DRIVERS OF THE OIL PRICE: AN EMPIRICAL ANALYSIS OF THE EFFECT OF OIL IMPORTS BY OECD REGIONS

A THESIS SUBMITTED TO
THE GRADUATE SCHOOL OF SOCIAL SCIENCES
OF
MIDDLE EAST TECHNICAL UNIVERSITY

BY

ÜMMÜGÜLSÜM GÜNEYLİGİL

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR
THE DEGREE OF MASTER OF SCIENCE
IN
THE DEPARTMENT OF ECONOMICS

SEPTEMBER 2013

Approval of the Graduate School of Social Sciences

Prof. Dr. Meliha Altunışık
Director

I certify that this thesis satisfies all the requirements as a thesis for the degree of Master of Science.

Prof. Dr. Erdal Özmen
Head of Department

This is to certify that we have read this thesis and that in our opinion it is fully adequate, in scope and quality, as a thesis for the degree of Master of Science.

Assoc. Prof. Dr. Elif Akbostancı
Supervisor

Examining Committee Members

Prof. Dr. Uğur Soytaş	(METU, BA)	____________________
Assoc. Prof. Dr. Elif Akbostancı	(METU, ECON)	____________________
Dr. Fatma Pınar Erdem	(TCMB)	____________________

I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

Name, Last Name: Ümmügülsüm, GÜNEYLİGİL

Signature :

ABSTRACT

DRIVERS OF THE OIL PRICE: AN EMPIRICAL ANALYSIS OF THE EFFECT OF OIL IMPORTS BY OECD REGIONS

Güneyligil Ümmügülsüm

MS., Department of Economics

Supervisor: Assoc. Prof. Dr. Elif Akbostancı

September 2013, 81 pages

This study analyzes the effect of oil imports by OECD regions on crude oil price by using Kaufmann's price rule as a benchmark. Using the autoregressive distributed lag (ARDL) cointegration approach; it is found that there is cointegration between crude oil prices, days of forward consumption of OECD crude oil stocks, OPEC quota, OPEC cheat and key variables imported crude oil by OECD. However, ARDL based error correction models (ECM) indicate that regional factors are not a significant determinant of crude oil price both in the short run and long run. Cointegration is also found when imported crude oil by total OECD is replaced with regional variables. For the model with OECD total, there is a significant positive long run relation between imported crude oil by OECD and crude oil prices. So, the role of OECD on world price is still important even if it experiences much lower oil demand growth compared to emerging countries. Moreover, in order to capture the dynamic responses, a vector autoregressive (VAR) methodology has been employed. The results show that imported crude oil by OECD in previous quarter; affects crude oil price more than imported crude oil in the present which proves imported crude oil by OECD in previous period has more driving power on the determination of oil price than imported crude oil by OECD in present period because price might be a late responser. And based on the graphs of impulse response functions (IRF), it is found that crude oil price does not response significantly to a shock in imported crude oil by OECD and vice versa.

Keywords: OECD, North America, Europe, Asia&Oceania, ARDL cointegration, ECM, VAR, IRF

ÖZ

PETROL FİYATI BELİRLEYİCİLERİ: OECD BÖLGESEL PETROL İTHALATI ETKİSİNİN AMPİRİK ANALİZİ

Güneyligil Ümmügülsüm

Yüksek Lisans, İktisat Bölümü
Tez Yöneticisi: Assoc. Prof. Dr. Elif Akbostancı
Eylül 2013, 81 sayfa

Bu çalışma Kaufmann'ın fiyat kuralını temel alarak OECD bölgesel petrol ithalatının ham petrol fiyatı üzerine etkisini analiz etmektedir. ARDL eşbütünleşme yöntemi kullanıldığında ham petrol fiyatları, OECD ham petrol stoklarının tükeneceği gün sayısı, OPEC kota, OPEC kotası ve üretim arasındaki fark ve OECD ham petrol ithalatı arasında eşbütünleşme olduğu görülmüştür. Ancak, ARDL yoluyla elde edilen ECM sonuçlarına göre OECD bölgelerinin petrol ithalatı kısa ve uzun dönemde petrol fiyatını belirleyen önemli bir değişken değildir. OECD bütün olarak modele yerleştirildiğinde, OECD petrol ithalatı ve petrol fiyatı arasında pozitif bir uzun dönem ilişkisi gözlenmiştir. Bu durum göstermektedir ki; gelişmekte olan piyasalara nazaran OECD'nin daha düşük talep büyümesine sahip olması OECD petrol ithalatının petrol fiyatı üzerindeki etkisini değiştirememiştir. Ayrıca, dinamik tepkilerin analiz edilebilesi amacıyla VAR yöntemi kullanılmıştır. Sonuçlara göre bir önceki çeyrekte ithal edilen petrol içinde bulunulan dönemde ithal edilen petrole göre petrol fiyatını daha çok etkilemektedir. Bu durumda petrol fiyatının talebe bir dönem gecikerek tepki verdiği sonucu çıkartılmıştır. Son olarak IRF grafiklerine göre ham petrol fiyatı OECD petrol ithalatında yaşanan bir şoka önemli bir tepki vermemektedir.

Anahtar Sözcükler: OECD, Kuzey Amerika, Avrupa, Asya&Okyanusya, ARDL eşbütünleşme, ECM, VAR, IRF

To my family

ACKNOWLEDGMENTS

I want to thank my thesis supervisor, Assoc. Prof. Dr. Elif Akbostancı, for her supervision, contributions, and academic support throughout this study. I am grateful to the examining committee members, Prof. Dr. Uğur Soytaş and Dr. Fatma Pınar Erdem, for their precious contributions and criticisms.

I would like to thank the Scientific and Technological Research Council of Turkey (TÜBİTAK) for their scholarship.

I thank my close friends Eda Çalgüner, Ekin Titrek, Mehtap and Mehmet Ergin, Hakan Güneş, Duygu Deveci, Fatih Şahan, Neslihan Arslan, Semih Ceyhan for helping me in construction of the framework of study, for their support, understanding, assistance, and encouragement.

I would like to express my gratitude to Uğurluer family; Aylin, Uğur and my little brother Uğurcan Uğurluer, Titrek family; Nazan and Ahmet Titrek, Çobanoğlu family; Şükran and Nusret Çobanoğlu for providing me with all the motivation and encouragement I need to fulfill this study.

I express my deepest gratitude to my parents, Nazife and Cafer Güneyligil and to my brothers Ali Kemal and Erman Güneyligil for their close support, understanding, assistance and encouragement throughout this study.

Finally, to my caring, supportive, beloved love; Yılmaz Uğurluer, I express my heartfelt thanks. Your encouragement when the times got rough are much appreciated and duly noted. It was a great comfort and relief to know that you were always with me while I completed my thesis. I am glad you are my love and always will be.

TABLE OF CONTENTS

CHAPTER 1

INTRODUCTION

1.1. OIL

Oil is a necessary source of energy for the world and will probably remain over many years, even under the most optimistic assumptions about the discovery of alternative energy sources. Lots of countries are significantly affected by developments in the oil market, either as producers, consumers, or both. In 2012, oil supplied about 36 percent of the world's energy needs, and in the future, oil is anticipated to continue to contribute a greatest portion of the world's energy mix (Exxon Mobile, 2012).

Oil is the most important source of primary energy in the world, accounting for about 33 percent of the total; the other two main fossil fuels, coal and natural gas, account for 28 and 23 percent, respectively. Renewable sources of energy are in a rapid growth phase, but they still account for only a small fraction of primary energy supply (International Energy Agency (IEA), 2012).

1.1.a. A Brief History of Oil Price Movements

The descriptive analysis of crude oil markets allows us to analyze oil price movements between the years 1970 and 2011. Major oil price movements are explained briefly one by one, with reference to paper named "*Historical Oil Shocks*" (Hamilton, 2010).

1973-1974: OPEC Embargo

Egypt and Syria began to attack Israel on October 6, 1973. Whereupon, on October 17, Arab members of the Organization of Petroleum Exporting Countries (OPEC) imposed an embargo on oil exports to the countries which sided with Israel.[1] Then, OPEC dramatically decreased total oil production causing a significant increase in oil prices.

1978-1979: Iranian Revolution

After the war in 1973, since Iran did not support Arab states, it started to increase its oil production during the 1973-74 embargoes. However, it was also facing with public protests during that time. Between October 1978 and January 1979, Iran decreased oil production down by 4.8 mbd which corresponds to 7% of world production at the time, because of the strikes in the oil sector.

1980-1981: Iran-Iraq War

Later in 1979, Iranian oil production came back to almost half of its pre-revolutionary levels but was edged out again when Iraq levied a war on Iran in September of 1980. The total amount of decrease in oil production was approximately 6% of world production at that time.

1981-1986: The Huge Price Fall

During OPEC Embargo, Iranian Revolution and Iran-Iraq War, oil production decreased and unsurprisingly this led to an increase in oil prices. But, oil demand response of consuming countries to the price increases of the 1970s in the long run was considerable. In the early 1980s, oil consumption in the world decreased significantly. This created a huge decrease in oil prices. For example between 1981 and 1985, Saudi Arabia which is the dominant producer in OPEC, cut 3/4 of its oil production to avoid a 25% decrease in the nominal price of oil and much more bigger decrease in the real price but even this cutback was not enough.

[1] OPEC member states are given in Appendix.

1990-1991: First Persian Gulf War

At the beginning of 1990, oil production in Iraq came back to the levels of the late 1970s but this had not last long. When Iraq went into Kuwait in August 1990, Kuwait's outstanding oil production was brought down. In total, Iraq and Kuwait were producing 9% of world oil. Additional to substantial loss of oil production, the concern about the war could spread to Saudi Arabia played significant role on doubled crude oil price in only a few months.

1997-1998: East Asian Crisis

Remarkable growth in East Asia was seen long before 1997. Even if their share of world oil consumption at that time was ordinary, their increasing growth rate could have been a cause for the price hikes in the mid-1990s. In 1997, Thailand, South Korea, and other countries in East Asia experienced serious problems in their financial systems. Therefore, investors started to worry about the Asian growth story, putting economic and financial strains on some other Asian countries. Following these, the oil price went down, decreasing below $12 a barrel in late 1998s and this was the lowest oil price since 1972 in real terms.

1999-2000: Continued Growth

The Asian crisis lasted in two years and showed that worries about Asian growth story were unnecessary because the countries in East Asia started to experience growth again. In 1999, world oil consumption turned back to phenomenal growth, and at the end of 1999, the oil price became closer to the level that was in 1997. Additionally, between November 1999 and November 2000, the West Texas Intermediate (WTI) oil price kept increasing by 38%.

2003: Venezuelan Chaos and the Second Persian Gulf War

In December of 2002 and January of 2003, a destructive strike in Venezuela removed about 2.1 mbd oil production. Following chaos in Venezuela, U.S. launched a war against Iraq resulting in elimination of an additional 2.2 mbd oil production. But it can be stated that, these decreases in oil production did not have much influence on global oil supply because oil prices did not increase, significantly after Venezuelan chaos and the Second Persian Gulf War.

2007-2008: Increasing Demand versus Stagnant Supply

Global economic growth seen in 2004 and 2005 was significant. In numbers, IMF estimated that real gross world product grew at an average annual rate of 4.7% and world oil consumption grew 5 mbd over this period put differently 3% per year. Oil demand continued to increase with world real GDP increasing an additional 5% per year in 2006 and 2007. For example, China which is defined as an emerging country, alone increased its oil consumption by 840,000 barrels a day between 2005 and 2007 (International Monetary Fund (IMF), 2009). Today, the world consumes 75 million barrels of crude oil every day, making it the world's biggest commodity market with transactions exceeding $400 billion per day, a number which will double to $800 billion or more in the next 20 years. Last year world crude oil demand grew by 3 %, the highest growth rate since 1988, and more than double the past 10 year's average (Energy Information Administration (EIA), 2013). This growing oil demand and not growing oil production especially after 2005 were the main reasons for the rise in the oil price over this period. The reasons for not growing oil supply with demand are (1) continued chaos in Iraq and Nigeria (2) mature oil fields with relatively rapid decline rates (3) oil production decline in the North Sea and Mexico's Cantarell, which had been the world's second largest producing field (4) changed role of Indonesia (one of the original members of OPEC): an importer instead of an exporter of oil (Hamilton, 2010).

The recent oil price rise and its unforeseen end in July 2008 reawakened the question about the underlying reasons for the price movements in crude oil market. An understanding of the crude oil market requires an understanding of basic factors which might have leading role in the oil market.

1.2. Demand Factors

An important crude oil variable is the market demand. In a price-quantity diagram, an increase in demand for crude oil shifts the demand curve to the right and leads to an increase in crude oil price if the supply curve is not completely elastic. After the series of oil price shocks in the 1970s, developed nations suffered because of their considerable dependence on oil import. Therefore, oil-importing countries attempted to decrease oil as an input and tried to substitute oil with appropriate alternatives if possible. These attempts resulted in a decline in oil consumption per head whereas total oil consumption is still growing. Such as oil demand in emerging countries that are not part of the Organization of Economic Cooperation and Development (OECD) has increased considerably beginning from 1990s. A continuing growth in oil demand is recognizable especially for China and India which are included in emerging countries. Indeed, after decades of self-sufficiency on crude oil, China began to import crude oil since 1996. Likewise, the crude oil import by India has risen quickly since late 1990s. For example, India's oil demand grew from around 1.6 mbd to 3.1 mbd and China's oil demand increased much more from nearly 3.5 mbd in 1990 to 9.0 mbd (more than double) in 2012 (BRICs, 2012). The increased demand for imported crude oil from China and India are stimulated by their rapid economic development in recent decades. So, their import shares have become an important factor in the competition for limited resources in the world oil market (Li&Lin, 2011).

On the other hand, oil demand in the OECD was 37.6 mbd at the end of 1990 and in 2012 it reached to 45.9 mbd. The OECD is comprised of the U.S., much of Europe, and other countries from all around the world. In 2012, oil consumption by OECD was 53 percent of world oil consumption, so these developed and developing economies consumed more oil than the non-OECD countries for now however they experience much lower oil consumption growth (IEA, 1990&2013).

In the light of the foregoing, research question for this study comes into the picture which is "In the existence of proven significance of growing oil demand by emerging countries, what is the role of OECD on the determination of oil prices?" In order to answer this question and analyze the role of OECD to reach to a meaningful result, OECD oil demand is examined in this study using share of imported crude oil by OECD regions: North America, Europe, Asia&Oceania and total OECD in world crude oil volume. It is analyzed regionally to decompose their effect on oil price. And it is analyzed totally to see the role of OECD on crude oil price in the existence of proven significance of growing oil demand by emerging countries. Signs for the coefficients of variables representing oil demand by regions and OECD total might be positive because an increase in oil demand leads to an increase in crude oil price if the supply curve is not completely elastic.

1.3. Stocks of Crude Oil

After the first oil crisis, OECD countries started to found an oil stock to avoid unexpected cutbacks of global oil supply. OECD crude oil stock was 143.7 million metric tons which corresponds approximately to 3.4 mbd in April 1990.[2] In April 2012, OECD crude oil stock reached to 17.0 mbd (IEA, 1990&2013). In order to see the effect of growing OECD stock on oil prices, Days variable is used in this study introduced by Kaufmann et al. (2004) which stands for the ratio of OECD stock in mb and OECD oil demand in mbd. Aim of including Days variable is to analyze independence of oil-importing countries from price shocks and OPEC. Kaufmann et al. (2004) finds a negative relationship between Days and price and explains it by saying "an increase in stocks reduces real oil price by diminishing reliance on current production and thereby reducing the risk premium associated with a supply disruption." On the other hand, according to Moebert (2007) positive coefficients for Days variable is also possible because "if crude oil stocks are filled (released) then demand increases (decreases) and crude oil prices might rise (fall)" meaning that there can be a positive relationship. Therefore, no specific sign can be assigned to the coefficient of Days variable, correspondingly OECD crude oil stock (Moebert, 2007).

1.4. Supply Factors - OPEC

The behaviour of OPEC which tries to cut their supply to push up the market price and thereby earn profits is also an important factor in crude oil market (Adelman, 1980, Kaufmann et. al., 2004). The following Table 1.1 shows cumulative crude oil production of OPEC member states from 1960 to 2011.

[2] Million metric tons (mmt) converted to mbd using conversion calculator of CME group.

Table 1.1: Cumulative crude oil production up to and including year (*1,000 b*)

Countries	1960	1970	1980	1990	2000	2011
Algeria	81,372	2,569,469	6,404,54	8,974,340	11,837,030	16,503,002
Angola	1,127	76,423	623,359	1,681,478	3,972,081	9,408,940
Ecuador	2,745	26,191	617,927	1,526,131	2,843,162	4,730,076
Iran	4,167,71	12,357,977	29,969,8	38,410,483	51,367,070	66,457,984
Iraq	2,750,43	7,476,078	15,826,1	22,246,208	26,918,241	35,565,137
Kuwait	4,333,049	13,028,906	21,993,1	25,857,094	32,092,887	41,518,527
Libya	-	5,476,384	12,810,8	16,929,582	21,993,272	27,773,330
Nigeria	12,318	1,138,896	8,389,45	13,656,562	20,572,881	28,919,160
Qatar	451,617	1,428,583	3,199,37	4,334,808	6,032,088	8,986,510
Saudi Arabia	4,345,24	13,283,848	42,306,7	61,814,608	91,266,532	125,786,28
United Arab Emirates	–	1,160,471	7,164,23	11,921,927	19,785,670	29,201,893
Venezuela	13,865,47	26,301,976	36,046,6	42,528,079	51,772,971	63,415,418
OPEC	**30,011,111**	**84,325,201**	**185,352,402**	**249,881,299**	**340,453,88**	**458,266,26**

Source: Annual Statistical Bulletin, 2012, OPEC.

Based on the crude oil production data given in Table 1.1, OPEC cumulatively produced 458,267 mb crude oil from 1960 to 2011. However, OPEC is usually defined as a cartel which means it does not open total production to trade and uses different tools to lead the oil market for its benefit. Such as, OPEC has decided to use oil production quota which is binding for all its member countries and measures the total OPEC supply after 1983. Additional to quota system, in March 2000, OPEC generated a target corridor between 22 and 28 US dollars to directly monitor the oil price. The aim of using target corridor was that if the oil prices are higher than the corridor, OPEC can increase its production and make more profits. Nevertheless, OPEC freezed target corridor in June 2005 because the market prices kept being above 28 US dollars for more than a year. After the market settled down, OPEC regenerated a new target corridor, again (OPEC, 2013).

Even though OPEC insists on its leading supplier role in oil market, OPEC member countries started to lose its authority in oil market and did not see recent market developments coming (Moebert, 2007). One of the reasons behind this loss is the discipline among OPEC member states which might decrease OPEC's power. Actually there exist two scenarios with opposite outcomes: (1) OPEC member states stick to co-decisions then they can increase OPEC power by protecting cartel stability (2) one of them breaks the rule and trades more oil than the approved by all OPEC members, then price of oil would decrease and other members would experience a significant loss which is not desirable. Second scenario was seen more in the past because every member state in OPEC has motives to trade more oil than the approved level at all times.

