	United Nations Conference on Trade and Development
U.S	United States
USD	United States Dollars
VAR	Vector Auto regression
WTI	West Texas Intermediate
$/b	Dollar per barrel

CHAPTER ONE
INTRODUCTION

1.1 Introduction

This Chapter is organized as follows: The Introduction gives a simple overview about the components of this chapter. This is followed by the Background which establishes the importance of the topic and provides a simple explanation for crude oil prices. The problem statement highlights the issues and the gaps in the literature that is going to be addressed in the study. The following subsections present the research questions, followed by the objectives of the study. Next is the significance of studying the determinants of crude oil. The scope of the study and delimitations of the study is provided in Section 1.7. Lastly, the organization of the study is laid out at the end of this chapter.

1.2 Background

Crude oil is a strategic commodity. It is a vital source of energy for the world. Oil production is characterized by high capital and high fixed costs - to produce a wide range of products through various stages of exploration and production, refining, marketing and transportation. In addition oil is a deplete resources whose price are determined by demand, supply and other variables. It should be noted that the supply of crude oil and demand for petroleum products is influenced by policies of producing and consuming governments too, especially in the medium and long-term.

In spite of the importance of the alternative oil resources, they are still cannot play a big role in the oil market because of the big difference in terms of cost, methods of use, volume of capital required and their effects on environmental pollution. Therefore oil is expected to play a major role in the coming years as shown in the Figure below.

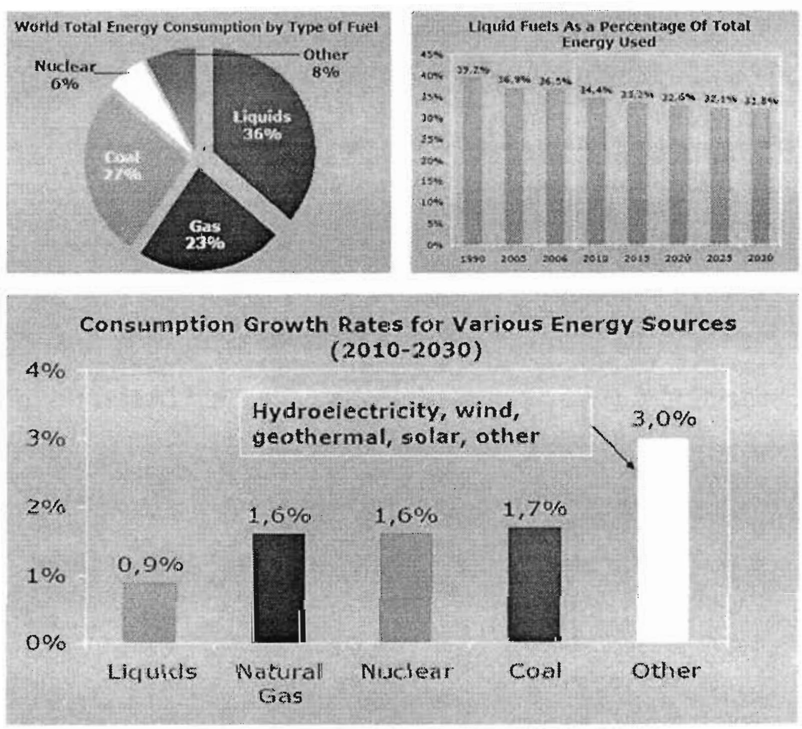

Figure 1.1
The Global Energy Consumption by Type of Fuels and Expected Growth 2010-2030
Source: Energy Information Administration, 2010

The Figure above gives a simple picture that oil is the dominant non-renewable energy source powering economies worldwide It also represents the highest percentage of fluid energy consumed, and reached almost the third of global energy consumption. The Energy Information Administration (EIA) expected that liquid fuel shares will grow in the future and it will constitute the largest share of total energy sources, i.e. almost 32% of total energy sources (EIA, 2010). Oil has gained importance not only from the size of the global oil trade, but as a strategic commodity of many industries, and the main source for the budget of most oil-producing countries, especially the members of the Organization of Petroleum Exporting Countries (OPEC).

The high volatility in oil prices, does not affect the interests of developing countries only, but producing and consuming countries as well. In addition, oil price fluctuations affected the government budgets, stock markets and macroeconomic variables. Moreover, high crude oil prices for a long time may lead to inflation; and finally recession in oil-consuming countries.

Understanding oil price behavior is useful because the changes in it will affect different macroeconomic variables, such as: the significant correlation between oil price and GDP, an increase in oil prices lead to slow down economic growth. Moreover, the effect of oil price changes on investment in the oil sector.

Why it is important to model oil price movements? Studying oil price movements are important for the following reasons

1. Changes in oil prices often have a big effect on the economy.
2. Studying oil price movement in order to analyze oil price behavior is a very interesting issue for both policymakers and agents in financial markets.
3. Many analysts have demonstrated that oil price changes are relatively high compared to changes of other commodities (Regnier, 2007).
4. Sadorsky (1999, 2003) used vector autoregressive analysis model with monthly data on industrial production to estimate the rate of interest, crude

oil prices and stock prices. He finds that oil price changes do have a significant effect on stock price changes.

5. There is considerable empirical evidence connecting oil price changes due to variables, including gross domestic product (Hamilton, 1996), stock returns (Sadorsky, 1999), the rate of interest (Ferderer, 1996; Papapetrou, 2001), and real exchange rates (Chen and Chen, 2007).

Historically, oil prices witnessed two major stages, the first stage started from 1859 when the oil was discovered until 1970 when OPEC was established and became one of the important players in the oil market. The second stage started from 1970 until the present where new partners entered the market such as oil of North Sea, the Gulf of Mexico and the opening up of Russia.

Real oil prices in the beginning were 20 USD per barrel reflecting the high fixed cost in the oil industry and then declined to be less than 20 USD per barrel. The figure below shows that real oil prices started with more than 100 USD per barrel and then the price declined to an average to less than 20 USD dollars per barrel except the crisis periods.

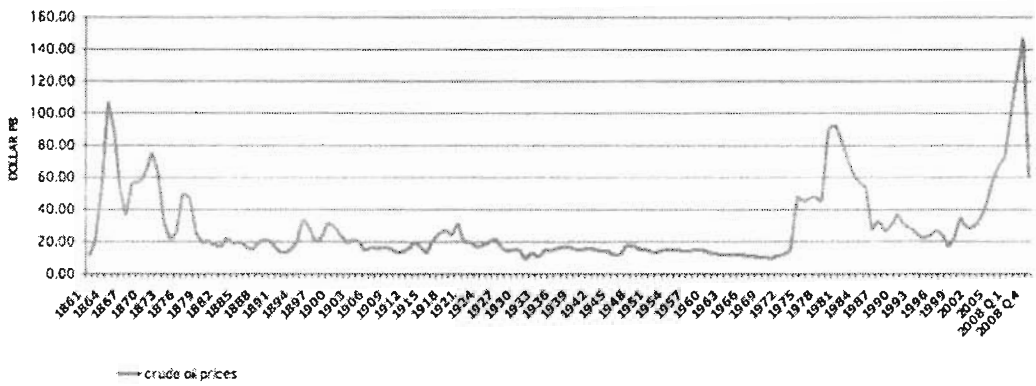

Figure 1.2
Oil Price Developments Since 1861 – 2008 (Real Prices in 2007/2008 USD)
Source: EIA, 2008

According to the Figure 1.2, oil prices became low and stable until the middle of the seventies. The stability in oil prices for this period can be explained by the constant increase in the oil supply and production. After that, many shocks, economic and political events had occurred that changed the world market for crude oil such as the formation of the Organization of Petroleum Exporting Countries (OPEC) in 1960, the shock of Yom October War between Israel and Arab countries in 1973/1974, the shock of 1979 of Iran, Iran and Iraq war during the eighties, the first and second Gulf War in 1990, 2003 and finally the big shock in 2008 (EIA, 2008).

Oil production & prices in the first stage were in the cartel hand, which was called the Seven sisters (Standard Oil of New Jersey or Exxon, Standard Oil of California or, Mobil oil, Gulf oil, Texaco, and British petroleum), (Sampson, 1975). The oil industry was integrated vertically in upstream operation (exploration, production) and its downstream operation (refining, marketing). The integration between production and refining caused the international market for crude oil exports from developeing countries to become a totally administered one. The major oil companies acted as a cartel in their various operations, including production and price setting. The prices in the first stage were stable and very low as compared to the prices in 2007, because it was under the cartel control as what have been described.

The second stage witnessed many important changes such as; new global companies entered the market, new producers such as Canada, Gulf of Mexico and North Sea, new consumers such as China and India, new instructions on oil uses, such as the tax on refining, and finally the appearance of the organization of the Petroleum Exporting Countries (OPEC) as a new dominant player in the oil market. The factors above, contributed to the gradual decline in the cartel's control of the oil market to OPEC. In the early 1970s, the main oil companies controlled about 70 percent of total crude oil in international trade. By 1979, their influence had been reduced, and they controlled only 40-50 percent of the international oil trade, oil companies lost their influence due to the entrance of newcomers in the international oil market. The newcomers consisted mostly of national oil companies of the producing as well as consuming countries.

The second stage also witnessed a lot of shocks. Most of the shocks were caused by political reasons except for 1986 and 2008. In the 80s oil consumption declined and the production outside OPEC increased at the same time, which caused a surplus in oil supply. Therefore, crude oil prices fell from $37 per barrel in early 1981 to about $29 per barrel in 1985, and then down sharply to about $10 per barrel in early 1986. In the nineties the oil market started recovering gradually, oil demand increased due to the increase in the rate of economic growth in East Asian countries such as China, India and Malaysia.

In general, the second stage showed that the demand for oil has increased significantly. This increase can be explained by several factors such as; the strong economic growth (especially in East Asian countries like China, India and Malaysia), the effects of industrialization and globalization in the last forty years especially in OPEC members.

Recently, the highest increased in demand came from the emerging markets, especially China and India. This increase is expected to continue in the future, possibly at a more moderate rate (EIA, 2008). At the same time, the supply of oil in this period has also increased but at a lower rate. In addition, the distribution, oil reserves, production and a large portion of oil supply is concentrated in the Middle East in the hands of OPEC countries, giving them market power to control oil prices by simply adjusting volumes. This explains that the supply of oil market is under oligopoly which managed by few sellers.

Oil prices to some extent are sensitive to changes in the market fundamentals (supply and demand), which were affected by economic factors and geopolitics in both producing and consuming countries. So, these will put an upward pressure on oil prices to increase.

The history of the oil price market showed four main events that had a significant impact on the oil price. The first event was the oil shock in 1973 as a result of the Arab oil embargo on the Western counties as a punishment for their support to Israel in the October War. The second event was the oil shock in 1979/1980 which was caused by Iran in 1979 and led to a sharp push in oil production. The third main event was the Gulf war in 1990 which resulted in a sharp decrease in production from the region and a significant increase in oil price. The fourth main event was the predictable U.S attack of Iraq in 2003. This led to the price increased to record levels and lasted for five years-until July 2008.

The impact of the last shock in 2008 is different from the three previous shocks for the following reasons: in the three previous shocks oil price rose noticeably for a continuous period of time. In addition, the price did not turn back to its original level after the crisis. Nevertheless, the recent shock in 2008 is different. It has been continuous and drastically as compared to the in oil prices during the three other shocks. Moreover, oil demand during the recent years continued to increase in spite of the high level of oil prices. Furthermore, the trend-oil prices showed volatility over the last five years before 2008. It increased sharply and reached its peak in 2008 where the oil price hit 147 USD per barrel in July2008.

Subsequently, the end of October 2008 oil prices went-down to below 70 USD per barrel representing more than fifty percent plunge from its peak just three months earlier. Hence, there is a discussion whether the price increase can be exclusively attributed to the fundamental changes or the geopolitics or economic factors that influenced them or whether there were other variables that played a role in this considerable price increased.

The latest high oil prices can have a positive effect on the investment in new technologies to enhance exploration and refining efficiency in addition to encourage discoveries of new conventional and non-conventional oil reserves. The investments in the oil market are ~~too~~ essential to increase oil production and give assurance of a continuous supply for the long time period. Although–high prices encouraged investment in such projects, may create periods of supply surplus and put a downward pressure on the oil price in the long run. The factors that may play a role in oil demand changes to some extent are the alternative energy sources and transportation cost. But these sectors are not fully developed until now.

Several recent studies indicated that the period of 2002 to the present, which has seen large fluctuations and sharp increased in oil prices was accompanied by the changes in the fundamentals of the oil markets as well as a the significant rise in the volume of financial transactions and speculation (Krichene, 2008; Kang et al., 2009; Kaufman, 2011). Price volatility of crude oil, also appeared in the period 2008-2009, and raises questions about how to determine the price of oil. There was also a complex interrelationship between the physical and financial markets.

The dramatic trend of oil markets in the past ten years, can be divided into ~~a~~ three main phases (Chevalier, 2010):

- 2000-2003 was marked by stability, the relative price differences within the band (22-28 dollars per barrel) which had been decided, and set up by the Organization of Petroleum Exporting Countries (OPEC).
- 2004-2007: The period between 2004 and 2007witnessed an explosion in demand for oil as a result of continuous increase in the global economic growth, in both emerging countries and in the United States. At the same time, there was a major escalation in the financial markets for products, refined oil and, more generally of the goods. This rapid growth in the financial area, where the volume of transactions that would today represent about thirty-five times the oil traded on the actual market - goes hand in hand with the increasing numbers of participants, and financial products and markets.
- 2008-2009: In the period 2008-2009, the competition between physical factors and financial factors seemed clear. Oil prices rose between January and July 2008, to 147 $/b, which put questions about the degree of potential role played by financial markets obviously between July and December 2008.

Oil prices dropped to 36 $/b, since financial changes in the attitudes of investors and the sudden declined in demand caused by the economic crisis. In consequence prices in 2009 rose to more than 80 $/b, which seemed to be under physical basics reasons when OPEC cuts their production.

According to the explanation above, there are four groups of possible explanatory factors contributed the evolution of prices of crude oil:

- The rapid increase in demand due to higher global economic growth.
- Falling or decreasing supply of oil and the fear of a supply shortage.

- Coordinated action by crude oil producers and political factors (geopolitics).
- The behavior of main participants in the financial market, and speculation.

    - Many conferences were held to find the main factors that determine oil prices in order to avoid the shocks and instability in the oil market or to reduce their effect at least, for example the conference which was held in October 2009 by the ministers of France. The conference concluded that the last crisis in 2008 was not like others; there was a huge upsurge in oil financial markets. Also, there were new variables which played a big role in oil market such as; convenience yield, days of forward supply, under investment in new production capacities, speculation by some financial actors, financial investors, and the functioning of financial oil markets" (Chevalier, 2010).

Days of forward supply are "an estimation of the number of days that a country can function using its own oil stocks given current demand" Mobert (2007). This variable indicates an importing country's independence from supply shocks and actions by OPEC. In other words, given an exogenous supply shock, such as an embargo or loss of upstream production a country can tap into their reserves for a certain number of days in order to not further disrupt other sectors of the economy that rely on crude oil as an input to production.

Dees et al. (2008) found an inverse relationship between days of forward supply and crude oil prices: as the number of days of forward supply increase there will be a negative effect on crude oil prices. In general, higher stock levels represent a psychological component that tends to keep crude oil prices lower or at least stable. Markets may, indeed, view higher stock levels as an extra supply cushion and therefore be less worried about supply disruptions. Accumulating stocks in such a fashion can best be described as the precautionary demand component of crude oil consumption. Dees et al. (2007) indicate that "individuals who hold stocks do so to avoid the risk of a disruption".

In general, an increase in stocks can be viewed as an increase in supply. It stands to reason that as stocks increase there would tend to be a negative effect on crude oil prices. As stocks increase there would be less reliance on current production, which reduces the risk of higher prices due to supply disruptions (Mobert 2007). Therefore, an increase in stocks should have a negative effect on prices. Additionally, an increase in stocks may send signals to economic agents that markets are well-supplied or even over-supplied given current demand and therefore crude prices should fall, ceteris paribus. Hence, an increase in stocks shifts the supply curve to the right, which causes the equilibrium price to fall, ceteris paribus. However, as indicated in Mobert (2007), this static analysis may not always hold. As crude oil stocks increase and prices fall, this may have a simulative effect on demand therefore putting upward pressure on prices. Mobert (2007) finds that the opposite may be true as well: as stocks decline this will have the effect of putting upward pressure on prices therefore reducing demand.

Regarding precautionary inventories, it does not make economic sense that agents with storage capacity would arbitrarily hold crude inventories for the sole purpose of quickly supplying the market following a supply shock. Petroleum Argus argued in 2006 that the crude oil markets indicated "just-in-time inventories are no longer appropriate" since OPEC's production capacity had declined significantly.

During periods when crude spot prices exceed futures prices the market is said to be normal or in backwardation. Conversely, in periods when futures prices exceed spot prices the market is said to be in contango. According to Litzenberger and Rabinowitz (1995) the crude oil market is in backwardation 80 – 90 percent of the time; or the oil forward curve is normal (spot prices exceed futures prices).

During periods of backwardation, crude oil producers have a stronger incentive to extract and sell crude oil because "ownership of reserves represents a call-option" (Fattouh, 2007). In other words, crude oil producers will want to produce and sell oil in the present when prices are higher rather than in the future when prices are lower given market backwardation. Additionally, given the costs to storing crude stocks, it does not make economic sense for a producer to extract crude, hold it in storage, and sell it in the future at a lower price. In other words, "weak backwardation is a necessary condition for current production" (Fattouh, 2006). Therefore, during periods of backwardation, economic agents with storage capacity will not accumulate crude oil inventories. Fattouh (2007) also notes that oil producers have the incentive to leave the oil in the ground and sell it in the future if futures prices exceed spot prices or when the market is in contango.

Hamilton (2008) provides a simple model to illustrate storage arbitrage and how futures markets can affect spot oil prices. Imagine there is an investor with crude oil storage capacity who is considering borrowing money to purchase Q barrels of oil. Assuming that the investor will also pay storage costs for storing the crude oil, Ct, and that he also pays interest on his original loan, it, then the investor will profit from storing crude oil today if $P_{t+1}Q > (1 + i_t)(P_t + C_t)Q$ Making such a bet requires examining future expectations. If it were the case that drilling rigs were expected to go offline in the future for maintenance then it is quite possible that futures prices will exceed spot prices and the investment could be more profitable, ceteris paribus.

Clearly, most people do not have the capabilities of storing crude oil. The alternative is to enter into a futures contract where an investor agrees to buy oil at some point in the future at a certain price that he and the other party agree upon today. In the event that an investor agrees to buy oil in the future at price Ft, then he will make a profit whenever $F_t < P_{t+1}$ because he can sell his contract to another investor at Pt+1 any time before the expiration of his contract. As mentioned above, expectations about the future may move the market into contango or backwardation.

For the following reasons, convenience yield has been introduced in this study as a non-financial or non-pecuniary benefit of holding crude oil inventories. Dahl (2004) explains that inventories can be used to offset unexpected increases in demand or augment supply when conditions become tight. Clearly, when oil is dearer it will command a higher price and therefore holding inventories will be a profitable endeavor (see Hamilton's equation above).

OPEC productions decisions are often ambiguous and may be interpreted in different ways by oil market participants and therefore have different effects on spot and futures prices.

With the prevailing uncertainty in the world oil market and vulnerability and the increase in role of OPEC, and the increase in the type and size of speculation and future markets, it has become more and more difficult to find accurate models for the main factors that determining crude oil prices. A review of the current models shows the diversity of conclusions. Today, even after the price collapse of 2008, many energy experts and analysts believe that oil prices would go up again sharply and surpass the price peak of 2008. The recent crisis has left a big question, whichever is playing a bigger role in the fluctuations in oil prices, is it supply and demand factors or financial factors? The answer to this question is one of the objectives of this study.

1.3 Problem Statement

Many studies have been undertaken on factors affecting crude oil prices. However, most of these studies ignored several important factors that have contributed to the fluctuation in the oil prices, e.g. days of forward supply, convenience yield, underinvestment and geopolitics. Also, the volume and content of supply, demand and financial variables have changed. In addition, the first three crises in oil market were preceded by high demand growth and low investment in new oil fields with low spare capacity and a weak U.S Dollar. But the last oil price crises in 2008 have been characterized by high global refinery utilization and refineries did not respond fast enough to the rise in demand. Moreover, Kaufman (2008) argued that there is empirical evidence that speculation and futures markets played a major role in past crises as well as the effect from a the sub-prime housing crisis (Hamilton, 2008).

Days of forward supply are one of demand variables suggested by Mobert (2007) and Dees et al. (2008), which estimates the number of days that a country can function using the own oil stocks which given on current demand. Convenience yield is one of supply variables suggested by a number of researchers of Colorado School of Mines (Shepherd, 2009). Moreover, Shepherd (2009) suggested that, further research should be assessed, whether the lack of investment directly responsible for the fluctuations in oil prices, and to what degree, as have been mentioned in the background.

The demand for oil in this study is different from the previous studies. Previous studies have only one type of demand "demand for consumption" but this study uses two different types of demand: physical represented by demand for consumption and financial represented by demand for speculation "paper" oil. Thus, the determinants under each one are not the same. Moreover, the demand equation will include the great demand of fuel by China, which can be considered one of the important additions in demand equation, since China is the second largest country in the world in oil consumption (Tunsj, 2010).

The importance of financial variables and geopolitics also increased the volume of transactions, of which speculation was estimated to represent about thirty-five times the oil traded in the physical market (Chevalier, 2010). Geopolitics has played an influential role in recent years during political conflicts and crises (Le Billon, P, 2009); especially due the increase in the conflicts in Arab countries such as Iraq, Palestine and Syria and some of them are OPEC's members.

This study differs from the others at least in four things. First, incorporating new variables like the days of forward supply, convenience yield, underinvestment. Second, highlighting explained the new variables in the demand equation such as China and India. Third, distinguishes between the demand for consumption and demand for stocks which have not done by the previous studies. Hence, the previous studies focused on demand for consumption only and ignored demand for speculation which is known "paper oil". However, this distinguishes in demand will give "unequivocal explanation of the massive oil price variations in oil prices" (Chevalier, 2010). Fourth, it will include the non-economic factors and their effects in determining the price of crude oil by presenting a variable called market instability. Thus, the price and production of crude oil will determine in accordance with its economic variables and non-economic (political) variables at the same time. The crises 1973, 1977, 1990, 2003 and lately 2008 illustrated this reality, and its impact was felt in most countries in the world.

1.4 Research questions

The focus of this research is to find what is determining crude oil price behavior through analysis and empirical study, and highlight the various factors believed to affect the oil price changes. Therefore, this research aims to answer the following questions:

1. Are oil prices determined by the convenience yield and total oil rigs (supply variables)?
2. Are oil prices determined by days of forward supply (Demand variables)?
3. Do OPEC capacity utilization and the conflicts in the Middle East have a significant impact on oil price changes (Geopolitics variables)?
4. Do speculation and future markets have a significant impact on changes in the price of oil (financial variables)?

1.5 Research objectives

The main objective of this study is to determine the variables that affect crude oil prices and to find which variables have played a big role in oil price changes, market fundamentals or financial variables. Moreover, to examine the effect of the new variables in supply and demand; days of forward supply, convenience yield, underinvestment and geological, political conflicts on crude oil prices. Therefore, to achieve the above goals, the specific objectives are followed:

1. To estimate the relationship between convenience yield, total oil rigs and crude oil price.
2. To estimate the relationship between days of forward supply and crude oil price.

3. To estimate the relationship between OPEC capacity utilization, the conflicts in the Middle East and crude oil price.

4. To estimate the relationship between speculation, future markets and crude oil price.

1.6 Significance of the study

There was a lot of work written on oil prices, but most focused on the effects of oil prices in developed countries, especially the U.S. Also, a lot of studies conducted on the effects of OPEC on the crude oil prices and oil market. Hence, previous studies explained oil price movements due to market fundamentals and economic variables. However, in spite of the importance of these variables, it is not enough to illustrate oil price movements because last two decades, oil market has witnessed many changes; in the supply side. For example, the emergence of new producers of oil like Canada, Alaska and North Sea oil. The rise in oil price made the uneconomic wells to be economic which means it became profitable wells. On the demand side, economic growth of East Asian countries such as China, India and Malaysia has the effect to increase oil demand. China became the second largest country in the world in oil consumption, which reflects the changes in the content of demand equation. Moreover, the new instructions on environment pollution encouraged the use of light oil which contains less sulfur; these instructions increased the pressure on refining utilization. Therefore refining utilization will be highlighted in this study.

The new technology in internet supported the speculators and facilitate their transaction. Hence, the volume and the content of speculation increased and also the parties include companies and governments not only individual investors (IMF, 2009). Furthermore new variables in oil market need to be highlighted such as; days of forward supply, convenience yield and underinvestment (Mobert, 2007; Dees et al., 2008; Shepherd, 2009).

Moreover, most of studies ignored the political effect or non-economic factors and their effects in determining the price of crude oil. OPEC as a political organization, the price and production of crude oil will determines in accordance with its economic imperatives and political strategies as well. Moreover, oil has a strategic importance. The crises in 1973, 1977, 1990, 2003 and lately 2008 illustrate this reality, and its impact affected the industrialized countries and developing countries at the same time. In addition, the increase in oil price is a major concern for the global community. Many conferences were held to reflect the concern of many governments such as; UK, France, USA and more than G-20 industrialized countries to find the drivers of oil prices, especially after the rapid growth in the volume of financial transactions (Chevalier, 2010).

This study focuses on economic as well as non- economic variables, especially the new variables such as; days of forward supply, convenience yield and refinery utilization. Market instability reflected by sudden changes in production and non-economic factors at the same time. Therefore, the study would identify and classify the economic and non-economic factors that influencing oil prices to four groups: supply, demand, geopolitics and financial variables and would determine the relative importance of each group of variables.

The study and test of the research hypothesis would identify the economic and non-economic factors influencing price movements, and would determine the relative importance of each group of factors.

Uncertainty and expectations about oil future prices, speculation and production in the oil market lead to inventory holdups during the times of supply disruptions (e.g., 1973 oil embargo), and inventory drawdown at times when the market is soft. The change in the inventory level creates a shortage and surplus and affects product and prices. In an attempt to account for the inventory-holding policies of oil consumers, world oil demand can be divided into two types: demand for consumption and stockpiling. With the demand for consumption equation, investors' expectations of prices and a non-economic variable like market instability are included.

The results of the study could be significant in extending similar studies through incorporation of new variables and it is expected to be useful in understanding the main determinants of oil price.

1.7 Scopes and delimitations of the study

This study focuses on the world oil market, especially on the crude oil market. Oil prices are too broad issues; therefore my focus will be on the major factors that affect crude oil price volatility especially in the recent years.

This study will cover the period 1986-2010 according to data availability. Also, the study focused on the factors determining crude oil prices in the last three decades. I prefer global data for refining capacity utilization but the available data are only for U.S. refining capacity, as many analysts mentioned (Kaufman, 2008). Thus, some of the years will not be normal, especially during the war or political effects such as; 1990, 2003 and 2008. However, data for days of forward supply are collected from OECD countries and the U.S. as the main oil consuming countries. Moreover, some of the variables are qualitative, such as political conflicts during the war; therefore I will use a dummy variable for it.

1.8 Organization of thesis

This thesis is divided into five Chapters. Chapter one presents, among others the background of the study, the problem statement, the objectives and the significance of the study. The relevant literature on theories on oil prices and the relevant empirical studies will be reviewed in Chapter two. Then, Chapter three discusses the research methodology, as well as the sources of the time series data. It is then followed by the theoretical framework and research hypothesis. Subsequently, Chapter four analyzes the research hypothesis and presents the findings of the research. Finally, the policy implications and the conclusions of the study are discussed in Chapter Five.

CHAPTER TWO
LITERATURE REVIEW

2.1 Introduction

This chapter starts with a discussion of the characteristics oil industry and then studies oil price development from 1859 until 2012, especially the changes and developments in the international oil market throughout the last three decades. These changes are radical and different from any other industry, and the criteria of these transformations lie in the very nature and characteristics of the oil industry. The discussion may be grouped into three sections:

- Oil market structure and the development of oil price
- Oil price theories.
- The previous work regarding the variables which affect oil price volatility.

2.2 Oil price, market structure and the development of oil prices

In this part I will briefly explain about oil price development, market structure and oil price future.

2.2.1 Oil price and market structure

Crude oil is a mixture of naturally occurring hydrocarbons which is refined into gasoline, diesel, heating oil, kerosene, jet fuel and generally thousands of other products known as petrochemicals. Crude oils get names due to their contents and origin location. Also, crude oil sorted due to their per unit weight (degree of gravity).

The heavy crudes generate more heat upon burning, but at the same time it has lower API gravity and oil market price in comparison to light (or sweet) crudes.

Crude oil also can be considered as liquid petroleum. It is an exhaustible, natural resource which consists of hydrocarbons in general (Britannica, E, 2008). According to the previous definition there is not one price for crude oil, but many (see appendix B).

Noreng (2002) illustrated that there are more than 160 different types traded oil; these vary widely with due to quality, organic location and availability. The quality of oil is measured in general by its density due to the American Petroleum Institute (API) gravity that recognizes between light and heavy crude oil. Heavy oil in particular has less attractive as it needs a longer and more complex refining process. While, light oil gives a higher yield of gasoline. High quality crude oils such as; UK oil in the Forties, the Norwegian oil and Venezuelan Light, definitely it will be more expensive than the oils that have less quality for instance; the Canadian Heavy oil and also Venezuelan Extra Heavy.

Acidity also can determine the quality of oil. Its measurement shows the percentage of sulphur content in the oil and recognizes between sweet (light) and sour (heavy) types. Oil can be considered sweet if it has a low percentage of sulphur. Vice versa, it will consider sour if it has a high percentage of sulphur. Sweet oil is more attractive as it is preferred in complying with the environmental standards and needs less refining to meet sulphur standards that are accepted for fuel (Noreng, et.al, 2002).

In general, world crude oil prices are recognized in relative to different markets traded benchmarks; West Texas Intermediate benchmark (WTI), Brent Blend benchmark (Brent) and Dubai benchmark, it also quoted at premiums or discounts according to these prices. These benchmark crude oil prices make a distinction between the oils that come from different geographic places. WTI represents the benchmark price of light, sweet oil, which is extracted and refined in the United States (U.S) and the Gulf beach of Mexico. WTI trades on the New York Mercantile Exchange (NYMEX) which are used as a means of transportation for hedging and speculation (Milonas, N. T., & Henker, T, 2001).

Brent oil is a benchmark price which is used for pricing oils from the North Sea fields which provide oil to the North West Europe where it is generally refined. It trades on the International Petroleum Exchange (ICE) in the UK (London). Brent is normally considered as the world benchmark, since it is used for pricing two Thirds of the internationally traded oil that come from western Europe, Africa and the Middle East. WTI and Brent in cooperation are of very high quality, specifically they are both light and sweet oils. Nevertheless the price of WTI is fairly greater than the price of Brent as the previous results to some extent more gasoline and somewhat less heating oil than Brent (Milonas and Henker, 2001).

OPEC basket price is a benchmark price that depends on the prices of seven different types of oils which extracted and refined by OPEC countries. OPEC basket price also is of a slightly inferior quality as compared to WTI and Brent; it is almost heavier and has more sour. Dubai is a benchmark price used for Middle Eastern oil that comes towards Asia. Generally, there are two main benchmarks for crude oil prices: West Texas Intermediate (WTI) and Brent crude oil. According to the quality, both are light sweet crude oils, even though WTI is in generally sweeter and lighter than its European counterpart. Therefore, this study will focus on WTI crude oil price, because this is the most universally traded oil.

2.2.1.1 Features of the oil industry

One of the basic features of the oil industry is the fact that oil is an exhaustible natural resource in the sense that the continued extraction of oil from a reservoir will lead finally to its total exhaustion. In particular, an extracted barrel cannot be replaced by another barrel, except by an exploration effort which might or might not end in the discovery of new reservoirs by Promote efficiency in the recovery of oil already in place and actually adding new reserves. This means that if a sufficient continuation of reserves is desired, the barrel extracted today demands the further expenditure of large sums of money because of the big capital risk involved in replacement, a risk which increases with the passage of time since the more oil is extracted, the less expected it is that new oil will be found.

The second feature of the oil industry is that it is mostly oriented to world market and its growth depends on worldwide trade. The world almost relies mainly on the exportation of oil from areas where oil consumption is low because of low levels of economic and social development to areas with no significant domestic oil production but with high rates of oil consumption.

The third feature of this industry is its steady and continued growth resulting from essential changes which have occurred in the economies of the industrialized countries, particularly since the Second World War, and transformation of their energy structure from a basic reliance on coal to a basic dependence on oil and gas. This transformation was due to the characteristics of oil, which made it the most suitable fuel for technological innovations and changes necessary for the Western economy.

Oil, as a scarce commodity, was more and more used as an industrial input and raw material input for the chemical and petrochemical industries and continues to be used chiefly as the primary fuel for the industry for transportation, domestic use and services. This turns oil into a strategic commodity strongly linked to world power politics because the security of its supply and the level of its price plays an important role in the process of economic growth.

The technological changes and the great increase in industrial production have made the world economy, especially in the industrialized countries, highly dependent on oil. In other words, economic growth increases social welfare for these countries, economic and political systems depend can no longer be achieved without oil. Another feature which represents the exclusivity of the oil industry is its integrated nature. This is correct since produced oil cannot be made available to end users without being passed through a variety of stages, each of which creates new added values. Hence, there exists an organic link between each stage, and all stages are interdependent. The extraction of crude oil cannot begin before the process of exploration and discovery of oil has been undertaken.

The crude oil cannot he used by consumers without being transported to the areas of consumption, where it is passed through a variety of refining operations and offered to consumers in the form of refined products. Accordingly, an investment in any one stage of the industry depends mainly on the nature and size of investments in other stages, and the amount of investment at each stage forms the market for the preceding stage and so on. Another important feature is that the oil industry is highly capital and technology intensive. The capital costs; i.e., expenditures necessary for installing production capacities, particularly at the stage of crude discovery and development, constitute a very high proportion of the total cost involved in the oil industry in general. With this high ratio of capital expenditure, operating costs of the industry (namely expenditures for the current requirements of production) are regarded as being low in relation to the overall cost structure.

The high capital risk at the phase of primary investment in oil exploration involves large expenditures in searching for oil, particularly in drilling exploratory wells which may turn out to be dry holes. However, the investments involved in developing oil fields, including transportation, export facilities and a variety of processing facilities and so on, are less risky. This feature played an important role in driving the structure of the industry to an oligopolistic basis with few operators because without price agreements between these operators, short-term market factors would lead to competition and price wars, highly damaging to the growth and survival of the industry.

2.2.1.2 Crude oil price development

The price of crude oil means a relationship between a unit of crude oil and monetary units. Oil prices are generally calculated on the basis of the barrel, which is equal to (159Liters) or on the basis of metric tons, which is equivalent to (7-8) barrel, depending on the degree of intensity of oil and content of sulfur which called the gravity or API, and its location . Note that each barrel contains (42) gallons. Commonly, The price of oil refers to the spot price per barrel of either WTI/light crude as traded on the New York Mercantile Exchange (NYMEX) for delivery at Cushing, Oklahoma, or refers to Brent as traded on the Intercontinental Exchange (ICE), into which the International Petroleum Exchange has been incorporated) for delivery at Sullom Voe.

In general, oil prices can be classified into two stages; the period 1860-1970 beginning of a quiet oil supply when it was perfectly adequate for all the needs of oil demand which shows oil market stability in this period. The prices were very low, according to exhaustible theory; the price of oil must increase at least at a rate equal to the rate of interest (Hotelling, 1931). The second period 1970- till recent. The period from 1970-2000 witnessed the emergence of OPEC as a new force and the use of oil as a weapon. In addition, the entry of new producers to the oil market like Canada and the North Sea and the emergence of national companies that have contributed to weaken the control of the cartel of oil companies.

The period from 2000- until recent reflects the interactions between the market fundamentals (supply and demand) and financial variables (speculation and future markets). New theories have appeared such as bubbles theory to explain the changes in oil prices, to illustrate oil price changes like bubbles theory. In addition, the importance of future markets and speculation increased as compared to the previous period. In spite of the decline in OPEC share, the market power of OPEC expected to increase in the future as a dominant producer according to the production capacity and oil reserve.

2.2.1.2.1 First stage: Oil price before 1970

The history of oil began in the middle of the 19th century where the market was driven by a demand for light kerosene, and then oil industry began to grow. For many decades, gasoline has been just a by-product of refined kerosene. But after the invention of the combustion engine and the automobiles, gasoline became the main product in the market. The first discovery of crude oil in the United States was in Pennsylvania 1859, by (Edwin Drake) and started its production rate 30 mb/d. But the price of crude oil on a commercial scale does not appear only in the year 1860, starting with 9.59 dollars per barrel and then dropped after one year to become 0.49 dollars per barrel as shown in Table 2.1. The big decline in one year because of the competition between monopolistic companies, in addition the increase in the amount of oil explored at the time.

Table 2.1

Annual Average Crude Oil Price for the Period 1860-2012 in $ / Pb(1)

Year	Nominal	Year	Nominal	Year	Nominal	Year	Nominal	Year	Nominal	Year	Nominal	Year	Nominal	Year	Nominal
1860	$9.59	1880	$0.95	1900	$1.19	1920	$3.07	1940	$1.06	1960	$2.91	1980	$37.42	2000	$27.39
1861	$0.49	1881	$0.86	1901	$0.96	1921	$1.73	1941	$1.14	1961	$2.85	1981	$35.75	2001	$23.00
1862	$1.05	1882	$0.78	1902	$0.80	1922	$1.61	1942	$1.19	1962	$2.85	1982	$31.83	2002	$22.81
1863	$3.15	1883	$1.00	1903	$0.94	1923	$1.34	1943	$1.20	1963	$2.91	1983	$29.08	2003	$27.69
1864	$8.00	1884	$0.84	1904	$0.86	1924	$1.43	1944	$1.21	1964	$3.00	1984	$28.75	2004	$37.66
1865	$6.59	1885	$0.88	1905	$0.62	1925	$1.68	1945	$1..05	1965	$3.01	1985	$26.92	2005	$50.04
1866	$3.74	1886	$0.71	1906	$0.73	1926	$1.88	1946	$1.63	1966	$3.10	1986	$14.44	2006	$58.30
1867	$2.41	1887	$0.67	1907	$0.72	1927	$1.30	1947	$2.16	1967	$3.12	1987	$17.75	2007	$64.20
1868	$3.63	1888	$0.88	1908	$072	1928	$1.17	1948	$2.77	1968	$3.18	1988	$14.87	2008	$91.48
1869	$3.64	1889	$0.94	1909	$0.70	1929	$1.17	1949	$2.77	1969	$3.32	1989	$18.33	2009	$53.48
1870	$3.86	1890	$0.87	1910	$0.61	1930	$1.19	1950	$2.77	1970	$3.39	1990	$23.19	2010	$71.21
1871	$4.34	1891	$0.67	1911	$0.61	1931	$0.45	1951	$2.77	1971	$3.60	1991	$20.20	2011	$87.04
1872	$3.64	1892	$0.56	1912	$0.74	1932	$0.87	1952	$2.77	1972	$3.60	1992	$19.25	2012	$93.02
1873	$1.83	1893	$0.64	1913	$0.95	1933	$0.67	1953	$2.92	1973	$4.75	1993	$16.75		
1874	$1.17	1894	$0.84	1914	$0.81	1934	$1.00	1954	$2.99	1974	$9.35	1994	$15.66		
1875	$1.35	1895	$1.36	1915	$0.64	1935	$0.97	1955	$2.93	1975	$12.21	1995	$16.75		
1876	$1.56	1896	$1.18	1916	$1.10	1936	$1.09	1956	$2.94	1976	$13.10	1996	$20.46		
1877	$2.40	1897	$0.79	1917	$1.56	1937	$1.18	1957	$3.14	1977	$14.40	1997	$18.64		
1878	$1.19	1898	$.91	1918	$1.98	1938	$1.13	1958	$3.00	1978	$14.95	1998	$11.91		
1879	$0.86	1899	$1.27	1919	$2.01	1939	$1.06	1959	$3.00	1979	$25.10	1999	$16.56		

The Table shows the annual average crude oil price from 1860 to 2012. The prices were very low in the beginning as compared to the prices nowadays, even if I used the price index for inflation. The Table shows also, low prices for the whole period before 1970; oil prices ranged less than \$3.0. For the period 1948 to the end of the 1960s, oil prices ranged from \$2.5 to \$3.0 and stayed stable for the period 1958 - 1970 around \$3.0 per barrel.

In the middle of the 20th century, seven major companies controlled oil production, refinery and all oil industry stages called "The seven Sisters" as below: (Sampson; 1975)

- Anglo-Persian Oil Company (name changed later to BP)
- Gulf Oil (merged later with Chevron)
- Royal Dutch Shell
- Standard Oil of California (name changed later to Chevron)
- Standard Oil of New Jersey (the name has changed later to Esso and were merged with Mobil)
- Standard Oil of New York (the name has changed later to Mobil and then were merged with Esso)
- Texaco (merged later with Chevron)

The posted price was predominant in this stage, which announced by companies or oil-producing countries to be working in the market, which includes the profit and a tax on the profits they deserve under the concession contracts granted to those companies operating on its territory. The Standard Oil of New Jersey Company in

USA 1880 declared the posted price for the first time and controlled the oil market at the time. This company did not involve other producers in the pricing process.

The posted price depends on several factors, such as; crude oil quality, density, sulfur and content of the geographical location of oil wells and the amount of remoteness from major markets for oil consumption. The oil companies used monopoly policies to serve their interests; they were manipulating the prices up and down to achieve their personal interests, they focused only on their interests, ignoring the interests of the exporting-producing oil countries.

In spite of the very low prices for the period 1947-1973; in general, it was less than$3. 0. But If it is converted to the real price including inflation in 2010 dollars we can get different numbers, crude oil prices changed between \$17 - \$19 through most of the period. It's clear that 20% of the increase was in nominal prices just kept up with inflation as shown in the Figure below.

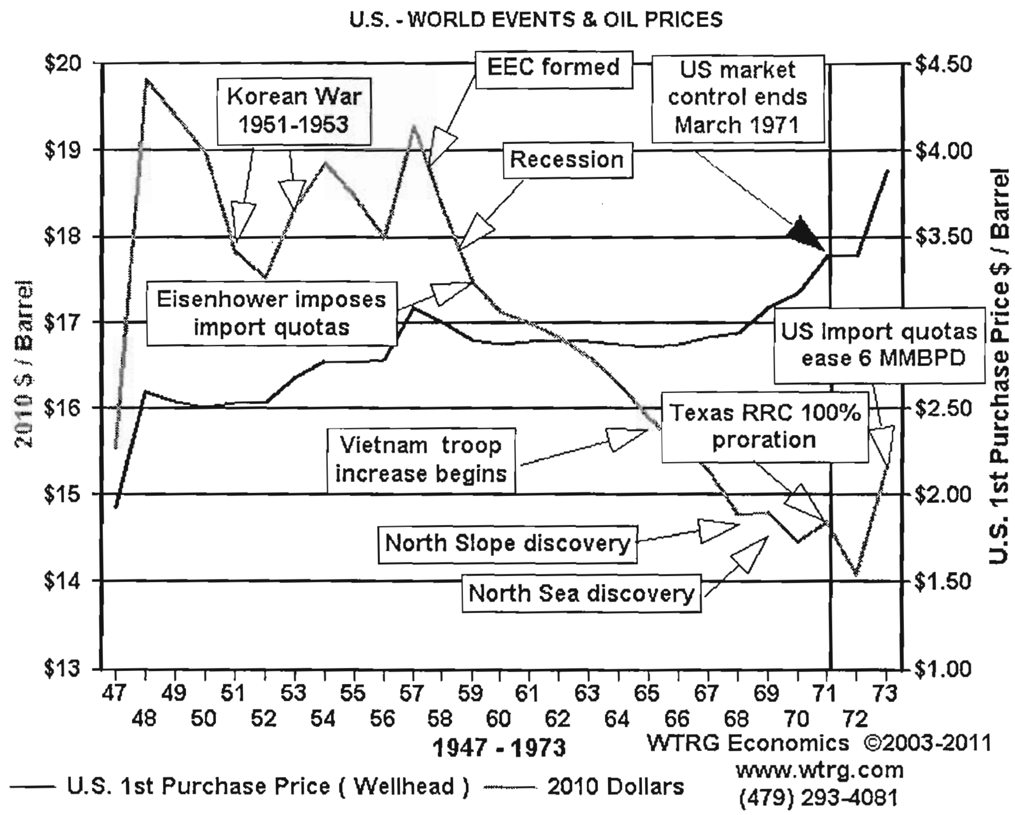

Figure 2.1
Oil Price Development From 1947-1973

The Figure shows also, that oil prices for the period1958 -1970 were stable next to $3.0 per barrel, but in actual terms, oil prices decreased from $19 to $14 per barrel due to inflation effect and the weakness of the US dollar.

In the 1950s, the cartel of oil companies (the seven sisters) administered or set the level of crude oil posted prices unilaterally. These posted prices determined the tax paid to the producing governments for lifting crude from the producing areas. The tax rate was five percent of profits realized from the sale of exported oil, calculated with reference to post price (see appendix B) (Griffin, J. M, 1986). Thus, the host governments had a strong interest in keeping these posted prices as high as possible. But, rapid expansion in the supply of crude oil associated with new discoveries in the mid and late '50s subjected the dominant posted prices to increase pressure, and produce countries were quite disturbed by the fact that producing country taxes per barrel had been declining systematically since 1957.

In February 1959, for example, the British Petroleum Company, the price leader in the Middle East, reduced posted prices by about eight percent (around 18 cents per barrel) and, in August 1960, Jersey standard or Exxon, announced another price cut of ten cents per barrel (Azzam,1976). The decline in these tax revenues could be traced to the declining world price of oil resulting from the discovery of numerous giant fields, mainly in the Middle East, as well as the entry of many new firms into the world market. The new entrants were motivated by the large profits involved, such that in 1950. As a result of this entry, the market share of the seven largest producers had declined from 98 percent in 1950 to 89 percent in 1957 and 76 percent in 1967 (Azzam, H. T,1976). As this trend continued, prices gradually declined, and decreases world oil prices posed a serious threat to them as well as it did for the international oil companies.

This serious loss in revenues and the threat of further losses persuaded the developing producing countries to move toward forming a united front against the international oil companies and led to the formation of the Organization of Petroleum Exporting Countries (OPEC) in 1960- The existing international framework for trade of oil was another reason for the formation of OPEC. One of the major consequences of the OPEC formation was that it prevented the reduction of posted price since its start. But OPEC was not very effective in the beginning and up until the 1967 Arab-Israeli War, it did not function successfully. This ineffectiveness can be explained by the behavior of international oil companies that tried to ignore the cartel completely and by using the principle of "divide and rule". They tried to deal with each country separately and since the countries were not that united, this policy was to some extent successful.

In summary, oil prices at this stage were very low and stable as compared to recent years. The cartel dominated the oil market in all its stages from the exploring till marketing. But the cartel's control began to decline slowly, many factors contributed to the decline in the cartel control such as; the emergence of the Organization of Petroleum Exporting Countries (OPEC), new discoveries of oil in the Middle East, nationalization of oil in Iraq, Iran and other countries.

2.2.1.3 The second stage 1970- until recently

This stage can be divided into two periods in accordance with oil market conditions:

2.2.1.3.1 Crude oil prices 1970 – 2000

During the '70s and '80s, the world oil market witnessed two important price shocks in 1973-74 and 1980. When the Arab-Israeli War in October 1973 has started, the Arab members of OPEC announced a unilateral increase in price, instituted production cutbacks and embargoed oil to the United States and the Netherlands. At the peak of the crisis, prices reached until $15-$16 per barrel, but settled in the $10 range by late indicating a fourfold rise in the price of the marker crude from the previous year. During the same period, the major oil companies' interests in the concessions between them and the producing countries were nationalized, and the role of the oil companies was transformed into service contractors and crude oil buyers. This change simplified the crude oil pricing in the market, such that the national oil company unilaterally announced the price of oil.

Saudi Arabia has good relations with the United States of America through the oil companies that invest in its territory and oil exploration. However, Saudi Arabia was not happy with that, because the U.S. was supporting the common enemy of Arab countries (Israel) in the war of 1973. Thus, this support forced Saudi Arabia to use oil as a weapon for the first time, where 10 ministers of the Arab oil met and decided to cut production by 5%, and then Saudi Arabia has cut to 10% which led to increase the fear of the main consuming oil countries. Thus, it is the first time that OPEC reduced oil production without returning to the cartel of oil companies. In sequence, Saudi Arabia nationalized 20% of its share in Aramco Oil Company then to 60%, and 100%, which encouraged the movements of nationalization for the rest of OPEC members. The cut in oil production during the war in 1973 showed two things: first, oil consuming countries largely depended on Middle East oil, especially OPEC. Thus, threatens the security and stability of the oil market during the crises. The second thing is a shift in the real market forces for the benefit of OPEC as a new dominant for the oil market.

The International Energy Agency (IEA) has established as an important tool for the major oil consuming countries to face the new threat, "OPEC". This agency has announced a number of laws and regulations to regulate the energy consumption and protect the interests of consuming countries members such as; built a strategic oil stock to meet the interruption of oil supplies in the future, as well as a number of instructions to rationalize the consumption of oil, also increased the investment in alternative energy sources and reduce dependence on OPEC oil through imports from other areas such as the North Sea, Canada and Alaska (Simmons, M. R., 2005).

Political events started coming in, one after the other starting with Iran 1n 1979 where was a mass revolution disrupted production and contributed the increase in oil prices. Meanwhile, the Iran - Iraq war in 1980 started, the seriousness of this war was among two big OPEC members that could threat the flow of oil. The war caused a big jump in oil prices to more than 40 $/b as shown in Figure 2.2 (Simmons, M. R., 2005). But meanwhile, consuming countries were able to absorb this crisis gradually as a result of the well prepared of IEA countries to face the second shock. The eighties witnessed a continuous decline in oil prices with a fall in OPEC quotas in favor of non-OPEC producers and national companies.

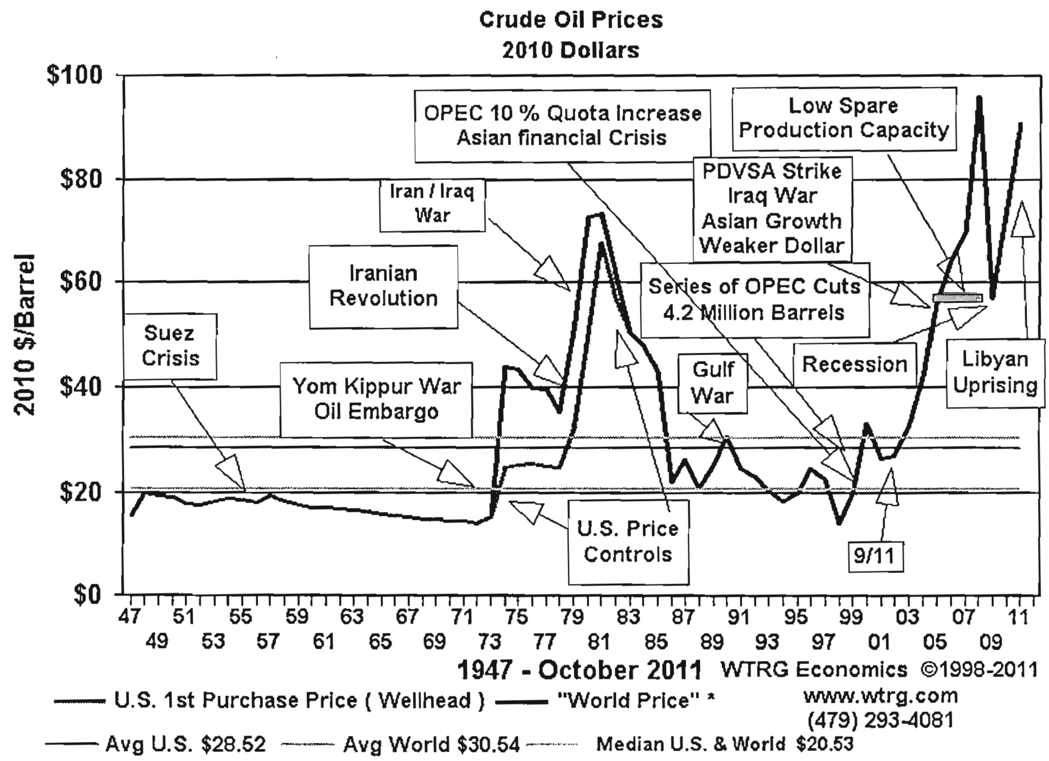

Figure 2.2
Oil Price and Political Events 1947-2011

The Figure above illustrates the most important political events that affected the oil market from 1947 till October 2011. At the end of 1980 and early 1981, the spot market for crude oil exceeded the official price by $2-$3 and reached their peak of almost $37 in late 1980 and early 1981. Thus, we see that both price shocks in 1973-74 and 1979-80 were triggered by political instability and prolonged uncertainty about stability in the Persian Gulf region.

In the following years oil prices have fallen steadily, as a result of low demand and the cheat in quota of OPEC members. OPEC was unable to act the group to keep the production down Also the production from the non OPEC countries increased. Thus, OPEC became a swing producer which means OPEC produces the difference between world demand and non OPEC production. Therefore, In January 1985, OPEC established a new system to audit oil production by member countries. However, this audit was intended to provide information only and, in the absence of an enforcement system, the audit system was disregarded too. The competition between OPEC and non OPEC producers and OPEC cheat made pressure on the oil prices to fall less than 12 $/b in 1986. In the beginning of 1990s, the conflict between Kuwait and Iraq started. Thus, oil prices rebounded back to 18 $/b. In spite of the Gulf war was a major political event, it did not affect the price of oil as much as previous crises.

1997 witnessed the Asian financial crisis, which led to reduced demand for oil and the economic recession later, and this illustrates the sensitivity of oil prices to crises, whether political or financial. The total nominal gross domestic production (GDP) in the region decreased at the time and therefore the price of oil fell instantly to 8 $/b.

2.2.1.3.2 Crude oil prices from 2000 - recently

Several experimental studies confirmed that the period after 2000 was unstable (Krichene, 2002; Mobert, 2007; Kaufman, 2011). This is due to several variables; the financial market size increased, political conflicts increased like Israel-Lebanon in 2001 and Arab conflicts in 2011, oil demand grown up as a result of the increase in economic growth rate of East Asian countries such as China, India and Malaysia, the significant increase in future market contracts and speculation. In addition, new theories have emerged, such as bubbles theory to explain the changes in oil prices, and to find an answer for this volatility and instability in the oil market in different periods, for example; the economic recession in 2008 and the recovery in 2009. This period can be divided into three sub-periods according to the movement of oil prices:

2.2.1.3.2.1 2000-2003

This period was characterized the stability of oil prices between 22 -28 $/b, OPEC has been succeeded in organizing its production to keep oil prices at the level mentioned. It was useful from their experience in previous years when prices fell to 10 $/b in 1998. However, the second Gulf War in 2003 did not significantly affect the stability of the price (Chevalier, 2010).

During the period 2000-2003, the oil prices continued to sustain the rise due to the growing U.S and the global economy. Nevertheless, this increase was suddenly broken up by the increase in production that coming from Russia. Also at the same time, the political effect of terrorist which attacked the World Trade Centre in 2001. These events made a pressure on oil prices to fall gradually.

Through the year 2002 a number of events kept crude oil price near to $30 per barrel (p/b). The first was in January when OPEC decided to cut their production quotas by 1.5 mb/d; combined with the political effect when Iraq did not agree to United Nations arms inspectors to go back to Iraq. The previous events put a small pressure on the price. By mid-year the EIA issued data showing that oil stocks fell to their lowest levels in the last twenty years around $32 for WTI oil price. This decline can be explained due to the general strike in Venezuela and the geopolitical events in the Middle East at the same time (EIA, 2007).

2.2.1.3.2.2 2003-2008 (The upward trend in oil prices)

Oil price of West Texas Intermediate (WTI) has increased slightly to 60 $/b and then to 80 $/b as a result of a combination of factors such as;

- The increase in global demand due to the strong increase in world economic growth, especially emerging countries in the east of Asia.
- The significant increase of oil demand from China and India, especially in the last ten years in line with the evolution in these two countries. In fact, many analysts argued that China and India have reshaped the landscape (annual energy outlook, 2006).
- The global demand for oil exceeded global refining capacity in 2004, especially after the new instructions of Energy Agency that urged the use of light oil, for reasons related to the environment and reduce the risk of environmental pollution. Thus, these instructions increased the pressure on refining utilization and thereby raising the price of oil.
- The rapid growth in the financial field - the volume of transactions increased to about 35 times a day from the oil trade in the actual market (Chevalier, 2010).

In the beginning of 2003 oil prices increased gradually from $32.5 per barrel to become over than $40 p/b in the end of 2004. This increase has continued to become $58 p/b in the beginning of 2005. In sequence, oil price increase more than $60 in August 2005, and then briefly rose over $75 in the mid of 2006 (EIA, 2007). The price after that jumped steeply to $99 by the end of the year. During 2008, oil price had been enormously volatile. In the first half of 2008, the price Jump to reach the highest level about $147 p/b but fell down again in less than $100 at the end of 2008(EIA, 2009).

The early increase in crude oil price in 2003 was generated by the political events in the OPEC member countries that make the oil market instable. First, Venezuela faced problems in production as a result of strikes and the political changes in January followed by the threat of the U.S. invasion of Iraq as well put high pressure on the prices. Especially, due to the dependence of United State on the Iraqi largest oil reserves. During U.S. invasion, in the mid of March, the Iraqi production declined rapidly and the price rose to $31 p/b. Second, Nigeria also faced political unrest at the same time, when violence broke among several ethnic groups in the Niger Delta area. Simultaneously, the demand for oil was continually increasing in this period, especially from Asia Pacific due the increase in the rate of economic growth in these countries. The U.S. witnessed a very cold winter in 2003 which made a significant increase in U.S. domestic consumption Moreover, The big loss of production capacity in Iraq during the second Gulf war. In addition, Venezuela and Nigeria combined with the increase in global demand and the price spike in 2003. Political turbulence in Saudi Arabia encouraged the increase in oil prices to the highest price in nearly two decades at that time, in NYMEX was quoted at $42 p/b.

Despite numerous attempts by OPEC to maintain crude oil prices and prevented from rising abruptly, but there are many indicators have been reducing non OPEC production and increasing oil prices. First, the Russian government decisions by freezing all the assets of the bank accounts of Yukos (one of the largest oil producers in Russia). Second, oil market strikes on September 2003 inflicted by Hurricane Ivan which hit the Gulf of Mexico and made about 61 percent production loss.

In late 2005, the oil price witnessed a small downturn when the Nigeria resumed its production after the conflict in the Niger Delta area. In addition, British Petroleum (BP) begins their first commercial crude oil production exactly from the Central Azeri field in the Caspian Sea. Therefore, the price started in on to rise once more and reached $58 p/b in April 2005. This is increasing in oil prices also attributed through the concern of the weak dollar for a long time.

In July and August 2005 the price continued to raise severely chiefly through the disruptions in production those results from the natural disasters in the Gulf of Mexico such as; storm Cindy, Hurricane Emily, Hurricane Dennis and Hurricane Katrina. Those Hurricanes made severe damages to Gulf of Mexico production facilities. In addition, the hurricane had a significant impact of the oil refineries in the area because refining capacity has declined about 2.2 mb/d, which drove the price of crude oil to rise to $66 p/b September 2005. As a response to the previous hurricanes, the United States government tried to reduce the pressure on oil supply by releases 30 million barrels of crude oil from the Sulphate Removal Package (SRP).

In 2006 European production faced difficulties through worker strikes in one of the largest oil refineries. In addition, Labor conflicts in the Netherlands and Nigeria affected oil production, as political instability started again over the Middle East. All the previous events had put more and more pressure on the oil price. Generally, a several factors made upper pressure on oil prices and contributed the rise in the first half of 2006; a rising total oil demand combined with weakened in oil supply at the same time and natural disasters with geopolitical instability. OPEC adjusted its oil output levels, and attributed the rise in oil prices to the lack of excess global refining capacity, not to the lack of production by the members of OPEC.

Oil prices till the first quarter of 2007 was quite stable, circling at around $60 p/b. Then the price raised to $73 p/b and in the mid of October WTI traded at$ 90 p/b. This increase was due to a combination of the political turbulence in Nigeria and Turkey in addition to a disturbance of the pipelines in Mexico and an accident and the North Sea (EIA, 2008).

2.2.1.3.2.3 The period 2008-until recently

At the beginning of 2008 oil prices reached new levels and break the all-time record. In January opened trading at a price $ 100 p/b which came mainly due to political events at that time. Then in March the price reached $ 110 p/b and increased again in April to $119 p/b. This increase was due to the political events between the U.S. and Iran; when the U.S. Navy opened fire on one of the Iranian boats when they reach the port. Then, oil prices continued to rise robustly making it the biggest one day raise in history and by the end of the month London Brent Crude was trading at $ 147 p/b. The main driver for this price increase was probably the political instability in the Mid-East and they were afraid of the possibility of Israel's attack on Iran.

The price jump was due to the tautness between the U.S and Iran (the second largest member of OPEC); and the fair from OPEC that could retaliate by blocking the Strait of Hormuz. By the end of July the price of oil jumped down to $128 p/b and in August declined also to be $113 p/b, finally by the end of 2008 summer the price became around $100 p/b.

In the beginning of September a Hurricane hit the Gulf of Mexico, which is considered the heart of the U.S oil refineries. Nevertheless, the oil price declined closing at about $100 p/b and In late September oil price fell down below $100 p/b when the U.S. Congress failed to pass the 700 billion dollar bailout program.. On October oil traded between $ 70-78 p/b, this drop can be explained by the effectiveness of the U.S. bank rescue plan to re-establish demand and OPEC production cuts were among the events that affected the price. Moreover, US dollar became stronger and the confidence in it increased. Also, the decline in European demand has also supported the oil price decline (EIA, 2008).

The crisis period can be summarized as; WTI oil prices increased in the begging of 2008 to become around 147 $/b in July of the same year. Many analysts see that this crisis caused by economic factors; when confidence in banks decreased, the customers withdraw their money and deposits from banks at one time, this action led to the bankruptcy of many of the banks at that time. But after July of 2008 oil prices fell again to become less than 40 $/b in December of the same year. Analysts like Kaufman (2008, 2011) and Mobert (2007) argued that the decrease in oil prices belongs to financial adjustment and falling in oil demand in the same time as shown in Figure below:

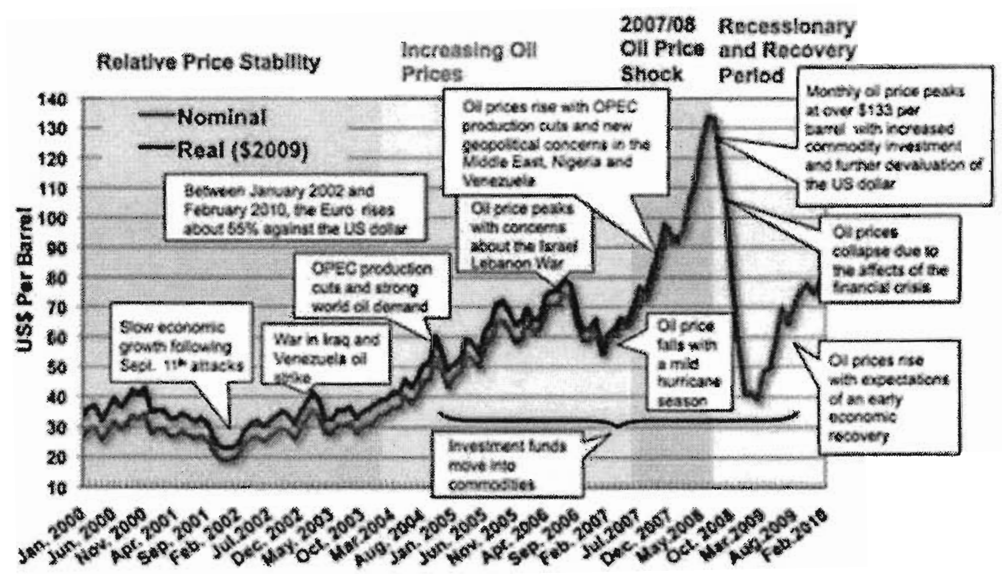

Figure 2.3

WTI Oil Prices 2000-2010

Source: Hamilton, J. D. (2011). Historical oil shocks

The Figure above shows the evolution of WTI monthly oil price during the period from January 2000 to February 2010 in nominal and real dollars in the United States, which clearly shows the crisis in 2008, followed by the great depression in 2009. Then prices started to rise again in 2009, rose to 80 $/b and this increase can be explained by a reduction in OPEC production to protect oil prices and due the increase in oil global demand.

In summary, in the period 1970 – 2000 OPEC became the dominant party on the oil market instead of the cartel of oil companies, but this control gradually decreased due to the emergence of new producers and the success of IEA members to reduce dependence on OPEC oil and find new sources. In addition, the deterioration in oil prices when OPEC became a swing producer. Finally, the emergence of financial crises in Russia and Asia as a new type of crisis and the emergence of so-called call for cooperation between producers to prevent the decline in oil prices. The property of the period 2000- until recently was instability in oil prices, political events have increased, OPEC once again emerged as an influential force in the oil market, the emergence of new forces in the equation of demand such as China and India, growth in the future markets and speculation increased as compared to previous periods and finally, the emergence of new theories to explain the fluctuations in the price of oil and the presence of a global fear that the crisis could come back again.

2.3 Crude oil price theories

Economic theories of natural resources in general, and exhaustible or non-renewable resources in particular, may be classified into three major categories:

1) Supply side theories

2) Market power theories (geopolitics)

3) Demand side and behavior of investor theories

The theories above have been applied to models for the purpose of analyzing and predicting the behavior of natural resources.

2.3.1 Supply side theories

2.3.1.1 Basic exhaustible resources theory

The question of pricing of an exhaustible resource like oil and the depletion of non-renewable energy resources has engaged the attention of economic analysts and energy specialists as well as decision makers around the world. Thus, there are a series of questions relating to this subject; what is the speed of depletion of non-renewable energy resources, and what is the time limit for the expected depletion? Is it possible to substitute other energy resources when oil price become so high, and to what extent? What are the main factors that controlling pricing depletion resource? What is the relationship between alternative energy sources and environmental pollution?

A vital economic analysis used advanced mathematics emerged for more than half a century ago. Analysis of Ramsey (1928) resolute consumption savings, Hotelling (1931) showed how exhaustible resources can be managed optimally. However, examining the theory of exhaustible resources in this Chapter can provide the theoretical background for the economic analysis of determining the optimal rate of depletion and the price of a natural resource; the price and depletion rate, which would lead to a smooth transition to alternative energy resources without volatility in oil prices when the resource is exhausted. Hence, the review started with the pioneering works of Gray and Hotelling and continued to review the literature on other world oil models.

Solow (1974) summarized the pricing process of exhaustible resources as follows:" owners must expect the net price of the resource to be increasing exponentially at a rate equal to the rate of interest". Because in equilibrium the value of deposit resource must increase to the level of the rate of interest that cover the extraction cost.

2.3.1.2 The Gray Model

Lewis, C. Gray (1914) argued that" the owner of a valuable mineral deposit desires the maximum present benefit from the limited supply which he owns". But if he does not expect an increase in the price of his product, he might exhaust all of the resources that he has as soon as possible and transform it from a non-interest yielding asset to money, which would earn the prevailing level of interest. Thus, the owner is prevented from the immediate appropriation of the resource because of the limitations in the market and the law of diminishing productivity. In addition, if the rate of interest is high, the postponement of production would be less profitable rather than with a lower rate of interest. Vice versa, if the price is rising and the prospect is that the rise will continue, the owner of the mine will find it profitable to decrease production at the present because the resources at his disposal are limited. Therefore, the decision of the owner of an exhaustible resource to increase or decrease output depends mainly on the rate of interest, the law of diminishing returns, and the expectations about future prices.

2.3.1.3 Hotelling model

Hotelling (1931) developed a mathematical analytical framework that became the vehicle for most of the research work done in this subject up to the present. Actually, Hotelling analysis can be easily applied to oil's special characteristics; multi uses of oil, high capital and strategic commodity needs geological operations to extract. Thus the equilibrium price of oil is not set by its marginal cost of production. But, oil's price is set by the range of its current and future uses.

On the case of a firm using renewable resources, for example, the decision to produce today does not affect the costs of producing in the future. As a result, marginal costs (MC) consist entirely of the marginal production costs (MPC).In the case of depleted commodity, the decision to produce a barrel of oil today, for example, precludes the possibility of producing it in the future. Therefore, the marginal costs (MC) in period t for the non-renewable sources should be modified to include the conventional marginal production costs (MPCt) and user costs (Ut), which explains the opportunity cost of producing it today. As follows:

$$MCt = MPC_t + Ut \tag{2.1}$$

The fundamental assumption under the economic theory of exhaustible resources is that resource owners are wealth maximizes attempting to produce the resource in a manner which will maximize the present value of the asset. Using the same principle of wealth or profit maximization, and setting marginal revenue (MRt) to marginal costs (MCt); users' costs (Ut) are obtained as follows:

$$Ut = MRT - MPC_t \tag{2.2}$$

Since Ut represents the opportunity value of selling the last barrel in period t. Hence, the producer may like to switch production to some other periods which means, he may seek to maximize his profit in the long run. Therefore, he should distinguish between producing the last barrel now or in the future. As shown below:

$$U_0 = U_1 = U_2 = U_3 = \dots\dots\dots = U_t \tag{2.3}$$

U_0 is the opportunity cost for all periods, t represents the time required to exhaust the oil completely. The above equation does not take into account the fact that a dollar today is worth more than a dollar in the future. Thus, to reflect this fact, profit-maximizes should discount future user costs at the rate of discount (r) as follows:

$$U_o = \frac{U_1}{1+r} = \frac{U_2}{(1+r)^2} = \frac{U_3}{(1+r)^3} = \dots\dots\dots = \frac{U_t}{(1+r)^t} \tag{2.4}$$

The equation above holds for the last barrel produced in any period. Thus, the user costs must rise by the rate of interest. For example, if current world oil prices are \$100 per barrel (U_0=100) and the discount rate is 10 percent (r=0.10), the price should be 110 next year, 121 \$/b in two years, and go on. Otherwise, the producer should sell the oil immediately. If the producer expects the price will rise to \$120 per barrel next year, he may find it profitable to decrease production this year and increase it next year when the new high price takes effect.

Hotelling presented this model under both perfectly competitive and monopolistic conditions; under competition, price equals marginal costs, which include only the user costs (U0). By substituting prices (P) for user costs (U) into equation 2.4 we obtain:

$$P_o = \frac{P_1}{1+r} = \frac{P_2}{(1+r)^2} = \frac{P_3}{(1+r)^3} = ... = \frac{P_t}{(1+r)^t} \tag{2.5}$$

Thus, prices should rise by the discount rate as below:

$$P_1 = P_o\,(1+r), P_2 = P_1(1+r), P_3 = P_2\,(1+r), ...\text{etc} \tag{2.6}$$

Hotelling concluded that under competitive market conditions, the price of oil should rise at an annual rate that is at least equal to the interest rate in capital markets, assuming the social discount rate and the market interest rate are equivalent. Under the monopoly condition, where prices are larger than marginal revenue, based on the conventional monopoly model, Hotelling indicates that marginal revenues (MRt) will rise over time at the rate of interest as below:

$$MR_o = \frac{MR_1}{1+r} = \frac{MR_2}{(1+r)^2} = \frac{MR_3}{(1+r)^3} = ..., = \frac{MR_t}{(1+r)^t} \tag{2.7}$$

The result above is derived from the equation (2.2) with MPC=0 since the monopolist is facing zero production costs also. Certainly, the increase in marginal revenue will lead to a rise in the price also, which make the monopolist restrict production based on future price expectations. Hotelling mentioned that prices will be higher initially and annual depletion will be lower, which implies a longer period of utilization. Moreover, assuming that the monopolist is facing inelastic demand curve with constant elasticity at every point in the long run as well as the short run. But, oil demand is not a static function with constant elasticity; the long-term demand elasticity is greater than the short-run. Also the model assumes that the quantity of the resource is fixed and available at zero cost and it is also known with certainty.

2.3.1.3.1 Analyzing Hotelling assumptions

Obviously, the oil market is a highly complex and uncertain place of decision-making processes. In the oil market, political effects, changes in weather, and revolution may cause rapid and unpredictable changes in oil market conditions (Palo Alto; 1982). Uncertainty about future conditions and lack of dependable information about the major factors that determining oil prices. This matter will make some of the problematic assumptions of Hotelling model. In other words, there are significant difficulties in applying this theory. The model assumed that quantity of depleted of resources and their life was under certainty. But the prevailing uncertainties in the oil industry, these assumptions were not realized, especially during the conflict periods such as; 1973, 1979 and 1990. However, there are too many unknowns about the exact rate of interest, supply of the exhaustible resource, extraction cost, and so on.

Hotelling assumed that the social discount rate equals the private discount rate. But private resource owners do not always discount their profit at the same rate as the society wishes to discount its time preferences. If the private rate of discount exceeds the social rate, then private ownership of resources would lead to a faster rate of resource exhaustion when the preference of society might be to extend the life of the resource as long as possible. Governments tend to choose the lowest discount rate to face future uncertainties. Private resource owners, on the contrary, are likely to choose the highest rate of discount in the absence of future markets.

According to Hotelling theory, an increase in interest rates leads to decrease in oil prices. But historically, high interest rates coincided with high oil prices. Therefore, an increase in interest rates should raise the cost of new energy facilities to be more than the existing ones (Samuel A. Van Voctor and Arlon R. Tussing, 1986). In summary, Hotelling theory is one of the best contemporary theories that explained how to determine the price of a depleted resource under perfect competition and monopoly. However, some assumptions of this theory need to be rewritten in order to comply with changes in the market such as the assumption of certainty.

2.3.1.4 Deterioration cost theory

The declining in oil extraction cost is one of the important factors that affected oil cost over time. It is linked to the second element in the evaluation of assets, which constitute the stock in order to change the supply of the properties over time (Gaudet, 2007). As soon as wells depleted, it would be difficult to reach the remaining oil in the deeper areas, also the quality of oil will be lower. The marginal value of oil in the ground (situ value) as a non-renewable source could be considered as the opportunity cost of extracting the well now instead of extract it later when the increase in oil price encourages to do so. Thus, the marginal value of oil will equal its price, minus its extraction it costs $\Pi_t = P_t - C_t$. But as have explained in Hotelling theory, the growth rate of the opportunity cost of non-renewable resource should increase exponentially at a rate equals the rate of interest.

$$\frac{\Pi(t)}{\dot{\Pi}(t)} = r \tag{2.8}$$

The main objective is to find the optimal quantity of oil that maximizes owner utility in the future. Thus, owner's utility at times t will equals profit minus extraction cost.

$$\frac{\Pi(t)}{\dot{\Pi}(t)} = r \tag{2.9}$$

Utility of owner $= \left(p_{(t)} - c(s_{(t)})\right) q_{(t)}$

Where, $\Pi(t)$ is the marginal value of the resource in the ground (situ value)

of the exhaustible resource, $\dot{\Pi}(t)$is the opportunity cost of the alternative

interest yielding the interest rate r. $p_{(t)}$ is the current market price, $c_{(t)}$is

the unit extraction cost, $s_{(t)}$ is the remaining resource stock which is
depleted at speed $q_{(t)}$.

Next steps show the profit maximization problem with the integrals discounted to the current value:

$$\text{Max} \int_0^{¥} e^{-rt} \left[p_{(t)} - c(s_{(t)}) \right] q_{(t)} d_{(t)} \tag{2.10}$$

Where, $s(t) = - q(t), S(t), q(t)^3 = 0$

The utility of owner can be maximized from maximizing the difference between the current market price and the cost of remaining resource stock if the difference is positive. Thus, The Hamilton function for the problem above will be:

$$H(q,s,t,\Psi) = e^{-rt} \left[P(t) - C\left(s(t)\right) \right] q(t) - \Psi(t) q(t) \tag{2.11}$$

With the shadow price represented by the current opportunity cost or the marginal value of exhaustible resources at the dynamic time:

$$\Psi = e^{-rt} \left[pq - c(s)q \right]$$

$$\dot{\Psi} = e^{-rt} \left[\bar{c}(s) \right] q \tag{2.12}$$

If have assume that the value of the marginal value of the marginal source of depleted as

$$\pi(t) = \Psi(t)e^{rt} \tag{2.13}$$

Where r is the opportunity cost of the alternate interest (the risk free interest ra
$\pi(t)$ is the marginal value of exhaustible resource.

Finally, the Hotelling rule with deterioration costs can be solved as follows (the full formula derived in appendix A).

$$\frac{\dot{\Pi}(t)}{\Pi(t)} - \frac{\bar{c}(s(t))q(t)}{\Pi(t)} = r \tag{2.14}$$

But if the owner of the well will extract resource now instead of making extracting in the future, resources would be more expensive because developing the well needs extra cost. It can be recognized from the equation above. Hence, the location value rate will grow less than the rate of interest.

Moreover, the result reached by Hamilton, even under the rule of competitive markets, the prices of non-renewable sources must exceed the marginal costs of extraction. Hamilton explained that the scarcity of resources leads to scarcity rent, but positively, which is also associated with market power. However, some empirical studies have proven the contrary.

Gaudet, G. (2007) done an empirical study of oil price and different materials. He argued that changes in oil prices, natural gas, and many materials during the last hundred years did not follow the variation of rate of interest. In summary, deterioration of the oil fields and the cost of the extract could provide an explanation for, why oil prices increased. But it will fail in explaining the stability in oil prices or the decline in it in different periods such as the periods in the last three decades.

2.3.1.5 Theory of technological changes

This theory explained the effect of extraction technology on oil prices. Also explained that develop an extraction technology should make oil prices cheaper. By identifying extract costs $c(t) = ce^{-Bt}$. Hence, the exponential function refers to technological progress that reduces the cost of extraction at the rate B. Consequently, price growth in the market can take the following format:

$$\frac{\dot{p}(t)}{P(t)} = r\left[1 - \frac{c(t)}{p(t)}\right] - B\frac{c(t)}{p(t)} = r - (r - B)\frac{c(t)}{p(t)} \tag{2.15}$$

The change in market price in this equation is likely to be weighted by two factors; interest rate and the reduction in extraction costs resulting from the use of new technology which is cheap. Thus, when the share of the costs of extraction exceeds the rate of technological development will be the dominant factor in determining this relationship, and vice versa. When the share of the cost of extraction is falling, the market price will move very close to the levels of interest rates, and gives U shape to the path of oil price (Slade, 1982). In summary, this theory combines technological advances with the costs of degradation which contributes to some extent in explaining the price movements, and justifies the low initial price.

2.3.1.6 The price path theory

By defining the extraction cost for the equations presented above, the prices of exhaustible natural source should rise steadily over time and can explain the path of the price implied by Hotelling theory using the following format:

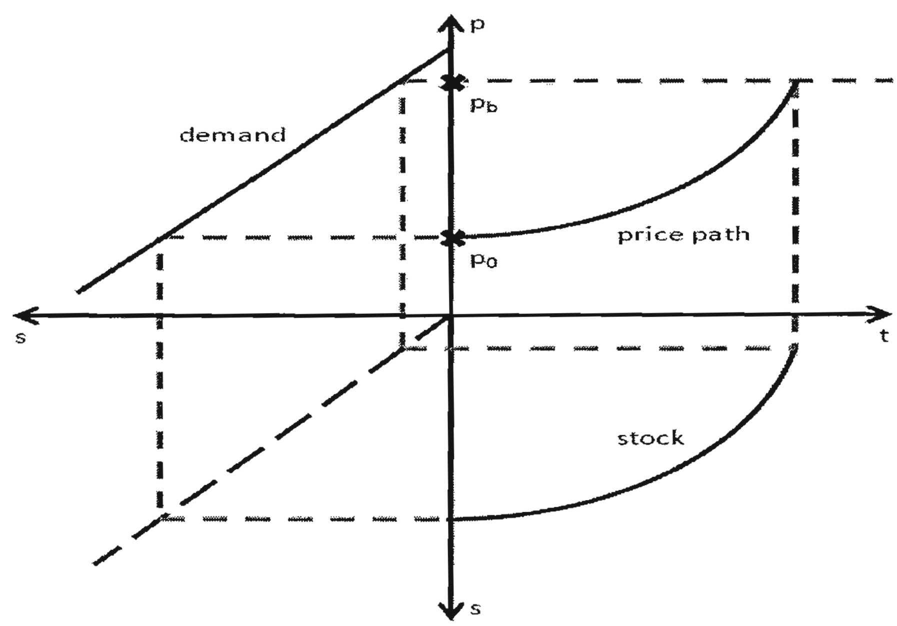

Figure 2.4
The Hotelling Price Path

Continues extract for the well will lead to a decline in the quality of oil extracted and reduction in storage quantity. This mechanism will continue until the price reaches the backstop price (Pb) which refers to the price of alternative resource that stop the extraction from the well; for example, assume that electronic energy shifts to nuclear energy, the extraction will continue till the price of the nuclear energy equals the price of extracting oil. In spite of the well is not fully extracted and the rest still in the ground, the producer benefit requires to postpone. This behavior can be explained due economic reasons, when the cost extraction of the rest oil in the well exceeds the oil price.

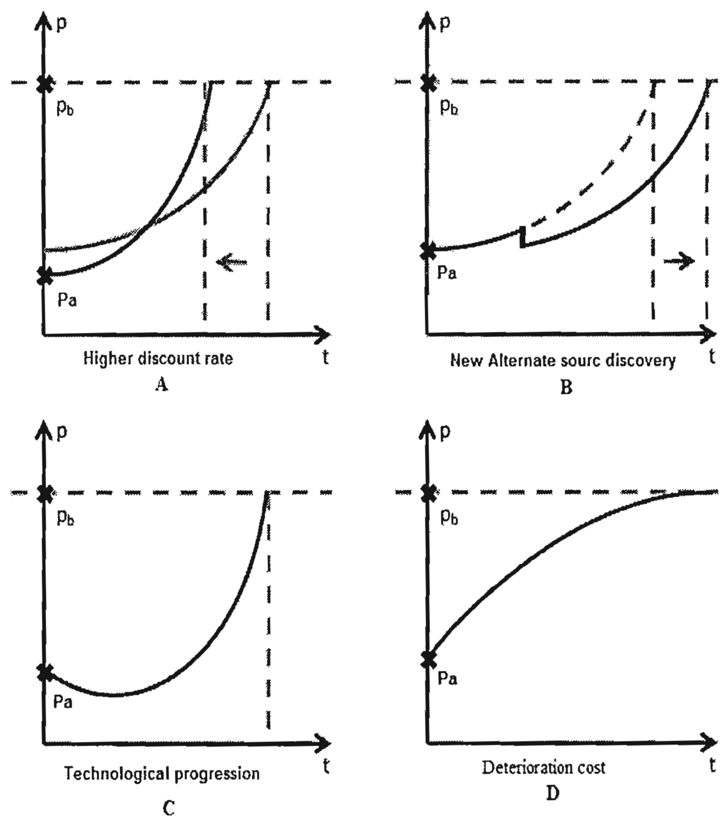

Figure 2.5
The Hotelling Price Path in Different Models

In other words, there may be some resources did not extracted from the ground, but there is no need to extract them anymore, because it's not economic, which means the alternative sources are cheaper. The price path could be illustrated in different kinds of situations according to the variables which be selected according to previously discussed theories. However, the Figure above explains four models for the Hotelling price path. Figure 2.5.A shows how a higher interest rate causes the stock of resources to be exhausted in the short time period, it started with initial price less than the backstop price because Pb will reach soon.