Another reason for the loss of authority could be the emergence of alternative energy sources and increase in substitutes of oil undoubtedly decreases OPEC’s power. As mentioned before in demand factors, per head consumption declined because oil importing countries suffered from very high oil prices and preferred alternative energy sources after the oil price shocks in the seventies. For example, in U.S., especially in California, green technologies are continuing to develop based on recent energy policies and government incentives (Center for Sustainable Systems, 2012). This kind of developments might create a risk for oil exporting countries mainly OPEC because most of them are highly dependent on U.S. oil demand.

Therefore, to fully understand OPEC’s effect on the oil price, some of OPEC variables introduced by Kaufmann et al. (2004) are used in this analysis. These variables are OPEC quota which is also called as production allocations set by OPEC and OPEC cheat which is the difference between actual OPEC production and quota in mbd. Higher production quotas mean higher supply and higher supply might result in decrease in oil prices. Similarly, if OPEC member states do not stick to cartel agreements and violate the production quotas, as a result of second scenario oil prices are expected to decrease.

In this study, the effect of OECD crude oil stocks, OPEC quota, OPEC cheat and core variables: imported crude oil by North America, Europe, Asia&Oceania and OECD as a whole are analyzed to find an answer to the question “In the existence of proven significance of growing oil demand by emerging countries, what is the role of OECD on the determination of oil prices?” Three methodologies are applied through this analysis:

1) The bounds testing (Autoregressive Distributed Lag (ARDL)) cointegration procedure introduced by Pesaran and Shin (1999) and developed more by Pesaran, Shin and Smith (2001).
2) Error Correction Model (ECM) following ARDL approach to determine whether there is evidence of relationship between crude oil price and imported crude oil by OECD regions and OECD in total, in the short run and long run.
3) Vector Autoregressive (VAR) model and Impulse Response Function (IRF) to evaluate the dynamic effects of the past interactions between the variables.

This study contributes to the literature in two dimensions. First one is, to the best of our knowledge, this is the first empirical study which analyzes the drivers of crude oil price by using both ARDL and VAR approaches together to examine the influence of OECD crude oil stocks, OPEC quota, OPEC cheat, imported crude oil demand in North America, Europe, Asia&Oceania and OECD on price. Secondly, this might be the first study that investigates both the effect of OECD regions and OECD as a whole for the period in which emerging economies have arisen.

The rest of the study structured as follows: Chapter 2 is the Literature Review section presented in four main parts; (1) Demand side (2) Supply side (3) Role of OPEC and (4) Role of Financial Markets and Speculation as the determinants of oil price in the literature. Chapter 3 is the Data and Methodology section which introduces the variables and specifies the models used in the empirical study, explains the sources of the data and interprets unit root test results. Also methodology is detailed in this section. Chapter 4 is the Empirical Analyses section which presents ARDL, ECM, VAR and IRF results. Finally, Chapter 5 provides a review of the outcomes and restates significant conclusions.

CHAPTER 2

LITERATURE REVIEW

Crude oil is the most traded and non-financial commodity of the world and supplies about 40% of the world demand for energy. Crude oil consumption increased by 0.8 million barrels per day in 2012, to 89.2 million barrels per day (IEA, 2013). U.S. Energy Information Administration (EIA) anticipates consumption growth will be more in the next two years; 0.9 million barrels per day in 2013 and 1.2 million barrels per day in 2014. The significance of crude oil comes from its derivative products which are usually key elements of everyday life. For example, gasoline, fuel, jet fuel, plastics and a series of essentials are generated from crude oil.

The latest boom in commodities prices and its sudden stop in July 2008 brought the argument back which is about the behavior of the crude oil markets and the determinants of crude oil price. There are several opinions about the determinants of crude oil price; some of them claim fundamental determinants are supply and demand, some of them believe it is OPEC behavior and the others insist the key role belongs to the financial markets especially to the speculation factor. The various theories and potential factors that arise in the academic discussion on the determinants of oil prices do not necessarily exclude each other, but rather tend to complement one another (Hamilton, 2009 and Dees et. al., 2007).

2.1. DETERMINANTS OF THE OIL PRICE

The potential drivers specified in the literature as the determinants of crude oil prices can be analyzed in four different groups. The first group includes demand centered researches which believe demand is mostly stimulated by global economic growth; secondly, supply centered researches which analyze the factors resulting from shortages and depletion; third group studies the behavior of OPEC, deeply and the last one captures the contribution of financial markets, materialized in speculation. Even though the literature suggests a wide range of researches to evaluate the differential role of each factor, there is no consensus on which factors matter to which degree, for which time period, and how these factors might interact (Breitenfellner et. al., 2009).

2.1.a. The Demand Side

Most of the latest studies indicate that increase in the crude oil demand stimulated the recent oil price boost between 2004 and 2008. This oil price boost is generally explained by the increasing demand of emerging economies. Hamilton (2009), for example, attracts attention to the high oil demand of China, the Middle East, and other Newly Industrialized Countries, which have made noteworthy contribution to the high oil prices in recent years. Additionally, low price elasticity of demand and failed increases in supply were the other factors that kept the oil prices high. In Hamilton's view, these three factors engendered the commodity speculation and the rise in the oil price; this might be a signal that scarcity rents begin to derive relevance.

Using forecast revisions to rank unexpected demand shocks, Kilian (2008) clarifies that the demand shocks stimulated by the high growth of emerging economies are the main factors which cause price of oil to increase. In addition to that, the ordinary increase in energy demand might be related with the variations in anticipations of future oil market developments. Kilian (2009) separates oil price shocks into three; (1) crude oil supply shocks, (2) aggregate crude oil demand shocks and (3) crude oil demand shocks. Kilian (2009) shows that mainly precautionary demand, which is associated with ambiguousness about future oil supply shortages given anticipated oil demand, pioneers the demand shocks in the oil sector. Using a structural Vector Auto Regression (VAR) model, Killian claims that a supply shock has a small temporary effect; on the other hand, fluctuations in aggregate demand have a large and persistent effect on the crude oil price.

In another study, Kilian and Murphy (2010) observe the relative importance of demand, supply and speculative demand shocks to the real oil price, again using a structural VAR model. Their analysis is constructed with a four-variable dynamic simultaneous equation model in the form of a structural VAR. In their model, y_t is a vector of endogenous variables including the percentage changes in global crude oil production, a measure of global real activity, the real price of crude oil, and the change in oil inventories. All data are monthly and the sample period is February 1973 - August 2009. They remove seasonal variation by including seasonal dummies in the VAR model. The corresponding structural model of the global oil market may be written as;

$$\beta_0 y_t = \sum_{i=1}^{24} \beta_i y_{t-i} + \varepsilon_t$$

where ε_t is a 4×1vector of orthogonal structural innovations and β_i, i=0,...,24 denotes the coefficient matrices. The seasonal dummies have been suppressed for notational convenience. The vector ε_t consists of structural shocks. (Killian&Murphy, 2010). The speculative demand is included in the changes in inventory levels, aiming to demonstrate changes in the future demand and supply. Even though they reach to the result that speculative demand had some effect on increases in oil price in the past, it did not contribute importantly to the latest oil price boost. Also, the effect of supply shocks is restricted. According to the VAR analysis results, predominant contribution was made by the movements in crude oil demand.

In a more recent study, Li and Lin (2011) give empirical proof on the alternating nature of world oil pricing system by introducing another oil price driver; emerging market factor. They use China and India as the representative of emerging markets to analyze whether the quantity of crude oil imported by China and India has any effect on the existing oil pricing system introduced to literature by Kaufmann et. al. (2004). They use Kaufmann's price rule as a benchmark and set the equation as follows;

$$Price_t = \beta_0 + \beta_1 Days_t + \beta_2 Quota_t + \beta_3 Cheat_t + \beta_4 Caputil_t + \beta_5 Chindia_t + \mu_t$$

where price is the real Brent price averaged on a monthly basis, Days is days of forward consumption of OECD crude oil stocks, Quota is the OPEC production quota, Cheat is the difference between OPEC production and OPEC quotas, Caputil is the capacity utilization by OPEC, which is calculated by dividing OPEC production by OPEC capacity and the Chindia which is the main subject of the research represents the demand for imported crude oil by China and India (Li&Lin, 2011). Their data covers the time period January 2002 - March 2010. Cointegration and Error Correction Model (ECM) developed by Engle–Granger (1987) and Gregory–Hansen (1996) are applied in their study. According to their results which are close to Hamilton's findings (2009), demand from emerging markets has turn into an important factor in the world oil pricing system. Empirical evidence strengthens theoretical hypothesis that growing oil import by China and India behave like a demand shock, stimulating world oil prices to notable levels.

2.1.b. The Supply Side

In the second group, there exist supply side studies which advocate that oil prices are affected mainly by supply side factors and many studies focus on the theory of exhaustible resources together with an emphasis on the potential exhaustion of oil. The theory of exhaustible resources developed by Hotelling (1931), says that the price of an exhaustible resource increases at the same rate with the interest rate. In more explanatory words, if crude oil producers intended to sell all of the resources presently at their disposal at the ongoing market price and invest their profits, the aggregate have to increase regularly at the rate of interest. Suppliers are not concerned with the time of sale only when oil prices and the interest rates increase at the same rate. Nevertheless, it is still doubtful that the implications of Hotelling's study can be applied to the oil market. One reason is that the amount of available stock of the resource which is basically oil reserves is unclear. Additional to the problem of uncertainty, Fattouh (2007) says that there exist technological improvements for the discovery and production of alternative sources of energy, thus oil is becoming replaceable instead of being exhaustible.

The impact of changes in the real interest rate on oil prices has been empirically evaluated regarding both the demand and the supply side. For instance, Frankel (2006) discusses that real interest rates may influence the real price of the commodities through different incentives such as making the keeping of stocks more or less attractive and changing the return on different ways of investment. Historical data on real commodity prices and the real interest rate supports the expectation that they have a negative relationship. Additionally, in Krichene's paper (2008), a VAR model is applied to examine the relationship between crude oil prices, the dollar's nominal effective exchange rate (NEER) and U.S. interest rates based on monthly, quarterly, and annual data. According to results of VAR analyses, it is not rejected that there exists at least one cointegration relation and both interest rates and the NEER influence crude prices inversely.

2.1.c. The Role of the OPEC

Undoubtedly, OPEC has a crucial role as a supplier in the world oil market considering its share both in world oil production and crude oil reserves. Today, based on OPEC's own figures, OPEC member states (currently, there exist twelve countries) provide 40% of world crude oil production and 55% of crude oil exports. Approximately 80% of known reserves are found in the OPEC member countries, 10% is in the Former Soviet Union (FSU) and 4% is in the OECD countries (OPEC, 2010). Among OPEC members countries, Saudi Arabia has the biggest share (19,2%) of known oil reserves in the world, followed by Iran, Iraq, Kuwait, Venezuela, and the United Arab Emirates (EIA, 2010).

There exist many studies on whether OPEC acts as a Cartel (Gulen, 1996), a dominant supplier, or a fringe producer (Griffin, 1985). However, according to Kaufmann et al. (2004), there is still no consensus on the OPEC behavior. Therefore, Kaufmann et al. (2004) try to analyze the effect of OPEC behavior on oil prices including OPEC capacity utilization which is calculated by dividing OPEC production by OPEC capacity: *Caputil*, OPEC quotas: *Quota*, cheat which is the difference between OPEC production and quota: *Cheat* and OECD stocks of crude oil divided by OECD demand for crude oil: *Days* in the model known as Kaufmann's price rule today;

$$Price_t = \beta_0 + \beta_1 Days_t + \beta_2 Quota_t + \beta_3 Cheat_t + \beta_4 Caputil_t + \mu_t$$

Econometric analysis of the model implies that all explanatory variables have a significant effect on determination of oil price and there is a statistically significant relationship among real oil prices and explanatory variables. Based on the Granger Causality test results, variables on the right hand side of the model Granger cause real oil prices however real oil prices do not Granger cause these variables.

Kaufmann's price rule is used as a benchmark for many other studies. For example, Dees et. al. (2007) constructs a structural model of the world oil market to evaluate oil price developments and analyze quantitatively the effect of oil related risk assessments. Oil price is set based on Kaufmann's price rule in terms of the changes in market conditions and OPEC behaviour. Econometric equation for the estimation of real oil price with quarterly data (1986:Q3-2000:Q3) has the following form;

$$ROIL_t = \alpha + \beta_1 DAYS_t + \beta_2 Quota_t + \beta_3 Cheat_t + \beta_4 Caputil_t + \beta_5 Q_1 + \beta_6 Q_2 + \beta_7 Q_3 + \beta_8 War + \mu_t$$

where ROIL is the US crude oil import FOB (Free on Board) price, variables added to basic model: Q1, Q2, and Q3 are dummy variables for quarters I, II, and III, War is a dummy variable for the Persian Gulf War (third and fourth quarters of 1990). In terms of the estimation results, the model reproduces past developments in oil markets and indicates that OPEC determinations about quota and capacity utilization have a significant, direct influence on oil price.

In a more recent study, Deng et. al. (2012) develops an econometric model including some variables (quota and cheat) from Kaufmann's price rule to figure out the relationship between real oil prices, OPEC production decisions, and global oil production. They analyzed monthly changes in real oil prices from the beginning of 2003 until the peak in oil prices in July 2008 by using co-movement of OPEC production decisions and New York Mercantile Exchange (NYMEX) crude oil futures prices. They apply a vector error correction model (VECM) which explains the short-run and long-run relationships between real monthly oil prices and the explanatory variables that characterized OPEC behavior and government decisions.

According to estimation results, the estimated coefficients on quotas and deviations are found as statistically different in magnitude either in the long-run or in the short run relationship. This suggests that global oil prices respond to changes in OPEC production whether as a result of changes in member quotas or as a result of deviations of members from their quotas (Deng et al., 2012).

Wirl and Kujundzic (2004) examine the impact of OPEC forum decisions on global oil market improvements. In contrast with Kaufmann et. al. (2004) who found OPEC behavior has a significant effect on oil prices, they reach to the conclusion that OPEC decisions have a small effect on directing oil prices. But, even if the effect is small and statistically insignificant, the direction of price adjustment has the expected sign similar to Kaufmann et. al. (2004).

2.1.d. The Role of Financial Markets and Speculation

Contribution of the financial markets to the oil prices, influence of speculation on price fluctuations has been broadly argued in the academic literature (Kaufmann, Ullman, 2009). For example, Soytas et. al. (2009) examines short run and long run dynamic interactions between the world oil prices, gold and silver spot prices, TL/$ exchange rate and a remarkable Turkish bond rate. Based on the long-run estimates, oil price is a world issue in the long run. Granger causality test implies that information from Turkish spot precious metal markets; exchange rate market and the interest rate do not have any effect on the forecasts of world oil prices in the long run. Since oil prices are global, it is expected that regional information especially from a developing country with relatively small oil consumption: Turkey is not significant in estimation of world oil prices. After this finding, Soytas et. al.(2010) analyzes the relationships between spot prices of precious metals (including platinum and palladium additional to gold and silver), oil and the $/€ exchange rate instead of TL/$ exchange rate. It is found that long-run equilibrium relationships between spot prices of precious metals, oil and the $/€ exchange rate do not exist. Oil is under the control of OPEC and the other oil-producing countries; has its own seasonality, inventories and hedging strategies (Soytas et. al., 2010).

In 2006, US Senate made an announcement that; based on a large volume of articles, energy outlooks and international policy analyses, lots of researchers are more concerned with the potential effect of speculators on the oil prices than they were in the past. Recently, so many speculators attracted by high returns, have entered to the oil market. According to Quarterly Review (2004) published by Bank for International Settlements (BIS), the sudden rise in oil prices experienced in recent years called attention to the role of speculators in the oil market. Investors expecting high returns have focused more on the commodity markets, especially oil because of the changing or even decreasing prices in asset, bond and credit markets. Similarly, Fattouh (2007) who analyzes the effect of OPEC, the erosion of spare capacity, the effect of speculation and inventories on oil price in his paper, highlights the increasing effect of futures markets on oil price determination, which associates the expectations of numerous market participants with the prices. In his view, “demand and supply determine the oil price in the long term, but they do so in a specific context. Unfortunately, the supply-demand framework analyses oil prices and makes projections in a neutral context” (Fattouh, 2007).

Miller and Ratti (2009) investigate the relationship between crude oil prices and stock market prices applying a VECM which gives structural breaks in the stochastic trend. In their study, after 1999, a break in the cointegration relation of oil prices with stock market prices was found. According to the results, before 1980, stock market prices had a significant positive effect on oil prices but after 1999, it turned into a negative effect. This finding implies existence of a direct relationship between stock market and oil price bubbles. Additionally, Ellen and Zwinkels (2010) study the role of speculation in the determination of oil prices. They analyzed demand factor as a real and a speculative part, respectively. The speculative part is analyzed with a behavioral model which separates fundamentalists and chartists.[3] According to their results, both parts have significant effect on the oil market but speculation driven demand has more significant effect on determination of oil prices.

Kaufmann (2011) says that the role of speculation is really hard to measure quantitatively. He overviews the changes that propose a role for speculation and he adds three more to the list of changes. Added indicators are as follows: “significant increase in private US crude oil inventories since 2004, repeated and extended break-downs in the cointegrating relationship between spot and far month future prices (starting in 2004) that are inconsistent with the arbitrage opportunities that enforce the law of one price, statistical and predictive failures by an econometric model of oil prices that is based on market fundamentals” (Kaufmann, 2011). He concludes it is not proved that speculation has an important effect on the recent price boost, solely. However if the indicators are analyzed all together, they represent significant changes in the process of price discovery that propose a role for factors other than supply and demand.

In this chapter, determinants of oil prices come forward in the literature are classified in four groups: Demand side, Supply side, Role of OPEC and Role of Financial markets&Speculation. The literature about the determination of oil prices does not reach to a common conclusion but it is worth to state that large volume of studies uses a common price rule as a benchmark which is known as Kaufmann’s price rule in the literature. Even though Kaufmann's main focus is on OPEC behaviour and the power they have on determination of oil prices, he also analyzes whether OECD have any effect on determination of oil prices by taking OECD oil stocks and oil consumption into account. Therefore, Kaufmann includes OPEC capacity utilization, OPEC quotas, cheat (the difference between OPEC production and quota) and days of forward consumption by OECD in his price rule. In the literature, Kaufmann’s

[3] Fundamentalists base their expectations on economic theory. They believe that the market price will revert to the intrinsic value of an asset and therefore bases expectations on the deviation of the market price from the fundamental value. Chartists, on the other hand, base their expectations on past price changes. They extrapolate information from previous prices, expecting trends to continue in the same direction.

study and other studies based on Kaufmann’s price rule find that OPEC capacity utilization, OPEC quotas, cheat and days of forward consumption are statistically significant in the estimation of oil prices.