Figure 2.5.B illustrates the impact of the discovery of an alternative source on the path of the price. According to the theory of Hotlink, this discovery was made before production; this discovery will affect and change the direction of Pb path. Therefore the final path that will appear in the Figure depends on the interest rate and the remaining total stock. Figure 2.5.C shows the effect of technological progress on the path of the price; technological changes will reduce the cost. Hence, the price path will take the form of U-shape Slade (1982).

Lastly, Figure 2.5.D shows the impact of the deterioration of the costs on the path of the price. In this model, the price will never reach a backstop price, and also the marginal cost of extracting oil will rise relatively, leading to an increase in backstop price to meet the increase in demand at the same time. Therefore, the shape of the path will depend mainly on the form of cost function that is often convex towards the top, according to economic theory. In summary, Hotelling rule theory and its concepts are necessary to provide a basic picture of the long-term factors determining crude oil extraction. It is difficult to cover all the variables affecting the extraction of crude oil, under the strong economic growth, non-competitive markets, and technological developments.

2.3.2 Market power theories (Geopolitics)

There are many producers who have their weight in oil market. OPEC for example, can be considered one of the important players in oil production. The quotas of the organization have reached about 45% of world production in 2008 and 55% of exports of crude oil (OPEC, 2008). Hence, these are important indicators of market power.

Many studies classified OPEC as a cartel, according to its power in the oil market in terms of production and reserves. But this description may not be accurate. Because OPEC does not satisfy the conditions of a cartel as Alshalabi argued in 1986 . Also Alhajji (2000) emphasized in his study that OPEC is not a cartel, the cartel should have one price not different prices. In addition to the competition between OPEC's members, especially the mid-eighties which almost led to a price war and weakens it strength at that time. Therefore, many economists and analysts wonder, whether OPEC manages oil production to make the oil market relatively stable or is it working for its own interests to maximize revenues.

2.3.2.1 OPEC's role

Oil crisis in 1973 encouraged many writers and analysts to write about market power; it described OPEC as the dominant producer in the oil market in this period. Salank (1976) was one of the first analysts who used the concept of Nash-Cournot equilibrium. This concept meant that, some players ignore the other player's reactions; the rest producers will take the path of the price from the dominant producer. While the dominant taking into consideration of price path, the production and choices of marginal producers. Hamilton (2008) studied the share of OPEC production over the past five years, argued that although the numbers published for the production cannot be trusted because of cheat in the quota and non-compliance with the specified production ceiling. Also He found there is consistency between the share of OPEC and the real production.

The dominant model emphasizes the structure of OPEC as a cartel. In this model, there is one dominant producer. Saudi Arabia sets the price, allow the other OPEC producers to sell any quantity of oil they wish, to cover the rest demand. Therefore, Saudi Arabia was the swing producer, trying to absorb the fluctuations in supply and demand in order to maintain monopoly prices to protect member interests. With such an arrangement, the monopoly firm is easy to operate; this approach runs the risk of inducing sufficient new production outside of Saudi Arabia. And thus make the strategy unworkable and ineffective for the dominant producer. The problem that faced the dominant producer was; how to choose a price which maximizes its wealth over time. It can set high prices, which induces the competitor fringe, and it must accept the decline in future market shares and profits. Or, it may choose to set low prices to deter entry and expansion of fringe competitors; depending on the rate of discount.

We can also question the credibility of OPEC by looking at the ads reserves of member countries. Its proven reserves in excess of what seem exactly the amounts of production per year, and by the changes in the sizes which are almost non-existent. However, OPEC to be able to use its strength in the oil market, it needs to achieve two factors: first to be the existence of spare capacity, given the flexibility to respond to the market changes shortage or surplus. Hence, according to statistics announced by the energy information administration (2009) that OPEC's spare output capacity was averaging 2.8 million b/d during the period 1999-2009 and also by 2013, OPEC expects to have spare capacity output of approximately 6 million barrels a day. Also mentioned that Saudi Arabia has the largest capacity in OPEC's members and the world due Aramco huge expansion last year 1n 2008 (US energy information administration, 2009). The second factor that there will be internal discipline to control production, and this is somewhat verified in the last period, although the fraud exists, but the rate is lower than the market in the eighties.

The oil capacity of Saudi Arabia has been used in many cases to compensate for the reduced production in other places. This was undoubtedly a positive impact on the stability of oil prices. The Saudis were managing to achieve two things, stability in prices during the past years and increase their share as a dominant in the oil market in recent years.

2.3.3 Demand side and the behavior of investor theories

Oil passes through several stages and several parties contribute to it before arriving to consumers in final form. A lot of parties have different interests, assumptions and information business. Theoretical and experimental evidence has shown that oil price has bubbles, when the price did not correspond to the fundamental value based on oil supply and demand. Also, physical issues create a lot of possibilities of the arbitrage, when the owners of the arbitrage change. Therefore, it's important to study the effect of distortions on oil prices.

2.3.3.1 Storage theory

This theory explains the behavior of investors and speculators in the oil market. If investors expected that oil prices will rise in the future based on economic indicators, investors can borrow money now and buy the oil to store it and sell it later when the price rises to maximize their profits. This requires that the price satisfies the following condition.

$$P_{t+1} f(1+i)(p_t + c_t) \qquad (2.16)$$

c_t refers to storage cost, i represents the rate of interest, p_t the price of oil in the current year, P_{t+1} the price next year.

Assume an investor expected a rise in oil prices in the future, according to his experience or to some indicators. Thus, the price of oil next year could be represented by the relation $(EXP.P_{t+1})$ because no one sure about the future. Assume another investor hair and share the same information that was displayed from the first investor. So, they will buy oil from the spot market now and sell it later in the future. In this case, the spot market price will rise and the future price of oil will decline in the current year; at the same time storage of oil will increase. Vice versa if investors expected oil prices to go down. Hence the storage of oil will decrease and spot market prices will fall also as shown in the Figure below:

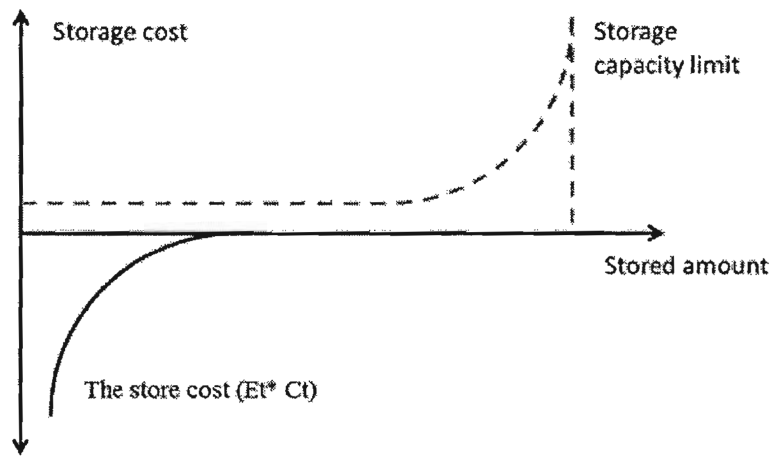

Figure 2.6
The Storage Cost Compared to the Stored Amount

The total cost of storage consists of the following factors

1. Physical cost
2. The opportunity cost (interest rate)
3. The risk premium for holding inventories (Hull; 2003) and Hamilton (2008).

The risk premium can be considered as "Convenience yield ". It is a non-financial benefit of holding crude oil inventories. Also convenience yield can be seen as a negative cost if investors failed in their expectations. On the other hand, could be considered as gains being realized from the expectations if it is right. Therefore, total storage costs-benefits can be simplified as the net cost of carrying oil C*.

Investors need to compare between two decisions to store or not based on their expectations for current price and the cost of storage as shown in the equation below:

$$E_t P_{t+1} = P_t + C_t^* \tag{2.17}$$

Investors could maximize its profits, not only through the oil is stored. They can use also future contracts. They can enter future contracts with other investors when they share the same information that oil will be sold in the future at the price F_t. This situation could be found when the investors buy a futures contract less than the price achieved in the spot market (Hull, 2003). However, the equation will be:

$$F_t = E_t P_{t+1} + \Psi_t^* \tag{2.18}$$

Where, $\Psi_t^* =$ transaction cost + risk premium + cost of marginal requirements.

Hamilton (2008) Argued that the equilibrium in both storage markets and future markets were required to hold at one time. Hence, if the oil price in futures contracts increased without any increase in the spot price; this process will encourage investors to store oil now and sold it in the future market later. And so on, storage will continue again till the equilibrium price covers the current price Pt and the storage cost.

$$F_t = P_t + C_t^* \tag{2.19}$$

Consequently, future prices will be to some extent, relatively higher than the spot market prices this is called contango. In addition, the cost could be negative if investors face unexpected changes in oil market fundamentals. Thus, spot price will exceed future price, this is called backwardation. Moreover, oil market can be in equilibrium if it is under backwardation or contango based on storage levels and its cost.

Ultimately, changes in futures prices as compared with spot prices are relatively low. Spot market price experienced the largest fluctuations. This relationship has been studied by Hamilton (2008), He concluded that the price of the current year Pt is the true price to predict prices in the coming year P_{t+1}. In summary, Storage theory illustrated the link between oil prices in the physical market and financial market due the relation between storage levels, storage cost and future markets.

2.3.3.2 Bubbles theory

Most of the previous theories focused on the supply side and market power. In spite of the significance of these variables, but it is not enough to provide a clear picture about oil price changes. Speculators, one of the factors that its importance has increased last decade. In addition, oil demand increased also based on the economic recovery and the increase in economic growth, especially in East Asia countries such as China, India and Malaysia, to meet the requirements of development.

Many analysts attribute the rise in oil prices in the last crisis to the behavior of speculators who distorted the oil market by creating unreal oil demand. Brunnermeier (2008) argued that oil prices in the last decade faced bubbles. He defined bubbles "Bubbles refer to asset prices that exceed an asset's fundamental value" because current owners believe that they are capable of re-sale the assets again in the future at a higher price. Also, he explained that there is empirical evidence that the price of oil could contain bubbles. In other words, oil price will not depend on market fundamentals only (supply and demand), but could be affected by the behavior of investors, according to the information available to them and the extent of homogeneity or variation of such information, and the different expected behavior of investors and the rationality of their behavior. Brunnermeier (2008) classified bubbles in oil prices too; rational bubbles, asymmetric information bubbles, bubble due limited arbitrage and heterogeneous beliefs bubble.

2.3.3.2.1 Rational bubbles

This model examines the behavior of rational investors who have the same information on the market. This model is somewhat theoretical and not easily applied in practice, not all investors are acting rationally, and complete identity in the available information to them is also too difficult to achieve on the other side. However, this can be achieved for some assets, for example, fossil fuels, does not favor its use because of pollution problems. Higher price for fossil fuels for any reason makes the rest alternatives cheaper. Therefore the demand will decrease and may become zero if the difference in the price was very high. The same thing happened to the goods that have fully alternatives which can be substituted with other commodities.

2.3.3.2.2 Asymmetric information bubbles

This model can be seen when investors have different information about the oil market, but they remain share a prior distribution. The prices in this model have a dual effect: it gives the index of the scarcity and gives useful signals at the same time on the oil market, because they reveal information gathered by other traders (Brunnermeier, 2001). It is not necessary that the presence of a bubble needs to be known commonality. For example, it may be any investor in general knows that the price exceeds the value of the revenue stream. However, even if there is an exchange of information among traders and investors and they can share their information. The discrepancy in the information of each investor will remain present, which shows that prices cannot fully reveal.

To keep the bubble persist, according to this model should meet certain conditions, including that there is some restrictions on the sale or purchase. Also, there is no doubt in the efficiency of the initial allocation, which may make investors believe that there can be gains from trade. This kind of bubble could be seen if the fund manager bought overpriced assets to make his clients believe that he has inside information of its own. If other fund managers will not buy as well as the fear of the potential risks of the accuracy of the information, they seem sleeves to their clients and may lose their customers; they seem such as they have a lack of information, which may expose them to risks of falling interest rate (Brunnermeier, 2008).

2.3.3.2.3 Bubbles due limited arbitrage

The third model examines the behavior of two types of investors; the first is the rational investors who base their decisions for non-psychological reasons. The second type is behavioral investors, who have influenced their decisions largely by psychological motives. Rational investors tend to attack the bubble and reduce their impact in order to arbitrage and make stability in the market, however, the bubble is possible to appear in several channels, including: first, make the key risks to the short risky asset bubble since the positive shift in the basics later had a subsequent retreat from the initial overpricing. Risk aversion limits the aggressiveness of traders and rational alternatives if the close hedges are not available.

The second risk can be resulting from noise traders on prices, which may lead to increased bubble and increase the risk of market instability and price volatility, which push up the oil prices in the future (Delong, 1990). Third, rational investors may face the risk of synchronization (Abreu and Brunnermeier, 2003). Behavior of individual traders cannot affect significantly oil market, but the synchronization behavior of traders in one direction will lead to expansion in the bubble size and growth. Each dealer will start asking himself when the other traders will face the bubble, and the timing of the reactions of other traders is difficult to predict. Thus, traders will face a lack of common knowledge.

2.3.3.2.4 Heterogeneous beliefs bubble

The fourth model illustrated that bubbles can occur when there are varying beliefs on the evaluation of the basic variables in the oil market such as; supply, demand and prices. According to this analysis, the investors may agree or disagree about the pricing; so they have identical information about the oil market. In other words, if the investors have the same signs or indicators of the oil market, the behavior of investors will vary because of the differences in their initial beliefs; therefore the bubble will appear to reflect this contrast. Also, they will not share their information about prices with the new traders. Combination of heterogeneous beliefs with existing restrictions on selling in the short term can lead to excessive price rises and pushing asset prices to higher (Brunnermeier, 2008).

2.3.3.2.5 Speculation and bubbles theory

Speculators in the oil market are the investors themselves, who do not deal with the real demand and supply of oil, but take care of the Securities only. In other words, they do not care about any, except the changes in the value of derivative securities of oil compared to the holdings. Their goal is to maximize the profit and they are playing a negative role in oil markets by creating extra demand, not a real demand in oil market which increases the instability of the oil market. The number of speculators in the oil market significantly increased in recent decade because of the ease to buy or sell by using the Internet and facilities using new technologies. Also, due the increase in the volume of money and assets traded in the market and due the increase in index trading. Speculators are diversifying their investments in different asset classes to reduce the risk pursuant to the base (do not put all your eggs in one basket), especially in the oil market. Thus the entry or exit of speculators in the oil market depends largely on their expectations for the future and their optimistic or pessimistic view of oil market.

According to Masters (2008), assets in investment funds for trading strategies of goods increased from $ 13 billion in 2003 to $ 260 billion in 2008. The implementation of these strategies through future markets and sold before the expiration date. Then used the proceeds to buy futures contracts again in the next month, and this strategy will continue again continuously. As the futures market is a zero-sum game; an increase in the size of the procurement of oil will drive futures prices to rise against the market fundamentals. In other words, there will be many sellers will take advantage from this situation before balancing delivers profits and the bubble bursts. However, this kind of situation may be limited by arbitration risk aversion and uncertainty about the information in the oil market. Thus the positive bubble in futures prices should not lead to an increase in spot prices, but only an increase in oil storage.

Borenstein (2008) finds that oil prices increased by 30% would require storing 3% of world oil supply and also he explained the importance of the rate of interest on the changes in oil demand. There is a situation where the bubble of any futures can lead to an increase in spot prices, when there are no clear implications for storage. If the spot price is completely elastic in the short term, any increase in the price of futures contracts will lead to increase in the current price of the amount itself. Thus, it makes futures traded and investment is more profitable, leading to an expansion in the bubble (Hamilton, 2008).

A report issued by the Prime Minister's Office in the United Kingdom (2008), this report shows another mechanism for the transfer of bubbles futures in the spot market. The report argued that market conditions will be largely responsible for pushing oil prices towards the top, only if there is a possibility to store oil. Because the current storage capacity will allow the seller to use negotiating power efficiently and effectively, and thus it is expected in this case that oil prices will increase, and there will be no need to use the oil storage or increase it. Despite the lack of evidence about this mechanism, it seems reasonable in theoretical side, to some extent (Janne, 2009). The report also studied different groups of market participants that succeeded to change oil price. This report aimed to find out, do investors can manipulate prices by changing their behavior, and to what extent. Moreover, the report concluded that there is a positive relationship between the traders and speculators and oil prices. In other words, most of the participant groups in the oil market showed a significant relation between changes in oil prices and the investor's behavior. The report also argued that hedge funds and speculators have the most impact of changes in oil prices.

In summary, the interest of analysts around the bubbles increased in the last decade. Brunnermeier (2008) classified bubbles in oil market to four main models; the first model assumes that all investors have rational expectations and the information is identical. The first model showed that bubbles followed the explosive path. But in The second model investor's information is asymmetric and non-identical, and that the bubbles could appear to reflect this difference in the investor information. The third model focuses on the interaction between rational and irrational traders (behaviorist), bubbles will continue, according to this model till the balance between investors will occur. Finally, the fourth model could arise if investors hold non-homogeneous beliefs, due to the potential psychological biases. Therefore, bubbles can occur to reflect the difference in the fundamental value that they agree or disagree about it. However, many questions remain unresolved so far. For example, there are many models, but they did not explain convincingly why and when the bubbles begin to appear.

In addition, most of the models explaining the behavior of bubbles, it will burst at the end of it, when in fact seem to be the bubbles diminish and become smaller after several weeks or even months, as what happened in the crisis of oil prices in 2008. The models which talked about the rationality and irrationality, these models did not explain why traders are not able to eliminate the mispricing introduced by traders' behavior. Moreover, these models did not explain the role of central banks to face the bubble and mitigation it, as happened in the recent crisis 2008. Despite these shortcomings, which stated, this theory remains one of important theories that explain the behavior of oil prices from the perspective of the demand side and speculators.

In summary, the theories of exhaustible resources focused on the supply side and put a basis for pricing of crude oil. It also explained that the net value of the resource or marginal profit, cost should increase by an annual rate equal to the rate of interest over time. Hence, it is a basic explanation for long run oil prices. The theory of market power focused on the geopolitics factors. Also, it tried to analyze OPEC's behavior and displays the importance of OPEC in the oil market as a political cartel. However, the dominant model represented OPEC as a cartel or dominant producer and Saudi Arabia could be the swing producer.

The third group of theories focused on the demand side and explained the behavior of speculators in making their decisions under different models. It showed that oil prices contain volatility and it was fluctuated; volatility in oil prices cannot be related to supply and demand variables alone. However, the theory reflected the importance of speculation, especially in the last decade, but did not explain the causal relationship. The fourth theory studied the speculator behavior and demand side to explain the bubbles in oil prices due four categories; rational bubbles, symmetric information bubbles, bubble due limited arbitrage and Heterogeneous beliefs bubble. The theory also reflected the importance demand side and investor behavior in the oil market.

2.3.4 Oil prices and empirical studies

Since 1973, economists have devoted considerable attention to analyzing how oil prices are determined. Some used complicated econometric models (Cremer and Salehi-lsfahani, 1991) while others looked at the political economy, such as (Griffen and Teece, 1982; Adelman, 1990; Stevens, 1995; Mabro, 1992). More recent approaches incorporate newer developments associated with commodity trading instruments (Vcrleger, 1991; Horsnell and Mabro, 1993; Banks, 1998).

The previous work on crude oil price modeling has in general focused on two theoretical aspects, the optimal control analysis of the pricing of a depleted resource and OPEC as a monopolist setting oil prices to maximize net present value. The methodologies which used in these studies include: simulation; the theory of exhaustible resources; game theory; industrial economics; and the economic efficiency models. Some of these approaches can find in (Mabro, 1992; Griffin and Xiong, 1997) examined OPECs production behavior when some members cheat on quotas.

MacAvoy (1982) studied market fundamentals (demand and supply) to clarify changes in oil prices. Griffin (1985) extended the analysis by looking at four different production models for OPEC members by using data for the phase 1971-1983. These models were cartel; target revenue; competitive; and also property models. Jones (1990) restructured Griffin's competitive and cartel models by using data for the period 1983-1988. Due to the restriction that Griffin's analysis covered a period when oil prices increased, and because the rapid growth of non-OPEC supply after 1988 was accompanied by the rapid drop in oil prices during the two decades in 1980's and 1990's, Watkins and Streifel (1998) add the interest in the competitive model of oil production.

Generally, the literature on crude oil markets can be classified into two major groups. The first one used long-run inter temporal dynamic optimization to get the time path of oil prices and the rate of extraction of crude oil. It applies the theory of exhaustible resources with a little different extension to the oil market where crude oil is considered a non-renewable resource. The second group focused on the short or medium-term behavior of the oil market, wherein oil depletion is not considered and agents are not interested with long-run aspects of the oil market. It used supply and demand as the main variables that govern the oil market.

The theory of exhaustible resources as we explained in the previous Section, was pioneered by the work of Hotelling (1931) illustrated his role which known "Hotelling rule" that the price of the resource minus the marginal cost have to grow at a rate equal to the discount rate of marginal extraction costs, in competitive markets. The extensions of Hotelling's model allowed for variable costs due to resource depletion and due changes in the reserves. In sequence, Pindyck (1978) used exploration variable and the average cost of production. Hotelling as well extended his model by the look at monopolistic prices compared to a competitive price Hotelling (1931). Stiglitz (1976) argued that the monopolist's ability to use its market power mainly depends on the price elasticity of demand. Polasky (1992) analyzed the value of information generated through exploration activity. The exhaustible resources theory was also used to find the role of international trade in oil prices, while a big part of trade in natural resources is international in scope. This issue was studied by using models of resource-exporting countries. In these models, the resource-rich countries are believed to maximize utility which is derived from consumption and they are limited by the balance of payments.

Numerous studies have attempted to test the Hotelling rule; some clarify that the rule is a good depiction of the real world; others question the reliability of the Hotelling rule. Slade (1982) and Moazzami and Anderson (1994) found evidence that the price path follows a U-shape which explains that resource prices will increase at least, complying with Hotelling rule. Krautkraemer (1998, 2005) showed that the basic Hotelling model of finite availability of non-renewable resources does not effectively explain the observed behavior of non-renewable prices. Recent evidence employed that an updated data set on world oil and allows for market structure and different demand elasticities for different periods: 1965-1973, 1973-1981, 1981-1990, and 1990-2006. She demonstrated that the basic Hotelling model does yield useful insights and several realistic results (Lin, C. Y. Cynthia., 2008).

Heal (1980) and Hart, et al. (2011) studied the markets for several metals by using long term series of oil prices. They introduced the foundation of expectations concerning the discount rate. Their findings showed no evidence that the discount rate affects the rate of price change. In sequence, Kisswani (2014) illustrated why the Hotelling rule is not supported by empirical evidence. He also showed several issues that contributed to this confusion. One of the Hotelling rule assumptions is perfect information about the parameters of the model by whether agents and the parameters are also assumed to stay constant. However, in real life this is not true. Because of many changes; changes in the resource stock size; in the market structure also from competitive to cartel; changes in property rights from companies control "seven Sisters" to OPEC control for exploration and extraction and other additional variables that could affect the price path and extraction decisions including taste and taxation factors that affect the demand.

The literature in the second group has examined the demand, supply and oil price volatility in the oil market. A lot of attempts have been made to estimate the demand for petroleum products in different countries. Baltagi and Griffin (1983) focused on the demand of some petroleum products in the Organization for Economic Co-operation and Development (OECD).

Wasserfallen and Guntensperger (1988) argued that there is a significant relationship between gasoline consumption and vehicle stock in Switzerland. Blum, Foos, and Gaudry (1988) as well considered the relationship between gasoline demand and other macroeconomic variables in Germany. In sequence, Sterner. and Dahl (1992) got the same results by using another survey of the gasoline demand models. In addition, McRae (1994) studied and estimated the gasoline demand for a number of developing Asian countries by using econometric models. Eltony and Al-Mutairi (1995) looked at the relationships between production and consumption of petroleum products in Kuwait using cointegrating econometric methodologies.

Kaufmann, et al. (2004) studied the relationship between real oil prices and OPEC behavior. They argued that there is a significant correlation between actual oil prices, OPEC quotas, cheating amount, OPEC capacity utilization and OECD stocks. Mazraati and Jazayeri (2004) found the same results also.

Numerous studies have attempted to explain structural of world oil prices, but they did not succeed because they ignored the important variables that affect the behavior of global oil prices, such as the political and military factors. Aune (2010) rejected all traditional explanations of OPEC behavior (Cournot model, competitive model, the dominant model). In the middle of 1986, Roland and Lorentsen described simultaneous econometric model for global oil market for the Norwegian Ministry of Oil and Energy. They used this model to predict the direction and the movement of prices of crude oil until 2000.

Kaufmann, et al. (1994) described an econometric model of supply and demand of oil to show the effect of geological and political variables into the LINK model. The model explained the changes in oil prices due to market conditions and OPEC behavioral changes. The results showed that OPEC can play a big role in determining oil prices. Noureddine (2005, 2007) built a simultaneous equation model (SEM) for the global oil and natural gas to show the positive relationship between them and to differentiate between short and long run variables. The model studied the effect of the rate of interest on oil prices. Thus, the results argued that oil demand were inelastic in the short term. The results also explained that the decline in interest rates may lead to higher oil prices: it may lead to price crises in the oil market.

For the more recent oil price studies, Dees et al. (2007) developed an econometric model for the global oil market explained the main factors in the oil price equation such as; supply demand and OPEC behavior under competitive and cooperative. Kaufman used the term "price rule", to explain oil price changes due studying OPEC's behavior and market conditions. The model found that capacity utilization and OPEC's behavior were the most important variables in the oil price equation. Mobert (2007) developed an econometric model for crude oil prices. The model showed the main factors driving the change in oil prices behind the crude oil price series at that time. He studied the impact of futures market variables on oil price. Also, concluded that refining utilization, future markets and speculation were the main factors that may explain oil price changes in the last crises.

Kaufmann et al. (2008) developed an econometric model to study the oil prices from 2004-2006 due the data availability till 2006. They expand a quarterly data which illustrated by Robert Kaufmann et al. (2004) and they develop it to combine other variables such as; OPEC capacity, market conditions, refinery utilization, OECD stocks and future markets. Therefore, they built an econometric model for the period 2004-2006 to find the effect of supply and demand variables on oil prices such as refinery utilization and the conditions in the New York Mercantile Exchange to illustrate the impact of future markets on oil prices also. They used dynamic ordinary least squares because their model included a large number of explanatory variables. The study showed that most of the price increase could be explained by shifts in the futures market and that higher refinery utilization rates reduce crude oil prices.

Kaufmann and Ullman (2009) looked more specifically at the influence of speculation in relation to market fundamentals and reached the conclusion that speculators exacerbated the price increase, which was initiated by market fundamentals. Aguilera et al. (2009) studied the influence of oil supply and found that depletion of oil resources are not behind the high price level observed in 2008. Kilian (2009b) highlighted the importance of demand growth for the oil price shocks. The results of the author's structural VAR model point out that the oil price increase in 1979/1980 and after 2003 was driven by positive global demand shocks and those disruptions of crude oil production played a less important role. Hamilton (2009) concluded that scarcity rent was an important permanent factor during the price increase up to 2008.

After the global crisis of oil in 2008, oil scientists and researchers can be divided into two main teams, the first team believes that the market fundamentals are the most important factor in the interpretation of changes in oil prices. The second team believes that financial factors, the futures market and speculators are the most important factors in explaining the changes in oil price after the crisis. Therefore, once again, Kaufmann in (2011) built an econometric model to study the role of market fundamentals and speculation in recent price changes for crude oil. His model hypothesized that the price collapse in 2008 were driven by both, market fundamentals and speculative pressures, also the continuous growth in Chinese oil demand. He argued the role of speculation due the significant increase in US crude oil inventories since 2004. He concluded also that changes in oil prices were related to the behavior and impact of noise traders on asset prices to show the importance of speculative expectations on oil prices. In the following pages I will study some empirical models that related to our study.

2.3.5 The main models

2.3.5.1 Alshalabi model (1986)

Alshalabi (1986) used an econometric model for estimating the supply of oil for the Gulf corporation council (GCC). In this sense, this model is different from the other models that I will discuss, and it only considers a specific region of the world oil market. His model can be classified as a supply side model, focus on oil supply function only. In addition, lacks the demand function and does not attempt to identify the factors affecting the price of oil. Actually, it is a very simple static model focus on OPEC and non OPEC oil producers in the period 1970-1984. The supply determinants in his model were; real price of oil (in 1980 dollars) at period t, oil proved reserves at period t, oil production from other OPEC members at time t and oil production from non-OPEC nations at time t. The results of the regression were statistically significant and presented a good fit to the data as shown Table 2.2.

Table 2.2
Summary of Alshalabi's Model, 1986

Model type	Econometric, Static, Descriptive model
Data range	Annual time series1970-1984, Long ranged model
Endogenous variables (DV'S)	Total number: 1, Supply of oil in GCC
Exogenous variables (IV'S)	Total number: 4, Real price of oil, Oil proves reserves, OPEC oil production, Non-OPEC Oil production.
Aggregate or Disaggregate variables	Regional, Aggregate
Estimation method	OLS, correctional procedures were used to correct autocorrelation
Validation/ Test of Model	None
Objective	To estimate the supply function of GCC

2.3.5.2 Morrison model (1987)

Morrison (1987) offered an econometric model to estimate OPEC demand. The objective of this model was to identify determinants of oil demand. The demand equation has five independent variables which are: GDP represents consumer's income, GDP in the previous period,the official price of crude oil, the price of oil in the previous period, and demand for oil in the previous period. This model is not an equilibrium model and did not consider the supply equation and the factors that determine oil price. Also, the model gave a good fit to the data provided.

Table 2.3
Summary of the Main Characteristics of Morrison Model, 1987

Model type	Econometric, aggregate, and Dynamic.
Data range	Annual 1960-1985, long ranged model
Endogenous variables (DV'S)	Total number: 1, Demand of OPEC oil
Exogenous variables (IV'S)	Total number: 5, world outside the Communist area GDP, Lagged GDP, Oil demand, Oil price and the lagged price of oil.
Aggregate or Disaggregate variables	Global, Aggregate
Estimation method	Regression analysis
Validation/ Test of Model	None
Objective	Estimate the demand for a world outside the Communist area and identify the determinants of demand

2.3.5.3 Kaufmann model (1995)

This model is an empirical attempt to describe the world oil market for project link which integrates the effect of market fundamentals, geological and political factors. Kaufman highlighted OPEC behavior before 1970 as a price taker when the prices were set by the cartel. The period after 1970 showed OPEC as a dominant in the oil market. In addition, he developed and modified Griffin's model (1986) to determine the economic variables that affecting OPEC members decisions. Thus, he concluded that OPEC's quotas played a big role in explaining the changes in crude oil prices. In other words, his results explained the relation between real prices and oil production; he found that the effect of oil production depends mainly on the capacity of OPEC in competitive business.

Table 2.4
Summary of the Main Characteristics of Kaufman 1995 Model

Model type	Econometric, Aggregate, Dynamic model
Data range	Annual 1960-1990, Long ranged model
Endogenous variables (DV'S)	Total number: 3, world demand, global supply and price rule.
Exogenous variables (IV'S)	Total number: 12, TRC, SITC3, OECD production, capacity utilization, OPEC capacity, OPEC capacity utilization, OPEC behavior, stocks, Geology, political variables(Dummy variables for 1973 and 1986 shocks) and lagged price of oil.
Aggregate or Disaggregate variables	Global, Aggregate OPEC behavior
Estimation method	Regression analysis and ARCH (Engle)
Validation/ Test of Model	Granger Sims test for causality, LM (Serial Correlation) (Godfrey), LM (Heteroscedasticity), (Breusch and Pagan), ARCH (Engle) and Reset test (Ramsey).
Objective	Describes a new model of the world oil market for Project LINK to integrate the effect of changes in the geological and political environment to find a price rule.

2.3.5.4 Dees et al. (2007) model

Dees et al. (2007) explained the behavior of supply, demand and the price of crude oil by using an econometric model. Moreover, he illustrated the behavior of oil price through a formula called "price rule". He explained the price equation in two main variables, the behavior of OPEC and the market conditions. Finally, concluded that the share of OPEC and the utilization capacity had a moral influence in determining the price of crude oil.

Table 2.5

Summary of the Main Characteristics of Dee's Al. (2007) Model

Model type	Econometric, Aggregate, Dynamic model. A quarterly model for the world oil market that includes a pricing rule and demand and supply schedules for different regions of the world
Data range	Long ranged model, a quarterly data for world oil for the period 1984-2002
Endogenous variables (DV'S)	Total number: 3, Global demand, Global supply, price of oil
Exogenous variables (IV'S)	Total number:12 For demand equation: Real GDP, Time trend, Real oil price Production equation: cost of production, real oil price, capacity utilization for OPEC, capacity utilization for TRC, OPEC quota. Price equation: OECD days, OPEC cheats, capacity utilization, OPEC's quota
Aggregate or Disaggregate variables	Global, Aggregate
Estimation method	Regression analysis, VAR and VECM models
Validation/ Test of Model	Used Dickey–Fuller statistics to test stationary, dynamic terms in the ECMs. This is in line with unit root test
Objective	Describes a structural econometric model of the world oil market that can be used to analyze oil market developments and risks.

2.3.5.5 Kaufman model (2011)

Kaufman (2011) used VAR model to study the effects of fundamentals and speculation on crude oil prices and the collapse of 2007–2008. He found that the price spike and collapse of 2007–2008 are driven by both changes in both market fundamentals and speculative pressures. he hypothesize that prices rise sharply in 2007–2008 because the ongoing growth in Chinese oil demand runs into a sudden and unexpected halt to a decade long increase in non-OPEC production. Also, he explained the importance of OPEC spare capacity due the increase in demand on OPEC production, which leads to an increase in OPEC capacity. In addition, he argued that speculation played a big role after 2004 based on the significant increase in private US crude oil inventories since 2004. Also, due the statistical and predictive failures by an econometric model of oil prices that is based on market fundamentals.

Table 2.6

Summary of the Main Characteristics of Kaufman's (2011) Model

Model type	Econometric, Aggregate, Dynamic model. A quarterly model for the world oil market that includes a pricing rule and demand and supply schedules for different regions of the world
Data range	A quarterly data for world oil for period 1997-2009
Endogenous variables (DV'S)	Total number: 4,Global demand, Global supply, speculation and price of oil
Exogenous variables (IV'S)	Refiner acquisition, foreign, Non-OPEC production, OPEC production, Chinese Demand for oil, oil inventory and five month forward contract for WTI and the spot price for Dubai-Fateh.
Aggregate or Disaggregate variables	Global, Aggregate
Estimation method	Regression analysis, he used a VAR model. Tests of Granger causality for a VAR are used.
Validation/ Test of Model	The cointegrating relationship is estimated using dynamic ordinary least squares
Objective	To analyze the price spike and collapse of 2007–2008 and to find the effect of supply, demand and speculation on oil prices during the collapse.

The Table below summarizes the main differences for Alshalabi, Morrison, Kaufman, and Dee's models.

Table 2.7
Summary of the Main Comparisons between the Models

Model	Morrison (1987)	Kaufman (1995)	Dee's et al. (2005)	Mobert (2007)	Kaufman (2011)
Model type	Econometric, Aggregate, Dynamic model	Econometric, Aggregate, Dynamic model	Econometric, Aggregate, Dynamic model. A quarterly model for the world oil market	Econometric, Aggregate, Dynamic model	Econometric, Aggregate, Dynamic model
Data range	Annual 1960-1985, Long ranged model	Annual 1960-1990, Long ranged model	Long ranged model, a quarterly data for world oil for the period 1984-2002	Monthly, 2002-2006	A quarterly data for world oil for period 1997-2009
IV'S	Total number: 1, Demand of OPEC oil	Total number: 3, world demand, global supply and price rule	Total number: 3,Global demand, Global supply, price of oil	Total number: 3, Demand, Supply, oil prices.	Total number: 4, Demand,Supply, speculation and oil prices.
DV'S	Total number: 5, world outside the Communist area GDP, Lagged GDP, Oil demand, Oil price and the lagged price of oil	Total number: 12,TRC, SITC3, OECD production, capacity utilization, OPEC capacity, OPEC capacity utilization, OPEC behavior, stocks, Geology, political variables(Dummy variables for 1973 and 1986 shocks) and lagged price of oil	Total number:1 Demand eq. : Real GDP, Time trend , Real oil price Production eq.: cost of production, real oil price, capacity utilization for OPEC, capacity utilization for TRC, OPEC quota. Price eq: OECD days, OPEC cheat, capacity utilization, OPEC's quota	Total number: 15, For demand equation: Q-global, Q-OECD, Q-China, Q-India, OECD days. Production equation: Number of rigs, VLCC Charter prices, global refining capacity, OPEC's production capacity, OPEC quota, OPEC cheats.Price equation: OECD days, OPEC cheat, OPEC capacity, OPEC's quota	Total number:1 Crude oil prices for WTI
Aggregate or Disaggregate variables	Global, Aggregate	Global, Aggregate OPEC behavior	Global, Aggregate	Global, Aggregate	Global, Aggregate
Estimation method	Regression analysis	Regression analysis and ARCH(Engle)	Regression analysis, VAR and VECM models	Regression analysis	VAR model
Validation/ Test of Model	None	Granger Sims test for causality,LM (Serial Correlation) (Godfrey)LM(Heteroscedasticity) (Breusch and Pagan)ARCH (Engle,1982)Reset test (Ramsey)	Used Dickey–Fuller statistics to test stationary, dynamic terms in the ECMs. This is in line with unit root test	ADF test, HEGY tests, test for unit roots, vector error correction model (VECM), Chow tests, Johansen test with one lag, Saikkonen and L¨utkepohl test	
Objective	Estimate the demand for world outside Communist area and identify the determinants of demand	Describes a new model of the world oil market for Project LINK to integrate the effect of changes in the economic, geological and political environment to find a price rule.	Describes a structural econometric model of the world oil market that can be used to analyze oil market developments and risks.	To test the impact of supply and demand variables as well as futures market variables on the crude oil price.	

The previous models did not distinguished between the demand of oil for consuming and for stockpiling. Also, they did not highlight the demand from China since it became the second country in oil consumption after United States. Kaufman's model covered most of the important variables such as; capacity utilization, OECD days, OPEC behavior, but did not cover the new variables like, convenience yield, market insatiable and the financial variables. Moreover, they used ordinary least squares (OLS) models in general, except Dees, who used Vector Auto regressive Analysis (VAR) and vector error correction models (VECM).

In spite of the method of OLS, in general, it gives optimal estimates of the unknown parameters, but it is very sensitive to the existence of unusual data points in the data used to fit the model. Perhaps one or two outlets can sometimes critically skew the results of OLS analysis, which makes model validation, particularly with respect to outliers, important to obtaining sound answers to the questions motivating the construction of the model. In other words, the OLS method has limitations on the shapes that linear models can assume over long ranges, probably weak extrapolation properties, and sensitivity to outliers. Moreover, OLS method is useful if there is trending, but actual oil prices don't have trained. Therefore have adopted VAR models for our study, since VAR models are preferred for stationary variables without time trends. Trending behavior can be found by including deterministic polynomial terms (Helmut Luetkepohl, 2011).

Vector autoregressions can be considered a concise tool of summarizing data, usually has little sequential correlation in residuals. In addition, it can be used to investigate complex relationships among variables. So, for the following pages explained the advantages and disadvantages of using a VAR combined with empirical studies that used VAR.

2.3.6 Vector Auto Regressive Analysis (VAR)

Vector auto regressions Model (VAR) is a model used to find the linear interdependencies among multiple time series and the dynamic influences of random disturbances in the system of variables. VAR models simplify the univariate autoregressions (AR) models. The variables in a VAR are considered symmetrical; each variable has an equation clearing up its evolution based on its own lags and the lags of all the other variables in the model. VAR modeling does not require professional knowledge, that in advance was used in structural models with simultaneous equations (Aysu, 2010). Vector autoregressions can be considered a concise tool of summarizing data usually have little sequential correlation in residuals. Also, it can be used to investigate complex relationships among variables.

The vector autoregressions (VAR) model is one of the famous successful models which is flexible, and easy to use for multivariate time series analysis. It is a standard expansion of the univariate autoregressive model to dynamic multivariate time series models. The VAR model has tested to be mainly useful for describing the dynamic behavior of macroeconomic and financial time series and also for estimating. It frequently provides better forecasts to those from univariate time series and includes theory-based simultaneous equations models. Forecasts by using VAR models could be quite flexible because they can be made conditional on the potential prospect paths of precise variables in the model. As well, to data description and estimating, the VAR analysis can use also for structural impact and also for policy analysis. In the type of structural models, certain assumptions on the causal structure of the data under test are imposed, and the resulting causal influences of unanticipated shocks or innovations to specified variables on the variables in the model are summarized. In other word, causal impacts are mostly summarized with impulse response functions and estimate error variance decompositions (Insel, et al., 2010).

Multivariate synchronized equations models which used widely for macro-econometric analysis while, Sims (1980) promoted vector autoregressive (VAR) models as alternatives. It follows that longer and more frequently observed macroeconomic time series identified four models that described the dynamic structure of the variables. VAR models can use for this purpose. They naturally treat all variables as a priori endogenous. Thus, they account for Sims' analysis that the exigent assumptions for a few of the variables in simultaneous equations models dedicated and often not backed by fully developed theories. Limits, including exogeneity of some of the variables, have imposed on VAR models based on statistical measures.

VAR model setup shows that the current values of a group of variables are somewhat explained by past values of the variables included. However, because they express the joint generation mechanism of the variables included. The structural VAR analysis makes an attempt to find structural economic hypotheses with the help of VAR models. Impulse response analysis, estimate error variance analysis, historical decompositions and the analysis of estimate scenarios are the tools which have been anticipated for disentangling the relations between the variables in VAR models.

Generally, VAR models are designed for stationary variables with no time trends. Trending behavior can be captured by counting deterministic polynomial conditions. 1980s witnessed the discovery of the importance of stochastic trends in economic variables and the development of the concept of cointegration by Granger (1981), Engle and Granger (1987), Johansen (1995) and others have proved that stochastic trends can also be described by VAR analysis. But if there are trends in the number of variables it may be required to separate the long-run relations from the short-run dynamics of the generative process of a group of variables. VAR models are preferred where cointegration relations are not modeled explicitly though they may be present. The benefit of levels VAR models over vector error correction models is that they can also be applied when the cointegration structure is not given (Helmut Luetkepohl, 2011).

In general, a VAR analysis proceeds by first specifying and estimating a reduced form model for the Data Generation Process (DGP) and then checking its adequacy. Model deficiency can be seen at the last stage are determined by adjusting the model. If the reduced form model passes the checking stage, it may possibly be used for estimating, Granger-causality or structural analysis. The major steps of this modeling method are demonstrated in the Figure 2.7.

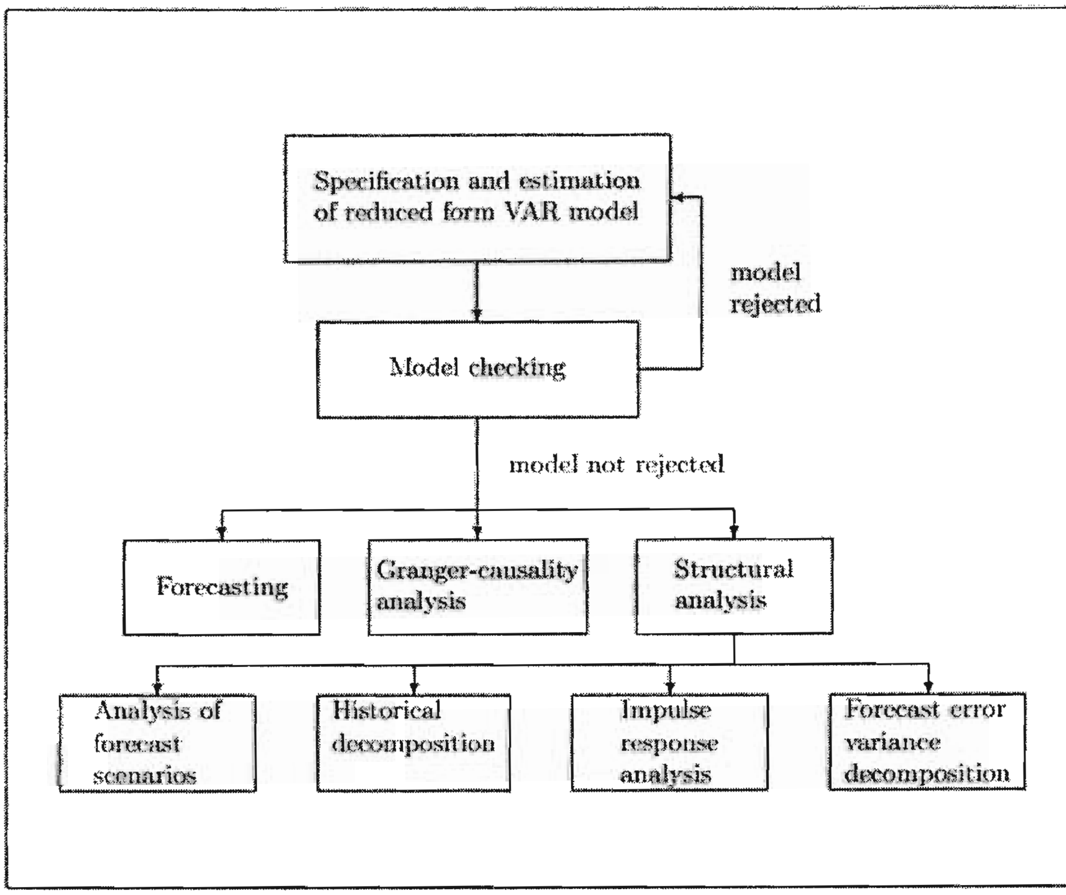

Figure 2.7
The Major Steps of VAR Model

2.3.6.1 Empirical studies which used VAR

Hamilton (1983) investigates the effect of oil price changes on the US economy by choosing seven variables for VAR model. He found that all but one economic recession are preceded by dramatic oil price increases after the Second World War. This does not mean that an oil price rise causes economic recessions. However, the increase explains a statistically significant correlation between oil price changes and economic recessions.

Burbidge and Harrison (1984) also run seven variables for VA R model with the monthly data of May 1962 - June 1982 for the following countries: US, Japan, Germany, Canada and the UK. According to the impulse response tests, the effect of oil price changes on industrial production in the US and UK was very big despite the fact that in Japan, Germany and Canada it is relatively small.

Hooker (1996) is found to some extent find different results that in data until the1973, Granger causality from oil price changes to US macroeconomic variable was exist, but if the data is extended to the mid 1990's the relationship is not robust. He investigates a few potential explanations about this phenomenon such as sample period issues, misspecification of linear VAR equations for the oil price and macroeconomic variables. But the data did not support that. In addition, his analysis also confirmed the fact that the oil price macroeconomic relationship has changed in a way which cannot be well represented by simple oil price increases and decreases.

Cologne and Manera (2007) investigate the relationship between oil price, inflation and interest rates with a somewhat different approach. They conduct a structural cointegrated VAR model for the following selected countries: Canada, France, Germany, Italy, Japan, United Kingdom and United states. They used the following variables in the short term; rates of interest, monetary aggregate, consumer price index (CPI), the real GDP, world oil price and the exchange rate expressed as the ratio of the SDR rate to the US SDR rate for each country (excluding US). For US, the ratio of the US SDR rate to the average of the other six countries' SDR rates are used for the exchange rate. In line with the impulse response analysis, it did not show a significant response of output to oil price changes at the level of 5% significance is found in all countries, whereas oil price changes have significant impacts on inflation and exchange rate. In the simulation exercises for estimating the total effect of the oil price changes in 1990, a significant effect in the US is due to monetary policy reaction. While in Canada, France and Italy, the total impact is offset partly by decreasing monetary policy.

Dotsey and Reid (1992) re-examine the effects of oil price changes and monetary policy shocks on the economy by using the VAR model. They found that positive oil price changes are associated with a decrease in industrial production, while monetary policy (M1) shocks are insignificant. Aliyu (2009) investigates the oil price shock effect on the macroeconomic performance of Nigeria from 1980 to 2007 by using the VAR model. He used different asymmetric transformations for oil price variables. They found significant positive effects of oil price increase in real GDP of Nigeria. Kilian (2009) estimates a vector autoregressive (VAR) model that specifies the first difference of global oil production, real oil prices. He supports arguments for the importance of demand-side in determining crude oil prices.

(Kaufmann and Ullman, 2009) used VAR model to study the origination for such a breakdown may be identified by an analysis of the price discovery process for ten crude oil contracts (spot prices for five crude oils and five future price contracts for three crude oils) Hamilton (2009) and Kilian (2009a; 2009b) argued the importance of the demand side and speculation. They attribute much of the 2008 price increase to a demand shock that originates in China. Fattouh (2010) used VAR model to study different grades of crude oil if their prices deviate by amounts greater than the spread that is implied by physical measures of quality (e.g. sulfur content, API gravity index). His results indicate that crude oil prices 'error correct' faster when their price spread exceeds some threshold, which presumably represents the costs of arbitrage .

Kaufman (2011) used VAR model to study the effect of fundamentals and speculation on crude oil prices. He found that the price spike and collapse of 2007–2008 are driven by both changes in both market fundamentals and speculative pressures. In addition, he argued that prices rise sharply in 2007–2008 because ongoing growth in Chinese oil demands.

2.4 Review the previous work on factors determining crude oil prices

Initially, WTI barrel at the beginning of 2007 was sold for about 91 \$/b, then at the end of 2007 prices record 145.31 \$/b, meanwhile, dropped to 30.28 \$/b just before Christmas 2008 (IEA, 2009). The Figure below shows daily WTI prices from January 2008 until the end of March 2009. This series seems to indicate a gradual downward trend in crude oil prices.

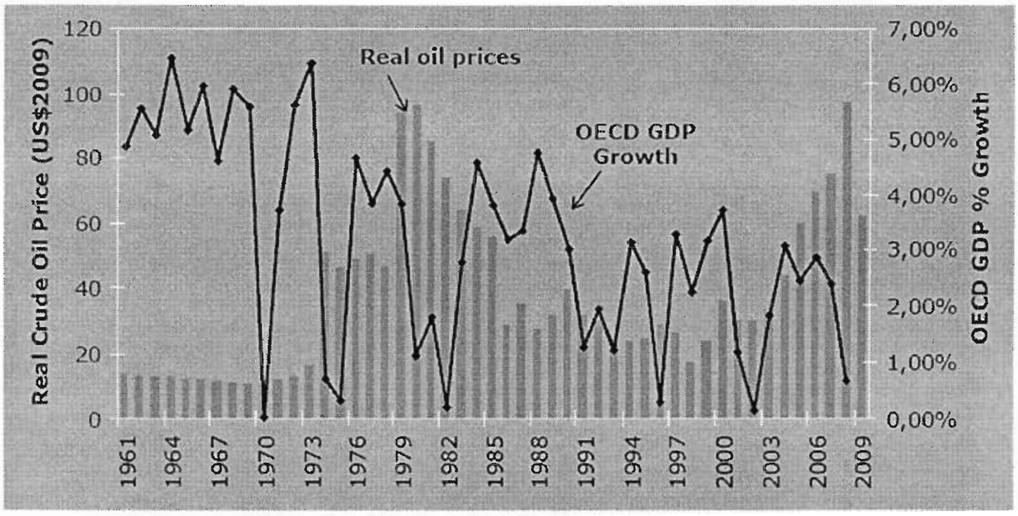

Figure 2.8
Real Oil Prices 1961-2009
Source: World Bank, Thomson, 2009

The Figure also, showed the real oil price volatility trend was followed OECD GDP growth. As stated in the introduction, there are a number of suppliers, demand and future market variables that are believed to have significant effects on oil prices, it might contribute the volatility of oil prices. Researchers, including (Mabro, 2006; Mobert, 2007; Fattouh, 2007; Dees, 2008) conducted econometric models to study the rapid changes in oil prices.

The rest of this Section will list the variables that affected oil prices and select the most important variables that played a big role in oil price changes. Therefore, these variables that will be divided into four main groups; supply variables, demand variables, geopolitics and financial variables.

2.4.1 Supply variables

Initially, this vsriable studied by many researchers such as (Aguilera et al., 2009; Fattouh, 2011; Kaufman, 2011), Aguilera concluded that Inexhaustible of crude oil resources was the main reason of oil prices rise in 2008. Fattouh (2011) argued that market fundmentals were the main reason for oil volatility in the last crisis. Moreover, Ali Naimi, Saudi oil and mineral resources minister, argued that the problem in the oil industry "it is not one of availability, it is a problem of supply" (Mabro and Fattouh, 2006). The coming words explain the main factors in oil supply equation.

2.4.1.1 Spare production and refining capacity

Many analysts argued that Spare production and refining capacity have significant impact on oil prices such as; Fattouh (2006, 2007), Mabro (2006), Mobert (2007), Dees (2008) and Kaufman (2011) argued that the deficitof production capacity in recent years tends to push up oil prices. Fattouh (2006) argued that the shortage of production capacity in the last two decades tends to push up oil prices.

Reduction in oil supply or increase in oil demand, especially during the crisis periods made pressure on crude oil producers and refiners to operate more and more; if refiners operate at or near full capacity will make upwards push on oil prices. Spare production and refining capacity have significantly decreased in recent years especially after the imposition of new laws of energy to reduce pollution, which lead to a preference for light oil to heavy oil, thereby increasing the bottlenecks in the refining capacity. As a result, the high utilization rate was the result of oil prices go up as shown in the Figure below:

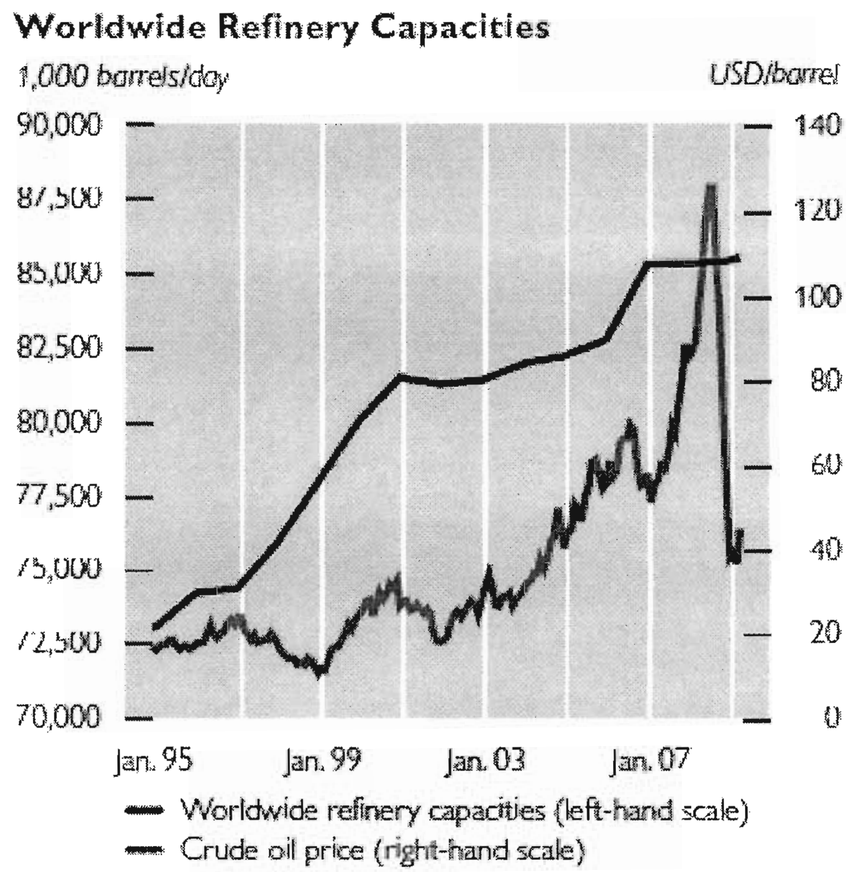

Figure 2.9
World Refinery Capacities and Crude Oil Price 1995- 2009, USD/Barrel
Source: Oil Market Report, EIA, Thomson, 2009

In another word, there is a negative relationship between refinery utilization and the price of oil, high rates of refinery utilization, helped to reduce the price of crude oil. Dees and Kaufmann et al. (2007) illustrated in econometric model that increases in refinery utilization rates have a negative impact on crude oil prices as refinery utilization increases; refineries will use heavy oil instead of light. Hence, the value of final products of heavy oil is less. Historically, the period 1995- 2009 showed an opposite relationship between world refinery capacity utilization and crude oil price (EIA, 2009). Higher levels of capacity utilization, both in up and downstream caused a pressure on prices and create volatility. For example the loss of U.S. refining capabilities following hurricanes Katrina and Rita in 2005. In addition, Shepherd (2009) used annual price data and capacity from 1986 to 2005 which derived from the EIA. He found an inverse relationship between spare capacity and crude oil prices.

2.4.1.2 Underinvestment in Upstream and Downstream

Crude oil production industry has three major sectors: upstream, midstream, and downstream. The upstream sector extracts, crude oil from sources such as land, seabed, or oil shale. Midstream sector consists of transportation in mainly a degree such as oil tankers, trucks, pipelines, and other materials or methods of transporting crude oil. However, The downstream sector refines crude oil down usable products such as gasoline, jet fuel and oil for heating. Hence,oil refinery industry constitutes the entire oil sector.

Kesicki, et al. (2009) argued that upstream sector was one of the reasons of crises observed in the middle of the 1980s; and also the recent oil price volatility. As the supply of oil increases, ceteris paribus, the capacity of utilization will increase also which explains a positive relationship between oil supply and capacity utilization. In other words, an increase in oil supply will encourage producers to utilize more of their production capacity. Producers and refineries cannot determine whether the rise in the price is temporary or permanent. If the producer or distiller thought that the rise is temporary; price will increase probably . Vice versa, If the producer or distiller took the increase in prices as dominant; then more additional investment expected to be added to capacity. Mobert (2007) showed that when demand exceeds refining capacity; a supply shortage of refined petroleum products expected in the oil market; which make upward pressure on prices. Vice versa, when demand is less; which means oil market faces surplus; oil price will fall.

In the downstream sector, high rates of utilization refers to the necessary investments in refineries, which have to adapt to the changing characteristics of heavy crudes to light crude, the main demand for petroleum products will be for light crude oil products. However, In the short run, if there are expectations of weak demand , low prices. It could not justify additional investment because there is no enough certain that returns can exceed the costs. These potential problems were not unknown. However, following the price collapse of 1986, Mabro (1986) concluded that low oil prices would hinder exploration and development of new oil fields, reduce refining capacity, and therefore contribute to lower crude oil output in the 1990s. As well, Baker Hughes (2009) studied the relation between the number of active rotary rigs and oil demand; he found this number could be a key indicator of demand products that used in the drilling process. He also emphasized that the number of active rotary rigs could be a good tool to measure the upstream investment in the crude oil industry.

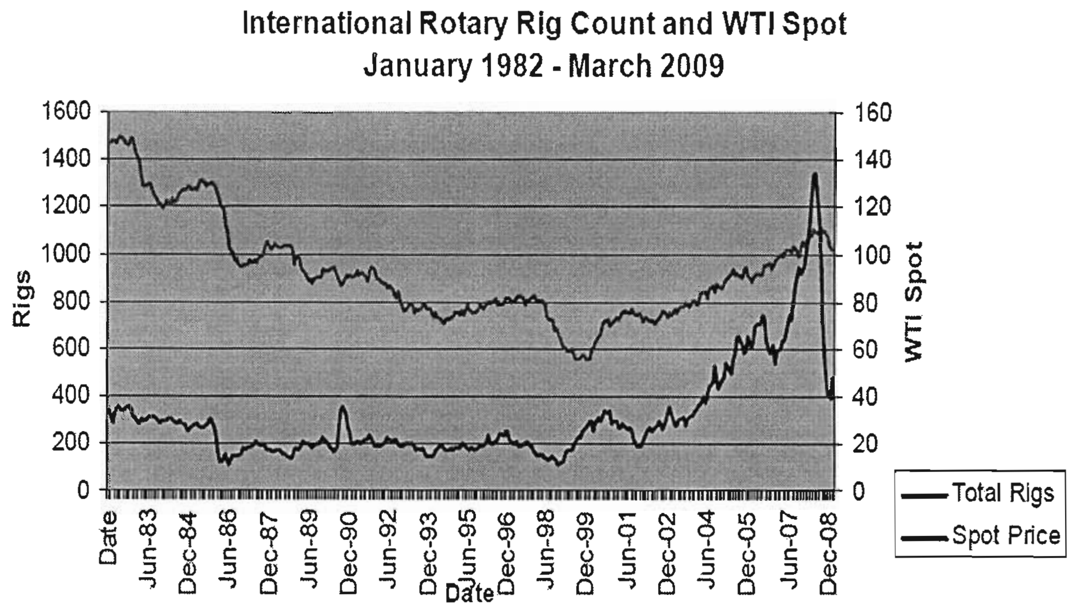

Figure 2.10
International Rotary Rigs and WTI Spot Price Jan 1982 – Mar 2009
Source: EIA website www.eia.doe.gov and Baker Hughes website: www.bakerhughes.com

From the Figure above it is clear that the number of active rotary rigs from 1982 to 2009 shows a positive relationship between WTI Spot Price oil prices and the number of active rotary rigs. Ringlund (2007) found that oil rig activity tends to increase oil prices in the long run. Furthermore, this study supported the above analysis that the periods of low prices will tend to reduce new investments due to lower prices; the revenues, perhaps will not increase enough to justify the cost of new investments.

In the short term, expectations of low demand and weak prices cannot justify additional investment because the investor would not be sure that returns exceed the costs. However, weak oil prices would decrease the exploration and reduce the investment in developing new oil fields.

2.4.1.3 Convenience yield and stock analysis

Convenience yield is non-financial benefit to maintain stocks of crude oil. It can be used to compensating for the unexpectedly rises in oil demand or supply. Hamilton (2008) suggested a simple model to explain storage costs; he illustrated the relation between future oil prices and spot prices. Assume that an investor is planning to borrow money to buy the quantity Q barrels of oil. Assume also, he paid the storage cost (C_t) with a rate of interest on his initial loan (i_t); so the investor profit equation for keeping oil in the stores today would be:

$$P_{t+1}Q > (1+i_t)(P_t + C_t)Q \tag{2.20}$$

If drilling rigs were expected to be under maintenance; investors will expect that its future prices will be greater than spot prices and the investment in this case would be more profitable. This is logic because the decrease in oil production capacity correlated with current demand. Thus, less active drilling rigs extracting will lead to less oil; finally, investors will think there is a shortage or supply shock. Vice versa, if new oil fields discovered; oil supply will rise, this will send a sign to investors that there is surplus in oil. Therefore the investment in this case would be not profitable and future prices expected to be less than spot prices.

Convenience yield consists of implicit benefits which the owners of a commodity receive from holding the inventories of oil. Hence, these benefits may arise because stocks may provide some value and productivity when the input for the production of another commodity or there may be a century convenience yield stocks held to meet unexpectedly demand. By adding convenience yield to the previous equation we get:

$$F_t^T = S_t e^{(r+\mu-\Psi)(T-t)} \qquad (2.21)$$

F_t^T indicates the future price at time t which delivered in the future at T.

S_t refers to spot price at time t.

r indicates interest rate.

μ refers to the cost of storage.

Ψ indicates the convenience yield to hold inventories.

Obviously, If the interest rate for the cost of borrowing plus cost of storages greater than the convenience yield of holding inventories; then the market will be in contango (future oil prices are greater than spot prices). Therefore, holding these stocks does not expect to make shortage in oil supply in the short run. Thus, owners of oil stocks will not sell parts of their inventories to meet demand needs or supply shortages in the short run (Shepherd, 2009). During the crisis periods; the benefits of holding oil inventories will be much greater in the short run; it's better for inventory holders sell their oil at a higher price now than in sell it in the future. Historically low, prices tend to encourage the accumulation of stock. OPEC production, for example reached an agreement in March of 1986, convenience yields decline again $ 0.03 per barrel for the next two years (Dahl, 2004).

2.4.2 Demand variables

The demand for oil is one of the key factors affecting the price of crude oil, especially in the recent years, Global demand has doubled as compared to previous periods up to 84.33 mbd of crude oil in 2009, twice the volume of demand in 1970 which was 46.8 mbd of crude oil (EIA, 2010). According to crude oil and natural gas sector reports (2009) OECD countries are the largest consumers of crude oil to show how global oil consumption rose significantly in 39 years. In addition, OECD oil consumption has been relatively flat since 2000 and that the world consumption increased significantly relative to the OECD trend line.

2.4.2.1 Gross domestic product (GDP)

This link between oil prices and the GDP has been studied extensively in many studies such as; Mobert (2007) , Hamilton (2008) and Kilian (2009). In general, studies tend to find that rise in oil prices have a negative impact on GDP and the rate of economic growth also. Moreover, the rise in oil prices correlated generally with oil shocks as shown in the Figure below. The Figure clearly shows that the crisis coincided with the increasing real GDP for these countries, even more than the convergence rate of increase in GDP with the rise in oil prices, especially during crises.

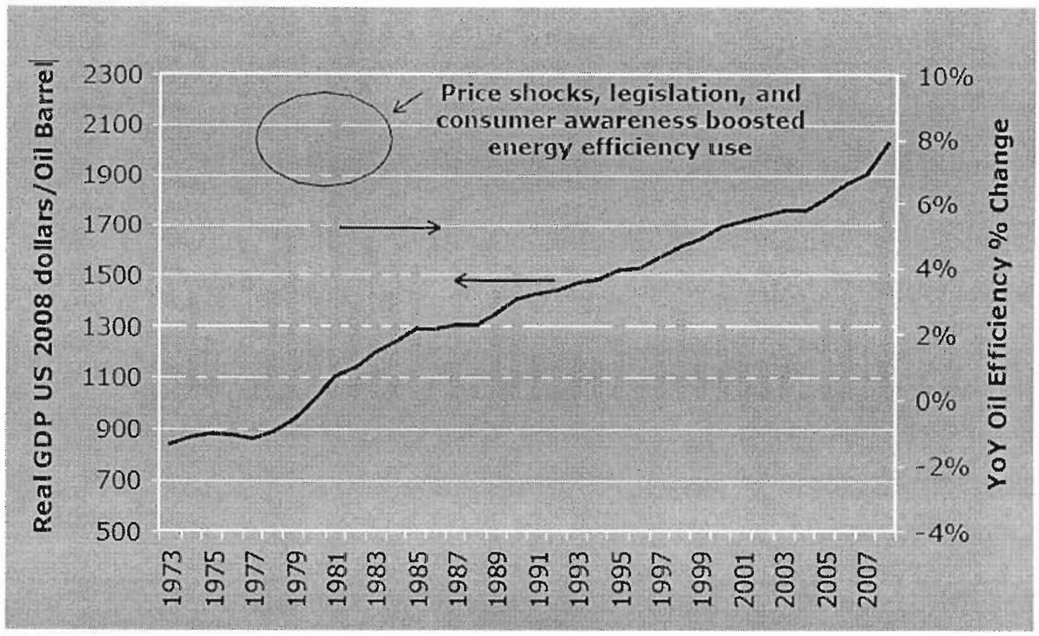

Figure 2.11
Real GDP US in 2008 Dollars/Oil Barrel 1973-2007
Source: Thomson and EIA, 2008

The boom in demand for oil during 1960 -1973 was driven mainly by OECD countries. That changed abruptly during the first and the second crises price of oil, which OECD demand dropped sharply. While North American demand for oil rose slightly during the nineties, oil consumption remained almost constant in the OECD countries.

Hamilton (2008) Used logarithmic transformations for oil consumption and U.S. real GDP for the period 1949 to 2007; he found that oil consumption trend was not deviated. Moreover, the oil price movement correlated to GDP changes; they were two somewhat asymmetric. A rise in oil prices doesn't always lead to fall in GDP, for example, at the end of the seventies, when Iran cut production, oil prices rose to $40 per barrel, but U.S. oil consumption fell to 16% and U.S. real GDP increased to 5.4 % (Hamilton, 2008). Therefore, several factors can be identified to show the final causal link on economic growth, such as; interest rates, monetary policy and market conditions (Frankel, 2006).According to conventional wisdom, an increase in GDP growth generally leads to higher oil prices as more oil is required to produce both fuels as feedstock to increase the production of goods and fuel. Hence, conventional wisdom indicates that high crude oil prices will cause contractions of GDP.

According to data provided by the IMF, world bank and OECD; increasing oil price $10 per barrel lead to a reduction in OECD GDP by 0.4% in 2 years (Morse, 2006). Many analysts argued that the recent period, which originated in the emergence of the largest economies in the world - especially China and India - have reshaped the landscape. There is fear that the oil resources and capabilities easily exhausted, especially when populous countries such as India and China, where strives to Western-style living conditions.

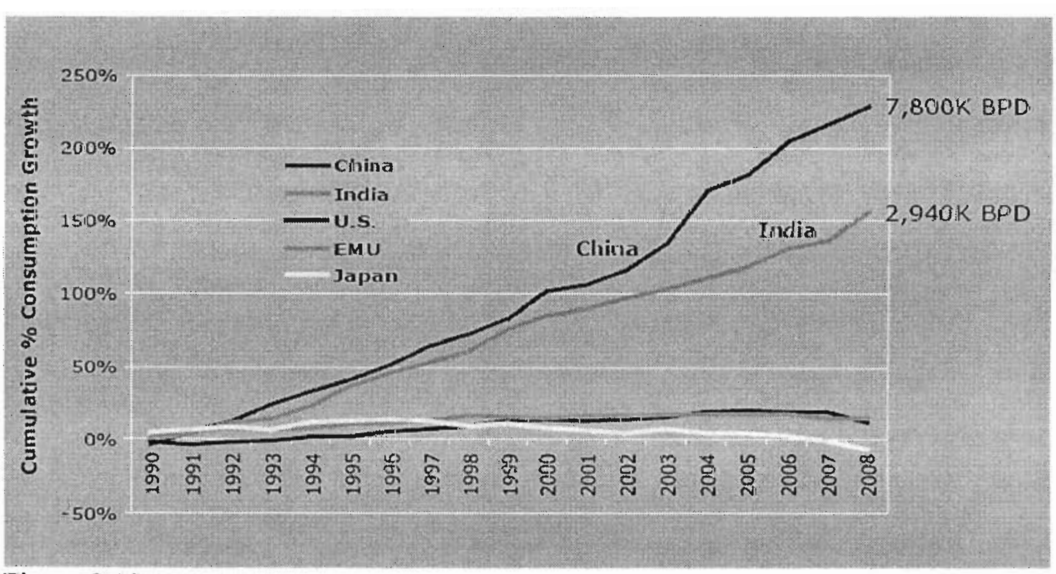

Figure 2.12

Consumption Growth in China and India 1990-2008

Source: World Bank, Thomson, EIA, 2010

The Table above shows a steady increase in the growth of consumption in China and India, especially in recent years, reflecting the importance of these two countries in the equation of demand for oil. The Table illustrates also , the consumption growth In China is greater than India. Hence reflects the importance of China and India as a key driver in the world demand equation. particularly in Asia and oil-producing countries in the Middle East.

2.4.2.2 Days for forward supply (OECD days)

Oil stocks can be represented by a variable known days of forward supply.

This variable estimates the number of days that a country can manage by using its own oil stocks to cover the current demand. In another meaning, it is a variable representing the number of days that a country can feed the needs of its industries from the available oil in the stores without resorting to import.

The Table below shows that the average number of days for OECD has maintained a high rate with an average 58.5 days. In other words, these countries can cover their economy needs for nearly two months, when a delay in the supply for any reason occur. The number of days raised in recent due two things; drop in oil prices after 2008, and the many political conflicts that create uncertainty and fair of oil cut.

According to economic theory an opposite relationship between days of forward supply and crude oil prices are expected. When the number of days of forward, increase, means there is a sign that oil supply is not enough to cover the market needs (oil demand exceeds oil supply); therefore oil price will rise.

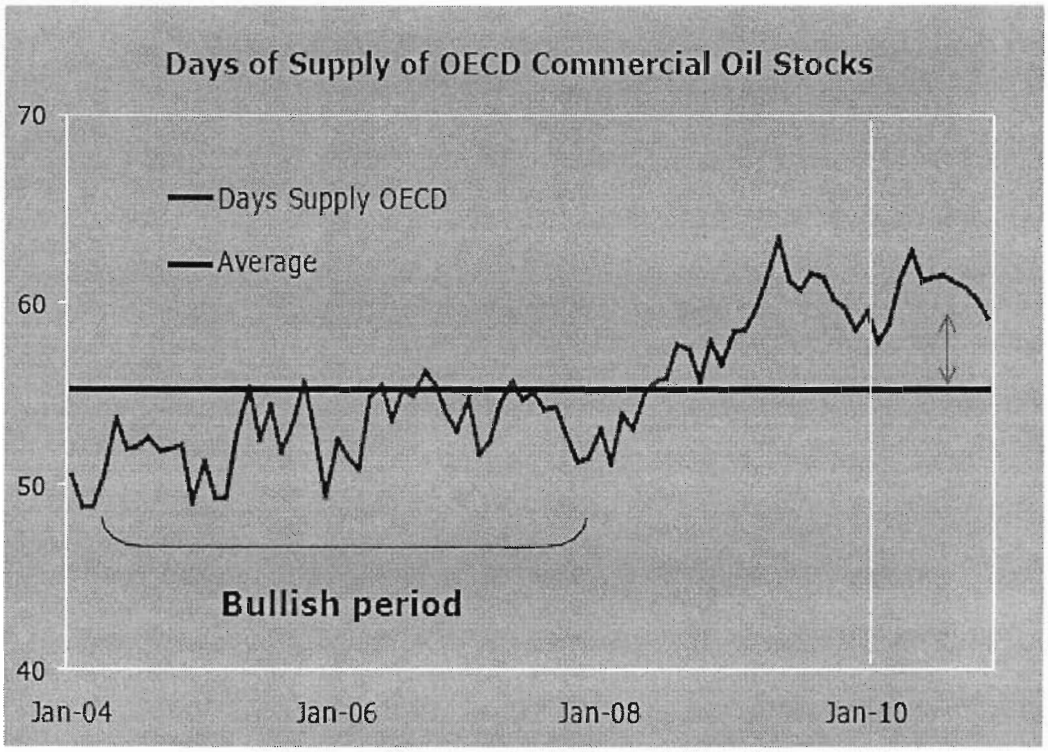

Figure 2.13
Days of Forward Supply Jan2004 – Jan 2010
Source: US Energy Information Administration, 2010

Following the oil embargo in the 1970s , many industrialized countries depend on Middle East oil imports. Hence, they create strategic oil reserves to feed their markets during the periods of supply shocks. As the days of forward supply rises, oil stocks will rise also. According to economic theory any increase in supply over the demand will put upward pressure on prices, ceteris paribus. When a buyer buys crude oil for refining purpose, his main consideration is the spot purchases. However, he may not receive the buyer's shipment of crude oil after one month, two months or more depends on the following: the distance from the source of production, type of transport and shipping delay in the middle of the road sector. Therefore, the buyer will have to buy crude oil at today's prices for delivery in the future.

2.4.2.3 Oil futures prices and spot oil prices

Oil futures prices reflect the price that both the buyer and the seller agree to be the price of oil upon delivery. Therefore, these prices give direct information or a sign about investor's expectations about the future price of oil.

Like other risky and uncertain assets, oil futures prices contain risk premiums, to show the possibility that spot prices at the time of delivery may be greater or less than the contracted price.

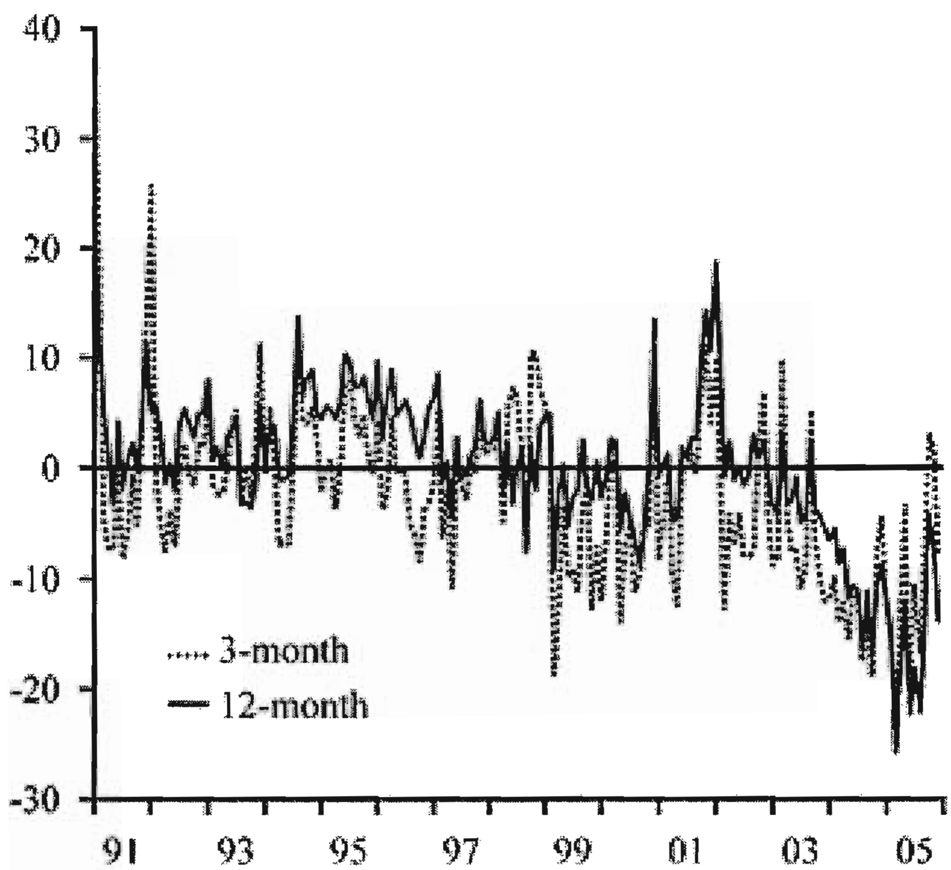

Figure 2.14
Risk Premiums for Oil Futures Prices
Source: Federal Reserve Bank of San Francisco, 2005

Figure 2.14 shows a measure of the risk premium for oil futures price contracts. Risk premium can be defined as the difference between the oil futures price and the expected future spot price from the Agreement Forecast's survey. The difference in the Figure up expressed as a percentage of the current spot price. The Figure shows also, although the oil price risk premiums are very close to zero on average, they are rather large and volatile over time. This advises that oil futures prices are not always the best predictor of future oil prices (Federal Reserve Bank of San Francisco, 2005).

Oil futures allow buyers of crude oil to hedge against price fluctuations, and can therefore mitigate the losses resulting from adverse price movements. In order to trade at futures, futures prices were introduced to provide information and discover the eighth oil shipments in the future. Vice versa, when futures prices exceed spot prices; it may be more profitable to store crude oil today in order to sell it for more profit in the future. Future prices also may be used as a tool for expectations. It can give a sign whether the oil market is in contango or not.

2.4.3 Geopolitics

Geopolitical instability was one of the main causes of fluctuations of oil prices in the past 30 years. Kesicki, et al. (2009) argued that the political events and geological variables are responsible for all the crisis of rising oil prices in 1970 and the recent crisis in 2008.

The word geopolitics consist of two syllables (Geo) means a geologist who studies the properties of oil in terms of density and the proportion of oil contains sulphur and other characteristics, while the second Section is (Politics) which is derived from the word politic itself,. So full meaning is geological and political factors that affect the price of crude oil.

2.4.3.1 Geological characteristics of oil

The oil can be divided into many categories depending on the intrinsic properties of certain oils. Heavy oil has a high density and does not flow easily. Sour oil contains large amounts of sulphur. Some oils are categorized into non-traditional which does not extract from underground reservoirs, it is derived from the processing of tar sands, shale oil or even industrially produced from coal liquefaction. It may also include oil, condensate, a gas condensate in the tank, and natural gas liquids (NGL), corresponding to the types of heavier hydrocarbons in natural gas sector. Norwegian petroleum directorate (NPD) explained the natural gas liquids in the form of a mixture of ethane and propane, isobutene, butane and naphtha (NPD, 2008). Natural gas liquids are the value of by-product of processing natural gas and are produced directly in this area, but in the central gas processing plants.

It should be noted that many countries or organizations have their own set of definitions which may differ from each other. For example, the NPD does not include the capacitors in the category of crude oil, while the energy information administration (EIA) in treating crude oil; applied many different classifications of crude oil based on the characteristics of different physical or chemical. It's the most common way to describe the oil density, often known as the gravity number. The American Petroleum Institute (API) defined the gravity degree according to the equation below (Dake, 2004).

$$API^{\circ} = \frac{141.5}{specific\ \ gravity} - 131.5 \qquad (2.22)$$

Often know the specific gravity and density of crude oil and water at 15.6 degrees Celsius. API gravity ranging from 0-60 degrees Celsius to show oil quality based on the density and viscosity; where dense oils have low degrees, and high viscosity oils have higher degrees. Hence, crude oil can be classified into three types: heavy oil or natural bitumen if API less than 10 °, Medium crudes when API between 10°- 30° and light crudes when API more than 30°. Refining heavy crude oils requires many complex processes, and products derived from them are relatively lower compared with the light oil, and thus are of less value in the market as compared to light oils.

2.4.3.2 Political influence

Political instability played a big role in the Middle East in Iran in the years 1973 and 1978, which caused the first and the second crisis in the oil price. Hence, few attempts have been done to compare the three crises in the price and that led to the price increase significantly (Radetzki, 2006; IMF, 2008; Stevens, 2008). Stevens (2008) found important similarities between them such as the demand subsidies and the impact of high demand in the three crises. Also, he found some differences such as the most exhaustible source's substitution potential for crude oil in the 21st century compared with the 1970s.

Generally, crisis can be classified as a political and financial crisis; political crisis such as the years 1973, 1979, 1990 and 2003; financial crisis such as the years 1997and 2008. Political conflicts in the regions of Europe and Asia, contributed greatly the instability of oil market, which led to increase the fluctuation of prices for example, Iraq - Iran, Turkey - Kurds, Israel – Palestine. Finally, the events in 2011 show more conflicts in many Arab countries such as Syria, Jordan, Libya, Yemen and Iraq. The significance of these conflicts could appear especially if we take into consideration that some of these countries are OPEC's members such as Iraq, Iran and Libya. Oil production in Iraq, for example, was not sufficient enough to ensure a steady flow of the markets. So far there are no signs of a positive development in this area, and it should be noted that Iraq was the second largest oil producer in OPEC. Terrorism has also affected oil prices, for example the attack on the industrial oil compound in Saudi Arabia by Al Qaeda on May 2004 was one of the reasons to push oil prices up.