CHAPTER 3

DATA AND METHODOLOGY

3.1. DATA

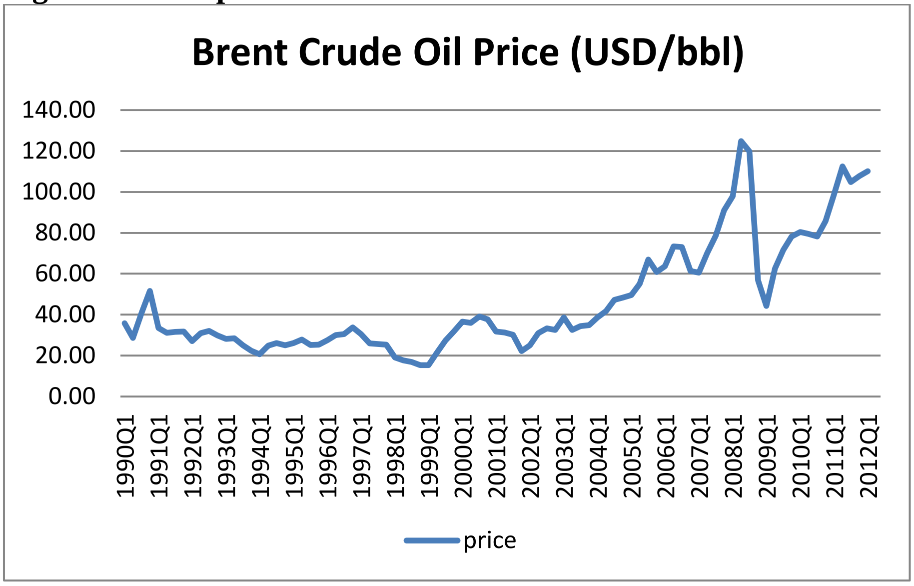
3.1.a. Introduction of Variables and Data Sources

Oil price is modeled following the price rule introduced by Kaufmann et al. (2004). Four variables used from the price rule are; Price, Days, Quota and Cheat in the world oil pricing system. Additional to these basic variables, North America, Europe, Asia&Ocenia and OECD variables are included in the model to see their effect on oil price. Among these variables, Price is the dependent variable whereas all other variables are used as explanatory variables. Data set used in the model consists of quarterly data and the data period is from 1990Q1 to 2012Q1.

Dependent variable Price is the real Brent crude oil price which is a type of petroleum classification given to oil from the North Sea. It is a major trading classification of sweet light crude oil comprising Brent Blend, Forties Blend, Oseberg and Ekofisk crudes (BFOE Quotation).[4] Data source for Brent price variable is Bloomberg, Energy&Oil Prices and Figure 3.1 shows the graph of Price variable.

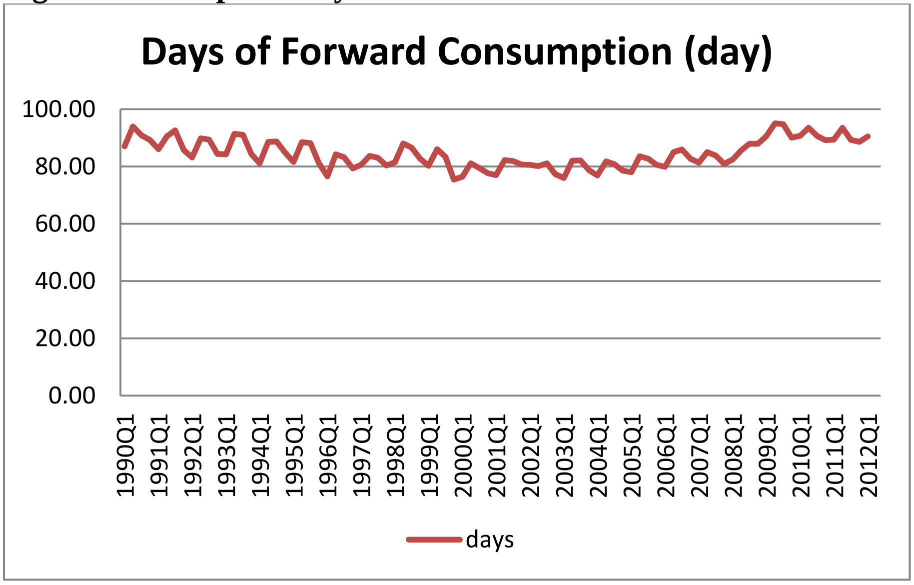
[4] The Forties Oil Field is the largest oil field in the North Sea, 110 miles east of Aberdeen. Oseberg is an offshore oil field with a gas cap in the North Sea located 140 km (87 miles) northwest of the city of Bergen on the southwestern coast of Norway. Ekofisk is an oil field in the Norwegian sector of the North Sea about 200 miles (320 km) southwest of Stavanger.
Source: The Brent Index, ICE Futures Europe, theice.com/brent and theice.com/brentnx

Figure 3.1: Graph of Price Variable



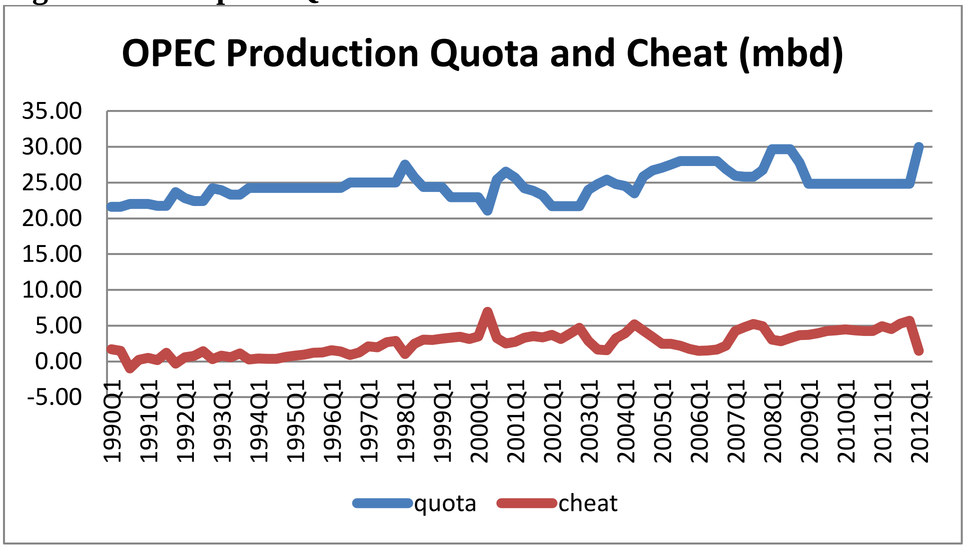
Days is days of forward consumption of OECD crude oil stocks which is calculated by dividing OECD stocks of crude oil by OECD demand for crude oil and data source is Oil Market Reports published by International Energy Agency (IEA). One can see the picture of Days variable in Figure 3.2 represented below.

Figure 3.2: Graph of Days Variable



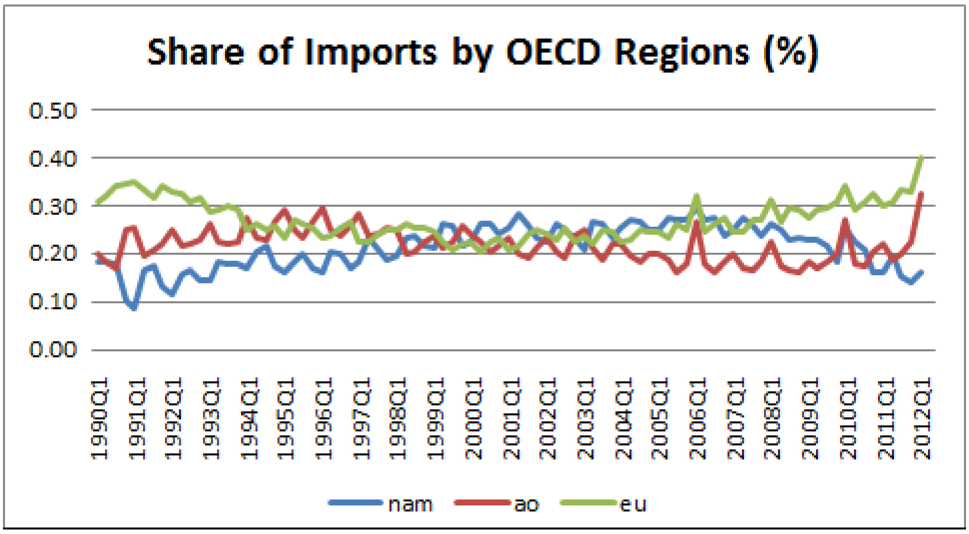
Quota is the OPEC production quota (million barrels per day) and data source is OPEC Production Allocations announced by OPEC. Cheat (mbd) variable is the difference between OPEC production and OPEC quotas, the relevant data is taken from OPEC. Figure 3.3 shows the picture of Quota and Cheat variables.

Figure 3.3: Graph of Quota and Cheat Variables



North America, Europe, Asia&Oceania and OECD variables which are the key variables of interest for this analysis represent imported crude oil levels and are computed as the share of imported crude oil by North America, Europe, Asia&Oceania and OECD in total world crude oil volume. Data source for these variables is U.S. Energy Information Administration (EIA) and Figure 3.4 represents the share of Imports by OECD Regions.

Figure 3.4: Graph of Crude Oil Imports by OECD Regions



Variable names are displayed in Table 3.1.

Table 3.1 Variable Names

Real Brent Crude Oil Price	**Price**
Days of Forward Consumption	**Days**
OPEC Production Quota	**Quota**
Difference between OPEC Production and OPEC Quota	**Cheat**
Imported crude oil share by North America	**NAM**
Imported crude oil share by Europe	**EU**
Imported crude oil share by Asia&Oceania	**AO**
Imported crude oil share by OECD	**OECD**

Calculated variables in equations are listed below;

$$Days = \frac{OECD\ stocks\ of\ crude\ oil}{OECD\ demand\ for\ crude\ oil}$$

$$Cheat = |OPEC\ Production - OPEC\ Quota|$$

$$NAM = \frac{Imported\ crude\ oil\ by\ North\ America}{World\ crude\ oil\ volume}$$

$$EU = \frac{Imported\ crude\ oil\ by\ Europe}{World\ crude\ oil\ volume}$$

$$AO = \frac{Imported\ crude\ oil\ by\ Asia\&Oceania}{World\ crude\ oil\ volume}$$

$$OECD = \frac{Imported\ crude\ oil\ by\ OECD}{World\ crude\ oil\ volume}$$

3.1.b. Model Specification

It is difficult to model the real price of oil characteristics because of its high volatility. Beginning with Frankel (1946), many other researches are carried out to find the determinants of the oil price. (Frankel, P.H., 1946)

Following the price rule introduced by Kaufmann et al. (2004), we start our model with the basic variables: Days, Quota and Cheat in the world oil pricing system:

$$Price_t = \beta_0 + \beta_1 Days_t + \beta_2 Quota_t + \beta_3 Cheat_t + \mu_t \quad (3.1)$$

This price rule is used as a benchmark model and the aim of this thesis is firstly to find out the impact of oil import by OECD regions; North America, Europe and Asia&Oceania, then total oil import by OECD. The main purpose is to see whether OECD still has a significant role on the determination of oil price or not when the effect of emerging markets which is previously excluded from this world oil pricing system is recently found as significant by Li and Lin (2011). Five models will be analyzed to determine the role of OECD regions in the description of oil pricing system. Therefore, firstly the variables NAM, EU and AO which stand for imported crude oil by North America, Europe and Asia&Oceania are added to the basic model one by one. Secondly, NAM, EU and AO are added to the basic model altogether. And finally OECD will be included in the model. With these variables, Equation (3.1) is extended as follows:

$$Price_t = \alpha_0 + \alpha_1 Days_t + \alpha_2 Quota_t + \alpha_3 Cheat_t + \alpha_4 NAM_t + \psi_t \quad (3.2)$$

$$Price_t = \theta_0 + \theta_1 Days_t + \theta_2 Quota_t + \theta_3 Cheat_t + \theta_4 EU_t + €_t \quad (3.3)$$

$$Price_t = \delta_0 + \delta_1 Days_t + \delta_2 Quota_t + \delta_3 Cheat_t + \delta_4 AO_t + £_t \quad (3.4)$$

$$Price_{t} = \pi_0 + \pi_1 Days_t + \pi_2 Quota_t + \pi_3 Cheat_t + \pi_4 NAM_t + \pi_4 EU_t + \pi_5 AO_t + \Omega_t \qquad (3.5)$$

$$Price_{t} = \gamma_0 + \gamma_1 Days_t + \gamma_2 Quota_t + \gamma_3 Cheat_t + \gamma_4 OECD_t + u_t \qquad (3.6)$$

Regression coefficient associated with the variable Days is expected to be negative because rise in stocks decreases real oil price by lowering dependence on current production therefore reducing the risk premium related with a supply disruption. Correspondingly, rise in the OPEC quota causes to reduce real oil price because supply is increased. Additionally an increase in the Cheat variable tends to decrease price “because an increase in OPEC production relative to their quota increases supply relative to the demand perceived by OPEC when setting the quota” (Dees et.al., 2007). Expected signs associated with the key variables for the analysis; NAM, EU, AO and OECD which represent imported crude oil level by regions and OECD in total are positive. In other words, Price is expected as a positive function of NAM, EU, AO and OECD because growing demand for imported crude oil causes real oil price to increase.

3.1.c. Unit Root Tests

Before moving to econometric analysis for the models introduced before, testing the order of integration is standard in applied econometric studies because the order of integration is an important subject to develop an appropriate econometric model and make inference. There exist many different tests to find out the order of integration and these tests are called as unit root tests which are generally a descriptive tool used for the classification of the series as stationary or non-stationary. The most common test for testing non-stationary: I(1) versus stationary: I(0) is the Augmented Dickey-Fuller (ADF) test. The null hypothesis for ADF test is that the series is I(1) against the alternative that the series is I(0). “The main reason that we focus on ADF test is that it is simple and there is no uniformly better alternative” (Elliot et. al., 1996). ADF Unit Root Test Results for all the variables are represented in Table 3.2.

Table 3.2 ADF Unit Root Test Results

Variable	Case	Statistics	Level	First Difference
PRICE	Intercept	ADF t- statistic	-0.201	-9.168
		P value	0.933	0.000***
	Intercept& Trend	ADF t- statistic	-2.335	-9.354
		P value	0.410	0.000***
DAYS	Intercept	ADF t- statistic	-7.379	-9.042
		P value	0.000***	0.000***
	Intercept& Trend	ADF t- statistic	-7.334	-9.030
		P value	0.000***	0.000***
QUOTA	Intercept	ADF t- statistic	-2.389	-7.493
		P value	0.147	0.000***
	Intercept& Trend	ADF t- statistic	-3.121	-7.422
		P value	0.127	0.000***
CHEAT	Intercept	ADF t- statistic	-3.086	-9.818
		P value	0.031**	0.000***
	Intercept& Trend	ADF t- statistic	-4.704	-9.738
		P value	0.001***	0.000***
NAM	Intercept	ADF t- statistic	-2.004	-4.024
		P value	0.284	0.002***
	Intercept& Trend	ADF t- statistic	0.923	-11.780
		P value	0.999	0.000***
EU	Intercept	ADF t- statistic	-0.905	-13.685
		P value	0.782	0.000***
	Intercept& Trend	ADF t- statistic	-0.602	-9.754
		P value	0.976	0.000***
AO	Intercept	ADF t- statistic	-1.136	-3.527
		P value	0.697	0.009***
	Intercept& Trend	ADF t- statistic	-1.101	-3.393
		P value	0.921	0.049**
OECD	Intercept	ADF t- statistic	-1.055	-13.724
		P value	0.729	0.000***
	Intercept& Trend	ADF t- statistic	-1.962	-13.575
		P value	0.612	0.000***

Rejection of null hypothesis is shown with * for 90 percent, ** for 95 percent and *** for 99 percent confidence levels.
Note: Critical Values for each variable is given in Appendix.

According to the results from Table 3.2, Price, Quota, NAM, EU and OECD variables are I(1) (integrated of order one) in both specifications at 99% confidence level. AO variable is also found as I(1) in intercept included case at 99% confidence level and in intercept&trend included case at 95% confidence level. On the other hand, Days variable is I(0) (integrated of order zero) in both only intercept and intercept&trend included cases at 99% confidence level. Similarly, Cheat variable is I(0) in intercept included case at 95% confidence level and in intercept&trend included case at 99% confidence level.

3.2. METHODOLOGY

3.2.a. ARDL Cointegration Approach

Over the past decade, several tests for cointegration have been introduced in the literature. In recent times, "Engle Granger (1987) two-step residual-based procedure for testing the null of no-cointegration and Johansen's (1991) system-based reduced rank regression approach are the two most commonly used cointegration techniques" (Narayan et. al., 2003). To apply these techniques, all the variables subject to the analysis must be I(1), thus same order of integration and being integrated of order one do matter before estimation. This necessarily requires a pre-testing procedure, and also proposes uncertainty into the analysis of levels relationships (Pesaran et. al., 2001; Cavanagh et. al., 1995).

In this study we have both I(0) and I(1) variables so Engle Granger and Johansen cointegration tests are not applicable to our model. Therefore, in this study, the bounds testing (Autoregressive Distributed Lag (ARDL)) cointegration procedure introduced by Pesaran and Shin (1999) and developed more by Pesaran, Shin and Smith (2001) is used. Three reasons for choosing this procedure are as follows:

- Firstly, contrary to other multivariate cointegration methods such as Johansen cointegration, the Bounds testing procedure allows the cointegration relationship to be estimated by OLS after the optimal lag length of the model is specified.

- Secondly, pre-testing of the variables for unit roots is not necessary for the Bounds testing procedure as opposed to other techniques such as Engle Granger and Johansen cointegration approach. It does not matter if the variables are I(0), I(1) or mutually cointegrated but in the presence of I(2) series, this test is not applicable.
- And thirdly, it has superior statistical features in small or finite samples and it is relatively more efficient in small data sizes like this analysis.

3.2.b. Error Correction Model (ECM)

Error Correction Models are a type of multiple time series models. ECMs estimate the speed at which a dependent variable returns to equilibrium after a change in an explanatory variable. The main features of ECMs are listed below:

- ECMs perform well to estimate both short term and long term effects of one variable on another.
- ECMs are usually the most appropriate models when dealing with both stationary and non-stationary variables.

ECMs are used in large number of studies because it is able to "induce flexibility by combining the short-run dynamic and long-run equilibrium models in a unified system" (Nwachukwu T. E., Egwaikhide F. O., 2007). Since we have both stationary and non-stationary variables in our study, after ARDL cointegration analysis, ECM will be applied to determine whether there is evidence of relationship between crude oil price and imported crude oil by OECD regions and OECD in total, in the short run and long run.