Historically, political influence was making its way into the oil business. As with the Arab oil embargo failed to begin the six Day War and the subsequent nationalization of the current activities of oil companies, political influence was at its peak in 1973 with the first oil price crisis. Ezzati (1976 and 1978) and MacAvoy (1982) argued that oil prices increased in 1973-1974 and 1979-1980. In 1980 Iran-Iraq conflicts attacked oil production in this area for eight years. Also, Kuwait – Iraq conflict in 1990 affected the oil market, which led to the Persian Gulf war, and the price of oil jumped again to 35 $/b. 21stcentury oil prices rose to new heights, as well as it crashed at top speed as the current economic crisis hit the fall of 2008, which explains the importance of political events on oil prices in the short term.

2.4.3.3 OPEC's role

OPEC played a big role in the oil market, Hence, 40% of the global oil market covered by OPEC which indicates a significant impact on global oil prices. In the early 1980s OPEC adopted a quota system in which the swing producer, Saudi Arabia, tried to set production limits for each member according to their reserves and production capacity and other variables.

Many studies have examined the behavior of OPEC, especially after 1973 when this organization was able to raise prices for the first time without reference to the cartel. Analysts have different views on the behavior of OPEC. Studies such as (Griffin, 1986; Jones, 1990; Dahl, 2004) rejected the assumption of competitive behavior of the market and emphasized the cartel behavior of OPEC. While studies such as (Verleger, 1993; Kaufman, 2004; Dees et al., 2007) emphasized the competitive, through lack of OPEC's power, as happened in the eighties, when OPEC became a swing producer to complete the lack in oil supply. Studies also emerged linking the three crises and the behavior of OPEC for example, Kesicki, P., E. Ram, et al. (2009) argued that all three price oil crisis marked by low OPEC surplus capacity, indicating the importance of OPEC's oil supply.

Many analysts concluded that price increases were the result of political factors that price was sustained at high levels because OPEC capacity was limited.Whirl (2008) argued that using different types of models for OPEC can help to explain oil price volatility. One of them, the political model motives, this approach indicates the political reasoning to OPEC decision makers. Their assumption was, politicians are much less concerned about profits than businessmen, however political markets may reward decisions that harm the economy. Wirl presented OPEC as a decision maker which maximizes the net present value of benefits; Political support was combined in his model.

2.4.4 Financial variables

The importance of speculation and future markets and other market participants increased in recent. This is due to the technological development that changed the form of the market, oil contracts can be done through the Internet with one click and without much effort. Therefore, many analysts attributed the rise in prices and changes to financial factors, which has seen an upswing in recent years (Dees, 2008; Kaufman, 2009; Irwin, 2009; Lee, 2010; Kaufman, 2011).

2.4.4.1 Future markets and speculation

A considerable amount of literature has been published on Futures Market and speculators to show their importance in the recent surge such as; (Mabro, 2006; Mobert, 2007; Fattouh, 2007; Dees, 2008; Kaufman, 2009; Irwin, 2009; Lee, 2010 and Kaufman, 2011). Kaufmann et al. (2008) used a model to analyze the oil price rise from 2004 to 2006 into fractions corresponding with OPEC surplus capacity, refinery utilization, the futures market and OECD stocks. However, the study showed that most of the price increase could be pointed by the shift in the future markets and the increase in refinery utilization rate.

Hamilton (2008) argued that oil speculators respond to supply and demand factors such as; production cuts, capacity utilization and stock levels. It is therefore fallacious to assert that futures market responsible arbitrarily for higher futures prices without any consideration for oil market conditions. Kaufmann and Ullman (2009) focused on the impact of speculation based on market fundamentals such. They conclude that speculators were the ones who contributed to the increase in prices, which started with the market fundamentals.

The relationship between the real economy and financial markets is too complicated. Futures markets helped to create expectations about future prices, and these expectations in turn determine prices. In this sense, the change in the relationship between spot and futures markets observed over several years showed that the long-term upward trend in prices caused by supply and demand variables developments were compounded by speculation (Kaufman and Ullman, 2009).Therefore, a buyer of crude oil may buy oil at today's prices for delivery in the future. Before the establishment of futures contracts of this type of transactions involved considerable risk in price.For example, the buyer might agree to buy oil price p for delivery within two months, but may change the conditions of the market and prices fall. Thus, the refinery has lost the amount purchased.

However, the liquid futures contracts allow purchasers of crude oil for hedging against fluctuations in prices and therefore can decrease losses due to opposite price movements to trade in the futures. Futures prices also introduced to provide information and discover oil deliveries in the future. And vice versa, when futures prices often exceed the spot prices could be profitablefor store oil today with the intent to sell to reap the profits in future.

2.4.4.2 U.S. Dollar depression and inflation

Since oil is purchased in dollars, it is logical to believe that exchange rates could affect the price of oil to some extent. Hence, there were several studied the impact of devaluation of the dollar and exchange rates on oil prices (Yousefi and Wirjanto, 2004; Hawks, 2007; Mirak-Weissbach, 2007; Verleger, 2007; Hamilton 2008). Yousefi and Wirjanto (2004) comparison between the exchange rates of major exporting countries in OPEC and the oil price movement. They found a small correlation between them. Hawks (2007) as he mentioned in his work that, while there was a trend between the movement of oil prices and the exchange rate movement, but it is not strong enough to explain what reasons.

In another study done by Chen (2007), a similar conclusion found support in oil prices as a prediction of future exchange rates. Verleger (2007) illustrated that if oil prices directly linked to the exchange rate; oil price movement may be an accurate reflection of the amount of confidence that the oil-producing countries have the capacity to control the inflation in Federal reserve. Radetzki (2006) examined the relationship between the price of oil, inflation and economic growth during the first oil price crisis and the rise of prices since 2003. He found rapid growth in oil prices due to manipulation of the exchange rate of the dollar. But there was a little support that it was the cause of high inflation in the prices of basic commodities.

Kesicki, F et al. (2009) argued that the weakening of the US-dollar has also been a limited influencing factor in the oil price in the past but it was responsible for a part of the recent oil price crises. Many studies argued that the increase in oil price shocks may lead to inflation (Fuhrer, 1995; Gordon, 1997; Hooker, 2002), which can be accompanied by a second-round effects through wage loop price. Hamilton (2008) by using logarithmic transformations of U.S. crude oil consumption and GDP from 1949 to 2000, illustrated the impact of a weak U.S. dollar on U.S. consumption and its GDP.

In summary, there are many factors affecting crude oil prices. Hence, the effect of these factors changed depending on time period, as well as the conditions prevailing in the oil market. Also, the significance of some variables have increased in recent years, such as; future markets, speculation, refining utilization, political variables and OPEC role. The content of some of these variables has changed relatively, for example, the demand equation, China and India may considered as key drivers. Speculation is not only run by individuals or companies. But also expanded to include government's speculation. Also, the use of strategic oil reserves as a means of price manipulation and speculation.

Generally, previous studies have shown that the supply and demand will play a key role in determining the price of crude oil, with other important factors including: OPEC's role, geopolitics, speculation, refining capacity, and dollar depression.

2.5 Conclusion

Many studies have been done after the crisis at the end of 2008 to explain oil price volatility, such as Hamilton (2008), Kaufman and Ullman (2009, 2011). Their main premise was that the oil price crisis was due to financial variables or market fundamentals. In spite of the importance given to, demand and financial variables, but their studies didn't mentioned the following:

- Demand variable in the past cannot be considered to be exactly the same variable as that of in recent years for the following reasons: the previous studies did not compare between demand for consuming purposes and demand for stocks. The demand for consumption indicates how much oil will be purchased at a given price and at a particular time, this variable depends on exchange rate, GDP and oil price. However, the demand for speculation and stocking oil such as; strategic reserve depends on rates of interest, shocks , geopolitics, days of forward supply and Convenience yield. Furthermore, they did not highlight the demand of China and India as new factors in the demand equation; as China became the second country in global consumption of oil in recent.
- The nature of, size and importance of speculation nowadays is unlike the speculation in the past., In the past it was run by individual companies, but now speculations are controlled not only by oil companies, governments also entered the game by using the strategic petroleum reserve. Their importance is portrayed by the sheer size of total transaction alone, e.g. in 1977, the market value of exports was 1.3 trillion US dollars, 4.6 trillion was in the foreign market exchange instructions, which means that the ratio of exports represent about 29% of the total world transactions (IMF, 1997; Martin Khor, 1997). While in 1997,

the market value of exports became 4.8 trillion US dollars, 325 trillion in the foreign market exchange, which means that the value of exports represent about 98.5% of the total transactions (IMF, 1997; Martin Khor, 1997). In another word, the ratio of exports became only 1.5%. For each $100, only $1.5 goes to exports and services, $98.5 used for speculation and investment. This reflects the big increase in speculation.

CHAPTER THREE
RESEARCH METHODOLOGY

3.1 Introduction

In the last chapter I have explained the oil price development from 1859 until 2012 and covered the theoretical and empirical studies that deal with crude oil price such as Hamilton, storage and bubble's theories. In this chapter, I will extend the Kaufman's model (2005) to find the answer for the main objectives of this study; are crude oil price changes controlled by fundamentals (supply and demand) or financial variables (future markets and speculation)? Also, will examine the effect of new variables such as; days of forward supply, convenience yield and underinvestment on oil price changes. As well, I will examine the effect of geological, political conflicts on crude oil prices.

To accomplish the above objective a VAR model will be used to estimate the effect of market fundamentals, geopolitics and financial variables. The Vector Autoregressive Model (VAR) has been chosen because of the following reasons:

- The VAR (1) model determines the feedback impacts by allowing current and past values of the variables in the model.
- In VAR models all variables have got the same treatment in the system. Also, for any variable there is an equation to show its evolution according to its own time lags in the model.
- Sims (1980) explained that VAR is a good model for regression analysis that prefer the distinction between endogenous and exogenous variables.

- VAR models can consider as a good step for testing interdependencies among the variables that selected in the model (W.Enders, 2004).
- The VAR analysis identifies the interrelationship among the economic time series rather than the parameter estimates.
- The residual correlation in the VAR model shows the interaction of the variables in the past periods or in lag periods.
- The major benefits of using the VAR model are the impulse response analysis, variance degradation, and the Granger causality tests. The function of an impulse response traces the reaction of the endogenous variables to one standard deviation shock or change to one of the disturbance terms in the model.
- In VAR models a shock to a variable refer to all of the endogenous variables during the dynamic formation of the VAR. As a result, an impulse response function explains the interaction between/among the endogenous variable sequence.
- VAR models in general are used to check the causality relationship between the variables in the model. Therefore, Granger causality offers important information about the exogeneity. In addition, for each variable there is an equation explains its evolution due its own lags in the VAR system.

Sims (1980) argued that VAR is a good system for regression models that prefer the distinction between endogenous and exogenous variables. So, VAR models can consider as a good step for testing interdependencies among the variables that selected in the model (W.Enders, 2003; Helmut, 2011). Our starting point is to test whether the series present a unit root or not to check stationarity. Therefore, the augmented Dickey Fuller (1979, 1981) will use to test for the stationarity of variables. Hence, the augmented Dickey-Fuller test (ADF) has been the most popular test used to check data stationary in empirical researches.

3.2 Sources and methods of data collection

The study adopts linear regression analysis. All variables are in logarithms (except the dummy) because it helps to transform large numbers to small and it is easier in terms of taking the differences between variables (Holden, 1997). In this Section quarterly FOB crude oil prices are taken, data set contains 100 observations from first Quarter 1986 to the Fourth Quarter 2010. The data are obtained from secondary sources like; World Bank, energy information administration in the United States, the international energy agency, Penn World Tables, statistical review of world energy, annual statistical bulletin, international monetary fund and intercontinental exchange. Thus, the main sources may come from the channels below:

- Data for oil prices, OECD oil stocks, and OECD demand for crude oil are obtained from the Monthly Energy Review (various years).
- Annual values for OPEC capacity are obtained from the US DOE/EIA.
- Quarterly values for OPEC capacity are interpolated by assuming a constant rate of change between annual observations.
- Data for OPEC production are obtained from the OPEC annual statistical bulletin.

3.3 The Framework

Researchers including (Mabro, 2006; Mobert, 2007; Fattouh, 2007; Hamilton, 2008; Dees and Kaufman, 2008; Kaufman, 2011) in arguing the significant changes in oil prices adopted specific variables in their models to analyze the reasons for oil price changes. Therefore, based on the theories and variables which were discussed in the literature review, the independent variables can be divided into four groups as describe below:

- Dependent variable: (WTI) Crude oil price is the dependent variable.

WTI is the price that has been used in this study for the following reasons:

- In this study the price of West Texas Intermediate (WTI) has been used in the regression. It is the reference oil in North America. WTI is a high quality oil due to its low sulfur content and its low density (EIA, 2006). The corresponding futures contracts traded on the NYMEX are the most liquid futures contracts worldwide. Also, The New York Mercantile Exchange (NYMEX) is the world's largest commodity market. For this reason, this data series is especially suited for my purposes since several futures market variables are included in the econometric specifications.

- Independent variables: There are a lot of variables affecting crude oil prices; the study classified them to four major variables:

1) Supply variables
2) Demand variables
3) Geopolitics
4) Financial variables

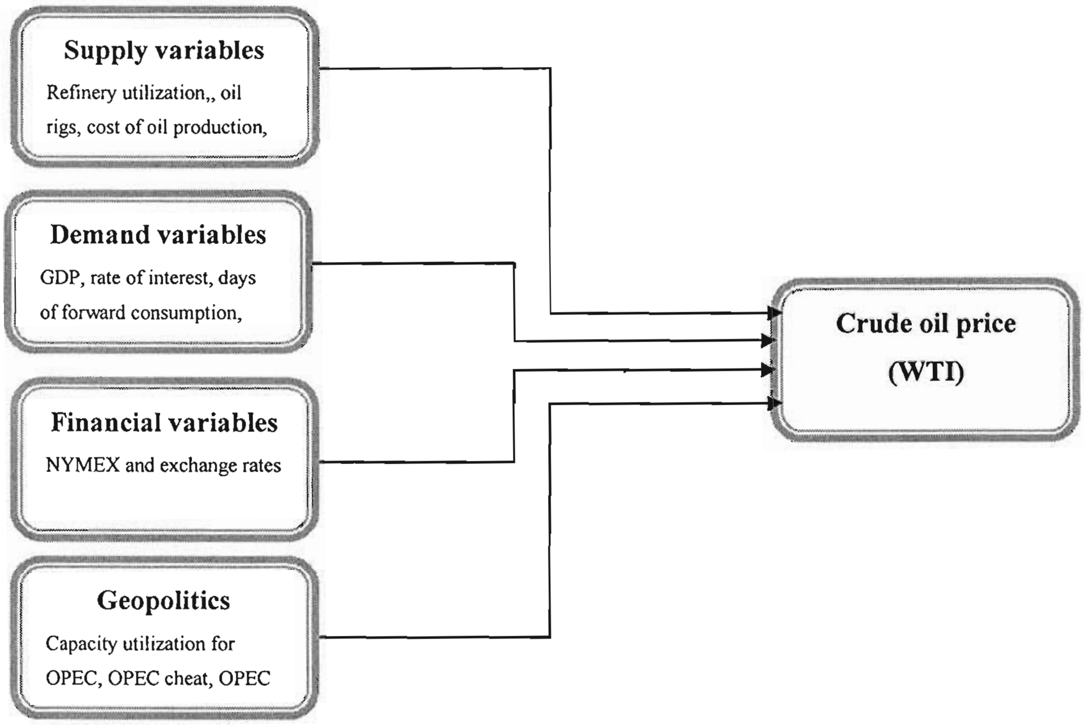

Figure 3.1
The Framework of Factors Determining Crude Oil Prices

The variables were selected based on literature review and the previous theories which discussed in chapter two.

3.4 Research hypothesis

Based on storage theory and the research objectives; the hypothesis to be tested are listed below they will be divided into two types; general and specific hypothesis for each group.

3.4.1 General hypothesis

1. H_0: There is no significant relationship between oil price and supply variables.

   H_1: There is a significant relationship between oil price and supply variables.

2. H_0: There is no significant relationship between oil price and demand variables.

   H_1: There is a significant relationship between oil price and demand variables.

3. H_0: There is no significant relationship between oil price and geopolitics.

   H_1: There is a significant relationship between oil price and geopolitics.

4. H_0: There is no significant relationship between financial variables and the price of oil.

   H_1: There is a significant relationship between financial variables and the price of oil.

3.4.2 Specific hypothesis

Specific hypotheses will be discussed during selecting the variables.

3.5 Selecting Variables

The main objective of this study is to identify the main factors that affect the price of crude oil. Thus, in order to achieve this goal, based on previous studies and theories that have been reviewed, I put four goals for the main group variables that affected crude oil prices. So, each group will be tested according to the indicators related to it. Therefore, based on literature review the following variables are considered as the important factors as shown in the Table below:

Table 3.1

Measurement of Model Variables and Sources of Data

variables	Indicators	Description	Measurement	Source of data
DV	FOB oil price	Free On Board (DV)	The average FOB price for crude oils imported from USA	Monthly energy review
Supply	$RIGS_{Total}$	Total oil rigs	Rig count, an indication of drilling activity	Baker Hughes BHI International Rig Count
Supply	OP_t^{Che}	OPEC cheat is the difference between OPEC production and OPEC quotas,	$OP_t^{Che}=OP^{Pro}-OP^{Quo}$	Monthly Energy Review
Supply	OP_t^{Quo}	OPEC's production share in mbd.	See eq. 3.3 $PROD_{OPEC}=DEM_{World}+\Delta Stocks_{OECD}-NGLS_{Natural\ gas\ liquid}-PROD_{Non\text{-}OPEC}-PG_{Processing\ gains}$	Monthly Energy Review
Supply	Con_{Yield}	Convenience yield	it represents the risk premium for holding inventories $F_t^T=F_Te^{(r-y)(T-t)}$	EIA
Demand	$Days_t^{OEC}$	Days of forward consumption	The OECD days ratio of OECD's oil stocks divided by Q OECD	OECD
Demand	GDP^{OECI}	GDP growth in OECD countries	OECD's real GDP data in millions of U.S. dollars, where 2000 is the base year.	(http://stats.oecd.org/ WBOS/ index.aspx)
Financial	NYMEX	Noncommercial for the fourth and the first month contracts positions for WTI crude oil futures.	The difference between noncommercial in the fourth and the first month contracts positions of the NYMEX WTI crude oil futures. $NYMEX=NY4_t-NY1_t$	U.S. Commodity Futures Trading Commission
Financial	P_i^D	U.S. Consumer Price Index	For adjustment purposes, the Consumer Price Index (CPI) from the Bureau of Labor Statistics will be used, and is based upon a 2000 base of 100.	Bureau of Labor Statistics
Geopolitics	$OP_t^{caputil}$	Capacity utilization for OPEC. Denotes the rate at which the processing capacities of the available refineries are utilized.	$\left((\frac{OP^{Pro}}{OP^{Cap}}*OP^{Quo})/(\frac{OP_t^{Che}}{\text{global oil demand}})\right)$	Monthly Energy Review
Geopolitics	$War^{Gul\ 1}$	Dummy variable added to explain the first gulf war 1990 in Iraq.		
Geopolitics	$War^{Gul\ 2}$	Dummy variable added to explain the second gulf war 2003 in Iraq.		

There are three types of crude oil according to the API gravity index; heavy oils, medium and light. Light oil refining preferred because it achieves revenue and profits greater than the rest of the types of oil, and this will lead to increase demand for light oil. However, the availability of light oil is limited. Therefore, to meet the rest of oil demand, refining of heavy oil will rise.

3.5.1 Total oil rigs

The cost of developing new oil wells has a large impact on the supply side. As it reflects the upward movements in the costs associated with exploring new oil fields. According to Baker Hughes that the number of active rotary rigs has increased, so it could be an indicator for oil supply products. The number of rotary rigs has increased significantly in the last ten years. In addition, total rotary rigs may consider as an instrument to measure upstream investment in the crude oil industry. Also provide an indication for the current level of oil production. Hamilton theory explained an inverse relationship between total rigs and the price of oil. When the number of rigs rises, the quantity of oil extracted will increase also, leads to an increase in oil supply, then the price decreases accordingly. Therefore, I assume a negative relationship between the number of rigs and crude oil price, ceteris paribus.

3.5.2 Organization of Petroleum Exporting Countries (OPEC)

Total oil production consists of two groups: OPEC and non OPEC countries. The significant of OPEC increased as it stated 40% of world production of crude oil, 55% of exports of crude oil, and more than 66% of world reserves of crude oil (OPEC, 2009), while North Sea oil and Canada in a steady decline. Therefore, the following indicators could be used to study the impact of OPEC on oil prices (Mobert, 2007; Dees and Kaufman, 2008):

- OPEC's quota. This indicator refers to the OPEC production quota (million barrels per day). It equals total world supply minus non-OPEC supply.
- OPEC capacity. This index has gained strength from the large reserve of this organization, more than two thirds global reserves. Therefore, I expect a significant negative relationship between OPEC production and crude oil price, ceteris paribus.
- OPEC's cheat, refers to the difference between OPEC crude oil production and OPEC quotas (mbd).

Hamilton (2008) has studied the share of OPEC's announcements for the last five years; he found that some members were producing above the level specified for them, and some of them less. So, I assume that there is an inverse relationship between OPEC cheats and the price of oil.

3.5.3 Convenience yield

As explained in storage theory in literature review, the total cost of storage consists of three types of cost; physical cost, interest rate and the convenience yield. Thus, convenience yield could be considered as a negative cost for investors if their expectations failed, since it represent the risk premium for holding inventories. Therefore, I expect a negative relationship between convenience yield and oil prices. According to the cost theory which discussed in Chapter two, future and spot prices will be explained in the formula $S_t = F_T e^{-r(T-t)}$. Hence, St the spot price at time t, F_T

represents the future prices of a contract that delivers in T. r means the interest rate (Working, 1949; Brennan, 1958). Therefore, the equation will be:

$$F_{t,T} = F_T e^{(r-y)(T-t)} \tag{3.1}$$

$F_{t,T}$ Refers to the futures price for maturity T at time t, r refers to the continuous compounded rate of interest used by market agents at time t for maturity. y is the convenience yield. Following Pindyck (2001) who states that there is no-arbitrage condition and explained that the foregone interest as the only cost of buying a commodity at time t and delivering it at maturity T. Agents incur the opportunity cost of purchasing the asset, but in return they benefit from possessing the commodity and being able to trade it until maturity. Therefore, I can model the convenience yield at time t for maturity T as:

$$y_{t,T} = S_t e^{r(T-t)} - F_{t,T}$$

This relationship can be tested following the Box-Jenkins methodology:

$$y_{t,T} = \alpha + \beta S_t + \gamma V_t + \varepsilon_t$$

$y_{t,T}$ Is convenience yield, Vt is a proxy for volatility, £t the error term, St the spot price at time t.

3.5.4 Days of forward consumption

OECD days are a variable shows the days of forward consumption, stocks of OECD crude oil. I can calculate it by dividing the stocks of the OECD over the demand of crude oil. Moebert (2007) used OECD stocks to create a variable called days of forward consumption. Also, Dees et al. (2007) found an inverse relationship between days of forward consumption and crude oil prices: as the number of days of forward consumption increase there will be a negative effect on crude oil prices. But the sign could be positive or negative, depends on the shortage or surplus in the oil market. In other words, if Market instability increased for any reason, such as an economic shock; will lead to an increase or decrease in oil reserves for a certain number of days of consumption. Although this variable was used as a strategic reserve to protect the OECD economies for security reasons, but also can be used for speculation in oil prices. Oil demand depends mainly on the expectations of oil investors, if they thought that the shortage in the oil market is temporary; the current demand will decrease, while the future demand will rise. So, I expect a significant relationship between OECD non-consumption demand and oil price.

3.5.5 Gross Domestic Product (GDP)

Shepherd (2009) hypothesized that crude oil demand and GDP showed a strong positive correlation over time indicating that periods of high GDP growth were associated with an increase in crude oil demand. Also, Kesicki, U. Remme, et al. (2009) argued that high growth of oil demand precedes an oil price crisis, which again leads to slow economic growth. In addition, OECD oil demand grew steady, relatively, while demand for crude oils from emerging economies such as China and India has increased significantly in recent years. After all, these emerging economies seeking greater market share to emulate western lifestyles. Many analysts believe that oil prices could rise rapidly in recent years, partly due the increase in demand from developing countries such as China and India (Mobert, 2007). Furthermore, China's consumption in 2009 increased almost four times the consumption In 1986

(EIA, 2010) which argued the view above. Therefore, I expect a positive relationship between GDP and oil prices, ceteris paribus.

3.5.6 Speculation and future markets

Many studies argued that trading, especially speculation can move prices away from fundamental values in some circumstances (Mobert, 2007; Weiner, 2008; Kaufmann and Ullman, 2009; Jane, 2010). Hence, Kaufmann and Ullman (2009) focused on the influence of speculation in relation to market fundamentals such as; supply and demand and they conclude that speculators exacerbated the price increase. Weiner (2008) made an investigation into the role of market speculation in rising oil and gas, he concluded:

- Rise in speculation. Over the past few years, speculators spent tens of billions of dollars in U.S. markets energy commodities.
- Speculation has increased oil and gas prices. It has contributed to rising U.S. energy prices, but the problem was the gaps in the currently available data, it prevents analysis to specify the amount of speculation.

Futures markets helped to create expectations about future prices, and these expectations in turn determine prices. Hence, when futures prices exceed spot prices may be profitable to store crude oil today in order to sell it for more profit in the future.

Mobert (2007) and Gurrib (2007) argued the commodity futures trading commission's net positions in the futures market as a good indicator for the behavior of investors and speculators. Thus, it can be calculated as the difference between noncommercial long positions and noncommercial short positions. If the difference of long positions exceeds short positions, then the oil price is positively affected. Therefore, according to the previous explanation I expect a significant relationship between future markets and oil price ceteris paribus.

3.5.7 Geopolitics

Political conflicts affected oil prices, and created instability in the oil market. Kesicki, et al. (2009) argued that the political events and geological variables are responsible for all the crisis of rising oil prices in 1970 and the recent crisis in 2008. For that dummy variables will be selected to represent the first and second Gulf war in Iraq 1990 and 2003.

3.6 Illustrative Model: Crude Oil Demand-Supply Nexus

The functions and equations below describe the main factors and variables which influence the crude oil price. Basically, the determination of the price of crude oil is done by market mechanism through the interaction of demand and supply. The complexity of the whole process can be imagined by just looking at the functions and the variables involved. The global market for crude oil consist of three sets of participants: oil consumers, OPEC oil producers, and non-OPEC oil producers. Hence, to accurately capture the real scenario, the model to be estimated will incorporate all the main functions and variables.

Price function

P_t = f(Supply variables, Demand variables, Geopolitics, Financial variables)

Supply function

$$\text{Total world production} = PROD^{OPEC} + PROD^{Non\text{-}OPEC} \qquad (3.2)$$

$$PROD^{OPEC} = DEM^{World} + \Delta\, Stocks^{OECD} - NGLS^{Natural\,gas\,liquid} - PROD^{Non\text{-}OPEC} - PG^{Processing\,gains} \qquad (3.3)$$

$$PROD_j^{Non-OPEC} = \theta(Cost^{Pro}, P^{Natural\,gas}, \frac{P^{oil}}{P_i^D}, RIG^{total}) \qquad (3.4)$$

Demand function

$$D = D^C + D^S \qquad (3.5)$$

$$D^C = \Psi(GDP, \frac{P^{oil}}{P_i^D}, EXC^{rate}) \qquad (3.6)$$

$$D^S = K(CH^{Poi}, INT) \qquad (3.7)$$

$$CH^{POIL} = P_t - P_{t-1} \qquad (3.8)$$

P_t : Price in the current year for the US FOB price measured in USD per barrel.

For j = US {lower 48 with Alaska, Canada, Asia, Africa, Europe, Latin America (Brazil, Mexico and others)}.

$PROD^{world}$: Oil production in mb/d, $PROD^{world}$: OPEC production, $PROD_j^{Non\text{-}OPEC}$: Non -OPEC production. $Cost^{Pro}$: Measure of oil production costs, $Stocks^{OECD}$: Oil stocks reported by OECD. $NGLS^{Natural\,gas\,liquid}$: Natural gas liquid in mbd, $PG^{Processing\,gains}$: Net processing gains in mbd $PROD^{OPEC}$: Production of OPEC, 0.96 : the highest level of OPEC. GDP: Real gross domestic price for world , P^{oil}: Crude oil price in USD, DC : Demand for consumption, DS: Demand for stockpiling, PD : domestic price index, EXC^{rate} : The exchange rate , INT: rate of interest, CH^{Poil} : The average change in crude oil price, Ref_t^{Utiil}: US refinery utilization. i :(United States, Euro countries, United Kingdom, Switzerland, other

Dev. Eco., Non - Japan Asia, Transition, Latin America, Rest of the world), MIij: Market instability.

3.7 Model Specification

This is a world oil model in which the behavior of three sets of participants: oil consumers, OPEC oil producers, and non-OPEC oil producers are studied. Hence, it will contain three main functions: demand, supply and oil price.

Price function

P_t = f(Supply variables, Demand variables, Geopolitics, Financial variables)

$$P_t = f(Days_t^{OECD}, DEM_t^{World}, SUP_t^{World}, OP_t^{caputil}, OP_t^{quota}, OP_t^{cheat}$$

$$, RIG^{total}, CON^{Yield}, NYMEX, \text{Dummy variables})$$

P_t : Price in the current year for the US FOB price measured in USD per barrel.

$$Day_t^{OECD} = \frac{\text{Total crude oil stocks of OECD countries}}{\text{OECD total demand of oil}}$$

OP_t^{Quo} : OPEC's production share in mbd. Quo means quota

$OP_t^{Che} = OP^{Pro} - OP^{Quo}$, pro means production, che indicates cheat in mbd, CON_{Yield} : Convenience yield, $OP_t^{caputil}$: OPEC's utilization capacity $= \left(\left(\frac{OP^{Pro}}{OP^{Cap}} * OP^{Quo}\right) / \left(\frac{OP_t^{Che}}{\text{global oil demand}}\right) \right)$

$Stocks^{OECD}$: Oil stocks reported by OECD. $NGLS^{\text{Natural gas liquid}}$: Natural gas liquid in mbd, $PG^{\text{Processing gains}}$: Net processing gains in mbd $PROD^{OPEC}$: Production of OPEC, 0.96 : the highest level of OPEC. GDP: Real gross domestic price for world , P^{oil}: Crude oil price in USD, DC : Demand for consumption, DS: Demand for stockpiling, PD : domestic price index, EXC^{rate} : The exchange rate , **INT**: rate of interest, CH^{Poil} : The average change in crude oil price, Ref_t^{Utiil} : US refinery utilization. i :(United States, Euro countries, United Kingdom, Switzerland, other Dev. Eco., Non - Japan Asia, Transition, Latin America, Rest of the world), MT: Market instability.

$$P_t = f(\text{Demand variables, Supply variables, Geopolitics, Financial variables})$$

$$P_t = a_0 + \lambda_1 Days_t^{OECD} + \lambda_2 DEM_t^{World} + \lambda_3 SUP_t^{World} + \lambda_4 OP_t^{caputil} + \lambda_5 OP_t^{quota} +$$

$$\lambda_6 OP_t^{cheat} + \lambda_7 Con_{Yield} + \lambda_8 (NY4_t - NY1_t) + \lambda_9 RIGS^{total} + \lambda_{10} War^{Gul} + \mu \qquad (3.9)$$

War^{Gul1} : Gul means gulf war, it is a dummy variable added to explain the Gulf war1990 in Iraq.

War^{Gul2} : is a dummy variable added to explain the Gulf war in Iraq 2003.

$NY4_t$: Means NYMEX in the fourth month contracts for West Texas Intermediate crude oil.

$NY1_t$: Means NYMEX in the first month contract for WTI.

μ : Errors

$a_0 =$ intercept parameter

$\lambda_1, \lambda_2, \lambda_3, .. \lambda_n$ = coefficients of the slope parameters in the model above.

Oil price equation in this model used as an instrument to calculate oil price determinants can be explained as follows. At any given price, oil demand determines the quantity of oil supplied. Non-OPEC producers adjust their production according to the new price which settled. In sequence, OPEC will equilibrate supply and demand as a swing producer. The oil price equation measures the main variables affecting oil prices. Also to what extent the OPEC responds to satisfy the call for its oil due the measure of capacity utilization and production relative to quotas. The oil price equation also measures the effect of market conditions such as; OECD stocks and capacity utilization. These variables could be a proxy for supply-demand conditions that account for random trends in the historical record of real oil prices.

To calculate the effect of market conditions in the New York mercantile exchange (NYMEX), I can collect observations on the near month contract and the contract for four months for West Texas intermediate (Cushing - USD per barrel). Also, to generate quarterly observations, I average the values of the days that are traded. I use this data to calculate the difference between a near month and four month contract. I compile the notes for the quarterly rate of GDP deflator in the United States in order to calculate the price of oil in real terms.

To represent the effect of refinery utilization rates non-linearity, and the circumstances prevailing in the New York Stock Exchange on the rise in crude oil prices and other variables, I will estimate (3.9) equation. According to previous analyses, time series for the real crude oil price and its determinants probably have a stochastic trend. Therefore, I calculate the time series properties of these variables in the equation (3.9) by using the augmented Dickey Fuller statistic (Dickey and Fuller, 1979) and a test statistic for quarterly data. First, I test to see if the variables are stationary I (0). If not, they are assumed to have a unit root and be I (1). If a set of variables is all I (1) they should not be estimated using ordinary regression analysis, but between them there may be one or more equilibrium relationships. I can both estimate how many and what they are (called cointegrating vectors) using Johansen's technique.

The objective in constructing the model was to find an answer to the question, what are the drivers of oil prices in the recent? In another word, does oil prices determined by physical or financial markets? Scientists and analysts have different views about the real reasons that led to the fluctuation of oil prices in recent years, some of them believe that market fundamentals are the main cause, while others believe that the growth of the financial markets, future markets and speculator activity was the main cause of fluctuation in prices.

As a result, new theories emerged to explain the changes in the oil market, such as bubble theory and the theory of storage, as an attempt to explain the new variables, such as; convenience yield, days of forward supply, refining capacity and OPEC capacity utilization, in order to reduce the fluctuation of oil prices, which have a big impact on oil producing and consuming countries. In our methodology to find an answer to one of the objectives of this study (are oil prices determined by fundamentals or financial factors), a Principal component analysis is used for the following reasons: PCA is a multivariate statistical technique which calculates the principal directions of variability in data and transforms the original set of correlated variables into a new set of uncorrelated variables.

The new uncorrelated variables are linear combinations of the original variables. These principal components represent the most important directions of variables in a dataset. Therefore, PCA can be considered as a powerful tool for analyzing data

(Smith, L, 2002; Stock and Waston, 2002; Bernanke, Boivin and Eliasz, 2008; P.Zagalia, 2010; Tatyana, 2010). Moreover, Principal component analysis (PCA) transforms a number of (possibly) correlated variables into a (smaller) number of uncorrelated variables called principal components. The first principal component accounts for as much of the variability in the data as possible, and each succeeding component accounts for as much of the remaining variability as possible.

Generally, principal component analysis has two main objectives (Tatyana, 2010)

- To discover or to reduce the dimensionality of the data set.
- To identify new meaningful underlying variables. According to this method, Plot of factors in PC1-PC2 coordinates system - factors corresponding to the points lying along with the horizontal axis are assumed to be fundamental factors as shown in the Figure 3.2.

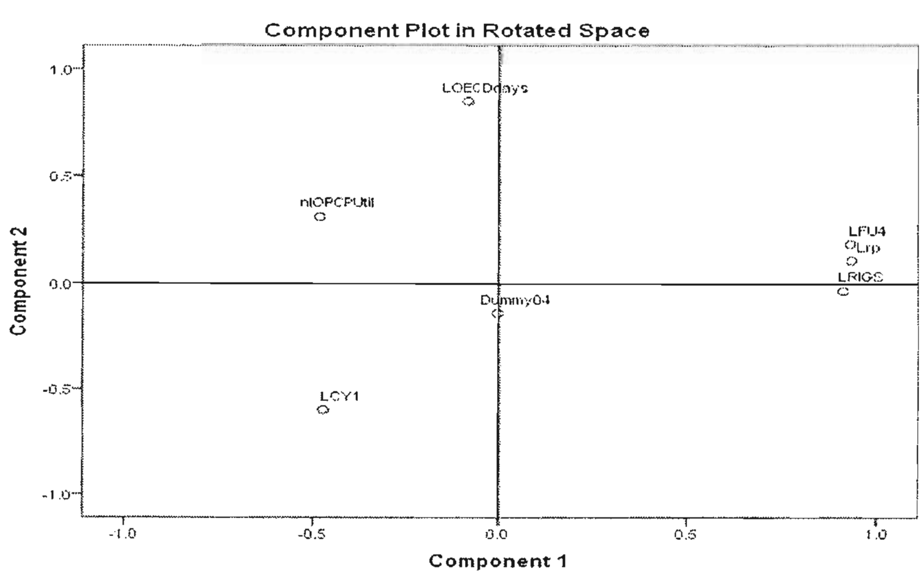

Figure 3.2
Plot of Factors in PC1-PC2 Coordinates System

LOECD days, FU4, Rigs, CY1, OPcputil and dummy are the independent variables which explain the main factors determining crude oil price changes.

3.8 Estimation technique and statistical tools

Time series for financial modeling in general required three main steps:

1. Model identification and selection.

2. Model estimation by using either maximum likelihood estimator or non-linear least squares estimator.

3. Model testing for stationary to make sure that the model satisfies the statistical conditions for data selected. Especially, the residuals of variables should be independent and constant due the mean and variance eventually.

Properties of models that are taken into account for choosing the best fitting model are presented below.

3.8.1 Model identification and selection

In the identification step, the residuals of estimation can be tested for Autoregressive Conditional Heteroscedasticity (ARCH) behavior. Tests for non-normality to make sure that certain assumptions about the model are satisfied due to the values for kurtosis. Tests are also performed to see if autocorrelation between variables have been removed or not. Test statistics are given by Ljung-Box-Pierce portmanteau tests for residuals and the squared residuals in the model as follows.

3.8.1.1 Jarque-Bera test

This test used to check normality of the data distribution. The hypothesis for this test is:

H0: the distribution of data is normal.

H1: the distribution of data is not normal.

The Jarque-Bera test statistic provides clear indication to reject or accept the null hypothesis of normality for the unconditional distribution according to the value for excess kurtosis. The test also is performed for goodness-of-fit test of whether sample data have the skewness and kurtosis matching a normal distribution or not. The test statistic can be defined as follows (G. M. Ljung; G. E. P. Box, 1978).

$$JB = \frac{n}{6}\left[S^2 + \frac{1}{4}(k-3)^2\right] \tag{3.10}$$

Where n refers to the number of observations; S is the skewness of the sample, and K is the kurtosis. Distribution of samples is normal if an expected skewness of 0 and an expected excess kurtosis of 0 (which is the same as a kurtosis of 3).

3.8.1.2 Ljung-Box test

The Ljung–Box test is a test used to check whether any of a group of autocorrelations of a time series is different from zero or not. The hypothesis for this test is:

H0: The data is random (not correlated).

H1: The data is random (correlated).

H0 means that data are independently distributed, while H1 shows that the data are not independently distributed. The test statistic can be defined as follows (G. M. Ljung; G. E. P. Box, 1978).

$$Q = n(n+2)\sum_{k=1}^{h}\frac{p^2k}{n-k} \tag{3.11}$$

Where n refers to sample size, $\hat{\rho}_k$ is the autocorrelation of sample at lag k, and h refers to the number of lags being tested. For significance level α, the critical region for rejection of the hypothesis of randomness is:

$Q f \chi^2_{1-a,h}$

Where $\chi^2_{1-a,h}$ indicates the quantile of the chi-squared distribution with h degrees of freedom.

3.8.1.3 Model estimation statistics tests

The idea of using these criteria is, if I have a data set, several models may be analyzed due to their values of information criteria.

3.8.1.4 Akaike information criterion (AIC)

The Akaike information criterion is a statistical tool used for measuring the relative goodness of fit for the model. It was developed by Hirotsugu Akaike. The values of AIC provide a means for selecting. The test statistic can be defined as follows (G. M. Ljung; G. E. P. Box, 1978).

$$AIC = 2k - 2\ln(L) \quad (3.12)$$

K refers to the number of parameters in the model, L indicates the maximum value of the likelihood function for the model estimation. According to this test, I prefer the model that has the minimum AIC value.

Hence AIC not only used for goodness of fit, but also gives a penalty if there an increase in the number of estimated parameters.

3.8.1.5 Bayes information criterion (BIC)

The Bayesian information criterion (BIC), named also Schwarz criterion is a statistical tool used for model selection. It is based on the likelihood function. This tool is closely related to AIC criteria. The formula for the BIC is (Akaike, H., 1977):

$$-2\ln p(x \setminus k) \approx BIC = -2\ln L + k\ln(n) \tag{3.13}$$

Where x is the observed data, n is the number observations, or the size of the sample, k is the number of parameters (regressors) including the intercept and L is the maximum value of the likelihood function for the model estimation.

In general, for fitting models, I can increase the likelihood by adding more parameters, but it may cause over fitting. This problem can be solved by using AIC due introducing a penalty term for the maximum number of parameters that can be used in the model. The penalty term in BIC is greater than AIC. Thus, the preferred model is the one that has a lower value of BIC.

3.9 Cointegration Analysis

Economic time series are said to be cointegrated if these series are integrated of order one, I (1) before differencing but are stationary, I (0) after differencing, and a linear combination of the I (I) series is stationary. Therefore, there is a long run relationship between these series because they do not drift too far apart from each other over time. The augmented Dickey Fuller is used to test for the stationarity of variables. The Johansen cointegration approach is used to investigate the long run relationship between crude oil prices and macroeconomic variables for the oil market. I will analyze the short run dynamic and interaction between crude oil prices, and the macroeconomic variables, based on the vector error correction model

(VECM) using Granger causality tests and the variance decomposition analysis (VDC).

3.9.1 Unit Root Test

The empirical investigations commence with an analysis of the time series properties and determine the order of integration for multivariate series. There are several variations of the unit root test: The augmented Dickey-Fuller test (ADF) (1979, 1981), Phillips-Perron (PP) (1988) and Kwiatkowski, Schmidt and Shin (1992). Stationarity means that when I consider two different time intervals, the sample mean and sample covariance of the time series over the two time intervals will be almost the same. In other words, a time series is called stationary if its statistical properties remain constant over time. The augmented Dickey-Fuller test (ADF) has been the most popular test used to check data stationary in empirical research. This test is applied in higher order and models where the error terms are serially correlated. The augmented Dickey-Fuller test (ADF) can be represented by the following equation:

$$\Delta Y_t = \Upsilon Y_{t-1} + X_t^{'}\delta + ... + \sum_{i=1}^{k} \beta_i \Delta Y_{t-i} + \epsilon_t \qquad (3.14)$$

Where $\Upsilon t \succ 0$ and $\Upsilon i \geq 0,\ i \succ 0$

The unit root test is carried out under the hypotheses

Ho: series contains a unit root.

Versus *Hr.* series is stationary.

So if I reject the null hypothesis (if the coefficient of the lag of *y* is significantly different from zero) then the series is stationary. But if I accept it (reject the alternative hypothesis), then the series is non-stationary.

The PP tests are based on the following equations:

$$Y_t = \mu + a^* Y_{t-1} + v_t \tag{3.15}$$

$$Y_t = \mu + \beta(1 - \frac{T}{2}) + a \sim Y_{t-1} + v_t \tag{3.16}$$

Where Yt represents: crude oil price (Pt), OECD days ($Days_t^{OECD}$), world demand of oil (DEM_t^{World}), world supply of oil (SUP_t^{World}), OPEC capacity utilization ($OP_t^{caputil}$), OPEC quota (OP_t^{quota}), OPEC cheat (OP_t^{cheat}), refinig utilization (Ref_t^{Utiil}), convenience yield (Con_{Yield}),the difference between the first month and four months contracts for New York mercantile exchange $(NY4_t - NY1_t)$,total oil rigs ($RIGS^{total}$), the first war Gulf (War^{Gul1}), and the second war Gulf (War^{Gul2})., T is the number of observations, μ is non-zero mean term, β linear trend term. In the equation below

$$AIC = T \log L + 2N$$

$$SC = T \log L + N \log T \tag{3.17}$$

The null hypothesis where Ho: a*=1 is tested by using the Z(a*) and Z(t a*) test statistics and Ho: μ =0 and a*=1 is tested by using the Z(a*) and Z(ta*)test statistics and Ho: μ =0 and a*=1 is tested by using the Z(ϕ1) test statistics.

In the equation 3.17 the null hypothesis where Ho: a*=1 is tested by usingthe Z(a*) and Z(t a*) test statistics and Ho: β =0 and a*=1 is tested by using the Z(ϕ2) . The adjusted Z test statistics are given in Perron (1988).

However, recently researchers pointed out that the standard ADF test is not appropriate for variables that may have undergone structural changes. Perron (1989) has shown the existence of structural changes biases of the standard ADF tests towards non-rejection of the null of a unit root. Perron (1989) demonstrated that if the observations corresponding to unique events (great depression (1929) and first oil crises (1973) isolated from Nelson' and Ploser's (1982) data, the results derived by Nelson and Ploser could be reversed for most of the variables.

3.9.2 Structural Shift and Unit Root Test

Perron (1989) and Balke and Fomby (1991) showed that if a series is stationary around a determined time trend; which has undergone a permanent shift sometimes during the period under consideration, is failed to be noted, this change in the slope will be mistaken by the usual ADF unit root test as a persistent innovation to a stochastic trend. A limitation on the Augmented Dickey Fuller (ADF) type endogenous break unit root tests is that, the critical values are derived while assuming no break(s) under the null. Hence, ADF will have low power if there has been a shift in the intercept or in the determined time trend (Campbell and Perron, (1991).

Perron (1989) and Zivot and Andrews (1992) provided an extension to the standard ADF test that takes into account, possible structural break(s) in the series and the intercept. Saikkonen and Liitkepohl (2002) and Lanne, Liitkepohl and Saikkonen (2002) proposed unit root tests that are based on estimating the deterministic term first by a generalized least squares (GLS) procedure under the unit root null hypothesis and then, subtracting it from the original series. Then, an ADF-type test is performed on the adjusted series, which also includes terms to correct estimation errors in the parameters of the deterministic part. It seems appropriate to test for unit root following the model proposed by Saikkonen and Liitkepohl (2002) and Lanne et al., (2002). The following equations present the structural break-oriented ADF test:

$$\Delta Yt = a_0 + B_t + \theta DUt + \delta DTB_t + (p-1)Y_{t-1} + \sum_{i=1}^{n} \Psi_i \Delta Y_{t-i} + u_t$$

$$u_t \sim i.\ i.\ d.(0,\theta) \tag{3.18}$$

$$\Delta Yt = a_0 + B_t + \theta DU_t + \delta DTB_t + \Upsilon DT_t + (p-1)Y_{t-1} + \sum_{i=1}^{n} \Psi_i \Delta Y_{t-i} + u_t \tag{3.19}$$

Where, two structural breaks are allowed in both, the time trend and the intercept, which occur at Tβ. Dummies DTB, DU, and DT, allow for a break in the level of the trend function, a break in the slope and breaks in both the level and the slope, respectively. *DTBt=1* if t =Tβ+1 (otherwise it is equal to zero), *DUt* = 1 if t >*TB* and *DTt= t-Tβ* if t >*TB,* zero when otherwise.

Saikkonen and Liitkepohl (2002) put forward that structural breaks may occur over a number of periods and display smooth transition to a new level. For example, when a level shift function, which is here denoted by a general nonlinear form ft(Θ)Υ, is added to the deterministic term, μt, of the data generating process, the model of

$$Y_t = a_0 + a_1 t + ft(\theta)'\Upsilon + v_t \tag{3.20}$$

Is shown, where *Θ* and *Υ* are unknown parameters, whereas *vt* are residual errors generated by an AR(p) process with possible unit root. In this study, I consider the shift function based on the exponential distribution function, which allows for a nonlinear gradual to shift to a new starting level at the time,

$$f(\theta) = \begin{cases} 0 & t \leq TB \\ 1 - exp\{-\theta(t - TB + 1) & t \geq TB \end{cases} \tag{3.21}$$

In the shift term ft (Θ)'ϒ, both Θ and ϒ are scalar parameters. The first one is confined to the positive real line (Θ > 0), whereas the second one may assume any value. The Saikkonen and LUtkepohl test in model below:

$$Y_t = a_0 + a_1 t + ft(\theta)'\Upsilon + v_t$$

Based on the estimation of the deterministic term, first by generalized least squares (GLS) determines the procedure under the unit root null hypothesis and then, subtracting it from the original series. An ADF-type test is then performed on the adjusted series, which also includes terms to correct estimation errors in the parameters of the deterministic part. The asymptotic null distribution is nonstandard, and the critical values are tabulated in Lanne et al., (2002).

3.9.3 Vector Autoregressive Model (VAR)

Vector Autoregressive Model (VAR) is a model used to find the linear interdependencies among several time series data. VAR models can describe the development of a set of k variables (endogenous variables) in the model at the same time period (t = 1, ..., T) which treated as a linear function. The variables are collected in a k × 1 vector Y_t, which has as the i^{th} element $Y_{i,t}$ the time t observation of variable Y_t. For instance, assume the i^{th} variable is oil supply, and then $Y_{i,t}$ is the value of oil supply at t. Hence, the reduced form of VAR given by (Walter Enders, 2003).

$$y_t = c + A_1 y_{t-1} + A_2 y_{t-2} + \dots\dots + A_p y_{t-p} + et \tag{3.22}$$

Where c is an intercept parameter for (k × 1) vector of constants, A1 is a matrix in the order (k × k) for every i = 1, ..., p, The l-periods back observation Y_{t-1} is called the i^{th} lag of y and e_t represent (k × 1) vector of error terms in the model.

A number of books and review articles deal with VAR models (Hamilton 1994; Johansen, 1995; Hatanaka, 1996; Liitkepohl and Kratzig, 2004; Liitkepohl, 2005).

A (reduced) pth order VAR, indicated VAR (p), is

$$y_t = c + A_1 y_{t-1} + A_2 y_{t-2} \ + A_3 y_{t-3} \ + A_p y_{t-p} + e_t \tag{3.23}$$

As c is a L× 1 vector of constants (intercepts), A_i is a L × L matrix (for each i = 1, ..., p) and e_t is a L × 1 vector of error terms satisfying the following conditions:

1. $\mathbf{E(e_t) = 0}$. Each error term has mean equals zero;
2. $E(e_t e_t') = \Omega$. The contemporaneous covariance matrix of error terms is Ω (a L × L positive-definite matrix);
3. $E(e_t e_{t-L}') = 0$. For any non-zero k, there is no correlation across time; particularly, no serial correlation in individual error terms (Hatemi.J, 2004).

The I th time lag periods of observation y_{t-1} is called the I^{th} lag of y. Hence, a p^{th} order VAR is also denoted a VAR with p lags. Special consideration needs to be given to the lag choosing process in the VAR model for the reason that all inference is dependent on the selected lag order (Hacker and Hatemi-J, 2008; Hatemi.J and Hacker, 2009).

A VAR with p lags can usually be re-specified as a VAR with only One lag by suitably redefining the dependent variable. The transformation amounts to just stacking the lags of the VAR (p) variable in the new VAR (1) dependent variable and adding identities to complete the number of equations.

For instance, the VAR (2) model

$$y_t = c + A_1 y_{t-1} + A_2 y_{t-2} + e_t \tag{3.24}$$

Can be re specified as the VAR (1) model

$$\begin{bmatrix} y_t \\ y_{t-1} \end{bmatrix} = \begin{bmatrix} c \\ 0 \end{bmatrix} + \begin{bmatrix} A_1 & A_2 \\ I & 0 \end{bmatrix} \begin{bmatrix} y_{t-1} \\ y_{t-2} \end{bmatrix} + \begin{bmatrix} e_t \\ 0 \end{bmatrix}$$

The symbol (I) refers to the identity matrix. The equivalent VAR (1) structure is more convenient for analytical derivations and allocate more compact statements.

A structural VAR with p lags is

$$B_0 y_t = c_o + B_1 y_{t-1} + B_2 y_{t-2} + B_p y_{t-p} + \gamma_t$$

As c_0 is a $L \times 1$ vector of constants, Bi is an $L \times L$ matrix (for each i = 0, ..., p) and γ_t is a $L \times 1$ vector of error terms. The main diagonal terms of the B0 matrix; the coefficients on the i^{th} variable in the i^{th} equations are scaled to 1.

The error terms γ_t (the structural shocks) satisfy the conditions (1) and (3) in the definition above, with considering that all the elements of the main diagonal of the covariance matrix $\sum E(e_t e_t') = 0$ are zero. That is, the structural shocks are uncorrelated. For instance, a Two variable structural VAR(1) can be presented as:

$$\begin{bmatrix} 1 & B_{0;1,2} \\ B_{0;2,1} & 0 \end{bmatrix} \begin{bmatrix} y_{1,t} \\ y_{2,t} \end{bmatrix} = \begin{bmatrix} c_{0;1} \\ c_{0;2} \end{bmatrix} + \begin{bmatrix} B_{1;1,1} & B_{1;1,2} \\ B_{1;2,1} & B_{1;2,2} \end{bmatrix} \begin{bmatrix} y_{1\ t-1} \\ y_{2\ t-2} \end{bmatrix} + \begin{bmatrix} i_{1,t} \\ i_{2,t} \end{bmatrix}$$

Where:

$\sum E(\Upsilon_t \Upsilon_t') = \begin{bmatrix} \sigma_1^2 & 0 \\ 0 & \sigma_2^2 \end{bmatrix}$; The variances of the structural shocks are indicated

$Var(\Upsilon_t) = \sigma_i^2 \ _{(i=1,2)}$ and the covariance is $\mathrm{Cov}(\Upsilon_1, \Upsilon_2) = 0$.

Reduced-form VAR

By multiplying the structural VAR by the inverse of B0 have getten:

$$y_t = B_0^{-1} c_o + B_0^{-1} B_1 y_{t-1} + B_0^{-1} B_2 y_{t-2} + B_0^{-1} B_p y_{t-p} + B_0^{-1} \Upsilon_t$$

And denoting

$$B_0^{-1} c_o = c, B_0^{-1} B_i = A_i \text{ for } i = 1, 2, \ldots\ldots, p \text{ and } B_0^{-1} \Upsilon_t = e_t$$

Have obtains the p^{th} order reduced VAR

$$y_t = c + A_1 y_{t-1} + A_2 y_{t-2} + A_p y_{t-p} + e_t$$

Note down that in the reduced form above all right hand side variables are predetermined at the time t. Since there are no time t endogenous variables on the right hand side, no variable has a direct synchronous effect on other variables in the model.

Nevertheless, the error terms in the reduced VAR consist of the structural shocks $e_t = B_0^{-1}\Upsilon_t$. Therefore, the accuracy of One structural shock $e_{i,it}$ perhaps can lead to the accuracy of shocks in all error terms, e.g. hence creating contemporaneous movement in all endogenous variables. As a result, the covariance matrix of the reduced VAR

$$\Omega = E(e_t e_t') = E\left[B_0^{-1}\Upsilon_t \Upsilon_t'(B_0^{-1})'\right] = B_0^{-1}\Sigma(B_0^{-1})'$$

Can have non-zero off-diagonal elements, as a result allowing non-zero correlation between error terms.

VAR is introduced by Sims (1980) and based on the idea that many macroeconomic variables and their movements are interrelated. The main advantage of VAR is that it does not use any preconceived economic theory on which the model is built and its practical ability to capture the dynamic relationships among the economic variables of interests. VAR model consists of a system of equations that expresses each variable in the system as a linear combination of its own lagged value and lagged values of all the other variables in the system and will regress each variable on all other lagged variables.

Two questions arise about the construction of a general VAR model.

First, how can I determine the set of variables to include in a VAR model?

Second, how can I determine the appropriate lag length?

The included variables in a VAR model are selected according to the relevant economic theory. The selected variables must have economic influences on each other. In other terms, there must be a causality between them. The over parameterization and loss of degrees of freedom problems must be avoided to capture the important information in the system. The appropriate lag length must be determined by allowing a different lag length for each equation at each time and choosing the model with the lowest AIC and SBC values. The same sample period must be considered for different lag lengths. If the lag length is too small, the model will be misspecified; if it is too large, the degrees of freedom will be lost. The VAR analysis determines the interrelationship among the economic time series rather than the parameter estimates. The residual correlation in the VAR model reveals the interaction of the variables in the previous periods.

The main uses of the VAR model are the impulse response analysis, variance decomposition, and Granger causality tests. Examining the estimated coefficients on successive lags in a VAR system is not meaningful enough to give an understanding of the dynamic relationships among the variables in the system. Rather, it is useful to trace out the system's response to typical random shocks that represent positive residuals of one standard deviation unit in each equation in the system. Therefore, Sims (1980) suggests the use of the impulse response and variance decomposition to help achieve this analytical interpretation of the VAR system. An impulse response function traces the response of the endogenous variables to one standard deviation shock or change to one of the disturbance terms in the system.

A shock to a variable is transmitted to all of the endogenous variables through the dynamic structure of the VAR. Time series analysis requires data to be covariance stationary, and that most macroeconomic series displays significant trends has led to first difference time series before estimating economic models. If the economic series is stationary only after differencing but a linear combination of their levels is stationary, then the series is said to be cointegrated. Although it can be used non-stationary series for regression analysis after differencing the series successively until stationary is achieved, this is not recommended two main reasons; first, when I difference variables than I are also differencing the error term in the regression, and this produce a non-invertible moving average error in the regression. Second, if I difference the variables; the model can no longer give a unique a long run solution (Asteriou & Hall, 2007).

In this study I use vector autoregressive (VAR) to investigate the interactions of crude oil prices and oil market variables. The VAR technique, as applied to a simultaneous equation system, estimates unrestricted reduced form equations with uniform sets of the lagged dependent variables of each equation as regressors. Because this approach sets no restrictions on the structural relationships of the economic variables, it avoids misspecification problems.

According to Sims (1980) a VAR is a system of regression model, or it is a multiple time series generalization of AR model. Focusing on the distinction between exogenous and endogenous variables, the results of this model will be re-specified with shorter lists of exogenous variables. Many of the exogenous variables are treated as exogenous by default rather than there being good reason to believe they strictly exogenous. Because some variables require an extensive modelling effort some variables are treated as exogenous. Also, some variables are treated as exogenous because they are policy variables even though they evidently have a substantial endogenous component. So if I have a list of exogenous variables in case endogeneity is doubtful, the identification of the model might well fail, and would at best be weak. Therefore, it is useful to use a VAR approach which all variables are treated as endogenous, and I do not have to worry about which variables are endogenous or exogenous. To test the interrelationship between variables, the VAR is a good starting point. The VAR model with only one lag in each variable would be:

$$y_t = \beta_{10} - \beta_{12}x_t + \gamma_{11}y_{t-1} + \gamma_{12}x_{t-1} + u_{yt} \tag{3.25}$$

Where *Yt* is a time series that is affected by current and past values of *Xt*.

$$x_t = \beta_{20} - \beta_{21}y_t + \gamma_{21}y_{t-1} + \gamma_{22}x_{t-1} + u_{xt} \tag{3.26}$$

Where *xt* is a time series that is affected by current and past values of *yt*. And I assume both *yt* and *xt* are stationary, and the errors *(uyt and uxt*) are not correlated. The model employed in this study is a finite order VAR which is a multivariate modeling, which each endogenous variable is regressed on its own lags and lags of all other variables in the system; the number of lags determines the order of the VAR" (Kakes, 2000, 36).

The baseline VAR model proposed in this Chapter includes the endogenous variables' vector (i.e. Z vector), as follows:

$$z_t = y_t z_{t-1} + \ldots . y_j z_{t-j} + c + \omega_t \tag{3.27}$$

Where $z_t =$ (Pt, Days_t^{OECD}, DEM_t^{World}, SUP_t^{World}, $OP_t^{caputil}$, OP_t^{quota}, OP_t^{cheat}, Con_{Yield}, $(NY4_t - NY1_t)$, $RIGS^{total}$, War^{Gul1}, War^{Gul2}) is (12x1) vector, yt is a (12x12)parametric matrix, c is a (12x1) constant vector, *et* is the (12x 1) Vector of random error terms with zero mean and constant variance, and j is the lag length.

3.9.3.1 VAR Model Checking

The steps for checking whether the VAR model stand for the Data Generation Process (DGP) of the variables effective range from formal tests of the underlying assumptions to informal steps like inspecting plots of residuals and autocorrelations. A reduced form is underlying every structural form, while model checking generally focus on reduced form models. If a particular reduced form model is not an adequate representation of the DGP, any structural form based on it cannot stand for the Data Generation Process well. Official tests for residual autocorrelation, non-normality and conditional heteroskedasticity for the reduced form VARs are in brief summarized in the following (Helmut L., 2011).

3.9.3.2 Tests for Residual Autocorrelation

Portmanteau and Breusch-Godfrey-LM tests are common tools for checking residual autocorrelation in VAR models. The null hypothesis of the portmanteau test is that all residual autocovariances are zero, that is, $H0: E(e_t e'_{t-i}) = 0, i = 1,2,3,\ldots$ The alternative hypothesis H_1: is that at least One auto-covariance and hence, One autocorrelation is nonzero. The test statistic is based on the residual auto covariance (Helmut L., 2011).

For low order autocorrelation the Breusch-Godfrey LM test is more suitable. It may be viewed as a test for zero coefficient matrices in a VAR model for the residuals,

$$U_t = B_1 U_{t-1} + \dots\dots + B_h U_{t-h} + e_t$$

The quantity e_t indicates a white noise error term. Hence, a test of $H0: B_1 = \dots\dots = B_h = 0$ versus $B_i \neq 0$ for at least one $i \in [1, \dots, h]$, may be used for checking that u_t is white noise. As a consequence, the LM test is applicable for levels VAR processes with unknown cointegrating rank (Helmut L., 2011).

3.9.3.3 Other Popular Tests for Model Adequacy

Non-normality tests are regularly used for model checking, even though normality is not a necessary condition for the validity of many of the statistical procedures related to VAR models. Nevertheless, non-normality of the residuals may point to other model lack for instance nonlinearities or structural change. Multivariate normality tests are in general applied to the residual vector of the VAR model and univariate versions are used to check normality of the errors of the individual equations. The default tests check whether the third and Fourth moments of the residuals are in line with a normal distribution, as suggested by Lomnicki (1961) and Jarque and Bera (1987) for univariate models.

Conditional heteroskedasticity is usually a concern for models based on data with monthly or that have a high frequency. So suitable univariate and multivariate tests are available to check for such features in the residuals of VAR models. Once more much of the analysis can be done even if there is conditional heteroskedasticity. It's noticeable that the VAR model shows the conditional mean of the variables which are often of primary interest. Nevertheless, it may be useful to check for conditional heteroskedasticity to better understand the properties of the underlying data and to increase inference. Also, heteroskedastic residuals can indicate structural changes.

3.9.4 Lag Length Selection

In order to embark on the cointegration analysis, it is imperative to determine of the optimal lag length for a VAR. Lag length selection is important for VAR specification because choosing too few lags result in misspecification and choosing too many lags result in unnecessary loss of degrees of freedom. To avoid this, lag lengths are selected using statistical tests, which include the modified Likelihood Ratio (LR) test, Akaike Information Criterion (AIC), Schwarz Information Criterion (SC) and Hannan-Quinn Information Criterion (HQ).

The Akaike Information Criterion (AIC) was developed by Akaike (1974) and given by:

$$AIC = T \log L + 2N \quad (3.25) \qquad (3.28)$$

The Schwarz Bayesian Criterion was developed by Schwarz (1978) and is given by:

$$SC = T \, logL + N \, logT \qquad (3.29)$$

Where L denotes the likelihood or the sum of squared errors, N is the number of parameters in the estimated model, T is the number of observations in the series.

3.9.5 Johansen Cointegration Approach

The second step is the Johansen cointegration approach, used to test the long run relationship between crude oil price and oil market variables. To fulfil this goal I use the maximum likelihood based cointegration approach introduced by Johansen (1988, 1991), only after examining whether there is unit root or not for each time series individually. If the time series are found to be integrated of the same order after the unit root tests, then these variables may be cointegrated. Cointegration deals with the relationships among a group of variables, where unconditionally, each has a unit root (Kogar, 1995). The procedure begins by expressing the stochastic variables in a (nxl) vector Yt as the unrestricted vector autoregressive (VAR) involving up to k-lags of Yt:

$$\mathrm{Y_t} = A_1 \mathrm{Y_{t\text{-}1}} + \ldots\ldots A_k \mathrm{z_{t\text{-}k}} + c + u_t \tag{3.30}$$

$$\mathrm{Y_t} = \mathrm{c} + \sum_{i=1}^{k} A_1 \mathrm{Y_{t\text{-}j}} + u_t \qquad \mathrm{u_t} \approx IN(0, \Sigma) \tag{3.31}$$

If the variables under consideration are cointegrated, the cointegration vector is normalized with respect to opcapu, opquo, opcheat, uscaputil, rigs, oecddays, nymex41 and convenience yield also, if the variables are cointegrated, it is feasible to verify the short run dynamic through vector error correction model. In order to use Johansen test, the VAR above needs to be turned into a vector error correction model (VECM) that can be written in its first difference form;

$$\Delta \mathrm{Y_t} = \Pi \mathrm{Y_{t\text{-}k}} + \Gamma_1 \Delta \mathrm{Y_{t\text{-}1}} + \Gamma_2 \Delta \mathrm{Y_{t\text{-}2}} + \ldots\ldots + \Gamma_{k\text{-}1} \Delta \mathrm{Y_{t\text{-}(k\text{-}1)}} + \mathrm{u_t} \tag{3.32}$$

$$\Delta \mathrm{Y_t} = \sum_{i=1}^{k-1} \Gamma_i \Delta \mathrm{Y_{t\text{-}i}} + \prod \Delta \mathrm{Y_{t\text{-}k}} + \mathrm{u_t} \tag{3.33}$$

Where $\prod = (\sum_{j=1}^{k} A_i) - I_g$ and $\Gamma_j = (\sum_{j=1}^{k} A_j) - I_g$, I_g is an identity matrix, and $\prod Y_{t-1}$ contains information regarding the long run equilibrium relationship between variables in Yt.

The long run relationship between stock price indices and macroeconomic activity is suggested by the rank of $\prod$ matrix, *r,* where r is *0<r<n.* And the two matrices α and β with dimension *(n* x *r)* are such that $\alpha\beta' = \prod$. The matrix β contains the *r* cointegrating vectors and has the property where β'Yt is stationary, and it is a matrix of long run coefficient, *a* is the matrix of the error correction presentation that measures the speed of adjustment in ΔY_t or it represents the speed of adjustment to disequilibrium.

There are two test statistics for cointegration under the Johansen approach:

$$\lambda_{\text{trace}}(\mathrm{r}) = -\mathrm{T}\sum_{i=r+1}^{g} \ln(1 - \lambda) \qquad (3.34)$$

$$\lambda_{\max} = (r, r+1) - \mathrm{T}\ln(1 - \lambda_{r+1}) \qquad (3.35)$$

Where r is the number of cointegrating vectors under the null hypothesis and λI is the estimated value of the ith ordered Eigen value from the $\prod$ matrix. It is self-evident that the larger λi, the large and negative will ln (l-λi) be, hence the larger the test statistics will be where T is the number of observations. The λ-trace test statistics, tests the existence of at least r cointegration vectors against a general alternative, while the null hypothesis of r against r+I cointegrating vectors is tested by λ-max.

3.9.6 Vector Error Correction Model

If the series is cointegrated, then the possibility of the estimated regression being spurious due to tribulations such as omitted variable bias, autocorrelation, and endogeneity is ruled out. Since our series is cointegrated, I can further proceed to determine the direction of causality, among the variables.

The Johansen's multivariate cointegration test involved testing the long-run relationships between the variables. The relationships among the variables are based on unrestricted vector auto regression (VAR) which presented in equation (3.33), and it can be written in its first difference form:

$$\Delta Z_t = \Gamma_1 \Delta z_{t-1} + \Gamma_2 \Delta z_{t-2} + \ldots.. + \Gamma_j \Delta z_{t-(j-1)} + \omega_t$$

$$\Delta Z_t = \sum_{i=1}^{j-1} \Gamma_i \Delta z_{t-i} + \prod \Delta Y_{t-j} + \omega_t \qquad (3.36)$$

Where $\Delta Z_t = z_t - z_{t-1}$, $\Gamma_i = -\left[I - \sum_{i=1}^{j-1} \Upsilon_i \right]$, and $\prod = -\left[I - \sum_{i=1}^{j} \Upsilon_i \right]$, the

$\prod$ Matrix is a (12 X 12) matrix (the matrix $\prod$ is 12 X 12 due to the fact I use twelve variables), ΠZ_{t-j} contains information regarding the long run equilibrium relationship between variables in Zt, and the matrix Γ_i comprises the short run adjustment parameters. The $\prod$ could be decomposed into the product for two $\prod$ by r matrix α and β so that $\prod$=αβ where β matrix contains r cointegration vectors and a matrix of long run coefficients, and a represent the speed of adjustment parameters to disequilibrium (Gan, Lee, Yong and Zhang, 2006).

It is imperative to determine the order of the VAR system before running Johansen cointegration. This is done by using the likelihood ratio tests, and these procedures yields two lags of the VAR as shown before. In addition, it is important to need to specify the deterministic components, whether these are restricted or unrestricted. Because the asymptotic distribution for the rank test depend on the deterministic components in the model (Juselius, 2006: 139) It will be convenient to distinguish between five different cases (models) often encountered in practice. If the following is the general vector error correction model (VECM):

$$\Delta Y_t = \alpha_{0y} + \alpha_{1y} t - \Pi_y z_{t-1} + \sum_{i=1}^{p-1} \Gamma_{iy} \Delta z_{t-i} + \Psi_y W_t + \omega_t = 1,2,\ldots,n \tag{3.37}$$

$Z_t = \left(y_t^-, x_t^-\right), y_t^-$ is an my x 1 vector of jointly determined (endogenous) 1(1) variables,

$X_t = \alpha_{0x} + \sum_{i=1}^{p-1} \Gamma_{ix} \Delta z_{t-i} + \Psi_x W_t + v_t$,x is an m x 1 vector of exogenous 1(1) variables.

$W = q\ xl$ vector of exogenous /deterministic 1(0) variables, excluding the intercepts and /or trends.

Accordingly, the cointegration analysis distinguishes between the five cases of interest ordered according to the importance of the trends:

Case I : $\alpha_{0y} = \alpha_{1y} = 0$ (no intercepts and no trends). However, this is quite unlikely to occur in practice.

Case II: $\alpha_{1y} = 0$ and $\alpha_{0y} = \Pi_y \mu_y$ (restricted intercepts and no trends),

Case III: $\alpha_{1y} = 0$ and $\alpha_{0y} \neq 0$ (unrestricted intercepts and no trends), *Case IV:* $\alpha_{0y} \neq 0$ and $\alpha_{1y} = \Pi_y \Upsilon_y$ (unrestricted intercepts and restricted trends),

Case V: $\alpha_{0y} \neq 0$ and $\alpha_{1y} \neq 0$ (unrestricted intercepts and trends). However, this model is difficult to interpret from an economic point of view (McaJee & Oxley, 1999). For this purpose various vector error correction models can be specified. Observing the short-run properties of the series, by utilizing such models, may provide very useful insights especially for policy makers. Relying on the presence of a cointegrating vector, the subsequent vector error correction model (VECM) can be written as follows:

$$\Delta P_t = \mu_1 + \Psi_1 ECT_{t-1} + \sum_{j=1}^{j} \Upsilon 1_{1i} \Delta P_{t-i} + \sum_{j=1}^{j} \Upsilon 2_{1i} \mathrm{Days}_{t-i}^{\mathrm{OECD}} + \sum_{j=1}^{j} \Upsilon 2_{1i} \mathrm{DEM}_{t-i}^{\mathrm{World}}$$
$$+ \sum_{j=1}^{j} \Upsilon 3_{1i} \mathrm{SUP}_{t-i}^{\mathrm{World}} + \sum_{j=1}^{j} \Upsilon 4_{1i} \mathrm{OP}_{t-i}^{\mathrm{caputil}} + \sum_{j=1}^{j} \Upsilon 5_{1i} \mathrm{OP}_{t-i}^{\mathrm{quota}} + \sum_{j=1}^{j} \Upsilon 6_{1i} \mathrm{OP}_{t-i}^{\mathrm{cheat}}$$
$$+ \sum_{j=1}^{j} \Upsilon 7_{1i} \mathrm{Con}_{t-i}^{\mathrm{Yield}} + \sum_{j=1}^{j} \Upsilon 8_{1i} (\mathrm{NY4}_{t-i} - \mathrm{NY1}_{t-i})$$
$$+ \sum_{j=1}^{j} \Upsilon 9_{1i} \mathrm{RIGS}^{\mathrm{total}}_{t-i} + \sum_{j=1}^{j} \Upsilon 10_{1i} \mathrm{War}^{\mathrm{Gul\,1}}_{t-i} + \sum_{j=1}^{j} \Upsilon 11_{1i} \mathrm{War}^{\mathrm{Gul\,2}}_{t-i} + \omega_t \tag{3.38}$$

Where ECT_{t-1} is the error correction term obtained from the cointegration equation $\Upsilon 1_{1i}, \Upsilon 2_{1i}, \ldots, \Upsilon n_{1i}$ *are* the estimated parameters, j is the lag length, and ω_t are stationary random shocks with zero mean and constant variance.

The long-run equilibrium relationship is attained by using two test statistics the trace statistics (λTrace), and the Max-Eigen value (λmax). The trace statistics tests the null hypothesis that the number of the cointegrating vectors is less than or equal to r against a general alternative. The Max-Eigen value tests the null hypothesis that the number of cointegrating vectors is against the alternative of r+1 cointegrating vectors.

Although there is no major differences between corresponding maximum Eigen value and trace tests, in some situation trace value tests tend to have more heavily distorted sizes whereas this power performance is superior to the maximum Eigen value competitors. The trace tests are advantages if there are at least two more cointegating relations in the process than are specified under the null hypothesis (Luutkepohl, Saikkonen, & Trenkler, 2002).

Although the race statistics take into account all (p-r) of the smallest Eigen value, and thus have more power than X Max statistics, where the Eigen values are evenly distributed (Dahalan, Subhash & Sylwester, 2005). On the other hand, the trace test seems to be more robust to excess kurtosis in innovations than the maximal Eigen value test (Cheung & Lai, 1993). So if the there is a conflict between the X Trace and X Max, it is recommendable to use this test(Johansen and Juselius, 1990).

Monte Carlo study by Gregory (1994) argues that both tests display some size distortion and size is better for max Eigen value test (which uses just one Eigen value) than for the trace test (which uses all Eigen values). Gregory (1994) corrected X Max test statistic for the number of estimated parameters to obtain satisfactory size prosperities in finite samples by multiplying the test statistic by a factor *(T-np)* IT. Where T is the number of observations, n the number of variables in the VAR system, and p is the lag length of the VAR (Maddala, 2002).

According to Harris (1996) the decision regarding the deterministic components in the model is not easy to determine. Hence, the next step is to choose the model. In order to do this I will apply Pantula principle (Johansen, 1992). The Pantula principle involves the estimation of all three models and the presentation of the results from the most restrictive hypothesis through the least restrictive hypothesis (Asteriou & Hall, 2007). I start from the smaller number of cointegrating vectors and see if I can reject the null hypothesis or not. If I can reject it, I move to the second model (to the right) and so on. I stop when I reach the point that the null hypothesis cannot be rejected. In other words, I start from the most restrictive model (model 2) and at each stage compare the Eigen value statistic with the critical value until I reach a specification for which I do not reject the null hypothesis (Meeusen, 1999).

3.9.7 Granger Causality Test

After determining the relationship between crude oil prices and oil market variables, each variable will be tested in Granger (1969) causality test.

The Granger causality test is used to test the exogeneity or independence of variables in a system or model, where each variable is regressed on the current and lagged values of the other variables, expressed as

$$Y_t = \sum \beta_j Y_{t-j} + u_t \tag{3.39}$$

With $\beta_j = 0$ for all j<0 if and only if *Yt,* fails to Granger-cause *Xt.* Given two time dependent variables, *Yt* and *Xt*, non-significant regression coefficients of the regression of *Xt* on the current and lagged values of *Yt*, suggest a lack of feedback from Yt to Xt , and Granger causality from X, to Y,, which is called the Granger non causality of Y, to Xt. In terms of market efficiency, Granger F-statistics tests whether or not the null hypothesis of Xt not Granger causing Yt in the equation, with the null hypothesis being rejected if the coefficients are significantly different from zero.

Rejection of the null hypothesis indicates an existence of a relationship between stock price and the underlying macroeconomic variable, or the weak-form of market efficiency. The concept of causality is based upon the prediction error with *Xt* to Granger-cause *Y,*, if *Yt* can be forecasted better using past values of Y and X than with Y alone. Granger causality testing allows (1) the testing of the theory which predicts the absence of causality from one variable to another, which can be rejected if causality is found, (2) the specification testing of distributed lagged models, since the coefficients on future *X* are non-zero, then a one-sided Y on X regression is a poorly specified dynamic relationship, with attempts to correct serial correlation in estimating such a one-sided distributed lag, which more than likely to produce inconsistent estimates, and (3) the relationship to prediction, which is important in building good, small forecasting models.

Therefore, the empirical work begins by identifying the stochastic properties of the variables used in the study. The (ADF) and the Phillips and Perron (PP) unit root tests are used to test for the stationary of variables. The Johansen cointegration approach is used to investigate the long run relationship between crude oil price and oil market variables. If there are variables cointegrated, I will analyze the short run dynamic and interaction between crude oil prices and the other variables based on the vector error correction model (VECM) by Granger causality tests and the variance decomposition analysis (VDC).

3.10 Methodological differences

This study will examine the important factors that affected crude oil price volatility in recent years; therefore the model included a new variables suggested from the previous studies to be highlighted such as; under investment, days of forward supply and the convenience yield. Therefore the methodology will differ from other studies in the following ways:

- The time series data will be longer than the previous studies and based on recent data (until 2010).
- Additional variables will be highlighted in this study (under investment, days of forward supply,..., etc.) And it will be examined in the model to clarify the relationship between them and oil price changes.
- The researcher distinguished in his model between the demand for consumption and the demand for non-consumption (reserve and speculation), and shows that the determinants for each one are not the same.
- Show the importance of speculation and future markets in determining the crude oil price volatility, especially in the recent years.
- Highlighted the demand of oil from china to show the importance and casualty in demand function. Thus, China is the second country in oil consumption in recent years. In summary linear regression analysis expected to use in the model of crude oil prices. Hence, it is a useful tool for modeling oil price changes

CHAPTER FOUR
EMPIRICAL ANALYSIS AND RESULTS

4.1 Introduction

This Chapter presents and analyses the impact of the main factors affecting crude oil prices and selected macroeconomic variables on world crude oil prices. Additionally, I examine whether the selected macroeconomic variables influence the crude oil price and its movement. I also examine whether the oil prices are determined by fundamentals (supply and demand) or geopolitics and speculation.

The data used in the study are described in Section 4.2 introduces descriptive statistics for the variables.I test for Multicollinearity in Section 4.3. Section 4.4 provides an investigation of stationary of the variables using the Augmented Dickey-Fuller (ADF) and The Phillips-Perron (PP) tests. In addition, I also consider a structural break in the series to take into account the permanent effect caused by shocks. Section 4.5 shows the results of VAR model. Section 4.6 provides the estimation of the long run relationship among variables by applying the Johansen cointegrating approach. Section 4.7 reports the next stage in the process of constructing the Error Correction Model which captures the behavior of the main factors affecting crude oil prices in the short run. After determining the relationship between Crude oil price and the main macroeconomic variables in the oil market, each variable will be tested in the Granger (1969) causality test in Section 4.8. Next, discussion on principal component analysis to find which group has the major effect on crude oil price movement, fundamentals (supply and demand) or financial variables are presented in Section 4.9. This Chapter then concludes in Section 4.10.

4.2 Data

Table 4.1 presents a summary of descriptive statistics of the variables, which include sample mean, standard deviation, skewness and kurtosis, Jarque- Bera statistics and its P-value. Table 4.1 presents a summary of descriptive statistics of the variables, which include sample mean, standard deviation, skewness and kurtosis, Jarque-Bera statistics and its P-value. (1)

Table *4.1*

Descriptive Statistics For The Crude Oil Prices Model

	LRP	LRIGS	LOPCAPUTIL	LOECDDAYS	LFUT4	TLCY
Mean	1.602	3.330	-2.290	-1.078	1.449	0.087
Median	1.575	3.312	-2.308	-1.081	1.329	0.100
Maximum	1.930	3.551	-1.714	-1.024	2.0919	0.159
Minimum	1.359	3.126	-2.850	-1.126	1.1239	0.001
Std. Dev.	0.129	0.096	0.201	0.024	0.2579	0.040
Skewness	0.575	0.464	0.221	0.196	0.9019	-0.569
Kurtosis	2.637	2.478	2.838	2.413	2.4959	2.508
Jarque-Bera	6.066	4.720	0.923	2.073	14.6029	6.400
Probability	0.048	0.094	0.630	0.355	0.001	0.041
Sum	160.181	332.990	-228.969	-107.787	144.885	8.737
Sum Sq. Dev.	1.635	0.920	3.997	0.057	6.563	0.160
Observations	100	100	100	100	100	100

(1) The Jarque-Bera test is based on the result that a normal distribution random variable has skewness equal to zero and kurtosis equal to three. The Jarque-Bera test statistic is: $JB = \frac{n}{6}(s^2 + \frac{k^2}{4}) \pm (kurt - 3)^2$, Where skew denotes the sample skewness and kurt denotes the sample kurtosis. Under the null hypothesis that is normally distributed $JB \sim x^2$ (2). So the critical values at the 1%, 5%, and 10% levels are, respectively, 9.21, 5.99, and 4.61

The mean and the median of all the variables are close together. It indicates that the variables are normally distributed, which are symmetric about their means. In addition, the Jerque-Beta test also indicates the variables follow a normal distribution except the Dummy variable for Gulf war and future prices. From the computed values of Jerque-Bera1 for all the variables are less than the critical value equal 9.21, at 1 percent significance level. Hence the null hypothesis of normality is not rejected for all the variables.

The Jarque-Bera (JB) test is based on the classical measures of skewness and kurtosis. As these measures are based on moments of the data, this test has a zero breakdown value, which mean a single outlier can make the test worthless (Oztuna, et al., 2006). According to Maysami et al. (2004), the Johansen cointegration test is based on a full information maximum likelihood estimation model, which allows for testing cointegration in a whole system of equations in one step, without requiring a specific variable to be normalized (Maysami et al., 2004). Therefore, the inclusion of the non-normality variables such as future oil price in the Johansen cointegration test is still valid in this study.

4.3 Multicollinearity

Multicollinearity is a statistical term for the existence of a high order of linear correlation amongst two or more explanatory variables in a regression model. In any practical context, the correlation between explanatory variables will be non-zero, although this will generally be relatively benign in the sense that a small degree of association between explanatory variables will almost always occur but will not cause too much loss of precision (Chris, 2008).

The presence of Multicollinearity usually results in an overstatement of the standard error, i.e. the standard error tends to be large, leading to small "t" value and a high coefficient of determination. The usual procedure when Multicollinearity exists is to drop the offending variable or alternatively to drop the variable that provides a lesser contribution towards model improvements. A simple procedure to determine which variable to drop is to calculate the correlation matrix. The correlation matrix in Table 4.2 and Table 4.3

represents the correlation coefficient and collinearity statistics for the variables used in this study.