3.2.c. Vector Autoregression (VAR) Model

In 1980, Sims brought a new econometric model called as Vector Autoregression (VAR) into the literature. A VAR is a k-equation, k variable linear model in which each variable is explained sequentially by its own lagged values in addition to past values of the remaining k-1 variables. This useful method offers a systematic way to analyze rich dynamics in multiple time series. Also the statistical toolkit that came with VAR model is simple to apply and interpret.

In opposition to traditional models, basic VAR systems have few assumptions about the fundamental structure of the economy and it allows the data determine the model rather than focusing on obtaining a good statistical representation of the past interactions between the variables.

A VAR model identifies the evolution of a set of k variables which are endogenous variables, over the same sample period t = 1,....,T as a linear function of their past evolution. The variables are gathered together in a k × 1 vector named y_t, which includes $y_{i,t}$: the time t observation of variable y_i as the i^{th} element. For example, if the i^{th} variable is Quota, then $y_{i,t}$ is the value of Quota at time t. When p represents the lag length, a p^{th} order VAR can be denoted as VAR(p) and its general formation is $y_t = c + \theta_1 y_{t-1} + \cdots + \theta_p y_{t-p} + \vartheta_t$, where c is a k × 1 vector of intercept terms, θ_i is a k × k matrix for every i = 1,...,p and ϑ_t is a k × 1 vector of residual terms (Lu&Xin, 2010).

In our study, a VAR model will be constructed to evaluate the dynamic effects of the past interactions between variables additional to ARDL and ECMs because ARDL approach is a single equation model and thus it is inadequate to observe feedback relations, appropriately.

3.2.d. Impulse Response Function (IRF)

In general, VAR models are analyzed more through impulse response functions. Impulse response function of a dynamic system is its reply when the system is confronted with a brief input signal which is called as impulse. An impulse response usually means the reaction of any dynamic system in response to a shock from outside.

A VAR model can also be written in a Vector Moving Average (MA(∞)) form as, $y_t = \mu + \varepsilon_t + \varphi_1\varepsilon_{t-1} + \varphi_2\varepsilon_{t-2} + \cdots + \varphi_k\varepsilon_{t-k}$. Then the matrix φ_s can be formulated as $\varphi_s = \frac{\partial y_{t+s}}{\partial \varepsilon'_t}$ which is, the row I, column j element of φ_s points out the outcomes of one unit increase in the j^{th} variable's innovation at date t (ε_{jt}) for the value of the i^{th} variable at time t+s (y_{it+s}), holding all other innovations at all dates constant. $\frac{\partial y_{it+s}}{\partial \varepsilon'_{jt}}$ which is a function of s, is the formulation of impulse response function. It identifies the response of y_{it+s} to a one time impulse in y_{jt} with all other variables dated t or earlier held constant (Lu&Xin, 2010).

Mainly, the impulse response function of VAR is applied to observe dynamic effects of the system when the model received the impulse. After the identification of the economic content of the statistically significant relationships through ARDL, ECM and VAR analyses, impulse response functions will be examined.

CHAPTER 4

EMPIRICAL ANALYSES

4.1. ARDL Cointegration Analysis

In Chapter 3, Unit Root Tests section, it is found that we have both stationary and non-stationary data series. Additionally, it is stated the best method to analyze the existence of a long-run relationship between Price and explanatory variables; Days, Quota, Cheat, NAM, EU, AO and OECD is ARDL model introduced by Pesaran and Shin (1999) and developed more by Pesaran et. al. (2001). The ARDL approach to cointegration gives both short run and long run dynamics simultaneously, in addition to the estimation of conditional error correction model represented in a general form as follows:

$$\Delta Price_t = \alpha_0 + \beta_0 + \sum_{i=1}^{n} \alpha_{1i} \Delta Price_{t-i} + \sum_{i=0}^{n} \alpha_{2i} \Delta X_{t-i} + \beta_1 Price_{t-1} + \beta_2 X_{t-1} + \mu_t \quad (4.1)$$

In the model:

- Δ stands for the first difference of that variable,
- α_0 is the intercept term,
- β_0 is the time trend,
- X is a s × 1 vector of explanatory variables,
- And μ_t is the residual term.

The left-hand side is the crude oil Brent price. The expressions $\beta_{1,}$ β_2 (number of βs depend on number of explanatory variables in ECMs because we have more than only one model) on the right-hand side correspond to the long-run relationship. Similarly, other expressions with the summation sign $\alpha_{1,}$ α_2 (depend on number of explanatory variables) stand for the short-run dynamics of the models.

In our analysis, the first stage is to test the null hypothesis of ARDL approach is that H_0:"there is no cointegration among the variables" against the alternative hypothesis H_1:"there exists cointegration among the variables" in other words there exists long run relationship between the variables. Econometric expressions for the null and the alternative hypothesis are:

H_0: $\beta_1 = \beta_2 = 0$ (no cointegration among the variables)

H_1: $\beta_1 \neq \beta_2 \neq 0$ (cointegration among the variables)

Before testing the null hypothesis for ARDL cointegration analysis, we have to choose optimal lag-length of the models introduced in Chapter 3: Model Specification.

4.1.a. Lag Length Selection

In order to find out the most appropriate lag length p and whether a deterministic linear trend must be included or not, OLS estimation method is applied for the models 3.1, 3.2, 3.3, 3.4, 3.5 and 3.6 respectively, with and without a linear time trend, for p =1,2,3,4. The decision criteria for the lag length selection is AIC (Akaike information criterion) and SC (Schwarz information criterion). The smaller the value of AIC and SC are, the better the model will be. Table 4.1 shows the necessary calculations for the lag length selection.

Table 4.1 Lag Length Selection Results

			Lag Length			
MODEL	Case	Information Criteria	1	2	3	4
3.1	Intercept	AIC	7.352594*	8.013107	8.079663	8.104294
		SC	7.577806*	8.239857	8.307975	8.334191
	Intercept &Trend	AIC	7.270415*	7.906057	7.955051	7.857683
		SC	7.523779*	8.161150	8.211902	8.116317
3.2	Intercept	AIC	7.391223*	8.052678	8.060238	7.993783
		SC	7.672739*	8.336116	8.345627	8.281154
	Intercept &Trend	AIC	7.314243*	7.919095	7.903028	7.741329
		SC	7.623911*	8.230877	8.216956	8.057437
3.3	Intercept	AIC	7.361467*	7.826366	7.842023	7.877889
		SC	7.642983*	8.109803	8.127412	8.165259
	Intercept &Trend	AIC	7.282877*	7.738801	7.753027	7.714424
		SC	7.592544*	8.050582	8.066955	8.030532
3.4	Intercept	AIC	7.368868*	8.006925	8.014898	7.816000
		SC	7.650384*	8.290362	8.300288	8.103371
	Intercept &Trend	AIC	7.274141*	7.911854	7.920228	7.686837
		SC	7.583808*	8.223635	8.234156	8.002945
3.5	Intercept	AIC	7.381765*	7.883045	7.775013	7.495410
		SC	7.775887*	8.279858	8.174558	7.897729
	Intercept &Trend	AIC	7.311970*	7.791794	7.663540	7.391102
		SC	7.734244*	8.216950	8.091624	7.822158
3.6	Intercept	AIC	7.341782*	8.029067	8.123154	8.119919
		SC	7.623297*	8.312504	8.408544	8.407290
	Intercept &Trend	AIC	7.277211*	7.940122	7.989456	7.900756
		SC	7.586878*	8.251903	8.303384	8.216864

*Minimum value of AIC/SC

According to Table 4.1: Lag length selection results, Lag one has the minimum AIC and SC for all models. Also, intercept&trend included case has lower AIC and SC compared to only intercept included case. Therefore, Lag one is chosen for the ARDL cointegration analysis.

4.1.b. Wald Test

The ARDL cointegration test is dependent on the Wald-test (F-statistic). The asymptotic distribution of the Wald-test is non-standard under the null hypothesis of no cointegration among the variables. Two critical values are given by Pesaran et al. (2001) for the cointegration test. The lower critical bound assumes all the variables are I(0) meaning that there is no cointegration relationship between the examined variables. The upper bound assumes that all the variables are I(1) meaning that there is cointegration among the variables. When the computed F-statistic is greater than the upper bound critical value, then the H_0 is rejected (the variables are cointegrated). If the F-statistic is below the lower bound critical value, then the H_0 cannot be rejected (there is no cointegration among the variables). When the computed F-statistic falls between the lower and upper bound, then the results are inconclusive. Table 4.2 presents computed F-statistics for the models.

Table 4.2: Computed F-statistics

MODEL	F-statistic
3.1	5.9036**
3.2	2.3554^
3.3	2.7797^
3.4	3.0381^
3.5	8.2658***
3.6	4.6886**

*Rejection of H_0
^Failure to reject H_0

Notes on Table 4.2

The critical value bounds to test the null hypothesis of no cointegration for the Model 3.1 are 3.48 and 4.45 for 90 percent, 4.06 and 5.11 for 95 percent, 5.31 and 6.41 for 99 percent confidence levels for intercept&trend included case (Pesaran et al. 2001, Table F, Case III: intercept and trend).

The critical value bounds to test the null hypothesis of no cointegration for the Models 3.2, 3.3, 3.4 and 3.6 are 3.06 and 4.08 for 90 percent, 3.53 and 4.66 for 95 percent, 4.61 and 5.78 for 99 percent confidence levels for intercept&trend included case (Pesaran et al. 2001, Table F, Case III: intercept and trend).

The critical value bounds to test the null hypothesis of no cointegration for the Model 3.5 are 2.57 and 3.64 for 90 percent, 2.94 and 4.08 for 95 percent, 3.66 and 4.97 for 99 percent confidence levels for intercept&trend included case (Pesaran et al. 2001, Table F, Case III: intercept and trend).

Rejection of null hypothesis is indicated with * for 90 percent, ** for 95 percent, and *** for 99 percent confidence levels, and ^ denotes acceptance of null hypothesis for 90 percent.

According to the results presented in Table 4.2, the null hypothesis is not rejected for the models 3.2, 3.3 and 3.4 which includes OECD regions; NAM, EU and AO, one by one. Failure of rejection for these models implies that there is no cointegration among the variables. To put it another way, the variables in these models do not have a long run relationship. On the contrary, the null hypothesis is rejected for the models 3.1, 3.5 and 3.6 (at 95, 99, 95 percent confidence levels, respectively). Model 3.1 is the basic model developed from Kaufmann's price rule. Model 3.5 includes all OECD regions; NAM, EU and AO when the model 3.6 involves OECD alone. Because we reject the null hypothesis, it can be said that, there exists cointegration among the variables for the models 3.1, 3.5 and 3.6.

4.2. ARDL Long Run Estimates and ECM

Since the results from Table 4.2 indicates there is a cointegration among the variables in the models 3.1, 3.5 and 3.6, three different ECMs based on ARDL approach are formed in order to analyze short run and long run relationships because a good time series modeling should identify both short-run dynamics and the long-run equilibrium at the same time. For the purpose of analysis, next step is the estimation of the coefficients for short run and long run relationships and also formulation of ECMs for the models 3.1, 3.5 and 3.6.

4.2.a. Model 3.1

Table 4.3: Estimated Long Run Coefficients using the ARDL Approach

	Dependent variable: Price	
Regressors	**Coefficient**	**P value**
Intercept	-1.623	0.175
Trend	7.610	0.023**
Days	1.953	0.030**
Quota	-0.969	0.078*
Cheat	-3.974	0.042**
Significance is denoted by * for 90 percent, ** for 95 percent and *** for 99 percent confidence levels.		

Estimates of long run coefficients imply that only intercept is not significant. Trend variable is significant and it has a positive effect (7.610) on price. Similarly, Quota and cheat variables are found as significant. Their behavior which is affecting price in a negative way (-0.969, -3.974) falls into line with the literature: rise in the OPEC quota causes to reduce real oil price because supply is increased and an increase in the Cheat variable tends to decrease price “because an increase in OPEC production relative to their quota increases supply relative to the demand perceived by OPEC when setting the quota” (Dees et.al., 2007). Days variable seems significant but contrary to expectations, it has positive sign (1.953), which means increase in days of forward consumption by OECD causes crude oil price to increase.

The short run estimates for the model 3.1 can be obtained by generating an error correction model (ECM) which is represented below:

$$\Delta Price_t = \alpha_0 + \beta_0 + \sum_{i=1}^{n} \alpha_{1i} \Delta Price_{t-i} + \sum_{i=0}^{n} \alpha_{2i} \Delta X_{t-i} + \psi ECT_{t-1} + v_t \quad (4.2)$$

where X is a 3×1 vector including Days, Quota and Cheat variables and ECT is the error correction term. All coefficients of ECM are the coefficients stand for the short run dynamics of the model’s convergence to the equilibrium and ψ represents the speed of adjustment. Estimated short run coefficients using the ARDL Approach are shown in Table 4.4.

Table 4.4: Estimated Short Run Coefficients using the ARDL Approach

ARDL(1,0,1,0)	Dependent variable: Price	
Regressors	**Coefficient**	**P value**
*d*Intercept	-4.133	0.212
*d*Trend	9.369	0.070*
*d*Days	0.497	0.040**
*d*Quota	-3.074	0.009***
*d*Cheat	-1.011	0.435
ECT(-1)	-0.254	0.002***

Significance is denoted by * for 90 percent, ** for 95 percent and *** for 99 percent confidence levels.
List of additional temporary variables created:
*d*Intercept = Intercept-Intercept (-1)
*d*Trend = Trend-Trend (-1)
*d*Days = Days-Days (-1)
*d*Quota = Quota-Quota (-1)
*d*Cheat = Cheat-Cheat (-1)

According to the results of the ECM based on ARDL approach, *ECT* is found as negative (-0.254) and highly significant at 99 percent confidence level meaning that in the short run there could be deviations from the equilibrium however in the long run they adjust and they move together again. Thus, ECM verifies the results of the Bounds testing for the existence of cointegration. In the short run, intercept term is found as insignificant again. Similarly, Cheat variable seems insignificant in the short run in opposition to long run. The other variables, trend, Days and Quota are found as significant like they are in the long run. Coefficients of trend and Days are positive (9.369, 0.497), when coefficient of Quota has a negative sign (-3.074) as expected.

4.2.b. Model 3.5

Table 4.5: Estimated Long Run Coefficients using the ARDL Approach

	Dependent variable: Price	
Regressors	**Coefficient**	**P value**
Intercept	6.744	0.558
Trend	9.408	0.000***
Days	1.262	0.039**
Quota	-0.278	0.015**
Cheat	-2.688	0.073*
NAM	14.446	0.296
EU	19.099	0.137
AO	-11.215	0.347
Significance is denoted by * for 90 percent, ** for 95 percent and *** for 99 percent confidence levels.		

Based on Table 4.5, estimates of long run coefficients imply that intercept is not significant. Trend variable is highly significant and it has a positive effect (9.408) on price. Similarly, Days, Quota and Cheat variables are found as significant. Days variable seem to have positive effect (1.262) on price whereas quota and cheat affect price negatively (-0.278, -2.688). NAM and EU have positive coefficients (14.446, 19.099) as expected whereas AO has a negative one (-11.215) which is opposite to expectations. But more importantly, NAM, EU and AO which are introduced as key variables for the analysis are all found as insignificant in the long run.

The short run estimates for the model 3.5 can be obtained by generating an error correction model (ECM) which is represented below:

$$\Delta Price_t = \alpha_0 + \beta_0 + \sum_{i=1}^{n} \alpha_{1i} \Delta Price_{t-i} + \sum_{i=0}^{n} \alpha_{2i} \Delta X_{t-i} + \Omega ECT_{t-1} + €_t \qquad (4.3)$$

where X is a 6×1 vector including Days, Quota, Cheat, NAM, EU and AO variables and ECT is the error correction term. All coefficients of ECM are the coefficients stand for the short run dynamics of the model's convergence to the equilibrium and ψ represents the speed of adjustment. Estimated short run coefficients using the ARDL Approach are shown in Table 4.6.

Table 4.6: Estimated Short Run Coefficients using the ARDL Approach

ARDL(1,0,1,0,0,0,0)	Dependent variable: Price	
Reg essors	**Coefficient**	**P value**
*d*Intercept	19.722	0.758
*d*Trend	16.603	0.001***
*d*Days	0.357	0.116
*d*Quota	-2.846	0.265
*d*Cheat	-1.346	0.298
*d*NAM	40.848	0.313
*d*EU	54.005	0.126
*d*AO	-30.171	0.573
ECT(-1)	-0.282	0.002***

Significance is denoted by * for 90 percent, ** for 95 percent and *** for 99 percent confidence levels.
List of additional temporary variables created:
*d*Intercept = Intercept-Intercept(-1)
*d*Trend = Trend-Trend(-1)
*d*Days = Days-Days (-1)
*d*Quota = Quota-Quota(-1)
*d*Cheat = Cheat-Cheat(-1)
*d*NAM=NAM-NAM(-1)
*d*EU=EU-EU(-1)
*d*AO=AO-AO(-1)

According to the results of the ECM based on ARDL approach, *ECT* is found as negative (-0.282) and highly significant meaning that in the short run there could be deviations from the equilibrium however in the long run they adjust and they move together again. Thus, ECM verifies the results of the Bounds testing for the existence of cointegration. Nevertheless, it is crucial to note that except trend and *ECT*, all other variables are found insignificant in the short run.

4.2.c. Model 3.6

Table 4.7: Estimated Long Run Coefficients using the ARDL Approach

	Dependent variable: Price	
Regressors	**Coefficient**	**P value**
Intercept	-2.346	0.166
Trend	7.197	0.091*
Days	2.191	0.019**
Quota	-4.096	0.041**
Cheat	-3.974	0.071*
OECD	8.378	0.010***
Significance is denoted by * for 90 percent, ** for 95 percent and *** for 99 percent confidence levels.		

According to Table 4.7, results for the estimates of long run coefficients indicate that only intercept term is not significant. Trend variable is significant and it has a positive effect (7.197) on price. Likewise, Quota and Cheat variables are found significant and they both affect price in a negative way (-4.096, -3.974) as expected. Days variable is significant but contrary to expectations, it has positive sign again (2.191). And the last variable OECD which is also interest of this analysis is found highly significant in the long run and it has a positive coefficient (8.378), unsurprisingly.

The short run estimates for the model 3.6 can be obtained by generating an error correction model (ECM) which is represented below:

$$\Delta Price_t = \alpha_0 + \beta_0 + \sum_{i=1}^{n} \alpha_{1i} \Delta Price_{t-i} + \sum_{i=0}^{n} \alpha_{2i} \Delta X_{t-i} + ¥ECT_{t-1} + \pi_t \qquad (4.3)$$

where X is a 4×1 vector including Days, Quota, Cheat and OECD variables and ECT is the error correction term. All coefficients of ECM are the coefficients stand for the short run dynamics of the model's convergence to the equilibrium and ψ represents the speed of adjustment. Estimated short run coefficients using the ARDL Approach are shown in Table 4.8.