Table 4.2
A Summary of Collinearity Statistics for Crude Oil Prices Model

Coefficients[a]

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Correlations			Collinearity Statistics	
	B	Std. Error	Beta			Zero-order	Partial	Part	Tolerance	VIF
(Constant)	1.101	.267		4.123	.000					
LOECDdays	.113	.151	.021	.748	.456	.065	.077	.020	.907	1.102
LRIGS	-.090	.076	-.068	-1.194	.236	.809	-.123	-.032	.223	4.491
LFU4	.524	.031	1.049	16.873	.000	.955	.868	.452	.186	5.387
nlOPCPUtil	-.064	.019	-.100	-3.296	.001	-.256	-.323	-.088	.777	1.286
Dummy04	.069	.018	.106	3.900	.000	.071	.375	.104	.972	1.028
LCY1	.028	.010	.100	2.714	.008	-.480	.271	.073	.529	1.891

Table 4.3
Correlation Matrix for Crude Oil Prices Model

Correlations		LOECDdays	LRIGS	LFU4	lOPCPUtil	Dummy04	LCY1
Pearson Correlation							
	LOECDdays	1.000					
	LRIGS	.052	1.000				
	LFU4	.077	.831	1.000			
	lOPCPUtil	.035	-.373	-.198	1.000		
	Dummy04	-.033	-.017	-.030	.134	1.000	
	LCY1	-.264	-.308	-.566	.117	.090	1.000

On the other hand, the VIF is the reciprocal of the tolerance (1 / Tolerance). Larger VIF values indicate a greater variance of the regression weight of the predictor. So if the VIF value is greater than 10, this indicates Multicollinearity. The VIF and Tolerance are expressed as below. On another hand, the VIF is the reciprocal of the tolerance (1 /

Tolerance). Larger VIF values indicate a greater variance of the regression weight of the predictor. So if the VIF value is greater than 10, this indicates multicollinearity. The VIF and Tolerance are expressed as below.

$$\text{VIF} = \frac{1}{1-R^2}, Tolerance = \frac{1}{\text{VIF}} \quad (4.1)$$

Where VIF is the variance inflation factor for the variable Xj, and R^2 is the coefficient of determination.

For the Table 1 data in the appendix C, the highest Pearson correlation coefficient was 0.98 between world oil supply (WS) and world oil demand (WD). The second highest correlation coefficient was 0.897 between United State capacity utilization and world oil demand. To ensure the robustness of our analysis on correlation among the variables, I further analyze the issue on multicolinearity using the tolerance and variance inflation factor (VIF) statistics. The tolerance values range from 0 to 1, where a value of 0.01 or less will indicate multicolinearity among variables. A tolerance close to 1 means there is a little multicolinearity, whereas value close to 0 suggests that multicolinearity may be a threat.

The following variables have been omitted from the model according to the VIF results which are greater than ten; WD, WS, USCAPUTIL, OPQUO and also OPCHEAT which is greater than seven. Thus, VIF indicates whether an independent variable is strongly correlated with other independent variable(s). In summary, the multicolinearity exists when the VIF is greater than 10, and the tolerance statistic is below 0.1. The result of the computed VIF for the series in this study is given in Table 4.2. All VIF are lower than 10 (except for the omitted variables) as evidence of the absence of multicolinearity between series in this study.

4.4 Unit Root Tests

In order to avoid spurious regression, I begin with an investigation of the properties of the time series that I are dealing with to determine if the variables are stationary or non-stationary in levels. The procedures used here are the augmented Dickey Fuller (ADF) and Phillip-Perron unit root tests for testing the stationarity of the time series.

4.4.1 Augmented Dickey Fuller and Phillip-Perron Tests

Using time series in econometric analysis has introductory steps. First, I should determine the form in which the series can be used for any subsequent estimation. Using macroeconomic series in level could lead to serious econometric problems. For instance, the use of non-stationary data can lead to spurious regressions. The time series data may contain a trend showing growth or decline over time, which must be removed prior to undertaking any estimation. Many over time, which must be removed prior to undertaking any estimation. Many macroeconomics time series variables are having such characteristic and difference stationary. The series is said to contain unit roots and non-stationary at level.

A series is difference stationary or covariance stationary when it has the following three characteristics: (a) exhibits mean reversion in that fluctuates around a constant long run means; (b) has a finite variance that is time invariant; and (c) has a theoretical correlogram (a scatter plot) that diminishes as the lag length increases (Asteriou and G., 2007). If ordinary least squares (OLS) estimation techniques are applied to non-stationary series, the result will produce spurious regression. This renders any subsequent hypothesis tests unreliable.In this study the augmented Dickey Fuller (ADF) (1981) and Phillip-Perron (PP) unit root tests are used to examine the stationarity of the time series used and the integration order of non-stationary time series. Table 4.4 shows Phillip-Perron results of the unit root tests applied to the oil price variables.

Table 4.4
Phillip-Perron Results of the Unit Root Tests Applied to the Oil Price Variables

Variable	Model 1 (Intercept)		Model 2 (trend and intercept)		Model 3 (None)	
LRP	-1.487	P value	-2.580	P value	0.618	P value
	-3.498		-4.053		-2.589	
	-2.891	0.536	-3.456	0.2905	-1.944	0.848
	-2.583		-3.154		-1.615	
LCY	-1.923		-3.753		0.039	
	-3.499		-4.056		-2.589	
	-2.892	0.320	-3.457	0.0235	-1.944	0.693
	-2.583		-3.155		-1.615	
LRIGS	-0.976		-2.255		0.432	
	-3.501		-4.059		-2.590	
	-2.893	0.759	-3.458	0.4540	-1.944	0.805
	-2.583		-3.155		-1.614	
LOPCCAPUTIL	-2.410		-2.436		0.122	
	-3.498		-4.053		-2.589	
	-2.891	0.142	-3.456	0.359	-1.944	0.719
	-2.583		-3.154		-1.615	
LOECDDAYS	-1.723				-0.267	
	-3.501		-1.395		-2.590	
	-2.892	0.417	-4.058	0.857	-1.944	0.588
	-2.583		-3.458		-1.615	
LFUT4	-0.359		-1.821		1.415	
	-3.499		-4.055		-2.589	
	-2.892	0.911	-3.457	0.687	-1.944	0.960
	-2.583		-3.154		-1.616	

Note: (***), (**) and (*) indicate significant at 1%, 5% and 10% levels, respectively.

Table 4.5

Augmented Dicky-Fuller Unit Root Test Results at First Difference

Variable	Model 1 (Intercept)		Model 2(trend and intercept)		Model 3(None)	
LRP	-7.046	P value	-7.139	P value	-6.971	P value
	-3.501***		-4.059***		-2.590***	
	-2.893**	0.000	-3.458**	0.0000	-1.944**	0.000
	-2.583*		-3.155*		-1.614*	
LCY	-4.317		-4.366		-4.305	
	-3.499***		-4.055***		-2.589***	
	-2.892**	0.001	-3.457**	0.0039	-1.944**	0.000
	-2.583*		-3.154*		-1.615*	
LRIGS	-6.746		-6.818		-6.761	P value
	-3.501***		-4.059***		-2.590***	
	-2.893**	0.000	-3.458**	0.0000	-1.944**	0.000
	-2.583*		-3.155*		-1.614*	
LOPCCAPUTIL	-9.248		-9.222		-9.300	
	-3.498***		-4.054***		-2.589***	
	-2.891**	0.0000	-3.456**	0.0000	-1.944**	0.000
	-2.583*		-3.154*		-1.615*	
LOECDDAYS	-4.800		-5.501		-4.819	
	-3.501***		-4.061***		-2.590***	
	-2.892**	0.0001	-3.459**	0.0001	-1.944**	0.000
	-2.583*		-3.156*		-1.615*	
LFUT4	-8.241		-8.250		-8.051	
	-3.499***		-4.055***		-2.589***	
	-2.892**	0.0000	-3.457**	0.0000	-1.944**	0.000
	-2.583*		-3.154*		-1.615*	

Note: (***), (**) and (*) indicate significant at 1%, 5% and 10% levels, respectively.

Table 4.6

Phillips-Perron Unit Root Test Results

Variable	**Model 1 (Intercept)**	**Model 2(trend and intercept)**	**Model 3(Trend)**
LRP	-4.555	-5.657	-5.212
	-5.920***	-6.320***	-5.450***
	-5.230**	-5.590**	-4.830**
	-4,920*	-5.290*	-4.480*
LCY	-4.086	-4.853	-4.195
	-5.920***	-6.320***	-5.450***
	-5.230**	-5.590**	-4.830**
	-4.920*	-5.290*	-4.480*
LRIGS	-4.386	-4.734	-4.644
	-5.920***	-6.320***	-5.450***

	-5.230**	-5.590**	-4.830**
	-4,920*	-5.290*	-4.480*
LOPCCAPUTIL	-4.772	-4.446	-3.975
	-5.920***	-6.320***	-5.450***

Table 4.6 (Continued)

Variable	Model 1 (Intercept)	Model 2(trend and intercept)	Model 3(Trend)
	-5.230**	-5.590**	-4.830**
	-4,920*	-5.290*	-4.480*
LOECDDAYS	-3.086	-5.262	-5.391
	-5.920***	-6.320***	-5.450***
	-5.230**	-5.590**	-4.830**
	-4,920*	-5.290*	-4.480*
LFUT4	-3.884	-3.967	-3.560
	-5.920***	-6.320***	-5.450***
	-5.230**	-5.590**	-4.830**
	-4,920*	-5.290*	-4.480*

Note: (***), (**) and (*) indicate significant at 1%, 5% and 10% levels, respectively.

The Table reports results for ADF and PP unit root tests based on a standard regression with constant, and with constant and time trend. The results showed that, the computed ADF test statistic for all the variables are smaller than the critical values (in absolute values) at the 1 %, 5% and 10% significance levels. Thus, I cannot reject the present of a unit root in the variables (null hypothesis). I conclude that all variabless in this study [(LRP, LCY, LRIGS, LOPCAPUTIL, LOECDDAYS, LFUT4 and DUMMY04).) are non-stationary. However, the same null hypothesis for the first difference of all variables is overwhelmingly rejected. Therefore, I conclude that all the variables in this study have a unit root in the levels and are stationary in the first differences. Results show that all the variables are each integrated of order one or I (1). In other words, I find all series to be non-stationary in levels and stationary after first differencing as shown in Figure 4.1 for the oil price model.

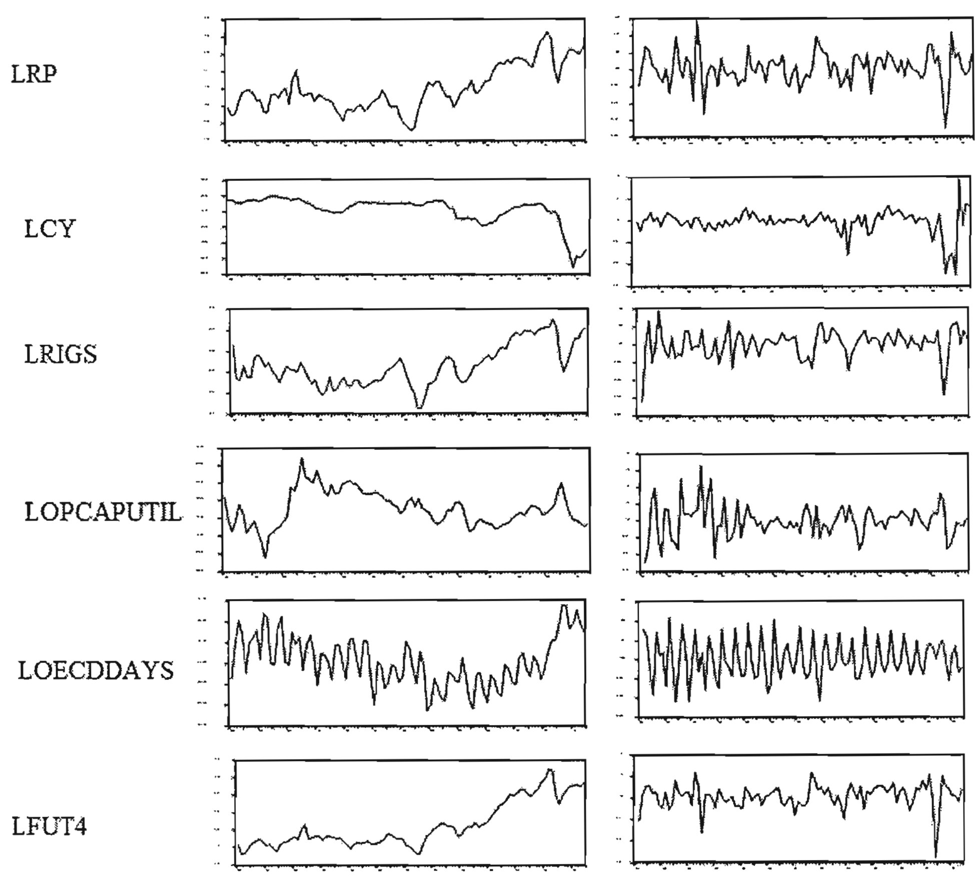

Figure 4.1
Stationarity at Level and at First Difference

4.4.2 Structural Shift and Unit Root Test

A unit root test which does not take account of the break in the series will have very low power. There is a similar loss of power if there has been a shift in the intercept (possibly in conjunction with a shift in the slope of the deterministic trend) (Assaf, 2008). Because if a series is stationary around a deterministic time trend which has undergone a permanent shift sometime during the period under consideration, failure to take account of this change in the slope will wrongly identify as a persistent innovation to a stochastic (non-stationary). Trend by the usual Augmented Dickey-Fuller (Fuller, 1979) unit root test (Perron, 1989; Balke and Fomby, 1991). There is also similar loss of power if there has been a shift in the intercept (possibly in conjunction with a shift in the slope of the deterministic trend). Tests for parameter instability and structural change in regression models have been an important part of applied econometric work. Bai (1997) and Bai and Perron (1998, 2003a) provide theoretical and computational results that further extend the Quandt-Andrews framework by allowing for multiple unknown breakpoints. Following Bai and Perron (2003), I estimate the equation specification using least squares to test whether the coefficients of that regression change through time. The sequential test results indicate that there is one breakpoint which is the Third quarter in (2004): I reject the nulls of 0, 2, and 3 breakpoints in favour of the alternatives of one breakpoint shown in Table 4.7.

Table 4.7
Bai-Perron Tests of Multiple Breakpoint Tests

Sequential F-statistic determined breaks: 1

Break Test	F-statistic	Scaled F-statistic	Critical Value**
0 vs. 1 *	35.69044	35.69044	8.58
1 vs. 2	5.440459	5.440459	10.13

* Significant at the 0.05 level.
** Bai-Perron (Econometric Journal, 2003) critical values.

Break dates:

	Sequential	Repartition
1	2004Q3	2004Q3

Table 4.7 (continued)

Multiple breakpoint tests
Bai-Perron tests of L+1 vs. L sequentially determined breaks
Break test options: Trimming 0.15, Max. Breaks 5, Sig. Level 0.05
Test statistics employ HAC covariances (Prewhitening with lags = 1, Quadratic-Spectral kernel, Andrews bandwidth)
Allow heterogeneous error distributions across breaks

In summary, both the standard unit root tests and the unit root, allowing structure breaks tests indicate that all seven series are non-stationary in levels and stationary after first differencing. Given these results, I proceed with the cointegration tests based on the assumption that all variables contain a unit root.

4.5 Vector Autoregressive Model (VAR)

Vector autoregressive (VAR) models are widely used in macroeconomic models. First, I test to see if the variables are stationary I (0). If not, they are assumed to have a unit root and be I (1). If a set of variables is all I (1) they should not be estimated using ordinary regression analysis, but between them there may be one or more equilibrium relationships. I can both estimate how many and what they are (called cointegrating vectors) using Johansen's technique.

A critical element in the specification of VAR models is the determination of the lag length of the VAR. The importance of lag length determination is demonstrated by Braun and Mittnik (1993) who show that estimates of a VAR whose lag length differs from the true lag length are inconsistent as are the impulse response functions and variance decompositions derived from the estimated VAR. I considered four lags, but then looked at Akaike Information (1974), Hannan and Quinn (1979), and Schwarz (1978) criteria. I was able to determine one lag as shown in Table 4.8.

Table 4.8
Lag Order Selection Criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	560.1381	NA	1.61e-14	-11.89544	-11.70482	-11.81847
1	1079.945	950.1853	6.47e-19	-22.02033	-20.49532*	-21.40458*
2	1153.343	123.1188	3.89e-19	-22.54501	-19.68563	-21.39047
3	1209.681	86.02156	3.47e-19	-22.70282	-18.50905	-21.00950
4	1282.694	100.4903	2.26e-19	-23.21922	-17.69107	-20.98711
5	1343.402	74.41653	2.04e-19	-23.47101	-16.60848	-20.70011
6	1419.650	81.98697*	1.43e-19*	-24.05698	-15.86007	-20.74731
7	1484.176	59.66928	1.46e-19	-24.39088*	-14.85959	-20.54242

* 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 SC: Schwarz inforr. -Quinn informatioı HQ: Hannan

The Schwarz Bayesian criterion (SC), and Hannan-Quinn information criterion (HQ) suggests a VAR of order one. Akaike information criterion (AIC) suggests a VAR of order seven. Likelihood-ratio (LR) and Final prediction error (FPE) suggests a VAR of order six. Given the fact that the sample is relatively small (only 100 quarters) I cannot take the risk of over-parameterization if I select longer lags. Therefore, the model with one lag appears to be more appropriate for the small sample. Hurvich, Shumway, and Tsai (1990) argue that the statistics of (SC) were based on tests without adjusting for the relatively small sample size. The AIC is not performed because Liew (2004) and Lütkepohl (2005) found that AIC is not performed than other information criteria (e.g. SBC and HQ) when the estimated sample size is greater than 60 observations (AIC is performed when the estimated sample size is less than 60 observations). Moreover, models with fewer lags explained the data without loss of power.

$$\Delta P_t = \alpha_t + \sum_{j=1}^{j} \Upsilon 1_{1i} \Delta P_{t-i} + \sum_{j=1}^{j} \Upsilon 2_{1i} \text{Days}_{t-i}^{\text{OECD}} + \sum_{j=1}^{j} \Upsilon 3_{1i} \text{OP}_{t-i}^{\text{caputil}}$$
$$+ \sum_{j=1}^{j} \Upsilon 4_{1i} \text{Con}_{t-i}^{\text{Yield}} + \sum_{j=1}^{j} \Upsilon 5_{1i} \text{FUT4}_{t-i} + \sum_{j=1}^{j} \Upsilon 6_{1i} \text{RIGS}^{\text{total}}{}_{t-i}$$
$$+ \sum_{j=1}^{j} \Upsilon 7_{1i} \text{War}^{\text{Gul}}{}_{t-i} + \omega \qquad (4.2)$$

In next Section I apply the residual diagnostic tests of the unrestricted VAR specified in equation 4.2 for lags 1.

4.5.1 Heteroscedasticity (Conditional)

The efficiency of the VAR model is examined from residual analysis for autocorrelation and Heteroscedasticity. Heteroscedasticity (Table 4. 9) Is examined by using an ARCH's test which is known as a general test for model specification. In ARCH test, the regression model of standard linear as below is estimated:

Table 4.9
Heteroskedasticity Test: Arch

Heteroskedasticity Test: ARCH			
F-statistic	1.656875	Prob. F(5,87)	0.1536
Obs*R-squared	8.085763	Prob. Chi-Square(5)	0.1516

$$Y_t = \beta_1 + \beta_2 X_{2t} + \beta_3 X_{3t} + \mu_t \qquad (4.3)$$

The residuals from the estimation of the regression model, μ_t, are obtained and used for the auxiliary regression as in equation 4.4.

$$\mu_t^2 = \alpha_1 + \alpha_2 X_{2t} + \alpha_3 X_{3t} + \alpha_4 X_{2t}^2 + \alpha_5 X_{3t}^2 + \alpha_6 X_{2t}^2 X_{3t}^2$$
$$+ \Phi_t \qquad (4.4)$$

The null hypothesis of homoscedasticity is that:

$$\alpha_1 = \alpha_2 = \alpha_3 = \alpha_4 = \alpha_5 = \alpha_6 = 0$$

Where a's are parameters excluded from auxiliary regression. While the alternative hypothesis is that at least one of the a's is different from zero. From the Table 4.9 it is clear that there is no heteroscedasticity and the null hypothesis for homoscedasticity cannot be rejected because the p-value (0. 1536) is greater than 0.05. Therefore the VAR model is not suffering from heteroscedasticity problem and the model is satisfactory in terms of specification.

4.5.2 The Breusch-Godfrey LM Test for Autocorrelation

Lagrange Multiplier (LM) approach is employed to test for serial correlation. This test gives us a conclusive result and it is powerful when a lagged dependent variable is used. For this test, the null hypothesis is no autocorrelation. The results appear in Table 4.10 suggests that there is no autocorrelation in the residuals. Serial correlation or autocorrelation is not a problem in our model, the null hypothesis cannot be rejected due to the fact that the p-values are higher than 0.05 for a 95% confidence interval.

Table 4.10
Breusch-Godfrey Serial Correlation Lm Test

Breusch-Godfrey Serial Correlation LM Test:				
F-statistic	1.142146	Prob. F(2,86)		0.3239
Obs*R-squared	2.535679	Prob. Chi-Square(2)		0.2814
Dependent Variable: RESID				
Presample missing value lagged residuals set to zero.				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	0.101812	0.134932	0.754540	0.4526
C(2)	0.000626	0.007082	0.088357	0.9298
C(3)	-0.013397	0.281074	-0.047665	0.9621
C(4)	0.009647	0.041745	0.231103	0.8178
C(5)	0.032171	0.138278	0.232653	0.8166
C(6)	-0.018839	0.048552	-0.388014	0.6990
C(7)	0.030691	0.280180	0.109540	0.9130
C(8)	0.042281	0.223123	0.189497	0.8502
C(9)	0.008164	0.020740	0.393655	0.6948
C(10)	-0.000309	0.004605	-0.067208	0.9466
RESID(-1)	-0.088657	0.247785	-0.357799	0.7214
RESID(-2)	-0.229091	0.153376	-1.493662	0.1389
R-squared	0.025874	Mean dependent var		2.69E-18
Adjusted R-squared	-0.098723	S.D. dependent var		0.041646
S.E. of regression	0.043653	Akaike info criterion		-3.310817

Table 4.10 (continued)

Sum squared resid	0.163879	Schwarz criterion	-2.994290
Log likelihood	174.2300	Hannan-Quinn criter.	-3.182788
F-statistic	0.207663	Durbin-Watson stat	1.933359
Prob(F-statistic)	0.996711		

4.5.3 Stationarity Condition (Normality)

I employ Jarque-Berra test to check if the residuals in the VECM are normally distributed. Normality property is also needed for valid inference when performing hypothesis testing. Jarque-Bera test statistic measures goodness-of-fit of departure from normality and the stability condition holds, H0: data are normally distributed. H1: data are not normally distributed. The null hypothesis is rejected at the 5 % significance level (0.1382) which means I accept the alternative hypothesis; data are not normal distributed. As can be seen in Figure 4.2 which indicating that the estimated VAR is normally distributed (stationary). This is a very favorable result because if the VAR were not normally distributed, certain results, such as impulse response standard errors, would not be valid making the model results and conclusions suspect.

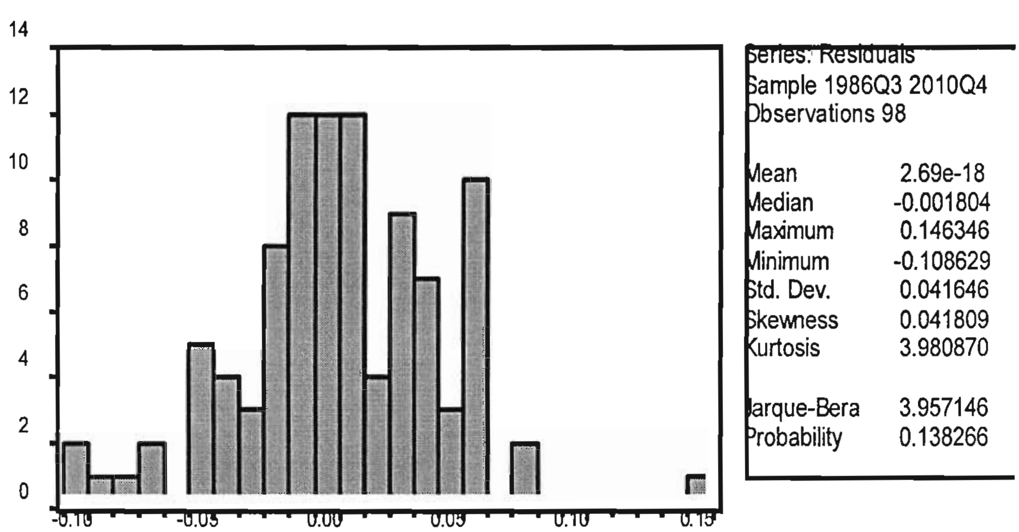

Figure 4.2
Jarque-Bera Tests for Normality (VECM with two Lags)

The results in Figure 4.2 indicated that the assumptions of normality of the data are met.

4.6 Cointegration and Error Correction Model

In this study, the long run relationships between crude oil prices and the other macroeconomics variables is analyzed using Johansen cointegration analysis. The Johansen cointegration test produces explicitly test for number of cointegration vectors by depending on the maximum likelihood estimator. The statistical test regarding the number of cointegration vector is presented in Table 4.11, 4.12, 4.13, 4.14, 4.15 and 4.16for all models: restricted intercepts and no trends, unrestricted intercepts and no trends and unrestricted intercepts and restricted trends respectively. The rank is dependent on the eigenvalue test results, which implies that there is at least one cointegrating vector in all models. So the results support the presence of one cointegrating vector that is stationary with the estimated and actual value fairly highly correlated. I interpret the vector as explaining real oil price and the cointegrating vector is normalized on crude oil price.

Sometimes λ-Max and λ-Trace statistics have different results. It is difficult to justify which is the best option if the contrary result appeared. Sometime the contrary results may result from the small sample and also a deterministic trend. Cheung and Lai (1993) stated that the trace test result should be better than Eigenvalue test statistics. Johansen suggested the need to test the joint hypothesis of both the rank order and the deterministic components. This method is called Pantula principle. All three models are estimated and the results are presented from the most restrictive alternative (like r = 0 and Model 2) to the least restrictive alternative (i.e. r = n-1 and Model 4). The process of Pantula principle is to move from the most restrictive model to the least restrictive model and then to compare the trace test statistic to its critical value at each stage. The test is completed when the null hypothesis is not rejected at the first time.

Table 4.11

Johansen and Juselius Cointegration Test Results (Model 1)

Unrestricted Cointegration Rank Test (Trace)

Hypothesized					
H0	H1	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
r=0	r>0	0.442	125.996	111.781	0.005
r=1	r>1	0.290	68.875	83.937	0.369
r=2	r>2	0.150	35.919	60.061	0.864
r=3	r>3	0.104	19.980	40.175	0.897
r=4	r>4	0.054	9.165	24.276	0.901
r=5	r>5	0.037	3.682	12.321	0.756
r=6	r>6	1.34E-05	0.001	4.130	0.977

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized					
H0	H1	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
r=0	r>0	0.442	57.121	42.772	0.001
r=1	r>1	0.290	32.95627	36.630	0.126
r=2	r>2	0.150	15.93861	30.440	0.845
r=3	r>3	0.104	10.81528	24.159	0.868
r=4	r>4	0.054	5.483473	17.797	0.931
r=5	r>5	0.037	3.680411	11.2249	0.680
r=6	r>6	1.34E-05	0.001310	4.1300	0.978

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis (1999) p-values

Table 4.12

Johansen and Juselius Cointegration Test Results (Model 2)

Unrestricted Cointegration Rank Test (Trace)

Hypothesized					
H0	H1	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
r=0	r>0	0.498	159.395	134.678	0.0008
r=1	r>1	0.297	91.849	103.847	0.2375
r=2	r>2	0.199	57.334	76.973	0.5869
r=3	r>3	0.149	35.534	54.079	0.6970
r=4	r>4	0.104	19.683	35.193	0.7463
r=5	r>5	0.052	8.871	20.262	0.7482
r=6	r>6	0.037	3.662	9.165	0.4648

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized					
H0	H1	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
r=0	r>0	0.498	67.546	47.079	0.000
r=1	r>1	0.297	34.515	40.957	0.221
r=2	r>2	0.199	21.795	34.806	0.690
r=3	r>3	0.149	15.855	28.588	0.754
r=4	r>4	0.104	10.812	22.300	0.767
r=5	r>5	0.052	5.209	15.892	0.870
r=6	r>6	0.037	3.662	9.165	0.467

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis (1999) p-values

Table 4.13

Johansen and Juselius Cointegration Test Results (Model 3)

Unrestricted Cointegration Rank Test (Trace)

Hypothesized					
H0	H1	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
r=0	r>0	0.490	152.308	125.615	0.000
r=1	r>1	0.294	86.299	95.754	0.187
r=2	r>2	0.198	52.158	69.819	0.542
r=3	r>3	0.146	30.483	47.85613	0.694
r=4	r>4	0.097	15.038	29.797	0.778
r=5	r>5	0.050	5.057	15.495	0.803
r=6	r>6	0.000	0.045	3.841	0.832

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized					
H0	H1	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
r=0	r>0	0.490	66.009	46.231	0.000
r=1	r>1	0.294	34.141	40.078	0.200
r=2	r>2	0.198	21.675	33.877	0.633
r=3	r>3	0.146	15.444	27.584	0.712
r=4	r>4	0.097	9.981	21.132	0.747
r=5	r>5	0.050	5.013	14.265	0.740
r=6	r>6	0.000	0.045	3.842	0.832

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis (1999) p-values

Table 4.14

Johansen and Juselius Cointegration Test Results (Model 4)

Unrestricted Cointegration Rank Test (Trace)

Hypothesized					
H0	H1	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
r=0	r>0	0.496	176.5170	150.559	0.000
r=1	r>1	0.319	109.342	117.708	0.150
r=2	r>2	0.240	71.677	88.804	0.442
r=3	r>3	0.198	44.755	63.876	0.658
r=4	r>4	0.097	23.112	42.915	0.874
r=5	r>5	0.082	13.119	25.872	0.729
r=6	r>6	0.047	4.767	12.518	0.630

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized					
H0	H1	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
r=0	r>0	0.496	67.175	50.600	0.000
r=1	r>1	0.319	37.665	44.497	0.228
r=2	r>2	0.240	26.922	38.331	0.532
r=3	r>3	0.198	21.642	32.118	0.521
r=4	r>4	0.097	9.993	25.823	0.963
r=5	r>5	0.082	8.352	19.387	0.789
r=6	r>6	0.047	4.767	12.518	0.630

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis (1999) p-values

Trend assumption: Linear deterministic trend (restricted)

Table 4.15
Johansen and Juselius Cointegration Test Results (Model 5)

Unrestricted Cointegration Rank Test (Trace)

Hypothesized					
H0	H1	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
r=0	r>0	0.491	171.787	139.275	0.000
r=1	r>1	0.318	105.568	107.347	0.065
r=2	r>2	0.240	68.006	79.341	0.262
r=3	r>3	0.198	41.100	55.246	0.464
r=4	r>4	0.097	19.461	35.011	0.740
r=5	r>5	0.082	9.514	18.398	0.528
r=6	r>6	0.012	1.180	3.8415	0.277

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized					
H0	H1	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
r=0	r>0	0.491	66.219	49.586	0.000
r=1	r>1	0.318	37.561	43.420	0.189
r=2	r>2	0.240	26.906	37.164	0.452
r=3	r>3	0.198	21.639	30.815	0.424
r=4	r>4	0.097	9.947	24.252	0.907
r=5	r>5	0.082	8.334	17.148	0.566
r=6	r>6	0.012	1.1799	3.842	0.277

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis (1999) p-values

Table 4.16
Johansen and Juselius Cointegration Test Results (All Models)

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

*Critical values based on MacKinnon-Haug-Michelis (1999)
Selected (0.05 level*) Number of Cointegrating Relations by Model

In summary, both λ-Max and λ-Trace statistics yield have the same results. In particular, the λ-Trace statistics tend suggests the same number of cointegrating vectors of the λ-Max statistics. As shown in Table 4.8.f, the null hypothesis of rank = 0 tests is rejected at the 5 percent significance level. This implies there may be one cointegrating vector. As for model 1, 2, 3, 4 and 5 which means, no intercept no trend, intercept no trend for none and linear, intercepts and trend for linear and quadratic (Table 4.11, 4.12, 4.13, 4.14 and 4.15), λ-Trace suggest one cointegrating vector as same as λ-Max suggest one cointegrating vector also. Finally, as for model 6 summarizes the results and show that the λ-Trace statistic rejects the null hypothesis of rank = 1 suggesting there may be two cointegrating vectors, while λ-Max suggest one cointegrating vector.

In this study the analysis on the cointegration relationship is based on the first cointegration vector. Dahalan (2003) states that the first cointegration vector corresponds to the largest Eigen value and it is the most correlated with the stationary part of the model. From the previous tests (trace and Eigen value) I found a cointegrating relationship between the variables at 1 percent significance level.

This can be interpreted as defining the long-run for real crude oil price. This cointegration relationship can be written as follows:

$$P = -1.843 - 0.061CY - 0.009OPCAP - 1.282OECD + 0.365FUT - 0.174RIGS - 0.056\,Dummy \qquad (4.5)$$

The results are statistically significant, and all variables have the correct sign except dummy variable for the Gulf War. Moreover, according to equation (4.5), it appears that there is a long-run relationship between LRP, LCY, LRIGS, LOPCAPUTIL, LOECDDAYS, LFUT4 and DUMMY04. As seen from Table 4.17.

Table 4.17
Normalized Cointegrating Coefficients (Standard Error in Parentheses)

1 Cointegrating Equation(s):		Log likelihood	1401.132			
Normalized cointegrating coefficients (standard error in parentheses)						
LRP	TLCY	LOPCAPUTIL	LOECDDAYS	LFUT4	LRIGS	DUMMY04
1.000	-0.061	0.009	-1.282	-0.366	-0.175	-0.057
	(0.155)	(0.028)	(0.210)	(0.050)	(0.12957)	(0.027)

The diagnostic tests fail to show that there is a significant serial correlation and heteroscedasticity (at the 1 percent level). In addition, results indicate the presence of non-normal residuals. But the Johansen cointegration method is not affected when the errors are non-normal and still robust (Gonzalo, 1994).

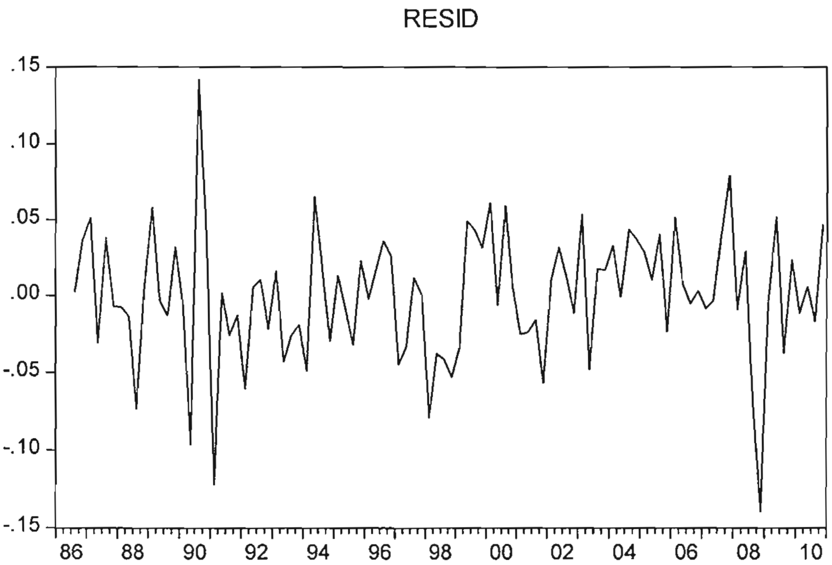

Figure 4.3
The Plot of Residuals for the Long Run Relationship

I will compute the series of residuals from the long-run equilibrium relationship and test the resulting series for stationarity. As can see from Figure 4.3, the residuals plot from long run equilibrium tends to be a stationary and it does not have a specific trend. This supports the residuals from the cointegrating vector is stationary. And Table 4.18 shows the summary tests for the presence of a unit root.

Table 4.18
Unit Root Test for Residual

Null Hypothesis: U has a unit root (U=resid)
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=11)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-9.442261	0.0000
Test critical values:	1% level	-3.499167	
	5% level	-2.891550	
	10% level	-2.582846	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(U)

Table 4.18 (Continued)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
U(-1)	-0.974535	0.103210	-9.442261	0.0000
C	-1.07E-05	0.004344	-0.002453	0.9980
R-squared	0.484134	Mean dependent var		0.000455
Adjusted R-squared	0.478704	S.D. dependent var		0.059254
S.E. of regression	0.042782	Akaike info criterion		-3.445017
Sum squared resid	0.173875	Schwarz criterion		-3.391930
Log likelihood	169.0833	Hannan-Quinn criter.		-3.423551
F-statistic	89.15629	Durbin-Watson stat		1.974587
Prob(F-statistic)	0.000000			

Perron Unit Root Test

Null Hypothesis: U has a unit root with a structural break in the intercept

Chosen lag length: 3 (Maximum lags: 4)

Chosen break point: 1999Q1

	t-Statistic
Perron Unit Root Test	-5.672958
1% critical value:	-5.92
5% critical value:	-5.23
10% critical value:	-4.92

Both of the ADF statistics and the Phillip - Perron (PP) are greater than the critical values (in absolute term). So I can reject the null hypothesis of a unit root in the series of residuals even at 1% significance level, which means that represents indeed a long run cointegration relationship between the specified variables. From the results of the cointegration test there is great evidence of the existence of a cointegration relationship between the time series considered (P, CY, RIGS, OPCAPUTIL, OECDDAYS, FUT and DUMMY). This leads us to conclude that there is a cointegration between crude oil prices and the other variables in the model.

4.7 Vector Error Correction Model (VECM)

If the series is cointegrated, then the possibility of the estimated regression being spurious due to tribulations such as omitted variable bias. Autocorrelation and indignity are ruled out. Since our series is cointegrated, I can further proceed to determine the direction of causality, among the variables. For this purpose various vector error correction models can be specified. Observing the short-run properties of the series, by utilizing such models, may provide very useful insights especially for policy makers. By substituting in the following equation for a vector error correction model (VECM):

$$\Delta P_t = \mu_1 + \Psi_1 ECT_{t-1} + \sum_{j=1}^{j} \Upsilon 1_{1i} \Delta LRP_{t-i} + \sum_{j=1}^{j} \Upsilon 2_{1i} \mathrm{Con}_{t-i}^{\mathrm{Yield}}$$
$$+ \sum_{j=1}^{j} \Upsilon 3_{1i} \mathrm{OP}_{t-i}^{\mathrm{caputil}} + \sum_{j=1}^{j} \Upsilon 4_{1i} \mathrm{OECD}_{t-i}^{\mathrm{days}} + \sum_{j=1}^{j} \Upsilon 5_{1i} \mathrm{FUT}_{t-i}$$
$$+ \sum_{j=1}^{j} \Upsilon 6_{1i} \mathrm{RIGS}_{t-i} + \sum_{j=1}^{j} \Upsilon 7_{1i} DUMMY_{t-i}^{GulfWar} + \omega_t \qquad (4.6)$$

Where ECT_{t-1} is the error correction term obtained from the cointegration equation $\Upsilon 1_{1i}, \Upsilon 2_{1i}, \ldots, \Upsilon n_{1i}$ are the estimated parameters, j is the lag length, and ω_t are stationary random shocks with zero mean and constant variance. The long-run equilibrium relationship is attained by using two test statistics the trace statistics (λ Trace), and the Max-Eigen value (λ Max). The vector error correction model will be:

D(LRP)t = C(1)*(LRP(t-1) - 0.061CY(t-1) + 0.009 OPCAPUTIL(t-1) - 1.282 OECDDAYS(t-1) - 0.365 FUT4(t-1) - 0.174 RIGS(t-1) - 0.056 DUMMY (t-1) - 1.843+ C(2)*D(LRP(t-1)) + C(3)*D(TLCY(t-1)) + C(4)*D(LOPCAPUTIL(t-1)) + C(5)*D(LOECDDAYS(t-1)) + C(6)*D(LFUT4(t-1)) + C(7)*D(LRIGS(t-1)) + C(8)*D(DUMMY(t-1)) + C(9) (4.7)

Table 4.19

Estimation of Error Correction Model

Error Correction:		Coefficient	Std.Error	t-Statistic	Prob.
ECT		-0.287	(0.110)	[-2.600]	0.0109
D(LRP(-1))		-0.182	(0.251)	[-0.723]	0.472
D(TLCY(-1))		-0.879	(0.502)	[-1.75]	0.083
D(LOPCAPUTIL(-1))		-0.033	(0.047)	[-0.709]	0.480
D(LOECDDAYS(-1))		-0.863	(0.276)	[-3.133]	0.002
D(LFUT4(-1))		0.559	(0.222)	[2.51]	0.014
D(LRIGS(-1))		-0.371	(0.137)	[-2.705]	0.008
D(DUMMY04(-1))		-0.025	(0.024)	[-1.032]	0.305
C		0.0003	(0.005)	[0.076]	0.940
R-squared	0.231	Akaike AIC	-3.312		
Adj. R-squared	0.161	Schwarz SC	-3.075	Determinant resid covariance (dof adj.)	1.77E-21
Sum sq. resids	0.174	Mean dependent	0.004	Determinant resid covariance	9.00E-22
S.E. equation	0.044	S.D. dependent	0.048	Log likelihood	1401.132
F-statistic	3.335	Akaike AIC	-3.312	Akaike information criterion	-27.166
Log likelihood	171.2962	Schwarz SC	-3.075		

From the diagnostic tests in Table 4.20, the model seems sufficient and adequate. However the total equation for the long and short run will be:

The results of the VECM estimate indicate that prices do not adjust immediately to the long-term relationship. The regression coefficient associated with the error correction term is negative and statistically significant (Table 4.11). The point estimate of the error correction coefficient is 0.29, which indicates that twenty nine percent of the disequilibrium among prices and the right-hand side variables in Eq. (4.6) is eliminated after one quarter. This result is consistent with the interpretation of Eq. (4.6) as a cointegrating relation in which the right-hand side variables ''Granger cause'' real oil prices. More specifically, ECT coefficient indicates that a deviation from the long run equilibrium value in one period is corrected in the next period by the size of that coefficient. For equation (4.6) the correction is around twenty nine percent (-0.287). Further, almost all adjustments take place within the same or following time periods, implying that the system settles down quickly. The residuals from the error correction model are free from autocorrelation as well as misspecification problems.