Table 4.8: Estimated Short Run Coefficients using the ARDL Approach

ARDL(1,0,1,0,0)	Dependent variable: Price	
Regressors	**Coefficient**	**P value**
*d*Intercept	-5.365	0.187
*d*Trend	16.457	0.116
*d*Days	0.501	0.046**
*d*Quota	-2.901	0.017**
*d*Cheat	-0.936	0.164
*d*OECD	11.062	0.036**
ECT(-1)	-0.228	0.001***

Significance is denoted by * for 90 percent, ** for 95 percent and *** for 99 percent confidence levels.
List of additional temporary variables created:
*d*Intercept = Intercept-Intercept (-1)
*d*Trend = Trend-Trend (-1)
*d*Days = Days-Days (-1)
*d*Quota = Quota-Quota (-1)
*d*Cheat = Cheat-Cheat (-1)
*d*OECD = OECD-OECD(-1)

The short run dynamics of the ECM based on ARDL points out that *ECT* is negative (-0.228) and highly significant at 99 percent confidence level meaning that in the short run there could be deviations from the equilibrium however in the long run they adjust and they move together again. Thus, ECM verifies the results of the Bounds testing for the existence of cointegration. In the short run, intercept, trend and Cheat variable are found insignificant whereas trend and Cheat seem significant in the long run. The other variables, Days and Quota are found significant like they are in the long run. Coefficient of Days is positive (0.501) contrary to expectations, when coefficient of Quota has a negative sign (-2.901) as expected. Most importantly, OECD variable is significant in the short run and its impact on price is positive (11.062) again, unsurprisingly.

As a summary, estimates of long run for the Model 3.1 which is called basic model introduced by Kaufmann et. al.(2004) and Model 3.6 which includes OECD representing imported crude oil share of OECD in the world, addition to the variables in basic model, are found as statistically significant. However, this is not the case for the Model 3.5 which includes all regional variables: NAM, EU and AO because long run estimates of Model 3.5 are found as insignificant in the long run. Significant long run estimates for Model 3.1 and 3.6 mean that the variables: Days, Quota, Cheat and OECD have an effect on Price in the long run. Additional to significant long run relationship, the signs of the coefficients are also important to interpret. Based on the empirical results, coefficient of Days is positive whereas coefficients of Quota and Cheat are negative for the Model 3.1. And for the Model 3.6, signs of the coefficients are the same for same variables additional to positive coefficient of OECD. Among these coefficients, only positive coefficient of Days is unexpected because Kaufmann et al. (2004) who introduced price rule including Days as an explanatory variable, finds a negative relationship between Days and Price and explains it by saying "an increase in stocks reduces real oil price by diminishing reliance on current production and thereby reducing the risk premium associated with a supply disruption." On the other hand, according to Moebert (2007) positive coefficients for Days variable is also possible because "if crude oil stocks are filled (released) then demand increases (decreases) and crude oil prices might rise (fall)" meaning that there can be a positive relationship (Moebert, 2007). Therefore, a positive sign for Days might be unexpected but it might happen as it is in this analysis. And it is important to highlight that estimated coefficient of OECD in the long run is found as not too big and thus economic implication of this result might be that OECD still has a statistically significant effect on world price even if it experiences much lower oil demand growth and its effect is not too much because significance of growing oil demand by emerging countries is proven.

For the ECMs, all *ECT* variables are found as statistically significant meaning that in the short run there could be deviations from the equilibrium however in the long run they adjust and they move together again. Therefore, it can be stated that ECMs verify the results of the Bounds testing for the existence of cointegration for the Model 3.1, 3.5 and 3.6.

4.3. VAR Analysis

In this part, a VAR model is generated to evaluate the dynamic effects in the analysis additional to ARDL models because ARDL approach is a single equation model and thus it is inadequate to analyze feedback relations, properly. Decision of whether the VAR model will be constructed with the variables in levels or in their difference form is critical since we have both stationary and non-stationary variables. According to Fanchon and Wendel (1992), there exist three approaches in estimation of VAR models with this kind of data, which are explained as follow:

- First one is the estimation of a VAR model which takes the difference of data on board to provide stationarity and apply error correction term to bring the loss of information caused by differencing data back.
- Second approach is the estimation of a VAR model with the variables in levels, if there is cointegration among the variables.
- And lastly, estimation of a Bayesian VAR in which estimates are not influenced by non-stationary data however the model is not appropriate if the variables are cointegrated.

In this analysis, there exist cointegration among the variables for the models 3.1, 3.5 and 3.6 based on ARDL cointegration test. Therefore, second approach can be applied to our analysis. However, **s**ince the models 3.1 and 3.6 denote significant long run relationships on the basis of results in the section 4.2: ARDL Long Run Estimates and ECM, estimation of VAR is applied for these two. Constructed VAR model in levels represented in a matrix form is;

$$\begin{bmatrix} 1 & b_{12} \\ b_{21} & 1 \end{bmatrix} \begin{bmatrix} x_t \\ y_t \end{bmatrix} = \begin{bmatrix} b_{10} \\ b_{20} \end{bmatrix} + \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} + \begin{bmatrix} x_{t-1} \\ y_{t-1} \end{bmatrix} + \begin{bmatrix} \epsilon_{xt} \\ \epsilon_{yt} \end{bmatrix} \quad (4.4)$$

In this model, x_t stands for Price variable and y_t is a vector of other key economic variables of interest which includes the variables: Days, Quota and Cheat for model 3.1 and the variables: Days, Quota, Cheat and OECD for model 3.6. ϵ_{xt} and ϵ_{yt} are orthogonalized disturbance terms.

4.3.a. VAR Residual Serial Correlation LM Tests

In this part, autocorrelation tests are applied to Models 3.1 and 3.6 to see whether there exists residual serial correlation or not. LM Residual Test is used and the null hypothesis for that is ‘no serial correlation at lag order h’. Table 4.9 shows the results of LM Test for Models 3.1 and 3.6.

Table 4.9: Autocorrelation LM Test

Model 3.1			Model 3.6		
Lags	**LM-Stat**	**P value**	**Lags**	**LM-Stat**	**P value**
1	15.57212	0.483	1	22.10667	0.629
2	17.54047	0.351	2	21.99990	0.635
3	14.95960	0.527	3	24.84587	0.471
4	23.93841	0.390	4	25.42044	0.439
5	13.30132	0.650	5	40.08119	0.028**
6	14.44674	0.565	6	37.19941	0.055*
7	22.03168	0.142	7	36.35709	0.066*
8	32.60286	0.008***	8	103.9886	0.000***
9	17.83016	0.333	9	37.82233	0.048**
10	18.95121	0.271	10	17.30683	0.870
11	4.705834	0.997	11	55.20631	0.000***
12	26.04303	0.053	12	21.65538	0.655

Rejection of null is denoted by * for 90 percent, ** for 95 percent and *** for 99 percent confidence levels.
P values from chi-square with 16 and 25 df for Models 3.1 and 3.6, respectively.

Based on the Table 4.9**,** null hypothesis is only rejected for lag order 8 which means there exists serial correlation at lag order 8 for Model 3.1. For Model 3.6, it is seen from the table that, there exist serial correlation at lag order 5, 6, 7, 8, 9 and 11.

4.3.b. VAR Lag Length Selection

VAR model is constructed for the models 3.1 and 3.6. First step to construct a VAR model and analyze impulse responses is the decision of the lag length. In this study we use some commonly used VAR lag order selection criteria which are LR (sequential modified LR test statistic), FPE (Final prediction error), AIC (Akaike information criterion), HQ (Hannan-Quinn information criterion) and SC (Schwarz information criterion) for leg length selection. Second step is the decision of including intercept&trend together or only intercept in the VAR model. AIC and SC are used for the decision of including intercept&trend together or only intercept in the model. The smaller the values of criteria are, the better the model will be.

Model 3.1

According to VAR Lag Order Selection Criteria applied for Model 3.1, Lag 4 is selected by LR, FPE and AIC whereas Lag 1 is selected by SC and HQ. Since 3 criteria suggest Lag 4 out of 5, lag length is chosen as 4 for Model 3.1.[5] Second step after lag length selection is to decide including trend or not. AIC and SC are used for this selection. Table 4.10 shows the value of AIC and SC for both cases.

Table 4.10: Value of AIC and SC for Model 3.1

Case	Information Criteria	Lag length is 4
Intercept	AIC	19.37498
	SC	21.32910
Intercept &Trend	AIC	19.18718*
	SC	21.25625*

*min value of AIC/SC

Based on the values given in Table 4.10, values of AIC and SC is lower for intercept&trend included case than only intercept included case. Therefore, VAR model includes both intercept and trend with the lag length 4 for Model 3.1. Also LM test for Model 3.1 indicates that there is no serial correlation at lag order 4 which allows the optimal lag length to be 4. VAR model is estimated accordingly and VAR Estimates for the dependent variables: Price, Days, Quota and Cheat are given in Table 4.11.a, Table 4.11.b, Table 4.11.c, and Table 4.11.d.

[5] VAR Lag Order Selection Criteria details for Model 3.1 are given in Appendix.

Table 4.11.a: Vector Autoregression Estimates for Price

Dependent Variable	Price	
Regressors	**Coefficient**	**P value**
Price(-1)	1.113	0.000***
Price(-2)	-0.817	0.000***
Price(-3)	0.593	0.002***
Price(-4)	-0.143	0.279
Days(-1)	-0.013	0.878
Days(-2)	0.080	0.376
Days(-3)	0.034	0.707
Days(-4)	0.274	0.004***
Quota(-1)	2.398	0.180
Quota(-2)	-0.916	0.704
Quota(-3)	-3.933	0.067*
Quota(-4)	1.456	0.335
Cheat(-1)	1.539	0.405
Cheat(-2)	-0.718	0.765
Cheat(-3)	-1.808	0.389
Cheat(-4)	-0.097	0.954
Intercept	-9.494	0.672
Trend	0.374	0.004***
Significance is denoted by * for 90 percent, ** for 95 percent and *** for 99 percent confidence levels.		

Table 4.11.b: Vector Autoregression Estimates for Days

Dependent Variable	**Days**	
Regressors	**Coefficient**	**P value**
Price(-1)	-0.047	0.756
Price(-2)	0.052	0.814
Price(-3)	-0.067	0.787
Price(-4)	0.260	0.135
Days(-1)	0.009	0.935
Days(-2)	0.006	0.957
Days(-3)	0.111	0.354
Days(-4)	0.114	0.352
Quota(-1)	2.400	0.307
Quota(-2)	0.142	0.964
Quota(-3)	-2.005	0.478
Quota(-4)	-0.595	0.764
Cheat(-1)	1.295	0.594
Cheat(-2)	0.228	0.942
Cheat(-3)	-2.963	0.284
Cheat(-4)	-0.045	0.983
Intercept	60.489	0.041**
Trend	-0.023	0.888
Significance is denoted by * for 90 percent, ** for 95 percent and *** for 99 percent confidence levels.		

Table 4.11.c: Vector Autoregression Estimates for Quota

Dependent Variable	Quota	
Regressors	**Coefficient**	**P value**
Price(-1)	0.048	0.001***
Price(-2)	-0.065	0.003***
Price(-3)	0.042	0.077*
Price(-4)	-0.005	0.724
Days(-1)	-4.380	0.999
Days(-2)	0.006	0.580
Days(-3)	-0.018	0.111
Days(-4)	-0.007	0.552
Quota(-1)	1.257	0.000***
Quota(-2)	-0.206	0.503
Quota(-3)	-0.165	0.547
Quota(-4)	-0.018	0.922
Cheat(-1)	0.751	0.002***
Cheat(-2)	-0.156	0.610
Cheat(-3)	-0.174	0.515
Cheat(-4)	-0.076	0.722
Intercept	4.342	0.131
Trend	-0.026	0.105
Significance is denoted by * for 90 percent, ** for 95 percent and *** for 99 percent confidence levels.		

Table 4.11.d: Vector Autoregression Estimates for Cheat

Dependent Variable	**Cheat**	
Regressors	**Coefficient**	**P value**
Price(-1)	-0.010	0.449
Price(-2)	0.012	0.536
Price(-3)	-0.018	0.396
Price(-4)	-0.003	0.825
Days(-1)	-0.006	0.515
Days(-2)	-0.013	0.204
Days(-3)	0.014	0.165
Days(-4)	0.017	0.115
Quota(-1)	-0.219	0.297
Quota(-2)	0.044	0.876
Quota(-3)	0.327	0.195
Quota(-4)	-0.195	0.269
Cheat(-1)	0.330	0.128
Cheat(-2)	0.061	0.826
Cheat(-3)	0.212	0.390
Cheat(-4)	-0.215	0.277
Intercept	0.500	0.849
Trend	0.045	0.003***
Significance is denoted by * for 90 percent, ** for 95 percent and *** for 99 percent confidence levels.		

Model 3.6

According to VAR Lag Order Selection Criteria applied for Model 3.6, Lag 1 is selected by FPE, SC and HQ whereas Lag 4 is selected by LR and AIC. Since 3 criteria suggest Lag 1 out of 5, lag length is chosen as 1 for Model 3.6.[6] Second step after lag length selection is to decide including trend or not. AIC and SC are used for this selection. Table 4.12 shows the value of AIC and SC for both cases.

[6] VAR Lag Order Selection Criteria details for Model 3.6 are given in Appendix.

Table 4.12: Value of AIC and SC for Model 3.6

Case	Information Criteria	Lag length is 1
Intercept	AIC	15.70649
	SC	17.64328
Intercept &Trend	AIC	15.39881*
	SC	16.40460*

*min value of AIC/SC

Based on the values given in Table 4.12, values of AIC and SC is lower for intercept&trend included case than only intercept included case. Therefore, VAR model includes both intercept and trend with the lag length 1 for Model 3.6. Also LM test shows that no serial correlation at lag order 1 which confirms that optimal lag length can be chosen as 1. VAR model is estimated accordingly and VAR Estimates for the dependent variables: Price, Days, Quota, Cheat and OECD are given in Table 4.13.a, 4.13.b, 4.13.c, 4.13.d, 4.13.e.

Table 4.13.a: Vector Autoregression Estimates for Price

Dependent Variable	**Price**	
Regressors	**Coefficient**	**P value**
Price(-1)	0.852	0.000***
Days(-1)	0.060	0.540
Quota(-1)	-1.638	0.033**
Cheat(-1)	-0.626	0.608
OECD(-1)	61.208	0.069*
Intercept	-27.956	0.462
Trend	0.249	0.021**
Significance is denoted by * for 90 percent, ** for 95 percent and *** for 99 percent confidence levels.		

Table 4.13.b: Vector Autoregression Estimates for Days

Dependent Variable	**Days**	
Regressors	**Coefficient**	**P value**
Price(-1)	0.170	0.012**
Days(-1)	0.121	0.264
Quota(-1)	0.141	0.866
Cheat(-1)	-0.890	0.508
OECD(-1)	0.156	0.996
Intercept	68.580	0.101
Trend	-0.093	0.429
Significance is denoted by * for 90 percent, ** for 95 percent and *** for 99 percent confidence levels.		

Table 4.13.c: Vector Autoregression Estimates for Quota

Dependent Variable	**Quota**	
Regressors	**Coefficient**	**P value**
Price(-1)	0.018	0.009***
Days(-1)	-0.001	0.897
Quota(-1)	0.914	0.000***
Cheat(-1)	0.508	0.001***
OECD(-1)	2.826	0.460
Intercept	-1.052	0.808
Trend	-0.034	0.005***
Significance is denoted by * for 90 percent, ** for 95 percent and *** for 99 percent confidence levels.		

Table 4.13.d: Vector Autoregression Estimates for Cheat

Dependent Variable	**Cheat**	
Regressors	**Coefficient**	**P value**
Price(-1)	-0.011	0.070**
Days(-1)	-0.007	0.427
Quota(-1)	-0.073	0.343
Cheat(-1)	0.399	0.001***
OECD(-1)	-3.131	0.356
Intercept	5.805	0.131
Trend	0.040	0.000***
Significance is denoted by * for 90 percent, ** for 95 percent and *** for 99 percent confidence levels.		

Table 4.13.e: Vector Autoregression Estimates for OECD

Dependent Variable	**OECD**	
Regressors	**Coefficient**	**P value**
Price(-1)	0.000	0.165
Days(-1)	-9.920	0.801
Quota(-1)	-0.001	0.688
Cheat(-1)	-0.002	0.665
OECD(-1)	-0.091	0.495
Intercept	1.110	0.000***
Trend	0.000	0.577
Significance is denoted by * for 90 percent, ** for 95 percent and *** for 99 percent confidence levels.		

Based on estimated VAR models for the variables included in basic model, only *Intercept* term seems to have a noteworthy effect when the dependent variable is Days and effects of other statistically significant variables on Price turn out to be small. Estimated VAR models for the variables included in basic model and also OECD, in other words for the variables included in Model 3.6, *OECD(-1)* has a remarkable effect on Price and effects of other statistically significant variables on Price are not much to mention. This remarkable effect of *OECD(-1)* might be interpreted as crude oil price is affected by imported crude oil by OECD in that period but the effect is not too much whereas the effect of imported crude oil by OECD in previous period is more. In other words, imported crude oil by OECD in previous period has more driving power on the determination of oil price than imported crude oil by OECD in present period because price might be a late responser.

4.4. IRF Analysis

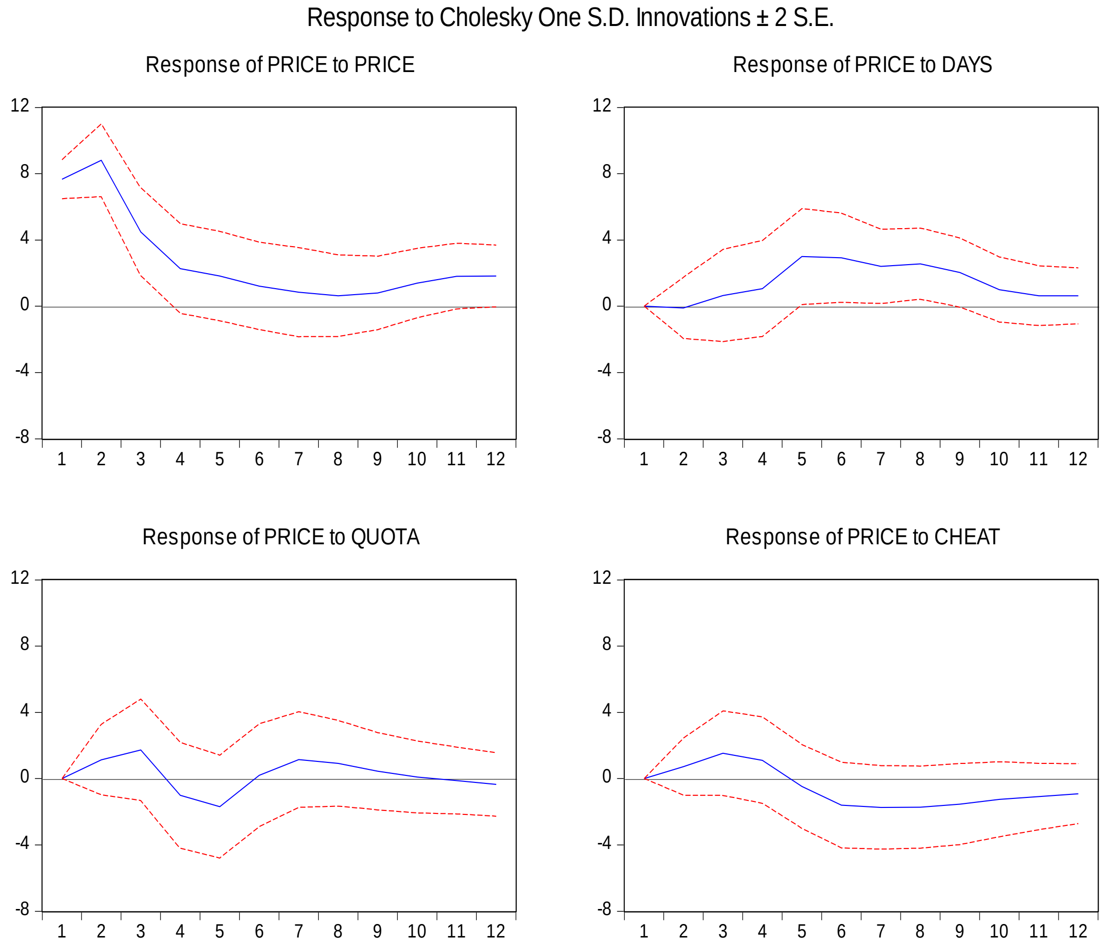
The impulse response function of VAR is applied to examine dynamic effects of the system when the model receives an impulse. The economic content of the statistically significant relationships are evaluated by analyzing impulse response functions. Aim of using these functions is to see the dynamic effects of a particular exogenous shock on an endogenous variable. Before moving to IRFs it is worth to highlight a few points about IRFs for a clearer understanding and interpretation of the impulse-response graphs. Horizontal axis (X-axis) in the graph shows length of the response in quarters and vertical axis (Y-axis) indicates the size of the response as a standard error. Continuous lines in the graph show the response of dependent variable against the shock (1 standard error) occurring in error terms. And discontinuous lines show confidence intervals obtained for ± 2 standard error. If discontinuous lines are above (positive) or below (negative) X-axis at the same time, it is said that the response is statistically significant. In opposite, if discontinuous lines are in different areas, reliability of the results is affected negatively (Erkilic, 2006).

It is time to trace out the dynamics effects for the VAR models constructed before firstly for Model 3.1 and then Model 3.6. We analyze the impulse response graphs for the Price variable which is our main dependent variable then the graphs belong to other variables in the case of a statistically significant result.[7] Figure 4.1-4.4 belong to the variables from the basic model (3.1) and Figure 4.5-4.9 belong to the variables from OECD included model (3.6).[8]

[7] Impulse response graphs with statistically insignificant results are all given in Appendix.

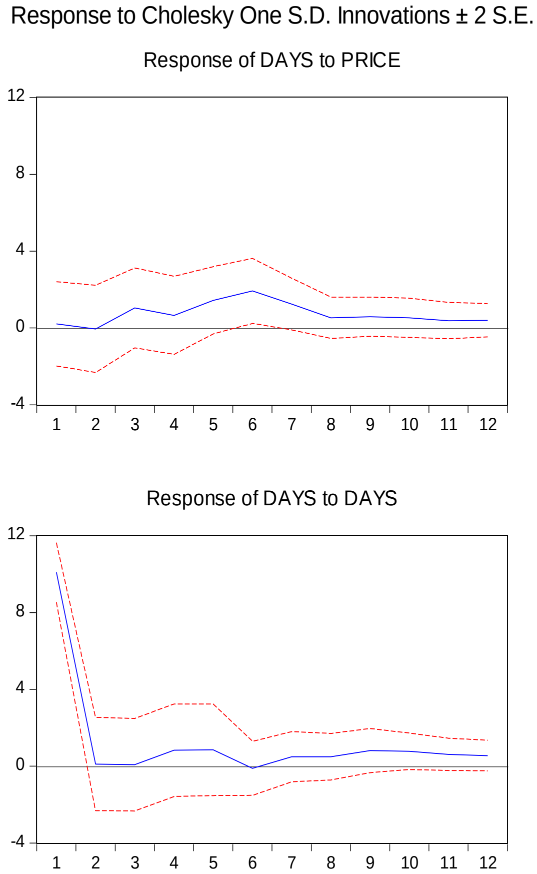
[8] Impulse response graphs based on generalized impulses give same results.

Figure 4.1: Impulse Responses of Price



Responses of the Price variable to an impulse in variables Days, Quota and Cheat can be seen together in Figure 4.1. The impulse response of analyses for Price starts with the response of Price to its own shock. According to Figure 4.1, the peak response occurs immediately and total impact persists nearly 3 quarters. The response of Price to its own shock is positive and statistically significant during first 3 quarters and then its response seems still positive but not statistically significant anymore. Response of Price to a shock in Days is not statistically significant during 5 quarters then between the quarters 5 and 8, its response is positive and statistically significant but after the quarter 8, response becomes statistically insignificant, again. As one can see from the Figure 4.1, response of Price to a shock in Quota and Cheat is not statistically significant for all quarters.

Figure 4.2: Impulse Responses of Days



Response of Days can be seen from Figure 4.2. Response of Days to a shock in Price mostly seems statistically insignificant however, between the quarters 5 and 7 a positive and statistically significant response is seen for a little while. Response of Days to its own shock happens immediately but not for so long and the response is positive and statistically significant until the quarter 2.

Figure 4.3: Impulse Responses of Quota

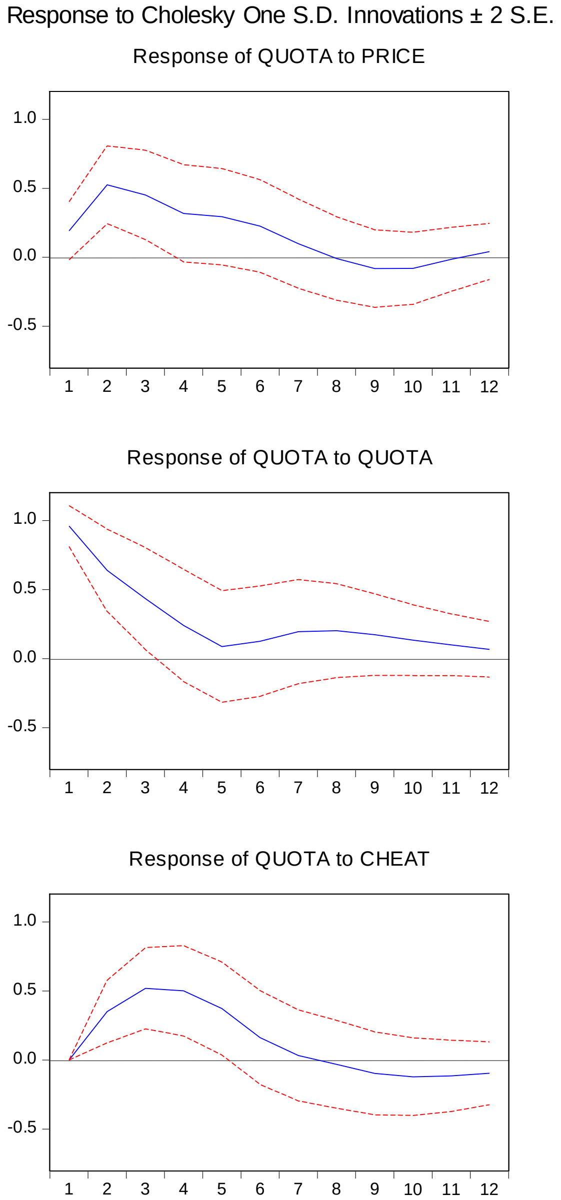
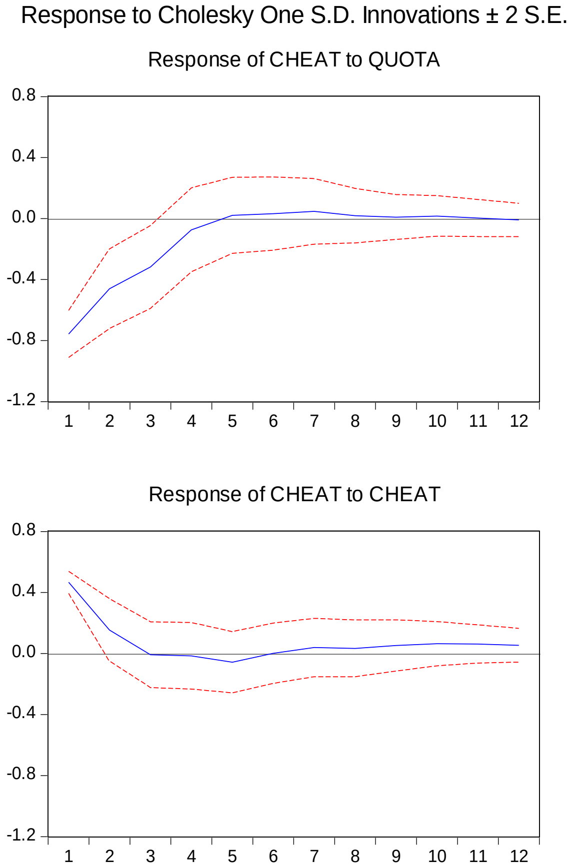


Figure 4.3 shows the Impulse Response Analyses of Quota. Response of Quota to a shock in Price is positive and statistically significant until the quarter 4. The response keeps being positive until the quarter 7 and then turns to negative between 8 and 11, after the quarter 11 it is positive, again. But, every response after the quarter 4 is statistically insignificant. Response of Quota to its own shock is positive and statistically significant until nearly the end of quarter 3 then it becomes statistically insignificant. Additionally, response of Quota to a shock in Cheat is positive and statistically significant until almost the end of quarter 5 and then response loses its significance.

Figure 4.4: Impulse Responses of Cheat



According to Figure 4.4, response of Cheat to a shock in Quota is negative and statistically significant until the quarter 3, then it becomes insignificant. Response of Cheat to its own shock is positive and statistically significant for about only 2 quarters then response is insignificant.

Model 3.6

Figure 4.5: Impulse Responses of Price

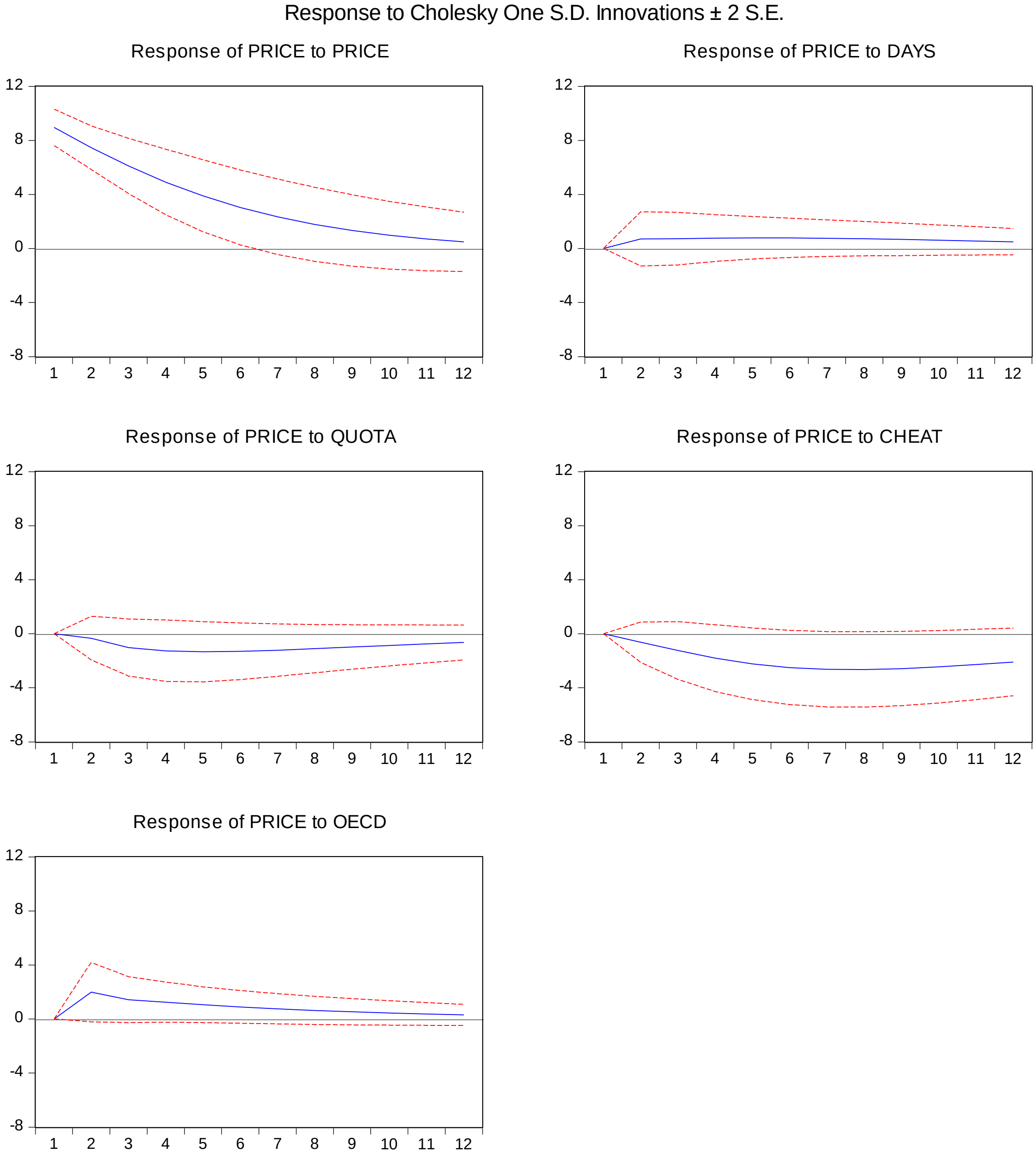
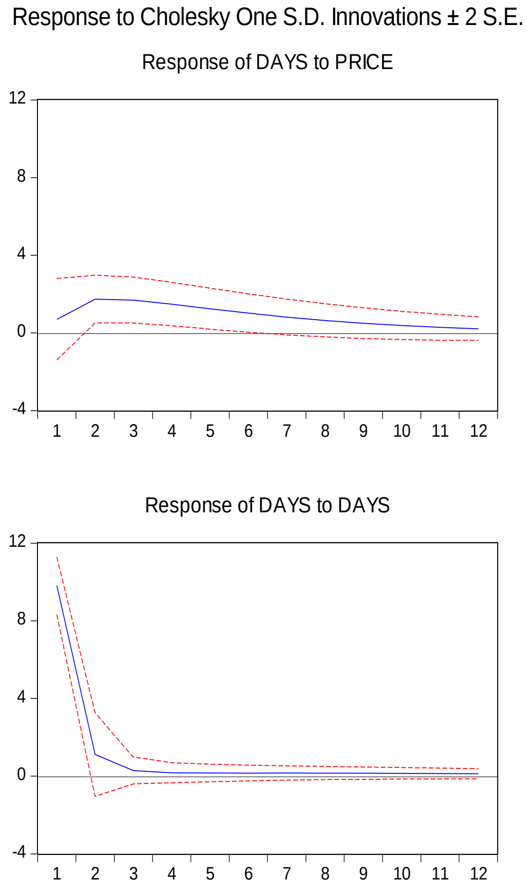


Figure 4.5 indicates that impulse response of Price is statistically significant only for the case of its own shock and that is positive and significant until the end of quarter 6. Response of Price to a shock in Days, Quota, Cheat and OECD are all statistically insignificant.

Figure 4.6: Impulse Responses of Days



Based on the Figure 4.5, response of Days to a shock in Price is not significant at first but nearly between the quarters 2 and 5, response is positive and statistically significant. After that, response becomes statistically insignificant, again. On the other hand, Days responses to its own shock immediately until the quarter 2 and response is positive, statistically significant. Then response turns out to be statistically insignificant.