The short run equation below examined the null hypothesis c(2)=c(3)=c(4)=c(5)=c(6)=c(7)=c(8)=0 by using the Wald test as shown in Table 4.12. According to the significant results for F-statistic and Chi-square (0.007, 0.004) of Table 4.12 I reject null hypothesis which means there are a short run relationship between variables.

Table 4.20

Wald Test for the Short Run Price Model Equation

Equation: Untitled

Test Statistic	Value	df	Probability
F-statistic	3.007467	(7, 89)	0.007
Chi-square	21.05227	7	0.004
Normalized Restriction (= 0)		Value	Std. Err.
C(2)		-0.243495	0.252567
C(3)		-0.386796	0.140993
C(4)		-0.022565	0.047105
C(5)		-0.853844	0.288605
C(6)		0.525728	0.224179
C(7)		-0.049149	0.042534
C(8)		-0.029777	0.025109

Restrictions are linear in coefficients.

4.8 Granger Causality Tests Results

The Granger causality test is used to test the exogeneity or independence of variables in a system or model. I can say that X Granger causes Y if lagged values of X help to predict current and future values of Y better than just lagged values of Y alone. Hence Granger causality merely refers to a lead-lag relationship between variables, and it may be that both variables are actually 'caused' by a third variable that is not in the model. The issue of causality between crude oil prices and the selected variables is by far theoretically controversial. In this study, the Granger causality test is used to determine the direction of causality between crude oil prices and the variables which selected in the oil price model. It is a testing whether crude oil price precedes the oil market performance or the reverse. In addition, it may happen at the same time "contemporaneous" as shown in table 4.21 below:

Table 4.21

The VEC Granger Causality Test Results

	rp	OECDdays	RIGS	FU4	OPcap	Dummy	CY1
rp		9.106***	8.120***	8.538***			5.963***
OECDdays			37.381***		5.481***	7.603***	
RIGS		4.621**		11.306***	13.735***		
FU4		2.709*	11.453***				
OPcap		2.999*	2.872*				
Dummy	3.303*			7.844***			
CY1	5.963***	2.792*		12.171***			

Bidirectional or Feedback relationships	unidirectional relationships
OECDdays ↔ Rigs	RIGS → P
OECDdays ↔ OPcaputil	OECDdays → P
OPcaputil ↔ Rigs	FUT4 → P
FUT4 ↔ Rigs	CY → P
	OECDdays → CY
	OECDdays → Dummy
	OPcaputil → OECDdays
	FUT4 → OECDdays
	FUT4 → CY
	Dummy → P
	Dummy → FUT4

Note: (***),(**) and (*) indicate significant at 1%, 5% and 10% levels, respectively.

Table 4.21 presents the short run causality test or Granger causality results from the error correction model among real oil price, days for forward consumption (OECD days), total oil rigs for drilling activity (Rigs), future oil contract for four months contracts (Fut4), capacity utilization for the available refineries in OPEC (OPcaputil), convenience yield as the risk premium for holding inventories (CY) and a dummy variable for the Gulf War (Dummy). The short run causality test can be conducted by applying the F-test of overall significance in the Wald test context to test the joint significance of the sum of the lags of each explanatory. The results show that four variables, namely, Rigs, OECD days, Fut4, and CY are significant which means can be considered as the most important variables in determining crude oil price. Also show that two variables, namely, RIGS and OECD days are found to be the most important variables in determining crude oil price. The results also indicate that the dummy variable for the Gulf War (Dummy) does not Granger cause many macroeconomic variables (OECD days, Rigs, CY and OPcaputil) except crude oil price (P) and four month NYMEX crude oil futures contract (Fut4).

As shown in panel 2. Table 4.21 the total oil rigs and OPEC capacity utilization appear to be Granger-caused by OECD days and future oil price for the fourth contract and vice versa. This means a unidirectional relationship from total oil rigs and OPEC capacity utilization, Total oil rigs with OECD days and finally with four month crude oil futures contract. This result may show the importance of the total oil rigs and OECD days in determining crude oil price.

4.9 Principal Component Analysis (PCA)

Principal component analysis (PCA) is a statistical technique that deals with a large number of (correlated) variables and reduces them to a smaller number of uncorrelated linear combinations, called principal components, that account for the most variability in the original variables. More details about PCA can be found in Jolliffe (2002). PCA has a long history as a statistical technique for analyzing time series, having been applied to all kinds of financial markets, becoming an extremely useful and fruitful technique in multivariate analysis, assisting, in particular, in the estimation of several multi-factor financial models and in the identification of the main risk factors in large portfolios of correlated financial assets (X. Bai, J. R. Russell and G. C. Tiao, 2002).

Principal component analysis can be applied to determine the factors that can explain variations of crude oil prices. In order to do so, factors described above are used to build seven principal components that may be represented as a linear combination of initial factors. KMO & Bartlett's Test of Sphericity is used to measure the sampling adequacy that is recommended to check the case to variable ratio for the analysis being conducted. In most academic and business studies, KMO & Bartlett's test play an important role in accepting the sample adequacy. While the KMO ranges from 0 to 1, the world-over accepted index is over 0.6. Also, the Bartlett's test of Sphericity relates to the significance of the study and thereby shows the validity and suitability of the responses collected to the problem being addressed through the study. For Factor Analysis to be recommended suitable, the Bartlett's Test of Sphericity must be less than 0.05.

The results of Kaiser-Meyer-Olkin Measure of Sampling Adequacy (KMO) and Bartlett's test of Sphericity were significant as shown in Table 4.22 which indicate the suitability of data for structure detection.

Table 4.22
KMO and Bartlett's Test

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.622
Bartlett's Test of Sphericity	Approx. Chi-Square	2022.433
	Df	55
	Sig.	.000

Table 4.23 shows the results for seven principal components. According to the method, each principal component is constructed in such a way that variance is maximized. In our particular case the first principal component PC1 explains 49 % of variance of the data set, while principal components PC1, PC2, PC3, PC4 together account for 89 % of the total variance in the data set.

Table 4.23
Principal Components Analysis

	PC 1	PC 2	PC 3	PC 4	PC 5	PC 6	PC 7	PC 8	PC 9	PC 10	PC 11
Standard deviation	5.390	1.981	1.324	1.084	.692	.308	.168	.040	.007	.006	.001
Proportion of variance	48.997	18.007	12.038	9.851	6.290	2.801	1.525	.366	.064	.056	.005
Cumulative Proportion	48.997	67.004	79.042	88.893	95.183	97.983	99.509	99.875	99.939	99.995	100.000

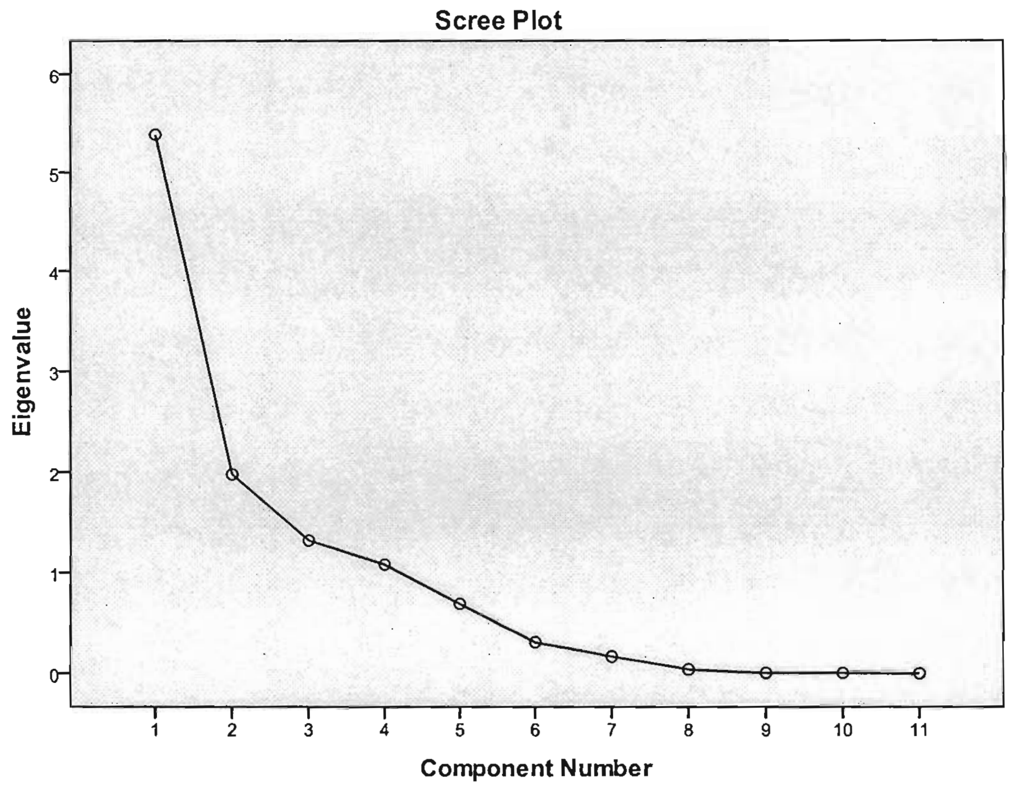

Figure 4.4
Scree Plot for the Principal Component Analysis

Scree plot has been used to determine the number of component analysis as shown in the Figure 4.4. It is clear that the first two components can explain the most svarying proportion in crude oil price. Since the first principal components explains around 63 % of the total variance proportion of the data set.

Based on the results of the principal components analysis seven main variables are chosen among all eleven variables considered. The choice is made by simply eyeballing by taking into consideration the fact that the distance between each single factor and a chosen axis should be minimal. Since the first principal components explains around 49% of the total variance of the data set, seven factors that are Located as close as possible to the PC1 axis are chosen as shown in Figure 4.5.

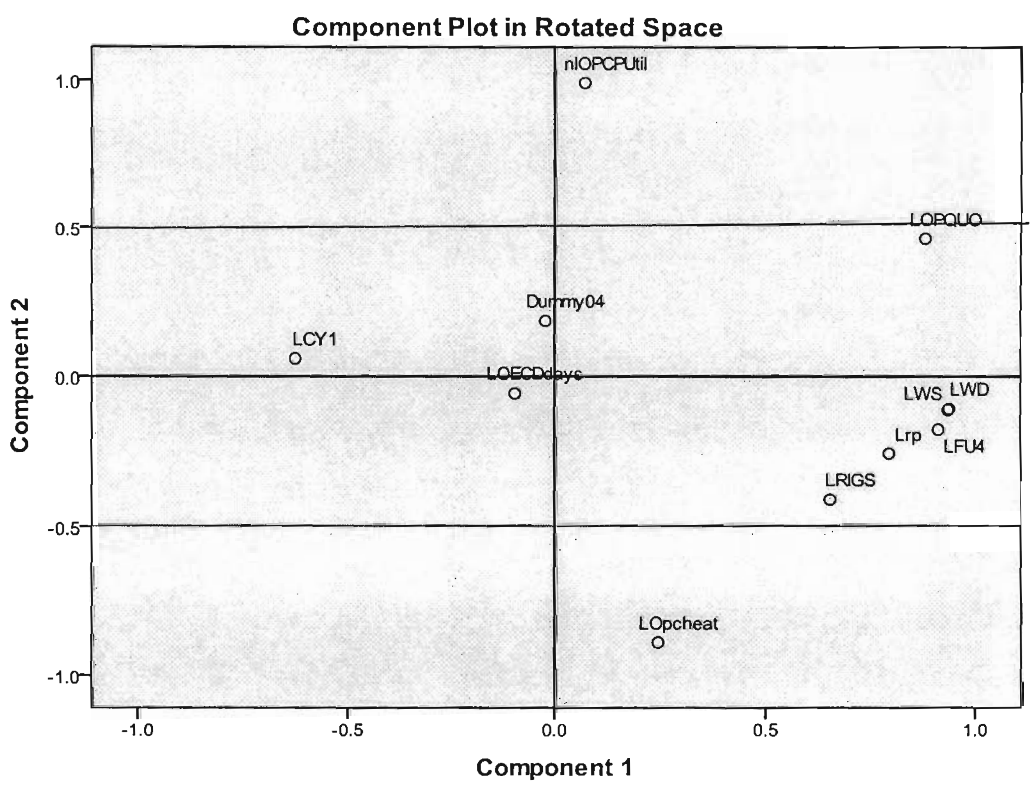

Figure 4.5
Component Plot in Rotated Space

Figure 4.5 Plot of factors in PC1-PC2 coordinates system - factors corresponding to the points lying along with the horizontal axis are assumed to be fundamental factors Tables 4.24 and 4.25 give evidence that use of principal component analysis substantially improves the results according to Eigen values. Now, almost all estimators are significant, positive signs except for convenience yield and OPEC capacity utilization. The Component Correlation Matrix shows very low correlation between PCA1 and PCA2 (0.15) which gives more evidence that the number of components extracted is correct.

Table 4.24
Pattern Matrix

Variables	Component 1	Component 2
LWD	.938	
LWS	.935	
LFU4	.912	
LOPQUO	.880	.460
Lrp	.793	
LRIGS	.653	-.409
LCY1	-.627	
LOECDdays		
nlOPCPUtil		.992
LOpcheat		-.887
Dummy04		

Table 4.25
Component Correlation Matrix

Component Correlation Matrix		
Component	1	2
1	1.000	-.145
2	-.145	1.000

4.10 VAR and Principal Component Analysis Results

In this study I examined the relation between crude oil prices and the main variables affecting its movement; fundamentals and financial variables. The cointegration analysis shows that there exist long-run relationship between the crude oil prices and its determinants. In our innovation accounting analysis, I can observe from the variance decomposition analysis that the crude oil prices respond to innovations in total oil rigs in operation, OECD days, future oil contracts and the convenience yield. The result in the short run is also supported by the Wald test which shows the degree of significance for each variable. In addition, our empirical findings indicate that there is Granger Causality between variables. The results showed the importance of the total oil rigs in operation and OECD days in determining crude oil price.

Finally, principal component analysis showed that seven variables are vertical, which supports that oil prices are determined mainly by fundamental variables (supply and demand).

CHAPTER FIVE

CONCLUSION, DISCUSSION AND RECOMMENDATION

5.1 Introduction

This chapter summarizes the main results of the study, presents the conclusions and recommendations for future studies.. This study focuses on the relationship between the specificied macroeconomic variables in oil market, e.g. fundamentals, convenience yield, OECD days, total oil rigs in operation and the financial variables side represented by future contracts, as well as the causality between them., This study also attempts to identify the relationship between geopolitics represented by OPEC behavior (which was proxied by OPEC quota, OPEC cheat and OPEC capacity utilization) and Dummy for the first and second Gulf War and oil market stability on crude oil prices changes.

Section 5.2 summarizes the whole study on the relationship between the crude oil price and the main determinants in the oil market, i.e. whether the crude oil prices are controlled by financial or fundamental variables. Section 5.3 gives a general overview of the achievement of this study. The objectives of this study are highlighted together with the results obtained from various estimations in order to provide general achievement of this research. Section 5.4 presents the implications that can be useful for oil companies or governments to reduce the effect of oil instability on their policies. Section 5.5 provides general suggestions to various limitations of the study. Lastly, Section 5.6 concludes with recommendations for future research.

5.2 Summary

The study begins with testing all variables for stationarity which are real oil price, convenience yield, total oil rigs, OPEC capacity utilization, OPEC quota, OPEC cheat, OECD days, future contract for four months and the difference between first and fourth future contract.. The augmented Dicky Fuller (ADF) and Phillips-Perron test (PP) were employed for testing unit root test. The ADF and PP suggest that all series are not stationary (except for OPEC quota and FUT4-1) because all of them have unit roots. However, I rejected unit roots for the series of all variables in first difference. As a result, this indicates that all variables are integrated of order one, I (1).

Thereafter, the study employs Johansen Cointegrating approach to determine the relationship between the crude oil prices and the main variables in the oil market as well as other macroeconomic variables (convenience yield, OPEC capacity utilization, days of forward consumption (OECD days), number of operating rigs, and four month NYMEX crude oil futures contract for the oil market. The results of the cointegration test show that there is evidence of the existence of a cointegrating relationship between the time series considered (CY, RIGS, OPCAPUTIL, OECDDAYS, FUT, DUMMY and P). This leads us to conclude that there is a cointegration between crude oil prices and the other variables in the oil market. Using Granger causality test, this study clarifies the impact of crude oil prices and the selected variables in the oil market.

Moreover, this study aims to investigate the relationship between the fundamentals variables and the financial variables to state whether crude oil price is determined by fundamentals or financial variables. Towards this end, I have used principal component analysis (PCA) to decrease the number of variables and to better capture the main variables influencing crude oil price. Based on PCA, I can conclude that the crude oil prices are more closely related to fundamentals. The results of Kaiser-Meyer-Olkin Measure of Sampling Adequacy (KMO) and Bartlett's test of Sphericity were significant (0.62, 0.00) respectively. In addition, it appears that convenience yield, oil supply, oil demand, OECD days have affected the crude oil prices changes. But the degree of this impact is different.

In order to capture the effects of the main variables in oil market, I have used vector error correction model (VECM). The result indicates that only the total oil rigs, convenience yields, OECD days and future prices are significant variables in the crude oil price changes. On the other hand, all the variable in Table 4.19 (CY, Rigs, OECDdays, OPcaputi) are negatively related to the crude oil prices except future contracts and dummy variable. Moreover, a dummy variable is expected to be negative because the cut in oil supply due the Gulf war will increase crude oil prices. It may be explained by the significant effect of OPEC cheat and the policies of OPEC organization during the crisis periods that allow increasing the oil supply more than the effect of the war itself.

In the last part, the study examines the short run equation of crude oil prices by using Wald test. The significant results indicate that there are short run relationships between the variables in the model. However, the short run results are consistent with Granger causality test results.

5.3 Discussions

Several studies have tried to assess the factors that determine oil prices. Most of the previous studies focused on the effects of oil prices in developed countries such as the U.S. market. In addition, a lot of studies focused on the impact of OPEC behavior on the oil market, as well as on the crude oil prices. Analysts also tried to illustrate oil price changes according to oil market fundamentals (supply and demand) and macroeconomic variables. Hence, in spite of the importance of these factors, but it is not enough to explain oil price changes especially in the last two decades. Recently, the oil market has witnessed many changes, in supply side (new producers of oil like Canada, Alaska and North Sea oil), demand side (the big increase in economic growth of East Asian countries such as China, India and Malaysia), political effects (Arab spring) and even in the type and size of financial factors.

Furthermore, the new instructions on environment pollution encouraged the use of light oil which contains less sulphur; these instructions increased the pressure on the refining utilization sector and consequently putting upward pressure on prices. In sequence, the growing gap between demand and oil supply, coupled with strong crude prices, is encouraging OPEC producers to further ramp up production. This is resulting in increased supplies of heavier crudes and further impacting light heavy differentials. This should cause light-heavy spread to widen, and hence improved complex refining margins.

Therefore the present study was designed to determine the effect of four groups of variables on crude oil prices; supply variables, demand variables, geopolitics variables and financial variables. The model of oil prices in this study can be explained as follows. At any given price, demand determines the quantity of oil supplied. Non-OPEC countries adapt their production to this new price and OPEC may act as the swing producer to equilibrate supply and demand. The findings of this study are consistent with fundamentals are the most important variables in determining crude oil prices according to PCA results. Using convenience yield, OPEC capacity utilization, OPEC cheat, OPEC quota, NYMEX WTI crude oil futures, days of forward consumption (OECD days), total oil rigs in operation and a dummy variable for the Gulf war, the results show that only WTI crude oil future 4 months contract variable affect positively on the crude oil prices. Hence, CY, Rigs, OECD days, and OPcaputil have a negative effect on crude oil prices as showed in Table 4.11.

The objectives of this study are achieved with the following results, obtained from the estimation of the crude oil price model and some selected variables from 1986 to 2010.

5.3.1 Objective 1

The first specific objective: To estimate the relationship between supply variables and crude oil price.

Results showed that the supply variables (total oil rigs and convenience yield) have a significant negative effect on the long run of crude oil prices (see table 4.19). This indicates that crude oil supply directly depends on the number of oil rigs in operation, which counts the number of active drilling rigs. The results show that there is a negative tradeoff between the number of active drilling rigs and crude oil prices. In other words, the number of active drilling rigs as an upstream variable in this study shows that more active drilling rigs reduce the crude oil price.

The negative sign for total oil rigs is consistent with Hamilton theory; an increase in total oil rigs will make pressure on oil supply to go up leads to decrease in oil prices. In other words, Hamilton theory explained an inverse relationship between total rigs and the price of oil. When the number of rigs rises, the quantity of oil extracted will increase also, leads to an increase in oil supply, then the price decreases accordingly. These findings of the current study are consistent with those of Mabro (1986); Barsky and Kilian (2002); Hamilton, 2003; Barsky and Kilian (2004); Mobert, J. (2007); Rotemberg (2007); Baker Hughes (2009) who found a negative relationship between the number of active drilling rigs and crude oil prices.

Results indicate that the convenience yield has a negative significant effect on the long run of crude oil prices. The negative sign of convenience yield is consistent with storage theory. According to storage theory, the total cost of storage consists of three types of cost; physical cost, interest rate and the convenience yield. Thus, convenience yield could be considered as a negative cost for investors if their expectations failed, since it represent the risk premium for holding inventories.

These findings of the current study are consistent with those of Pindyck, (2001); Hamilton (2008); Li & Tang, K. (2011); Kaufman, (2013) who found a negative relationship between crude oil prices and the convenience yield. Although it is difficult to measure the physical cost of storage, it can be approximated by the marginal convenience yield, which is the flow of benefits that accrue from the marginal unit of inventory (Pindyck, 2001). Because storable commodities will carry a storage cost associated with delivering the commodity in the future, and because markets with a delivery risk may carry a stochastic convenience yield.

In general, there are different extraction costs, and in the case of perfectly competitive market it means that the oil reserves with the lowest extraction cost will be extracted first. In this case, according to the Hotelling's theory, it will lower the initial gross price in the beginning of extraction, increase the rate at which the gross price increases (even though the net price increases at the same rate as before according to the Hotelling's rule), and shorten the time to complete exhaustion of the oil reserve. Despite the importance of other factors affecting the price of crude oil, but the principal component analysis in this study showed that the supply factors are the most influential variables on the price of crude oil (see figure 4. 5). This result indicates that the oil-producing countries and OPEC may have the biggest impact on crude oil prices. Especially, some of the oil market indicators such as petroleum reserve in recent years, referring to the low reserves of crude oil-producing countries outside OPEC such as North Sea, Alaska, Norway and Mexico.

5.3.2 Objective 2

The second specific objective: To estimate the relationship between demand variables and crude oil price.

Results showed that oil demand variables are the most important factors that affect oil price changes as explained in Figure 4.4, Factors in PC1-PC2 coordinate system - factors corresponding to the points lying along with the horizontal axis are assumed to be fundamental factors. This indicates that oil demand is one of the key factors affecting the price of crude oil especially in the recent years. There are several possible explanations for this result, Global demand has doubled as compared to previous periods in the seventies and the significant increase in GDP in most developed countries (Mobert, (2007; Hamilton, 2008; Kilian, 2009; Kaufman, 2011). In addition, many analysts argued that the recent period, which originated in the emergence of the largest economies in the world - especially China and India (Gately & Huntington, 2001; Li, 2007; Hamilton, 2008; Nandha & Faff, 2008).

These findings of the current study are consistent with those of Mobert (2007), Hamilton (2008), Kilian (2009, Kaufman (2011) who found a significant negative relationship between oil demand and crude oil prices. The present findings seem to be consistent with other research, such as Hamilton (2008), Used logarithmic transformations for oil consumption and U.S. real GDP for the period 1949 to 2007; he found that oil consumption trend has the biggest effect on crude oil price movements.

The results of this study show that OECD days or days of forward supply has a negative significant effect on the long run of crude oil prices (see Table 4.19). This indicates, as the days of forward supply rise, oil stocks will rise also. In other words, the negative sign means; an increase in oil stocks lowers real oil prices by reducing reliance on current production and thereby lowers the risk premium that is associated with a supply disruption. According to economic theory any increase in supply over the demand will put upward pressure on prices, ceteris paribus.

Moreover, The VEC Granger Causality test results show that OECD day's variable has bidirectional or feedback relationships with total oil rigs in operation and OPEC capacity utilization. Also, OECD days have unidirectional relationships with convenience yield and the dummy variable which is represented by the Gulf war. Moreover, principal component analysis indicate that OECD days is the nearest factor in PC1-PC2 coordinate system which explains the changes in crude oil prices (see Figure 4.5).

These findings of the current study are consistent with those of Mobert, (2007), Dees, et al. (2007), Hamilton, (2008) and Kaufmann (2008) who found a negative effect between OECD days crude oil prices. However, from the point of view positive coefficients can also be expected. If petroleum stocks are filled (released) then demand increases (decreases) and crude oil prices might fall. In line with Mobert (2007) who finds that the positive sign may be true as well: as stocks decline this will have the effect of putting upward pressure on prices therefore reducing demand.

5.3.3 Objective 3

The third specific objective: To estimate the relationship between Geopolitics and crude oil price.

This objective consists of two parts. The first part is geological which focused on oil properties such as; light, heavy and the sulfur content. The importance of this factor came from the environmental laws that have enacted laws to no energy, causing significant pressure on the capacity of the refinery. Therefore, to test this side I have used OPEC capacity utilization which denotes the rate at which the processing capacities of the available refineries are utilized. OPEC capacity utilization is calculated by dividing OPEC production over OPEC capacity, multiplying this quotient by OPEC's production share, and dividing this product by OPEC cheat (the difference between OPEC production and OPEC quota). The theory of market power focused on the geopolitics factors. Also, it tried to analyze OPEC's behavior and displays the importance of OPEC in the oil market as a political cartel. The second part illustrated by OPEC's role and political conflicts that affected oil prices.

The importance of this variable comes from the fact that, low levels of spare capacity erode OPEC's ability to act as a swing producer to balance supply and demand contributing to price volatility (e.g. Gately, 1984). Also, an additional bottleneck for quantity adjustments lies in the fact that refineries cannot process all types of crude oil (Plourde and Watkins, 1998).

Results showed that the geopolitics variables (OPEC capacity utilization and the dummy variable) have a negative non-significant effect on the long run of crude oil prices as shown in Table 4.19. The negative relationship between refinery utilization rates and crude oil prices may be explained by the fact that, increasing rates of the refinery utilization forces refinery to buy crudes that are less well suited to their refineries. This will reduce yield, which decreases the value of products they produce, which reduces the price they are willing to pay for crude oil. Similarly, as refineries reach capacity, the demand for crude oil drops which also reduces prices. In other words, the maximum capacity that each OPEC country can produce at without damaging the reservoirs, while permitting itself long enough production life commensurate with its economic strategy (Oil & Gas Journal, Jan 9, 1989, p.29). Kilian (2008) identifies capacity utilization rates close to 90% as an important threshold in safeguarding the long-run productivity of an oil field. The rates close to Kaufman (2008) who found it around 96%. Nonetheless, the negative relationship is consistent with those generated with a reduced-form model of oil prices (Kilian, 2008) and Kaufmann, et al. (2008).

The P value of OPEC capacity utilization in the short run is significant (P value is less than 0.05) as shown in the Table 4.20. But it is not significant in the long run, which is consisting with other analysts such as Gileva, (2010) who found P value equals (0.69). A possible explanation for this might be that Non-linearity in the relationship between price and OPEC supply. This procedure is based on the notion that if non-linear combinations of the independent variables have any power in explaining the dependent variable, then the linear model is misspecified (Kaufmann, Dees, Gasteuil & Mann, 2008).

The dummy variable for the Gulf War was found negative. But according to the economic theory shocks like wars will lead to decrease in oil supply and finally oil prices go up which means positive sign not negative. This result may be explained by the fact that OPEC cheats and OPEQ quota will increase oil supply more than the cut in oil demand, which finally give an opposite sign to the effect of wars on oil prices. In line with Le Billon, and El Khatib, (2004) Dees, Karadeloglou, Kaufmann, and Sanchez, (2007), Maslyuk, and Smyth, (2008). Also, the dummy variable was not significant may be because the Gulf war occurred only in four quarters out of one hundred observation which cannot statistically make a big sense or because did not include the other hurricanes like a Ivan hurricane (2004), hurricane Katrina (2005) and hurricane Gustav (2008).

5.3.4 Objective 4

The fourth specific objective: To estimate the relationship between Speculation, future markets and crude oil price.

Number of speculators in the oil market significantly increased in recent decade because of the ease to buy or sell by using the Internet and facilities using new technologies. Also, due to the increase in the volume of money and assets traded in the market and due the increase in index trading.

Results showed that the financial variables (speculation and future markets) have a positive significant effect on the long run of crude oil prices (see Table 4.19). In addition, Table 4.24 for principal component analysis showed that there is a positive significant relationship (0.91) between four months future contracts and crude oil prices. This indicates that crude oil price directly depends on the future oil contracts for four month contract; a price for a contract specifying the earliest delivery date as four months ahead.

The positive sign for total four month contract is consistent with Hamilton theory that oil price will increase, when the price did not correspond to the fundamental value based on oil supply and demand. In other word, when futures prices exceed spot prices may be profitable to store crude oil today in order to sell it for more profit in the future. Moreover, The VEC Granger Causality test results show that FUT4 has a bidirectional relationship with total oil rigs in operation and unidirectional relationships with OECD days and the convenience yield. Moreover, principal component analysis indicates that OECD days are the nearest factor in PC1-PC2 coordinates system which explains the changes in crude oil prices (see Figure 4.5).

These findings of the current study are consistent with those of Weiner (2008); Hamilton (2009); Ullman (2009); Jane (2010); Kaufman (2011) who found a positive significant relationship between future contracts and crude oil prices.

Futures markets are much more effective in price determination than the spot market because of the large volume of transactions. (Fattouh 2006) believes that futures prices are determined by these transactions through the interaction of buyers and sellers; not by arbitrary price-making mechanisms designed by governments. Therefore, futures prices paint a very clear picture of the global oil market and enable market participants to make well-informed allocative decisions. But according to Hamilton (2008), oil speculators respond to supply and demand factors such as production cuts, capacity utilization, stock levels, and consumption. It is therefore fallacious to assert that futures market participants arbitrarily bet on higher futures prices without any regard for oil market conditions.

The present findings seem to be consistent with Kaufman (2008) who found that financial factors might have contributed the oil price increase. Most of the increase can be explained by concerns about future oil market conditions, as represented by the shift of the futures market from backwardation to contango.

There was a lot of work written on oil prices, especially after the oil crisis in 2008 which affect most of economies, companies and even households. The main concern is to find an answer to the question: what is driving crude oil price changes? Analysts have two views. The first group argues that the main change in oil prices belongs to the fundamentals (supply and demand variables). The other claims that financial variables (speculation and future markets) play a big role in crude oil price changes. Each team has his own arguments and evidences. The results of this study confirm that oil prices in the last decade especially after the crisis in 2008 are determined by fundamental variables due to the significant results for total oil rigs, OECD days, convenience yield and OPEC's role in the VAR model and principal component analysis.

The previous results supported that crude oil prices are affected by three main variables; Supply variables represented by total oil rigs and convenience yield, demand variables represented by OECD days, and financial variables which explained by future oil contracts as shown in Figure 5.1

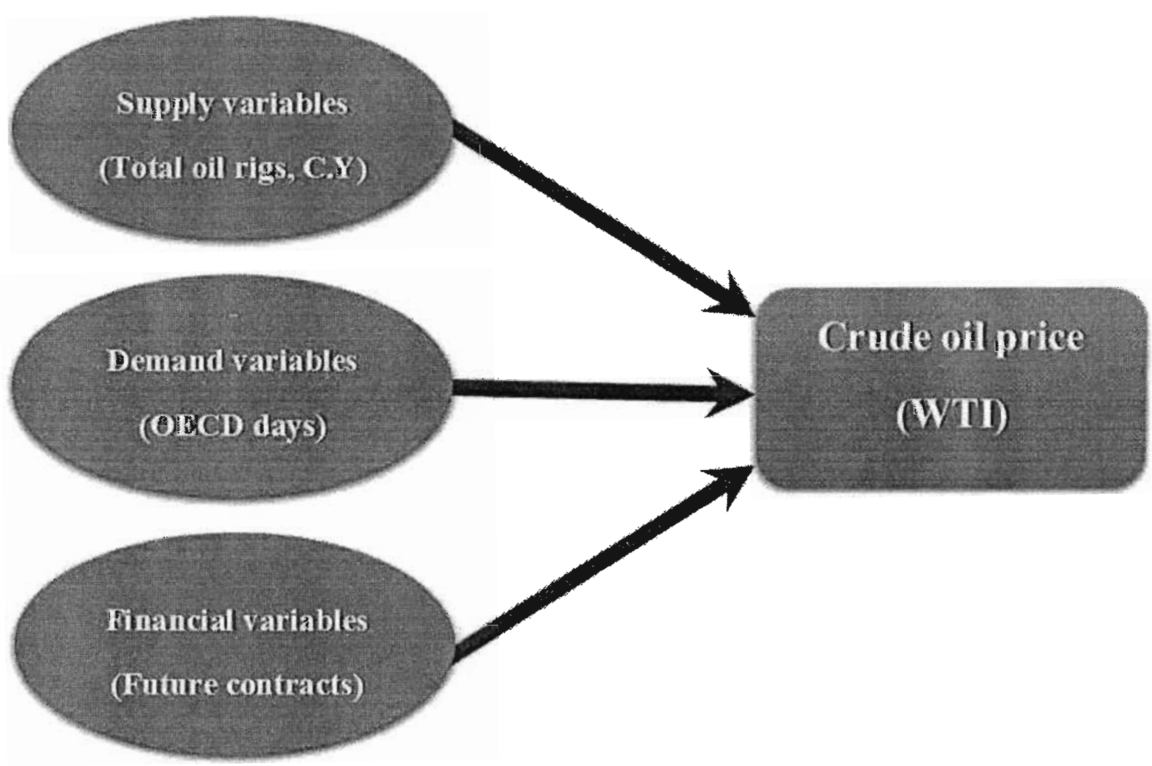

Figure 5.1
The Supported Results Regarding the Hypothesis Testing

Despite the significant results of fundamentals and future markets, the results of this study cannot ignore the significant effect of geopolitics variables on crude oil price according to the results of principal component analysis.

5.4 Policy Implications

There was a lot of work written on oil prices, especially after the oil crisis in 2008 which affect most of economies, companies and even households. In addition, many conferences were held to reflect the concern of many governments such as; UK, France, USA and more than G-20 industrialized countries (Chevalier, 2010). The main concern is to find an answer to the question: what is driving crude oil price changes? Analysts have two views. The first group argues that the main change in oil prices belongs to the fundamentals (supply and demand variables). The other claims that financial variables (speculation and future markets) play a big role in crude oil price changes. Each team has his own arguments and evidences. The results of this study confirm that oil prices in the last decade, especially after the crisis in 2008 are determined by fundamental variables due to the significant results for total oil rigs, OECD days, convenience yield and OPEC's role in the VAR model and principal component analysis. Despite the significant results of fundamentals, the results of this study cannot ignore the significant effect of future contracts on crude oil price according to the VAR model results and principal component analysis.

The VECM results in this study for the error correction model Eq. (4.7) indicate that the cointegrating relationship given in Table 4.19 can be interpreted as an equation for the long-term determinants of oil price. The error correction term (Ect) in Eq.

(4.7) is negative. This value indicates that total oil rigs, OECD days, OPEC capacity utilization, convenience yield and future oil contracts "Granger cause" real oil prices. The implication of this result, studying the previous variable effects could be useful for consuming, producing oil countries and oil companies to reduce the effect of oil price changes on their policies.

The negative long run relationship between the crude oil prices and convenience yield assert the importance of investors' decision in drilling sector. Dahl (2004) explains that inventories can be used to offset unexpected increases in demand or augment supply when conditions become tight. This is can be true when oil is dearer it will command a higher price and therefore holding inventories will be a profitable endeavor (Hamilton, 2008). In other words, investors need to compare between convenience yield and the sum of storage cost and interest costs. If convenience yield is less than the sum of interest and storage costs, this will give a sign that the oil market is in contango (futures prices are greater than spot prices). This means that inventories are high and that holders of these inventories do not anticipate supply shortages in the short run. In sequence, holders of oil inventories do not anticipate having to sell portions of their stock to satisfy demand or augment supply shortages in the short run; Vice versa when the market in backwardation (futures prices are smaller than spot prices). Moreover, convenience yield can help speculators by giving a simple picture for oil market; is it in contango or in backwardation because it shows how spot and futures prices are affected by convenience yields. It is believed that the study will be able to provide valuable information in helping both investors and speculators to implement optimal policies.

The relationship between crude oil prices and capacity utilization of the oil market are very important. The results of this study show that there is a negative relationship between OPEC capacity utilization and the crude oil prices; higher refinery utilization rates reduce crude oil prices. This effect is associated with shifts in the production of heavy and light grades of crude oil and price spreads between them. In other words, the investors in refinery sector can use this information to predict movements in the oil market prices.

Uncertainty and expectations about oil future prices, speculation and production in the oil market lead to inventory holdups during the times of supply disruptions (e.g., 1973 oil embargo), and inventory drawdown at times when the market is soft. The change in the inventory level creates a shortage and surplus and affects product and prices. The results of the study are useful for producing and exporting countries in devising their pricing and production policies. At the same time, the importing and consuming countries would benefit from the study in their forecasting and planning efforts. Moreover, it would be significant in extending similar studies through incorporation of new variables and it is expected to be useful in understanding the main determinants of oil price.

Crude oil and natural gas are exhaustible natural resources, in the sense that they are available in limited quantities. Crude oil is available in limited quantities according to the exhaustibility theory. In the global oil market there is a fair of exhaustibility especially after the low levels of exploration and reserve for oil producers outside

OPEC. The essential implication of exhaustibility is that extraction of the resource in one period directly affects production and consumption in ensuing periods. This implies that market behavior for such goods has to be analyzed within a dynamic context. Principal component analysis findings show that there was no systematic speculator behavior driving prices up. Still speculators in general were one of the main variables, while actually speculators are much needed in the market to generate liquidity and fight bubbles through arbitrage.

Oil prices are expected to rise in the future. A general explanation for the high prices in the future is that supply capacity will not keep up with the growing demand. Oil supply will reach record highs with the help of new, more expensive production. Crude oil price will be affected not only by the high marginal costs but also by convenience yields by giving up inventory.

Finally, it appears that while oil prices are going down again after the crisis in 2008, the most crucial long-term drivers remain. Oil demand will inevitably continue growing even if it is now held back for a few years by the stagnating world economy. Old oil fields will decline and new replacing capacity will cost more to produce. Surely oil will not run out, but it will become increasingly more expensive.

5.5 Limitation of the Study

Crude oil prices are too broad issues: they affect both micro and macro economy at the same time. Therefore, the study focuses on the main factors that explain crude oil price movements to find an answer to the question: what is driving crude oil prices? Are its fundamentals or traditional factors?

Like every research work, this study has some limitations. First, it covers 1986-2010 in order to reduce the number of oil crisis period like 1973, 1979 and the early 1986 in order to avoid using many dummy variables. Second, the study focuses on the last three decades so as to capture the main variables that affect crude oil prices. Third, I would have used global data for refining capacity utilization but the only available data is the U.S. refining capacity, as many analysts mentioned (Kaufman, 2008). However, data for days of forward supply have been collected from OECD countries and U.S as the main oil consuming countries due the lack of data.

Fourth, the recent conflicts and/or wars such as the 'Arab Spring' resulted in instability in oil prices, and indirectly affect related variables. Moreover, some variables such as political conflicts or war cannot be quantified, thus necessitating the use of dummy variables.

5.6 Recommendation for Further Research

This study provides much-needed analysis of the relationship between macroeconomic variables in the oil market and the crude oil prices. Moreover, it studies the main variables that played a big role in the changes of oil prices.

However, it seems that there remains plenty of research to be done in this area. There is a need to include other variables not included in this study such as the relationship between the refining capacity utilization in the whole world and the crude oil prices. Therefore, if data is available it is better to use data for oil companies and countries which can help to capture a better picture of the variables that affect crude oil prices in the oil market. Also for the dummy variable it will be instructive to add other periods of crisis such as Ivan hurricane (2004), hurricane Katrina (2005) and hurricane Gustav (2008). Moreover, some of my model variables have been omitted because they are not integrated in the same level. Therefore, it will be adding more insight to use a statistical program that can fix this problem like Microfit. This study investigates oil price determinants by applying the VECM approach. It might also be more interesting to include the time period surrounding the first two oil price shocks of the 1970s and 1980s in future research.

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