Figure 4.7: Impulse Responses of Quota

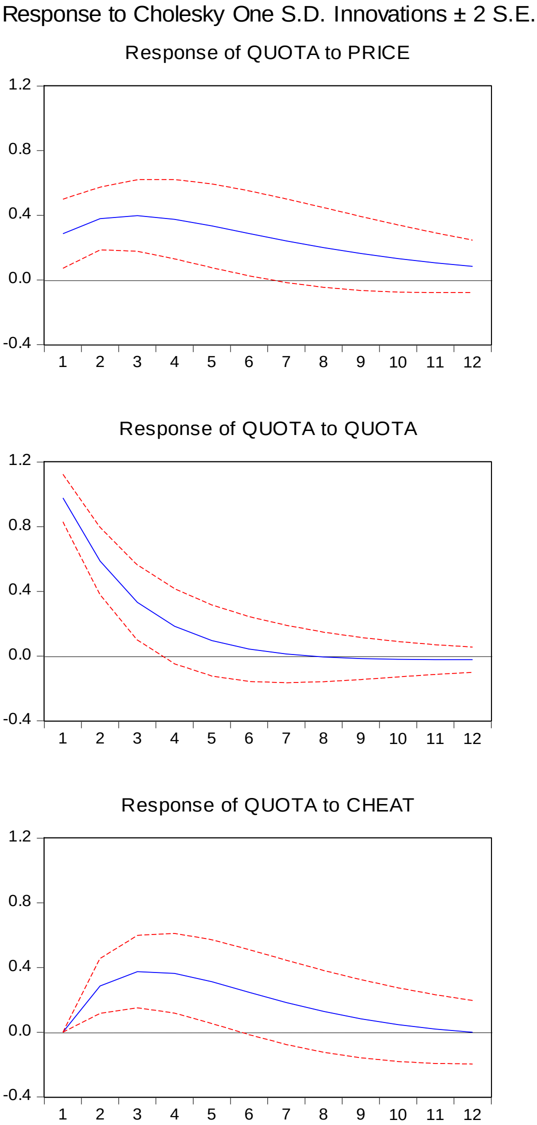
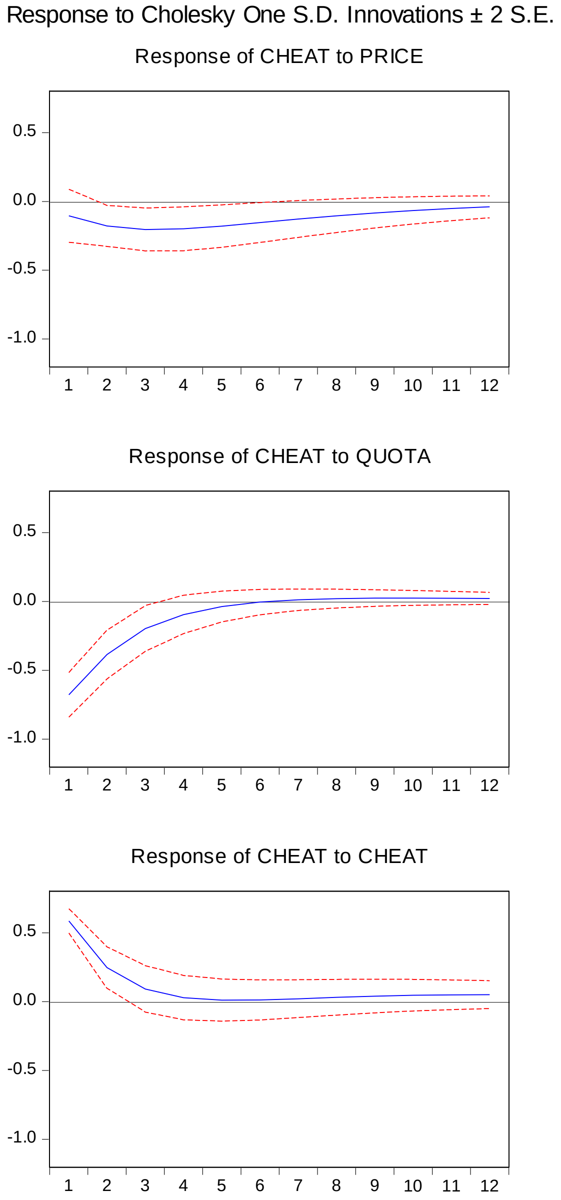


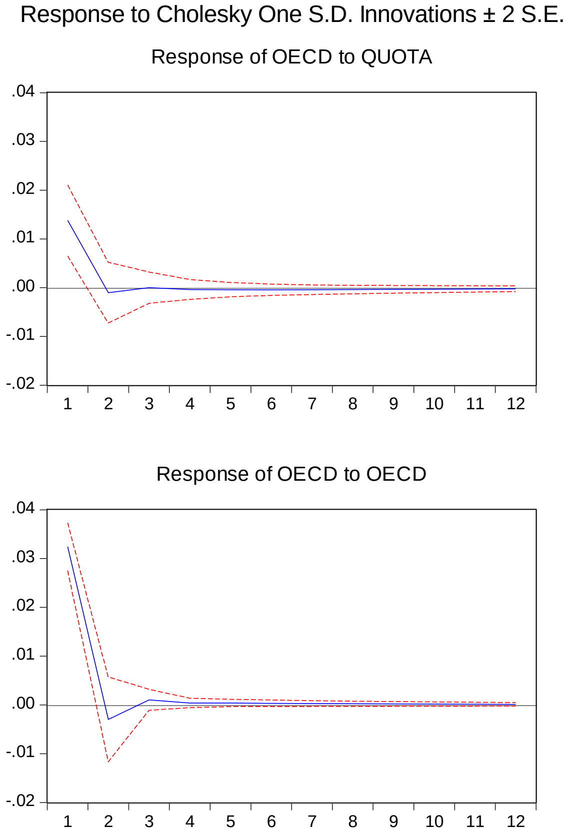
Figure 4.7 displays the Impulse Response Analyses of Quota. Response of Quota to a shock in Price is positive and statistically significant until the end of quarter 6. The response keeps being positive but it becomes statistically insignificant. Response of Quota to its own shock is positive and statistically significant until nearly the end of quarter 3 after that it is statistically insignificant. Lastly, response of Quota to a shock in Cheat is positive and statistically significant until the end of quarter 5 and then response is not significant anymore.

Figure 4.8: Impulse Responses of Cheat



According to Figure 4.8, response of Cheat to a shock in Price is statistically insignificant at first but response becomes negative and statistically significant between the quarters 2-6. Then it is statistically insignificant, again. Response of Cheat to a shock in Quota is negative and statistically significant until the quarter 3, after that it is insignificant. And response of Cheat to its own shock is positive and statistically significant until the end of quarter 2, then response is insignificant.

Figure 4.9: Impulse Responses of OECD



Finally, impulse response of OECD is shown in Figure 4.9. Response of OECD to Quota is positive and statistically significant just for the first quarter, then response turns out to be statistically insignificant. And response of OECD to its own shock occurs immediately but not for so long. Response is positive and statistically significant for nearly 2 quarters. After that it becomes statistically insignificant.

As a result of IRFs, all of the variables response to their own shocks, expectedly. IRF graphs for the VAR models of basic variables: Price, Days, Quota, and Cheat show that Days has a positive effect on Price and Price has a positive effect on Days but their times do not collide with one another. Statistically significant response of Price to Days occurs between the quarters 5-8 whereas statistically significant response of Days to Price is seen between the quarters 5-7. Therefore, it can be said that their responses might be reciprocal but response of Price to Days continues longer. So, it might be said that OECD crude oil stocks and price affects each other but effect of OECD crude oil stocks on price continues longer.

There exist some changes with the inclusion of OECD additional to basic variables. Such as reciprocal response of Price and Days disappears when OECD is included in VAR. Actually, statistically significant response of Days to Price is still seen but when OECD is included, Price responses only to its own shock. The economic reason behind that might be increase (decrease) in OECD import level of crude oil can be explained by decrease (increase) in OECD crude oil stocks. Therefore, effect of OECD crude oil stocks on price is eliminated with the effect of imported crude oil by OECD. Quota responses to itself, Price and Cheat, positively and this does not change with the inclusion of OECD. At first, Cheat seems to response positively to itself and negatively to Quota but when OECD is included Cheat starts to response negatively to Price addition to itself and Quota. OECD responses to its own shock but its response to a shock in price is not significant. That is to say dynamic effect of OECD on Price is not seen from IRF and vice versa. Lastly, it is important to state that OECD responses to a shock in Quota. The economic reason behind that might be the traditional thought of OPEC acts as a cartel thus OPEC Quota sets the oil price. So, OECD member states behave OPEC quota as a determining factor rather than price when they decide on their oil import levels.

CHAPTER 5

CONCLUSIONS

Oil is a required source of energy for the world and will probably remain over many years, even under the most optimistic assumptions about the discovery of alternative energy sources. Since oil has a big foot in the market and thus oil price movements attract much attention, there exists a large volume of literature on this subject. In the literature, the potential drivers specified as the determinants of crude oil prices are analyzed mainly in four different groups. The first group covers demand centered researches which believe demand is mostly stimulated by global economic growth, secondly, supply centered researches which analyze the factors resulting from shortages and depletion; third group studies the behavior of OPEC, deeply and the last one captures the contribution of financial markets, materialized in speculation.

Going through the literature, it is found that Kaufmann's price rule which includes both demand and supply factors in the model, used as a benchmark for many other studies. Such as, Li and Lin (2011) analyze the effect of imported crude oil share of China and India in the world by adding Chindia factor to Kaufmann's price rule. Similar to analysis of Li and Lin (2011), since aim of this study is to examine the effect of imported crude oil share of OECD regions and OECD in total, Kaufmann's price rule is used as a benchmark again and the variables North America, Europe and Asia&Oceania which stand for OECD regions and OECD are included in the model.

This study models the effects of imported crude oil by OECD, in particular OECD regions: North America, Europe and Asia&Oceania on world crude oil prices following the price rule introduced by Kaufmann et al. (2004), within the framework of ARDL cointegration and ECM based on ARDL approach. Then VAR model is generated to evaluate the dynamic effects of the system. Finally, the economic content of the statistically significant relationships are assessed through impulse response functions. To the best of our knowledge, this might be the first analysis which uses these methodologies together to analyze the relationship between crude oil price and OECD regions and OECD as a whole for the period: 1990Q1-2012Q1 in which emerging economies have arisen. Moreover, this study combines traditional variables: OECD crude oil stocks, OPEC quota, OPEC cheat with the contemporary ones: imported crude oil by North America, Europe, Asia&Oceania and OECD.

The empirical analyses begin with ARDL cointegration approach introduced by Pesaran and Shin (1999) and developed more by Pesaran et. al. (2001) based on the fact that bound testing approach allows the variables to be stationary, integrated of order one or like our case, a mixture of both. After controlling the existence of cointegration, the analyses continue with ECM based on ARDL approach of Pesaran and Shin (1999) to investigate the short run and long run relationships.

The results of the ARDL cointegration tests suggest that there is cointegration between the price and basic variables; OECD crude oil stocks, OPEC Quota, OPEC Cheat which are included in Kaufmann’s price rule. Similarly cointegration is found when basic variables and imported crude oil by NAM, EU and AO put into model all together. Also for the model including OECD alone instead of regional variables, there exists cointegration. After cointegration tests, ECM based on ARDL approach is applied. Based on the results of ECM, it can be said that regional factors do not have significant effect on world oil price in the long run. On the other hand, long run relationship is detected for the model which includes only basic variables and for the model including both basic variables and OECD alone. Estimated coefficient of OECD in the long run is found as not too big and thus economic implication of this result might be that OECD still has a statistically significant effect on world price even if it experiences much lower oil demand growth and its effect is not too much because significance of growing oil demand by emerging countries is proven.

Empirical analyses carried on VAR modeling because ARDL approach is a single equation model and thus it is inadequate to analyze feedback relations, properly. Based on the approach developed by Fanchon and Wendel (1992), VAR model is estimated in levels of raw data for the variables which are found as both cointegrated and statistically significant in the long run for two cases: (1) Only basic variables from Kaufmann's price rule are included in VAR (2) OECD is included additional to basic variables. Based on estimated VAR models for case (1), effects of other statistically significant variables on Price are small. Only *Intercept* term seems to have a noteworthy effect when the dependent variable is Days. And estimated VAR models for case (2), *OECD(-1)* has a remarkable effect on Price and effects of other statistically significant variables on Price are small like case (1). In economic content, remarkable effect of *OECD(-1)* might be interpreted as crude oil price is affected by imported crude oil by OECD in that period but the effect is not too much whereas the effect of imported crude oil by OECD in previous period is more. To put it another way, imported crude oil by OECD in previous period has more driving power on the determination of oil price than imported crude oil by OECD in present period because price might be a late responser.

Next, impulse response functions are analyzed through graphs. IRFs are applied to both basic model and OECD included basic model to enable comparison. Unsurprisingly, all of the variables response to their own shocks. Outstanding results based on IRF graphs of basic model is that Days which represents OECD crude oil stock has a positive effect on Price and Price has a positive effect on Days but their times of response do not collide with one another. Positive and statistically significant response of Price to Days takes longer time. Economically, interpretation of this result might be that OECD crude oil stocks and price affects each other but effect of OECD crude oil stocks on price continues longer.

A few changes occur when OECD is included in basic model. First one is reciprocal response of Price and Days disappears when OECD is included in VAR model. Actually, statistically significant response of Days to Price is still seen but when OECD is included Price responses only to its own shock. Economically speaking, increase (decrease) in OECD import level of crude oil can be explained by decrease (increase) in OECD crude oil stocks. Therefore, it might be said that, effect of OECD crude oil stocks on price is eliminated with the effect of imported crude oil by OECD. Lastly, OECD responses to its own shock as expected but it is interesting that OECD responses to a shock in Quota and do not response to Price as statistically significant. The reason behind that might be the traditional thought of OPEC acts as a cartel thus OPEC Quota sets the oil price. Therefore, OECD member states accept OPEC quota as a determining factor rather than price when they decide on their oil import levels.

These results would have critical policy implications for policy makers in OECD whether they make oil demand supply projections regionally or totally to control their dependence on oil import. And outcomes of this study would make OECD realize that even if they still have a power to impact world oil price, they might be about to lose its power in the existence of proven significance of growing oil demand thus growing economy in emerging countries. It will also provide help to fill in the gap of how OECD demand for imported oil might have impacted the growth of OECD economy as most of studies so far has been concentrated on how raised oil prices would affect OECD economy.

REFERENCES

Adelman, M. A., 1980. *The Clumsy Cartel*. The Energy Journal, **1**(1), 43–53, 1980.

Bank for International Settlements (BIS), Quarterly Review, 2004. *International banking and financial market developments.* ISSN 1683-013X, June, 2004. www.bis.org.

Breitenfellner A., Crespo Cuaresma J. and Keppel C., 2009. *Unveiling the determinants of crude oil prices.* Working Paper Series, RePEc.

BRICs Joint Statistical Publication, 2012. *Economic and Social Indicators: Comparison of BRICs Countries*. August 2012.

Cavanagh, C.L., Elliott, G., Stock, J.H., 1995. *Inference in models with nearly integrated regressors*. Econometric Theory 11: 1131–1147.

Center for Sustainable Systems, 2012. *U.S. Renewable Energy Factsheet*. University of Michigan. Pub No. CSS03-12.

Dees, S., Karadeloglou, P., Kaufmann, R.K., Sanchez, M., 2007. *Modelling the world oil market: assessment of a quarterly econometric model*. Energy Policy 35 (1), 178–191 Elsevier.

Deng A., King K. and Metz D., 2012. *The Role of Political Events and Economic News, Financial Trading, and Market Fundamentals.* BATES WHITE Economic Consulting, An Econometric Analysis of Oil Price Movements, January 2012.

EIA, U.S. Energy Information Administration, 2010, 2013. *Energy Outlook.* May 2010. *Short Term Outlook*. June 2013. www.eia.gov.

Ellen, S., Zwinkels, R.C.J., 2010. Oil price dynamics: A behavioral finance approach with heterogeneous agents. Energy Economics, Elsevier, November. Vol. 32(6), pages 1427-1434.

Elliot, G., T.J. Rothenberg, and J.H. Stock (1996). *Efficient Tests for an Autoregressive Unit Root*. Econometrica, 64, 813-836.

Engle, R.F., Granger, C.W.J., 1987. *Cointegration and error correction representation: estimation and testing*. Econometrica 55: 251–276.

Erkilic, S., 2006. *Türkiye'de Cari Açığın Belirleyicileri*. Central Bank of the Republic of Turkey, General Directorate of Statistics, November 2006, 75-89.

Exxon Mobile, 2012. *The Outlook for Energy: A View to 2040*. www.exxonmobil.com.

Fanchon, P., Wendel, J., 1992. *Estimating VAR models under non-stationarity and cointegration: alternative approaches for forecasting cattle prices*. Applied Economics, 24, no. 2, 207-217.

Fattouh, B., 2007. *WTI benchmark temporarily breaks down: is it really a big deal? Middle East Economic Survey*, XLIX(20), May, 14.

Frankel, J. A., 2006. *The Effect of Monetary Policy on Real Commodity Prices*. NBER Working Paper No. 12713, December, 2006.

Frankel, P.H., 1946. *Essentials of Petroleum: A Key To Oil Economics*. Franck Cass, London.

Gregory, A., Hansen, B., 1996. *Residual-based tests for cointegration in models with regime shifts*. Journal of Econometrics 70, 99–126.

Griffin, J.,1985. *OPEC behavior: a test of alternative hypothesis.* American Economic Review, 75(5), 954–963.

Gulen, S.G.,1996. *Is Opec a Cartel? Evidence from cointegration and causality tests*. Energy Journal, 17(2), 43–57.

Hamilton, J. D., 2009. *Causes and consequences of the oil shock of 2007–2008*. Brookings Papers on Economic Activity, 215–261.

Hamilton, J. D., 2010. *Historical Oil Shocks*. Department of Economics, University of California, San Diego. 13-25, December 22, 2010.

Hotelling, H., 1931. *The Economics of Exhaustible Resources.* Journal of Political Economics, April 1931, 39, 137-175.

IEA, International Energy Agency, 1990&2012. *Oil Market Reports (OMR)*, April 1990, February 2012. www.iea.org.

IMF, International Monetary Fund, 2009. *Annual Report 2009: Fighting the Global Crisis.* IMF Publication Services. April 30, 2009. www.imf.org.

Johansen, S., 1991. *Estimation and hypothesis testing of cointegration vectors, in Gaussian vector autoregressive models*. Econometrica, 59:1551-1580.

Kaufmann, R.K., 2011. *The role of market fundamentals and speculation in recent price changes for crude oil.* Energy Policy 39, 105–115.

Kaufmann, R.K., Cleveland, C.J., 2001. *Oil production in the lower 48 states; economic, geological, and institutional determinants.* Energy Journal 22, 27–49.

Kaufmann, R.K., Dees, S., Karadeloglou, P., Sanchez, M., 2004. *Does OPEC matter? An econometric analysis of oil prices.* Energy Journal 25 (4), 67–90.

Kaufmann, R.K., Ullman, B., 2009. *Oil prices, speculation, and fundamentals, interpreting causal relations among spot and futures prices.* Energy Economics 31, 550–558.

Kilian, L., 2008. *The Economic Effects of Energy Price Shocks.* Journal of Economic Literature, 46, 871-909.

Kilian, L., 2009. *Comment on causes and consequences of the oil shock of 2007–2008*. Brookings Papers on Economic Activity Spring 2009, 267–284.

Kilian L., Murphy D., 2010. *Why Agnostic Sign Restrictions Are Not Enough: Understanding the Dynamics of Oil Market VAR Models*. August, 2.

Krichene, N., 2008. *A simultaneous equations model for world crude oil and natural gas markets.* International Monetary Fund Working Paper African Department, WP/05/32.

Li H., Lin S.X., 2011. *Do emerging markets matter in the world oil pricing system? Evidence of imported crude by China and India.* May, 3, Energy Policy 39 (2011) 4624–4630.

Lin, S.X., Tamvakis, M., 2010. *OPEC announcements and their effects on crude oil prices*. Energy Policy, 38 (2), 1010–1016.

Lu, C., Xin, Z., 2010. *Impulse-Response function Analysis: An application to macroeconomy data of China.* Department of Economics and Society, Hogskolan Dalarna, Sweden, June, 2010.

Miller, J.I., Ratti, R.A., 2009. *Crude oil and stock markets: Stability, instability, and bubbles*. Energy Economics, 31(4), 559-568.

Moebert, J., 2007. *Crude oil price determinants*. Darmstadt discussion papers in economics, Working Paper Series, May, 16 2007 No. 186.

Narayan, P., Narayan, S., 2003. *Savings Behaviour in Fiji: An Empirical Assessment Using the ARDL Approach to Cointegration.* Monash University, Discussion Papers. No. 02/03.

Nwachukwu T. E., Egwaikhide F. O., 2007. *An Error-Correction Model of the Determinants of Private Saving in Nigeria.* The African Economic Society (AES) Conference, July 2007.

OPEC, Organization of Petroleum Exporting Countries, 2010, 2012, 2013. *World Oil Outlook.* May 2010, 5-8. *Annual Statistical Bulletin*. June 2012, 18-30. *Monthly Oil Market Report*. April 2013, 25-32. www.opec.org.

Parsons, J.E., 2009. *Black gold and fools gold: speculation in the oil futures market*. Center for Energy and Environmental Policy Research, 09-013.

Pesaran, M.H., Shin, Y., 1999. *An autoregressive distributed lag modeling approach to cointegration analysis.* Cambridge University Press, Cambridge.

Pesaran, M.H., Shin Y. and Smith, R.J., 2001. *Bounds testing approaches to the analysis of level relationships*. Journal of Applied Econometrics, 16: 289-326.

Soytas, U., Sari, R., Hammoudehb, S., Hacihasanoglu, E., 2009. *World oil prices, precious metal prices and macroeconomy in Turkey*. Energy Policy, 37 (2009) 5557–5566.

Soytas, U., Sari, R., Hammoudehb, S., 2010. *Dynamics of oil price, precious metal prices, and exchange rate.* Energy Economics, 32 (2010) 351–362.

US Senate Declarations, 2006. http://www.senate.gov/pagelayout/history/hmultisectionsandteasers/DeclarationsbyCongress.htm.

Wirl F., Kujundzic A., 2004. *The impact of OPEC Conference outcomes on world oil prices 1984-2001*. The Energy Journal 25, 45–62.

APPENDICES

APPENDIX A

OPEC Member Countries
(with year of membership)

Algeria (1969)
Angola (2007)
Ecuador (1973)
Iran (1960)
Iraq (1960)
Kuwait (1960)
Libya (1962)
Nigeria (1971)
Qatar (1961)
Saudi Arabia (1960)
United Arab Emirates (1967)
Venezuela (1960)

OECD Member Countries
(with year of membership)

OECD North America
Canada (1961)
Mexico (1994)
Unites States (1961)

OECD Europe
Austria (1961)
Belgium (1961)
Czech Republic (1995)
Denmark (1961)
Finland (1969)
France (1961)
Germany (1961)
Greece (1961)
Hungary (1996)
Iceland (1961)
Ireland (1961)
Italy (1961)
Luxembourg (1961)
Netherlands (1961)
Norway (1961)
Poland (1996)
Portugal (1961)
Slovak Republic (2000)
Spain (1961)
Sweden (1961)
Switzerland (1961)
Turkey (1961)
United Kingdom (1961)

OECD Asia&Oceania
Australia (1971)
Japan (1964)
Korea, South (1996)
New Zealand (1973)

APPENDIX B

Critical Values for ADF Unit Root Tests

PRICE	Level			First Difference		
Confidence Levels	99%	95%	90%	99%	95%	90%
Intercept	-3.508326	-2.895512	-2.584952	-3.508326	-2.895512	-2.584952
Intercept&Trend	-4.068290	-3.462912	-3.157836	-4.068290	-3.462912	-3.157836
DAYS	**Level**			**First Difference**		
Confidence Levels	99%	95%	90%	99%	95%	90%
Intercept	-3.506484	-2.894716	-2.584529	-3.509281	-2.895924	-2.585172
Intercept&Trend	-4.065702	-3.461686	-3.157121	-4.069631	-3.463547	-3.158207
QUOTA	**Level**			**First Difference**		
Confidence Levels	99%	95%	90%	99%	95%	90%
Intercept	-3.506484	-2.894716	-2.584529	-3.507394	-2.895109	-2.584738
Intercept&Trend	-4.065702	-3.461686	-3.157121	-4.066981	-3.462292	-3.157475
CHEAT	**Level**			**First Difference**		
Confidence Levels	99%	95%	90%	99%	95%	90%
Intercept	-3.506484	-2.894716	-2.584529	-3.507394	-2.895109	-2.584738
Intercept&Trend	-4.065702	-3.461686	-3.157121	-4.066981	-3.462292	-3.157475
NAM	**Level**			**First Difference**		
Confidence Levels	99%	95%	90%	99%	95%	90%
Intercept	-3.511262	-2.896779	-2.585626	-3.511262	-2.896779	-2.585626
Intercept&Trend	-4.069631	-3.463547	-3.158207	-4.069631	-3.463547	-3.158207
EU	**Level**			**First Difference**		
Confidence Levels	99%	95%	90%	99%	95%	90%
Intercept	-3.507394	-2.895109	-2.584738	-3.507394	-2.895109	-2.584738
Intercept&Trend	-4.075340	-3.466248	-3.159780	-4.068290	-3.462912	-3.157836
AO	**Level**			**First Difference**		
Confidence Levels	99%	95%	90%	99%	95%	90%
Intercept	-3.514426	-2.898145	-2.586351	-3.514426	-2.898145	-2.586351
Intercept&Trend	-4.076860	-3.466966	-3.160198	-4.076860	-3.366966	-3.160198
OECD	**Level**			**First Difference**		
Confidence Levels	99%	95%	90%	99%	95%	90%
Intercept	-3.513344	-2.897678	-2.586103	-3.513344	-2.897678	-2.586103
Intercept&Trend	-4.075340	-3.466248	-3.159780	-4.075340	-3.466248	-3.159780

APPENDIX C

VAR Lag Order Selection Criteria for Model 3.1

Endogenous variables: PRI DAY QTA CH
Exogenous variables: C T
Sample: 1 89
Included observations: 85

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-930.6142	NA	45869.97	22.08504	22.31494	22.17751
1	-794.7596	252.5296	2736.308	19.26493	19.95462*	19.54234*
2	-777.7441	30.02734	2680.903	19.24104	20.39052	19.70339
3	-760.5814	28.67184	2628.806	19.21368	20.82296	19.86098
4	-743.4552	26.99891*	2595.934*	19.18718*	21.25625	20.01942

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

VAR Lag Order Selection Criteria for Model 3.6

Endogenous variables: PRI DAY QTA CH OECD
Exogenous variables: C T
Sample: 1 89
Included observations: 85

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-761.3568	NA	52.46941	18.14957	18.43694	18.26516
1	-619.4493	260.4420	3.357817*	15.39881	16.40460*	15.80337*
2	-599.7546	33.82860	3.833371	15.52364	17.24786	16.21717
3	-573.7734	41.56992	3.813281	15.50055	17.94320	16.48305
4	-543.5659	44.77811*	3.486406	15.37802*	18.53910	16.64950

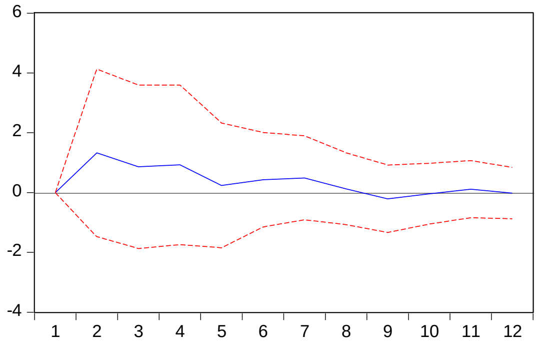
* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

APPENDIX D

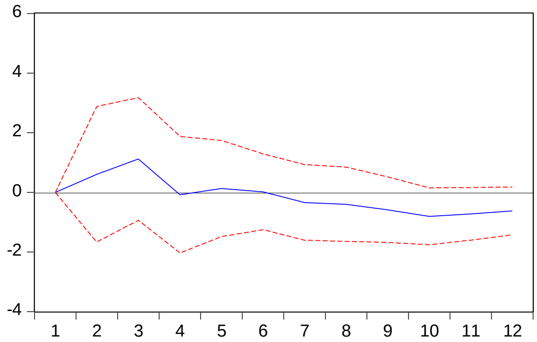
Graphs of Impulse Response Function with Insignificant Results for Model 3.1

Response to Cholesky One S.D. Innovations ± 2 S.E.

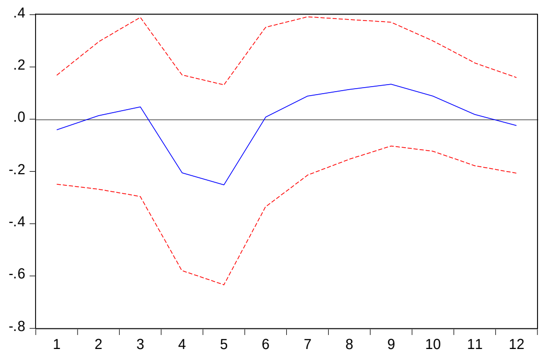
Response of DAYS to QUOTA



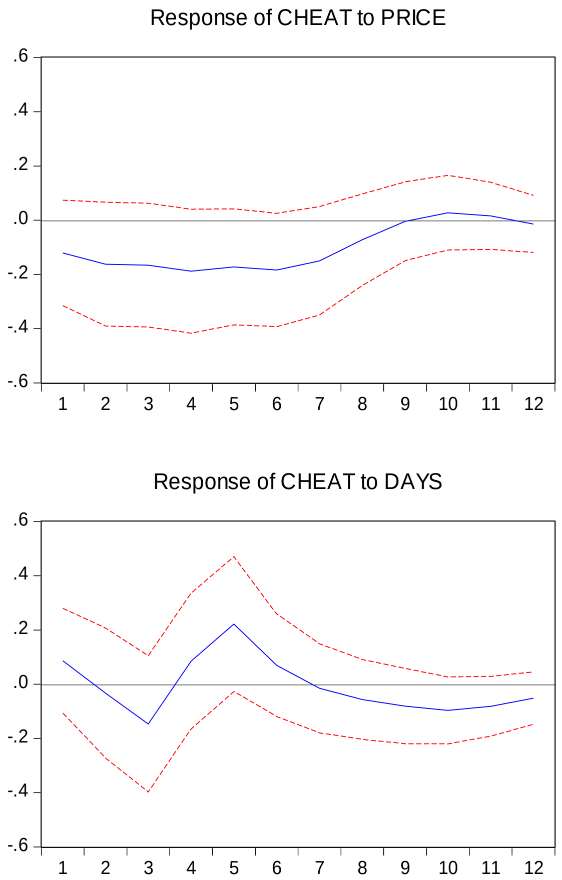
Response of DAYS to CHEAT



Response of QUOTA to Cholesky
One S.D. DAYS Innovation



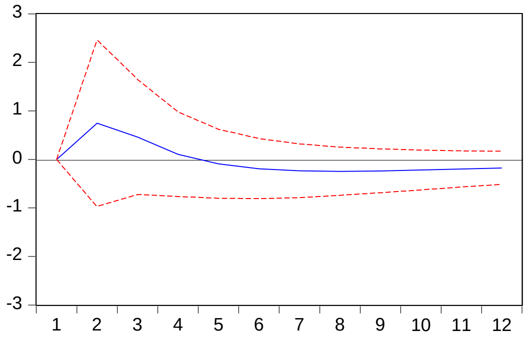
Response to Cholesky One S.D. Innovations ± 2 S.E.



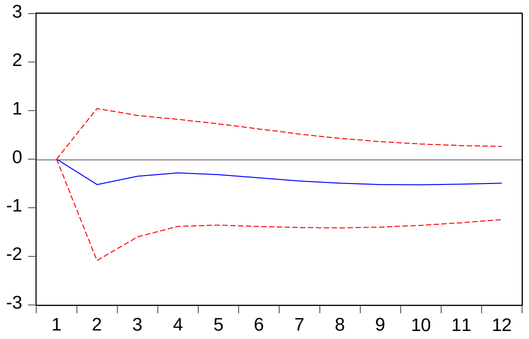
Graphs of Impulse Response Function with Insignificant Results for Model 3.6

Response to Cholesky One S.D. Innovations ± 2 S.E.

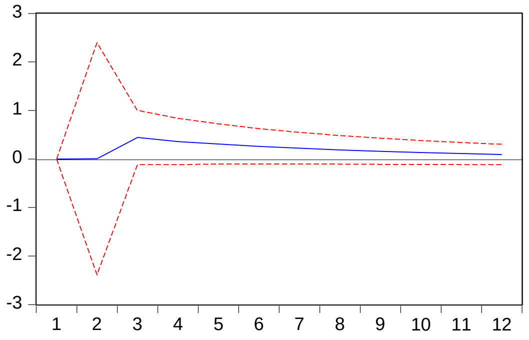
Response of DAYS to QUOTA



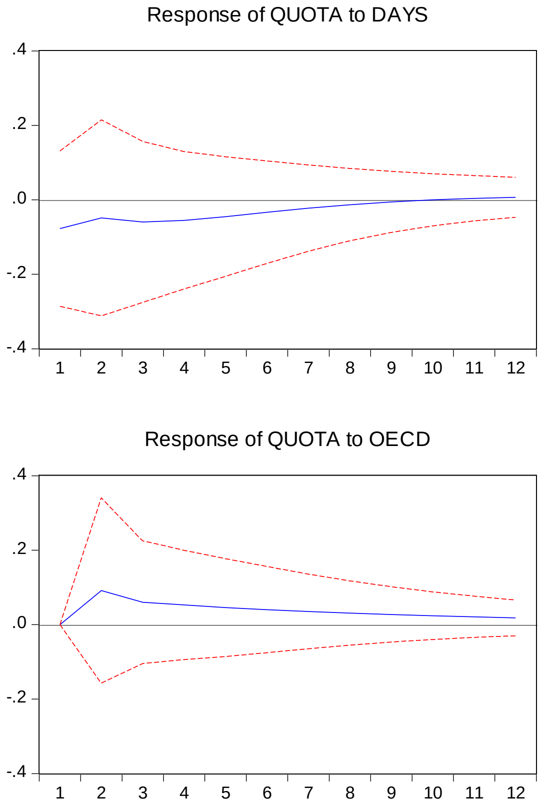
Response of DAYS to CHEAT



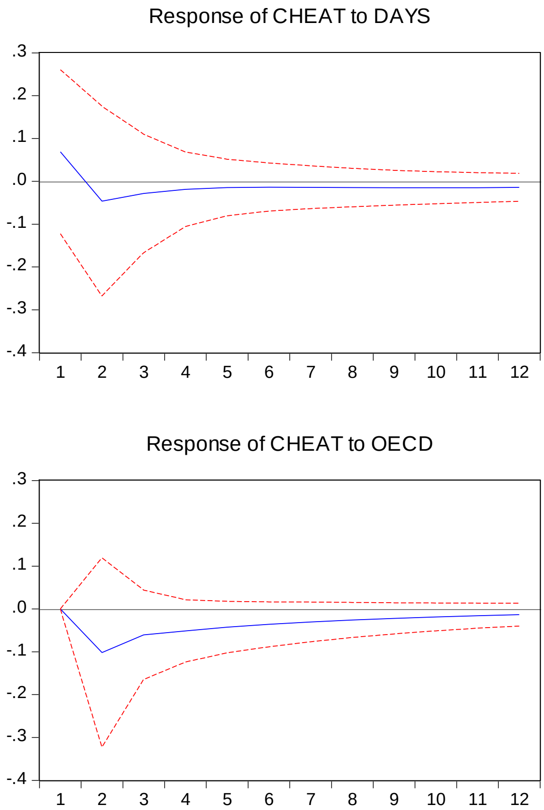
Response of DAYS to OECD

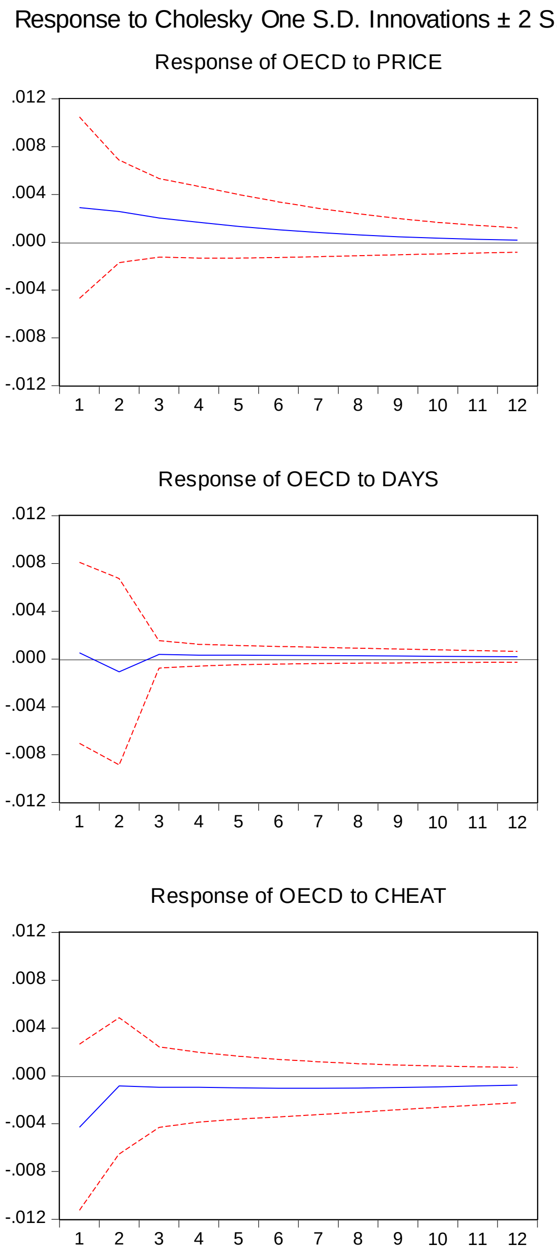


Response to Cholesky One S.D. Innovations ± 2 S.E.



Response to Cholesky One S.D. Innovations ± 2 S.E.




Response to Cholesky One S.D. Innovations ± 2 S.E.
Response of OECD to PRICE
.012
.008
.004
.000
-.004
-.008
-.012
1 2 3 4 5 6 7 8 9 10 11 12
Response of OECD to DAYS
.012
.008
.004
.000
-.004
-.008
-.012
1 2 3 4 5 6 7 8 9 10 11 12
Response of OECD to CHEAT
.012
.008
.004
.000
-.004
-.008
-.012
1 2 3 4 5 6 7 8 9 10 11 12

APPENDIX E

TEZ FOTOKOPİSİ İZİN FORMU

ENSTİTÜ

Fen Bilimleri Enstitüsü ☐

Sosyal Bilimler Enstitüsü ☒ X

Uygulamalı Matematik Enstitüsü ☐

Enformatik Enstitüsü ☐

Deniz Bilimleri Enstitüsü ☐

YAZARIN

Soyadı : GÜNEYLİGİL
Adı : ÜMMÜGÜLSÜM
Bölümü : İKTİSAT

TEZİN ADI (İngilizce) : DRIVERS OF THE OIL PRICE: AN EMPIRICAL ANALYSIS OF THE EFFECT OF OIL IMPORTS BY OECD REGIONS

TEZİN TÜRÜ : Yüksek Lisans X Doktora ☐

1. Tezimin tamamından kaynak gösterilmek şartıyla fotokopi alınabilir. X
2. Tezimin içindekiler sayfası, özet, indeks sayfalarından ve/veya bir bölümünden kaynak gösterilmek şartıyla fotokopi alınabilir. ☐
3. Tezimden bir bir (1) yıl süreyle fotokopi alınamaz. ☐

TEZİN KÜTÜPHANEYE TESLİM TARİHİ: